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Fluency Assistance Device (FAD): Masker Upgrades

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Jake Finkbeiner and Chad Long

Introduction

Around seventy million people internationally have a stutter, a form of a fluency disorder. Some fluency assistance devices are available to the public, but most are highly expensive or unreliable. The Fluency Assistive Device (FAD) team seeks to assist a niche community of these individuals who currently rely on a device known originally as the Edinburgh Masker by partnering with Dave Germeyer. Utilizing his expertise in repairing the Edinburgh Masker, FAD is developing two new versions of the masker to increase its portability, functionality, and cost-effectiveness.

The first is an update of the original called the Analog Masker (Version 1.1). A prototype of the Analog Masker V1.1 has been developed, tested and is currently being revised based on the results. Revisions include updating the layout of the board and finalizing the power supply circuitry. The second version, known as the Digital Masker (Version 1.0), will use a Bluetooth-enabled microcontroller to achieve masker functionality. Bluetooth audio output for the Digital Masker has been tested, and two algorithms have been created for the masking output. The supporting software for the Digital Masker is nearing completion. The schematic and the layout design have been started for future implementation of the hardware.

Figure 1: Original Edinburgh Masker (V1.0)

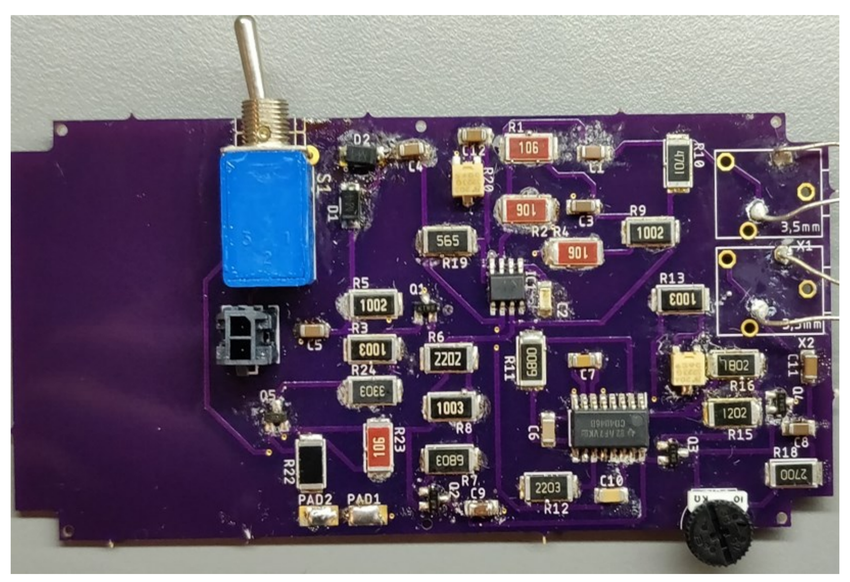

Figure 2: Prototype Analog Masker V1.1

Specifications

The team desires to produce a replacement product for the Edinburgh masker that is:

- **Affordable**. The client should not have to pay more than $50 for the product
- **Effective**. The client should receive a comparable or improved product compared to the original masker
- **Portable**. The device should fit in the user's pocket, or be able to discretely attach to the client
- **Robust**. The device should withstand the occasional drop and normal wear and tear

Clients

Our team aims to serve those reliant on the Edinburgh Masker for fluency assistance, including and extending beyond Dave Germeyer's clientele. To visit Dave Germeyer's website on his project, go to:

https://www.mnsu.edu/comdis/kuster/edinburghmasker.html

Analog Masker V1.1 Progress

For the purely analog version of the masker, the team has created the PCB design shown below in Figure 3. The Analog Masker V1.1 retains the core functionality of the original Edinburgh masker (see Figure 3) while satisfying the new specifications.

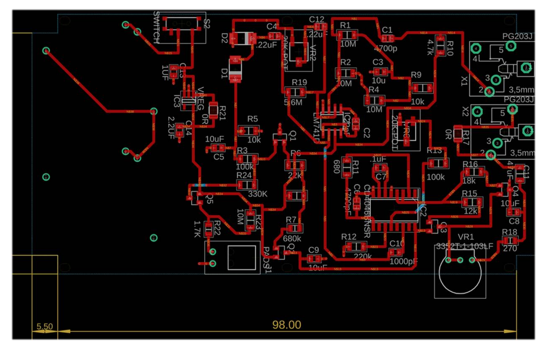

Figure 3: Routed PCB design

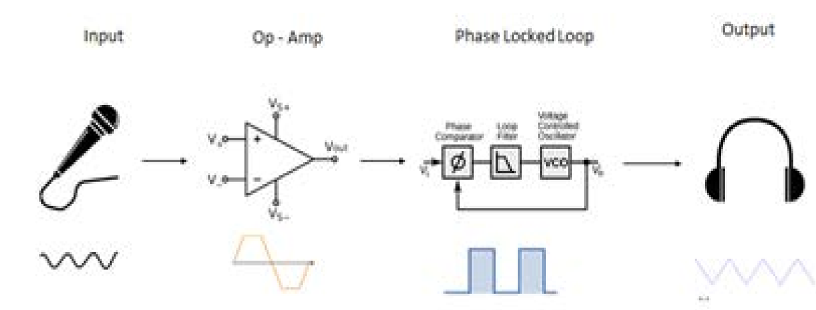

Figure 4: Original Masker Design

Converting an audio device to a smaller form factor involves some challenges. A carefully designed board must retain the user's key voice characteristics, avoid external noise interference, and ensure production integrity. To address these issues, the team has worked with Jared Momose to follow best practices regarding the ground plane and best circuit trace paths. The V1.1 Prototype Board has been ordered and tested, and an updated version has been designed and is ordered and waiting to be tested to compare performance to the Original Analog Masker V1.0.

Analog Masker V1.1 Testing

After the prototype for Analog Masker V1.1 was working, a comparison was a necessary next step to verify the original functionality of the masker. A list of parameters for comparison was created, and both V1.0 and V1.1 maskers were tested for each of the parameters. As shown in Table 1 below, the Analog Masker V1.1 uses less power than V1.0 but has a significantly lower output power. However, the functionality of V1.1 appears to be the same of V1.0 for its intended purpose of blocking the sound of the user's own voice in his or her ears. Overall, there are several important differences between Analog Masker V1.0 and 1.1. In the future we hope to get the overall masking functionality to closer resemble that of V1.0 so that we may finalize the V1.1. design.

Table 1: Results of Various Tests Comparing V1.0 and V1.1 Maskers

Specification	Analog Masker V1.0 (SN17)	Analog Masker V1.1 (SN1)
Output Power (dB)	-23.05 dBm	-31.31 dBm
Power Consumption (mW)	71.5 mW	19.9 mW
Output Amplitude (Max)	4.96 Vpp	740 mVpp
Input to Output Delay (s)	1.98 ms	1.01 ms
THD Male (125 Hz)	.1323	.2460
THD Female (200 Hz)	.1281	Unable to read due to jitter

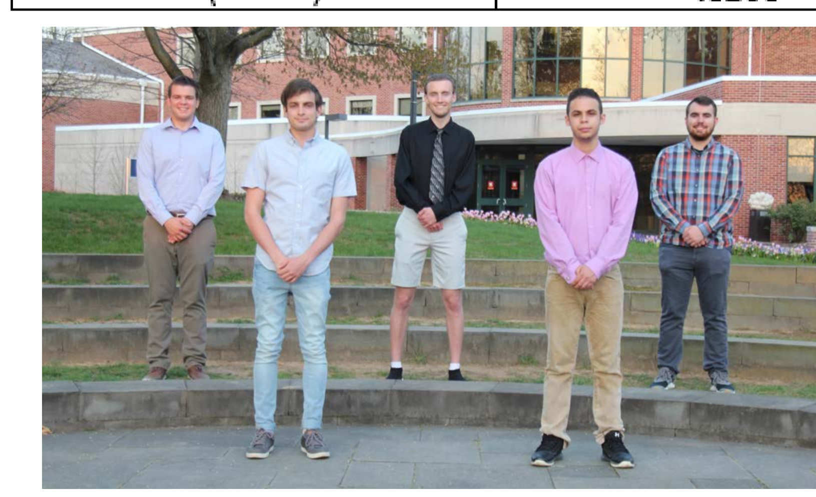

Figure 6: FAD Team (Spring 2021)

Team Members:

Michael Jenkins (SPM)
Corey Bean
Chad Long
Larry Vega
Jake Finkbeiner

Digital V1.0 Progress

As a more major upgrade of the original Edinburgh masker, the team has also developed a Digital Version 1.0. The digital masker wirelessly transmits the output of a stutter-therapy algorithm into the user's ears using Bluetooth (BT). In general, the software can be broken up into three general processes: the startup process, the peer connection process, and the signal generation and transmission process. Each process relies on the numerous modules and submodules, including the Main and BT modules, and the ADC, Timer, and GAP submodules. The masker primarily uses FreeRTOS to communicate events between the different modules and submodules of the program. Additionally, the team has made progress towards two of the three algorithms described above, but we still need to test those algorithms on the device to ensure that they work properly. As of now, the team has almost finished implementing Bluetooth output for the device. EAGLE designs have been started which resembles an ESP-32 DevKit, and components will be added as they get implemented in the testing as shown in Figure 5 below. Soon the team will shift focus fully towards algorithm development and

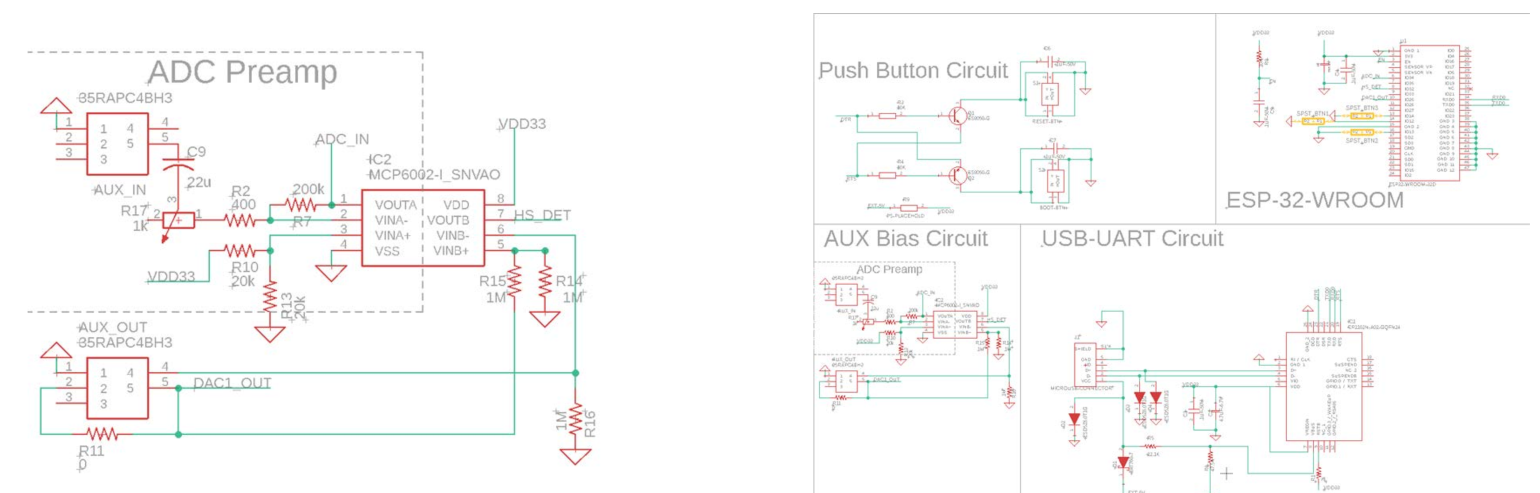

Figure 5: Current Digital Masker V1.0 Schematic

Conclusions

The Fluency Assistive Device team (as seen in Figure 6) is providing a modern upgrade to an outdated technology. FAD currently has updated the masker circuit with modern components and have planned an experiment to test different resonance points and sensor placement which we hope to conduct as soon as COVID-19 restrictions are lifted. Surface mount components are implemented to reduce the physical size of the circuit. The team also is developing Bluetooth technology to potentially provide a wireless alternative. Moving forward FAD will be revising Analog Version 1.1 and will create an Analog Version 1.2 after gathering data from testing. Currently the Analog Masker V1.1 is in the testing phase and will be compared to the original Analog Masker V1.0. As a result of testing, the Analog Masker V1.1 will be modified so that its functionality more closely emulates that of the Analog Masker V1.0. The team will also continue developing software, hardware, and algorithms for the Digital Masker Version 1.0. This includes utilizing the new serial algorithm tester to test different implementations of our masking algorithm.

Acknowledgments

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