Assignment 3 – Literature Review

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Table of Contents

Cellphone High Fidelity Audio Interface

Market summary

The market focuses on audio consumers, specifically, on individuals that enjoy HI-FI (High Fidelity) audio, also known as Hi-Res (High Resolution). The products that are sold in this market seek to overcome the limitations that many general devices, like smartphones, have for streaming high quality audio. Mostly, these limitations are due to the DACs (Digital to Analog Converter) selection. Consequently, many companies have started to develop external DACs that are capable of reproducing audio that meets the Hi-Res standard. Some of the companies that already have a presence in this niche are FiiO, Shangling and Hidizs.

This market comprises mainly audiophile people; they are individuals enthusiastic about extremely high-fidelity sound reproduction. Furthermore, High-resolution audio, as of the day of writing this research, includes those digital sound files sampled with a bit deep of 24-bit at a frequency of at least 96kHz. Some file formats that allow said sampling quality are WOV, AIFF, FLAC, ALAC, DSD, and MQA (Sony, 2024). Additionally, most of the mainstream audio streaming apps currently support Hi-Fi; some examples are Apple Music, Amazon Music, Tidal, Qobuz and Primephonic.

In the final part of this section, a list of commercial DACs will be provided. All the following products provide a solution to the incapability of smartphones to output Hi-Res audio information:

1. **FiiO JadeAudio KA1 Headphone Amps Tiny Amplifier USB DAC** (figure 1) with a cost of $69.99 CAD, supports up to 32bit/384kHz, multidevice and MQA rendering.

Figure 1: FiiO JadeAudio KA1 Headphone Amps Tiny Amplifier USB DAC

Retrieved from: https://www.amazon.ca/JadeAudio-KA1-Headphone-Resolution-Smartphones/dp/B09VSVH9F3/ref=asc_df_B09VSVH9F3/?hvadid=579028755756&hvdev=c&hvdvcmdl=undefined&hvlocint=undefined&hvlocphy=9000895&hvnetw=g&hvpone=undefined&hvpos=undefined&hvptwo=undefined&hvqmt=undefined&hvrand=9051585050014697897&hvtargid=pla-1656877535894&linkCode=df0&mcid=c340e01ec0c737e49bbc53f7b47bfaf5&tag=googleshopc0c-20&th=1

2. **SHANLING UA2 Plus Portable Headphone Amplifier** (figure 2) with a cost of $119.99 CAD, supports up to 32bit/768kHz, compatible with various OS like Android/iOS/Windows/Mac/Nintendo Switch.

Figure 2: SHANLING UA2 Plus Portable Headphone Amplifier

Retrieved from: https://www.amazon.ca/SHANLING-UA2-Plus-Headphone-Amplifier/dp/B0BMLS9GX7?th=1

3. **Hidizs S9 PRO Balanced & Single-Ended Mini HiFi DAC & AMP (Figure 3)**, supports up to 32bit/768kHz, compatible with Windows/Android/Mac OS/iOS/iPad OS System, Single-ended 3.5mm + Balanced 2.5mm jack.

Figure 3: Hidizs S9 PRO Balanced & Single-Ended Mini HiFi DAC & AMP
Retrieved from: https://www.hidizs.net/products/hidizs-s9-pro-balanced-single-ended-mini-hifi-dac-amp?spm=..product_cf59d482-a8aa-41bf-8721-e61d0a30dc88.header_1.1&spm_prev=..product_8a31e6be-c4ee-4d52-83f8-c7e563336041.header_1.1&variant=44495f43-57f5-497a-9cdb-cf0480494d3c&srsltid=AfmBOopcNY9DOo9goOlqUlXC7IUSvhiwvv6AosJCrMXslT3aRJ46L_m3-ZI

Competitive Analysis			
	FIIO JadeAudio KA1 Headphone Amps Tiny Amplifier USB DAC High Resolution Lossless	**SHANLING UA2 Plus Portable Headphone Amplifier**	**Hidizs S9 PRO Balanced & Single-Ended Mini HiFi DAC & AMP**
Price	$69.99 CAD	$119.99 CAD	$80.80 CAD
Compatibility	Android/ iOS/Windows/MacOS/other devices(like player/tablets)	Android/iOS/Windows/Mac/Nintendo Switch (iOS requires special cable for USB DAC)	Windows/Android/ Mac OS/iOS/iPad OS System
Input Connector Type	Lightning	Female USB Type-C	Female USB Type-C
Output Connector Type	3.5mm Female jack	3.5mm/4.4mm Female Jack	Single-ended 3.5mm + Balanced 2.5mm female jack
Conversion Quality	32bit /384KHz	32bit/768kHz	32bit768kHz

Table 1: Competitive Analysis

Important protocols

I2S

The serial bus interface known as I2S has been a useful protocol since 1982 designed to transfer digital audio data between IC (Integrated Circuits). Moreover, it is useful for dealing with numerous of serial data related with high-quality digital audio(Miller, 2022). Pulse-code modulation (PCM) audio data is transmitted from a controller to a destination using the I2S protocol. Some of the important lines it uses are the bit clock, the word select, and a data line.

USB Audio Class 2.0

As stated in the "Universal Serial Bus Device Class Definition for Audio Devices" specification, the USB Audio Class 2.0 is the second generation of the standard that applies to all devices that are used to manipulate audio, voice and sound-related functionality (USB.org, 2006). This Class definition provides the minimum capabilities that a device must meet to comply with USB, which is an important feature since most modern OS have built-in drivers to talk with these devices. Furthermore, this specification includes sturdy synchronization schemes to ensure reliable transmission. Additionally, this protocol allows for both audio and control signals to be shared over the USB differential pair; this is useful feature that reduces the need for individual settings for each audio device. Lastly, the Audio Class 2.0 provides a Sampling Rate Converter Unit; said

module provides the capability of dynamically changing the clock frequency at which our audio system is operating without altering the USB transfer frequency. The adaptability of the audio frequency provides a wide range of possible audio files that can be reproduced using the same hardware.

Power Delivery

USB Power Delivery (PD) is a specification that grant for extra flexibility when transmitting power between USB devices. This new standard allows for up to 240W to be transmitted using the USB C connector/cable (USB.org, 2021). Although that amount power is excessive for most electronic applications, the standard provides a handshake method to determine which Voltage/Current are required by the load device. This is a key feature since it allows multiple devices to efficiently communicate with the power source and avoid hardware damage (Harrison, n.d.).Furthermore, this protocol allows for simultaneous data and high power transfer over the same cable; this is paramount to provide fast charging capabilities in cellphones while syncing data with a computer.

Current Open-Source Alternatives

This section includes the current market price of some Electronic Components/Modules; All the prices were obtained from digikey.ca.

There are a couple of open-source hi-res Digital Audio Interfaces available online. For example, Lu (2015/2024) shared a schematic of a Hi-Res DAC based around the PCM1792A. It utilizes an I2C protocol to communicate the data to the DAC and uses a series of low-distortion op-amps to condition the signal for its use with low-power headphones. The most updated version of this IC has a cost of around 30 CAD, which would increase the price of the audio interface close to the commercial tendency. However, one interesting feature in their design is an LED indicator for the sampling frequency. This circuit will inform the user the current sampling rate of the digital music being played.

Another Open source that made considerable advances in hi-res Digital Audio Interfaces is Bandou et al. (2017).They developed and published a complete PC sound card based on the XMOS XS1-L2 processor and the CS42448 Codec. The processor oversees the interfacing between the PC and the two audio Codecs (Input and Output). This approach of using separate Interfacing and Conversion ICs seems to be useful to reduce the cost of the components. Furthermore, it provides the capacity of adapting the codec capabilities to the client needs. The ICs also seen to be cheaper than one proposed in the previous project; the CS42448 costs around 14 CAD and the XMOS processor has a price of nearly 30 CAD. Nonetheless, since the Audio Device referenced in this capstone project is intended to be a speaker interface, using components of the same performance as in this project will be overengineering. More affordable alternatives will be explored.

Additionally, Dyk (2020/2022)published a USB audio interface based on the Teensy4 microcontroller. He used a development board in conjunction with the ES9023

DAC module manufactured by Suptronics. This microcontroller allows to use the Teensy GUItool to easily select the registers and libraries that allow the device to be recognized as a USB audio device by a PC. It is mentioned by the author that this set up is tested at 16bit/44.4kHz resolution; However, it can go up to 92kHz. This is not considered as Hi-Res audio; nonetheless, this project provides a design architecture that can be extended to higher-performance components that could, potentially, reach the intended Hi-Res quality. The approach of using a development board greatly simplifies the hardware design process; however, this kit by itself retails at about 35 CAD. Furthermore, it incorporates a micro-USB connector that is considerably outdated for a consumer product in 2024. Despite that, the approach of incorporating a programmable as an Audio Codec could be useful; especially considering the extra user-interface features that were mentioned in the second paragraph of this section.

Although there exist several commercial an open-source alternatives for Audio Interfacing via USB, many of them are either focused entirely on heavy audiophile users or extremely casual listeners. There aren't many options available for the average consumer who enjoys casually listening to high-quality audio. Furthermore, many of the options discussed above include some external power supply to function; however, none of them offer the capability of charging the device where they are getting the digital audio information.

Therefore, based on our literature search, it seems that there is not a device that can provide Hi-Res audio quality along with general user features like device charging and reproduction feedback. Consequently, creating such a device could be a great solution for audio enthusiasts who want to experience deeper acoustic experiences without many of the sacrifices that high-fidelity equipment usually entails.

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