Bluetooth 24-bits Headphone Adapter

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1 Introduction

1.1 Objective

With the progress of the semiconductor industry, people started to cut down the cord, ditch the heavy equipment, to persuade the freedom of portability. This is refining the way how people consume music contents in daily life. Since we stepped into the era of LTE, the rich bandwidth of mobile network, the music industries have shifted their concentration onto a music streaming service. As streaming cost is aggressively cheaper than purchasing songs stand alone, people tend to compromise on the audio quality. Major streaming services are providing the users with 16-bits, 96 kbps for mobile low tier standard, 128 kbps for desktop standard. However, the base of the standard is raising up to 160 to 320 kbps for a premium audience [1]. Also, some Hi-Fi oriented services started streaming in 24-bits or even higher. It waves the flag of next generation service in the market.

Yet, when we look at the popular peripherals, we know that for music enthusiasts, the top headphone sets are all using analog signal as input. Also, they play at a high impedance level. However, normal mobile devices won't be able to drive them. Now, from the observation, the number of mobile devices, which are taking the music quality into consideration, is increasing. The Bluetooth standard is coming to version 5.0. With the push from chipsets manufacturers, we can foresee a trend of public to have the investment onto the newer peripherals. 16-bits exists for a reason, and became a symbol of an era. However, innovators are not stopped and satisfied.

To follow this innovative movement, our goal is to make a Bluetooth headphone adapter that can transmit 24-bits audio data with a portable size and a longer battery life than the ones that are available on the market. The adapters on the market generally provide 16-bits audio data and last only for 9-15hours [2]. We aim to make ours to transmit 24-bits and 192kbps audio data while the battery last 40 to 50 hours.

1.2 Background

As an evidence of this innovative movement to provide better audio quality, LG came up with LG V20 last year with the support of playing 24-bits audio data [3]. The major music streaming services such as Spotify, Apple Music, Amazon Music Unlimited, Tidal, and Google Play Music started to provide the audio files with maximum of 256kbps to 1411kbps [1]. As the trend moves to the wireless audio devices, the necessity of a device that can play the audio files as provided from those music streaming services will eventually increase.

1.3 High-Level Requirements

- Adapter must be able to produce audio quality of 24-bits and 192kbps; better than that (16-bits, 128kbps) of Bluetooth headphone adapters on the market
- Adapter must be able to operate longer time; ideally 40~50hrs battery power.
- Adapter must be small size as possible; to keep it portable.

2 Design

Adapter requires a total of 6 sections to make it a successful product: a data input unit, a DAC unit, a control unit, a power supply, an information indicator, and an analog output. The data input unit will receive audio data through two methods: Bluetooth for wireless connection and USB-C for wired connection. Bluetooth A2DP protocol will send AAC audio data to ensure 24-bits and 192kbps. USB-C will also send AAC audio data to ensure 24-bits and 192kbps. The DAC unit will receive this 24-bits and 192kbps digital audio data and convert it to analog audio data. The control unit will allow the user to increase/decrease volume and mute/unmute the audio. The power supply will provide 5V/12V appropriately for each module from the lithium-ion battery. The information indicator will be showing the title of the audio data on ink screen and LEDs will indicate the analog signal from DAC and control unit. The analog output will be sending out the 24-bits audio data through 3.5mm audio jack.

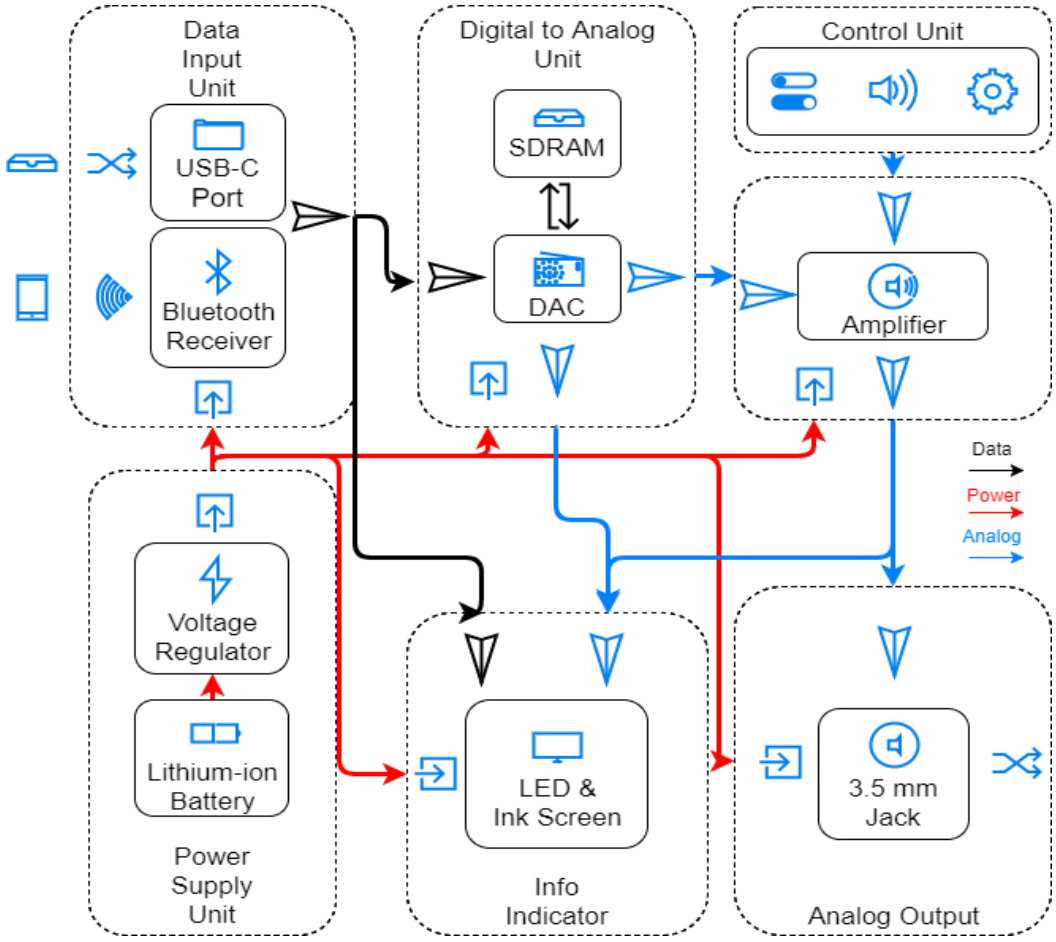

Figure 1 – Block Diagram

2.1 Data Input Unit

A data input unit retrieves audio data through two methods: Bluetooth or USB type-C. Using Bluetooth A2DP protocol, AAC codec audio data will be transmitted wirelessly. By using AAC codec, the audio data of 24-bits and 192kbps can be transmitted. Another method, USB type-C, transmit the audio through the wire. To keep the consistency of the audio data transmission, USB type-C will also transmit AAC codec audio data with 24-bits and 192kbps.

2.2 Digital-to-Analog Unit

A digital-to-analog unit receives the digital audio data from a data input unit. This digital audio data is AAC codec with 24-bits and 192kbps. We will use PCM1794A 24-bits DAC chip to receive, convert digital to analog audio data with SDRAM to keep it buffered, then send out the analog audio data to the amplifier.

2.3 Control unit

A control unit allows the user to control the volumes. The mute/unmute button will allow the user to mute the sound or to unmute the sound. The volume controller will allow the user to increase or to decrease the volume of the sound. This is connected directly to the amplifier circuit. The amplifier will increase the voltage of converted analog audio data.

2.4 Power Supply Unit

A power supply will provide constant voltage of 5V/12V to keep the adapter running. Lithium-ion battery will be charged using USB-C port. We expect battery to provide enough power to run the device for 40~50hours. The power from the Lithium-ion battery will go through a voltage regulator to supply 5V/12V to the adapter system.

2.5 Info Indicator

An info indicator is used to show the information from the data input unit and the control unit. The digital data from the data input will be sent to Ink screen to show the title of the song that is currently being played. The analog data from the control unit, passed through amplifier, will be sent to LEDs to show the status of whether the device is muted/unmuted and the approximate volume that is being played.

2.6 Analog Output

An analog output contains 3.5mm audio jack to output the analog audio data. The earphone or headphone with 3.5mm audio jack will be plugged into it, to receive the analog audio data.

2.7 Risk Analysis

The transmission of 24-bits AAC codec through Bluetooth A2DP will be the major part of our project. The common Bluetooth earphone/headphone available on the markets uses SBC codec, which only transmit 16-bits audio data. Since we are aiming to increase the audio quality by increasing the bits and the kbps, we need to make sure that we fully understand how the transmission work.

After receiving proper AAC codec audio data, the conversion of digital audio data to analog audio data using 24-bits DAC chip along with SDRAM as a data buffer will be the next task to focus on. We are expecting some delay caused by the conversion of digital to analog. But, we are aiming to make sure the song is played without having a glitch.

Another risk we are considering is the usage of the 5V voltage regulator. We listed 12V just in case when the headphone plugged in has a high-impedance and sensitivity. If the amplifier is powered with 5V only, definitely the high-quality headphones will not be playing the music properly due to lack of power.

3 Ethics and Safety

In our project, one of the most important safety concern is the usage of Lithium batteries. Lithium batteries contain both cathode and fuel in a container. These two parts can react and cause fire or explode. An explosion can also be caused by overcharging or overheating the batteries. We will closely monitor the temperature of the battery to make sure that our battery stays within 0 °C to 45 °C during charging and disconnect the battery from the entire circuit if the temperature is abnormal to avoid further chemical reaction and potential fire hazard or explosion. We will also make sure that we disconnect the battery if the voltage is over 4.2V.

We will not make false claims about our project, according to the IEEE Code of Ethics, number 3: “to be honest and realistic in stating claims or estimates based on available data” [4]. We will make sure to provide 24-bits audio data through Bluetooth connection and DAC; even though the method for the users to check this is almost none at all.

References

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[2] “iTrip Clip Bluetooth Headphone Adapter,” *Griffin Technology*, 2017. [Online]. Available: https://griffintechnology.com/us/itrip-clip-bluetooth-headphone-adapter. [Accessed: 21-Sep-2017].

[3] *LG V20™: Superior Video, Photography, & Next-Level Audio | LG USA*, 2016. [Online]. Available: http://www.lg.com/us/mobile-phones/v20. [Accessed: 21-Sep-2017].

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