Find the right PMIC for your wearable systems

Bonnie Baker - November 14, 2017

The wearables market is far from saturated. The market share for wearables (smart wrist bands, watches, and jewelry) is actually expanding by leaps and bounds. As the follow-on to the conventional watch, wearing a smart device around the wrist has become almost second nature. The health conscious and WiFi-connected smart watch will soon fall out of the “like to have” category and become a “must have.”

Smart watches already identify the time of day and date. Beyond these basic functions, these watches monitor your waking and sleeping movements and execute connections to iOS, Android, and Windows devices (Figure 1).

Figure 1 Smart watches monitor your waking and sleeping movements and execute connections to iOS, Android, and Windows devices.

With all this increased functionality, the smart watch manufacturers are demanding smaller-size, lower-power circuitry with higher functionality. After all, the entire system must easily fit around the wrist.

Staying with the standard power solution

In the smart watch system, the first and foremost electronics low-power dissipation and size problems are with the power supply. Most systems require a battery charger and three regulated outputs for common circuit functions. Power systems with buck and boost converters are the most power efficient. The low-dropout linear regulators (LDO) win as low-noise devices, but power
efficiency can be a weakness.

**Figure 2** Traditional power system with one inductor

The traditional system (Figure 2) uses one inductor to generate a buck output voltage of 2.05V and three LDOs to complete a total array of four power supply rails (3.3V, 2.05V, 1.85V, and 1.2V). The four power supply rails drive the microcontroller, audio receiver and speakers, microphone, Bluetooth transceiver, and sensors. The total dissipated power is 56.8mW.

This system seems to meet design requirements, with a few exceptions. The power supply requires four devices plus one inductor. Included with these devices are the required by-pass capacitors (~7) and resistors (~5). All devices and components must reside on a tiny PCB. The system in Figure 2 requires a PCB area of approximately $6.8 \times 8\text{mm} = 52.8\text{mm}^2$. Additionally, the inefficiency of the LDOs create some uncomfortable heat.

There are two alternatives that can reduce the power in this system: 1) reconfigure the power supply, 2) reduce the power supply rail requirements in the Bluetooth, audio, microcontroller, and sensor circuits. Frankly, it is worth the time to tackle both challenges, but let’s talk about the first; reconfiguring the power supply.

**Apply innovation to your thinking**

In this system, we need four different power supply rails; 3.3V, 2.05V, 1.85V, and 1.2V. In Figure 2, the LDOs create three of the four voltages. LDOs are notorious for their low power efficiencies, as the buck-boost converters have better efficiency numbers.

An optimum power supply system for this application would be to use switching power supplies for at least three of the four rails. The drawback of this approach is that each switcher requires its own inductor. This is where innovation comes into play.

The circuit needs a single power management solution which integrates the four power supply rails: Bluetooth and audio (1.85V), microcontroller (1.2V), sensors and interface (2.05V and 3.3V).
Additionally, it is important that the three buck-boost converters use only one inductor between them to keep the real-estate consumption down.

The power-management-integrated-circuit (PMIC) is shown in Figure 3. The part uses a single-inductor-multiple-output (SIMO) architecture to provide three switching regulator functions while using only one inductor. Note that the SIMO blocks replace most of the low-efficient LDO functions. Additionally, there is a battery charger and power-path management for the Li-ion battery. The total dissipated power in Figure 3 is 35.53mW.

The SIMO regulator

A SIMO converter operates just like a buck or boost converter that is in a discontinuous mode. The SIMO control loop oversees the entire operation of the device. Each SIMO output has its own internal feedback to allow for separate programmable voltage rails.

The SIMO regulator ensures that all outputs use the inductor at different times and in a timely manner. Figure 4 shows a sketch of typical inductor current waveforms during SIMO operation.

![Figure 3 Single-inductor-multiple-output (SIMO) power tree](image)

![Figure 4 SIMO inductor current waveforms for three outputs](image)
The variables in Figure 4 are:

- SSB0 → Output voltage of channel 0
- SSB1 → Output voltage of channel 1
- SSB2 → Output voltage of channel 2
- $V_{\text{IN}}$ → SIMO power supply voltage
- $L$ → Inductor value

Theory versus reality

There are several devices in the marketplace that use the SIMO converter technique. For example, the MAX77650 has three SIMO buck-boost outputs, an LDO, and a Lithium-ion battery charger (Figure 5).

Figure 5 Single-inductor-multiple-output power tree

The system in Figure 5 really fits the bill. The compact form factor of this device allows the user to digitally program their desired power rail values. This power supply requires one device plus one inductor and by-pass capacitors (~8). This PMIC, as it resides in a smart watch, has a PCB with a real-estate area of approximately $4.8 \times 5.4 \text{mm} = 25.9\text{mm}^2$.

Wear your electronics in comfort

Wearable electronics are very demanding and their functionality is constantly changing. Today you
can find a wrist watch that has Bluetooth, audio, and sensor capability and tomorrow will bring even more functions to this wearable device. But, first and foremost is the need for small form-factor, power-efficient electronics, with a long-lasting battery life. The SIMO converter provides wrist watch designs with an efficient, compact, low-power, high rail-density PMIC solution. All these features help the tiny space-constrained gadgets achieve rich, user-focused functionality in a compact body without compromising battery life.

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