Electrical Overview

Year: 2024 **Semester:** Fall **Team:** 12 **Project:** USB Microphone Interface
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Author: Shubo Xie **Email:** xie347@purdue.edu

Assignment Evaluation: See Rubric on Brightspace Assignment

1.0 Electrical Overview

Our design uses a 32-bit Cortex M7 microcontroller which will collect the audio input which is handled by the codec and apply different DSP effects, and it also configures the interface to other major components. In addition to processing audio input, codec can also be used as audio output to play the processed signal. The rotary encoders and push buttons will be used to allow the user to adjust the parameters of DSP effect. Our device includes an LCD screen to display a graphical user interface that shows the DSP parameters. The power of all components will be delivered from a USB port, and the USB port can also be the audio output. Our DSP will implement IIR filters and FFT algorithms.

2.0 Electrical Considerations

2.1 Operating Frequency

The operating frequency of our microcontroller allows frequency up to 216 MHz [1] which offers a lot processing power, making it well-suited for a wide range of audio processing tasks. However, 50 MHz to 100Mhz operating frequency will be sufficient to handle most of our audio processing tasks effectively. The ADC and DAC of audio codec will have 8kHz to 96kHz sampling frequency [2]. The master clock of codec requires 12.288MHz frequency [2], and the slave clock needs 48kHz frequency [2]. The SPI interface can communicate at up to 50 MHz [1]. The I/O ports with interrupt capability can have up to 108 MHz frequency [1]. The I2S master clock can generate all standard frequencies from 8 kHz to 192 kHz [1], while the operating frequency of I2S is determined by the audio sample rate.

2.2 Power Budget

The power supply of our design will be provided by the USB port. The USB 2.0 allows hosts to deliver 5V at 500mA, for a total power output of 2.5 watts, and USB 3.0 allows 5V at 900 mA [3]. Most components can operate at 3.3V, and the regulator will handle the 5V voltage to output steady 3.3V power supply.

The current requirement for each of the components are listed in the table below:

Device	**Maximum** (mA)
Microcontroller	230
Audio Codec	10
LCD Display	80

Rotary Encoders	5
Total	**325**

Table 1: Current Consumption

2.3 Voltage Tolerances

The microcontroller can operate at voltage ranging from 1.6V to 3.6V [1]. The maximum voltage of LCD display is 4.6V, and its minimum voltage is -0.3V [4]. The audio codec used a maximum voltage of 3.63V minimum voltage of -0.3V [2]. We make our voltage tolerances as 3.3V ±10%. Higher voltage will have higher noise susceptibility so that audio application can have better signal quality. Thus, the voltage trade off will be considered at the end of design.

3.0 Interface Considerations

3.1 I2S Interface

The I2S interface will be used to transmit the processed signal from the audio codec to the microcontroller. The I2S interface in our microcontroller can only operate with a 16/32-bit resolution as an input or output channel [1], and we may consider using 16-bit resolution to transfer signal. The audio codec typically acts as the master device, controlling the timing of the data transfer, while MCU acts as the slave device. I2S has at least three lines including a serial data line (SD), a serial clock line (SCK) and a word select line (WS). The SD line will be used to sample the input signal and encode it into a digital format which can be read by the MCU. The SCK provides the clock signal to synchronize the data transfer. We may not use the WS line since we only use one audio channel. Instead of transmitting data, I2S can also be used by microcontroller to send commands to the codec to adjust setting such as volume.

3.2 SPI Interface

Our design uses SPI interface to interface between the microcontroller and LCD screen. The microcontroller will act as the master device, while the LCD screen acts as the slave device. Thus, the microcontroller will generate the clock signal on the SCK line to synchronize data transfer. The SPI interface can operate at 4 to 16-bits resolution [1], and we choose 16-bits to have faster speed of displaying. When we are configuring the SPI interface, we need to make sure to set up the clock polarity, clock phase, clock frequency and data order.

3.3 USB Interface (Stretched Goal)

The USB interface is used to transfer the data processed by microcontroller to the user device. We have not determined which USB standard we are going to choose but it will be selected between USB 2.0 and USB 3.0, since they provide sufficient current consumption to our design. To make user's device recognizing our data, we will have built-in library to help with that. Also, we will use established USB protocol libraries to simplify development to ensure communication between USB poet and user's device. The big question we have not finished here is which end acts as the host and which end acts as the device.

4.0 Sources Cited:

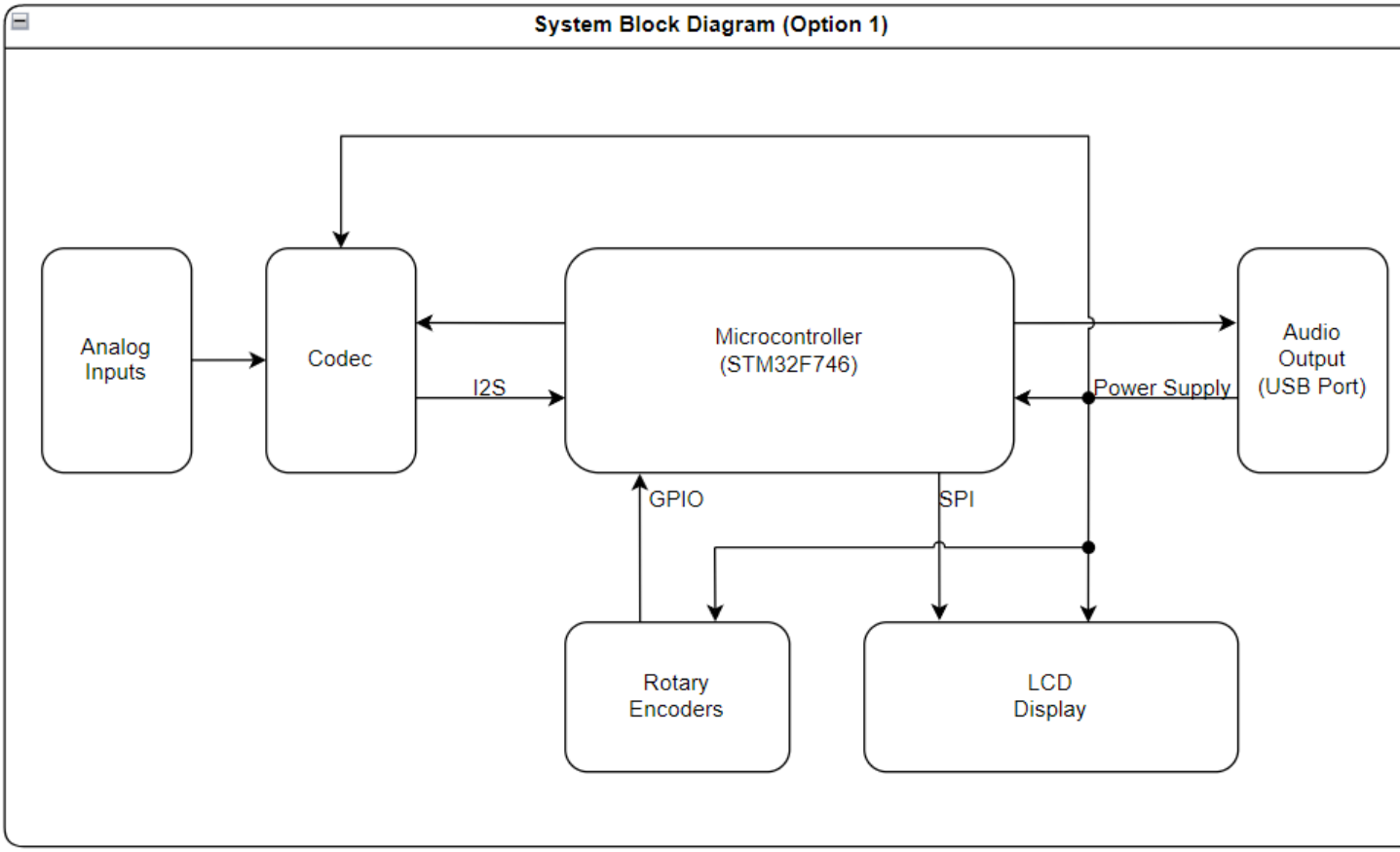
[1] "This is information on a product in full production. STM32F745xx STM32F746xx," 2016. Accessed: Feb. 04, 2024. [Online]. Available: https://www.st.com/resource/en/datasheet/stm32f746ig.pdf

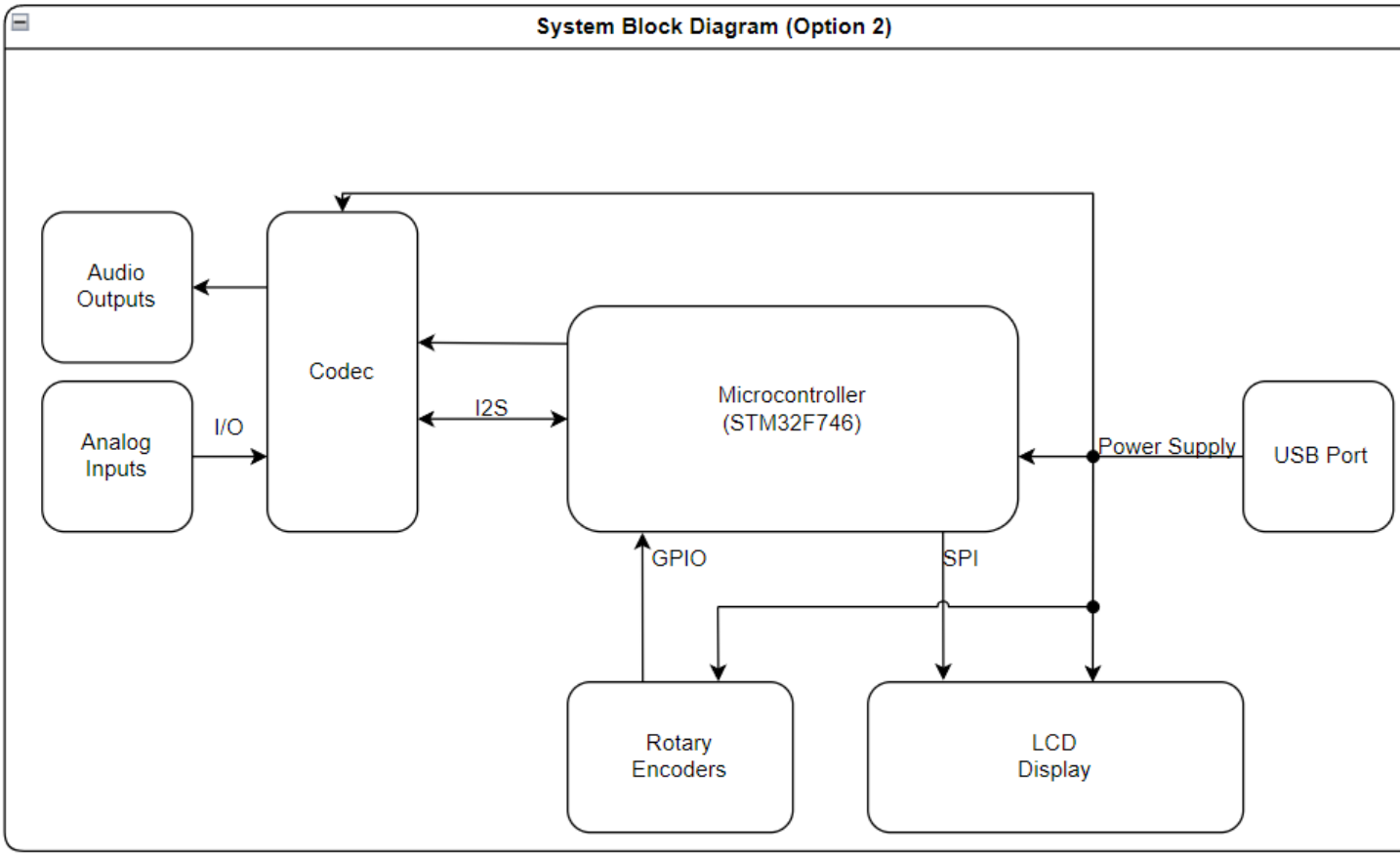
[2] "Portable Internet Audio CODEC with Headphone Driver and Programmable Sample Rates WOLFSON MICROELECTRONICS plc." Available: https://cdn.sparkfun.com/datasheets/Dev/Arduino/Shields/WolfsonWM8731.pdf

[3] "USB Charging and Power Delivery | Eaton," *Eaton Website*. https://tripplite.eaton.com/products/usb-charging#:~:text=1%20Default%20Power (accessed Feb. 04, 2024).

[4] Shenzhen ChengHao Optoelectronic R., "/18." Available: https://cdn-shop.adafruit.com/product-files/2770/SPEC-CH280QV10-CT_Rev.D.pdf

Appendix 1: System Block Diagram


System Block Diagram (Option 1)
Analog Inputs
Codec
I2S
Microcontroller (STM32F746)
Power Supply
Audio Output (USB Port)
GPIO
SPI
Rotary Encoders
LCD Display


System Block Diagram (Option 2)
Audio Outputs
Analog Inputs
I/O
Codec
I2S
Microcontroller (STM32F746)
Power Supply
USB Port
GPIO
SPI
Rotary Encoders
LCD Display