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Fluency Assistance Device (FAD): Masker Upgrades

Timothy Fair

Elijah Wood

Jake T. Finkbeiner

Chad M. Long

Jon R. Sweeton

See next page for additional authors

Authors
Timothy Fair, Elijah Wood, Jake T. Finkbeiner, Chad M. Long, Jon R. Sweeton, and Harold R. Underwood

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Tim Fair and Elijah Wood

Introduction

Around seventy million people internationally have a stutter, a form of a fluency disorder. Some fluency assistance devices are available to the public on the market, 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.

One effort is an update of the original called the Analog Masker (Version 1.3). A prototype of the Analog Masker V1.3 has been developed, revised, and is currently being tested. Revisions include updating the circuitry and making a new case enclosure. The other effort is an innovation known as the Digital Masker (Version 1.0). This will use a Bluetooth-enabled microcontroller to achieve masker functionality. Bluetooth audio output for the Digital Masker has been tested, and alternative algorithms are being coded 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)

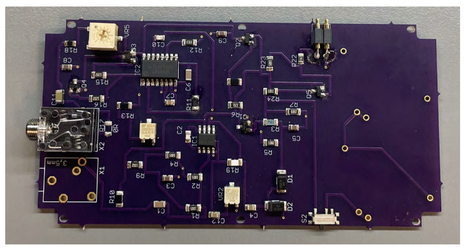

Figure 2: Prototype Analog Masker V1.3

Design Goals

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 at least a comparably functioning upgrade, or improved product performance compared to the original masker.
- **Portable**. The device should fit in a client's pocket, or discretely attach to the client's clothing.
- **Flexible**. A digital device will allow for masker variability as well as Bluetooth capability.

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 V1.3 Progress

For the purely analog version of the masker, the team has created a PCB layout design as shown below in Figure 3. The Analog Masker V1.3 retains the core functionality of the original Edinburgh masker (see Figure 4) while satisfying the new smaller size, button battery and updated component specifications.

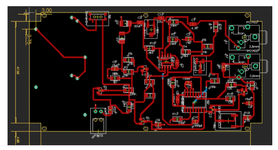

Figure 3: Routed PCB design

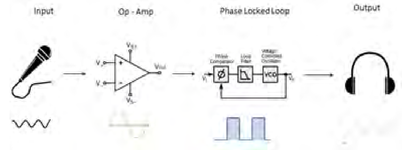

Figure 4: Original Masker Design

The Analog Masker needs to be able to accurately track and mask a range of audio frequencies while having lower power consumption than the Edinburgh Masker. To address this, the team examined and tested different versions of the Edinburgh Masker, implemented certain design changes to handle a lower button battery voltage, and wired the V1.3 on a breadboard for easy testing. The breadboarded V1.3 has a tracking range of about 100Hz while using 6V to power the circuit. With the breadboarded version built and successfully tested, our team is now focusing on implementing the V1.3 PCB. Modifications and testing to compare its performance with the original Edinburgh Masker are under way.

Analog Masker V1.3 Testing

After the prototype for Analog Masker V1.3 is completely functional, it will be compared with the original version to verify its performance and functionality. A list of parameters for comparison will be created, and both the Edinburgh Masker and V1.3 maskers will be tested for each of the parameters. We are currently modifying the V1.3 protoboard to be ready for parameter and use testing.

The Fluency Assistive Device Team

Figure 6: FAD Team (Spring 2022)

Team Members (left to right):

Elijah Wood

Tim Fair

Jake Finkbeiner

Chad Long (SPM)

Jon Sweeton

Acknowledgments

We would like to thank Dave Germeyer for his support, Dr. Underwood for his guidance, Jared Momose for his input on PCB production, and the Collaboratory for funding of this project.

Digital V1.0 Progress

As a more substantial and innovative upgrade to the original Edinburgh masker, the team has also developed a Digital Masker Version 1.0. The digital masker will wirelessly transmit the output of a stutter-therapy algorithm into the user's ears using Bluetooth (BT). There are three main stutter-therapy algorithms to be implemented on the digital masker. Delayed Altered Feedback (DAF) takes the voice audio input from the user and delays it slightly before replaying it into the user's ear, Frequency Altered Feedback (FAF) takes the input from the user and shifts the pitch before replaying into the user's ear, and Masking Altered Feedback (MAF) takes the input from the user and generates a noise signal similar to the original Edinburgh masker before replaying into the user's ear. In general, the software for the digital masker 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. The team has made progress towards coding two of the three algorithms described above. DAF has been developed and tested accordingly to show proper functionality of various delays. MAF is currently being developed by the team with FAF to follow in the near future. Additionally, the team has almost finished implementing proper 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.

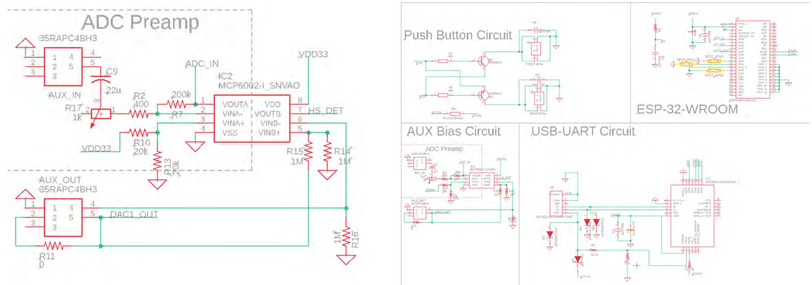

Figure 5: Current Digital Masker V1.0 Schematic

Conclusions

The Fluency Assistive Device team (Figure 6) is providing an upgrade to a legacy technology on which a number of clients actively depend. FAD currently has updated the analog masker circuit with available components to satisfy the smaller size constraint and lower button battery voltage. Currently the Analog Masker V1.3 is going into the testing phase and will be compared to the original Edinburgh Masker, to verify and characterize its performance, before client trials. The team has also made progress on software, hardware, and algorithms for the Digital Masker Version 1.0. With DAF currently developed and fully functional, and MAF currently being developed, emphasis in the future will be on completing FAF as well as verifying that Bluetooth functionality successfully works with all three masking algorithms.

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