Power Management Solutions for Portable Medical Applications

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The availability of portable medical equipment to diagnose a health issue inside or outside of the doctor’s office or hospital is rapidly increasing. Portable healthcare devices help medical professionals to monitor vital signs, restart the heart, and look inside the body with ultrasound before the patient is taken to the hospital. The goal is to offer home healthcare devices that are easy to use, interoperable and offer diagnostic value so that insurance will cover the cost. This eliminates the need for a hospital visit and reduces healthcare costs. Portable medical equipment is also used by patients at home to monitor blood pressure, lung capacity, glucose levels, and log heart events. Many of these portable medical devices come with USB or wireless data connections, allowing medical professionals to monitor patients 24/7 in the hospital and at home. Also, the Continua Alliance is establishing the interoperability protocols based on USB, Zigbee and Bluetooth standards that will accelerate the adoption of these communication interfaces. The requirements for increased computing power, smaller size, and longer run time when operating on battery power make the power system design for portable medical devices very challenging. The power system has an effect on battery size, run time, standby time, bill of material cost, and reliability.

Portable medical systems cover an extremely wide range of applications, including blood pressure monitors, glucose meters, pulse oximetry and ultrasound. Some applications require the hardware to operate for long periods of time, while other applications require a short operation time and a long standby time. As different as the end applications may be, most portable systems can be simplified to a core set of functions: a sensor to collect data, a microprocessor with application specific software to analyze the data, memory to store the software and data, and a data connection to access the results. Figure 1 shows a typical handheld portable system with keypad and display. Portable systems must be capable of maximum processing power when connected to the power line without generating excess heat, and maximum battery lifetime when portable. Maximum battery life (the time that the portable device can operate from the battery before recharging or replacement is required) is determined by power system elements such as battery capacity, power system efficiency, and power management software. Battery life can be maximized only when all of these power system elements are working together to reduce the drain on the battery. Most high-performance portable systems are powered by rechargeable Lithium-Ion batteries with a nominal 3.6-V output.

Portable systems contain multiple integrated circuits, each with its own optimized semiconductor process and operating voltage requirements. ICs designed for portable applications use a lower operating voltage than supplied by the battery, creating the need for step down voltage regulators. The most popular regulators in use today are low dropout (LDO) and step-down switching regulators, as shown in Figure 2. An LDO consists of a voltage reference, error amplifier, voltage divider, and a pass transistor. The low dropout regulator is a simple way to produce a lower dc voltage from a higher dc voltage using only two external capacitors. Unfortunately, LDOs can be inefficient when Vin is much greater than Vout because power not delivered to the load is lost as heat. LDO efficiency is approximately (Vo/Vin)×100%. The LDO has no way to store significant amounts of unused energy, so power not delivered to the load is dissipated as heat within the LDO. For example, a 2.6-V LDO connected to a 3.6-V battery has 72% efficiency. In addition, the LDO’s quiescent current and enable functions are important to review when specifying LDOs for maximum power savings. Low quiescent current (Iq) increases system autonomy by consuming less power when the system is in idle mode between normal operation and sleep modes. An enable input pin permits the LDO to shut down, consuming less than 1 µA in sleep mode and increasing battery life. The ADP150 is a good example of a low Iq LDO.

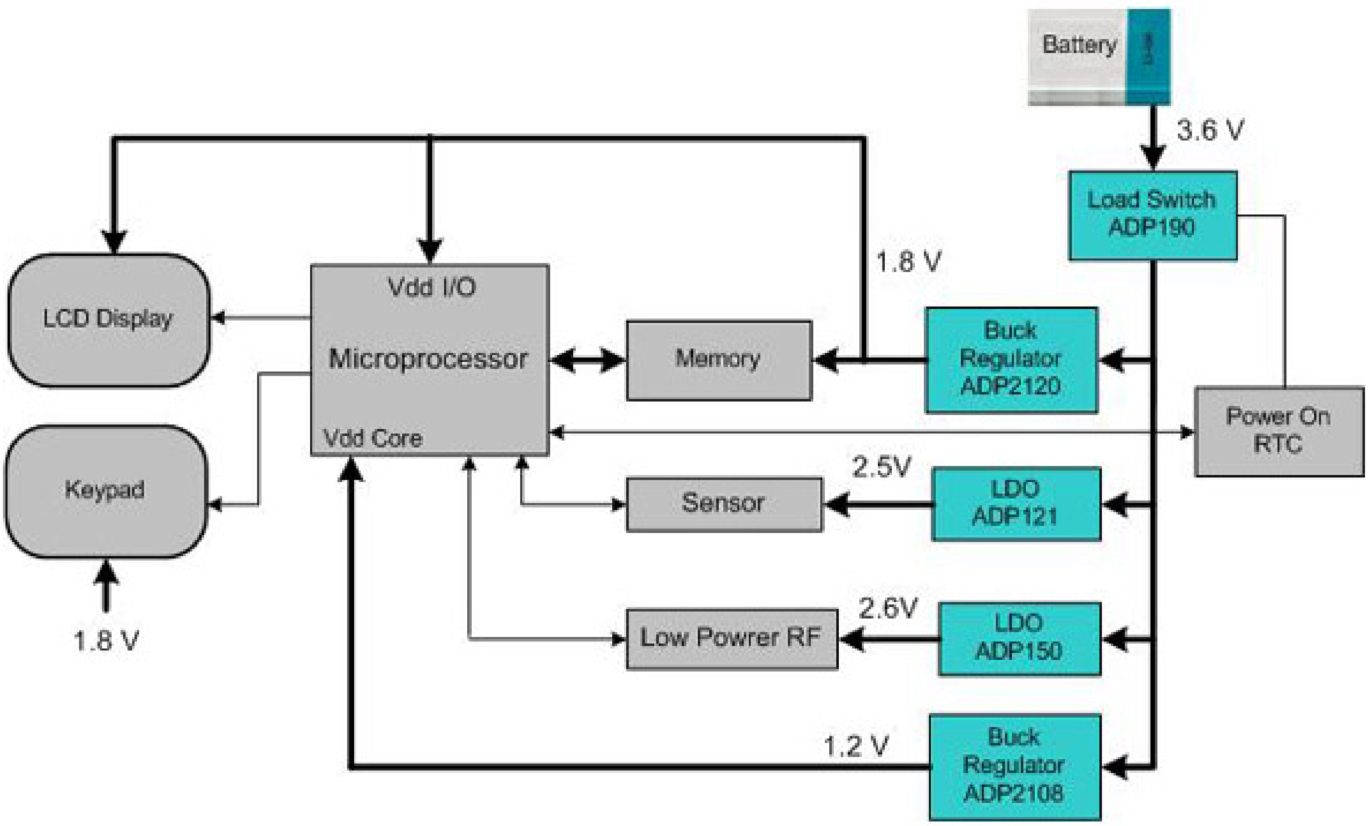
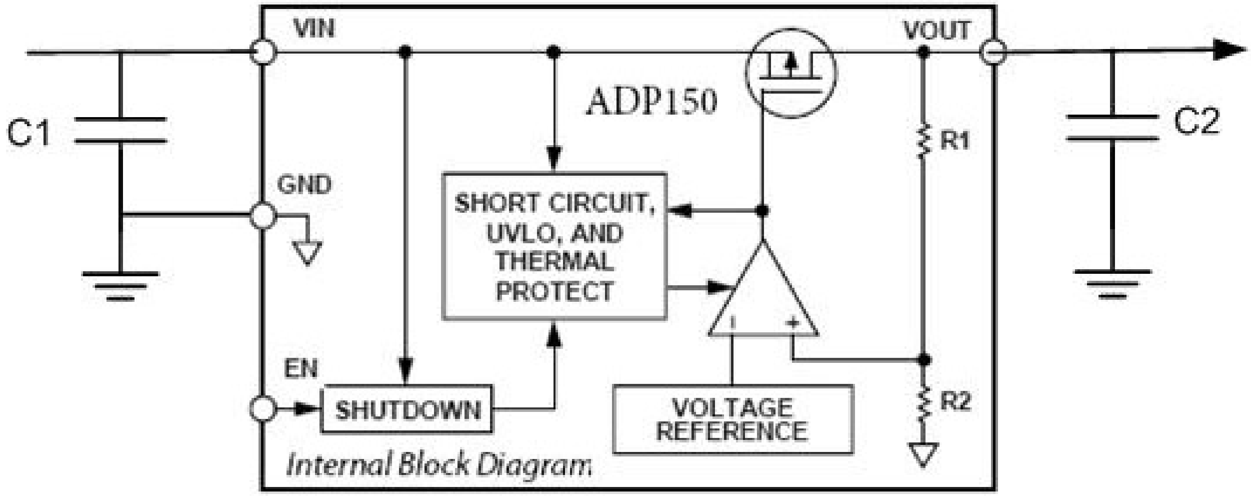
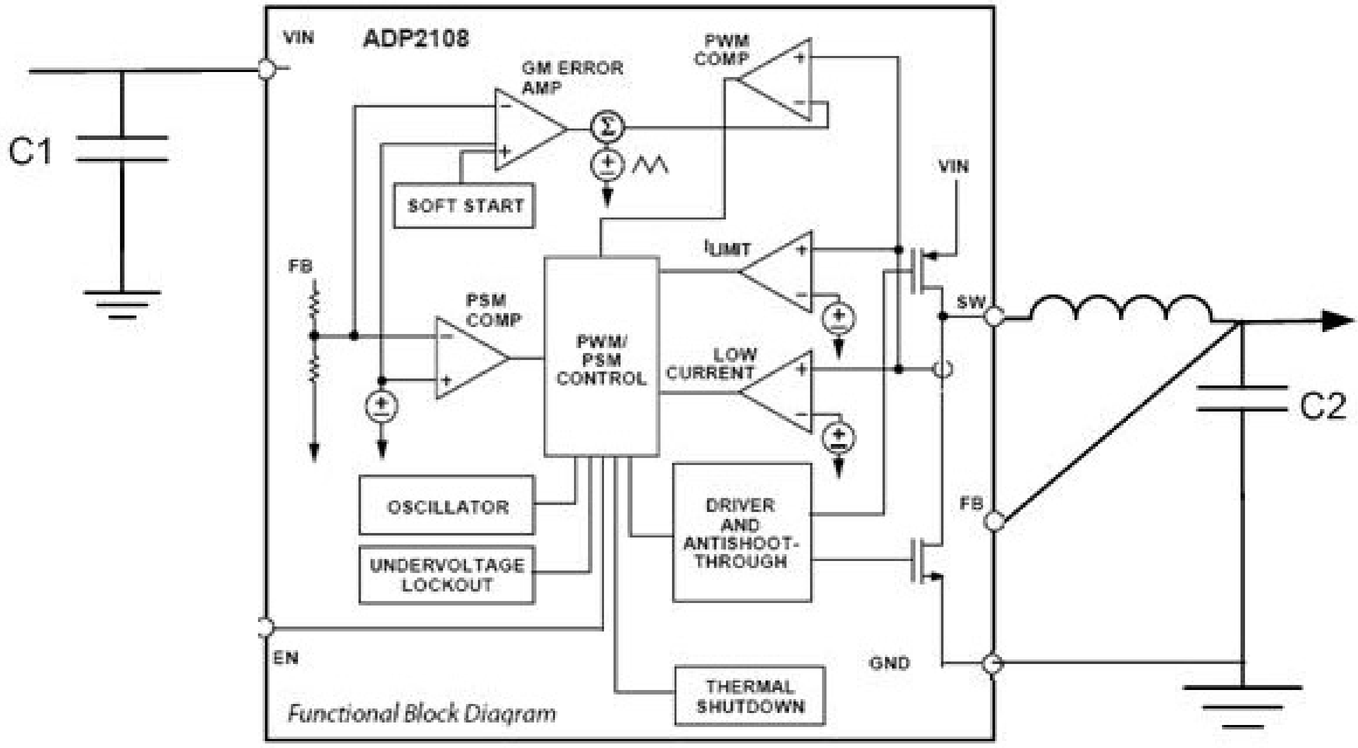


Figure 1. Generic Handheld Portable System.

When the supply voltage is much greater than the operating voltage, switching dc-to-dc converters are a better choice for high efficiency because they transform one dc voltage to another, temporarily storing energy in an inductor's magnetic field and then releasing it to the load. Portable switching regulators operate at frequencies from 500 kHz to 3 MHz. The switch-mode dc-to-dc converter comes in many topologies; synchronous step down buck regulators with internal switching elements, used when the output voltage is much lower than the input voltage, are the most popular in portable systems. System efficiency can be improved by replacing a low dropout regulator (LDO) with a buck regulator. For example, when using an LDO to lower the system voltage from 3.6 V to 1.2 V to power a microprocessor core with a load current of 300 mA, the LDO efficiency is approximately 1.2V/3.6V × 100%, or 33%—with 67% of the input power lost to heat. To improve efficiency and lower the operating temperature, replace the LDO with a buck converter such as the ADP2108. The buck achieves higher efficiency because energy is stored in the inductor's magnetic field. Using ADIsimPower™, the ADP2108's efficiency for the same conditions is 80%, an improvement of 48% over the LDO. Design engineers will find the ADP2108's small solution size, using only two decoupling capacitors and a 1 µH chip inductor, is almost a drop in replacement for the LDO. Additional power saving features to look for when specifying buck converters are low quiescent current, enable, and a power saving mode when the load current is small.



LDO



DC-DC Converter

Figure 2. Functional Block Diagram for LDO and Buck Converter.

Optimizing portable system hardware efficiency will not achieve optimum battery life without also optimizing the power management software. The demand for increased computation power to run the complex application-specific software requires power-hungry high-speed microprocessors. Decreasing processor speed reduces power consumption and extends battery runtime by decreasing software performance. System architects can improve system efficiency by selecting the optimum processor speed for the application. Another way to save power in portable systems is to shutdown unused subsystems such as the microprocessor, display backlighting, data port, and sensors between measurements, using the regulator's enable input or load switches such as the ADP190 or ADP195 to isolate the battery as shown in Figure 1.

When designing portable power systems there is no one size fits all solution. There are many ways to solve the problem of long battery life, and some will work better than others. Using the techniques described in this article will improve system efficiency, lowering internal temperatures and operating cost for both portable and line powered medical equipment.

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