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USB-C to 3.5mm adapter with PCB in audio jack

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ABSTRACT

Traditional USB-C to 3.5mm adapters are provided for use with smartphones and other devices that do not include a 3.5mm audio jack. Such adapters have several problems that can impact user experience. Examples of the problems in current adapters include vulnerability to RF radiation interferences, desensitization of the cellular receiver in the phone, co-existence, antenna detune effect, etc.

This disclosure describes an improved design of a USB-C to 3.5mm adapter. In the design, the USB-C PCB is moved away from the device end to make it less vulnerable to the radiations from the device. The techniques further include propose use of a braided cable between the main PCB and the USB-C plug to shield from noise coupling. Signals along the wires from USB-C plug to audio jack are either power or digital and are robust in the presence of noise sources. Further, only USB signals run from USB-C plug side to the audio jack, eliminating the need to twist the microphone signal with the ground signal.

KEYWORDS

- Universal Serial Bus
- Type-C
- USB-C
- audio adapter
- 3.5mm adapter
- Audio jack
- Phone accessory

BACKGROUND

USB Type-C is a next generation universal interface for many devices, e.g., smartphones, tablets, laptops, etc. Many premium devices feature a digital audio platform and do not include a 3.5mm analog headset jack. To allow users to continue use of a traditional 3.5mm headset, many phone manufacturers provide USB type-C to 3.5mm adapters.

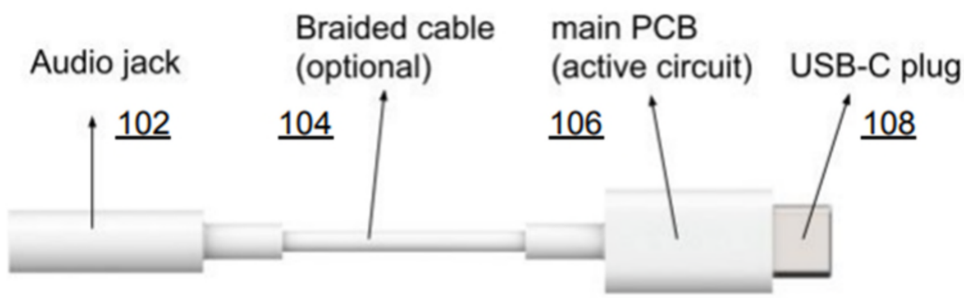

Fig. 1: An example of a current USB-C to 3.5 mm adapter

Fig. 1 illustrates an example of a current USB-C to 3.5 adapter. In this design, the main PCB (106) is next to the USB-C plug (108). A braided cable (104) connects the audio jack (102) to the USB-C PCB. The adapter includes two parts:

1. **USB-C portion:** The USB-C portion of the adapter transforms digital signals from the device into analog high-fidelity audio output that plays through a 3.5mm interface. This portion includes a USB-C plug connector (108) and a printed circuit board (PCB) (106). The PCB includes electrical components such as audio codec, power management IC, EEPROM storage IC, etc. The PCB also include peripheral parts such as capacitor, resistor, inductor, ferrite beads, etc.
2. **Audio jack:** The audio jack (102) allows a traditional 3.5mm earphone to be plugged into the adapter.

Further, some adapters may optionally include a braided cable (104). This type of USB-C to 3.5mm adapter has several drawbacks:

Vulnerability to radio frequency (RF) radiation interferences

When the adapter is plugged into a phone, the USB-C PCB is positioned next to the lower antennas of the phone. The RF radiation gets coupled to the USB-C PCB and can corrupt the electrical signals. For example, the USB signal integrity may degrade, and the audio codec may get desensitized by the strong RF coupling. A solution is to add a metal shell to shield the entire PCB from RF radiation; however, this adds to the cost of the connector.

Desensitization to phone

The bottom antennas of a phone are often the primary antennas that transmit and receive cellular signals. As the USB-C PCB of the adapter is close to the bottom antennas in the phone, radio noise from the PCB including clock harmonics directly couples to the phone antenna. As a result, the cellular receiver inside the phone can be desensitized. Desensitization can significantly impact user experience as users may not be able to receive calls while using a headset.

Coexistence

Proximity of the PCB to the bottom antenna can also lead to the high cellular power directly coupling into the audio codec. Rectification of the radio signal adds noise to the audio band. As a result, the user may experience substantial noise while making a call using a headset plugged into the adapter.

Antenna detune

When the USB-C PCB, with a big metal shell is close to the bottom antenna of the phone, the antenna detunes and may require impedance tuning. To perform such tuning, the phone may need to include additional antenna tuning circuitry to tackle the detune effect.

DESCRIPTION

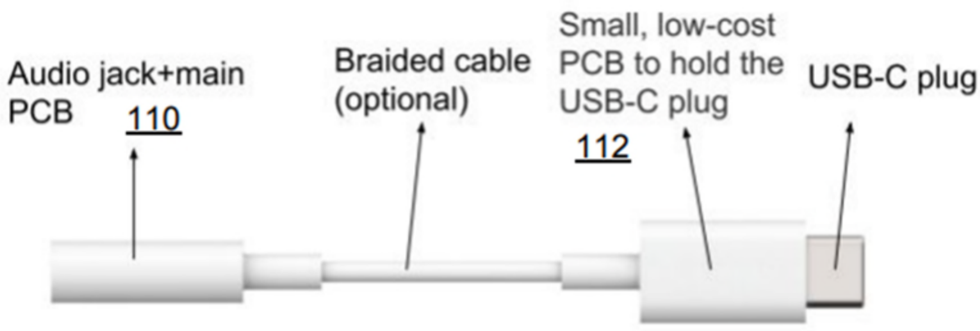

Fig. 2: Adapter with main PCB in audio jack

Fig. 2 illustrates an adapter that includes the main PCB in the audio jack to address drawbacks of the current adapter designs. The main PCB (110) is integrated with the 3.5mm audio jack. A small, low-cost PCB (112) is used to hold the USB-C plug.

On the USB-C side, the adapter includes the USB plug connector. On the audio jack side, the adapter incorporates audio codec, power management IC, EEPROM storage IC, and other peripheral components such as capacitor, resistor, inductor, ferrite beads, etc.

By moving the PCB away from the phone, the design illustrated in Fig. 2 addresses the problems existing in the traditional adapters. The PCB is less vulnerable to the noise radiations from the phone. Instead of analog audio signals, per the techniques of this disclosure, all signals along the wires from USB-C plug to audio jack are either power or digital. Such signals are more robust to noise sources. Moreover, with the USB-C PCB away from the USB-C connector, issues such as desensitization, coexistence, and detuning effects are alleviated.

In the design illustrated in Fig. 1, the main PCB is next to the USB-C plug. Multiple audio signal wires go from the main PCB to the audio jack. Twisting microphone signal with the ground signal is necessary to mitigate common mode noise for Audio Breakthrough, which is a compliance requirement. In the design of Fig. 2, twisting microphone signal with the ground signal is not necessary, since only USB signals run from USB-C plug side to the audio jack.

Further, the use of Braided cable from audio jack to USB-C PCB eliminates noise coupling. The use of such a cable may be optional depending on the specific signal.

CONCLUSION

This disclosure describes an improved design of a USB-C to 3.5mm adapter. In the design, the USB-C PCB is moved away from the device end to make it less vulnerable to the radiations from the device. The techniques further include propose use of a braided cable between the main PCB and the USB-C plug to shield from noise coupling. Signals along the wires from USB-C plug to audio jack are either power or digital and are robust in the presence of noise sources. Further, only USB signals run from USB-C plug side to the audio jack, eliminating the need to twist the microphone signal with the ground signal