CHAPTER 16
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X10 Single Switch Scanning Environmental Controller

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INTRODUCTION

The X10 Scanning Controller (XSC) provides an interface between a single switch operator and an X10 remote module controller. The XSC has eight LED's that display the current state of up to eight devices. The LED is OFF if the device is OFF, and ON if the device is ON. These same LED's are also used during scanning.

All devices are assumed in the OFF state, and scanning is OFF (idle state) when the XSC is first turned ON. When the control switch is pressed, the XSC starts scanning. When scanning, LED one blinks, then LED two blinks, then LED three and so on. The length of time that each LED blinks is adjusted by the user through a potentiometer on the circuit board. If the switch is pressed while an LED is blinking, then the state of the device corresponding to that LED is toggled (i.e., if the device is OFF it is turned ON, if it is ON it is turned OFF). If the switch is not pressed for ten passes, then scanning is terminated until the switch is pressed again.

SUMMARY OF IMPACT

The Single Switch Scanning Environmental Controller is being used in a training program for a disabled adult who is learning the necessary skills to use the system in his home environment. This individual will be able to function more independently as a result of this controller.

Also being fabricated are wireless control switches (infrared) to enable him to operate the controller from his wheelchair without the need for interconnecting cables between the wheelchair and the controller. The controller is making it possible for him to easily turn things ON and OFF that he otherwise could not do.

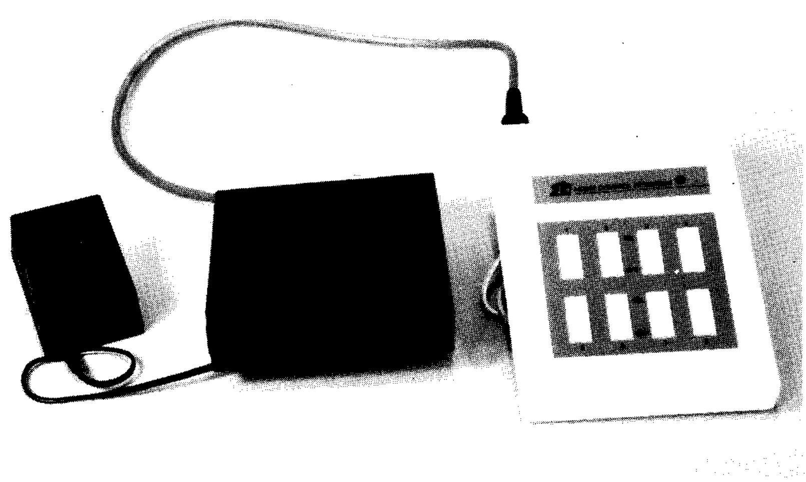

Fig. 16.1. Xl 0 Single Switch Scanning Environmental Controller.

TECHNICAL DESCRIPTION

The heart of the XSC is an 8748 micro-controller. This controller monitors the pressing of a switch, controls the LED's, and communicates with the X10 Controller serially.

The switch is interfaced to the 8748 through an optical isolator for electrical safety (refer to Figure 16.1). This isolator is connected to the TO pin on the 8748, which is also connected to a pull up resistor. When the switch is pressed, the isolator is energized and the TO pin is pulled low.

The LED's are driven by 7406 open collector inverters. These inverters are in turn driven by port 1 of the 8748. When a logic 1 is applied to the input of a 7406, its output is pulled low, allowing current to flow through the LED.

The rate timer is a retriggerable one-shot, and is triggered on the rising edge of port 2 bit 2 (P2.2). The state of the timer is monitored though P2.1. The 50KR POT determines the length of time P2.1 will stay high after P2.2 is pulsed.

The serial input of the X10 is driven by the 7437 (2 input NAND gate). One input of the gate is tied high while the other input is connected to P2.0. By toggling P2.0 at the appropriate rate, serial output is achieved.

The Scanner controller has two switch blocks (4 bits each). SW1 specifies the base house code to use with the X10 controller. The second switch block (SW2) indicates the maximum number of devices to scan. Each line is latched high (in software) before reading the switch settings. Closing a switch pulls the corresponding line low. For this reason, an ON switch results in a logic 0.

The Scanning Environmental Controller can be duplicated for about $270, including the cost of the X-10 Controller, the control modules and a simple hand operated switch.

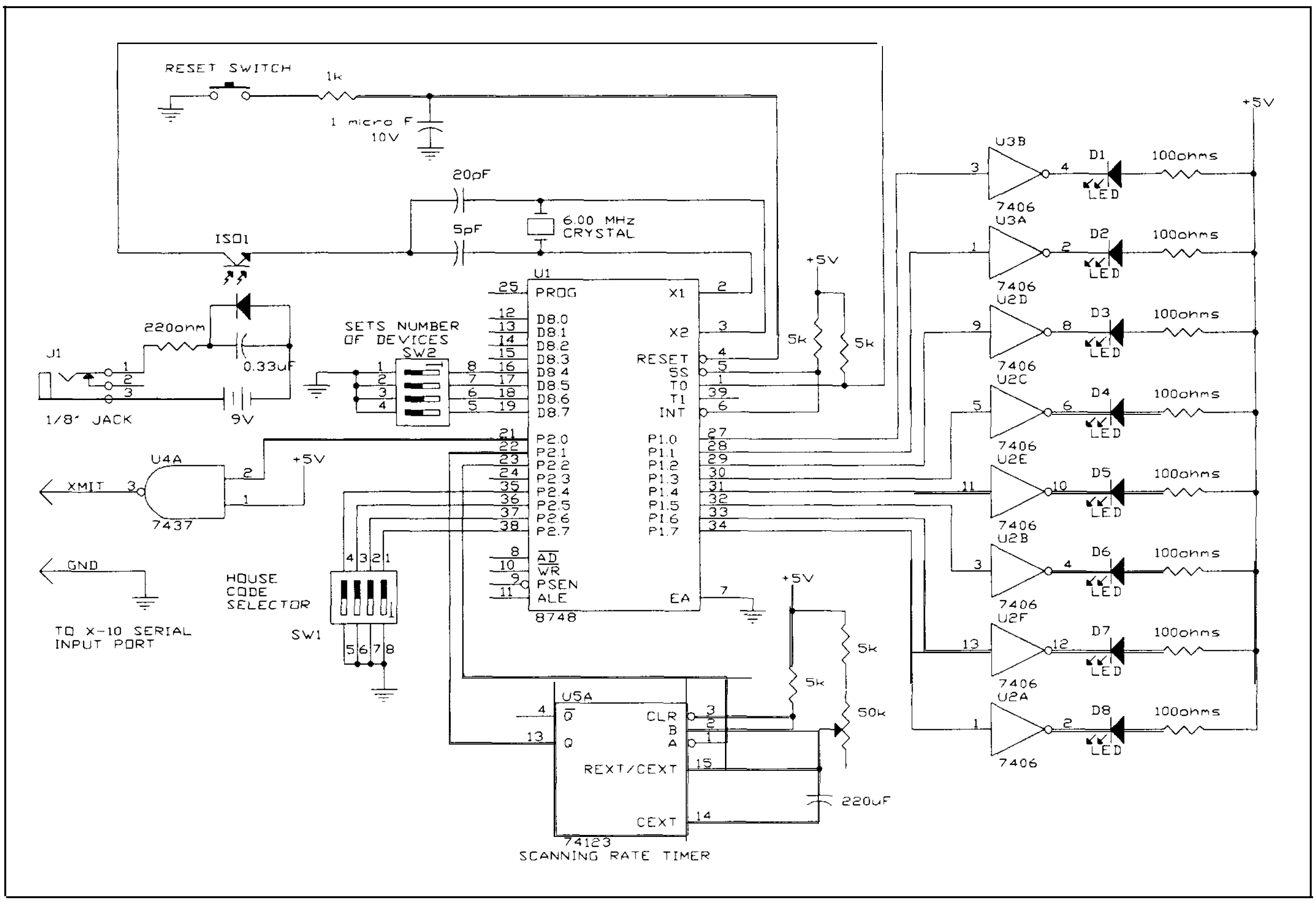

Fig. 16.2. Circuit Diagram for the Xl 0 Single Switch Scanning Environmental Controller.

Ultrasonic Mobility Aid

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INTRODUCTION

The Ultrasonic Mobility Aid (UMA) has been designed for use by visually impaired individuals. This device is an electronic version of the traditional white cane. It provides the user with a larger picture (twelve foot radius) of the environment than the traditional cane. With the addition of a tactile transducer, the UMA may also be used by individuals who are deaf and blind. The UMA is a hand-held battery operated device capable of detecting objects within 12 feet of the user.

Blind individuals who need to negotiate their way through an unfamiliar environment can use the Mobility Aid. The blind person points the sensor in the direction of travel and moves the sensor from side-to-side and up-and-down. By doing this a variable tone is generated alerting the user to the presence of objects and their proximity to the user. A high frequency tone corresponds to an object that is close, while a lower frequency tone means that the object is further away. The absence of any object within 12 feet of the mobility aid results in no tone. Through the use of this sensor, a dynamically changing picture of the user's environment may be realized.

SUMMARY OF IMPACT

The Ultrasonic Mobility Aid is in the process of being evaluated by two people who are blind. Two deaf-blind users will evaluate the aid when the tactile transducer is completed and packaged. Both of the present users are essentially totally blind, being able to distinguish bright lights but not able to discern objects or obstructions. Both are independently mobile, both use long canes, neither uses a guide dog. Both lost sight in early infancy, both are professionally employed.

Their reaction has been that whereas the unit functions as intended and is useful for its intended purpose, a person skilled in the use of a long cane is unlikely to give up the cane in favor of the UMA. There are several reasons. Foremost is the fact that both drivers and pedestrians tend to give way when the cane is seen. A driver is not as likely to yield to a person in a crosswalk carrying a flashlight. Also the "echo" and tactile feedback from the long cane carries information concerning the texture of the surroundings (wood fence versus hedges versus glass doors) which provides location clues.

The UMA, however, does detect obstacles at head-high levels which are not detected by the long cane. For this reason, the recommendation is that a subsequent version be designed to be worn on a belt loop and emit a warning when obstacles endangering the head or upper torso are encountered.

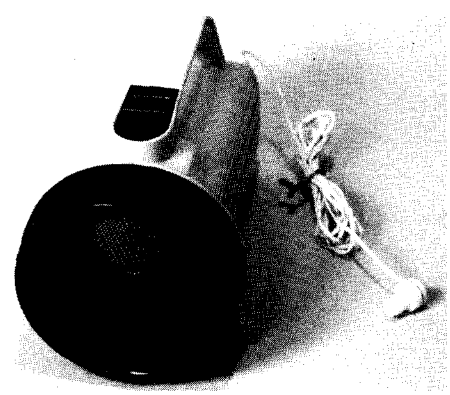

Fig. 16.3. Ultrasonic Mobility Aid.

TECHNICAL DESCRIPTION

On a system level, the Mobility Aid is broken down into three sections:

Ultrasonic Board - This circuit board contains the necessary circuitry to emit an ultrasonic pulse and process the return echo. This board is manufactured by Polaroid Corporation for use in their One Step cameras.

Transducer - The transducer sends and receives the ultrasonic signal (pulses) generated by the Ultrasonic Board. This transducer is also manufactured by Polaroid Corporation.

Detection Circuitry - This digital circuitry measures the time delay between the send and receive pulses. An audible tone is generated with a frequency proportional to the time delay between the send and receive pulses.

The basic function of the circuit is to measure the time delay generated between the send and receive pulses. The closer the unit comes to an object the less time it takes for the return pulse to be received.

The Ultrasonic Board is driven at 2 Hz through a low impedance switching circuit (see block diagram). At this switching rate the user is sufficiently informed of changing conditions. Polaroid has designed the Ultrasonic Board to transmit a 1 millisecond burst of four separate frequencies (50KHz, 53KHz, 57KHz and 60KHz). Each frequency is used to detect a different surface topology. The implementation of the four mentioned frequencies insures a return echo will be received. Send and receive signals are taken from their respective outputs on the Ultrasonic Board. The amplitude of these signals is too small to be utilized directly and therefore amplification is required. Once a send signal is generated, the rising edge of the 50KHz pulse triggers the 555 which is configured as a nonretriggerable one-shot with an on-time of 1.1 milliseconds. This 555 configuration resets the 4520B binary counter during the 50KHz pulse and ignores the remaining send pulses. The send pulses are also directed to the set input of the 4043 RS flip flop (FF). The implementation of the FF acts as a means to utilize only the first send pulse. The Q output of the RS-FF is directed through a delay (two inverters) to the active high enable of the 4520B counter and the active low enable of the 4042A D latches. The delay insures that the counter is reset before being enabled. Once enabled, the counter begins the count sequence. Counting continues until a return echo is received by the transducer. Since the return echo may contain more than one pulse, only the first rising edge is detected at the reset input of the RS-FF. Once detected, the Q output goes low, disabling the counter, and simultaneously enabling the latch. The count data is latched to the eight jam inputs of a 40103B presettable binary down counter. The down counter, configured in the divide-by-N mode, produces a variable output frequency. This variable output is governed by the 40103's clock frequency divided by the binary word present at the jam inputs. The 401038 produces an unsymmetrical wave form. Therefore, a 4018A presettable Divide-by-N counter, set in divide-by-2 mode, is used to obtain a symmetrical output wave form. The ultrasonic board is capable of detecting reflected echoes up to 35 feet away. To limit the range of the object sensor, a four bit magnitude comparitor is used to test the upper four bits of the latches count. By ANDing the output of the Divide-by-N counter with the results from the magnitude comparitor, only signals corresponding to distances less than or equal to twelve feet are passed to the earphone (the user). The entire system costs about $100 to build.

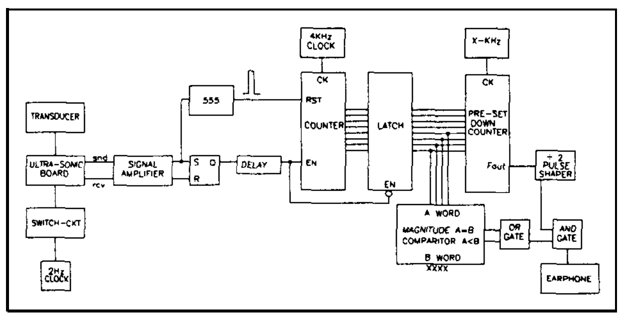

Fig. 16.4. Ultrasonic Mobility Aid Circuit.

Basic Needs Communicator

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INTRODUCTION

The Basic Needs Communicator is a device designed for use by non-speaking, physically disabled people who have the physical ability to operate a single switch. This device allows people who are unable to communicate orally and have limited manual dexterity to express ten needs (or messages) via synthetic speech.

Mounted on the front panel of the communicator are ten LEDs. Pictures, each representing a specific need, are placed over the LEDs. The pictures are sequentially illuminated by the LEDs. A need is selected (or expressed) by pressing the switch when the corresponding picture is illuminated. Located on top of the device is an audio output jack for connection to a speaker, a potentiometer to control the volume, a potentiometer to control the scanning rate and a switch input jack.

SUMMARY OF IMPACT

The Basic Needs Communicator was built for use as a diagnostic and teaching tool at a rehabilitation center that provides services for physically disabled and mentally retarded children.

An individual has been identified from among the client population for whom the communicator may be appropriate. He has some experience using a hand operated switch and has used a nontalking row-column scanner with some success. He will begin training on the new system following summer vacation.

Initially it will be used on a table next to his wheelchair. As he learns to use it, it will be mounted on his wheelchair tray so that he can express his needs anytime he is in his chair, which is most of the day. The communicator should ease his frustration in not being able to express himself to the staff and to others in his classroom.

TECHNICAL DESCRIPTION

The Basic Needs Communicator consists of the following units:

- Micro-controller
- Scanning LED driver
- Scanning Rate Timer
- Speech Synthesizer
- Audio Amplifier

An 8748 micro-controller (refer to Figure 16.6) is the heart of the system. Each need (message) is broken down into phonemes and stored (in EPROM) in the

Fig. 16.5. Basic Needs Communicator.

8748. When a need is selected, the corresponding phonemes are passed to an SC-01A speech synthesizer chip that produces the speech. Scanning is achieved by sequentially applying a binary value to bits O-3 of port 1 on the 8748. These lines drive the inputs to a 74542 4-Line to 10-Line decoder. Each output (active low) of the decoder is connected to a separate LED (10 in all). As the inputs to the decoder change, each LED is turned ON then OFF in turn.

The 8748 scans the LEDs at a rate determined by the 74123 Retriggerable Monostable Multivibrator (timer). The timer is triggered by applying a pulse to its A input (via pin 5 of port 1) at which point the Q output of the timer goes high. The Q output remains high for a period dependent on the RC time constant of the external resistor/capacitor combination. This time period is adjusted by rotating the potentiometer. When the Q output goes low, the 8748 advances to the next LED, and retriggers the timer. The switch is monitored through the TO test pin of the 8748. When the switch is closed TO is pulled low at which point the corresponding message (phonemes that make up the message) is sent by the controller to the SC-01A. Each phoneme is passed from the 8748 to the SC-01A through bits O-5 of port 2. A phoneme is latched into the SC-01A by pulsing the STB (strobe) line at which point the A/R (Acknowledge/Request) line goes high. The next phoneme must not be passed to the SC-01 until it is Requested (when the A/R line goes low). The A/R line is not TTL compatible. For this reason a transistor is used to provide an (inverted) TTL signal. The A/R line provides the timing between phonemes to produce clear speech. The SC-01A generates an audio signal (based on each phoneme) at its AF and AO lines. These lines drive the input of the Audio Amplifier (built around the LM386). The pitch (or duration) of the phonemes is adjusted by rotating the potentiometer connected to the MCRC and MCX lines of the SC-01A. This potentiometer (and its associated capacitor) provide the SC-01A with external timing for phoneme spacing. The system costs about $130 to build. The SC-01A and the 8748 are the most expensive components at $40 and $10 respectively. Access to a Votrax TNT or PSS speech synthesizer makes it relatively easy to generate and test the phonemes before loading them into the 8748.

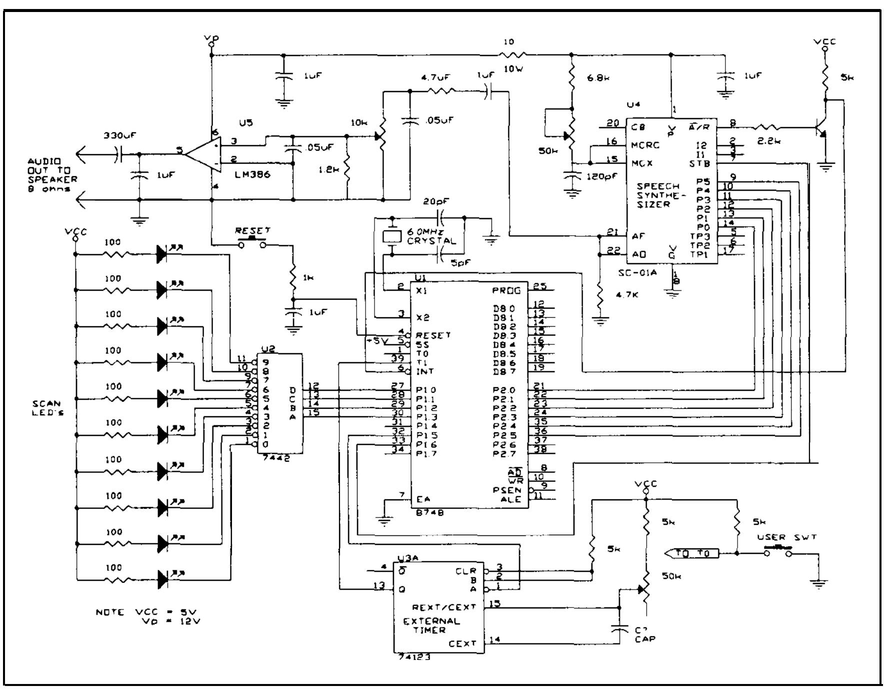

Fig. 16.6. Circuit Diagram for the Basic Needs Communicator

Single Switch Calculator

Designers: Thomas Girourd and Bernard Lamarre
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Supervising Professor: Professor Philip H. Viall
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INTRODUCTION

The Single Switch Calculator is a device designed for use by disabled persons who have the physical ability to operate a single switch. Persons who have limited manual dexterity can control this calculator with a single switch. Digits (0-9), operators (+,-,x,/) and a decimal point (.) are displayed on the top of the unit. Each function (digits, operators and the decimal point) is illuminated one at a time by LEDs. Six seven segment displays are used to display the numbers selected and the result of an operation. A user makes a selection by pressing the switch while the desired function is illuminated. The scanning rate can be adjusted to suit the user by rotating a potentiometer located on the unit's side.

SUMMARY OF IMPACT

There are many people in the world today who are unable to operate a conventional calculator due to a physical disability. For them, the choices are to make calculations mentally or to rely on others. In many instances, disabled individuals never master mathematical concepts because they are physically unable to write down a column of figures.

The single switch calculator will be used to explore simple math concepts with a group of youngsters who are severely physically involved and who have not been exposed to math problems beyond single digit calculations.

TECHNICAL DESCRIPTION

The heart of this device is an 8751 micro-controller (refer to Figure 16.8). The 8751 monitors the switch interface, controls the scanning of the 16 LEDs, and displays the selected numbers and the result of each operation on the seven segment displays.

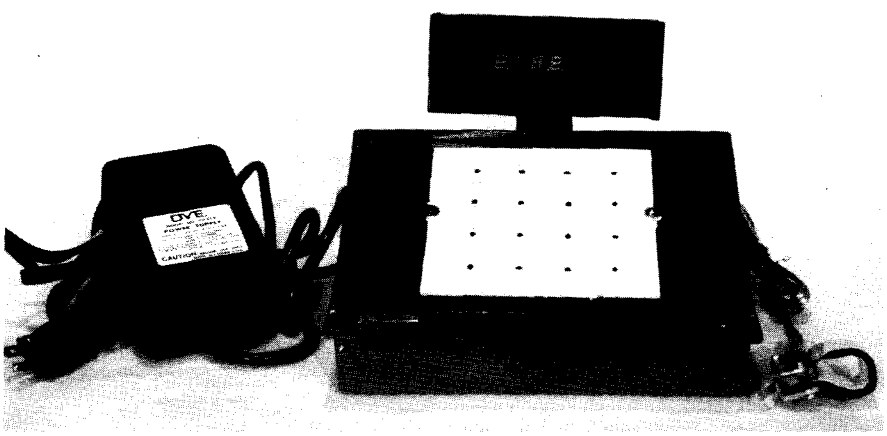

Fig. 16.7. Single Switch Calculator.

The 8751 illuminates each function by applying a four bit value to the lower four bits of port 3. These four bits drive a 74154 (4 to 16 decoder). Each output of the decoder drives a 7404 inverter which in turn drives one of the 16 LEDs. By sequentially changing the value applied to the decoder each LED is illuminated in turn.

The scanning rate is governed by a 74123 retriggerable monostable multivibrator (timer). The timer is activated by applying a pulse to its A' input (via port 3 bit 7). At this point its Q output changes state (monitored via port 3 bit 6). The length of time the timer remains in this state is controlled by the RC time constant of the capacitor and potentiometer. The time delay can be extended by the 8751 by applying another pulse to the A'input before the timer times out (thus the name retriggerable).

Each of the six digits is displayed by outputting three packed BCD numbers to ports 0, 1 and 2. Each nibble of these three ports drives a 74243 buffer which in turn drives a 7447 BCD to seven segment display driver. Each of the six 7447s is connected to a seven segment display.

To conserve power (for battery operation) each display is connected to Vcc through a separate transistor (operating as a switch). The transistor and buffer in each of the six display units are enabled one at a time by the outputs of a 74138 3-line to 8-line decoder. This allows the buffer and transistor to be enabled when the corresponding output of the decoder is selected. Each output of the decoder is sequentially enabled by a 74161 counter that is clocked by a 555 timer. The frequency of the timer is adjusted by a potentiometer attached to the 555 timer. By multiplexing the displays only one of them is ON at any given time thus conserving power.

The program contained within the 8751 can be broken into the following stages:

1. Illuminate the current function.
2. Trigger the external timer.
3. Wait for the timer to time out or the switch to be pressed.
4. Process the current function if the switch is pressed.
5. Select the next function.
6. Repeat, starting with step 1.

Some functions were not implemented in this prototype. Multiply, divide and clear subroutines still need to be written. The prototype can be duplicated for about $80.

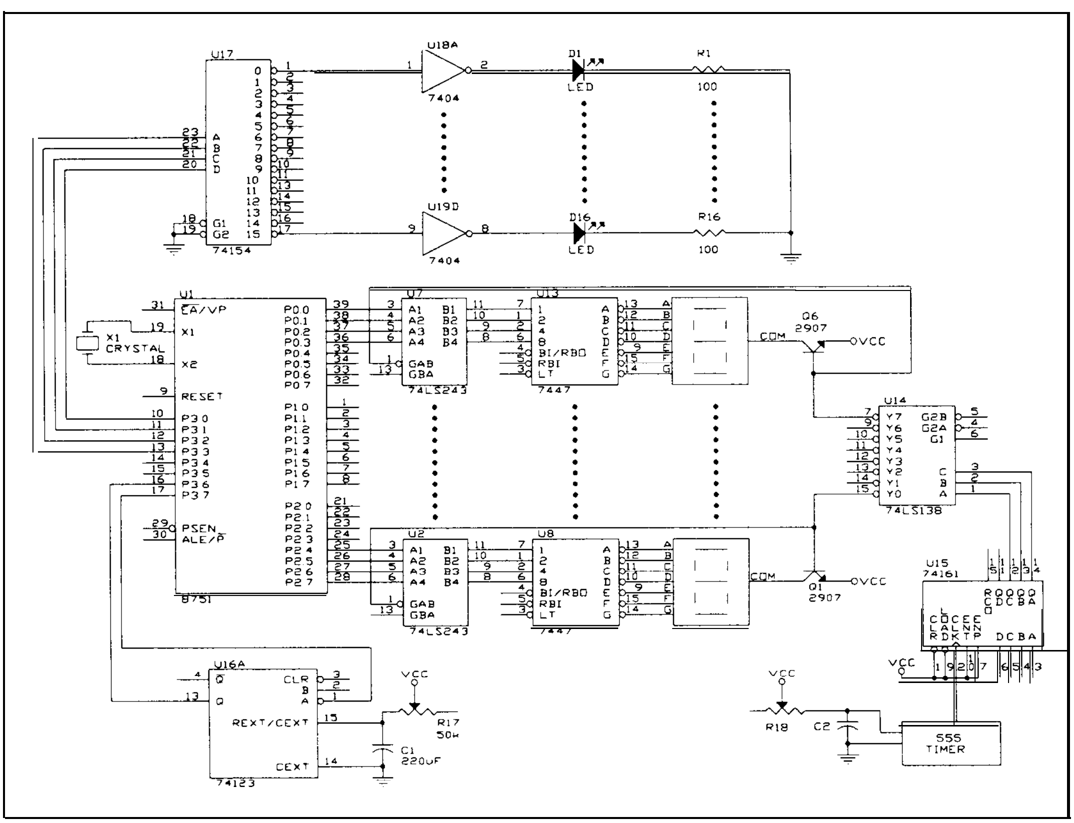

Fig. 16.8. Circuit Diagram for Single Switch Calculator.