Technical Article Release

Extending the Battery Life of Wearable Devices
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Thin, small and lightweight – these are the physical requirements of wearable devices and the reason why the main constraint in wearable technology today is battery life. Conventional batteries that fit the bill, such as lithium-ion (Li-ion) coin cells, may be fine for sensors and other very low power wearable devices, but they struggle to keep up with the demands of more capable wearables such as fitness bands and smartwatches. Most of the smartwatches that are currently available have a battery life measured in days, for example. Furthermore, the much anticipated Apple Watch may be releasing this April with as low as 2.5 hours of battery life.

Figure 1: The Apple Watch is Apple’s first Wearable, featuring revolutionary new technologies and a pioneering user interface. (Photo courtesy of Apple, Inc. PR)

Extending the battery life is critical for these types of devices to gain market acceptance and for the wearables market to achieve the huge projection of 380 million units in use worldwide by 2018. Energy harvesting, wireless charging, battery management, power management, and low power solutions are all possible considerations to extend the battery life of a wearable design. This article will highlight some of the latest products available relating to these areas, to help designers of wearable devices create good power solutions as well as make the most of their power budgets.

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Energy Harvesting Power Management

Energy harvested from the body such as from body heat or motion, or from the environment such as ambient light yields only microwatts to milliwatts - not enough to power something like a smartwatch. Texas Instruments (TI) has a device, the bq25570, which can take the 300 to 400 millivolts that is collected by energy harvesters and boost this power to 3 to 5 volts, which is enough to charge a battery. Now, this wouldn’t produce enough charge to power a smartwatch, but it could extend the runtime. The “Ultra Low Power Harvester Power Management IC with Boost Charger” as the bq25570 is named on the datasheet, also includes a highly efficient nano-power buck converter to provide the option of a second power rail to the system.

Traditional (USB or Adapter) Battery Charging

Charging the wearable’s battery can of course be done the traditional way, by plugging the device into a USB port or adapter. TI’s new bq25100 single-cell Li-ion charger provides a tiny solution that is half the size of existing charger solutions, while supporting low cost unregulated adapters, which may be used in the cost-sensitive wearables market. The charger IC has a high (30V) input rating with input overvoltage protection at 6.5V, amongst other protection features. Maxim’s MAX14676/76A provide another option for battery charge management in wearable applications. The highly integrated MAX14676/76A, described as “Wearable Charge Management Solution ICs”, include not only a linear battery charger, but also numerous low-power power management peripherals to save system board space while extending battery life. These include a 1.8V low quiescent current (Iq) 200mA buck regulator, 3.2V low-Iq 100mA low dropout regulator (LDO), 2.0V “always-on” 50µA LDO, +5V safe output LDO, 6.6V low-Iq 120µA charge pump, and even a 5V to 17V output boost converter to support a wide variety of display options.

Both the bq25100 and MAX14676/76A can be paired with a wireless power receiver/transmitter solution to provide wireless charging capability to a wearable device design.

Qi-Compliant Wireless Charging Solutions

Wireless charging has become very popular for wearable devices due to the convenience. With the regularity that smartwatch batteries need recharging, for example, consumers find it easier to just drop their device on a charging base rather than fiddle with plugging it into a cabled connector. Thus, many wireless charging solutions are available from various manufacturers. Solutions from Texas Instruments are highlighted below.

TI offers a wireless charging solution reference design, TIDA-00318, which is suitable for low power wearable devices. The solution pairs the bq25100 single-cell Li-ion linear charger described earlier, with a bq51003 Qi compliant wireless power receiver for an overall Qi compliant wireless charger solution. Qi is an international standard for interoperability of wirelessly charged devices; Any Qi certified wireless power receiving device, such as the Moto 360 smartwatch, can work with any Qi certified charging base. Thus, any wearable implementing the TIDA-00318 design should be able to gain Qi certification and work with any Qi charging base. The TIDA-00318 is for 135mA charge current applications and is ultra small, fitting in just 5x15mm².

For an even smaller wireless charging receiver solution for wearables, TI has the TIDA-00329 reference design. The design is only 5.23mm x 5.48mm and incorporates your choice of the bq51003 Qi compliant wireless power receiver or the bq51050B/51B Qi compliant wireless power charger. The tiny design can deliver up to 2W of power.
On the wireless power transmitter, or charging-base side of a wearable device’s wireless charging solution, TI provides the TIDA-00334 reference design. The transmitter design employs the bq500212A IC in a small form factor suitable for wearable devices. The power source to the unit is 5V from a Micro USB connector. The low power design supports output power at the receiver up to 2.5W.

The TIDA-00334 wireless transmitter reference design is laid out in a 30mm area that matches the diameter of the round Wurth coil 760308101103, which is slightly larger than a US Quarter or 2 Euro coin.

Figure 2: Wurth Elektronik’s WE-WPCC Wireless Power Charging Receiver Coil is compliant with the Qi standard of WPC.

Power Management

Ultra-low power conversion is critical to achieving optimal battery life in wearable devices. Below are some of the latest low power products or highly efficient dc-dc converter products available.

TI’s TPS727xx series of 250mA LDOs feature ultra-low Iq of just 7.9µA, very low dropout (65mV typical at 100mA, 130mV typical at 200mA, and 163mV typical at 250mA), and excellent line and load transient response. The LDOs also feature high power supply rejection ration (PSRR) of 70dB at 1kHz for quiet performance in RF applications, and are stable with small, low-cost 1.0µF ceramic capacitors. Also now available from TI are the TPS82740A and TPS82740B 200mA step-down converter modules that offer 95% conversion efficiency and consume only 360nA Iq during active operation and 70nA during standby. The tiny modules are available in a fully integrated, 9-bump MicroSiP™ package, which incorporates a switching regulator, inductor and input/output capacitors to achieve a solution size of only 6.7 mm². Step-up, or boost conversion is generally not as efficient as step-down conversion. However, stepping up from the battery voltage is often necessary to power various circuits in the system, especially displays. Maxim has a new 1A step-up converter, the MAX8627 that generates a boosted output voltage from 3V to 5V from a single-cell Li-ion battery, with up to 95% efficiency and consumes just 20µA Iq. Silicon Labs now has the TS33x step-up converters with industry-leading Iq as
low as 150nA. The TS33x steps up input voltage from 0.9V to 3.6V to eight selectable output voltages ranging from 1.8V to 5V.

**Bluetooth, Microcontrollers, and other Low Power Solutions**

In actuality, everything in the system needs to be taken into consideration when trying to extend battery life in wearable device designs.

A common way to save battery life is to offload higher power consuming functions such as processing and displaying to something else, such as a smartphone, tablet, or PC. Bluetooth® Smart, or Bluetooth Low Energy, is automatically built into most new smartphones and thus is the de facto standard for wireless communication for wearables. Bluetooth can also be used to send information from the smartphone to the wearable, and TI offers a “Bluetooth Wearable Watch Development System” called the **TI Meta Watch™** that enables rapid development of connected watch applications. The Meta Watch SDK/API makes it easy for the watch to display information from mobile applications or Internet services. The development system includes a nice watch with a display, as well as a 3 ATM water resistant stainless steel case, a leather strap, a mineral glass crystal, a vibrating motor, a three-axis accelerometer, and an ambient light sensor.

*Figure 4* **Texas Instruments Meta Watch™ Bluetooth® Wearable Watch Development System** enables rapid development of “connected watch” applications.

The Meta Watch platform is optimized for low power operation and is based on the TI 16-bit **MSP430™** ultra-low-power microcontroller (MCU) and **CC2564 Bluetooth host controller** interface solution.

The choice of MCU is important to the power management of wearable devices, as efficient MCUs can process data quickly and go to sleep, saving power. Low power sleep modes are also beneficial to minimize power consumption when the system is not in use. Designers of wearable devices today have a broader range of MCUs available to them than ever before, as 32-bit MCUs have become cost-competitive with 16-bit MCUs. **ARM’s Cortex-M series** of 32-bit processor cores optimized for cost and power sensitive MCUs are seeing success in the wearables market. Ranging from the ultra-low power Cortex-M0 and M0+ to the high-performance Cortex-M7, the ARM Cortex-M series is a broad offering to meet the differing needs of various wearables. MCUs based on the ARM- Cortex-M series are available today from many different suppliers, including **Texas Instruments**, and **STMicroelectronics** with the large line of STM32 MCUs, including the **STM32 L1** and **L0 Ultra-Low-Power MCUs**.

And finally, consideration must be given to the power management of the myriad of sensors that are incorporated into wearables. Sensor technology improvement is one of the developments that is fueling
the wearables market. But we mustn’t forget the peripheral circuitry for sensors. STMicro addresses the sensors in wearables with low power sensor signal conditioning, by offering the OA4NP quad, low power op amp that consumes just 580nA per channel (at 1.8V power supply).

This is just a small slice of low power management technology available today and how products can work together to create the ultra-low power systems that enable the emerging wearables market. However, it’s important to realize that ultra low power devices don’t stop with wearables; new low power technology also drives other applications where battery life and/or energy harvested energy is critical to conserve.