Low-volume speech

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Abstract

This project is the outcome of the necessity of a female patient of Parkinson's disorder and hearing disability of having someone to tell her to speak louder when her voice level could not be heard. The idea was to build an electronic equipment capable of picking up the user's voice, process its level and determine if this level is in fact too low. If the equipment finds that the user is indeed speaking too low, then it activates a vibrating motor, like the one used in pagers, so the user feels the indication to speak louder. Once the user adjusts the voice, then the equipment stays in its passive mode, not activating the alarm. This way the device substitutes for the person, always alerting the user to speak louder when the voice level is too low.

During this project, all the electronics knowledge available was compiled producing a piece of equipment useful to people with disabilities. The capstone design course is definitely an effective one to all future engineers. It prepares the student not only academically, but also introduces him or her to a professional environment, learning how to behave in work groups. It also encourages the student to develop a research and investigative perspective, something that is very important for an engineer.

Sinopsis

Este proyecto surge de la necesidad que tiene una paciente de Parkinson de que alguien le avise cuando habla con una voz muy baja. La idea es construir un equipo electrónico que pueda captar la voz de la persona, procesar su nivel de voz y determinar cuán bajo está hablando. Si el equipo determina que, en efecto, está hablando muy bajo, entonces debe activar un motor que vibre de manera que la persona al sentir la vibración sepa que tiene que subir

la voz. Una vez la persona ajusta su volumen de voz, el equipo permanece pasivo sin activar el motor vibrador. De esta manera el equipo reemplazaría a la persona que ahora acompaña la paciente para avisarle que suba el nivel de voz.

Durante el desarrollo de este proyecto se han podido recoger prácticamente todos los conocimientos electrónicos aprendidos y consumados para lograr un equipo muy útil para personas con este tipo de problema debido al mal de Parkinson.

Introduction

Engineers acquire knowledge and develop skills to solve problems. These problems sometimes are related to helping people with disabilities to improve their quality of life. This project came out of one of those cases in which a person with Parkinson's disease has a difficulty hearing and needs someone by her side alerting her that her voice has dropped too much in intensity. This way the person can rise her voice again.

The project visualizes the design and construction of a device capable of simulating the same function of that person alerting the user to speak louder. This device should recognize the voice of the user and identify when the environment gets noisy. Depending on the noise in the environment, the equipment should adjust itself forcing the threshold value up so the user would speak louder than before to overcome the surrounding noise.

This device should sample the user's voice for some time and determine, compared to the threshold value, whether the user needs to speak louder. The user will be alerted by the activation of an alarm in the device. This alarm will be a vibration that the user can feel.

Objectives

The objective of this project is to design and develop a device that alerts the user when the voice has lowered so much that it cannot be heard easily.

The prospective user of the device was a person with Parkinson's disease, so every detail during the design phase paid attention to this matter

This device must be small, light, comfortable and easy to install. It must adjust itself to noisy environments that force the user to speak louder, otherwise the device will falsely alert the user. To alert the user, a vibrating source must be used instead of any sound or visible source because the user has a hearing problem (This is the main reason in designing the device). Any visible source will distract both the user and the public during a conversation.

Design specifications

Input circuits

The voice detector must:

- be located as close as possible to the user to be sensitive enough to pick up only the user's voice.
- be small, light and comfortable.
- be used in either ear.
- fit the user's ear without dropping from a rough movement by the user.
- require low power input
- be as small as possible so the person can cover the device with his/her hair without showing a bulky appearance in that area.
- have a frequency response in the range from 200 Hz to 7000 Hz as the range for standard human voice.

The noise detector must:

- be placed where the surrounding noise can be picked up.
- be small, light and require low power input
- be as small as possible so the person can cover the device with his/her hair without showing a bulky appearance in that area.
- have a frequency response range from 100 Hz to 10000 Hz to pick up a good range of frequencies to detect any noise.

The level amplifier must:

- be designed so it can be duplicated for the noise signal.
- amplify the signal from some millivolts to the order of up to 5 volts to be used as the input of the processing unit.
- include a potentiometer to control the output signal from the amplifier as the input of the processing unit.
- use small components to occupy as small space as possible.
- require low power input.
- be able to process and filter signals in the frequency range of both the voice and noise circuits discussed before.

Processing unit

Physical considerations

The processing unit must:

- be a small microcontroller.
- allow to be installed into a socket without the need of soldering.
- have a small number of pins.
- require low power input.

The following features are required:

- EPROM capability.
- RAM capacity.
- I/O ports needed to analyze the input voice and produce the output signal to alert the user.
- an analog to digital converter to read the analog voice signal and convert it to a digital equivalent to be processed by software.
- a timer option to measure the input signal by time intervals.

The software must:

- be as compact as to occupy as little space as possible.
- have enough EPROM capacity.

Output circuit

The alert device must:

- provide a sensible signal, such as a vibration of some kind that the user can feel.

- require low power input.

- be compact and light.

The trigger device must:

- work with an input voltage of TTL 5 volts coming from the microcontroller.

- have a protection at the interface with the microcontroller so as not to let some current go back to the microcontroller.

- have the power to activate the alert device.

There is a timing consideration as follows:

- Once the microcontroller activates the output circuit, the trigger device should maintain the input signal for a period of time long enough for the user to feel the alert vibrations.

Block diagram

To begin with the project, the first step was to prepare a functional block diagram (fig. 1) showing the different pieces that would eventually be designed. These blocks represented, at the same time, the order in which the project would be developed.

Microcontroller output circuit

The first two blocks designed were related to the input circuits. One of the blocks represented the voice input circuit and the other block represented the noise input circuit. The function of these blocks was to sample both the user's voice and the surrounding noise to be processed by the processing unit. Separating the voice from the noise was the best way to compensate for the voice level when the environment would start to get noisy.

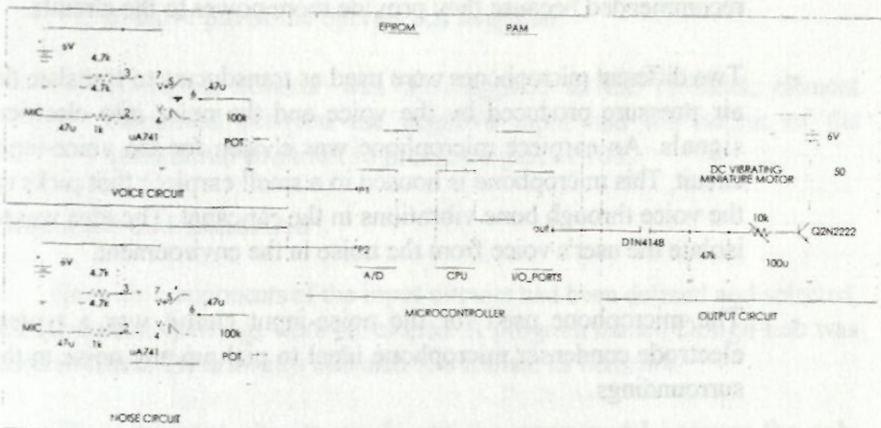

Figure 1. Block diagram

The third block was the processing unit. This was basically a microcontroller capable of processing two input signals, one for the user's voice and the other one for the surrounding noise. Once the processing unit samples both input signals, it determines when the user begins to speak at a too low speech level and then it activates an alarm.

The last block comprised an output circuit composed of a trigger circuit, a basic timer and an alarm device. The function of this output circuit is to produce a vibration generated by a DC miniature motor such as the ones used for pager applications. The microcontroller sends an input signal (TTL +5 volts) to the trigger circuit. This maintains the voltage for a certain time so as to activate the vibrating motor to alert the user to speak louder.

Input circuits

Components

- The input circuits work, as the rest of the device, with +6 volts DC. This voltage is provided using two cell-type batteries of +3 volts DC, each one connected in series. Lithium batteries are strongly recommended because they provide more power to the circuits.

- Two different microphones were used as transducers to translate the air pressure produced by the voice and the noise into electrical signals. An earpiece microphone was chosen for the voice-input circuit. This microphone is housed in a small earpiece that picks up the voice through bone vibrations in the ear canal. The idea was to isolate the user's voice from the noise in the environment.

- The microphone used for the noise-input circuit was a typical electrode condenser microphone ideal to pick up any noise in the surroundings.

- An operational amplifier 741 was used as the amplifier element in both the voice and noise circuits. This amplifies the signal coming from the microphone in millivolts into some volts lower than 6. An IC chip model 1458 from Radio Shack was used. This chip contains two general-purpose 741 operational amplifiers sharing the power supplies and ground pins.

- A potentiometer was used at the output of each circuit to control the output signal from both the voice and noise circuits going into the processing unit. In this way the desired level of both circuits could be adjusted. The adjustment of these levels was to be done during the experimentation stages and not by the user.

- Miscellaneous components such as resistors and capacitors were used to finish the amplifier design.

- A capacitor of 0.47µf at the interface between the microphone and the negative input of the operational amplifier and another capacitor of 0.47µf at the output of the operational amplifier were used to couple devices to filter out any DC signal and let just the analog signal to be amplified. Two resistors of 4.7kΩ were used to create a voltage divider circuit and provide a reference voltage into the positive pin of the operational amplifier.

- A 100kΩ resistor was then applied as the feedback element connected between the negative input and the output of the operational amplifier to provide a gain of 100.

Schematic and simulation

Once the components of the input circuits had been defined and selected, the schematic drawings were developed. A program named Design Lab was used to create the drawings and also to simulate its behavior.

The two input circuits would use the same model because the only difference between them would be the physical characteristics of the microphones. Design Lab program provides a simulator that can trace the input and output signals. In this way the components such as resistors and capacitors can be adjusted until the desired gain is reached.

When the desired results were obtained after some simulations, then the final schematic drawing was created and printed (fig. 2).

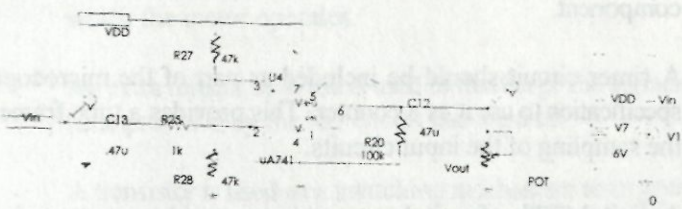

Figure 2. Input circuits

Processing unit

The processing unit is the heart of the device. It processes two input signals, one coming from the user's voice and the other coming from the noise in the surroundings. The processor then performs a sampling period to determine whether the user has been speaking in a too low voice level. If the processor finds out that this is the case, it then sends a high TTL signal (+5 volts) to the output circuit and activates the alarm for a couple of seconds.

Components

- The main component is a microcontroller capable of reading two analog signals as inputs and sending one digital signal as output.

- This microcontroller must have an EPROM capability. This is so because it could be needed to reprogram the microcontroller after the experimentation stage.

- RAM to load the program and save some critical values.

- It is very important to have the capability of an analog to digital (A/D) converter, as part of the microcontroller to save space; otherwise, there will be a need to add an A/D converter as an extra component.

- A timer circuit should be included as part of the microcontroller specification to use it as a counter. This provides a time frame to do the sampling of the input circuits.

- A digital (TTL +5 volts) output pin to provide an output signal to the output circuit.

Design Lab program was used for the schematic diagram. For the creation and simulation of the microcontroller, a program from the MicroChip Company was used. This application contains an editor to create the source code in Assembly language, a debugger to analyze the code and a simulator to simulate the behavior of the microcontroller. After creating the source code, the debugger was used to run each one of the code lines to make sure the program was running smoothly. The simulator was used to test the behavior of the microcontroller using an external DOS file, which contained dummy values representing the voice level. Figure 3 shows the flow chart.

Output circuit

The output circuit warns the user that the voice is reducing its level (fig. 4). A simple timer circuit was used to activate a miniature DC motor causing a vibration that the user can feel. This motor is like one used in pager applications.

Components

- The output circuit works with the same +6 volts DC source.
- A diode is used as the first element between the microcontroller and the output circuit to prevent any undesired DC current to enter the microcontroller.
- An RC circuit with a variable resistor to control the time during which the motor operates.
- An extra resistor of 47kΩ is used to discharge the capacitor after the time provided by the RC circuit has expired.
- A transistor is used as a switching mechanism to trigger the current from the source into the DC motor.

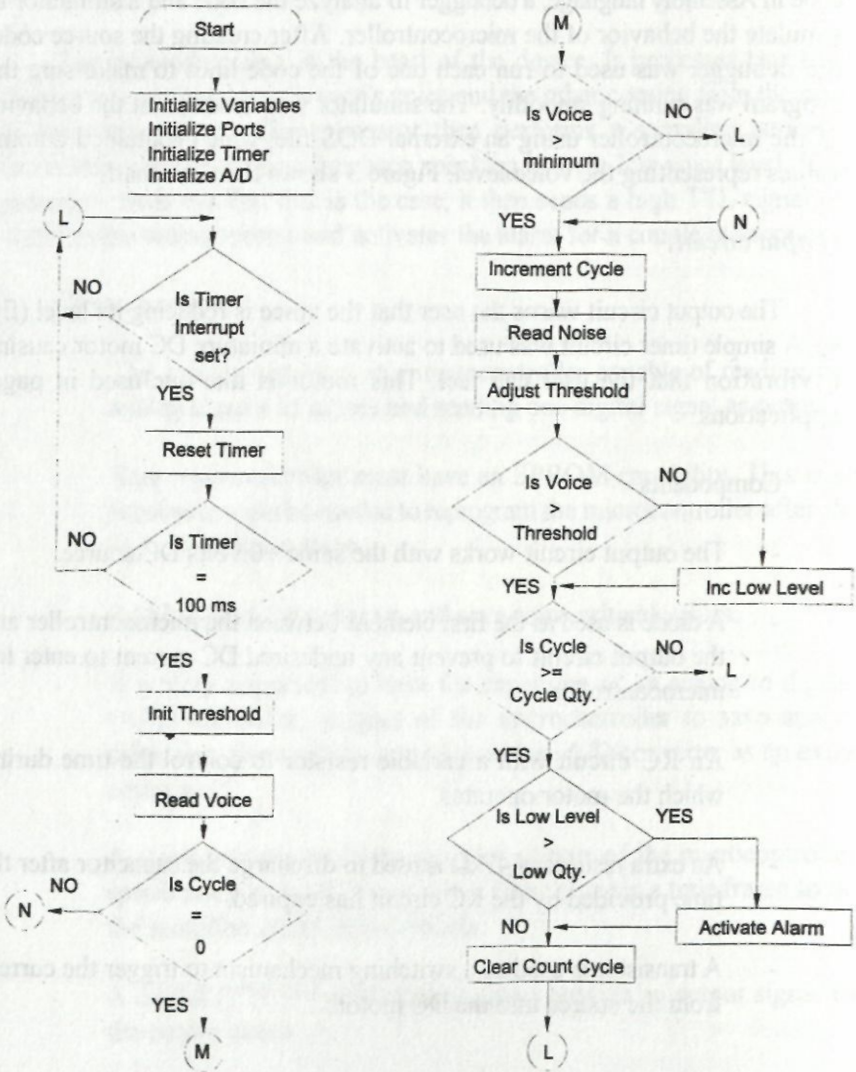

Figure 3. Flow chart

Figure 4. Output circuit

The simulation of the output circuit shows the output voltage when the circuit has an input voltage of +5 volts. Then the circuit is simulated when the input gate is open and no signal is fed. In order to simulate this and watch the behavior of the timer circuit, a switch was used at the input. This switch is normally closed and opens after 1 ms. This way a transition can be seen and also the time produced by the RC circuit in which the motor stays running during that period of time.

Construction specifications

Input circuits

- Operating voltage: +(4 to 6) DC volts.
- Frequency response: (200 - 7000) Hz.
- Voice level (decibels): up to 95 dB.
- Microphone capsule should be similar in size to the ones used for hearing aid devices.

- A voice microphone is a separate piece that connects the rest of the circuit using a pair of wires. The microphone earpiece can be hooked in the user's ear like a hearing aid piece and the cable with a pair of wires ends up in a male connector. This male connector will then match a female connector to the amplifier portion of the voice-input circuit.

<u>Noise microphone</u>

- Operating voltage: + (4 to ¢) DC volts.
- Frequency response: (100 - 10000) Hz.
- Voice level (decibels): up to 95 dB.
- Signal to noise ratio: > 40dB.
- Physical size: <10mm (diameter), <10mm (height).
- Microphone consists of an electrode condenser microphone cartridge.
- The noise microphone must be installed with the rest of the input circuits in the main board. It must be located so that the electrode membrane that receives the sound pressure impact faces to the exteriors. This way it will capture the noise of the surroundings.

<u>Amplifier</u>

- Operating voltage: + (4 to 6) DC volts.
- Frequency response: (100 - 10000) Hz.
- Amplifier gain: 100 or more.

- A single integrated circuit chip is used. The 1458 dual operational amplifier IC contains two 741 operational amplifiers. Each one of these operational amplifiers is used for each one of the input circuits; one for the voice circuit and the other for the noise circuit. This IC is installed in the main board.

Processing unit

- The microcontroller chosen to use was MicroChip PIC 1 7C7 1. This microcontroller is an 8-bit and RISC architecture based processor. It has 36 bytes of RAM, 1 kilobyte of EPROM, 13 I/O pins and a 4-channel high-speed 8-bit A/D converter.

- Besides having all the features necessary for the design, this microcontroller was chosen also because it is small and the programming code occupies less space than any other microcontroller.

- Physical characteristics: one 8-pin CERDIP package IC.

- The microcontroller was installed into a socket installed in the main board. It has a connection from the 6-volts source to the supply pin and a ground connection. One of the A/D channels was connected to the voice circuit. Another A/D channel was connected to the noise circuit. A digital output was connected to the output circuit.

- MicroChip provides an application to connect programmer equipment and download the source code to the microcontroller. This was used to program the microcontroller.

Output circuit

- All the components of the output circuit were installed in the main board.

- The digital output pin used in the microcontroller to activate the alarm was connected to the output circuit through a diode to protect the microcontroller.

- This diode was joined to a RC circuit, loading a capacitor. The RC circuit used a variable resistor to control the timer and this circuit was connected to a transistor to control the motor. The motor connects the battery supply at one side and the collector band of the transistor the other side.

Construction costs

The cost of all the required components is around $83.00 per single unit quantities. This cost can drop to around $50.00 in thousand quantities.

Conclusions

We were assigned a project that could help a person with Parkinson's Disease. It was our goal to design, test and create a device that would detect when this person lowered his/her speech volume. At that instant a device must provide an alert signal to warn that person that he/she has reached a voice level that cannot be easily heard. The challenge of this project is to use the speech sound as the input to the device, compare that signal against other people's hearing threshold levels and then alert that person.