Component Analysis

Year: 2024 Semester: Spring Team: 12 Project: Microphone Interface
Creation Date: 1/31/2024 Last Modified: 2/3/2024

Member 1: Liam Roach Email: leroach@purdue.edu
Member 2: Jakub Kowalski Email: kowals14@purdue.edu
Member 3: Joshua Hom Email: hom2@purdue.edu
Member 4: Shubo Xie Email: xie347@purdue.edu

Assignment Evaluation: See Rubric on Brightspace Assignment

1.0 Component Analysis:

Our device has five major components: the MCU, which is the heart of the device, performing digital signal processing and other functionalities, the screen, which will display a graphical user interface that visualizes users controlled parameters of the DSP, a codec, which will handle the analog to digital conversion of the incoming audio signal, buttons, and rotary encoders, which will be used in conjunction to allow the user to control parameters of the DSP.

1.1 Analysis of Component 1: MCU

Our choice of MCU fell between the STM32F746 and the STM32F407. Our project requires an MCU capable of handling DSP algorithms in real-time to achieve low latency between the input and output signals, interfacing with an LCD and codec, and receiving inputs from rotary encoders and buttons. To achieve this, we require an MCU with enough RAM to handle the DSP, support for USB connectivity, and enough interfaces to be able to attach other components.

The F746 is our go-to choice for the project. Here is a comparison with the F407:

MCU	**F746 [5]**	**F407 [7]**
Core	Frequency up to 216 MHz, 462 DMIPS / 2.14 DMIPS/MHz, FPU, and DSP instructions	Frequency up to 168 MHz, 210 DMIPS / 1.25 DMIPS/MHz, FPU, and DSP instructions
Clock	4-to-26 MHz crystal oscillator	4-to-26 MHz crystal oscillator
Flash	1 MB	1 MB
SRAM	320KB (including 64KB of data TCM RAM + 16KB of instruction TCM RAM)	192+4 KB (including 64 KB of data CCM RAM)

USB	USB FS and HS host/device/OTG	USB FS and HS host/device/OTG
SPI	6 (3 multiplexed w/ I2S)	3 (2 multiplexed w/ I2C)
I2C	4	3
I2S	3	2
LCD	LCD parallel interface with 8080/6800 modes LCD-TFT controller with DMA2D	LCD parallel interface with 8080/6800 modes
Price	$16.50	$9.09

At first glance, some features between the F746 and F407 are comparable, such as clock speed, flash size, and USB capabilities. However, the F746's core can operate a little over twice as fast at 462 DMIPS. It also has much more SRAM which includes TCM RAM, a low-latency memory that guarantees a consistent access time [11]. It also includes an LCD-TFT controller with DMA2D which can accelerate certain graphical operations [12]. As we are planning on implementing the device with one MCU, the ability to quickly perform graphical operations and quickly access parts of the memory will greatly influence the latency of the output signal. Overall, the better performance of the F746 gives us more room to implement our DSP algorithms, and the surplus of available peripherals for the F746 provides flexibility in evolving the design of our product as we prototype.

1.1 Analysis of Component 2: Screen

For our screen choice, we require a display that is capable of a high enough refresh rate to reflect the changes being done to parameters and a large enough area to comfortably fit our UI. We also could benefit if the display was also touchscreen to implement a stretch goal of touchscreen input. An ideal type of display for this is an LCD. When looking at other display options such as OLEDs, we were not able to find a choice that would realistically be used in our device as most of the options were too small to use as a display for our applications. Therefore, we took a look at two different LCDs from Adafruit: a 2.8" 240x320 TFT LCD with capacitive touch and a 5" 800x480 TFT LCD which uses resistive touch.

LCD	**2.8" 240x320 TFT LCD[13]**	**5.0" 800x480 TFT LCD[14]**
SPI	Yes	No
Parallel Interface	8/16-bit	24-bit
RGB	Yes	Yes

Price	$19.95	$27.50

Our choice for the project is the 2.8” TFT LCD. Although the size of the display is smaller, it has the advantage of offering more choices to interface with (SPI and parallel). This adds flexibility to our implementation of the interface during prototyping. The 2.8” LCD also makes use of a capacitive touchscreen which is ideal for applications such as smartphones due to the fact you don’t need to apply a ton of pressure to detect input and they offer sharper display [15]. The resistive touchscreen is ideal to use in manufacturing or a device like an ATM because they are more resistant to outdoor elements and relies on pressure to be applied instead [15]. Our device doesn’t need the amount of resistance that the resistive touchscreen offers, so the 2.8” capacitive touch display would be more appropriate to use.

1.1 Analysis of Component 3: Codec

The codec in our design will be responsible for converting an incoming analog audio signal to a digital signal that will be transmitted to the MCU via I2S. For this purpose, it is required that the codec have an analog to digital converter, as well as I2S support. In order to simplify the design effort, it is desired that the codec used have built in signal amplification and noise reduction so that that functionality need not be implemented by us. Additionally, the availability of a development board for the component is essential for the sake of prototyping and an SSOP or similar package is desirable, but not required. We were able to immediately obtain a dev board for the WM8731 codec [9], which initially appeared to satisfy all of our requirements. However, after looking at the availability of the component for purchase, we discovered that it was no longer in production, and while there was an SSOP version made, only the QFN version was available for purchase. Alternatively, we looked into the CS4272 codec [10], which was also out of production, but did have an SSOP package that was in stock. Additionally, the component had an ADC and I2S functionality, but there was no amplification circuitry within the chip, so we would have to design our own circuit to achieve that functionality.

Feature	WM8731	CS4272
I2S	Yes	Yes
ADC	Yes	Yes
Built-in amplification	Yes	No
Package	QFN	SSOP

We’ve decided to go with the WM8731 in the end, regardless of the fact that we would have to solder a QFN package, since we would rather do that than have to add additional complexity to our design.

1.1 Analysis of Component 4: Buttons

The buttons will be used to change in between effects for our project. They will not need to have special features such as fast response time or resistance to external elements. For this reason, simple push buttons would suffice for the design. The selection of the button would be based around the aesthetic. Aspects that were searched for were silicon padding for grip and a tall enough dome so the base of the button can be hidden below the packaging. Button [1] has silicon padding which is one of the desired characteristics. However, it only stands at 5 millimeters in height, making it less flexible when designing the packaging. Button [2], has a height of 12 millimeters which is also a desired characteristic, but the material is plastic. Button [3] is slightly larger in base than the other two buttons and has soft tactile buttons which allow it to be quieter.

Feature	**5mm [1]**	**12mm [2]**	**5mm [3]**
Dimensions	6x6x5mm	6x6x12mm	8x8x5mm
Price	$0.13	$0.25	$0.20
Material	Silicon & Translucent	Plastic	Soft Tactile

The 5mm [1] seems to be the best choice for now. It is the cheapest and has silicon padding. It is not as tall as the 12mm [2], but packaging may be able to accommodate this. Also one important aspect of this component is that it is relatively cheap and not complicated to operate. This means that this component is interchangeable later on if needed.

1.1 Analysis of Component 5: Rotary Encoder

The rotary encoders will be used to precisely adjust the DSP in our design. For our prototype, we used quadrature rotary encoders. This means that they will have two channels that will need to be read. Most of these rotary encoders also have a built-in button into them, but they are not necessary for our project since we will also have individual buttons. We plan to have at least three rotary encoders. The most important aspect of the rotary encoders is the number of pulses per revolution. It seems that the price will increase with the number of pulses. Rotary encoder [4] seems to come in a standard size and comes with a knob. [6] Does not come with a knob but has 32 pulses per revolution. However, it is much more expensive than the other options. It also seems to have a more complicated pinout. [7] also has 24 pulses per revolution but does not come with a knob. It is also the smallest of the three.

Feature	**Rotary Encoder [4]**	**EM14R1B-M20-L032S [6]**	**EN12-HS22AF18 [7]**
Dimensions	12x13x25mm	14x15x30mm	12x13x16mm
Price	$4.50	$33.69	$1.96

Pulses per Revolution	24	32	24

Rotary Encoder [4] seems to be the best choice. It is affordable and comes with a knob which will decrease the workload in packaging. It also has relatively a good amount of pulses per revolution compared to the rotary encoder [6].

2.0 Sources Cited:

1. Soft silicone top 6mm push-buttons (20-pack)[Online]. Available: https://www.adafruit.com/product/4183
2. Tactile Switch Buttons (6mm tall) x 10 pack[Online]. Available: https://www.adafruit.com/product/1490
3. Soft Tactile Button (8mm) x 10 [Online]. Available: https://www.adafruit.com/product/3101
4. Rotary Encoder + Extras [Online]. Available: https://www.adafruit.com/product/377

5. "STM32F746NG - STMicroelectronics," *STMicroelectronics*, 2023. https://www.st.com/en/microcontrollers-microprocessors/stm32f746ng.html
6. EM14R1B-M20-L032S [Online]. Available: https://www.mouser.com/ProductDetail/Bourns/EM14R1B-M20-L032S?qs=%2FxQVPCMPNzgg0PIKBH1KsQ%3D%3D&mgh=1&srsltid=AfmBOoq8MTZSmIbzHmz3Cd9m2NNalV9_VDrC7pw1iab7hQYznCy0rvEfxeA
7. "STM32F407VG - STMicroelectronics," *STMicroelectronics*, 2023. . https://www.st.com/en/microcontrollers-microprocessors/stm32f407vg.html
8. EN12-HS22AF18 [Online]. Available: https://www.digikey.com/en/products/detail/tt-electronics-bi/EN12-HS22AF18/7720708
9. WM8731CLSEFL Cirrus Logic Inc. | Integrated Circuits (ICS) | DigiKey, https://www.digikey.com/en/products/detail/cirrus-logic-inc/WM8731CLSEFL/5409907
10. CS4272-CZZ Cirrus Logic Inc. | DigiKey, https://www.digikey.com/en/products/detail/CS4272-CZZ/598-CS4272-CZZ-ND/923162?curr=usd&utm_campaign=buynow&utm_medium=aggregator&utm_source=octopart
11. "Documentation – Arm Developer," *developer.arm.com*. https://developer.arm.com/documentation/den0042/a/Tightly-Coupled-Memory
12. "8. Hardware acceleration | TouchGFX Documentation," *support.touchgfx.com*. https://support.touchgfx.com/docs/development/board-bring-up/how-to/08-hardwareacceleration
13. Adafruit Industries, "2.8" TFT Display - 240x320 with Capacitive Touchscreen," *www.adafruit.com*. https://www.adafruit.com/product/2770?gad_source=4&gclid=Cj0KCQiA5fetBhC9ARIsAP1UMgFl-_XTRAG8wFE_dz3De6djqvdGWgr5hG411CJiByo91h4MHoQMaPkaAszKEALw_wcB
14. A. Industries, "5.0" 40-pin TFT Display - 800x480 with Touchscreen," *www.adafruit.com*. https://www.adafruit.com/product/1596
15. "What to choose? The difference between capacitive and resistive touchscreens - Clicktouch," *clicktouch.eu*, Oct. 25, 2021. https://clicktouch.eu/en/capacitieve-vs-resistieve-touchscreens/