Let the power fall

The tension between system integration and product differentiation is making power management more difficult in portable devices by Luke Collins

Power management has become a major headache for designers. To try to stop the battery draining in a matter of minutes, large sections of a portable device need to be turned off or at least slowed down when they are not heavily used. Doing this effectively needs co-operation between the system functions and the power-management circuitry. But, right now, as there are few standards in place, this level of power management needs co-operation between the suppliers of system devices and those making the power components.

One such scheme is the PowerWise protocol developed by ARM Holdings and National Semiconductor. The companies produced the first version of the specification in October 2003, and revised it in February this year. It defines a two-wire serial bus and a communications protocol that lets a digital device tell the power-management chips exactly the voltage it requires. When a processor needs maximum performance, it can ask for the maximum voltage. This will allow its transistors to switch at their highest possible speed. For less timing-critical routines, the voltage can be wound down. The processor will still run, but more slowly.

Paul Greenland, director of marketing for analogue power management at National, said: "What we've got is the power management equivalent of a fuel injector, where we can give the chipset precisely the right amount of energy for its given operating state and no more.

"The open standard interface has the high bandwidth and low latency required to give you the agile, predictive and adaptive power management you require to maximise the power efficiency of the system."

National has tied up agreements with several chipmakers, which plan to put the PowerWise performance monitor module on some of their devices. These include Matsushita Electric, Philips Semiconductor, Samsung Electronics and ST Microelectronics.

If there really was just one chip controlling all the functions in a high-volume design such as a mobile phone, power management based on protocols such as PowerWise would be relatively straightforward.

Greenland explained that a problem in handset designs is that the SoC vision has not happened, at least not in the way that was envisaged several years ago when it became clear that modern processes could put all the functions needed in a handset into one chip. Although it is possible to mix RF, analogue and all the logic functions using a 90nm process, other factors have cropped up that force the use of multiple chips. It has proved too expensive to try to make a chip that does it all. As a result, handset designers have used the conventional mix-and-match approach.

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"A lot of ancillary applications processors are creeping into the platform as customers specialise their handsets," said Greenland. That means companies such as National have to achieve much more widespread use of their power-control protocols. "We've got to grow relationships and co-operation with those chipset vendors so they include our hardware performance monitors on their ICs, to give the most efficient overall system," he added.

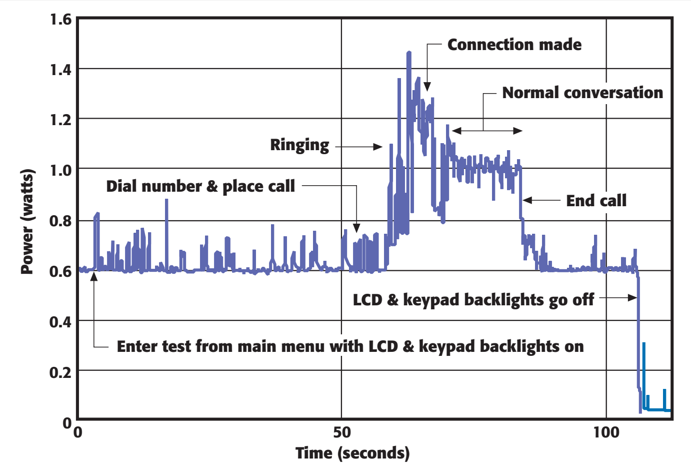
Chris Neil, vice president of the power management business unit at Maxim Integrated Products, claimed integration on the power management side is needed to cope with the needs of complex digitally intensive systems, where processors may be running with radically different clock speeds and voltages that vary over time. "Is the complexity really worth the tradeoffs? I think it is. Why turn on all the lights in your house to full brightness if you are only in certain rooms?"

Neil said traditional approaches to power management have done a lot: "Typical features that have brought our customers value are high efficiency, low quiescent current, low drop-out voltages, which all give us longer battery life. But we need to take another notch down in more active power management."

Neil claimed claimed a typical cellphone controller device integrates six to 12 low drop-out regulators, two or three step-down converters and a charger. These can be adjusted, sequenced, and enabled by an I^{2}C interface so that certain phone blocks are turned off when not in use. Such controllers can also have their own power-consumption profiles, moving between fully active, standby, sleep and deep sleep states to increase battery life.

"This level of control would be difficult if they were discrete," Neil argued.

Although there are moves to bring more power management functions together, Reno Rossetti, senior director of strategy for the analogue product group of →



The power consumption profile of an RF power amplifier

Fairchild Semiconductor said that even highly integrated mass-volume applications, such as MP3 music players, will include a rich load of discrete analogue voltage regulators, bus switches, load switches, regulators, buffers and inverters.

Neil said such components should be chosen on the basis of low quiescent currents and high efficiencies. He also recommended replacing inefficient linear regulators with

Expanding batteries

Changes in battery chemistry will force alterations to the power circuits in portable systems. Uwe Mengelkamp, worldwide director for power converters at Texas Instruments, claimed: "Batteries will span a wider range of voltages."

Chris Neil, vice president of the power management business unit at Maxim Integrated Products, agreed: "It used to be that the end of battery life was about 3V, but these will come down to 2.2V," he said. "This will create another set of challenges, of how to provide power supplies that both step down and step up the battery voltage."

Neil added that the typical lithion-ion battery range is 4.2V to about 2.7V. Many systems are powered from a simple linear regulator or switching step-down converter – sometimes called a buck converter – and shut down when the battery hits 3.0V.

"There are new batteries coming that will extend the lower range down to maybe 2.2V," he added. "This will necessitate step-up and step-down converters that are efficient over the whole battery range, whether above or below the supply."

Mengelkamp said: "People are now looking at lithium manganese batteries. When fully charged they deliver 4.5V, higher than the 4.2V of lithium-ion cells and, where the cut-off of those has been 3.3V, lithium manganese has a cut-off of just 2.3V. This drives the need for a buck-boost converter rather than the simple buck converters that have been used in most systems." He added: "The transition between buck and boost modes has to be managed very well."

Motorola's Razr V3 has a light sensor so that the keypad's backlight only comes on when it is dark.

more efficient high-speed step-down power converters.

There is only so much that power-management chips can do. To conserve power, engineers have to think about how their designs are partitioned. "Battery conservation is one of the main issues in partitioning," said David Milne, CEO of Wolfson Microelectronics, speaking at the recent Fabless Forum organised by the IET and the Fabless Semiconductor Association. "We see pressure all the time to reduce power consumption. Today, the analogue bits consume more power in an MP3 player than the digital."

Partitioning decisions may be relatively simple and may just involve moving digital operations around rather than transferring analogue into the digital domain. For example, designers can put a small microcontroller in their power-management ICs so they do not have to turn on one of the system's main microprocessors to manage system power. Some cellphone designs put the real-time clock on the power-management chip for the same reason.

Another simple power-saving technique is to sense the ambient light around a display and use that information to automatically control its backlight. This is a trick used in Motorola's Razr series of phones, among others.

Neil said some designers are using class-D switching amplifiers on loudspeaker amplifiers to improve their efficiency to the 90% range. The class-D approach uses pulse-width modulation, a primarily digital technique, to provide amplification for an analogue output. Milne said the higher efficiency of the class-D amplifier has been used successfully to avoid the need for fans to remove heat from high-power outputs in home audio systems and digital TVs. The same advantages have led to phone and portable device designers adopting the architecture. However, such amplifiers can make type approval more difficult to achieve in phones because of the digital interference that they can produce.

More efficient organic displays may reduce the pressure on power management.

Wolfson decided to put both class-A/B and class-D amplifiers into an integrated audio codec for handsets. When the phone is playing music and is not being used to make calls, the codec uses the more efficient class-D amplifier. If a call comes in, software in the baseband controller can tell the codec to use the class-A/B amplifier instead, reducing the interference that might be picked up by the RF section.

Experts reckon one of the most important ways of saving power in wireless portable equipment is by paying careful attention to the RF power amplifier (PA) stage, particularly in third-generation (3G) phones based on the wideband code-division multiple access (WCDMA) standard.

Rosetti said: "If you look at the power consumption profile of the PA during a phone call, the peak power is during the connection phase. In 3G phones, power amplifier efficiency is only 20%. I think we can help those guys bring back the efficiency to 50% and even above. Think what you can do with that."

Greenland agreed: "In some handsets they use a switching RF PA, and that is quite efficient. But the non-linearity of the switching RF PA is unacceptable in WCDMA handsets, so they use a linear power amplifier, which is highly inefficient. But if you optimise that linear amplifier by supplying it with an optimised bias voltage, which varies in time and matches the operating point of the RF PA, you can get a drastic increase in the efficiency."

Rossetti applauded the efforts that discrete IC makers, system chip designers and power management specialists are making to eke the last Joule from power sources, but asked whether their effort was misplaced.

"Should we perfect the last horse buggy when the automobile is on the horizon? Should we squeeze the last drop of energy out of batteries or the last percentage point out of voltage regulators? The answer is yes," Rossetti said. "But there are more exciting things we can do, so let's make sure we don't get too fixated with the incremental things we can do." As well as better management of RF PAs, better displays may do more to improve the life of battery-powered systems than strict control over voltages to different parts of a system.

"OLED displays eliminate the backlight so they can be smaller, thinner and consume less power," said Rossetti. Perhaps more important is a move away from the battery altogether. Fuel cells will provide a dramatic improvement in power density.

Rossetti said: "Fuel cells are not going to be easy, but people are doing it. We're going to have our eight hours-plus of mobility. We should work as a team and as an industry to aid that technology to come to maturity."

However, designers are likely to have to deal with batteries in portable systems for some time to come. Commercial methanol fuel cells still look to be some years out and there remain safety concerns about their use on aircraft – one of the places where people will want six or more hours of active use from DVD players and personal digital assistants. ■

Wall warts and all

The concentration today on power savings in portable electronics remains on conserving the battery. But a change to the way that chargers and tethered power suppliers are designed could have a dramatic effect on energy consumption and even help put a big dent in the carbon-dioxide emissions from power stations.

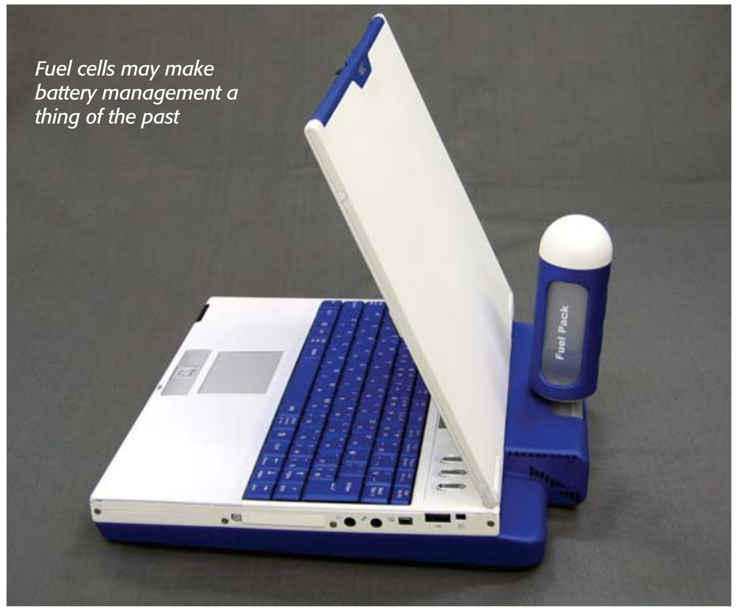
Doug Bailey, vice president of marketing for Power Integrations, said: "The most empowered environmentalist on the planet is the engineer," Bailey explained 900 million cellphones will be produced in 2007, and that with cordless phones that will add up to more than one billion chargers drawing no-load power whether or not the phone is connected.

"That is 1GW of power used for no purpose whatsoever. Engineers have the power to build this waste into what they design, or to take it out. An engineer sitting alone at his desk can make choices, to use a more efficient chipset, a power-management device or design a more efficient power supply. Designing a more efficient power supply is also a very easy way to meet the new voluntary standards and also to save energy.

"One of the wonderful things about being an engineer is that you can effect change. When you are engineer building products and you save one watt in 10 million parts you've saved 100MW and that's cool.

"It's better than waving a placard outside some embassy," Bailey concluded.

Fuel cells may make battery management a thing of the past



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