CHAPTER 17

UNIVERSITY OF WASHINGTON
DEPARTMENT OF ELECTRICAL ENGINEERING
SEATTLE, WASHINGTON 98195

Principal Investigator:

Yongmin Kim (206)545-2271

"Computer Input Device"
An Adaptive Device for Computer Usage
By the Mentally and Physically Disabled

Designers: Dan Tran and Wai Kam

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

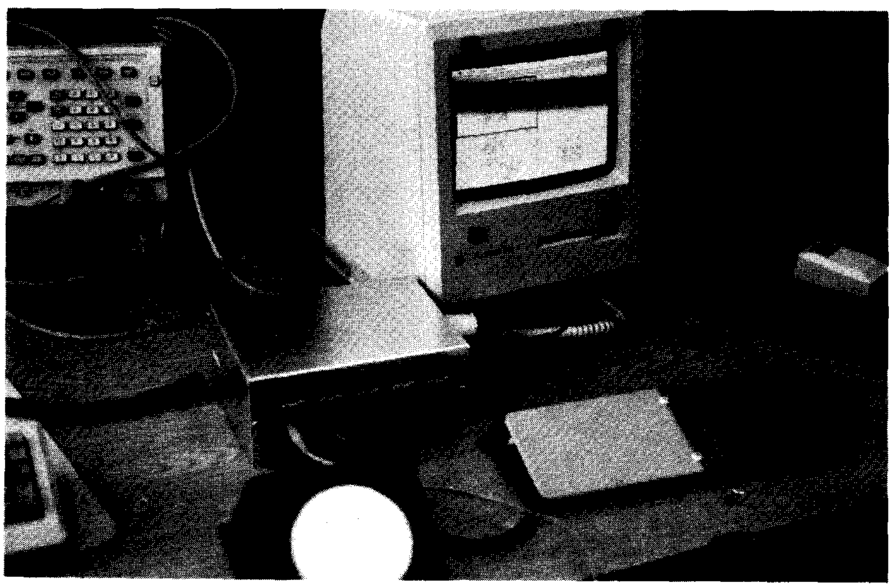
INTRODUCTION

The Computer Input Device was designed so the computer can be easily operated by physically and mentally disabled individuals, without disrupting the operation of the normal keyboard. The Computer Input Device allows the disabled individual to use the computer by utilizing several large keys on a device situated between the keyboard and the computer.

This computer input device incorporates the following features. There are five large selection keys to communicate with the computer, the keyboard is able to communicate with the computer at all times, the selection keys are programmable, and the device is safe and easy for the student to use. The computer input device has been designed to be easy to use without requiring the user to do a lot of typing.

SUMMARY OF IMPACT

The Fircrest School in Seattle is a residential facility for the developmentally disabled. At Fircrest, there are special software programs written for the Macintosh computers that enable the handicapped students to make choice selection. The students find it difficult to operate the keyboard because of individual physical or mental disabilities. The Computer Input Device was designed to help physically and mentally handicapped students use the Macintosh computer without the difficulty associated with the regular keyboard.



The Computer Input Device (CID) is interconnected between the Macintosh keyboard and the Macintosh main unit by standard telephone RJ1 1 cables; the keyboard plugs into the CID and the CID plugs into the Macintosh. The CID is enclosed in a metal box with two RJ1 1 jack on either side. There are five 1/8" phone jacks arranged horizontally on the surface of the box for connection of a variety of switch-type input devices (large format switches are available at Fircrest School). There is also a row of five DIP switches and five buttons for programming the CID.

When no selection is made on the CID, commands from the Macintosh (sent on the bidirectional serial data line) are directly passed to the keyboard. However, when one of the buttons connected to the CID is pressed, Inquiry and Instant commands are intercepted by the CID and the assigned code for the CID input is injected into the serial data line to the Macintosh.

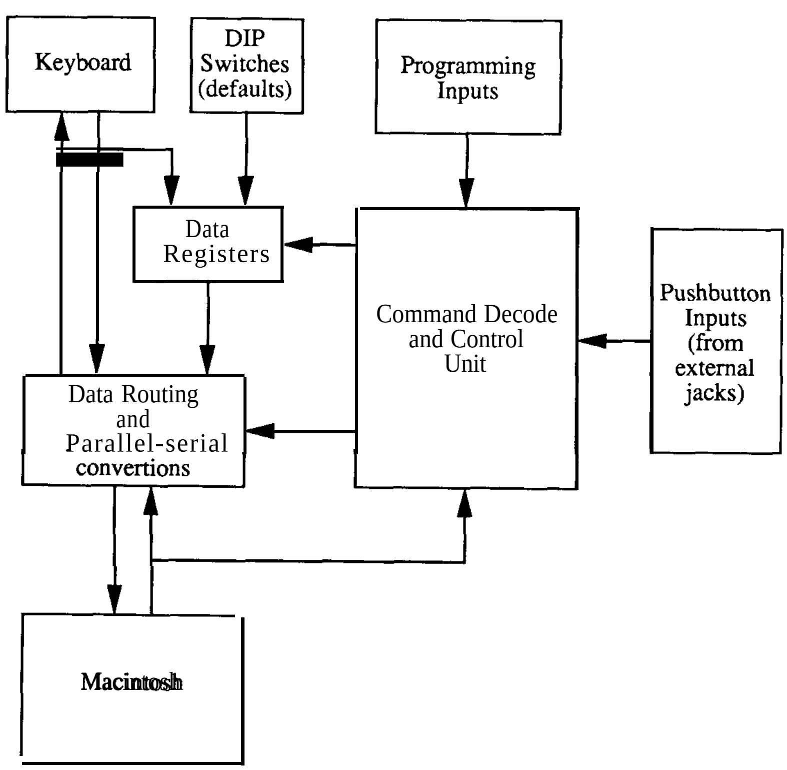
The code assigned to each of the CID button inputs are stored in five 8-bit registers. These registers are preloaded, on power up, with the DIP switch settings on the front oanel of the CID. This default setting any of the five CID inputs may be overridden by pressing the corresponding programming switch and the desired key on the keyboard simultaneously. This causes the keyboard code to be loaded into the appropriate register.

The data clock signal from the keyboard is used as the system clock for the CID. Control of the data flow is maintained by a state machine implemented in a single PAL22V10.

Crosstalk and reflection problems were major sources of error in the initial prototype and the designers were required to provide termination resistors and Schmitt triggers on the data and clock lines of the RJ1 1 cables.

Software utilizing single keystroke inputs from disabled students was already available from Fircrest.

The approximate cost of the CID is $250. This project allows those lacking the manual dexterity to operate a keyboard needed in using the Macintosh computer.



“Remote Controlled RF Traffic Light Controller”
An Aid in Educating the Mentally or Physically
Disabled in Pedestrian Safety

Designers: John Rivard and Jeff Schroeder

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

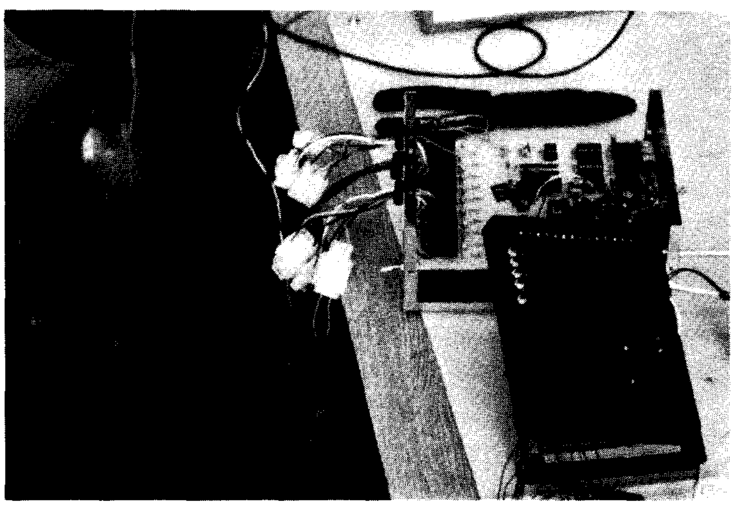
The Remote Controlled RF Traffic Light Controller is an instructional device for educating physically and mentally disabled individuals in pedestrian safety. It consists of one hand-held remote control unit and two receiver stations, each connected to a set of traffic and walk lights, to be used in a controlled environment such as a school campus. Each light station stands alone with its own power supply and receiver unit, and consists of a green-yellow-red traffic light, a walk/don’t walk light, and a walk button. The intersection operates in one of two main modes, cycling or flashing.

Only two light sets and two receiver circuits were implemented in this project, but to allow for future expansion, the remote unit is able to control a full bi-directional intersection made up of four corner stations, with each station consisting of two traffic light sets and one receiver unit.

SUMMARY OF IMPACT

Fircrest School in Seattle is a residential treatment facility for the developmentally disabled, serving approximately 500 such individuals. Although most are permanent residents, some will leave the school to live on their own or in halfway houses. Fircrest has acquired two sets of traffic lights and walk signals for use in teaching clients how to obey traffic lights and to safely cross normal intersections. The goal of this project was to design and build a single remote control unit and the receiving control logic for the two sets of lights that Fircrest already has, incorporating Fircrest’s specifications for the system.

For the handicapped individual to be able to live independently, either on their own or in a halfway house, basic survival skills for the city, such as pedestrian education and safety need to be mastered. The Remote Controlled RF Traffic Light Controller should be very helpful in training these handicapped individuals in a safe and familiar environment.



The Remote Control RF Traffic Light Controller (RC-RFTC) is a revised and updated design of the older "Remote Controller for Traffic Light" project.

In this improved configuration, there is a separate hand-held controller unit and stationary traffic unit. The mode of communication has been improved in both reliability and flexibility. Whereas the older project used pulse coded modulation (PCM) and the analog circuitry of a toy car, the RC-RFTC uses a walkie-talkie transmitter and receiver to transmit DTMF encoded tones. The use of monolithic DTMF encoders and decoders makes this form of communication more reliable as well as more flexible. One of sixteen different 2-tone combinations can be transmitted at a time (equivalent to 4 bits of information). Furthermore, the walkie-talkie circuits allow half duplex communication between the hand-held controller and light station; this too is an improvement over the simplex communication channel used before.

The hand-held unit front panel has five switches and 2 arrays of LEDs. The row of LEDs at the top represents the cycling of the controller through the different states. The other LED array mimics the current status of the traffic and walk lights. The toggle switches control the power and operational mode of the controller.

The controller unit broadcasts the current state to the traffic light stations. The traffic light stations respond by turning on and off the appropriate lights for the received state. In turn, each traffic light station is capable of transmitting the status of the walk button back to the controller.

An Intel 8031 microcontroller is employed in the controller unit to process the inputs and track the states. The 8031's internal timer is used to provide the timing of the state transitions. The use of a programmable microcontroller as opposed to the fixed state machine used previously, allows state durations to be varied and state transitions made more complex. Two modes of operation are currently supported: cyclic and flashing.

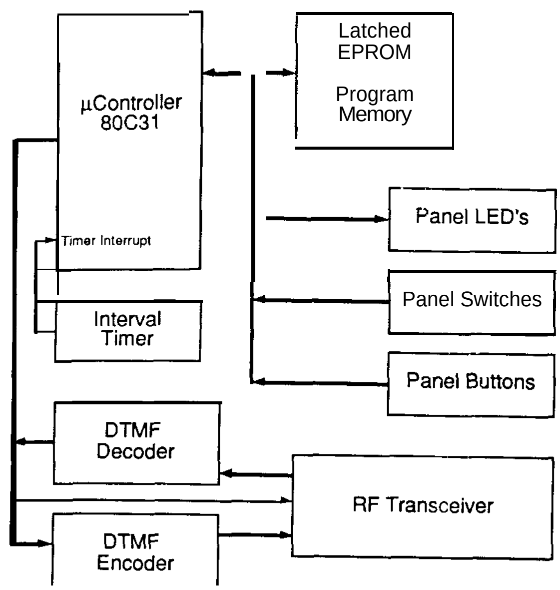
In the cyclic mode, the lights sequence through a traffic light pattern typical of a four-way intersection. The use of the walk button is optional; if not used, the walk light is programmed to come on automatically, following the lead of the traffic lights.

In the flashing mode, one direction is set to flashing red and the other to flashing yellow. This simulates a typical intersection of a side street with a minor thoroughfare.

The approximate cost of this project is $250.

RF Traffic Light Controller

Remote Control Unit Block Diagram and Schematic

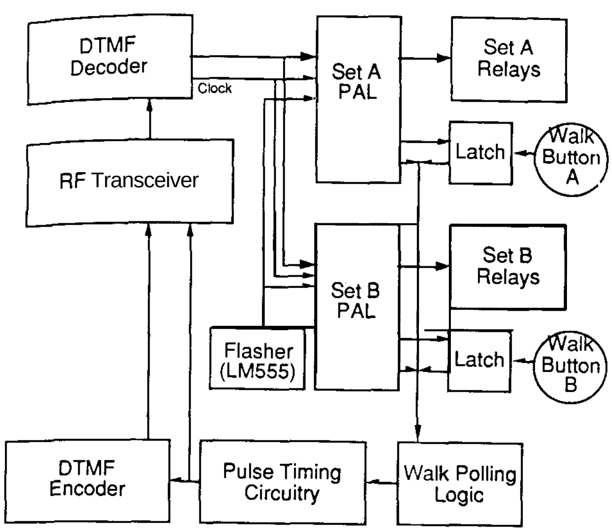


REMOTE CONTROL UNIT

Figure D: Remote Controller Block Diagram

RF Traffic Light Controller

Receiver Station Block Diagram and Schematic



TRAFFIC LIGHT RECEIVER UNIT

Figure E: Receiver Station Block Diagram

Receiver Station Hardware Description

Each receiver station consists of a receiver control circuit and up to two sets of orthogonally placed traffic lights. The station must be transportable for use outdoors and must not require external hookups for power. In the following sections we will discuss the packaging and power requirements of the receiver station, and will describe the remote receiver circuitry, decoding circuitry, walk button and polling circuitry, and remote transmitter circuitry of the receiver station.

Packaging and Power

Due to the size of the traffic lights themselves, the receiver station is not intended to be completely portable, though it must be transportable. In addition, the entire station must be

"Self Injurious Behavior (SIB) Data Collection Unit"
A Micro-Controller Based Device

Designers: Steven Martin and Steven Bohrer

Disabled Coordinator: Dr. John Eiler of Fircrest School

Faculty Supervisor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

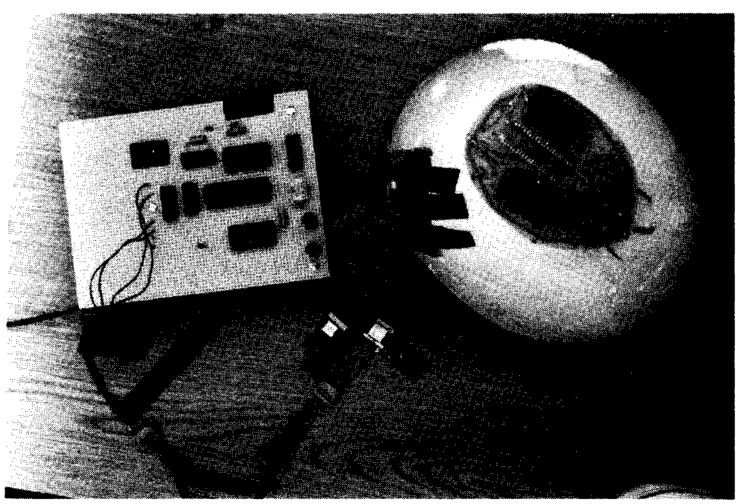
INTRODUCTION

The SIB Data Collection Unit (DCU) is a helmet-mounted microcontroller based data collection device designed to measure treatment progress for patients suffering from Self Injurious Behavior. The SIB monitor measures and records the force and frequency of a patient's self-inflicted blows to the head, which is the usual manifestation of SIB. The parameters recorded are time of day, number of blows, and force of blows.

The severity of the blows that the SIB patient typically inflicts upon himself requires that he always wear a sturdy helmet, resembling a motorcycle helmet. The battery powered DCU is imbedded in the protective foam inside the helmet. The device senses forces on the helmet by collecting analog signals proportional to the accelerations experienced by the helmet. Total data collection time can be up to four hours. The accumulated data can be downloaded to the SIB Data Storage Unit (DSU) that has been separately developed by a different team.

SUMMARY OF IMPACT

Fircrest School in Seattle is a residential treatment facility for the developmentally disabled. A number of these physically and/or mentally disabled individuals suffer from Self Injurious Behavior. The SIB Data Collection Unit can provide researchers at the Fircrest School with reliable, comprehensive data that can be easily obtained and readily downloaded to a Macintosh. The three main concerns with researchers at Fircrest are the frequency of occurrences, the force of impact, and the time of day of the occurrences. It is hoped that by analyzing the data obtained with the SIB DCU, that a Behavioral Therapist will be able to determine treatment progress in reducing not only the frequency, but also the force of the blows a SIB patient endures.



The SIB DCU is based on the Motorola MC68705G2 microcontroller with onboard 2K ERPOM. The four I-bit I/O ports are assigned as follows: 2 ports to interface to the 32K x 8 SRAM used for data storage, 1 port for data transfer (to the SIB Data Storage Unit, DSU) and 1 port for control signals.

To detect the rapid accelerations and decelerations associated with violent head movement, two commercial accelerometers are orthogonally mounted within the helmet. The accelerometers which consist of strain gauges in a Wheatstone Bridge configuration produce differential voltages as it undergoes stresses due to acceleration.

The output of the accelerometers from a typical blow to the helmet resembles a exponentially decaying sinusoid. This differential signal is amplified using an instrumentation amplifier which converts the signal to a single-ended output, provides signal gain and offset adjust. The following analog stage rectifies the bipolar signal. Finally, just prior to digitization, the signal is fed into a peak and hold circuit to capture the maximum acceleration.

The conditioned accelerometer signals are digitized using a successive approximation 8-bit A/D converter. The A/D converter is activated under microcontroller direction.

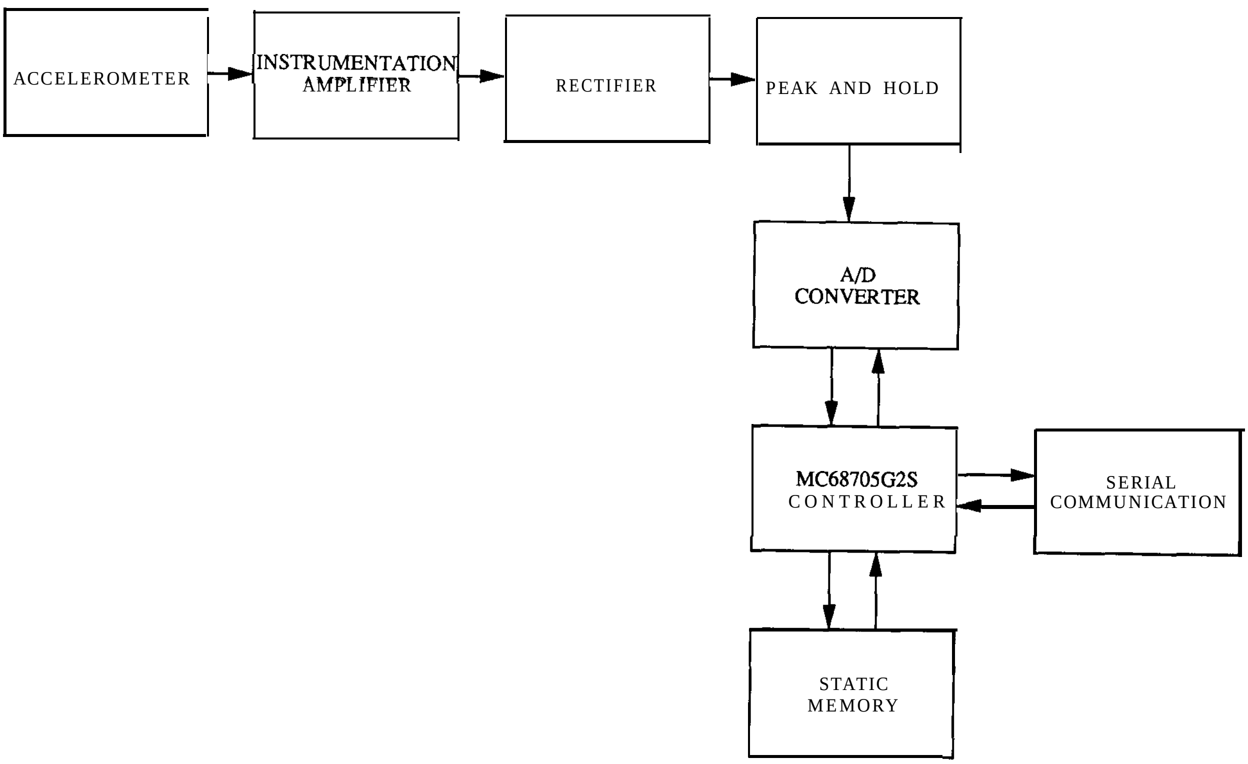
A data communication channel to the Data Storage Unit (DSU) is provided by a USART and an RS-232 compatible port. The DCU resets, changes data threshold, collects data and downloads data under the direction of the DSU.

The microcontroller runs in the power saving Wait mode between data collection intervals. When the microcontroller's built-in timer generates an interrupt, the processor reads the accelerometer values, calculates the magnitude of the resultant force vector, storse the data in SRAM, and checks for commands from the DSU in the USART. If a command is detected in the USART, a software interrupt is generated so that the proper action can be taken.

Since the accelerometers are mounted orthogonally, the magnitude of the resultant force vector is easily computed as the square root of the sum of the squares of each of the accelerometer values. To reduce the computational overhead, the square root was implemented using a lookup table technique.

The actual force magnitude value is not directly stored. Rather, 120 different histograms representing the number of blows in each of 256 different force ranges over a period of 2 minutes is stored. With the 32 K x 8 memory of the DCU, there is enough data storage for 4 hours of data collection.

The approximate cost of the project is $350.



"Self Injurious Behavior (S.I.B.) Monitor"
A Data Storage Unit

Designers: Rochelle Mai and John Ogden

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle. WA 98195

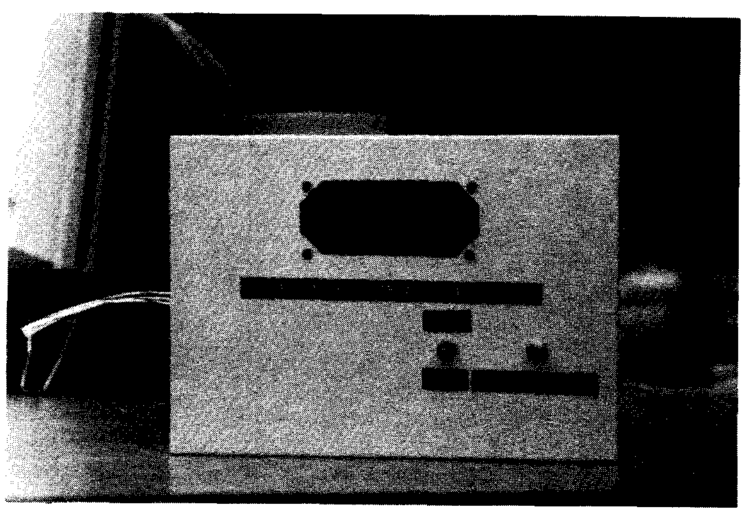
INTRODUCTION

The SIB Monitor is an automated data collection tool designed to measure treatment progress for patients sufferine from Self Injurious Behavior. The SIB monitor measure: and records the force and frequency of a patient's self-inflicted blows to the head, which is the usual manifestation of SIB. The monitor output can be downloaded to a Macintosh computer for analysis by a Behavioral Therapist.

The SIB Monitor consists of two modules: A Data Collection unit (DCU) and a separate Data Storage Unit (DSU). The severity of the blows that the SIB patient typically inflicts upon himself requires that he always wear a sturdy helmet. The DCU is mounted inside this helmet to measure and store impact data for four hour periods. The DSU provides bulk data storage of the data accumulated by the DCU. When full, the DSU provides for serial download to a Macintosh computer for analysis by the therapist. The two module design provides the best compromise for providing high storage capability and meeting the size and power constraints of the helmet.

SUMMARY OF IMPACT

Fircrest School in Seattle is a residential treatment facility for the developmentally disabled. A number of these physically and/or mentally disabled individuals suffer from Self Injurious Behavior (SIB). SIB can vary widely in severity, but at its most extreme, it can cause extensive tissue and sensory damage, and is extremely difficult to treat. A problematic issue in alleviating SIB has been measurements of treatment progress. It is hoped that by analyzing the data obtained with the SIB monitor, that a Behavioral Therapist will be able to determine treatment progress, reducing not only the frequency, but also the force of the blows a SIB patient endures.



The DSU is housed in a 10" x 6" x 2" metal enclosure. Mounted on the upper surface are an LCD display and two toggle keyswitches. Mounted on the side is an RS-232 compatible cable and connector.

The DSU design centers around its Motorola MC68705G2 microcontroller. This processor features built-in 2K EPROM, 112 bytes of RAM, 32 I/O lines (organized as 4 8-bit ports), on-board timer and interrupts.

The four I/O ports are used for the address bus, the data bus, control signals, and the key input bus.

The specification called for the DSU to support a memory size of 256 Kbytes (equivalent to store 8 downloads from the DCU). However, the microcontroller can only access 64 Kbyte. To expand the memory range, a 24-bit memory address register formed by 3 8-bit registers is provided to interface to the data storage memory. This provides a maximum addressing capability of 16 Mbytes.

Besides the memory system, three other types of devices are interfaced to the microcontroller: the LCD display, the keyswitches and the USART.

The 16 x 1 character LCD display is used to provide an interactive interface to the user. One of the keyswitches, labeled "Select", is used to scroll through the different DSU operations. The other switch, labeled "Up/Down", is used to select the value or setting for each option.

The USART allows data to be downloaded from the DCU or uploaded to a host computer. RS-232 drivers and receivers translate the TTL signal levels of the USART to and from RS-232 levels.

The DCU does not directly store actual force magnitude values. Rather, 120 different histograms representing the number of blows in each of 256 different force ranges over a period of 2 minutes is stored. With the 32 K x 8 memory of the DCU, there is enough data storage for 4 hours of data collection.

The DSU's 256 Kbyte memory allows up to 8 downloads of DCU memory or 32 hours worth of data collection. However, due to the exorbitantly high prices of memory at the time of this project, only 32 Kbytes of SRAM is currently installed.

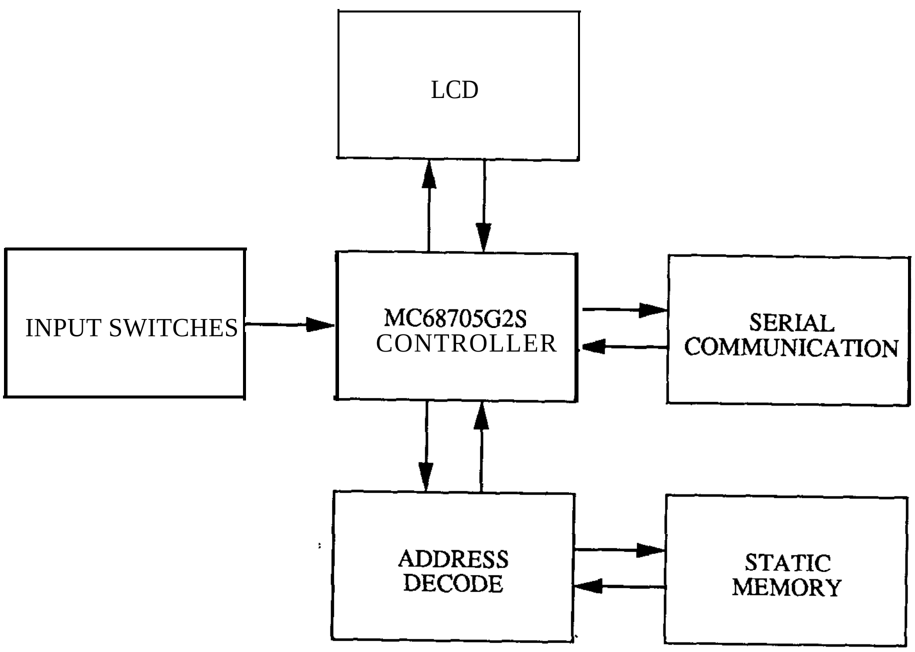
The processor normally runs in the power saving Wait mode. However, when an interrupt is received from the keyswitches, the processor becomes active and enters its interrupt service routine (ISR). Currently supported operations are: DCU Download, DCU Diagnostics and Computer Upload.

In DCU Download mode, the download command word ($55) is sent to the DCU. The DCU responds by sending its status code (including the number of histogram records accumulated so far) followed by the existing data.

DCU diagnostics allows the user to set the DCU threshold value and check the amount of remaining DSU memory. If the DCU threshold is changed, the DCU threshold command ($02) is sent followed by the new threshold value.

The Computer Upload function sends all the histogram records in memory to the host computer connected to the RS-232 cable. The data is first converted to decimal ASCII characters and delimited by commas before transmission. Further, a carriage return and line feed is inserted after every 16 histograms of data.

The approximate cost of the DSU is $300.



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

Designers: Meng Chao and Khai Trinh

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

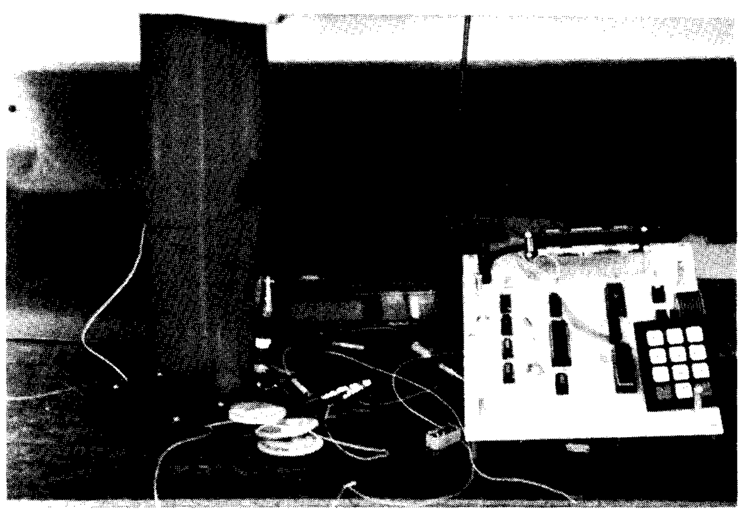
INTRODUCTION

The Vocational Production Moniotor (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 student supervisor. Any device such as a radio or recording which may be switched on by a relay, may be used as a reinforcer.

The VocMon can display the production rate (PR), the total elapsed time (TET), the total time (TWT) and the total reinforcement duration (TRD). In addition, it is programmable. It allows the instructor or supervisory personnel to easily change the default reinforcement duration. The VocMon is made up of two separate units, the Sensor unit and the Data Collector (microcontrol) unit. The microcontrol unit is capable of accepting data from four different sensor units and calculating the production rate of each.

SUMMARY OF IMPACT

The VocMon system was first conceived at the Fircrest School in Seattle. 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 situation. The VocMon system can be helpful in raising the productivity levels of handicapped workers by providing tangible rewards for greater efficiency.



The VocMon design centers around the Intel 8031 I-bit microcontroller. The main unit consists of the microcontroller, support chips (EPROM, latches, etc.), an 16 x 1 LCD display and a 3 x 4 numeric keypad. The each sensor unit is enclosed within a 1 ft high, 5 inch diameter PVC pipe. 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 accomodate up to four sensors and four individually controlled reinforcers.

The IR emitter is pulsed by the microcontroller. The IR detector output is amplified, filtered and transmitted to the microcontroller. If an object is dropped into the pipe it interrupts the IR signal and the expected pulse pattern is not received by the IR detector.

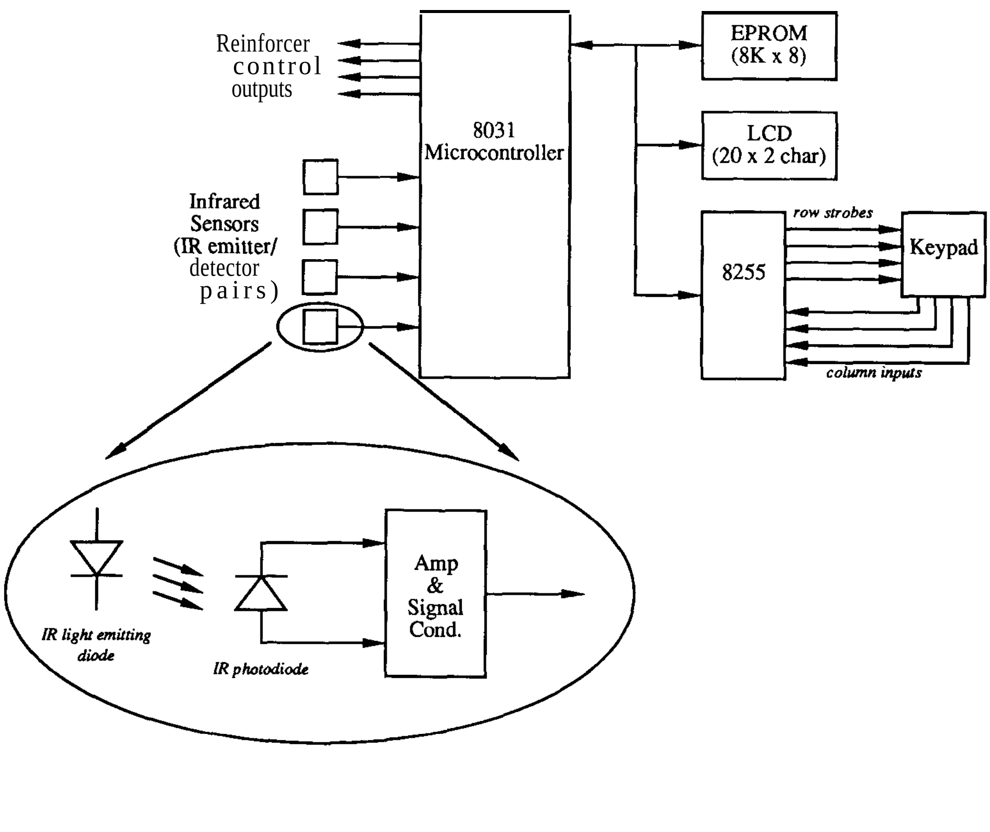
The LCD is interfaced to one of the microsontroller's I/O ports. Another port is used by the sensors and reinforcer outputs. Another is used to connect to an Intel 8255 Parallel Input/Output (PIO) chip to expand the number of control ports. Currently, the PIO is used just to interface to the keypad.

The keypad is decoded using a row scanning technique. Using the row lines coming out of PIO, each row of the keyboard row is strobed sequentially with a low pulse. If a key is pressed in a row, the low pulse is transferred to a column input on the PIO. The combination of row and column uniquely identifies the key.

The built-in timer of the microcontroller is used to time reinforcer activation, find total elapsed time, find total work time and to calculate production rates.

The software allows changing parameters such as the threshold production rate for reinforcer activation and the reinforcer duration.

The approximate cost of me VocMon and a single sensor unit is $200.



"Choice Selection System"
A Training System for Nonverbal Disabled Individuals

Designers: Roman Mach and John Gilbert

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

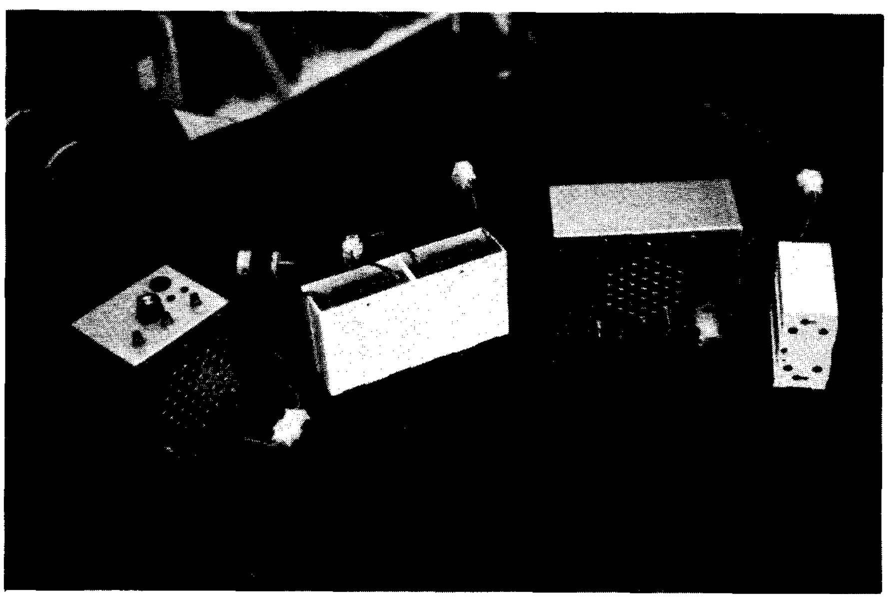
INTRODUCTION

The Choice Selection System, which is designed for the Fircrest School in Seattle, allows nonverbal students to mdke structured choice selections from visual cues. The student chooses from a linear array of three to six Choice Selection Modules (CSM). Each CSM holds some visual stimulus that represents a distinct choice available to the user. Each CSM has a light source, which is lit in turn. During this illumination, a switch closure will result in a speech segment being produced, corresponding to the picture on the illuminated CSM. Pictures indicating available choices can be readily attached to the display and the scan rate among the multiple CSM's is easily adjustable.

A series of CSM's is controlled by a Digital-to-Analog/Controller Module (DAC), or a Programming Module (PRM). The DAC allows playback of the digitized sound, and is intended for use by a student. The PRM allows digitizing and playback, and is intended for use by a therapist or other supervisory personnel for programming of the choices.

SUMMARY OF IMPACT

The Fircrest School in Seattle is a residential facility for developmentally disabled individuals, some of whom are nonverbal. The Choice Selection System allows these nonverbal students to vocalize their desires via the CSM modules' prerecorded messages. It could benefit them by providing the ability to make structured choice selections to indicate basic wants and needs, for example, desired foods from a menu, preferred leisure or educational activities or daily clothing selections.



The CSM's and the DAC, or PRM, are interconnected using a five-ine bus plus a daisy-chained CASCADE line to pass control from module to module.

The five-line bus includes two lines for power and ground, a clock line to synchronize the CSM's with either the DAC or PRM, a bidirectional data line for a digitized audio signal and a control line for command transmission to the CSM's.

The CASCADE line is interconnected between the CASCADE IN and CASCADE OUT inputs (outputs) of adjacent units. It is used to pass a single bit token. When a CSM receives the token at its CASCADE IN input, then a communication link (for data and commands) is established between the CSM and the DAC (or PRM). An LED on the CSM case is illuminated to indicate that this is the active module. This protocol is maintained by identical state machines in each module.

Commands are sent over the CONTROL lines as varying length pulses of 1 to 4 clock pulses. By enabling a counter for the duration of the CONTROL pulse, the value that remains in the counter is the 2-bit instruction code. Commands are ADVANCE (DWELL), RECORD, PLAYBACK and RESET.

The design of the PRM and DAC modules is nearly identical and differs only in the PRM's ability to record (digitize) sound. In fact, the same printed circuit board layout is used for both modules.

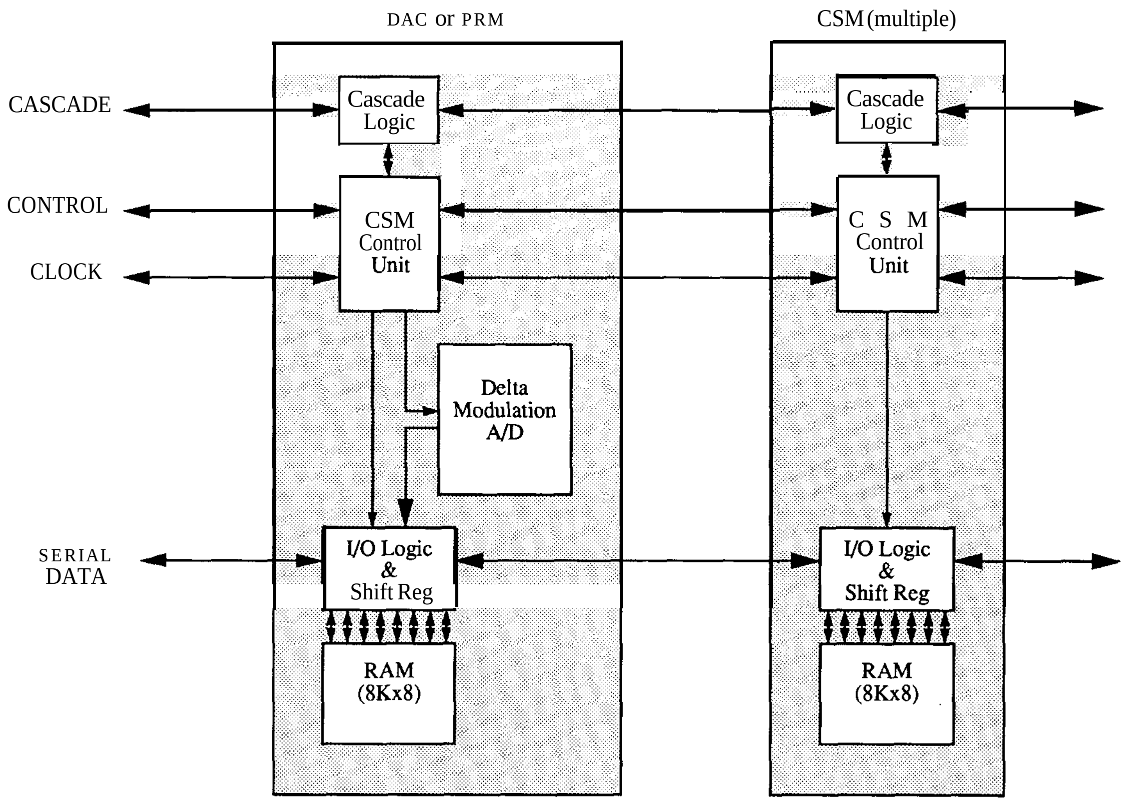
The method of digitization chosen is Continuously Variable Slope Delta (CVSD) Modulation or Delta Modulation. The Motorola MC3417 CVSD modulator/demodulator serves as both the A/D converter and D/A converter for the system. It is operated at a 16 KHz sampling rate.

For RECORD operations, the serial data stream from the CVSD chip is transmitted by the PRG to the CSM over the DATA line. Once in the CSM, it is shifted into an 8-bit CMOS shift register and stored in an 8K x 8 SRAM. The process is reversed for PLAYBACK.

The audio output from the CVSD converter is lowpass filtered by a two-pole Butterworth 1461 Hz active filter and a single pole Butterworth 2040 Hz active filter. This combination was experimentally determined to give the best overall playback sound quality.

The input signal to the CVSD converter is bandlimited to 15 - 2040 Hz by a three-pole bandpass filter (cascaded Butterworth lowpass and highpass filters).

The approximate cost of this project, which includes one DAC, one PRM and two CSM's, is $740. $250 each for the DAC and PRM and $120 each for the CSM's.



"Calculator for the Handicapped"
An Input Calculator For the Physically Disabled

Designers: Patrick Phung, John White and Glenn Yu

Disabled Coordinator: Mr. Al Ross

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

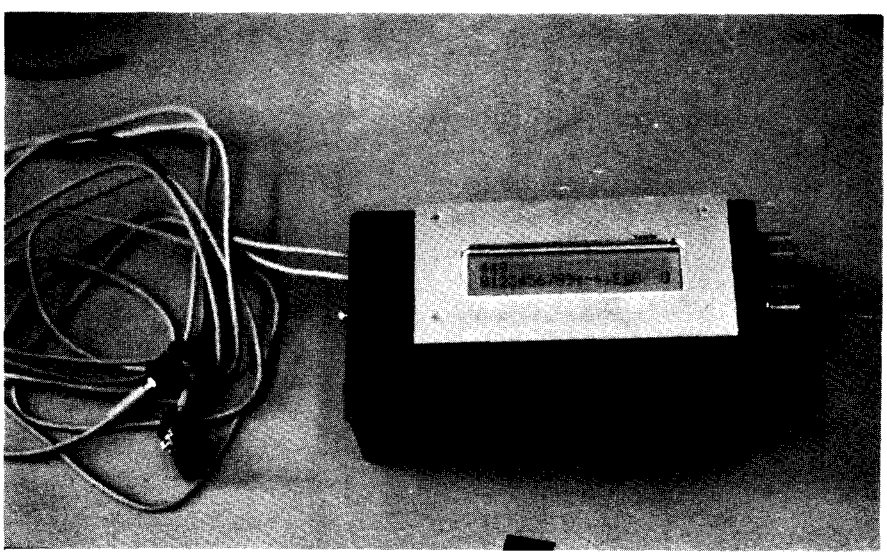
INTRODUCTION

The Calculator for the Handicapped has been designed to allow physically and/or mentally disabled persons to control the operation of a calculator using only one or two switches which they can easily control. Two modes of operation are supported. In the single switch mode, the LCD will display all the digits and the mathematical operations available to the user on the screen. A cursor will scroll automatically through the digits and the operations one at a time, and the scrolling rate can be varied through a variable switch on the calculator. If the user wants to choose a digit or operation, he or she hits the switch when the cursor reaches the desired location. In the double switch mode, the user has more control over the selection process, and the selection (digit or operation) can be entered in Morse Code, since the switch can be decoded as dots or dashes. In both modes, the input selections and results of the calculations are displayed on the LCD.

The calculator is designed to be as small as possible so it will not obstruct the user's vision and movement. The casing is free of sharp edges to prevent the user from any potential injuries and it has self-contained batteries. Three forms of power supply provide portability and long-term use: battery power, wheelchair battery power, or power from a standard AC outlet.

SUMMARY OF IMPACT

Due to the limited controlled movements of a handicapped person, such an individual is not able to use the standard calculators that are widelv available commercially. Since many handicapped people are more mobile because of govenmental support and public awareness, and many are living independently or in halfway houses, they are starting to need and desire such conveniences as a calculator. Not only can a calculator be an aid in budgeting, for example, on shopping excursions, it can be very helpful for those handicapped individuals whose motor control is such that holding a pen or pencil is problematic.



Externally, the calculator is extremely simple. The only visible external features on the 6" x 3-1/2" x 2" black metal enclosure are a 20 x 2 LCD display, two dials, a DC power jack, two switch input jacks and three switches.

Inside the calculator is an Intel 8031 microcontroller which provides the computational power as well as overall system control.

The LCD display is memory mapped into the 8031's address space. Scroll rate is determined by a potentiometer whose output is digitized by an d-bit A/D converter. The digitized value is used by the microcontroller to control the scroll rate of the LCD display.

The handicapped user provides input to the calculator by using head switches (or some other type of momentary contact switch) connected to the switch input jacks. These switches are debounced using an RC circuit and Schmitt triggers. The debounced signals are connected directly to the 8031's interrupt inputs.

Power can be supplied either from internal NiCad batteries or from an external voltage regulator connected to the DC power jack. A battery charging circuit was incorporated so that the DC power jack can also be used to recharge the NiCad batteries.

To conserve power and make it easier for a physically handicapped person to activate the calculator, a special on/off circuit is incorporated into this device. When either input switch is depressed, power flows to the microcontroller long enough for it to start up and activate a relay which will channel power into the circuit on a more permanent basis. Since the relay is under the microcontroller's control, power can be turned off under software control as well as manually by the user.

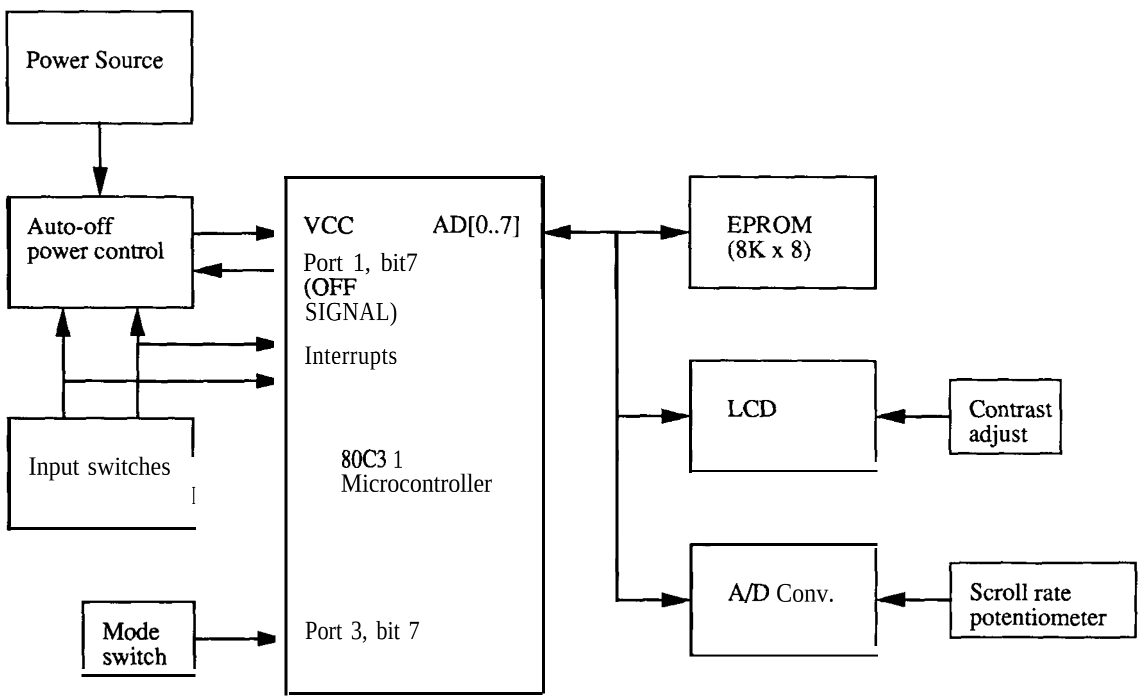
There are two operational modes which the software supports: scrolling (single button) and Morse Code (two buttons).

In the former mode, the 8031 causes the cursor to constantly scroll through all the possible inputs (digits, operators, and editing functions) at the rate set by the scroll rate dial. When the headswitch is pressed, calculator accepts as input whatever is currently at the cursor. In the latter mode, the user uses Morse code to provide input to the calculator. In this mode, one headswitch represents dot and the other dash.

In both modes of operation, the calculator uses Reverse Polish Notation since it minimizes the number of keystrokes needed to make a calculation.

All of the arithmetic operations are done in floating point using a slightly modified floating point package obtained from Intel for the 8031 microcontroller.

The approximate cost of the calculator is $250 (not including the headswitches).



"Data Acquisition System (DAS) for Use in Prosthetic Adjustment"
A Portable Visual Display Unit for Recording Data

Designers: Will R. Cummings and Shahram Rezaimiri

Disabled Coordinator: Ms. Joan Sanders

Supervising Professor: Dr. Yongrnin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

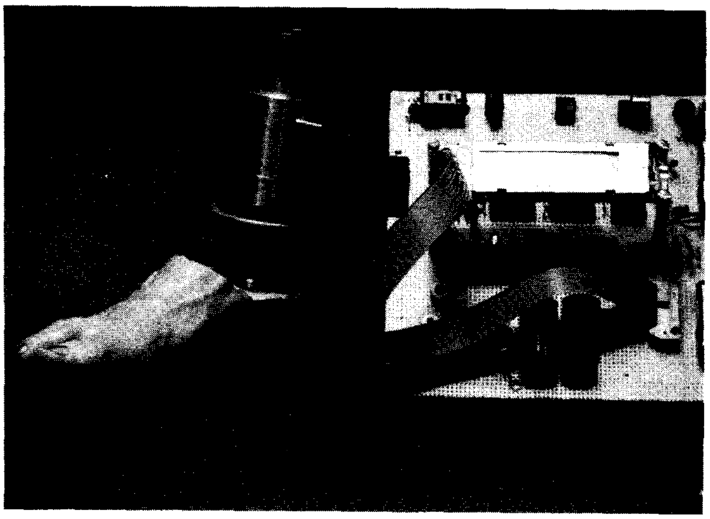
A common rehabilitation treatment for below-knee amputation is the use of a prosthetic leg. The Seattle Foot, developed by Veterans Administration and the University of Washington, is one of these prosthetic legs available. The prosthesis consists of a socket, shank, and foot. During prosthetic fitting sessions, the relative positions of these three components must be established to help achieve a stable gait and maximize comfort for the amputee. Usually this is accomplished during a succession of fittings with fitting judgement based on the prosthetist's visual observations, clinical experience, and patient feedback.

Recently, the instrumentation was developed to record the axiaiforce, bending, and torsional movements in the prosthetic shank of the Seattle Foot during ambulation. This' adds a quantitative tool that can help the prosthetist improve effectiveness and efficiency in the fitting process.

However, the current computer-based data collection system is not portable and requires the use of a 15 meter instrumentation cable. The Data Acquisition System (DAS) is a portable visual display unit for recording shank bending data. The DAS is a microcontroller-based device which records and displays amplified analog signals emanating from strain gauges bonded to the prosthetic shank, and could be carried by the prosthetist while walking with the amputee without the cable during the fitting session.

SUMMARY OF IMPACT

For the below-the-knee amputee, the use of a prosthetic leg is a main key in returning to a normal life and mobility. Accuracy of fitting of the prosthesis is of prime importance in achieving a stable gait and maximizing comfort for the amputee. The Data Acquisition System for use in prosthetic adjustment can increase the accuracy of the fitting, while eliminating any interference from a long instrumentation cable during the fitting.



This data acquisition and display system (DAS) is relatively simple. It consists of a microcontroller, EPROM, SRAM, A/D converter, LCD display and a few buttons.

The signal from the strain gauges in the prosthetic device are amplified and filtered externally before entering the DAS. The signal received by the DAS from the prosthetic device has a bandwidth of DC to 30 Hz.

Within the DAS, the Intel 8031 microcontroller activates the 8-bit A/D converter at 170 Hz and stores the captured data in the 8K x 8 SRAM. Currently, only 1600 bytes of data are stored for each sampling period. This is roughly equivalent to 10 seconds worth of data. The input range of the A/D converter is 0 to +5 volts.

A 1 second window of the captured data is displayed on the 160 x 32 dot matrix LCD module. The internal display memory is addressable from outside the LCD module in 8 pixel blocks, The software supports horizontal scrolling of the display by transferring diffemt sections of SRAM memory into the display memory. This allows the user to review the entire 10 second sample within a scrolling 1 second window. The software also supports adjustment of the displayed (vertical) voltage range.

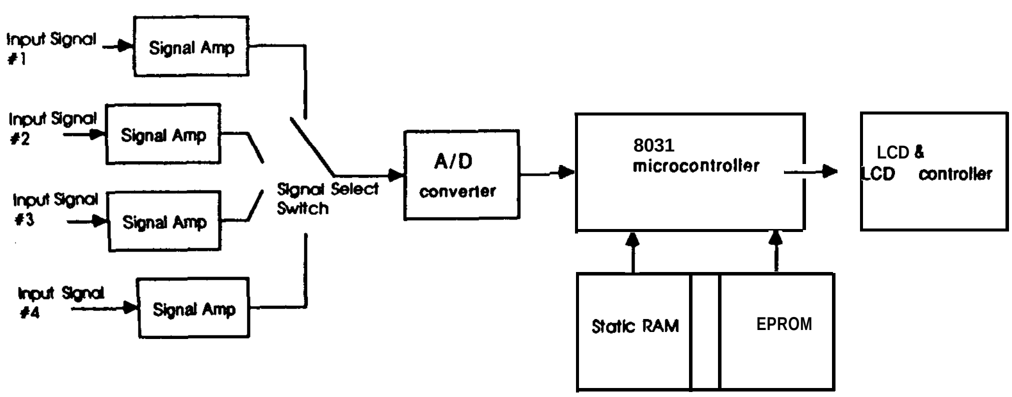
More advanced post-processing features such as measurement cursors are not difficult to add, but unnecessary for DAS's intended application--a portable field unit for prosthetic adjustment.

Pushbutton inputs are read as polled interrupt lines through the 8031's two interrupt inputs.

All external devices (EPROM, LCD display and A/D converter) are memory mapped within the microcontroller's external memory address space.

The approximate cost of this project is $250.

Block Diagram



"Multiple Input/Output Module (MIMO)"
A Microswitch/Reinforcer Training
Module for the Handicapped

Designers: Chi-Shung Wang and Vincent Chung

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

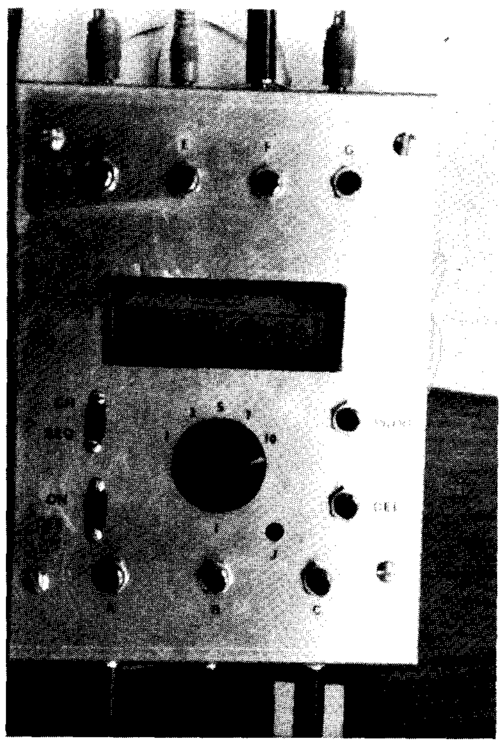
INTRODUCTION

The purpose of the Multiple Input/Output Module (MIMO) is to teach handicapped children social interaction skills and increase their capability of handling a more complex environment. A MIMO is needed in order to simplify the task of the teachers. The MIMO is actually an interface module between the user(s) and the reinforcers. There are three input keypads (A, B, and C) used by the students and four reinforcers (W, X, Y, and Z) connected to the module. The teachers can set different combinations or sequences of inputs to activate a particular reinforcer. The students, by cooperating to provide the correct inputs, can turn on one or more reinforcers (toy, TV, etc.).

During normal operation, the module has two modes, the chord mode and the sequential mode. In the chord mode, the students are required to press a combination of keys (using the keypads or the push buttons A, B, and C). If the response is correct, one or more reinforcers will be turned on with a certain time interval. In the sequential training mode, the students are required to respond to an instruction by pressing a sequence of keys with a time constraint between each key press. The time constraint is set up by the user during the time of programming. If the response is correct and within the time constraint, the device corresponding to this sequence will be turned on as a reinforcer for a certain time interval.

SUMMARY OF IMPACT

The Multiple Input/Output Module (MIMO) was designed to teach handicapped children social interaction skills and to aid their capability of handling an increasingly complex environment. A MIMO is needed in order to simplify the task of the teachers. The teacher can easily reconfigure which input controls which output as well as input/output combinations. The MIMO can provide positive reinforcement, through which the child can learn cause and effect, and increase his ability to gain control over his environment.



The MIMO box includes four 1/4" phono output jacks at the upper edge for connection of the reinforcers. Just below the jacks are the reinforcer programming buttons. At the lower edge are three more 1/4" phono jacks for connection of the input switches. Mounted just above are the input programming buttons.

The most prominent feature of the box is the 16 character by 1 line LCD display just below the reinforcer programming buttons. Below the display are the power switch, chord/sequential mode select switch, program and delete buttons and two dials which set the time that reinforcers will remain on.

The design of MIMO is centered around the Motorola MC68705U3 microcontroller. The microcontroller's four control ports, built-in timer and memory greatly simplified the hardware design.

Two of the control ports on the microcontroller are used to interface to the LCD display and to control the Relay Driving Unit of the reinforcer outputs. The remaining two ports are used to monitor the status of the various switches, buttons and dials.

The Relay Driving Unit consists of four NPN transistors which provide the coil current required by the relays. A parallel capacitor and resistor combination connect the transistor emitter to ground. When the transistor is turned on, the capacitor is momentarily shorted, causing a current surge that causes the relay to switch. After the capacitor has charged, the parallel resistor limits the circuit to the minimum holding current for the relay.

While the MIMO may be programmed using the panel switches and buttons, an RS-232 interface is also included to allow downloading of often used configurations. This greatly simplifies the programming task for the teacher. One of the microcontroller's interrnpt lines is connected to the RxD line so that an interrupt is generated when data is received.

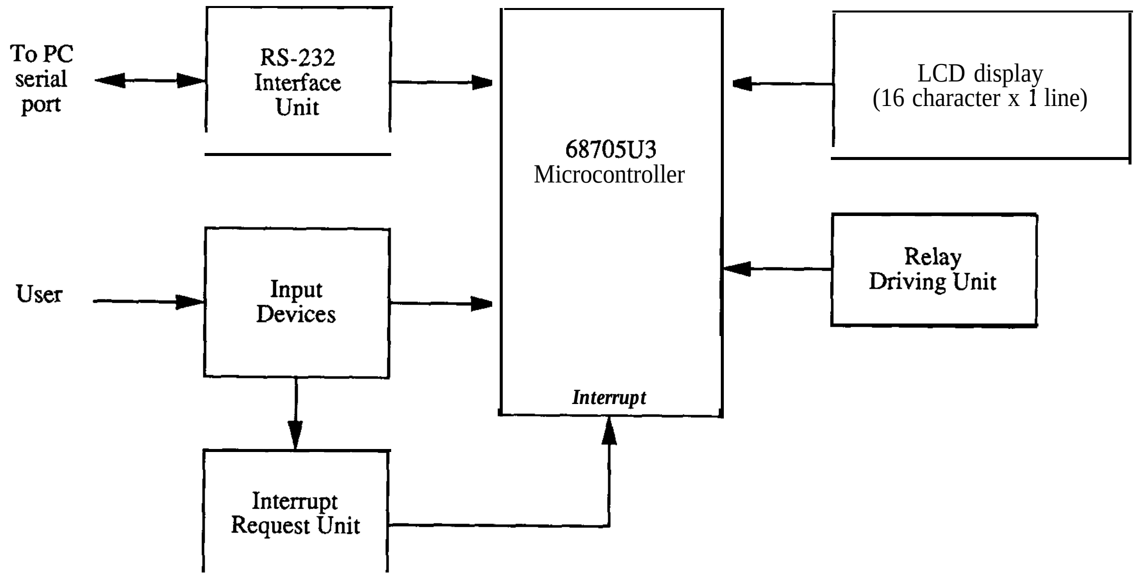
As mentioned before, two dials on the MIMO's control panel set the time delay that the reinforcers will remain on. The timing control that makes this possible is provided by the microcontroller's built-in timer.

The microcontroller's other interrupt line is used to detect when any of the MIMO's buttons are pressed (including the external input switches which connect through the front panel phono jacks). All of the debounced button signals are combined together in the Interrupt Request Unit which generates the interrupt signal.

The software architecture is organized as a single main loop and two Interrupt Service Routines (ISR). The main loop monitors the status of reinforcer delay time dials and updates the LCD display.

One of the ISRs handles the configuration download protocol when data is sent over the RS-232 port. A user-friendly download program has been implemented for IBM-compatibles running MS-DOS. The other ISR controls the manual front panel programming and the monitoring of user inputs.

The approximate cost of MIMO is $300.



“Macintosh Touch Screen”
A Computer Input Device for the Physically and Mentally Disabled

Designer: David Wu

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

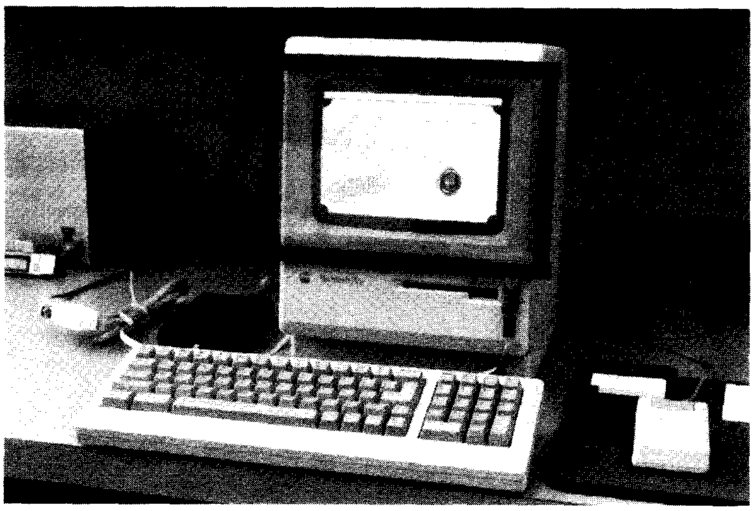
Department of Electrical Engineering
University of Washington
Seattle. WA 98195

INTRODUCTION

The purpose of the Macintosh Touch Screen project is to make the touch screen a usable input device for particular software programs written in Pascal and presently used by the Fircrest School in Seattle, a residential school for the developmentally disabled. Computer touch screens are most useful where flexible user input such as typing is needed but is impractical due to the user's physical or mental handicap, or developmental skill level (primary education). Existing alternative input methods include the mouse, joystick, touch tablet, and touch screen. It was Fircrest's suggestion that we develop the touch screen as a viable alternate input device for use with their software. The touch screen chosen for this project is the Elegraphics DuraTouch resistive touch screen.

SUMMARY OF IMPACT

Computers can be an effective learning and positive reinforcement tool for the physically and mentally handicapped. Touch screens provide a more intuitive and directly associative method of input than more conventional devices. A user can point with a finger directly at an image instead of using an intermediate device with which he must associate a screen image. In cases where the user's mental development is not at the level necessary for indirect association, direct touch of the computer screen may be the only viable alternative. Physically and mentally handicapped individuals should find using the Macintosh Touch Screen much more straightforward than using an indirect input device such as a mouse.



The essence of the Macintosh Touch Screen project is the careful selection of an appropriate touch screen device and the creation of a software library to communicate with the touch screen.

The Elographics DuraTouch resistive touch screen was chosen both for its low cost and the availability of a RS-232 compatible controller manufactured by Elographics. The controller is interfaced to the Macintosh through its RS-422 modem port. Since RS-422 uses differential signals, it was necessary to ground the positive side of each RS-422 receiver effectively transforming the serial modem port to the RS-423 standard (which is compatible with RS-232 devices at distances of up to 50 feet away).

Power for the controller and touch screen are tapped off of the Macintosh's external drive port.

The software routines are implemented as a Turbo Pascal 1.1 library. There are currently five routines in the library: *InitSer*, *CalibrateTS*, ***CheckSerPort***, ***FlushSerBuf*** and *GetTouch*.

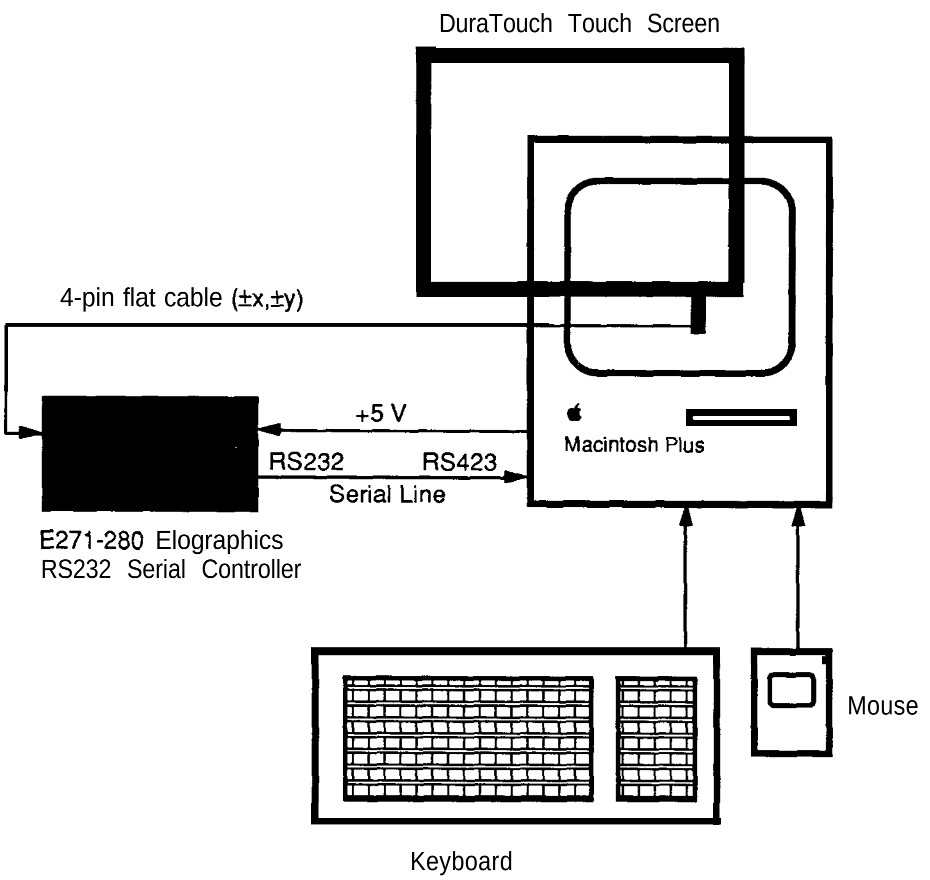
InitSer uses the Macintosh RAM serial driver to initialize the serial modem port for 9600 baud, no parity and 7 data bit communication with the touch screen. It is used at the beginning of any program which uses the touch screen.

CalibrateTS establishes the mapping of touch screen coordinates to screen coordinates by asking the user to press the corners of the active window. From the received coordinates, horizontal and vertical scaling factors are determined. Note that the active window may be any size from full screen to only a small portion of the screen.

CheckSerPort, FlushSerBuf and *GetTouch* are used to maintain the serial port input buffer. ***CheckSerPort*** checks for the presence of data in the serial port input buffer; ***FlushSerBuf*** clears the buffer; and *GetTouch* returns the oldest data in the buffer.

The approximate cost of the Macintosh Touch Screen project is $500. The majority of the budget was spent on the Elographics DuraTouch touch screen. Software tools were already available from Fircrest for the software development portion of this project.

Macintosh Plus Touch Screen General Configuration



"Remote Controller for Traffic Lights"
An Aid in Educating the Mentally or Physically Disabled in Pedestrian Safety

Designers: George Lippincott and Woobin Lee

Disabled Coordinator: Dr. John Eiler of Fircrest School

Faculty Supervisor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

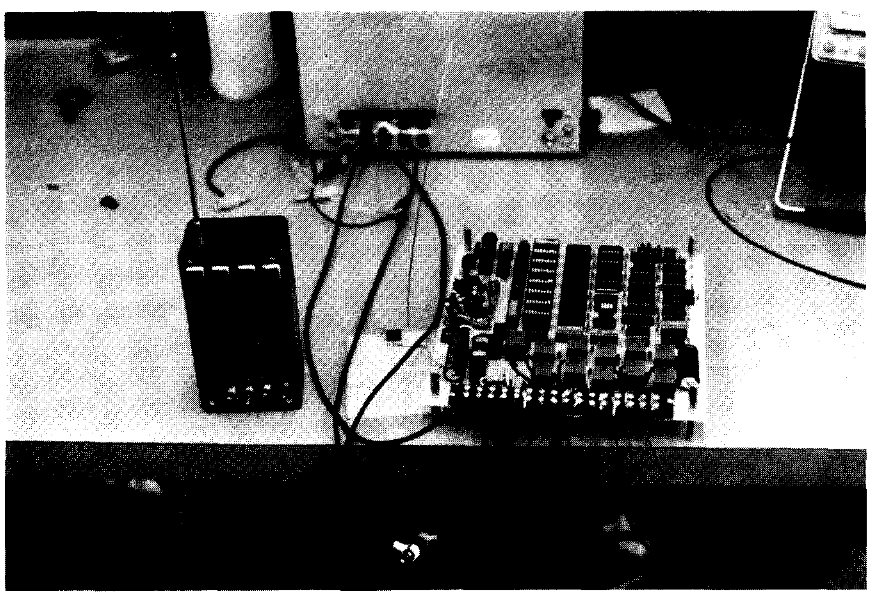
Fircrest School has obtained donations of several traffic signal lights for potential application in teaching basic community survival skills to developmentally disabled students, within the safety of the campus. While staff are available to mount this equipment, a control device is necessary to enable the instructors to unobtrusively operate the signals in training situations.

The Traffic Light Controller, which consists of a hand-held transmitter and a receiver capable of controlling the lights for a single intersection, incorporates four pushbuttons and three toggle switches on the transmitter. Using the pushbuttons, the instructors can decide if they want the lights to be controlled automatically or if they would like to control the lights themselves. A dial on the transmitter allows the instructor to control the speed at which the lights automatically change. The toggle switches allow for manual control of the traffic lights by the instructor.

SUMMARY OF IMPACT

Fircrest School is home to about 500 mentally or physically handicapped people. Although most are permanent residents, some will leave the school to live on their own or in halfway houses. Fircrest has acquired two sets of traffic lights and walk signals for use in teaching clients how to obey traffic lights and to safely cross intersections. In order to teach pedestrian safety effectively, instructors must be able to simulate a normal intersection at many different locations on their campus since it will be important for the clients to become responsive to the traffic signals in a variety of surroundings and situations.

For the handicapped individual to be able to live independently, either on their own or in a halfway house, basic survival skills for the city, such as pedestrian education and safety, need to be mastered. The Remote Controller for Traffic Lights should be very helpful in training these handicapped individuals to cross the street in a safe and familiar environment.



The remote controller consists of two units: a hand-held transmitter and a receiver. The transmitter includes a dial to control the cycle rate of the traffic signals under automated control, toggles to vary the operation under automated control, and four pushbuttons to override automated control and allow manual operation of the traffic lights.

RF communication between the transmitter and receiver was built around the RF circuitry of an electric toy car. The RF carrier signal is pulsed using a form of PCM: a long pulse represents a '1' and a short pulse a '0'.

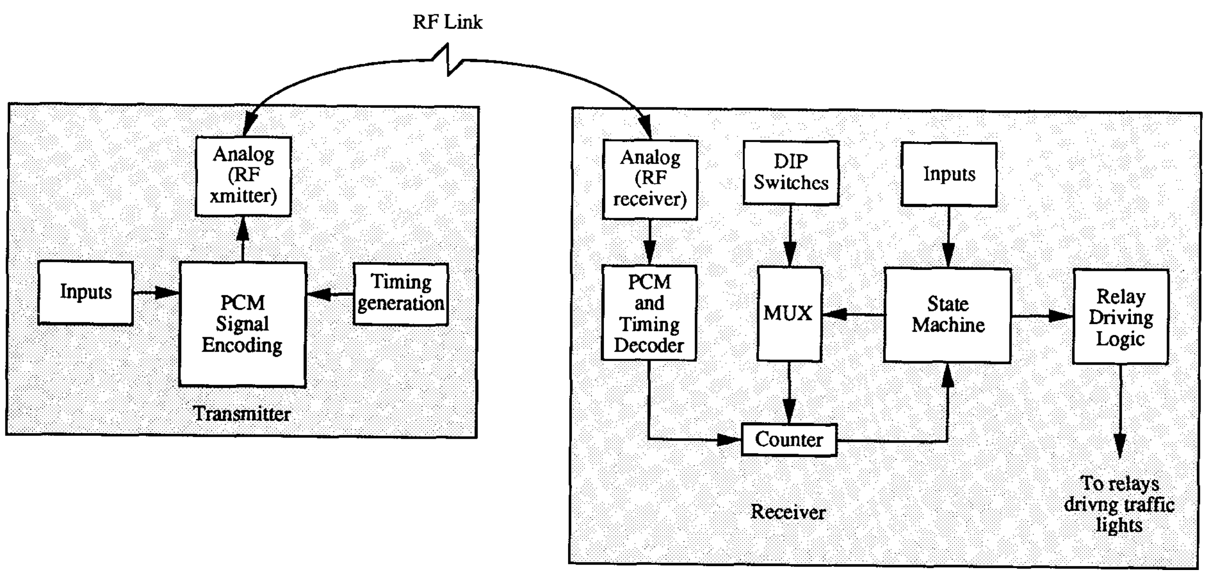
The receiver unit contains the state machine which controls the traffic lights. It consists of an analog portion which receives and translates the transmitted RF signal, a 10 state finite state machine and a power output section which drives relays to the traffic lights.

Clocking of the state machine is under the control of the hand-held transmitter. The transmitter periodically sends out small data packets indicating the current state of the input switches. 2 bits are for the pushbutton status, 3 bits are for the status of the toggle switches, a single bit for timing (or system clock) and a single parity bit.

Every 16th transmission triggers a one-shot. While the one-shot is active, transmission of the timing bit is blocked. The pulse width of the one shot is controlled by a potentiometer which can be adjusted via the dial on the transmitter. This arrangement allows the clocking to be varied in increments of 1/16 of the maximum transmission rate (currently 8 Hz). Slower rate can be obtained by using the 'Next State' toggle on the transmitter.

The states of the finite state machine (FSM) on the receiver unit have a one-to-one correspondence to the pattern of ON and OFF traffic lights. Each state is decoded and drives the traffic light relays. The TTL signals are used to drive NPN transistors whose collector currents in turn activate the relays.

The approximate cost of the project is $350.



"Portable Data Collector Unit"
A Data Collector for Use in Behavioral Treatment Programs

Designers: David McKinstry and Donald Lee Pierce

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

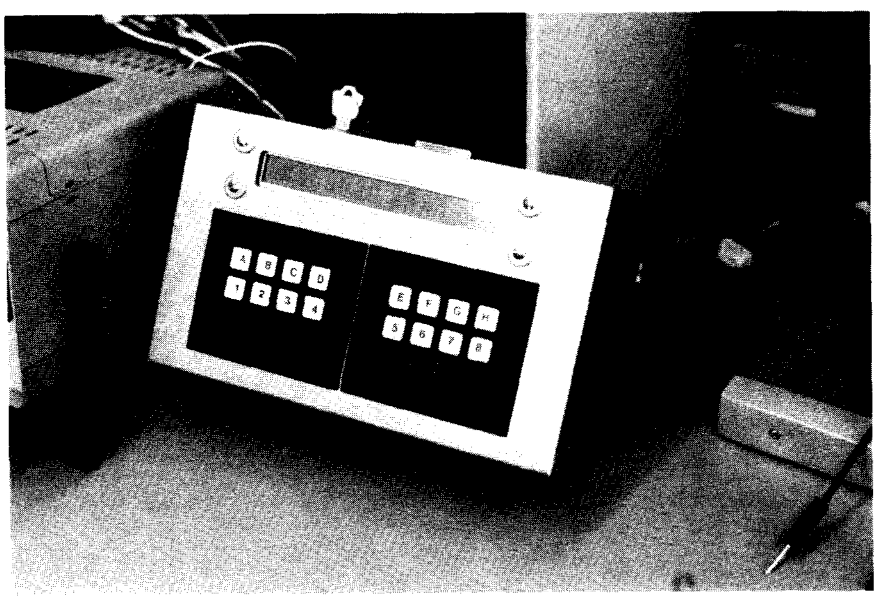
INTRODUCTION

The Portable Data Collector Unit (PDCU) is designed to track and record adaptive and maladaptive behaviors, as well as behavioral remforcements, of mentally and physically disabled individuals in a treatment program. This data is currently being collected at Fircrest School in Seattle, using Videx optical bar code scanners. These readers are very attractive because of their small size, their ability to run all day on batteries without a recharge, and their ease of operation. Data is downloaded througn a Macintosh modem port when the scanner is placed into its recharger.

The Portable Data Collector Unit replaces the optical scanners with a simple keypad and display system, and is an improvement over the present system. A menu-driven display which prompts for and only permits entry of data in the correct sequence reduces errors and the need for data editing. Data transfers to and from the data collector take place over a serial link to either a Macintosh or IBM-compatible personal computer.

SUMMARY OF IMPACT

Fircrest School is a residential treatment facility in Seattle for the developmentally disabled. Manv of its residents have treatment programs which require that a staff member constantly monitor and reinforce their behavior. In order for behavioral training programs to be effective, adaptive and maladaptive behaviors and any reinforcements that are given must be accurately tracked and recorded by the staff. Accurate collection of this data using the Portable Data Collector can then permit psychologists to refine and optimize the treatment program for these handicapped individuals.



The PDCU is housed in a 10" x 5" x 2" metal enclosure. Mounted on the top surface is a 40 x 2 character Sharp LCD display. Below the LCD are two 3 x 4 membrane keypads placed side-by-side. On one end of the box are a locking keyswitch to turn the PDCU on and off and a DB-25 connector for RS-232 communication.

The 40 x 2 character display is divided into an array of 8 x 2 display fields. The top two rows of the keypads have a one-to-one correspondence with these display fields, resulting in a large matrix-of 16 programmable "soft-keys". Two of the remaining 8 keys in the bottom row are used as ENTER and CLEAR keys. The rest are available for future expansion.

The PDCU is controlled by an Intel 8031 microcontroller. 8 Kbytes of program memory is provided by a 27C64 EPROM; 32 Kbytes of data storage is provided by a 62256 static RAM. The LCD display and the two keypads are interfaced to the 8031 via its I/O ports. RS-232 downloading capability is provided through the built-in serial communications port of the 803 1. The serial port's TTL levels are shifted to RS-232 levels by a +5V Maxim MAX232 transceiver (which eliminates the need for the bipolar power supply used by most RS-232 transceivers).

The keypads are read by using a row scan technique. Each row is strobed in turn by a low pulse. When a key is pressed, the low pulse is transferred to a column which is detected by the microcontroller. The row and column pair uniquely identifies each key.

The 8031's internal timer is used to implement an interrupt driven clock to track the time of day for the system. The remaining interrupt is used for the RS-232 serial communication.

The software implements a hierarchical menu system. At the highest level, client names are displayed. If the corresponding soft-key is pressed, then a list of behaviors is presented that may be recorded for that patient. At the end, the information is redisplayed for verification by the clinician. By forcing the user to use this prompted input format, data entry errors are minimized over the current bar code system.

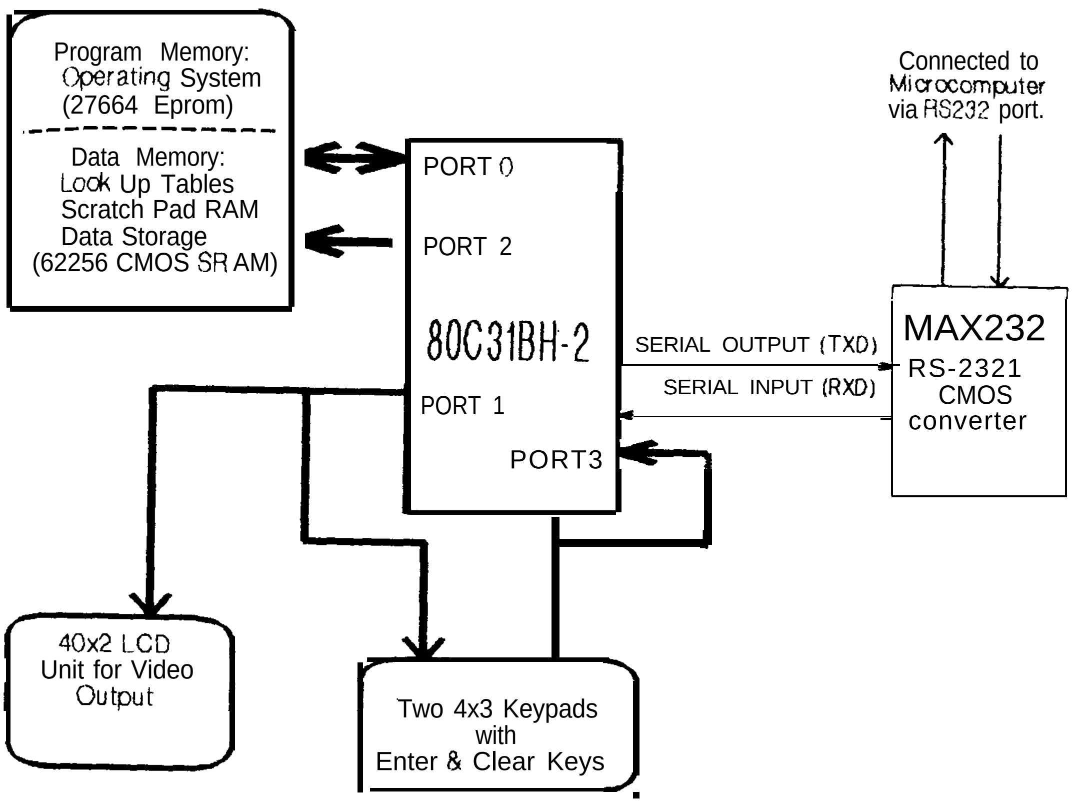
The approximate cost of this project is $275.

Portable Data Collection Device

Block diagram for proposed EE478 project

Lee Pierce and Dave McKinstry

02/24/88



"Safety Sensor System"
An Electronic Bed Safetv Device for
the Physically and Mentally Disabled

Designers: B. Kongsang, S. Chen, and R. Farahi

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

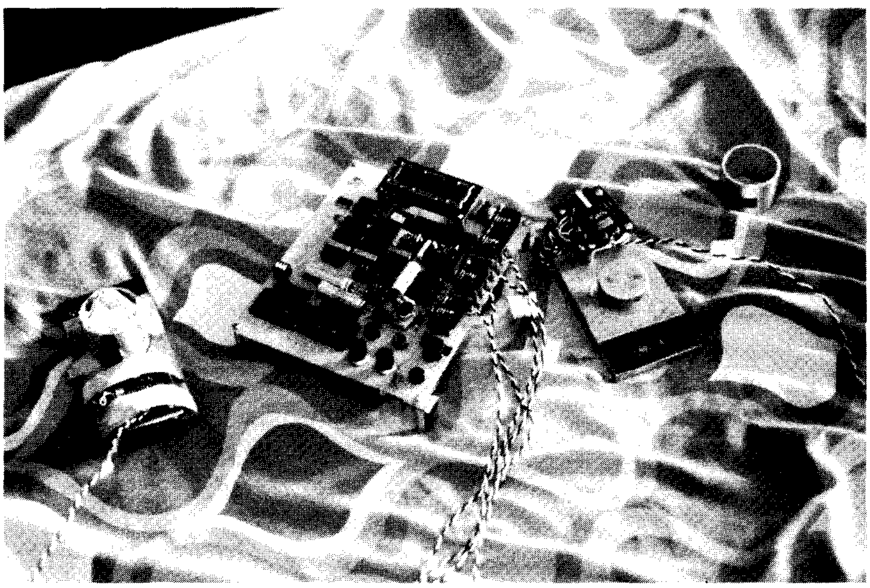
INTRODUCTION

The Safety Sensor System is designed to detect the activity of a mentally or physically disabled client while that individual is confined to bed, and set an alarm to help prevent the client from falling out of bed. In order to predict whether the client is going to leave the bed, there must be some way to detect the client's position on the bed. The Safety Sensor System measures the weight under each bed leg and calculates the center of gravity of the client on the bed. By knowing the location of the center of gravity, the location of the client on the bed can be determined. The static analysis for determining the center of gravity is straightforward and requires knowing the weight on only three of the bed legs. An alarm activates when the center of gravity comes "too close" to one of the edges of the bed. A safety region will be specified by the user of the system, who normally is a supervisor, nurse, or other staff.

The Safety Sensor System is physically attached to the bed, and it is small and portable for easy installation. In order to ensure patient safety, the Safety Sensor System is enclosed in a small box which protects the clients from accessing any of the electrical components and wires. A key switch is used to ensure the system's functionality. Only staff who have keys to the key switch can reset the system. Otherwise, the system will be in the surveillance modes all the time. This prevents the system from being unintentionally stopped by the clients.

SUMMARY OF IMPACT

Fircrest School in Seattle is a residential facility for the developmentally disabled. Several Fircrest School students with severe mental disabilities require restraining devices while sleeping. If these students leave their bed unassisted, they could injure themselves. Currently, soft waist restraints have been utilized at Fircrest School, but the use of less restrictive electronic sensor systems may enhance the independence and quality of life for these disabled persons, while adequately guarding their safety. The Safety Sensor System could be used in other settings, such as nursing homes and hospitals where patients need close monitoring, especially during reduced staffing periods at night.



The Safety Sensor System consists of a main controller unit and four strain gauge units. Each of the strain gauge units is mounted underneath one of the legs of a bed. Signals from the strain gauge units are transmitted to the controller as current loops over twisted pair wire.

The controller unit is designed around the Motorola 68705U3 microcontroller. Devices interfaced to the microcontroller include a 16 by 2 LCD display, a 12-bit CMOS A/D converter, a key switch and BCD dial switches.

The LCD display provides feedback to the staff while configuring the system. The user is prompted step-by-step to enter the safety boundaries and when to place the client in the bed. The BCD dial switches are used to input the safety region dimensions.

Each of the strain gauge units uses two 120 ohm resistive strain gauges. Each gauge is bonded above and below a cantilevered beam upon which the bed leg rests. As the beam bends under the weight of the bed, the gauges on top and bottom undergo tensile and compressive stresses, respectively, which produces resistive changes. The gauges are used in a Wheatstone bridge configuration with two other precision 120 ohm resistors so that the changes in resistance can be detected as a voltage signal.

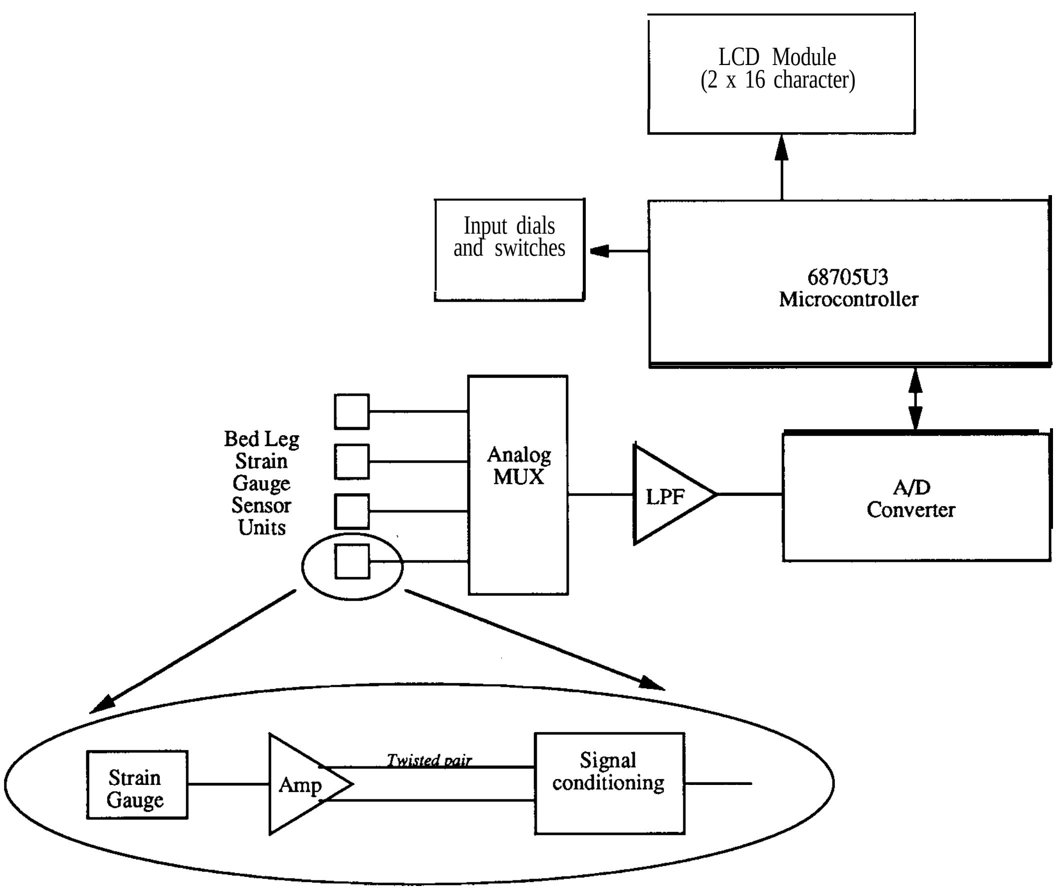
Low-level voltage from the strain gauges is amplified and converted to a current for transmission as a variable current loop by an Analog Devices AD693AD sensor transmitter.

On the controller unit, the current loop signal is transformed back into a voltage signal by a load resistor and further amplified and lowpass filtered. The final signal output of 0 to 4 volts corresponds to a weight range of 50 to 350 pounds. The four resultant signals, one from each strain gauge unit, is directed to the A/D converter by a four input analog multiplexer.

The center of gravity of the client is calculated by the microcontroller using the weight sensed at three of the legs (the fourth is needed to calculate the total weight of the client). If the center of gravity leaves the defined "safety zone," then an alarm signal is activated. The alarm signal is armed or disarmed by the keyswitch position.

Note that all calculations are done with integer arithmetic.

The approximate cost of the Safety Sensor System is $550.



"Electromyographic (EMG) Switch"
A Biofeedback Device to Measure Muscle Potential

Designers: Gary Cheung and Rondy Ng

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

The Electromyographic (EMG) Switch is specially designed to measure muscle potential during contraction and relaxation. This device is microcontroller based and has options normally not available in some of the commercial ones. It will provide precise artifact-free feedback in virtually any environment. The device may be used with surface electrodes on any part of the body. This device is designed to provide biofeedback for a wide range of portable EMG applications. To help stimulate learning of biofeedback techniques, two jacks are provided to allow control of reinforcers in response to muscle tension.

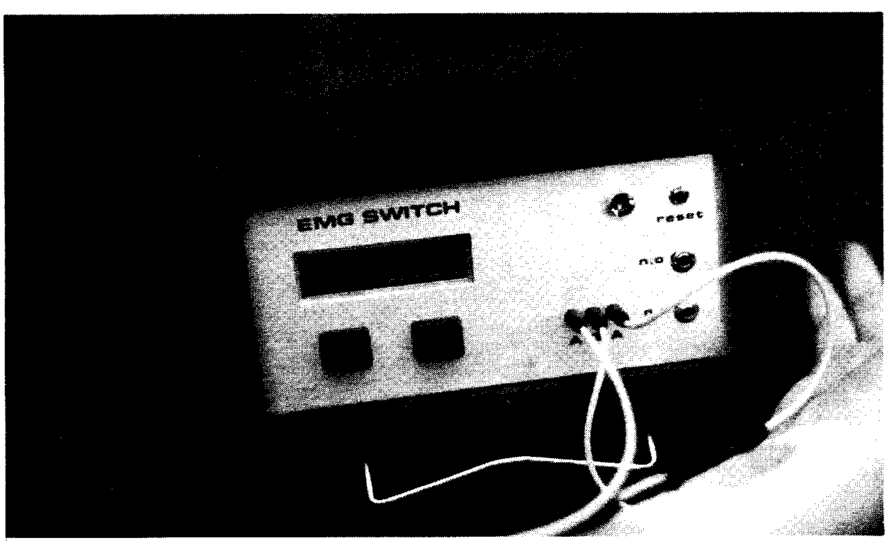
The EMG biofeedback electrode-assembly consists of two active and one inactive electrodes. The active electrodes are placed in a bipolar configuration on the skin along the long axis of the muscle. The amount of EMG recorded is the algebraic sum of all action potentials of the contracting muscle fibers between the electrodes. Since this device is designed to be used by people with no prior experience with EMG, only two buttons are used to implement all of the functions.

SUMMARY OF IMPACT

Fircrest School in Seattle is a residential facility for the developmentally disabled. The EMG switch was designed for the clients at the Fircrest School, who have mental and/or physical handicaps. Some of these handicaps involve abnormal muscle contraction and relaxation that are easily triggered by external events such as hand clapping.

Electromyography (EMG) is a technique used in diagnostic neurology for the investigation of patients presenting neuromuscular disorders. The investigation is performed on the neuromuscular apparatus and essentially consists of recording the action potentials generated by muscles and nerves. That muscular contraction produces electrical activity which is connected with discharges generated in the muscle fibers and that most of these discharges have been induced by impulses coming from the nervous system.

EMG has been used in clinical settings to correlate with states of tension or stress. Recordings are taken to reflect the level of muscular tone which in turn reflects the mental and emotional level of the patient. The most promising research with EMG is in biofeedback research in which patient is given the EMG records and learns to gain control of specific areas of his skeletal musculature - relaxing or contracting them at will. Usually, the patient is given auditory and/or visual displays of his individual myoelectric potentials recorded by means of electrodes. The cues provide the patient with an awareness of the twitching of individual muscle units. He may learn in a few minutes to control this activity and can give many responses with only the feedback cues as a guide. The aim of the EMG Switch is to teach the patient to gain control of his muscles and learn to correct such abnormal muscle behavior through biofeedback.



The EMG Switch (EMGS) is packaged in a 6" x 6" x 2-1/2" metal enclosure. On the front panel are an LCD display, two buttons, an LED power light, a reset button, two phone jacks for external devices and three iacks for the surface electrodes.

The EMGS is designed around the Motorola MC68705U3 EPROM microcontroller. It includes 3.8 Kbytes of ERPOM, 128 bytes RAM, an internal timer and 4 8-bit I/O ports.

The electrode signals are fed directly into a differential instrument amplifier. Two electrodes serve as the amplifier's inputs and the third serves as an analog ground. The amplified signal is then conditioned by passing through three filters: a 2nd-order Butterworth LPF, a 2nd-order Butterworth HPF and a biquad elliptical notch filter.

The LPF and HPF together form a bandpass filter to band limit the signal before digitization. The notch filter is tuned to reject 60 Hz power line interference.

The filtered signal is amplified and rectified prior to digitization byt the 12-bit A/D converter (Teledyne TSC8705).

The internal timer of the microcontroller is used to measure the "tensed" and "relaxed' EMG signal duration times of the test subject.

The I/O ports of the microcontroller are used to interface to the LCD display, the A/D converter, the input buttons and the output relays.

The user interface consists of a 16 character by 2 line LCD display and two push buttons. The top line of the display is used to relay status information. The bottom line of the display is used to label the current function of the buttons mounted just below the display (i.e., soft switches).

The software supports continuous monitoring of the EMG signal value, calibration of tense and relaxed EMG levels, calculation of an activation threshold level (for biofeedback) and control of external electrical devices (via the output relay) through EMG biofeedback techniques. The system was sucessfully integrated and demonstrated. It is being used by the Fircrest School.

The approximate cost of the EMG Switch is $300 (not including the non-reusable electrodes).

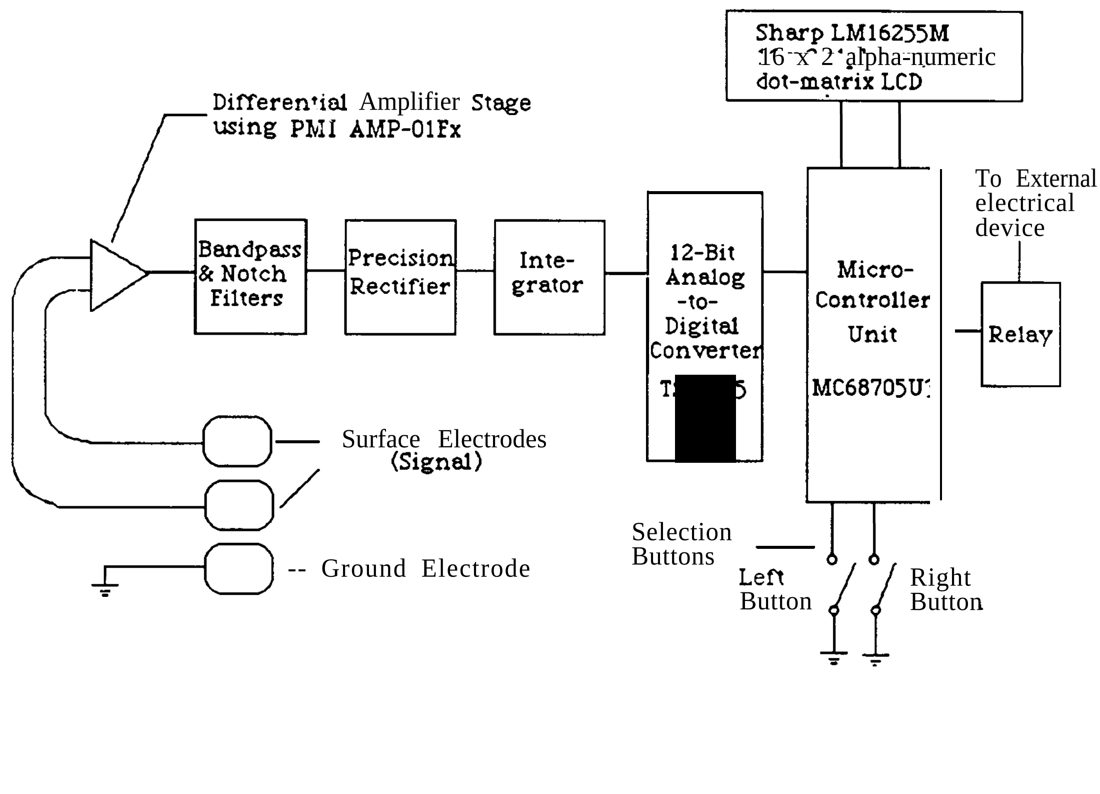


Fig. 1. Block Diagram of the EMG Switch

“Telephone Training Set”
A Teaching Aid for the Physically and Mentally Disabled

Designers: David T. Kirkland II and Hsien Li Young

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Yongmin Kim, Ph.D.

Department of Electrical Engineering
University of Washington
Seattle, WA 98185

INTRODUCTION

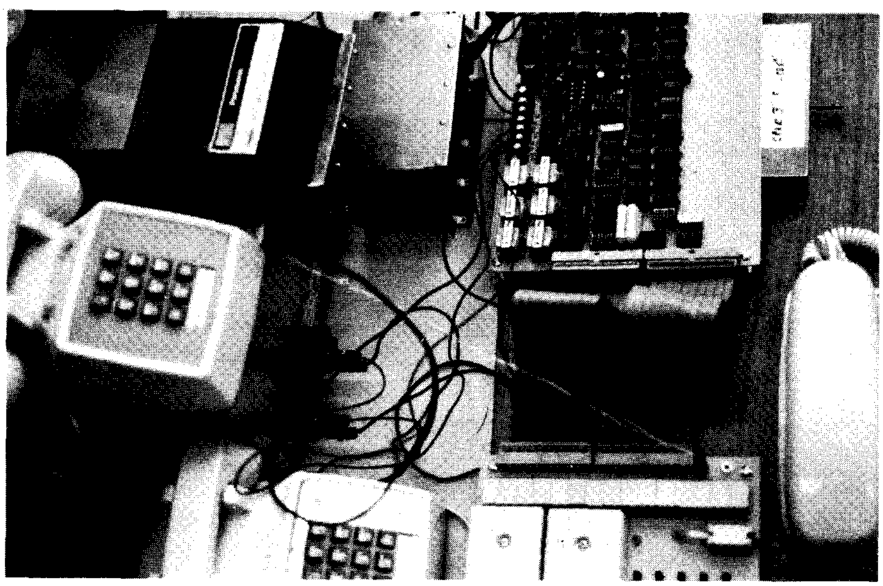
The Telephone Training Set is a training device for the physically and mentally disabled. The system includes a teacher console, teacher headset, student phone, third-party phone, and recording capability. A jack is provided so that the output of a tape recorder can be directly coupled to the phone line through a transformer. The phone set will facilitate training in the functions of telephone usage, utilizing ring and tone generation, handling recorded messages, and dialing capabilities. The dialing at the student station, as well as an on-hook or off-hook indicator for the student phone are displayed at the teacher station.

The basic requirement for the telephone training set is to allow a teacher to have complete monitoring and controlling capabilities of a remote student telephone station, with the option that a third-party could participate at a different station. The teacher is able to control the tones that would normally be generated by the telephone company, such as dial and busy tones, and is able to control the ringmg of the student phone. The set also has the facility to play recorded messages, such as those encountered when an invalid number is dialed.

SUMMARY OF IMPACT

The Telephone Training Set was developed as a training device for the physically and mentally disabled. It was developed to a set of requirements derived by the faculty at the Fircrest School of Seattle, and built for use by this school, which is a residential treatment facility for approximately 500 developmentally disabled individuals.

When successfully trained using this telephone set, the handicapped individual can gain greater independence in one important area of daily living, placing and receiving phone calls. This capability can be of vital importance especially to those individuals who will eventually leave the facility to live independently or in a halfway house.



The Telephone Training Unit (TTU) was designed as a realistic teaching tool to familiarize disabled students with the operation of standard telephone equipment. One of the chief design criteria was that the system must maintain a high degree of realism. To that end the TTU incorporates real phones in a simple telephone loop. In addition, a monitoring and control station is coupled into the loop to allow the teacher to maintain the behavior of the setup.

The system is organized as a basic telephone loop; devices are inductively coupled into the loop with transformers. Two telephones are connected into the system loop for the students to use. An additional phone is provided for the teacher to monitor "calls".

At the teachers station, there is a display that indicates the off-hook condition of the telephones as well as displaying the number that has been dialed on the telephones.

The off-hook condition of a telephone is detected with the aid of a current sense resistor. When a telephone handset is picked up, a switch is closed which causes DC current to flow in the loop. The voltage developed across the sense resistor is amplified and filtered by an active filter to produce the off-hook signal. This signal activates the LED indicator at the teacher's console.

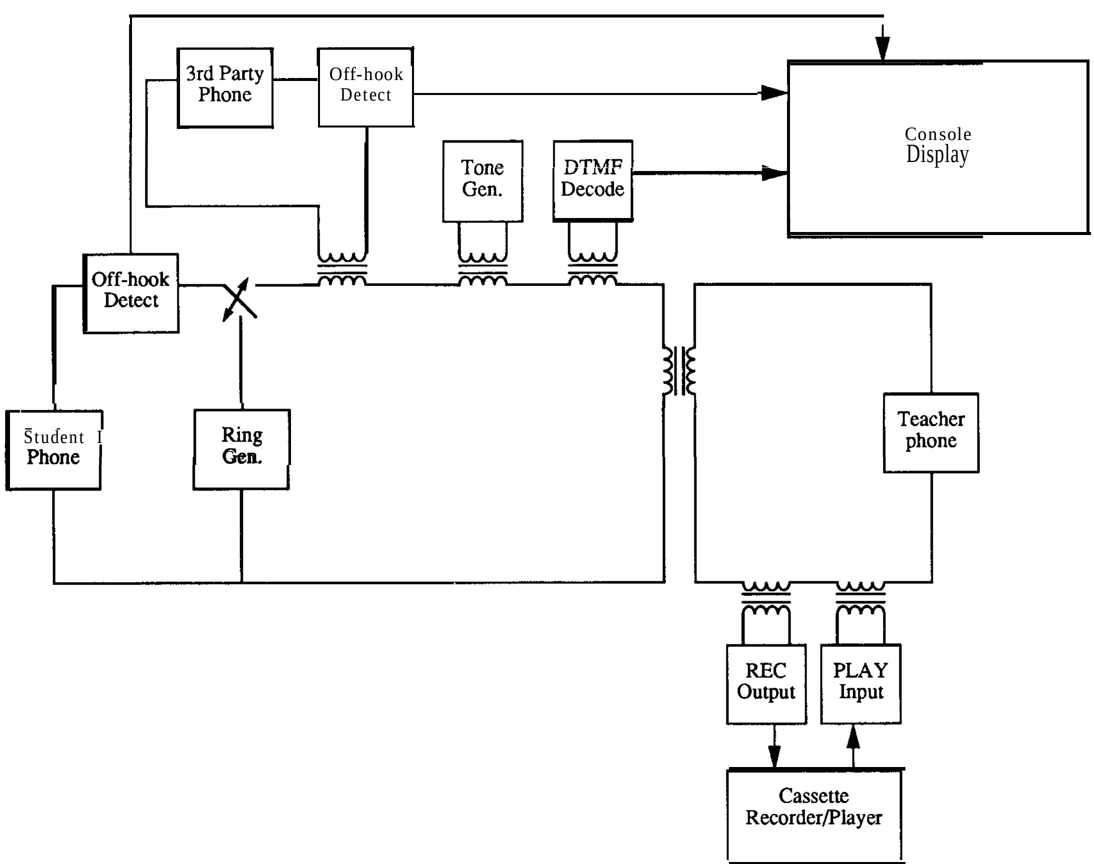
The number dialed by a student is displayed at the teacher's console on a multiplexed LED display. Each digit is detected and decoded using a DTMF decoder chip which translates the touch tone signal into a BCD digit. As each digit is received, it is loaded into the LED display. The display can accommodate up to 15 digits.

Generation of the busy, dial, ring-back and off-hook tones are created by summing together sinusoidal signals. The different frequencies (eight total) are generated using function generator chips. The appropriate frequencies are added together using op-amp summing circuits for each of the tones. The appropriate tone is selected by using an analog multiplexer. The chosen tone signal is coupled into the telephone loop by a transformer.

A ringing telephone requires a 120V, 30 Hz signal. This is produced by a special purpose ring generator chip. It is switched into the circuit by a relay switch.

The TTU has record and play jacks for connection of tape recorders so that prerecorded messages (i.e., "Please dial again...", "That number is no longer in service...", etc.) can be used to respond to student inputs. This also makes it possible to record student interaction with the TTU setup.

The approximate cost of this project is $750.



"Intelligent Wheelchair Controller"
A Safety Device for the Physically and Mentally Disabled

Designers: Richard Burton and Randy Stamper

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

INTRODUCTION

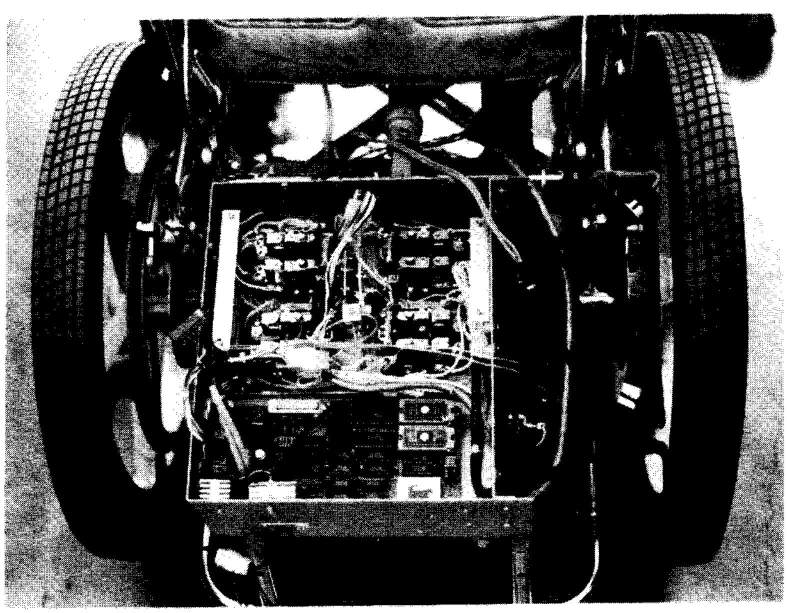
The Intelligent Wheelchair Controller is an electric wheelchair controller that incorporates a number of safety features to effectively reduce the risks of injury to the physically or mentally disabled individual who relies on an electric wheelchair for mobility. The controller puts constraints on such parameters as speed, acceleration, and maneuverability, as well as incorporating an ultrasonic sensor system to-detect oncoming obstacles.

A late addition to the project was an infrared tape tracking system whereby the wheelchair would follow prelaid tracks of non-reflective tape. The operator applies pressure on the joystick and wheelchair will do the rest. The system should be able to follow a straight line or turn a 90 degree corner.

SUMMARY OF IMPACT

Mobility is a key problem among many disabled people. The electric wheelchair was designed to be an effective solution to this problem, although it has some drawbacks. A major drawback is that there are handicapped individuals who cannot control their physical actions to any reliable degree, and therefore run into potentially dangerous situations when operating an electric wheelchair.

Since the handicapped individuals using electric wheelchairs can vary so much in their level of disability, the Intelligent Wheelchair Controller is a useful tool in preventing accidents. For instance, without the controller, the individual can sometimes jam the joystick forward full throttle, unable to control the speed of the wheelchair. If this were allowed to happen, they will eventually ram into something or someone inadvertently, thus subjecting themselves and others to the possibility of serious injury. The ultrasonic sensor system to detect oncoming obstacles will also be of great help in preventing collisions. The ultimate goal of the Intelligent Wheelchair Controller is to enable the handicapped individual to function as independently as possible with minimal supervision.



The Intelligent Wheelchair Controller (IWC) setup includes a processor board enclosed in a large 1 foot by 1 foot by 5 inch box plus a potentiometer-type joystick, sonar sensor and infrared emitter/detectors.

The joystick allows the user to provides direction and speed control inputs to the processor board.

The sonar sensor is used to provide of the most important saftety features of the IWC. It detects objects in front of the wheelchair to prevent collisions.

The IR emitter detector pairs are mounted on each wheel with slotted disks interposed between the emitter and detector. As the wheels (and the disks) spin, the slots cause the detectors to see a train of pulses which translates into wheel speed.

Finally, another set of IR emitter/detector pairs is used to provide the wheelchair with a reflective tape tracking mechanism.

The IWC was designed around an Intel 80186. The 80186 was chosen because many of the peripheral functions normally provided by external chips (i.e., memory decode, interrupt control, timers, etc.) are already integrated into the device.

A total of 80Kbytes of memory is interfaced to the 80186--64Kbytes of EPROM and 16Kbytes of SRAM. The EPROM contains the startup and IWC code while the SRAM stores the interrupt vectors and program data.

Four 8-bit input and four S-bit output ports are provided to interface with external devices such as the joystick and IR emitter/detector pairs. Since the digital input devices are mounted up to a meter (1 m) away, all the digital inputs are feed through Schmitt triggers to help reject noises and glitches caused by reflection problems.

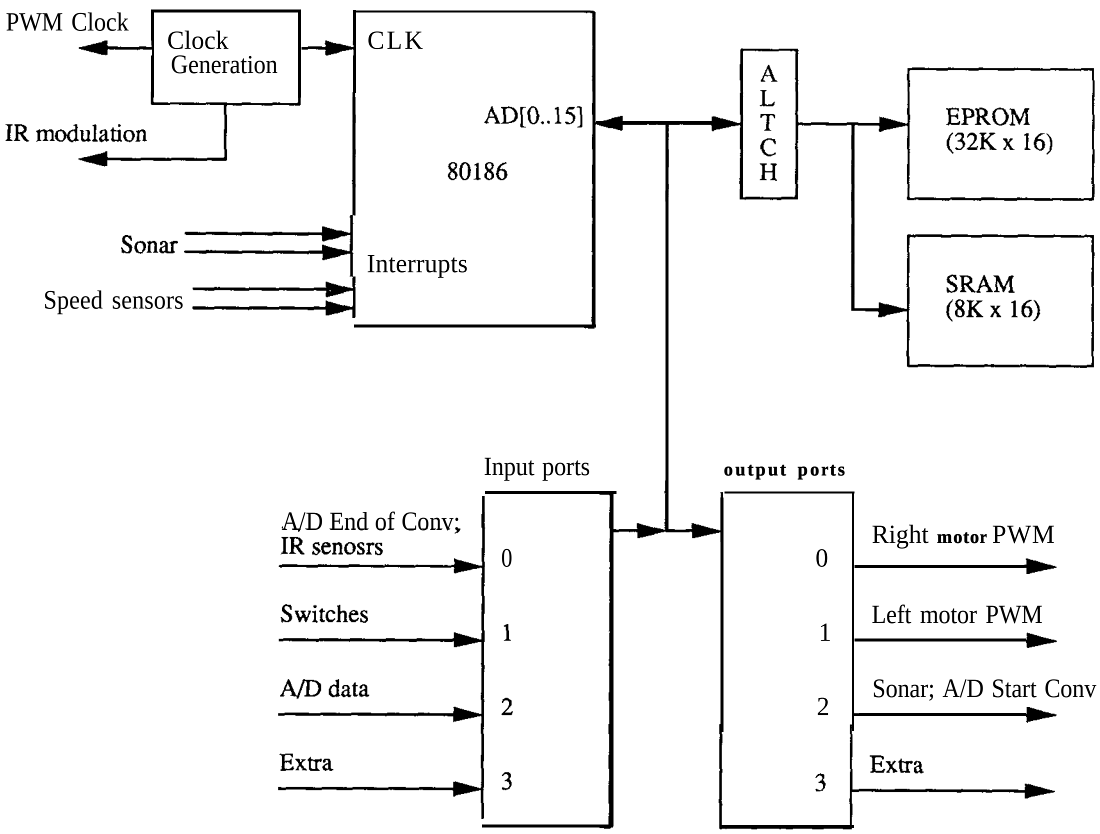
In order to process the joystick input, the joystick potentiometers are connected to an A/D converter which digitizes the joysticks X and Y positions. The potentiometer outputs are filtered with 1uF capacitors to remove any glitches that might occur.

Continuous speed control of the motors is provided by using pulse width modulation (PWM). As a safety precaution, a 100ms one-shot is provided so that if the motors are driven continuously for more than this time (due to a hardware or software failure), then the motors will be cut off. Motor direction is controlled by relays which can reverse the current flow through the motors.

The built-in timers of the 80186 are used to provide real time and as a range finder for the sonar signal.

Power is provided by two 12 volt automobile batteries connected in series to provide +12 and +24 volt outputs.

The approximate cost of the IWC is $500 - 600.



"Everest and Jennings Infrared Mobility System (JIM)"
A Motorized Wheelchair for the Disabled

Designers: Warren Edwards and Cam Ritchie

Disabled Coordinator: Dr. John Eiler of Fircrest School

Supervising Professor: Dr. Yongmin Kim

Department of Electrical Engineering
University of Washington
Seattle, WA 98195

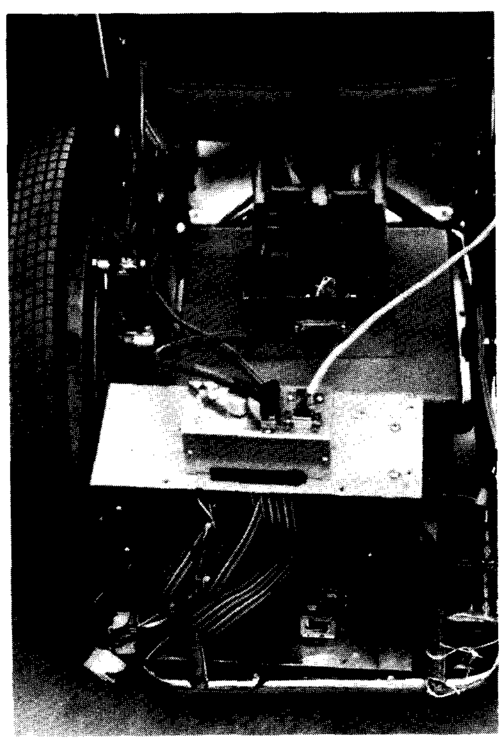
INTRODUCTION

The Everest and Jennings Infrared Mobility System (JIM) is a versatile motorized wheelchair. JIM can be used for training purposes as well as for everyday personal transportation. JIM's features include five speed settings and is equipped with a sonar collision detection system that will stop the wheelchair whenever it comes within six feet of an obiect directlv in front of it. JIM also features an infrared-tape tracking system that will allow those clients being trained on motorized wheelchair control to do so safely. For those clients who are unable to use the attached iovstick control. JIM is flexible enough to allow the attach--m&t of alternate control methods such as lighted micro-switch panels. JIM's control functions are centralized in two positions on the chair. Input from the user is accepted at the joystick interface on the right arm rest of the chair's seat. The instructor controls are centralized behind the seat and allow the instructor to configure the chair for each client.

JIM incorporates a number of safety features. Its maximum speed is slow enough that it is not a hazard and the user is protected from collisions by the sonar. JIM's joystick is also equipped with a time-out feature that automatically turns the wheelchair off if there has been no change in the joystick position for six seconds. This feature prevents any client from moving in an uncontrolled fashion due to a seizure or muscle spasms.

SUMMARY OF IMPACT

Training mentally and physically disabled clients to use their motorized wheelchairs involves a step by step process to teach independence and safety. This training process is currently being developed at Fircrest School in Seattle, a residential treatment facility for developmentally disabled clients. The first step in the training process is to familiarize the client with the motorized wheelchair, with subsequent stages of the training procedure giving the client higher levels of independence. The ultimate goal of JIM is to enable the handicapped individual to function as independently as possible with minimal supervision.



The Everest and Jennings Infrared Mobility System (JIM) is an upgrade of the Intelligent Wheelchair Controller (IWC). The power consumption characteristics are improved and the tape tracking mechanism expanded and made more reliable.

One of the problems with the power distribution of the IWC was that it causes more power to be drawn from one of the two batteries than the other. Furthermore, the voltage regulators are inefficient when converting the available +12 volts to a relatively low +5 volts. In JIM, a more efficient switching power supply was substituted for the 5 volt regulators. Also, all the TTL parts were replaced with equivalent 74HC-series CMOS parts and the 80186 CPU was replaced with the CMOS version.

The infrared sensor array for the tape tracking mechanism is organized as two banks of eight emitter/detectors sensors. One bank is located behind the front wheels of the wheelchair and the other is located behind the battery compartment at the rear. Each sensor is mounted on a small 1-1/2" x 1" printed circuit board (PCB). They are connected to the 15" wide mounting rail by DB-9 connectors at 1-7/8" intervals. This arrangement allows damaged sensors to be removed for repair or replacement.

The sensors are strobed in sequence by the output of a 3-to-8 decoder (front and back simultaneously). The decoder is contolled by a 3 bit Sensor Counter. This arrangement prevents the IR from neighboring sensors from contaminating the amount of detected light. The sensor outputs are sequentially read back by 8-to-1 analog multiplexers. The multiplexer output is filtered by a 3 pole highpass Butterworth filter to remove interference from the ambient room light. This filtered signal is fed into an analog comparator and compared with the calibrated threshold level.

Each sensor is pulsed four times. If four pulses are detected, then the sensor is regarded as being above the reflective tape. This, coupled with the sensor number in the Sensor Counter, is used to produce the sensor signls to the spare IWC 80186 input ports (via 3-to-8 demultiplexers).

The IR sensor system is interfaced to the original IWC box by a DB-25 connector. It uses the extra 8-bit input port that was incorporated into the IWC for future expansion.

The approximate cost of this project is $300.