



APPLICATION NOTE 3174

Selecting Power Management for Cellular Handsets

Abstract: New generation cellular handsets are smaller than previous generations, capable of PDA functions, delivering e-mail, instant messaging, and web browsing on a larger, more colorful display. Some models include FM radios, MP3 players, and digital cameras.

Even with increased functionality, consumers expect enduring battery life without an increase in size. Cramming more into a smaller handset while draining less power has propelled power-management design into a critical role. To meet the challenge, analog IC manufacturers have developed smaller, higher performance power-supply solutions.

Power-Management ICs

At the heart of most wireless handsets beats a power management IC (PMIC). The PMIC handles most of the power-supply requirements and other blocks such as interface or audio. Leading analog semiconductor manufacturers provide PMICs as full custom, semicustom, and/or standard products, usually using a 5V submicron BiCMOS process optimized for mixed-signal and power supplies. Any block that is not already integrated elsewhere in the handset is a candidate for integration in the PMIC; some moderation is advised, however, as shown in **Figure 1**. There are reasons not to integrate a particular block: 1) the block may be cheaper or smaller if designed using a different process; 2) the block may change from one design to the next due to advances in technology or changing customer requirements; 3) the block may not be common across platforms; 4) the block may present an aggressive design challenge/risk to the schedule; and 5) the block may be ill-suited for integration due to performance reasons such as noise coupling.

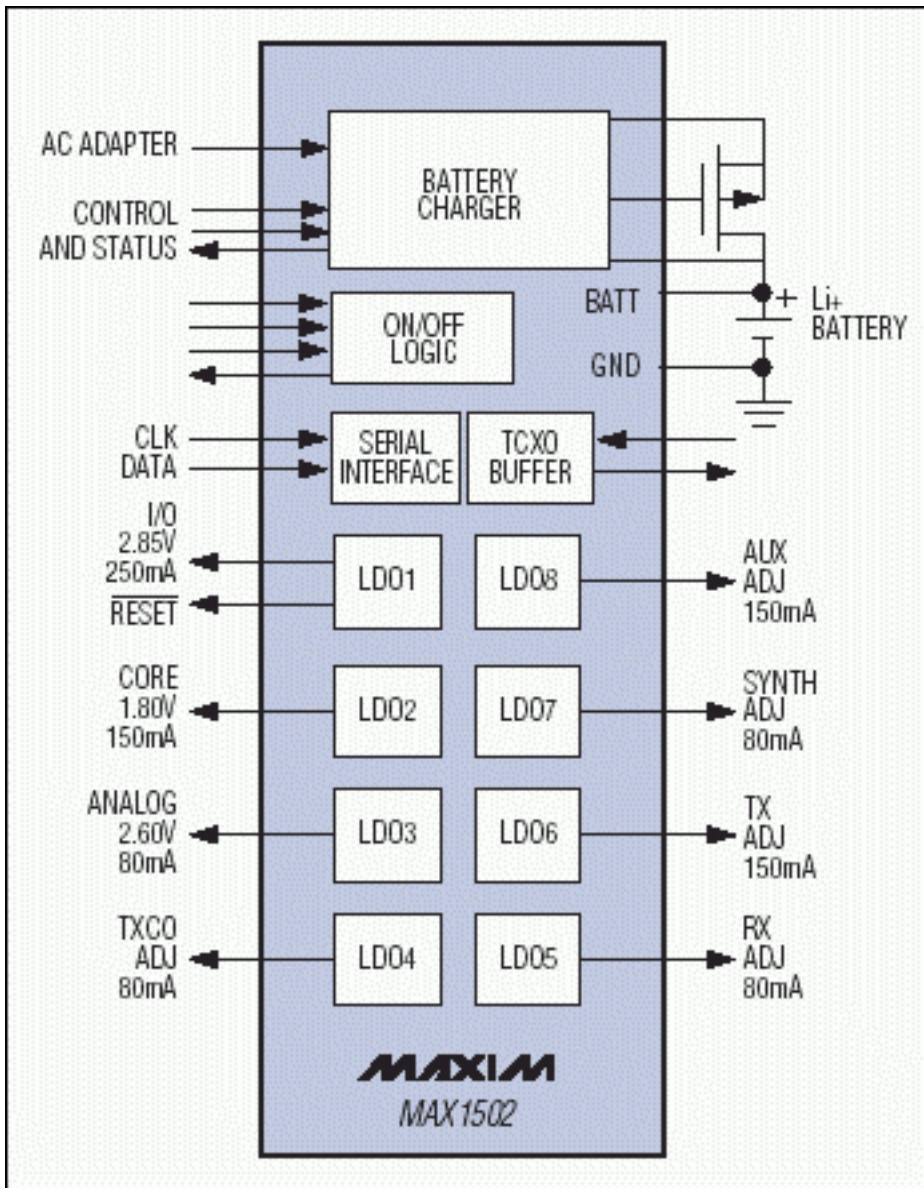


Figure 1. An example of low-risk, constrained integration, the MAX1502 standard-product power-management IC integrates only the most common blocks required to support popular CDMA chipsets.

Nonetheless, the reasons to integrate as many blocks as possible into the PMIC are obvious cost and size savings, especially when the integration is common for a significant volume of handsets. Risks may be managed by gradually increasing the integration over successive designs.

Low-Dropout Linear Regulators

Cellular handsets typically require from 5 to 12 individual low-dropout (LDO) linear regulators. This number is high, not because there are this many individual voltages, but because the LDOs also act as on/off switches with powersupply rejection ratio (PSRR) to prevent noise coupling. Most LDOs are integrated in the PMIC, but a few discrete units remain due to PCB layout/routing, the noise sensitivity of specific components like the voltage-controlled oscillator, or the need to power a nonstandard block such as an integrated digital camera. In discrete form, the single 150mA LDO in a SOT23 package was a popular choice for many years. However, today's newer packages, submicron processes, and better designs offer higher performance in a smaller size. You can now get a single 300mA LDO in a SOT23, dual 150mA LDOs in a SOT23, or a single 120mA LDO in a tiny SC70 with both standard and extra-low-noise (10 μ V_{RMS} and 85dB PSRR) variants. Furthermore, a modern UCSP™ provides the tiniest size possible, while the new QFN package permits the largest die size and provides the highest thermal conductivity in a plastic 3mm x 3mm footprint. QFN packages thus enable higher current LDOs and more LDOs per package. There are even triple, quadruple, and quintuple LDOs, which reduce the demarcation between a discrete implementation and a PMIC.

Stepdown (Buck) Converters for the Processor Core

As simple and small as the LDO is, its major weakness is efficiency, especially when powering a low-voltage circuit. As PDA and Internet functionality have increased in cell phones, more powerful processors are applied with ever-decreasing supply rails ranging from 1.8V down to 0.9V. To keep battery current in check, an efficient stepdown switching regulator should power the core. Low cost, small size, high-efficiency, low-quiescent (standby) current, and fast transient response are design concerns. Reconciling this difficult grouping of characteristics demands experienced analog design and some ingenuity. Today, only the leading analog semiconductor manufacturers offer appropriate buck converters in small SOT23 packages with 1MHz or faster switching to allow small external inductors and ceramic capacitors.

Stepdown (Buck) Converters for RF Power Amplifier

In the mature Japanese cell phone market, buck converters are also used to power the CDMA radio's power amplifier (PA) with varying VCC supply voltage in response to varying distance from the base station. When multiplied by the transmit-probability density function, a buck converter can save an average of 40mA to 65mA of battery current. The amount of current saved depends on the number of output voltage steps, the PA's characteristics, and whether transmitting voice or data in an urban or suburban environment. Based upon Japanese success and pioneering efforts at one European WCDMA innovator, now Korean, American, and other European cell phone makers are testing or designing with switching regulators. Buck converter requirements are very small size, low cost, low output ripple, and high efficiency. Again, SOT23 converters are a good choice. To keep dropout as low as possible, a discrete low- $R_{DS(ON)}$ P-channel MOSFET is usually used to power the PA directly from the battery when transmitting at high power. To further reduce overall size, the newest stepdown converters (e.g., the MAX8500 family) integrate this additional FET.

LEDs, LEDs, and More LEDs

For wireless handsets with color displays, white LEDs now dominate backlighting applications due to circuit simplicity and very high reliability. Efficiency exceeds that of halogen but does not yet equal that of fluorescent bulbs. Modern designs typically utilize three or four white LEDs for the main display, two white LEDs for the subdisplay (in the case of a clamshell design), and six or more white or colored LEDs behind the keyboard. If camera is integrated, there may be four more white LEDs for flash/strobe and mpeg movie light. That totals up to 16 LEDs in one handset, all of which need to be driven with a constant current.

Years ago, the first generation of color handsets in Japan used inefficient 1.5x charge-pumps and ballast resistors. (That solution effectively discarded the 40mA they struggled to save by adding a buck converter to the PA.) Today, most designs use an inductor-based boost converter for much higher efficiency. The newest 1x/1.5x chargepumps, however, obtain similar high efficiency without the inductor, but with more wires to the LEDs. Because the market for white LED power is so large, there are an overwhelming number of ICs available. Concerns are high efficiency, small external components, low input ripple (to avoid coupling noise into other circuits), a simple dimming interface, and any other feature that reduces cost or adds reliability, such as output overvoltage protection. Some PMICs include a white LED power supply, but usually do not power multiple displays or the camera strobe, or they may be inefficient or switch too slowly. This would require large inductors and capacitors and generate large input ripple. Adding a discrete IC to work in conjunction with the PMIC or finding a highly integrated discrete solution (such as the MAX1582, **Figure 2**) is often required.

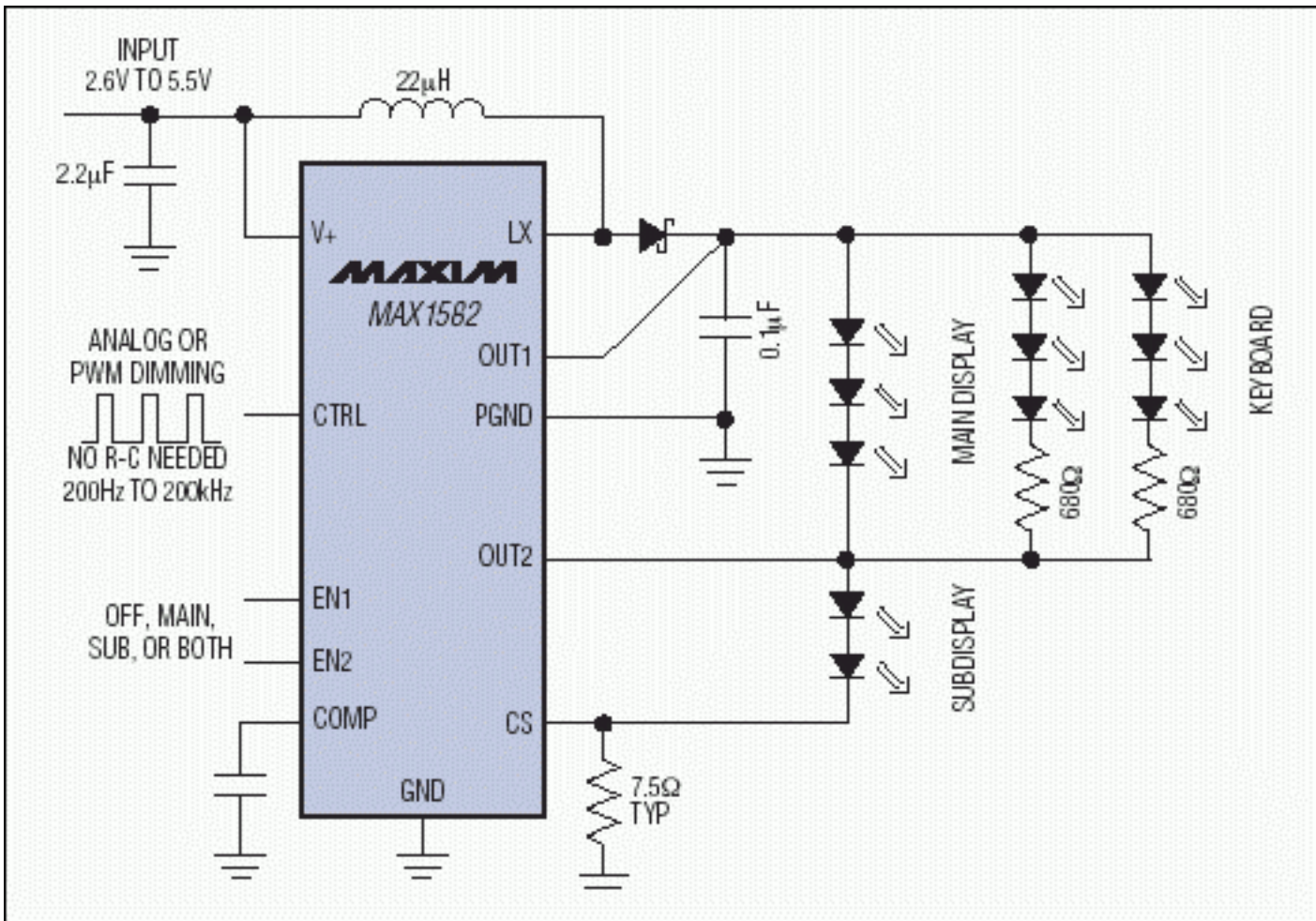


Figure 2. Because LED backlighting is one of the highest consumers of battery power in a handset, the MAX1582 utilizes a high-efficiency boost converter topology to illuminate the main display, subdisplay, and keyboard.

Battery Charging

Nearly every wireless handset charges its three NiMH cells or single Li+ cell with a simple linear charger. Most often the charger is integrated in the PMIC, although the current-sense resistor and/or pass transistor may be external for simplicity. There are many options for keeping thermal dissipation in check: 1) charge at C/4 or slower; 2) make the wall adapter output somewhat resistive so most of the voltage drop occurs there; 3) use pulse-charging and a current-limited wall adapter; 4) include feedback to regulate the wall adapter so that the voltage drop across the pass transistor is constant; or 5) add a constant thermal-control loop that throttles back the current to maintain a constant die temperature, which is only practical when the pass transistor is on the PMIC. Discrete charger ICs may offer some flexibility, but the benefits are largely reduced for cell phones because an integrated charger can be easily reprogrammed through the PMIC's serial interface to accommodate varying battery chemistry or capacity.

A similar article appeared in the May 2003 issue of *Connecting Industry* (UK).

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