Power management in limelight

By Paul Errico
Marketing Engineer
Interface Product Group
Analog Devices Inc.
Wilmington, Mass.
Matt Smith
Senior Applications Engineer
Interface Product Group
Analog Devices Inc.
Limerick, Ireland

The growth in portable equipment, particularly laptop PCs and wireless communication gear, has brought voltage-monitoring and power-management functions from the back room into the limelight. Equipment ranging from simple handheld receivers, monitoring instruments and personal digital assistants up to high-performance laptop computers poses unique design challenges.

Line-operated equipment—ranging from industrial controllers to high-end medical imaging systems using ultrasound—also need power-management techniques. Thus, maximizing system performance and increasing functionality while minimizing power consumption will be a critical design challenge into and beyond the millennium.

Designers are employing a number of power-management techniques for both portable and line-operated systems. Simple voltage-reduction tactics use a combination of software and hardware methods such as dynamic clock management and reduced-power "suspend" or "standby" modes.

Other ways to attack the problem include single-supply linear or mixed-signal ICs, high-efficiency dc-dc converters, low-dropout regulators, battery chargers and other voltage-conversion products. Other classes of products that manage power include battery-backup switchovers, temperature sensors, watchdog timers, reset generators, charge pumps, voltage-monitoring and standby/sleep-mode interfaces.

Some might ask if it wouldn't be simpler to use a switch to remove the load from the power source when the system has to operate in a low-power mode, thereby reducing the total power consumption. That technique might be applicable in all-digital architectures. However, in high-resolution data-acquisition systems such as basestations, medical instrumentation, PC data-acquisition cards or industrial controllers, power must be applied to precision voltage references hundreds of microseconds prior to any measurements.

Low-voltage ICs

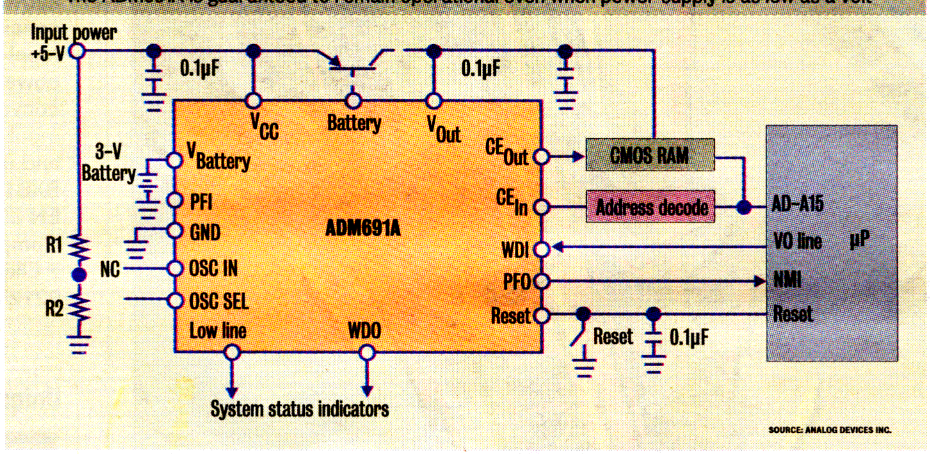
In the quest for reduced power consumption across the board, low-voltage ICs have become the norm. Products specified for operation at 3.3, 3 and 2.7 V and below are now widely available. Operating at low battery voltages, where noise margins are compromised, voltage-monitoring and supervisory ICs play an increasingly crucial role.

Supervisory ICs range from simple three-terminal power-on reset generators like the ADM809 from Analog Devices to much more complex products featuring multi-supply monitoring, watchdog time-out monitoring, memory protection and even battery-backup switching capabilities.

Although residing behind the scenes, the supervisory IC has a critical role to play—especially when things go wrong. Indeed, the device is unique in that it must continue to operate correctly even when all other circuitry has given up—that's when protection is needed the most. For this reason, supervisory ICs are usually independent and are not embedded with other functions.

Low-voltage monitoring chip keeps tabs on microprocessor

The ADM691A is guaranteed to remain operational even when power supply is as low as a volt



The supervisory IC is generally specified to operate well beyond the range of the circuitry it is protecting. For example, low-voltage monitoring ICs such as the ADM691A are guaranteed to remain operational with supply voltages as low as 1 V. During power-up, this guarantees that the supervisory circuit has established control well before the remaining circuitry is enabled. Similarly, during power-down or power failure, the IC continues to protect even when the remaining circuitry has become unstable or unpredictable.

Additional power-monitoring features on products such as the ADM69XA provide early warning of impending power failure. By accurately monitoring the preregulator voltage, it is possible to achieve an advance warning of several crucial milliseconds. In those moments, the supervisory IC can do an orderly system shutdown prior to losing power completely.

Once power has returned, systems that need to resume activity at the point of power loss can use the ADM691A, which features battery-backup switching to preserve RAM contents during temporary power loss. Usually a 3-V lithium battery is switched in to provide short-term memory protection. Since power consumption is especially critical during battery backup, the supervisory IC should automatically disable some of its unused functionality, thereby preventing unnecessary additions to the power figure.

Supervisory ICs also monitor for correct software and code execution, as well as for power-supply glitches, brownouts or failures. Strictly speaking, this is not a power-management problem, but is often induced by one. A watchdog timer guards against power glitches that escape the attention of the voltage monitor and send the microprocessor into unknown territory.

The watchdog expects attention. If it is not forthcoming—possibly as a result of a system stall—the watchdog supervisory circuit can reset the system to a known safe state. Software monitoring therefore goes hand in hand with hardware monitoring and control.

Voltage monitoring

Power-supply voltage monitoring is an increasingly important diagnostic tool for both line- and battery-operated systems. This is especially true in mission-critical applications like LAN servers, medical instrumentation and communication equipment. It is no longer acceptable to have internal power supplies drift astray without prior warning. Products ranging from window comparators to more intelligent chips based on analog-to-digital converters measure power-supply integrity.

One example of a window-comparator solution is the ADM9264, which monitors both undervoltage and overvoltage on four separate supplies—12, 5, 3.3 and 2.7 V—as found on a PC motherboard, as well as two additional inputs. The advantage of using window comparators as opposed to solutions based on A/D converters is low power and low cost. That's because these circuits provide real-time event outputs instead of using a processor to interpret the output.

With many portable products, packaging is second only to battery life. Thus, many ICs are becoming available in three-pin, space-saving SOT-23 packages up to multilead thin small-outline packages.

Finally, designers of 5-V and 3-V systems also must address high-voltage/high-output-current I/O legacy issues. For example, the ubiquitous RS-232 communica-

▶CONTINUED ON PAGE 103

Power-managing in forefront

▶CONTINUED FROM PAGE 92

tions port lives on despite today's low-voltage requirements and emerging new interface standards such as IRDA (Infrared Data Association) and Universal Serial Bus. Efforts at introducing a low-voltage version of RS-232, called EIA562, did not gain acceptance due to compatibility concerns with existing RS-232 peripherals. The designer must therefore work within low-voltage/low-power constraints while ensuring compatibility with high-output-voltage standards like RS-232.

The most efficient way of simultaneously achieving both goals is by integrating charge-pump technology onto low-supply-voltage ICs. This technology, now mature, allows the designer to continue with a low-voltage (3-V) single-supply design while the on-chip charge pump can develop the bipolar supplies (> ±5 V) required for RS-232 levels.

I/O circuits operating at low supply voltages and with smaller and smaller geometries become more vulnerable to damage caused by external sources such as electrostatic discharge (ESD). A common misconception is that ESD is only a threat during equipment assembly. In fact, ESD continues to be a threat to semiconductors throughout the life of a system. User-accessible I/O lines such as RS-232 ports are constantly being threatened when attaching a printer, modem or simply by accidentally touching the exposed pins.

The European Community has taken steps to standardize the level of protection to external transients on electronic products. ESD protection to previously unheard-of levels as high as 15 kV is required. The conflicting challenge of low-voltage operation, yet high-voltage protection for ICs connected to the outside world, has forced the development of new on-chip protection structures.

New transceiver type

The ADM2XXE family is an example of a new generation of RS-232 transceiver products that operate from a single supply, are fully RS-232-compliant at data rates up to 500 kbits/second and pack on-chip ESD protection structures that provide transient protection up to 15 kV. The devices boast extremely low power consumption coupled with a sleep mode where power consumption drops to less than 5 μW. This scheme facilitates intelligent power management, where the software recognizing that the serial port is no longer in use issues a sleep or shutdown signal.

Remote wake-up is ensured by maintaining limited functionality in the sleep mode. Two receivers stay functional during shutdown so that a wake-up call from an external source can arouse the entire system. Such a technique can reduce power dramatically, with only minor drawbacks. The wake-up time can be an issue with some systems where settling or a warm-up period is required before full accuracy or even functionality is achieved.

Analog Devices' integrated charge-pump converter/RS-232 transceiver is ideal for the application and meets the dual goals of single-supply operation and RS-232 compliance. A charge-pump converter by itself can also be used where local dual supplies are necessary. Charge-pump-type converters are ideal wherever power requirements are modest. They can provide both step-up voltage doubling or inversion using a simple switched-capacitor technique. Coupled with a low-power shutdown mode, they may be the answer to the problems of power distribution and management.