Initial Project Proposal

Year: 2024 Semester: Spring Project Name: USB Microphone Interface
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1.0 Description of Problem:

Digital audio plays a ubiquitous role in today's world. We can find it being used across many different areas such as online communication, livestream content, podcasts, or even live performances. In all of these scenarios, it's necessary to use a microphone to convert the analog signal of your voice into a digital form for computer processing. However, a common issue that arises for users is the quality of their audio: oftentimes having to deal with things such as low volume, background noise, or overall muddy audio quality among other things. Especially in live settings, it's necessary to have some sort of tool which can receive our audio input and then process it to our needs in order to achieve the greatest quality audio possible for a given microphone.

2.0 Proposed Solution:

Our proposed solution is to create a microphone interface intended to be used for USB microphones. This interface would receive the input from the microphone, and perform various kinds of DSP to the signal using a microcontroller, with additional physical inputs in the form of knobs in order to adjust any of their parameters. This would allow the user to fine tune various effects which they would like to apply in order to adapt to their relevant environment, microphone, as well as intended sound they would like to achieve. The interface will also contain a visual display of the frequency spectrum of the signal on an LCD screen in order to help visualize the actual changes being applied to the signal, allowing the process to be more intuitive for users. The interface would be connected through a USB to a computer as its output, from which it would also receive its power from.

3.0 ECE 47700 Course Requirements Satisfaction

The proposed USB microphone interface plans to incorporate push buttons, USB passthrough ports, LCD displays and rotary knobs. We are going to have two USB ports, one for input and another for output. Also, the input port can be connected to any device from users, like a microphone and headphone, with the output port connecting to the speaker or any recording devices. The microcontroller will interface with these peripherals and apply digital signal processing to the digital audio signal from the USB input.

3.1 Expected Microcontroller Responsibilities

For the project proposed, a microcontroller will be used for the purposes of interfacing with input and output audio devices. The microcontroller will apply various digital signal processing effects to the input digital audio signal, such as equalization and reverb. Additionally,

the microcontroller will provide a graphical user interface via the LCD display that shows the various parameters for the DSP effects. Future functionality may be added to accommodate for the planned features.

3.2 Expected Printed Circuit Responsibilities

For the proposed project, the PCB is expected to incorporate a microcontroller, several rotary knobs, a LCD display, two push buttons and two USB interfaces to connect the input and output devices. Our design will be powered from the output USB port to microcontroller, LCD display and USB input device. The PCB will provide an interface between the microcontroller and the LCD screen. Additionally, our solution will connect rotary encoders to the microcontroller using a multiplexer. Future functionality may be added to accommodate for the planned features.

4.0 Market Analysis:

In this digital age, with the booming industry of small podcasts, independent artists, and individual content creation, a USB audio interface is a core necessity. Standard audio visual (AV) equipment for high quality sound and mixing for a professional production usually requires a mixer board and a technician [1]. However, people that are starting out in a business that requires these usually cannot afford these. There has been a fast rise in popularity of podcasts, independent musicians, and small content creators[2][3][4]. And these creators and artists would need to have tools that can quickly adjust sound to raise the quality of their work as much as possible. Podcasters can connect their headphones and microphones to allow real-time monitoring. Musicians can connect and record multiple electrical instruments. Streaming influencers can also modify their voice instantly for entertainment. This is where the USB microphone interface comes in. Its limited amount of basic functions makes adjusting audio easy and cost-effective[5].

5.0 Competitive Analysis:

There is a diverse selection of devices that have similar capabilities to our proposed solution. However, our proposed solution is significantly different from any products that we were able to find. Nearly all of the products we researched involved some form of analog to digital conversion or digital to analog conversion. This comes with a large price tag, and by focusing purely on USB audio and digital signal processing, our proposed solution is able to remain fairly cheap. This is, of course, a negative aspect of our proposed solution since it could potentially exclude users who wish to have analog input or output. We believe, though, that this is acceptable since such functionality could be enabled via the use of a usb ADC or DAC.

5.1 Preliminary Patent Analysis:

There are some patent iterations with the same core idea of a microphone interface. Many of these patents are present but expired due to fees. We tried to gather patents for a microphone connection, audio signal processing, and a USB output.

5.1.1 Patent #1: US20100161857A1

This [6] is a USB Audio Controller which includes an USB interface unit, a storage interface unit, an audio interface unit, and a processing unit. This design is the most similar to

our idea with the exception of a storage unit which will not be included in our project. The design was made in 2009 and expired due to fees.

5.1.2 Patent #2: US8335328B2

The programmable integrated interface circuit [7] includes feedback, amplifier and a bias circuit. This design has the idea of what we would be looking for when trying to find a chip that receives and outputs an audio signal. It doesn't include audio signal modifications nor a means to a USB output. This was created in 2007 and is still active.

5.1.3 Patent #3: US8687823B2

The microphone interface [8] and method of operation that includes transducer and audio processing circuitry. This design seems to be customized specifically for a microphone transducer input but still has the aspect of an Analog-to-Digital converter for audio processing. This was started in 2010 but expired due to fees.

5.2 Commercial Product Analysis:

In order to address the issues of audio quality in the live recording space there are many products available in the market to address the needs of several different users. They vary in size and functionality, which brings a slew of pros and cons to each device depending on the needs of the user. Larger devices such as the TASCAM Model 12 and Rode Rodecaster Pro II offer support for multiple input devices and have lots of functionality, making them ideal for podcasters to use in a live group settings, although the downside is their larger size making them less portable, as well as their price range between $700-$600. Another product such as the Shure MVX2U is much smaller and thus more portable and also cheaper at a price of about $130, however it relies on additional applications in order to perform DSP on the audio signal. Our solution aims to balance this, offering a relatively small and portable device which also includes built in DSP capabilities making it ideal for solo users, as well as ideally being produced at a cheaper cost to make it a more attractive option for consumers.

5.2.1 Commercial Product #1: Rode Rodecaster Pro II Podcast Production Console

The Rode Rodecaster Pro II [9] is a console designed specifically in mind for podcasters to help control the quality of the audio from multiple microphone inputs, as well as including smart pads which allow the user to play sound bites such as intro music, sound effects, etc. The big pro to this console is how it allows multiple inputs to be used by several mics, it also includes several outputs for headphone jacks so that each user can play back their voice into their headset, and the added convenience of sound effect pads used for podcast environments. However the main con of this is the lack of appeal to users who are only looking for a product for solo usage. The amount of sliders, buttons, pads, and other inputs can make its appearance seem cluttered and possibly turning away potential buyers looking for something simple they can use on their own.

5.2.2 Commercial Product #2: Shure MVX2U

The MVX2U [10] is a unique device which acts as an in-line mic activator with +60dB gain that serves to boost the dynamics of microphones with low output volume while also being a XLR to USB converter at the same time. It also works with the ShurePlus MOTIV app which gives the user the ability to perform DSP on the output to configure it to their liking. The major benefit to this device is how small and easily portable it is. Although our device will also be portable and relatively small compared to other products, the MVX2U is quite literally pocket-sized which gives it an edge over our product. However, a significant trade off is that it relies on additional software in order to be able to perform DSP. This can become a convenience issue since it would require you to download the software on each device you would want to perform DSP on. Our product, however, has the necessary software built into the physical device, and allows the user to quickly switch from one output to the other without having to worry about downloading any additional apps to perform DSP.

5.2.3 Commercial Product #3: TASCAM Model 12 Mixer

While not strictly a USB microphone interface, this audio mixer [11] can function as a USB audio interface with a computer, and a USB microphone could be routed to one of the channels where EQ and effects can be applied similarly to our proposed solution. Some pros of this device compared with our solution are that this device has multiple channels and supports analog input, output, bluetooth, and audio recording/playback. However, a serious con with this device is that it is not portable like our device is. Additionally, depending on the use-case, a lot of the functionality of this device could be unnecessary and become an inconvenience to the user.

5.3 Open Source Project Analysis:

There are relatively not a lot of projects for designing a usb microphone to add signal effect to the input. Our solution may not have more functionality than a mixer but we are portable to take and simple to use in real life. However, there are several projects below that are similar to our idea.

5.3.1 Open Source Project #1: fiberaudio-108

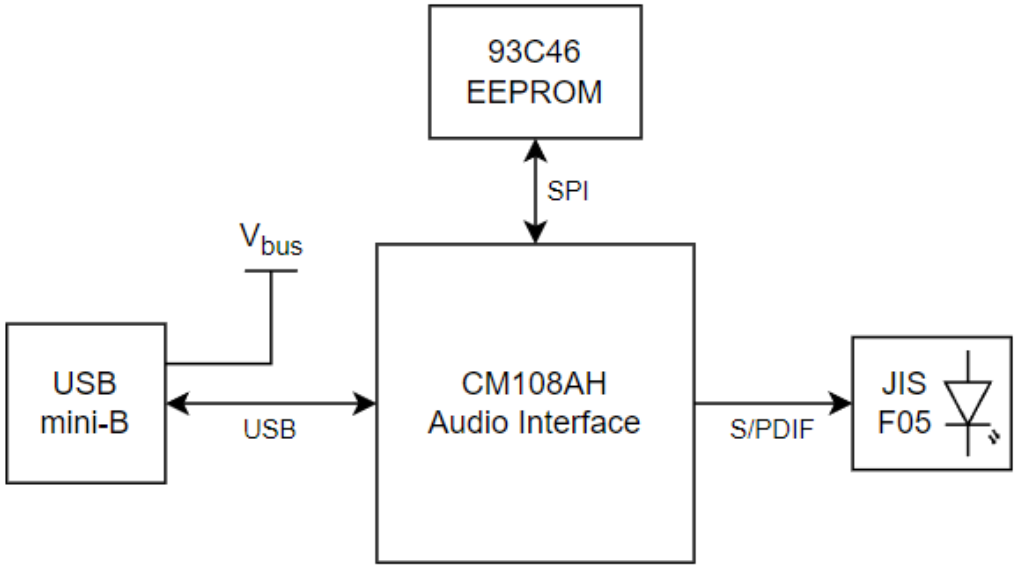

Figure: A low-cost USB audio interface

The USB audio interface [12] has a low-cost S/PDIF optical output for portable computers and tablet devices, and the audio audio transmission eliminates hum caused by ground potential differences, and noise feed-through from power supplies. This project is licensed under the CERN Open Hardware Licence Version 2. Compared to this project, our project has more features like the external know controlling the gain effect and LCD display the frequency spectrum. Also, instead of using low-cost S/PDIF optical output, we are using USB ports to increase the compatibility of our solution to other output devices. Additionally, we are using C as our source code language, while python is more convenient but less efficient.

5.3.2 Open Source Project #2: A USB Microphone for online meetings

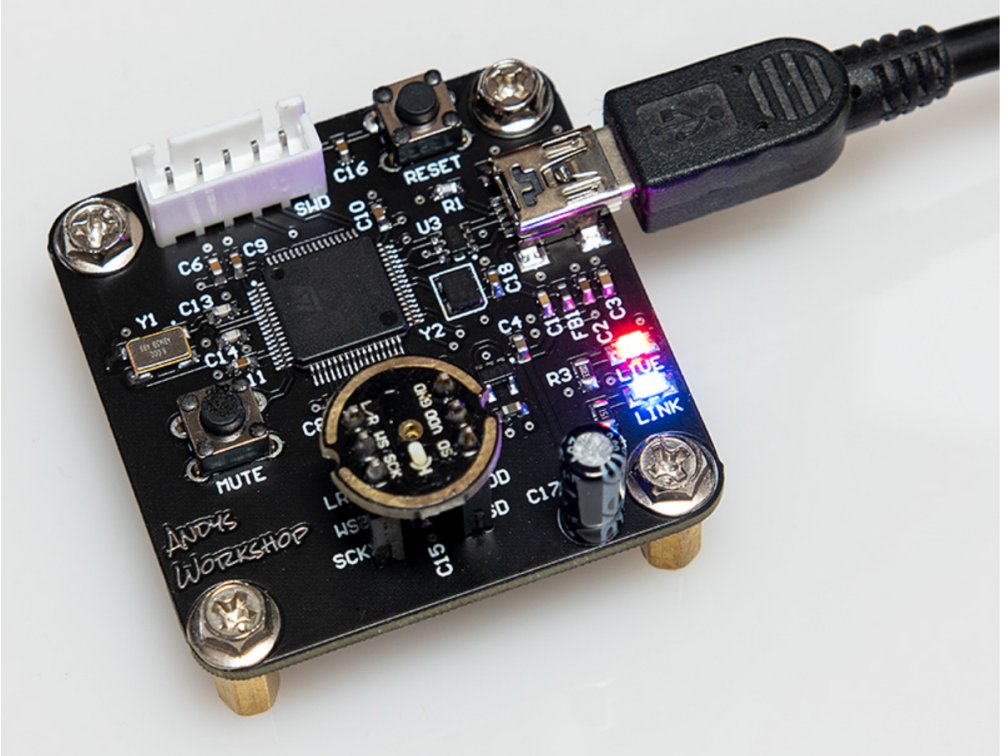

Figure: A USB Microphone for online meetings design

The USB microphone for online meeting [13] is a 48kHz 16-bit USB microphone implemented using an I2S INMP441 MEMS microphone and an STM32F446 Microcontroller, and it's features also include real-time graphic equalizer and smart volume control audio processing using ST Micro's GREQ and SVC libraries. The entire project is open source in github, and all firmwares is available to purchase online. For this project, the author came up with two possible options, one would be part_analogue and the other all_digital but both of them are designed around a MEMS microphone for translating sound pressure levels into an electrical signal. For our project, we are still thinking about which microphone we are going to use but we have selected an all-digital design for our project. Inspired by this project, we may make our own microphone to fulfill the hardware requirement.

5.3.3 Open Source Project #3:

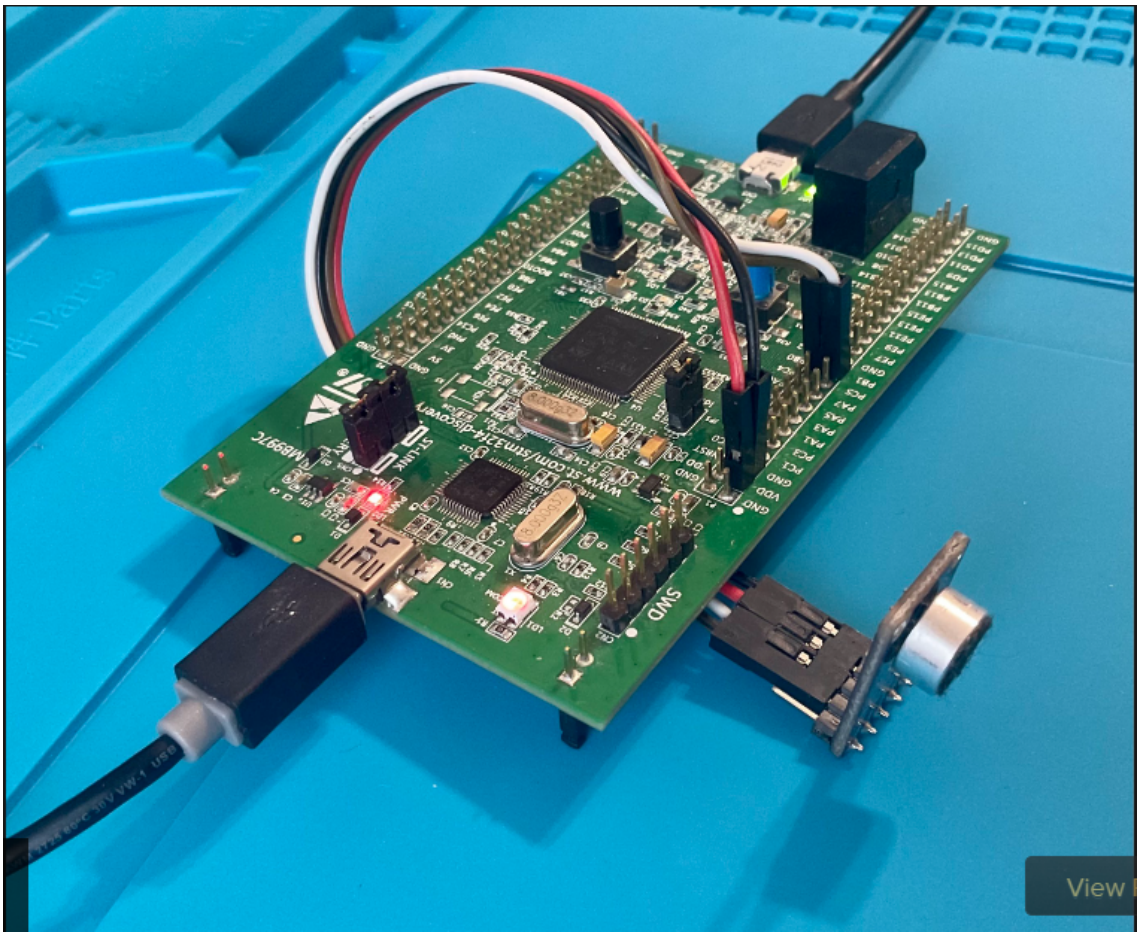

Figure: STM32F4_USB_MIC

The STM32F4 USB MIC [14] is able to capture ADC data and send it to PC as audio data via USB port. The MCU of this project is STM32F4, and it uses a MAX9814 microphone amplifier which needs an ADC input to sample the audio and a GPIO output to set the gain. This project seems like an open source project, since it does not show its license. The reason why I list this project is that we can use the method of it to configure our output port, and our output should connect to any laptop or speaker to process the signal input, which has the same purpose of STM32F4 USB MIC project. While this project did not make any effect on input signal, it can be a foundation of our project.

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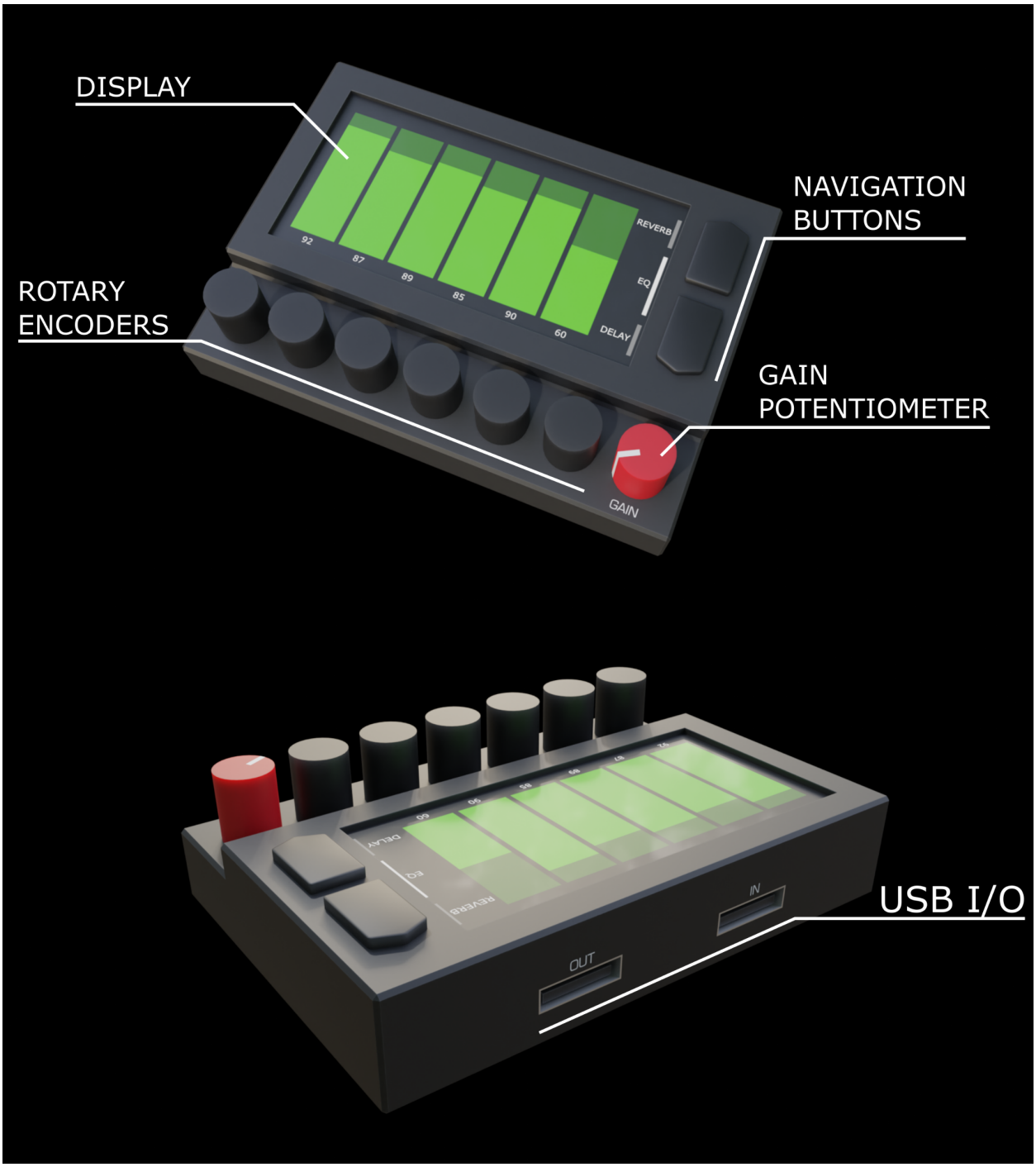
Appendix 1: Concept Sketch


DISPLAY
NAVIGATION BUTTONS
ROTARY ENCODERS
GAIN POTENTIOMETER
USB I/O
REVERB
EQ
DELAY
GAIN
IN
OUT