Chapter 9
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PROGRAMMABLE DIGITAL SPEECH SYNTHESIZER

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INTRODUCTION

A private practice of speech-language pathologists uses previously designed voice communication assistants (VCAs) to aid patients with limited verbal skills in expressing words and phrases. These devices allow the patient to press a button, which then causes a word, such as "yes" or "room", to be "spoken" by the device. While these devices are useful, they are limited in their capabilities due to 1) associating a single word with each button, and 2) not allowing customization through use of different words or phrases. The device described here was designed to overcome these two limitations.

The goal is to design an affordable, fully programmable (i.e., allowing changeable messages), battery operated, lightweight, hand held, and easy to use VCA. This VCA incorporates a matrix of buttons that act as the interface to the user. The button leads to a keyboard encoder chip that determines the address of the button pressed and relays it to the controller processor. The processor, in turn, prompts the digital record and playback chip to either record or play back a message for the corresponding button, depending on the mode of operation (playback or record). The VCA also incorporates a distress siren, operated by a separate button, for emergency use.

SUMMARY OF IMPACT

Over the past few years, the client has found VCAs to be valuable for allowing patients to communicate with staff members. Previous designs have been limited, however, by having few and fixed phrases. By allowing different phrases to be “spoken”, and by allowing each phrase to be reprogrammed, this device should enhance the usefulness of VCAs by allowing them to be customized for each patient.

TECHNICAL DESCRIPTION

The VCA uses an array of 16 buttons to act as the interface for the user. When a button is pressed, a message is played or a new message is recorded, depending upon the current mode of operation. (playback or record).

The VCA uses a keypad encoder to determine which button was pressed, and outputs the corresponding address to the controlling processor. The processor then determines what mode of operation the unit is in, and prompts the digital record / playback chip to perform the corresponding function.

If the VCA is in record mode, the digital record / playback chip records a message via the onboard microphone. If the unit is in playback mode, the digital record / playback chip outputs the recorded audio message to the amplifier and, in turn, to the speaker. If the distress siren button is pressed, a button / siren is activated until the button is pressed again.

Operational Processing:

A DS5000 microprocessor was selected to control the VCA. This processor has four 8-bit ports, a lithium battery backup, and 32k of RAM, making it a self-contained unit, simplifying the hardware design and reducing cost considerably. Upon power-up, the DS5000 initializes itself (by setting up interrupt vectors, output ports, etc.) and waits for a button to be pressed. Once pressed, an MM74C922 keypad encoder pulls the data available (DA) line to the microprocessor high. The processor then determines if the mode switch is set to record or playback. Depending upon its setting, it then proceeds in one of two ways: playback mode or record mode.

In playback mode, the microprocessor reads the keypad encoder chip's output as an address of the message to be played. The microprocessor powers up the

ISD2590 digital Record and Playback chip, places the chip in playback mode, and sends the address of the message to the ISD chip. The Chip Enable pin on the ISD chip is then pulled low, activating the current message. Once an End of Message (EOM) marker is encountered, the ISD chip is then powered down to save power.

In record mode, the microprocessor reads the keypad encoder chip's output as an address at which the audio message is to be recorded. The ISD chip is first powered up and the address of the message is sent to the ISD chip. Next, the chip enable pin is held low for the duration of the recording. Once the button is lifted or the record time limit is reached, the ISD chip is again powered down.

In addition to the record and playback mode, an alarm siren is also included. When the alarm button is pressed, a piezo electric element is driven directly from a 5V supply.

The final implementation of the VCA meets all of the requirements established by the client. The buttons are large and easily manipulated; the emergency siren is sufficiently loud; the corners are dull; each of the 16 messages are fully programmable with phrases of up to 5 seconds each; and the unit can be switched from record to playback mode.

In order to reduce power consumption over previous designs, the 11MHz clock was reduced to 1MHz. This reduces the overall power consumption to 11mA.

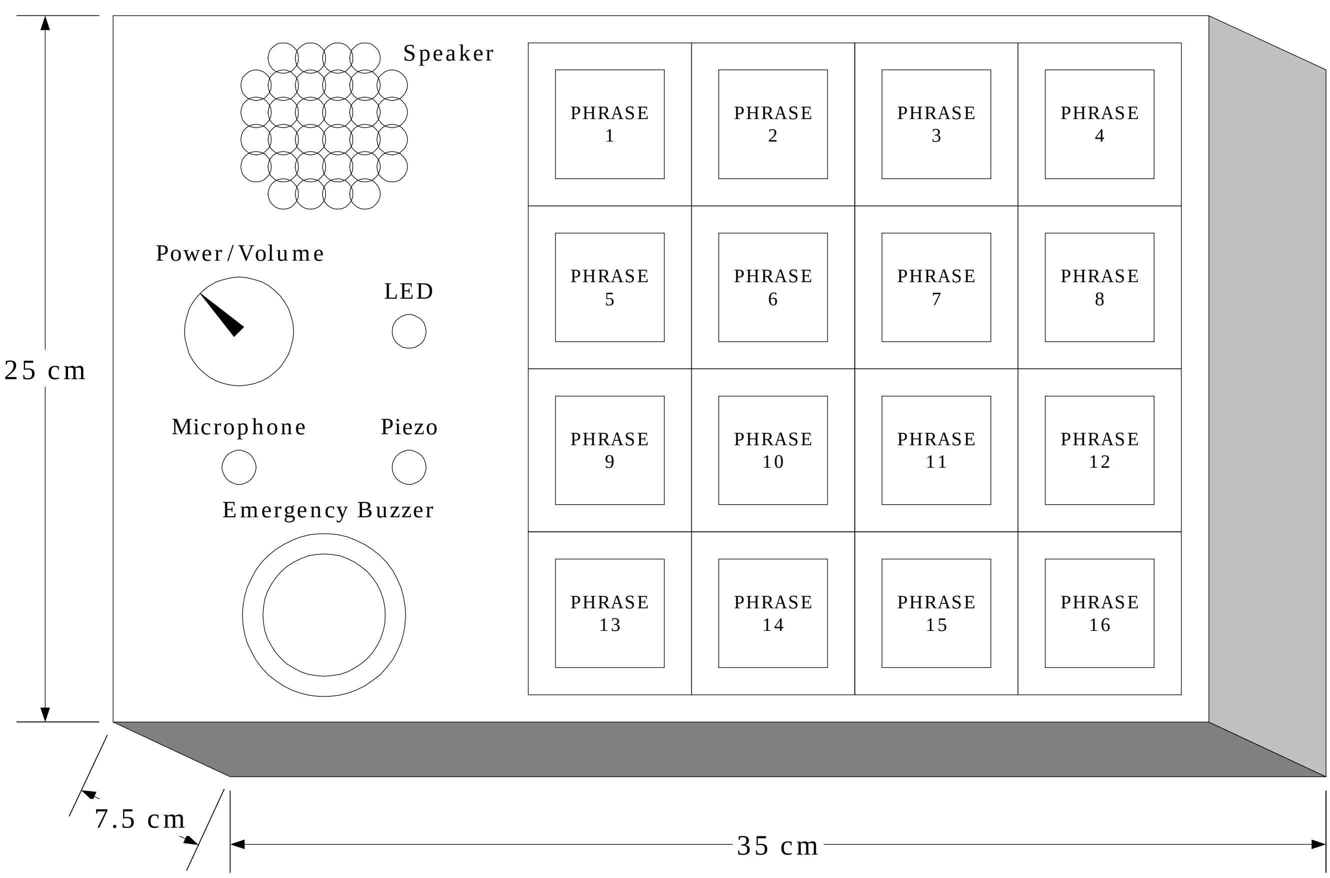

Figure 9.1. Configuration of the Verbal Communication Assistant. The record / playback switch is recessed and located on the back to prevent accidental switching to record mode.

AUDIO AMPLIFIER

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INTRODUCTION

An Audio Amplifier was built for patients who have difficulty vocalizing at a volume needed for effective communication. It entails a microphone headset that amplifies the voice of the operator and transmits it to a nearby FM receiver. The FM receiver is then able to amplify the patient's voice for improved communication.

SUMMARY OF IMPACT

The purpose of this project was to design a voice amplifier that will be portable and effective in allowing the user the freedom to participate in conversation without overexertion. The design consists of a small personal voice amplification aid for those who are unable to vocalize at the volume needed for everyday conversation. When used with any standard FM receiver, this device provides effective amplification of the user's voice. In addition, once the transmitter and/or radio receiver are tuned, the design is simple and easy to use, requiring no difficult manipulation. This device will enhance the ability of the operator to communicate with others by making his or her voice loud enough to be clearly understood. To date, the design has not been field tested.

TECHNICAL DESCRIPTION

The Audio Amplifier consists of three main parts: the microphone, amplifier, and FM transmitter. For ease of use and comfort to the operator, a Shure HW501 microphone headset was selected. This microphone can be worn comfortably throughout the day, and has in impedance of 200 Ohms, and a frequency response range of 50 to 15,000 Hz (well beyond the vocal range). In order to amplify the signal from the microphone, a Texas Instruments TLC251 low-power operational amplifier was used. This amplifier acts as a buffer between the microphone and the FM transmitter. A Sound Feeder SF120 (manufactured by Akron Research Inc.) takes the amplified audio signal and broadcasts an FM signal from 88MHz to 108MHz. This device was selected since it is readily available, has low power consumption, and is FCC certified.

Since the device operates on the FM band, any FM radio could be used as the receiver. An FM receiver based upon the Philips TDA7000 chip was included in the design. The TDA7000 is a chip that implements a mono FM radio from an antenna to the audio output signal that will be sent to the amplifier. This chip was chosen due to the requirement for only one tunable LC circuit of which one variable capacitor is required to perform all the tuning. This results in ease of tuning, and also keeps the size to a minimum because only a small number of external ceramic plate capacitors and resistors are required.

The internal workings of the TDA 7000 consists of a local oscillator, mixer, two-stage IF filter, IF limiter and amplifier, FM demodulator, and an audio muting circuit. Before the actual signal enters the chip from the antenna, it passes through an external RF selective LC circuit that suppresses unwanted signals, such as TC. The signal then enters the chip's mixer, where the signal is mixed with the VCO frequency. The signal then passes through a series of two IF filters and an IF limiter/amplifier. The IF signal then enters the FM demodulator and is converted to the audio frequency. This is then amplified and sent to a speaker, from which the operator's voice can then be heard.

The transmitter portion of this circuit requires a single 1.5V battery and draws a total of 10.19mA. This should provide continuous use for approximately 90 hours when supplied with a AA battery. The receiver portion of the circuit draws 11.6mA at 9V, resulting in a life of approximately 1 hour.

The cost of this project is approximately $124

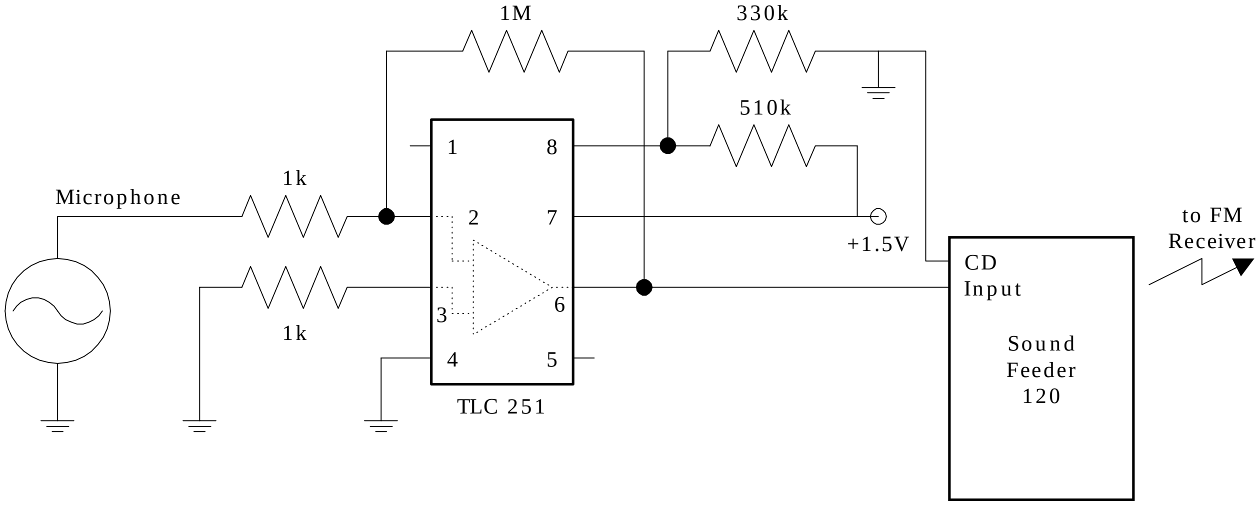

Figure 9.2. Transmitter Portion of the Audio Amplifier.

MOTORIZED CLAMP

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INTRODUCTION

Typically, woodworking requires two hands: one to hold the project and one to do the work, such as painting or varnishing. Unfortunately, this makes woodworking challenging for those with limited use of an arm or hand. This project was designed to help a client who enjoys woodworking. The Motorized Clamp is easily controlled by one hand. It holds an object in place, enabling the operator to use one fully functional arm and hand to work on the project. It entails a robotic arm with a clamp attached. Switches located on a nearby control box control the arm.

SUMMARY OF IMPACT

For those with limited use of an arm or hand, woodworking can be challenging. The Motorized Clamp is a device that can be easily controlled with one hand, effectively giving the operator a second hand for working.

TECHNICAL DESCRIPTION

The mechanical construction of the robotic arm consists of two rotational joints for the base and shoulder, and a prismatic joint for the clamp, as shown in figure 9.3. The device is made of lightweight aluminum to provide a sturdy base and to maximize the carrying capacity of the device.

12V DC servomotors are used to drive each joint. These motors are geared down using work gears to prevent slippage. The base joint is capable of rotating +/- 90 degrees and carries the rest of the root on a lazy-Susan bearing. The shoulder joints are actuated using a threaded rod. This arrangement allows greater loads to be lifted by gearing down the DC motor, provides some added stability to the shoulder joint, and prevents slippage by using a work-gear. The clamp is also actuated using a threaded rod, which moves the clamp from +14cm in the full-open position fully closed.

A control switch is used to move the arm from one position to another. This is accomplished by sending a signal from the user's input switch to the position circuitry, which, in turn, controls the motor for the desired motion. The clamp and arm are designed with sensory feedback to prevent hyper-positioning.

Two 6V lantern batteries provide power. The expected life of the batteries is approximately 6 hours of continuous use. Since the motors are not run at all times while the operator is woodworking, this should provide adequate power for one or two weeks of normal use.

The circuitry involved in this design deals with powering and controlling the motors. Power is provided to the motors via a +12V supply. A double-pole double-throw switch is used for each joint to allow the operator to select the direction of motion of the motor, causing the arm to move up or down or the clamp to open or close. Normally closed switches are located on the +12V line to prevent hyper-positioning the arm. When the clamp reaches a limit, a sensor opens the switch (normally closed), shutting off power to the clamp.

The total cost of the arm is $277.85

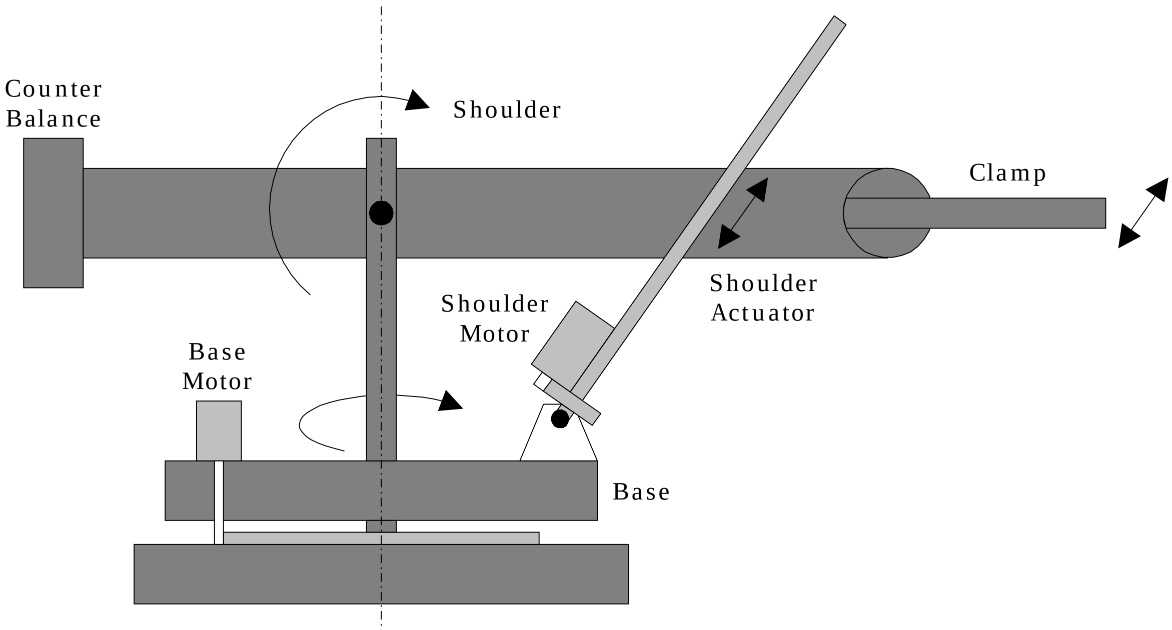

Figure 9.3. Mechanical Configuration of the Motorized Clamp.

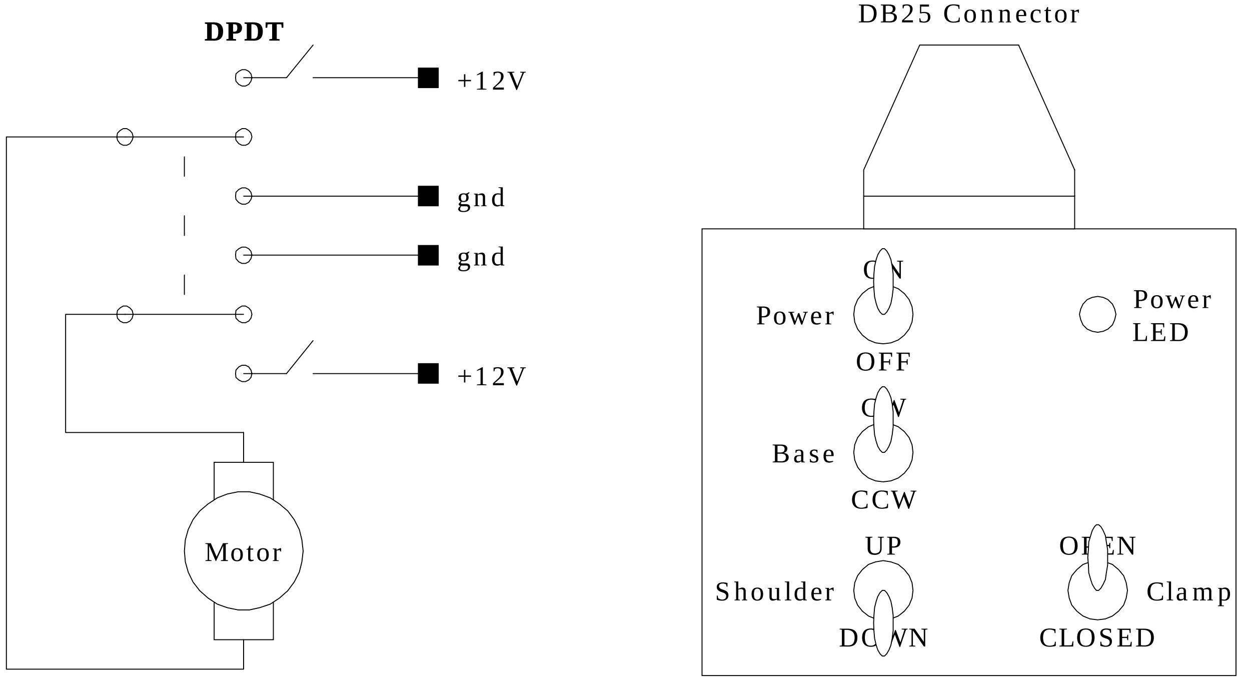

Figure 9.4. Electrical Configuration of the Motorized Clamp. Each of the three motors can be driven forward or backwards. To prevent hyperextending a joint, sensors are used to shut off power to the motor if driven too far.