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A portable phonatory feedback device for patients with speech disorders

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A PORTABLE PHONATORY FEEDBACK DEVICE FOR PATIENTS WITH SPEECH DISORDERS

A Thesis

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering

in

The Department of Mechanical Engineering

by

Richie Sajan
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ABSTRACT

Vocal intensity-related speech disorders such as dysarthria and vocal nodules can limit quality of life and reduce the patient’s ability to interact with family, socialize, or pursue employment [1]. Behavioral speech therapies exist to address these issues but have limited effectiveness because they are expensive and clinic-based. The ability to monitor vocal intensity outside of the clinical setting will greatly aid in the treatment of these speech disorders, enabling patients to make quicker progress by reinforcing techniques learned in the clinic. The Voice Volume Monitor (VVM) is a portable and cost-effective therapeutic aid designed for this purpose, providing real-time feedback regarding speech volume to the user. Initial testing of a prototype with patients at the Our Lady of the Lake Voice Center has shown positive results.
CHAPTER 1. INTRODUCTION

Speech is one of the primary means of human communication and is employed to convey information in a wide range of situations. As such, there are many instances, both therapeutic and otherwise, where a personal monitoring device providing real-time feedback regarding speech volume will prove beneficial. The Voice Volume Monitor (VVM) has been developed to address this need. The VVM has a variety of potential applications such as providing feedback to singers, lecturers or actors regarding voice volume. However, it is currently being tested as a therapeutic tool to treat speech disorders associated with Parkinson’s disease and vocal abuse.

Parkinson’s disease is a chronic disorder of the nervous system that adversely affects motor skills, speech and other physiological functions. It is estimated that approximately 4 million people suffer from Parkinson’s disease and nearly 60,000 new cases are diagnosed every year in the United States alone [2]. Of individuals with Parkinson’s disease, it has been reported that at least 75 percent have speech and voice disorders [3]. Some speech disorders commonly observed among these individuals is hypophonia or reduced loudness of speech and dysarthria, characterized by a soft, monotone voice and imprecise articulation [4].

The best approaches that currently exist to help with these problems are behavioral speech therapies such as the Lee Silverman Voice Treatment (LSVT). Here, the patient performs a series of voice exercises aimed at increasing phonatory effort while receiving feedback from a speech therapist regarding vocal intensity. Studies have shown that increased phonatory effort results in a corresponding increase in articulation effort and resemblance to habitual speech [5]. Therapies like the LSVT help patients recalibrate their perception regarding speech output. However, these therapy sessions are expensive, time consuming, and require long-term
dedication and assistance from both family members and speech therapists. Also, this treatment has limited effectiveness since the therapist cannot monitor the patient’s speech once they leave the clinic and return to a more familiar environment.

Other speech disorders are caused as a result of vocal abuse or misuse. Vocal abuse refers to behavior such as speaking with excessive loudness which could strain or damage the vocal folds. Some examples of disorders caused by vocal abuse are vocal nodules, vocal polyps, and laryngitis. These disorders are widely prevalent and yet easily preventable. Treatments for these involve training to keep the vocal intensity at a reasonable level and sometimes speech therapy sessions so that the individual can learn proper speech techniques.

The ability to monitor vocal intensity outside of the clinical setting will greatly aid therapists in the treatment of these speech disorders, enabling patients to make quicker progress by reinforcing techniques learned in the clinic. The VVM described below has been designed for this purpose.

This device is an analog electronic speech therapy aid designed to notify the user when their vocal intensity level goes either above or below desired threshold vocal levels. The voice signal is picked up from the user by means of an ear microphone, which is equipped with a piezoelectric accelerometer. During speech, sound is transmitted in the form of vibrations to the bones in the ear. The microphone picks up these vibrations and converts them into an electrical signal. The speech signal obtained is analyzed using an electronic signal processing circuit designed to amplify the signal and compare it to predetermined thresholds set by the speech therapist during a clinical session or by the users themselves. If the vocal intensity of the user remains at a level outside the acceptable range for more than a few seconds, a small
motor in the device will vibrate, notifying the user of the need to regulate their voice back to within the recommended range.
A given patient will only use either the low trigger or the high trigger depending on their specific needs. For this reason, the same type of vibrational feedback is provided for both the low and high triggers. The time delay before vibration and the intensity of vibration can be adjusted depending on the needs of the user.
This device could prove extremely helpful in the therapy of voice intensity-related speech disorders by giving patients real-time feedback and helping them recalibrate their vocal levels.
A prototype has been developed and tested with patients at the Our Lady of the Lake (OLOL) Voice Center in Baton Rouge under the supervision of Dr. Melda Kunduk.
CHAPTER 2. DESIGN

The underlying issue with patients suffering from the speech disorders addressed by this device is an inability to receive accurate feedback regarding their own vocal intensity. This is usually caused by deterioration of auditory faculty or other physiological functioning. The VVM addresses this need by providing an external, real-time source of feedback by which the user can confidently speak and regulate their vocal intensity. It does this using the electronic components and circuitry configured as shown in the feedback system below.

![VVM Feedback Cycle Diagram]

**Figure 1 - VVM feedback cycle**

The loop begins with the microphone which functions as a voice transducer, converting the user’s speech into an electrical signal. This signal is processed by the signal conditioning circuit where it is amplified to a convenient range for ease of analysis. The heart of the device is the control logic circuit which compares the speech signal with preset reference levels to determine if the vocal intensity level is within the required range. If it is determined that the vocal intensity is not within this range, a signal is output to the timing comparator and then to the
vibrating motor, alerting the user. The user regulates their voice volume level based on this vibration, thus completing the feedback loop.

2.1. MICROPHONE

The function of the VVM is to compare the amplitude of the user’s voice signal with preset reference voltages. In this system, the microphone serves as the transducer, converting the sound energy from speech into electrical signals which can be easily analyzed.

2.1.1. SELECTION

Microphones come in various shapes and sizes. For ease of use, the selected microphone needs to be unobtrusive such that it does not interfere with the daily activities of the user. From the different options available, the decision came down to choosing between the throat microphone and the ear bone microphone. Both of these are discreet and function by sensing vibrations caused as a result of speech instead of the sound itself. Of the two, the throat microphone is restrictive to the user due to its placement around the neck, making the ear bone microphone the more reasonable choice. The Ear Bone Vibration Speaker-Microphone (Part# TWRVIBKEN from Harvest One Limited, Hong Kong [6]) was chosen as the best microphone for this purpose.

Originally designed for use with Two-way radios, this microphone has a switch such that power is provided to the microphone only when the Push-To-Talk (PTT) button is held down. Since it will be inconvenient to keep this PTT button held down whenever the user needs to talk, the switch is disabled so that the microphone is always powered. This device also has the capacity to function as a speaker but only the microphone is used for the purposes of the VVM.
The ear microphone functions by sensing vibrations caused in the ear bone as a result of the user’s speech. These vibrations are converted into electrical signals by a piezoelectric sensor within the microphone as seen in Figure 2.

![Figure 2 - Ear bone microphone](image)

Because it only picks up vibrations from the ear bone, this microphone is not affected by noise from the environment of the user. For this reason, it can be used even in noisy settings, i.e., the placement and functioning of the microphone ensures that only the speech signal of the user is picked up and analyzed by the device. Also, since this microphone does not require an external element like a boom to place the microphone closer to the mouth, it is more discreet than other microphone options.

### 2.1.2. CIRCUIT

Initial testing with the ear microphone has shown that obtaining a speech signal directly from microphone output (shown as contact ‘3’ in Figure 3) does not give a usable signal. It is assumed that this is because both speaker and microphone elements are contained within the
same earpiece and separate circuitry is needed to isolate the microphone signal. The circuit in Figure 3 shows the configuration used to obtain a signal from the microphone.

![Microphone circuit diagram](image)

**Figure 3 - Microphone circuit**

This circuit was obtained from the User manual for the Kenwood TH-D7A Two-way radio [7], one of the radios for which this microphone was originally designed. A sample of the speech signal obtained from the microphone can be seen in Figure 4, where Microphone output (V) is the same as $V_{out}$ from Figure 3. Since the vibrations in the ear bone are small, the magnitude of the signal obtained from the microphone is small, in the order of tens of millivolts. The voltage increment with each block for the graph below is 50mV (as shown at the top left corner of the figure).

![Speech signal graph](image)

**Figure 4 - Speech signal from microphone**
2.2. SIGNAL CONDITIONING CIRCUIT

The purpose of the signal conditioning circuit is to ‘prepare’ the speech signal obtained from the microphone for use with subsequent components. The original speech signal has a small magnitude and is hard to analyze. The signal conditioning circuit consists of 2 parts – the amplifier circuit and the filtering circuit, which amplify this signal and bring it to a form that can be easily compared with the reference levels. Figure 5 shows the path of the signal from the microphone as it passes through the components of the signal conditioning circuit.

![Signal conditioning circuit diagram](image)

**Figure 5 - Signal conditioning circuit**

The amplification is done using a quadruple operational amplifier (the Texas Instruments OPA 4353 IC). This operational amplifier (op amp) IC has rail-to-rail inputs and outputs and can be powered by a single power supply of +5V. The single supply nature of the op amp has an added advantage in that, while both positive and negative signals can be accepted as input to the IC, only a positive output signal is generated. Because of this feature, these op amps can be used in the inverting and non-inverting amplifier configurations to intrinsically function as half-wave rectifiers without the need for external diodes. This is seen in the first two op amps.
As can be seen from Figure 4, the speech signal obtained from the microphone has both positive and negative sections. Even though the negative component of the signal is smaller when compared to the positive component, it was decided to amplify both parts so as to retain and use as much of the speech signal as possible.

2.2.1. NON-INVERTING AMPLIFIER

The first op amp functions as a non-inverting amplifier, amplifying the positive component of the speech signal and providing a positive output signal.

![Image of non-inverting amplifier](image)

**Figure 6 - Non-inverting amplifier**

This op amp provides a gain of 11 to the input signal using resistors with values of 10KΩ and 100KΩ, arranged as shown in the circuit in Figure 6. The gain for non-inverting amplifiers is calculated as shown below:

\[
\text{Gain} = 1 + \frac{R_4}{R_3} = 1 + \frac{100K}{10K} = 11
\]

As mentioned earlier, the single supply nature of the op amp used ensures that only the positive component of the speech signal is amplified while the negative is set to zero. Figure 7 shows the output generated from the non-inverting amplifier. In this graph, the voltage increment with each block is 500mV, reflecting the increase in the order of magnitude of the signal when compared to the signal in Figure 4.
2.2.2. INVERTING AMPLIFIER

The second op amp functions as an inverting amplifier, amplifying the negative component of the speech signal, and inverting it to provide a positive signal.

This op amp provides a gain of 10 to the input signal using resistors with values of 100KΩ and 1000KΩ, arranged as shown in the circuit. The gain for inverting amplifiers is given by:

$$\text{Gain} = -\frac{R_5}{R_6} = -\frac{1000\text{K}}{100\text{K}} = -10$$

The negative sign of the gain indicates the inversion of the signal. The inverting amplifier arrangement amplifies and inverts both positive and negative components of the signal.
However, the single supply nature of the op amp ensures that only the positive component of the amplified signal (the inverted negative component) is generated as output.

Figure 9 shows the output generated from the inverting amplifier. In this graph, the voltage increment with each block is 500mV reflecting the increase in the order of magnitude of the signal when compared to Figure 4.

![Inverting amplifier output](image)

**Figure 9 - Inverting amplifier output**

### 2.2.3. IMPEDANCE BRIDGING

While both amplifiers provide a gain of approximately 10, the inverting amplifier uses higher values of resistance (100KΩ, 1000KΩ) than the non-inverting amplifier (10KΩ, 100KΩ). This is to increase the efficiency of transmission of the signal.

Signal transmission efficiency increases when the input impedance (“resistance” seen by the signal as it enters a component) is high. This is called impedance bridging. For the inverting amplifier, the input impedance is determined by the resistance at the negative input (R6) in Figure 8; therefore, a relatively higher value (100KΩ) is chosen for this resistor.

For the non-inverting amplifier however, impedance bridging does not influence the choice of external resistor values since there are no resistors in the path of the signal as it enters the op amp. Therefore the input impedance is determined by the impedance of the op amp itself,
which in the case of the OPA 4353 is approximately \(10^{13}\) Ω. This high impedance is sufficient for efficient transmission of the signal.

2.2.4. SUMMING AMPLIFIER

The outputs from the inverting and non-inverting amplifiers now have to be combined to form a positive amplified signal. This is done using a summing amplifier. The outputs from the inverting and non-inverting amplifiers are provided as inputs to a third op amp as shown in Figure 10. The configuration shown allows this op amp to function as a non-inverting summing amplifier.

![Figure 10 - Summing amplifier](image)

The summing amplifier merely adds the output signals from the inverting and non-inverting amplifiers. The gain of the inverting amplifier circuit (10) is slightly smaller than the gain of the non-inverting amplifier (11). These values were chosen so that convenient resistor values could be used and do not adversely affect the functioning of the VVM. Figure 11 shows the output from the summing amplifier. It can be seen that the combination of the inverting, non-inverting and summing amplifiers essentially acts as a full-wave rectifier with a gain of approximately 10.
2.2.5. LOW-PASS FILTER CIRCUIT

The fully rectified signal is still not in a state where it can be analyzed easily. To obtain a representative measure of the signal amplitude, it is made to pass through a passive, low-pass filter circuit consisting of a resistor (R12) and capacitor (C4) set up as shown in Figure 12.

![Figure 12 - Low-pass filter circuit](image)

This circuit attenuates signals with high frequencies and allows low frequency signals to pass. It could be said that the low-pass filter performs the function of providing a moving average, capturing the general trend of the voice signal while ignoring the peaks and troughs. The values of the resistor (22KΩ) and capacitor (22μF) are selected so as to eliminate the ripples in the signal. The cut-off frequency for this low-pass filter circuit is given by

$$f_c = \frac{1}{2\pi R_{12}C_4} = 0.33 \text{ Hz}$$
Figure 13 shows the output of the low-pass filter, which is an average of the output from the summing amplifier shown in Figure 11.

Finally, this filtered signal passes through a fourth op amp which functions as a non-inverting amplifier. The gain for this amplifier can be varied using a potentiometer (variable resistor). This fourth amplifier is added to the circuit to provide a simple means of tuning the overall gain of the signal without having to change resistors at multiple stages.

2.3. CONTROL LOGIC

The heart of the VVM lies in the control logic which is implemented using a quad comparator IC (the Texas Instruments TLC3704) and logic function IC (the Texas Instruments SN74LVC1G0832). Three comparators are used to compare the speech signal to three threshold voltages while the logic IC analyses the output from the three comparators and generates an output voltage only when the user is to be notified.

2.3.1. COMPARATORS

The output signal from the signal conditioning circuit is provided as input to the first three comparators in the TLC3704 IC. Each comparator compares this signal with an adjustable
reference level – ‘A’, ‘L’ or ‘H’. ‘A’ is a fixed reference voltage of 0.2V, which is just above the quiescent voltage of the microphone. When the user is not speaking, the microphone output will be slightly lower than 0.2V, but when they begin speaking the signal exceeds 0.2V. Thus, ‘A’ is used to differentiate between when the user is not speaking and when they are speaking too softly. ‘L’ represents the ‘LOW’ reference voltage which defines the minimum desired vocal intensity. If the voice signal goes below this reference level, the user is speaking at a level that is too soft and feedback is required. ‘H’ represents the ‘HIGH’ reference voltage which defines the maximum desired vocal intensity. If the voice speech goes above this reference level, the user is speaking at a level that is too loud and should be notified. Between ‘L’ and ‘H’ is the vocal range that the user is trying to maintain. Figure 14 shows the relative positions of the three reference levels with respect to a typical speech signal.

![Speech signal with comparator reference levels](image)

**Figure 14 - Speech signal with comparator reference levels**

The output from a comparator is a digital signal – it provides +5V if the input signal is greater than the reference voltage and 0V if it is smaller than the reference voltage, as seen in Figure 15, where 1 is the input signal and 2 is the comparator output. If the inverting and non-inverting inputs are switched, it performs in the opposite manner, generating 0V if the input signal is greater than the reference voltage and +5V if it is smaller, as seen in Figure 16.
As can be seen in Figure 17, comparators ‘A’ and ‘H’ use the first configuration while comparator ‘L’ has the second (switched) configuration. This switched configuration is employed so as to simplify the logic required to notify the user at the required voice levels.
With the comparators in this arrangement, the comparator outputs for the possible positions of the smoothed speech signal are tabulated below. These outputs can also be seen in Figure 17 where $V_0 = +5V$ and is represented by the digital output ‘1’ in Table 1.

### Table 1 - Comparator outputs

<table>
<thead>
<tr>
<th>Speech signal position</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Comparator ‘A’</td>
</tr>
<tr>
<td>Below reference level ‘A’</td>
<td>0</td>
</tr>
<tr>
<td>Between ‘A’ and ‘L’</td>
<td>1</td>
</tr>
<tr>
<td>Between ‘L’ and ‘H’</td>
<td>1</td>
</tr>
<tr>
<td>Above ‘H’</td>
<td>1</td>
</tr>
</tbody>
</table>

### 2.3.2. LOGIC

The digital outputs from the three comparators are analyzed by the logic IC such that an output signal is generated only if the input signal is either between ‘A’ and ‘L’, or above ‘H’, which are the two ranges of speech volume where the user needs to be notified. The following logic function yields an output signal at the appropriate vocal intensity levels

$$Y = (A \cdot L) + H$$

where $A, L, H$ are the comparator outputs

- $Y$ is the logic IC output
- ‘$\cdot$’ represents the ‘AND’ Boolean operator
- ‘+$’ represents the ‘OR’ Boolean operator
The different comparator output possibilities and their output after using this logic operation are listed in Table 2. When the logic output $Y$ is 1, a signal is sent to the motor. A signal is not sent when the output $Y$ is 0.

**Table 2 - Logic output example**

<table>
<thead>
<tr>
<th>Comparator Outputs</th>
<th>Logic Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A$ $L$ $H$</td>
<td>$Y$</td>
</tr>
<tr>
<td>1 0 1</td>
<td>1</td>
</tr>
<tr>
<td>1 0 0</td>
<td>0</td>
</tr>
<tr>
<td>1 1 0</td>
<td>1</td>
</tr>
<tr>
<td>0 1 0</td>
<td>0</td>
</tr>
</tbody>
</table>

2.4. TIMING CIRCUIT

The switching time of the logic IC is almost instantaneous. As a result, a fluctuating speech signal will cause a rapid on-off switching of the motor as the signal passes the different threshold voltages. This undesirable trait is amplified with the wave-like nature of the speech signal, as exemplified in Figure 18 below. The timing circuit is added to address this issue.

![Figure 18 – Output without timing circuit](image)

![Figure 19 - Timing circuit](image)
The output signal from the logic IC passes through an integrator circuit, which consists of a resistor and capacitor in the configuration shown in Figure 19. When a constant signal is sent to the integrator, the output is a gradually increasing voltage signal as seen in Figure 20. This output is sent to a comparator which determines the onset of motor vibration. The rate at which the signal increases can be changed by adjusting the value of the resistor \( R \) in Figure 19. The time delay before the onset of vibration of the motor can be adjusted from between 1 second to 4 seconds by using a potentiometer to change the value of this resistance.

The timing comparator makes use of the fourth comparator in the TLC3704 quad comparator first used in the Control Logic part of the circuit. Figure 20 shows the output of the VVM with a varying speech input and a timing circuit employed using a time delay of 3 seconds.

![Figure 20 - Final output after timing circuit](image.png)
2.5. POWER

The components of the circuit have been selected such that a single voltage supply of +5V is sufficient. The power is provided by a 9V battery with the voltage regulated down to 5V using a voltage regulator IC (the Texas Instruments LP2981-50). This 5V supply then is used to power the components of the circuit as shown in Figure 21.

![Power Supply Configuration Diagram](image)

Figure 21 - Power supply configuration

2.6 ENCLOSURE

The electronic circuit described above is assembled on a printed circuit board (PCB) which has dimensions of 2.35” x 3.15”. The PCB and battery are housed in a plastic enclosure which is approximately 5” x 2.75” x 1”. This enclosure comes with a clip for belt attachment and a separate compartment for the 9V battery so that batteries can be replaced without having to completely open the enclosure. Figures 22 and 23 show the PCB and plastic enclosure.
Figure 22 - PCB inside enclosure

Figure 23 - VVM Prototype Enclosure
CHAPTER 3. VOICE VOLUME MONITOR DATA

Below are graphs of output data from the VVM. Signal 1 (lower signal) is the input voltage from the microphone while signal 2 (upper signal) is the output going into the motor. The reference voltages used in the following graphs are A (0.5 V), L (1 V) and H (3 V) with a delay of 1 second before the onset of vibration.

Figure 24 shows a graph of the output with an input that spans 3 vocal ranges (between ‘A’ and ‘L’, between ‘L’ and ‘H’, and above ‘H’).

Legend:
- - - - Reference
- - - - Cue to stop
- - - - Cue to start
- - - - 1 second delay

The user starts off speaking too soft (between ‘A’ and ‘L’) and a signal is sent to the motor after approximately 1 second (the gridlines divide the x-axis in 1 second increments). When the user’s voice rises to the required level (between ‘L’ and ‘H’), the motor output stops almost instantaneously. When the user’s voice becomes too loud (above ‘H’), the signal is again sent to
the motor after 1 second. The signal stops immediately as the user recognizes the motor vibration and lowers their volume below H. When the volume drops below ‘L’ again, the motor begins after 1 second.

Figure 25 below shows the graph of the speech signal and output to the motor when the user is speaking within the appropriate vocal range (between ‘L’ and ‘H’).

When the user stops speaking, their voice drops below ‘L’ momentarily but proceeds below ‘A’ in less than 1 second, thereby not triggering the motor. When the user next begins speaking, their voice quickly rises above ‘L’ in less than 1 second again preventing the triggering of the motor. In this manner, the Voice Volume Monitor is designed to allow for normal speech with minimal interruption, while notifying the user only in the case of a real issue.
CHAPTER 4. OPERATION

4.1. CALIBRATION

The VVM has two modes of operation. It can be used to notify the user when their voice level goes:

1. below a certain vocal loudness
2. above a certain vocal loudness

The acceptable range of vocal intensity is different for patients with Parkinson’s disease-related disorders and for those with vocal abuse-related disorders. Since it is not expected that a patient will suffer from both types of disorders, a given patient will only use either the low trigger or the high trigger depending on their specific needs.

The reference level settings may have to be customized for each user. Below are instructions on how to set the reference levels:

1. Set knobs ‘A’, ‘L’ and ‘H’ (Figure 25) to the maximum setting.

2. Instruct the user to speak continuously at level ‘H’. The device should not be vibrating at this point. To set ‘H’, slowly decrease the setting of knob ‘H’ until the device vibrates.

3. Next instruct the user to speak continuously at their lowest possible voice level, i.e. level A. The device should not be vibrating at this point. Slowly decrease the setting of knob ‘A’ until the device vibrates. Reference ‘A’ is now set.

4. Next instruct the user to speak continuously at level ‘L’. The device should be vibrating at this point. Slowly decrease the setting of knob ‘L’ until the device stops vibrating. Reference level ‘H’ is set and the user can stop speaking at level ‘L’.
For Parkinson's disease patients:

5. After completing the first 4 steps, increase the setting of knob ‘H’ to the maximum setting.

For vocal abuse patients:

5. After completing the first 4 steps, decrease the setting of knob ‘L’ to the minimum setting.

Figure 26 - PCB layout with knobs for A, L, and H
CHAPTER 5. TESTING

5.1. RESULTS

A prototype of the VVM was tested with patients at the Our Lady of the Lake Voice Center in Baton Rouge under the supervision of Dr. Melda Kunduk. A total of 4 patients, 2 with Parkinson’s disease and 2 with vocal abuse disorders, were tested for 5-10 minutes and a questionnaire was provided after the test to obtain their feedback regarding the device. The results of this survey are below.

1. How was the weight of the Voice Volume Monitor?

![Weight Survey Graph]

2. How was the size of the Voice Volume Monitor?

![Size Survey Graph]
3. How comfortable was the Voice Volume Monitor to wear on your belt/wrist?

4. How would you rate the intensity of the tactile feedback/vibration from the Voice Volume Monitor?
5. How would you rate the practicability of the Voice Volume Monitor in terms of its wearability?

![Bar chart showing wearability ratings](chart1.png)

6. How distracting was the vibratory feedback from the device during your communication with others?

![Bar chart showing distraction levels](chart2.png)

- No problems. After the vibration I adjusted my voice volume and continued to talk. No breakdown in communication occurred.
- The vibration was mildly distracting and intermittently the flow of the conversation was disrupted.
- I stopped talking each time the device vibrated, I forgot what I was saying and communication stopped.
- Other (N/A)
7. Would you like to be able to adjust the intensity of the vibration?

8. Would you wear this device if it was recommended to you to monitor your voice volume?
5.2. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

The availability of a portable, real-time feedback device could prove to be extremely useful in the treatment of vocal-intensity related speech disorders such as those associated with Parkinson’s disease and vocal abuse. The Voice Volume Monitor is an electronic, therapeutic aid that is designed for this purpose and can provide real-time feedback regarding speech volume with minimal interruption to normal functioning.

Some modifications to the design of the VVM could help enhance its features and make it more user-friendly. For example, the ‘A’ reference level only needs to be calibrated once for each microphone. Therefore the external knob for ‘A’ can be eliminated by installing an internal trim pot that can be calibrated before the first use of a microphone. Also, markings can be indicated on the external knobs that will help speech pathologists quantify the progress of the patient.

Initial testing at the Our Lady of the Lake Voice Center in Baton Rouge has shown positive results but long-term testing is required to further validate the effectiveness of this device. This testing could include asking the patient to use the VVM over a longer period of time such as for a few hours every day for a week. When the patient returns to the clinic after a week, their voice patterns can be recorded and the change in their vocal intensity levels can be documented to trend improvements over a longer period.
REFERENCES


The components listed below are used in the design of the Voice Volume Monitor:

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*These parts were obtained as free samples from the manufacturers.

The parts listed in the table above have been indicated in the circuit schematic and printed circuit board layout shown in the following pages.
Figure 27 - VVM Circuit Schematic
Figure 28 - VVM Printed Circuit Board Layout
VITA

Sajan, Richie was born in Dubai, United Arab Emirates, in August, 1986. Richie came to the United States to pursue his higher education and joined Louisiana State University (LSU) in August, 2004. In May of 2008, he completed his undergraduate education with a Bachelor of Science in Mechanical Engineering. Richie joined the graduate program at LSU in June, 2008, and is expected to receive his Master of Science in Mechanical Engineering in December, 2010. Richie is the elder son of Sajan Koshy and Sheela Sajan and has a sister, Melnie Sajan.