CHAPTER 3
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Speech Aid

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INTRODUCTION

A microprocessor based portable speech aid device has been designed for impaired children with severe motor handicaps. Other speech aids are available; however, there are groups of disabled individuals who have difficulty using them or are unable to use them. The speech aid consist of a microprocessor, encoder/decoder circuit, memory, and signal processing circuitry. The circuitry is housed in an enclosure as shown in Fig. 3.1. The speech aid allows for complete messages to be recorded as on a tape recorder and then selectively played back as chosen by the handicapped individual. A set of eight LED's provides a scanning output for selecting the desired message. The desired message is selected via an external switch. The device is battery operated and portable.

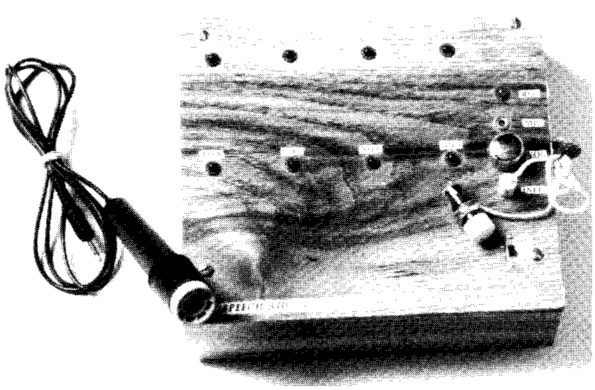

Figure 3.1. Picture of Speech Aid device.

SUMMARY OF IMPACT

There are two groups of persons who are unable to speak. The first group consists of persons who also have motor impairments that limit the use of their extremities. This group includes individuals with cerebral palsy and paralysis. The second group does not have physical difficulties that constrain communication other than speech production difficulties. The difficulty for the first group is two-fold. First, these persons do not have any speech ability, and second, they may not have the manipulative control necessary for functional conversation and writing. Therefore, these individuals usually have a much more severe communication problem that the people in the other group. In such cases, appropriate communication aids are indispensable for interacting with their families and community. Even the ability to express elementary needs and emotions, such as happiness, sadness, hunger, or a need to use the toilet is important. Although communication devices exist, none of them are suitable for speech impaired individuals who also have severe motor impairments. The device designed meets these needs and provides communication for severe physically disabled individuals requiring communication aids.

TECHNICAL DESCRIPTION

The device is developed around a Motorola MC68HC11A8 microprocessor. A block diagram of the device is shown in Fig. 3.2. Adaptive Delta Modulation (ADM) is used for the speech encoding due to the relative low memory requirement and single-bit stream format. Delta modulation (DM) is a subclass of differential pulse code modulation, utilizing only one-bit quantizers. Adaptive delta modulation dynamically changes the step size with input variance. A number of methods of ADM have been proposed in adapting the amplitude of the step. Some of the approaches can be grouped as instantaneous, syllabic, and hybrid adaptation. In this design, syllabic adaptation is utilized by adapting the step size over time intervals of about 5 to 20 ms.

Although the adaptation memory is usually only a few samples, the changes in A (step size) F occurs relatively slowly in continuously variable slope DM (CVSD). The step size can be updated as follows:

$$A(n) = \begin{cases} \beta\Delta(n-1) + D_2 & \text{if } c(n) = c(n-1) = c(n-2) \\ \beta\Delta(n-1) + D_1 & \text{Otherwise} \end{cases}$$

where $0<\beta<1$ and $D_2 \geq D_1 > 0$. If the output changes for three or four consecutive samples, the step size changes, and decays at a rate specified by β. Usually, β is near unity, and D_2 is small compared to Δmax, resulting in slow adaptation. A block diagram of a CVSD encoder and decoder is shown in Fig. 3.3.

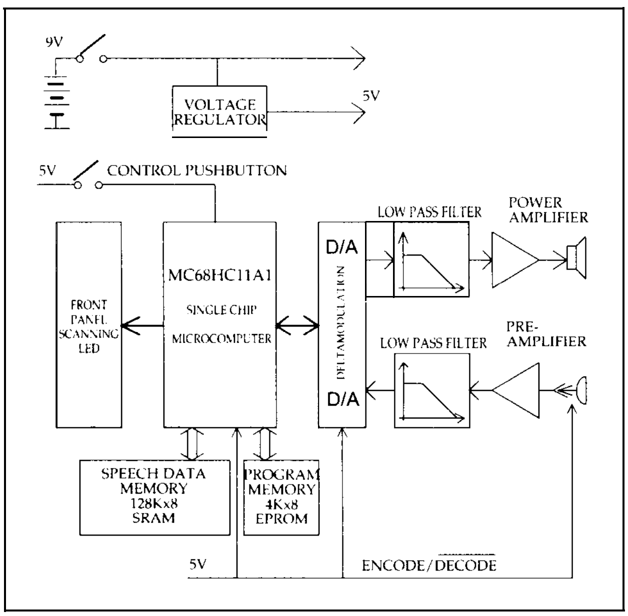

Figure 3.2. Block diagram of Speech Aid circuitry.

A set of eight LED's is used in a scanning mode with each LED representing some message. This scanning mode allows the individual user to utilize a single channel input for selecting the desired message. This input can be provided by a microswitch or some special device that provides a suitable interface for the individual. One of the special features of the device is its ability to record a message directly, essentially making it a digital tape recorder with eight separate recording channels. This is due to the single delta modulation chip used being able to perform both encoding and decoding. As can be seen from Fig. 3.2, amplifiers and low pass filters are used to condition the input during recording and the output during playback.

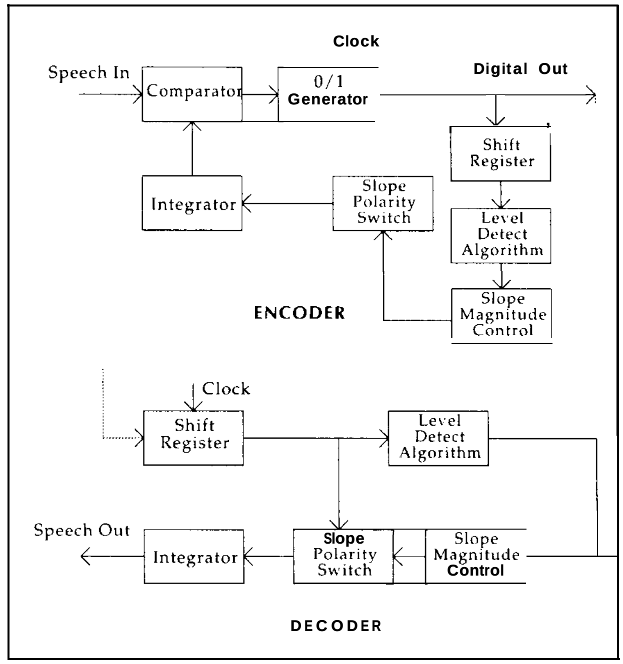

Figure 3.3. Block diagram of CVSD encoder and decoder.

The software is divided into four functional program blocks that are 1) the LED scanning routine, 2) the message location determination, 3) the recording routine, and 4) the replay routine. The programs are written in MC68HC11 assembly language, which is actually the enhanced MC6800/MC6801 instruction set. The program was developed on an IBM AT and down loaded to an MC68HC11 Evaluation Board (EVB) for testing and evaluation. Once the hardware and software were developed the program was down loaded on the prototype board. The entire device cost is approximately $150.00. Further information is available on request.

Timer Switch

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INTRODUCTION

A timer switch has been designed for handicapped children that allows for increased benefit derived from play. Fig. 3.4 shows the timer switch. The device can accommodate a variety of switches and toys. A range of timing intervals (period of time device will remain on) is available. The device uses almost no power when not in use resulting in a prolonged battery life. In addition, a built in battery checker allows for the condition of the battery to be determined anytime to see if the battery needs replacing.

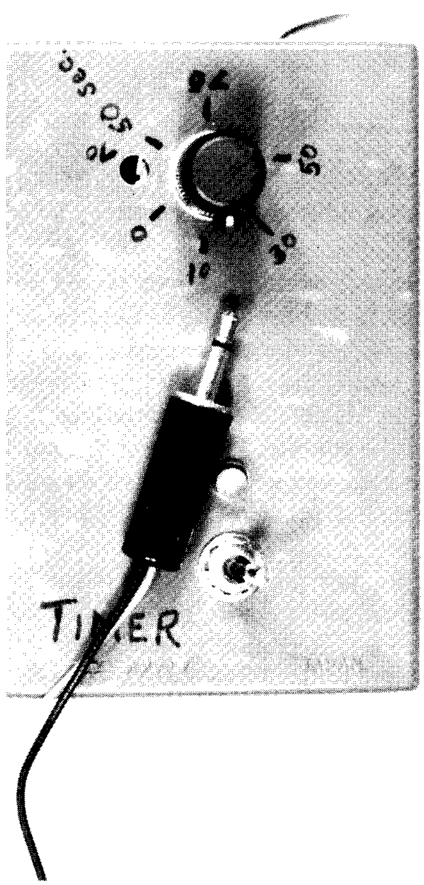

Figure 3.4. Picture of Timer Switch device.

SUMMARY OF IMPACT

The interaction between a child and a toy in the development and learning process is well known to educators who work with physically disabled children. Through purposeful play a child develops physically, emotionally, cognitively, and socially. Such developmentally appropriate play can often be provided by low cost battery-operated toys. With modifications, often in the switching unit, a disabled child can participate in this crucial activity. However, most modified battery-operated toy with a single switching input requires a child to apply constant contact on the switch to activate the toy. Severe motor impaired children have difficulty maintaining this contact for a prolonged period of time, resulting in a lack of proper control of their environment during play. The timer switch provides the child with an opportunity to obtain the maximum benefit from the interaction with a toy. As a result, the child can develop more toward his/her full potential and ability, enhancing other areas of development. In addition, the teacher/therapist can objectively measure the child's ability to understand cause-and-effect relationships.

TECHNICAL DESCRIPTION

Fig. 3.5 is a schematic diagram of the timer circuit used. Any switch with a 3.5 mm connector that the child can utilize plugged into connector A can be used. The circuit takes advantage of a very simple circuit using a LM322 precision timer in combination with a transistor, Q1, which has near zero current supply demand between timing intervals. As the child depresses the external switch, the circuit closes the relay that is connected to a toy or a tape recorder's remote. When the relay closes, this activates the toy or device for a predetermined period of time. After this period of time the relay opens, deactivating the toy. The 20 KΩ resistor in combination of Rt and Ct determines the time period. The

20 kΩ resistor is a trimmer pot that can be used to calibrate the timing period when needed. By adjusting the 100 KΩ resistor, Rt, the specific time period can be set.

The addition of a battery test circuit designed around a LM611 allows for determining whether the battery is low or not. A green LED indicates when the relay is closed, however, a red LED indicates whether the battery is low and needs to be replaced. The complete device costs approximately $20.00.

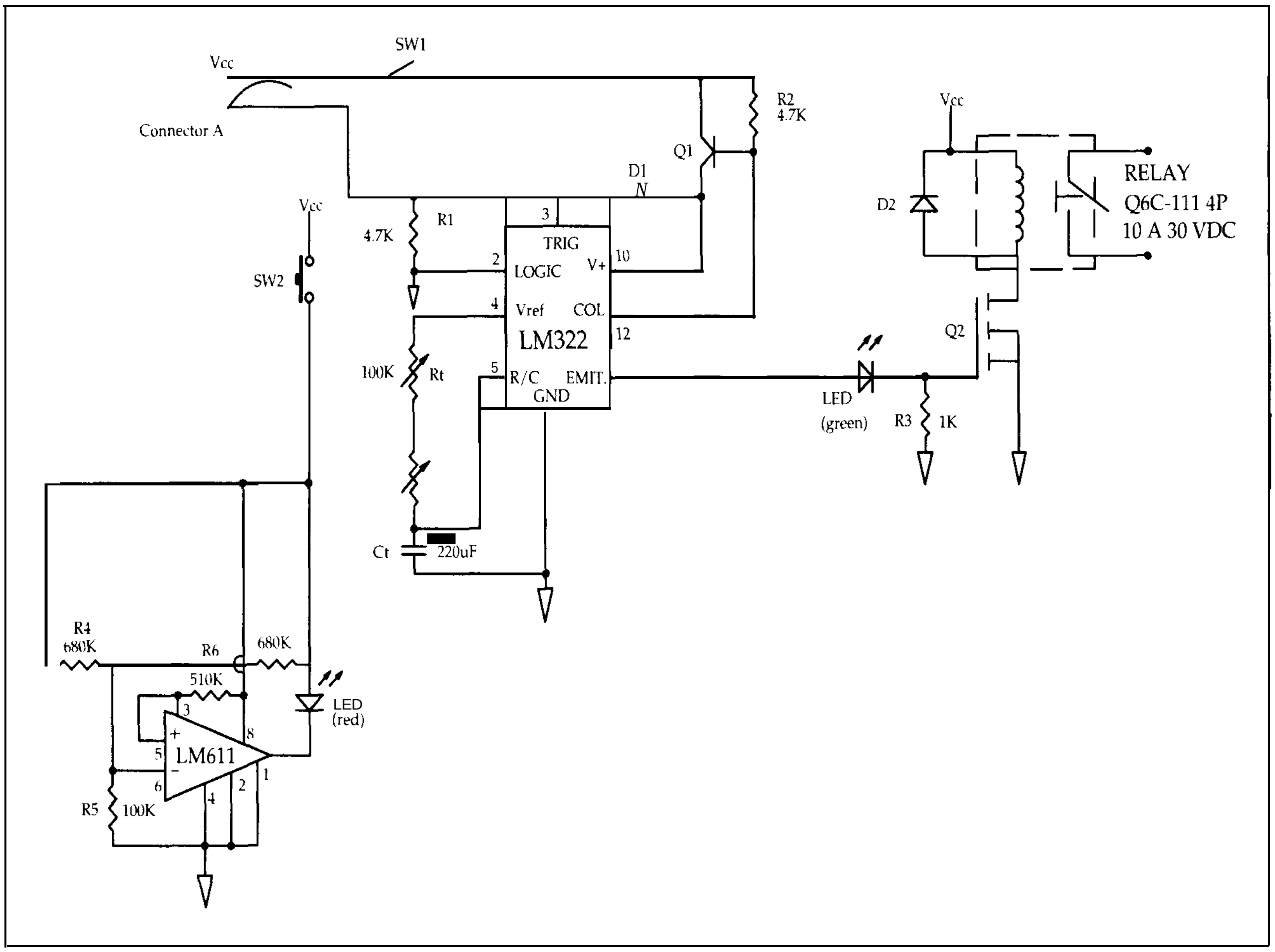

Figure 3.5. Schematic of Timer Switch circuits.

Visual Scanner

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INTRODUCTION

A visual scanning device consisting of 4 LED's (light emitting diodes) has been designed for use with young severely disabled children. The device shown in Fig. 3.6 provides space for various objects such as toys or pictures to be placed by each LED. Different displays can be used with the device since the display is a separate unit. The orientation of the display (horizontal or vertical) can also be change. The scanner is battery operated and portable.

SUMMARY OF IMPACT

One of the needs of a young child is the development of the relationship between abstract words and real objects. For many handicapped children this becomes difficult due to cognitive and physical disabilities. Additionally, many electronic assistive devices use a scanning mode in providing selections for single inputs. Therefore, one method of developing the relationship between words and the objects they represent is to utilize scanning LED's with space for various objects. A therapist can ask the child to select a specific item and the child would then depress a switch when the appropriate LED is lit.

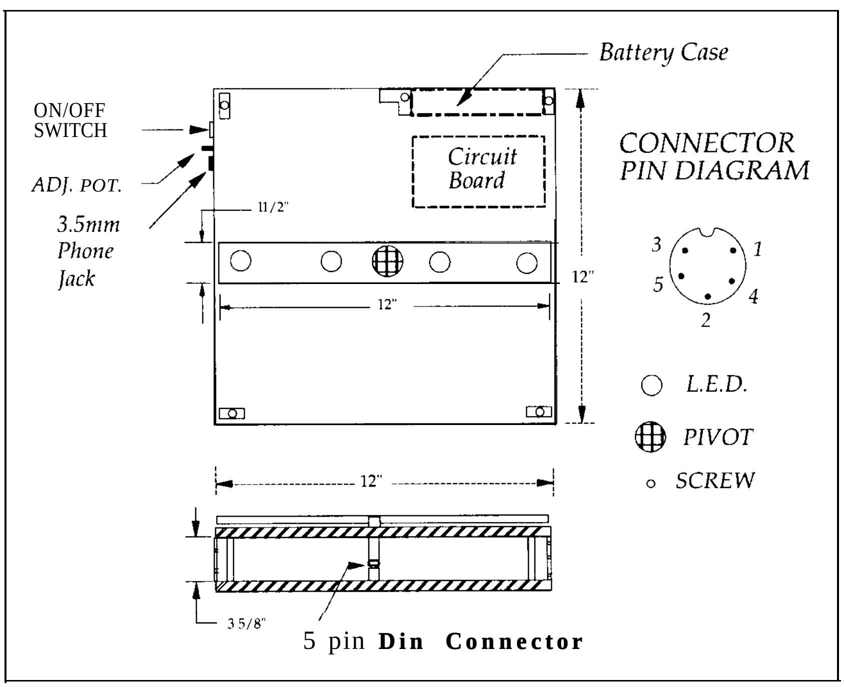

Figure 3.6 Physical drawing of Visual Scanner device.

TECHNICAL DESCRIPTION

The visual scanner circuit is shown in Fig. 3.7. The circuit is composed of three stages that are the clock circuit, one-shot, and counter/scanner circuit. A 4098 multivibrator is set up in a monostable or "one-shot" mode. When the external switch, SW, is closed the one-shot multivibrator emits a pulse to the inhibit pin of the counter that enables and disables the counter's operation. The 555 timer circuit provides the clock pulse to the counter determining the scan rate. The clock rate is set by an adjustment potentiometer, R9. A 4017 CMOS decade counter activates the LED's through driver transistors. Each LED is activated in a O-l-2-3 sequence. When the counter reaches 4 it resets itself and repeats this sequence until the counter is disabled. A D type flip-flop is used to provide a clean stable pulse to the counter from the clock and one-shot. LED's were selected due to their low power requirements allowing the design to be battery operated.

The circuit can be easily modified for any number of LED's up to about 9. For example, if a 3 LED device was desired, it is necessary to connect #3 pin (pin 7) to the reset pin (pin 15). The LED display is connected to the circuitry by a 5 pin DIN connector. The LED display module is mounted to the main unit by a fixture that allows rotation of the display module from zero to 90 degrees. Additionally, since the display module is a separate unit, other display modes, such as LED's at each corner and different color and size LED's, can be accommodated. The entire device cost is approximately $45.00 and complete drawings are available on request.

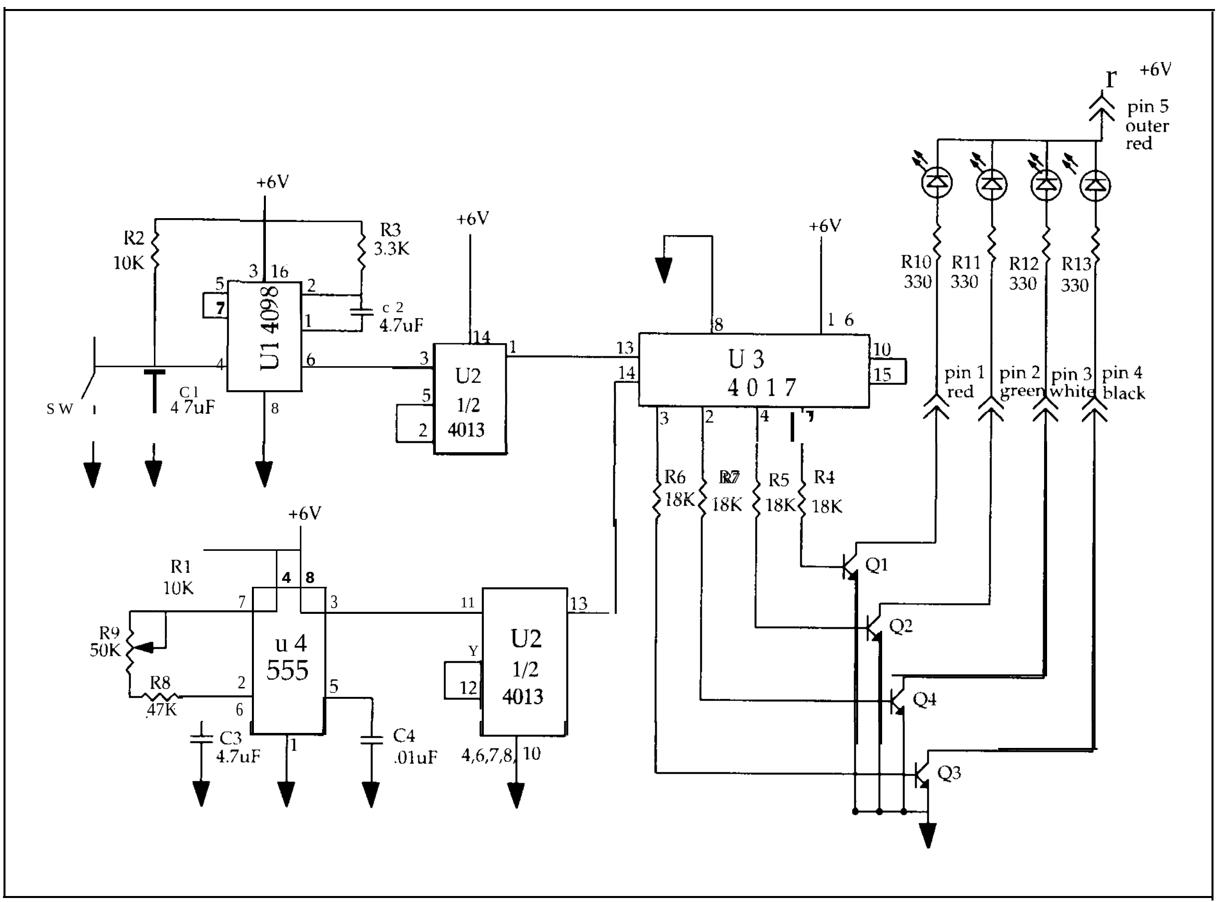

Figure 3.7. Schematic of Visual Scanner Circuitry.