How to Design Tiny, Long-Lasting, and Safe Battery Products with Switching Chargers

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TEXAS INSTRUMENTS

Introduction

Wearable applications, such as smartwatches and headphones, are becoming increasingly popular. Perhaps the most important design consideration for wearable devices is reducing size and weight in order to provide the user with a more comfortable and enjoyable experience. However, a small solution size typically means the battery capacity is small as well. This presents designers with a challenging tradeoff between small size and long battery life. Additionally, safety is critical, since these devices are worn on a person's body.

The BQ25619 has several features that address the three concerns above, thus making it an ideal choice for wearable applications. The high integration and boost mode of the device allow for a smaller solution size and reduced component count. Meanwhile, the high-efficiency, low termination current, and low battery leakage current help maximize battery runtime, even when using small batteries. Finally, the BQ25619 offers several unique safety features, such as boost overcurrent protection and a highly adjustable JEITA profile, which are not offered by other chargers on the market.

Figure 1. Typical Charging Case Application for Earbuds

Smaller Solution Size

The BQ25619 is a highly integrated, single-chip solution that can operate in buck or boost mode. This allows for a smaller solution size because fewer external components are needed. Several FETs are integrated, including the:

- Input reverse-blocking FET (Q1)
- High-side switching FET (Q2)
- Low-side switching FET (Q3)
- Battery FET (Q4)

Additionally, the BQ25619 integrates the buck charger and the boost regulator into one solution with a single inductor. This eliminates the need for a separate boost converter, and further reduces the total solution size.

The BQ25619 can detect when an adapter has been inserted or removed, and automatically transition between charge mode and boost mode. When an adapter is connected, the BQ25619 operates in charge mode. The device acts as a buck converter and steps down the adapter voltage in order to charge the battery. When the adapter is removed, the BQ25619 operates in boost mode and steps up the battery voltage in order to charge any accessories connected to PMID. The boost output voltage can be set between 4.6 V–5.15 V in order to optimize the efficiency of a downstream linear charger. Figure 2 shows the operation of the BQ25619 in charge mode and boost mode.

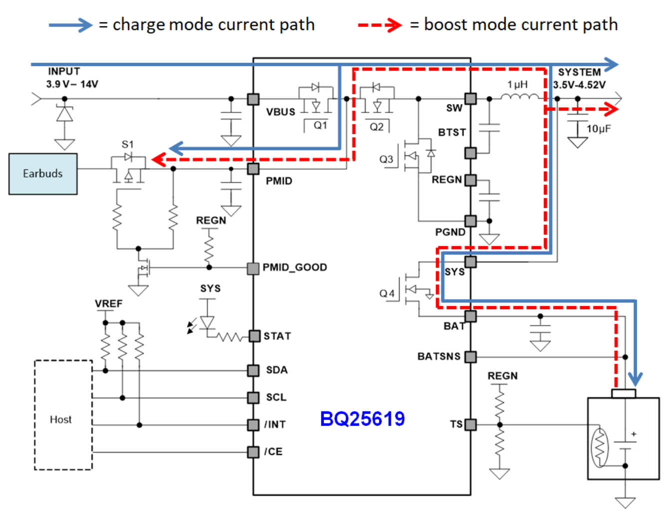

Figure 2. BQ25619 Operation in Charge Mode and Boost Mode

Longer Battery Runtime

The high boost mode efficiency, low termination current, and low battery leakage current of the BQ25619 all help prolong the runtime of the battery. This is highly desirable in wearable applications since the battery is typically small, so efficiently using the entire battery capacity is crucial.

Depending on the operating conditions, the BQ25619 can achieve efficiencies above 96% while running on battery power in boost mode. High efficiency means reduced power loss, thus maximizing the available power from the battery.

The high maximum charge current (1.5 A) of the BQ25619 allows for faster charging, while the low minimum termination current (20 mA) helps extend battery runtime. A low termination current setting fully utilizes the battery capacity, and allows even small batteries to be fully charged.

Finally, the BQ25619 has a very low battery leakage current (typically 9.5 µA during system standby, and only 7 µA in ship mode). Since the leakage current is so low, the battery discharges very slowly when not in use, thus extending the shelf life of the battery.

Safety

The BQ25619 has several unique safety features that are not offered by other chargers on the market, such as PMID_GOOD and an adjustable JEITA profile. The PMID_GOOD pin drives an optional external PMOS FET (S1) in order to provide an extra layer of protection from fault conditions. If a fault such as overvoltage or overcurrent occurs, then PMID_GOOD goes low in order to turn off the PMOS FET and disconnect the boost output from any accessories that are attached to the PMID pin. This feature helps ensure safety, and protects any devices that are connected to PMID.

The BQ25619 also has a highly adjustable JEITA temperature profile that offers more flexibility than other chargers on the market. The BQ25619 can detect the battery temperature through the TS pin and reduce the charge current, and charge voltage, accordingly when the battery is warm or cool. This is crucial because charging a Li-ion battery at the full charge current and charge voltage can be unsafe if the battery temperature is too high or too low. The BQ25619 addresses this concern by allowing the user to set their desired “warm” and “cool” charge current, charge voltage, and temperature thresholds through I^2C control.

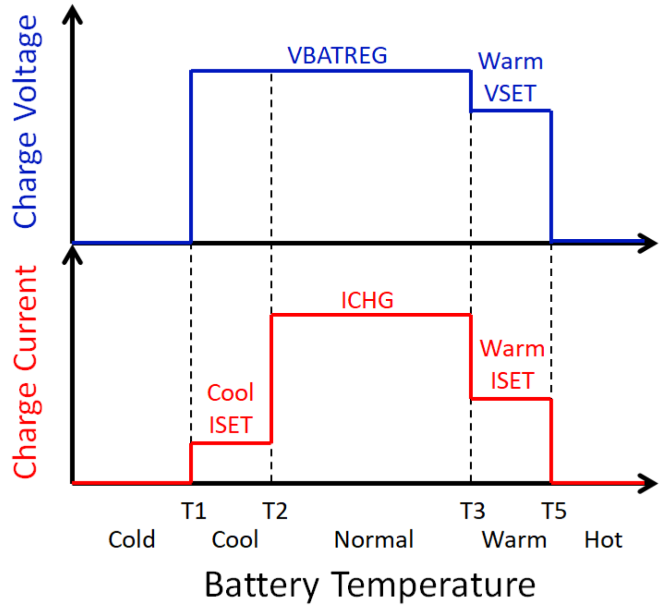

Figure 3. BQ25619 Adjustable JEITA Temperature Profile

Figure 3 above shows the adjustable JEITA profile parameters. The T1 and T5 temperature thresholds are chosen by selecting appropriate TS pin resistor divider values. All the other parameters (T2, T3, VBATREG, Warm VSET, ICHG, Cool ISET, and Warm ISET) can be easily set through I^2C control. This gives designers maximum flexibility when creating custom temperature profiles that best suit their application.

Conclusion

The BQ25619 has several features that reduce the total solution size while simultaneously maximizing battery runtime and prioritizing safety. These features make the BQ25619 an ideal choice for use in wearable applications.

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