

Improve Efficiency in TWS and Hearing Aid Earbuds with a Buck-Boost Converter

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True wireless stereo (TWS) earbuds are getting very popular since the first generation emerged in 2015. TWS earbuds are similar to wireless earbuds, but they do not have any connecting wires. Each earbud has an independent battery and a dedicated charging case is used to recharge them. Compared to their wired counterparts, TWS earbuds are lighter, more portable, and more discrete.



Figure 1. True Wireless Stereo Earbuds

A dedicated charging case contains a larger battery to recharge the smaller batteries in the earbuds. The earbuds can be connected to the case either via contacts or wirelessly. Consider the case with contacts, as shown in Figure 1. However, in both cases, several performance parameters become important for the best user experience:

- The number of times the earbuds can be recharged using the case is important (for example, when you travel and do not have access to electricity).
- The charging speed defines how long you have to wait until the earbuds can be used again.
- The so-called shelf-life is a concern. The charger case must keep its state-of-charge as long as possible, so it can be used after being stowed away for a longer period of time.

- The earbuds must be cool after charging, as it would feel uncomfortable to put warm earbuds into ears.

Using a buck-boost converter with output voltage that can be dynamically adjusted during operation, you can address all these concerns.

Figure 2 shows a system block diagram of the TWS earbuds. Due to size limitations, the earbuds usually have linear battery chargers. These linear chargers need some voltage headroom and have to be supplied with a voltage higher than the battery voltage of the earbud. The battery in the charger case and the earbuds are usually single-cell Li-ion batteries. Depending on their state of charge, their voltage can be between 2.5 V and 4.2 V typically. Therefore, the case battery voltage needs to be increased or decreased to provide proper voltage to charge the earbud batteries. For this, a converter is needed in the charging case.

In the past, the following solutions were used for the converter block in the charging case:

- A boost converter can be used to boost the case battery voltage and supply the linear chargers in the earbuds. However, in this approach, a large portion of power is dissipated in the linear chargers which heats up the earbuds, especially when the earbud batteries are empty.
- A boost converter followed by a linear regulator solves the previous problem by shifting the losses from the earbuds to the case where it is easier to dissipate the heat. However, the losses are still there, decreasing the overall efficiency.
- Boost followed by a buck converter solves the previous problem by replacing the linear regulator with a buck converter. This increases the efficiency, but results in double conversion with two cascaded switching converters.

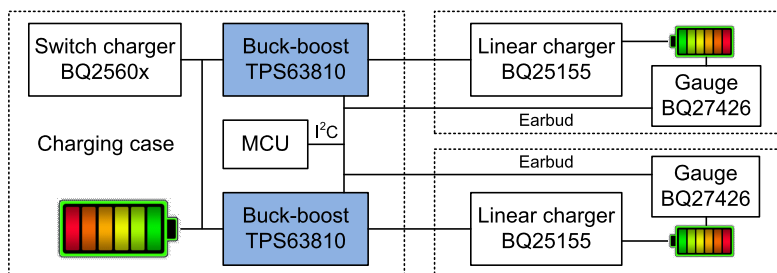


Figure 2. System Block Diagram of TWS Earbuds

Table 1. Comparison of Different Converter Solutions in TWS Charging Case

	BOOST	BOOST + LINEAR	BOOST + BUCK	BUCK-BOOST
Charging efficiency	70% - 72%	70% - 72%	82% - 85%	92% - 93%
Case self-heating	Low	High	Low	Low
Earbuds self-heating	High	Low	Low	Low
Case battery life	Normal	Normal	Better	Best

Using a four-switch non-inverting buck-boost converter, such as the [TPS63810](#), the case battery voltage can be increased or decreased with a single converter stage, maximizing the conversion efficiency. Compared to the former approaches, a buck-boost converter can increase the charging efficiency by 10-30% typically, as shown in [Table 1](#). As a result, the number of recharge cycles out of the charger case is increased. The output voltage of the [TPS63810](#) can be adjusted during operation through I²C interface. This lets you dynamically set the most suitable voltage for the linear charger on the earbud side, minimizing losses in the linear charger and maximizing the charging efficiency. Alternatively, a buck-boost converter with conventional voltage feedback using a resistor divider can be used. The output voltage can be dynamically adjusted as described in the [Dynamically Adjustable Output Using TPS63000 Application Report](#).

Since there are individual batteries in the earbuds, the earbuds can be at different states of charge. For example, you might use a single earbud for making phone calls. As a result, the batteries are at different voltages when you put the earbud back into the case for charging. Using two buck-boost converters, both batteries can be charged independently for the fastest and most efficient battery charging.

References

- [TPS63810 2.5-A Buck-Boost Converter with I²C Interface Data Sheet](#) (SLVSEK4)
- [bq25600 and bq25600D I²C Controlled 3.0-A Single Cell Battery Charger for High-Input Voltage and Narrow Voltage DC \(NVDC\) Power Path Management Data Sheet](#) (SLUSCJ4)
- [BQ25155 I²C Controlled 1-Cell 500-mA Linear Battery Charger With 10-nA Sleep Mode, PowerPath With Regulated System \(PMID\) Voltage, ADC, and LDO Data Sheet](#) (SLUSDO1)
- [BQ27426 System-Side Impedance Track™ Fuel Gauge Data Sheet](#) (SLUSC91)
- [Dynamically Adjustable Output Using TPS63000 Application Report](#) (SLVA251)

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