WHITE PAPER

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AM37x power-saving techniques lead to ultra-low-power for battery-operated applications

Introduction

Wireless telecommunications has given rise to a host of new portable applications. As the wireless industry has evolved, cell phones and, more recently, smartphones have demonstrated how ultra-low power consumption can lead to innovation and the invention of new types of battery-operated devices. Those wireless handsets were just the beginning of the growing demand for the convenience of battery-operated applications in the consumer, business and industrial marketplaces.

Over the years, Texas Instruments Incorporated (TI) has pioneered the transfer of ultra-low power consumption technologies from the wireless industry to the broader and newly emerging segments that require a battery to operate. And with devices like **TI's Sitara™ AM37x ARM® Cortex™-A8-based processors**, system performance need not be sacrificed to achieve ultra-low power consumption.

(continued)

Embedded system designers can have it both ways and, in the end, bring to market much more competitive battery-operated products, including portable data terminals, point-of-sale devices, handheld gaming consoles, media players, portable medical diagnostic equipment, smart watches, communications hot spots, battery-backed home and building automation, navigation systems, test and measurement devices, smart displays, human machine interfaces (HMI) and many more.

Power management methods

Several techniques can be implemented to reduce active and static power consumption. The most prominent and effective of these methods are the following:

Dynamic Voltage and Frequency Scaling (DVFS)

The typical battery-operated device does not require the system's full processing capabilities at all times. That is, not all of the applications and subsystems are always active. Typically, a portion of a system does not function at all for certain periods of time. When this is the case, the system could remain in the active mode without the processor running at its maximum operating frequency. The voltage supplied to the processor can be lowered when a lower frequency is sufficient to run the application, which reduces power consumption. Intelligent power management can reduce the power drawn from the battery by monitoring when the system does not need the processor at its maximum speed and then dynamically scale the voltage to the processor in response to the system's performance requirements.

Dynamic Power Switching (DPS)

Establishing several power domains in chip architecture can reduce overall power consumption by allowing power management to supply minimum power to those domains that are not processing during any given period of time. Again, intelligent power control is needed to monitor the processing in each power domain and dynamically switch domains to a lower power mode when the processing element is not engaged. Subsequently, the system's power management must be able to instantaneously provide power to domains when they are called upon.

Adaptive Voltage Scaling (AVS)

Adaptive Voltage Scaling (AVS) is an aspect of TI's SmartReflex™ power savings technology. AVS is possible because the semiconductor fabrication process produces chips that have slight variations in their performance characteristics. For example, the target frequency for Sitara AM37x ARM Cortex-A8 processors is 1 GHz, but a particular AM37x processor may be able to run at 1 GHz while consuming less power than other AM37x processors. Chips that can run at a target frequency with a lower voltage are said to be "hot," "strong" or "fast." Devices that require more power are said to be "cold," "weak" or "slow." The on-chip SmartReflex technology is able to sense whether a device is hot or cold and dynamically optimize power consumption according to the characteristics of each chip.

Static Leakage Management (SLM)

SLM reduces power consumption beyond the levels achieved by DVFS and DPS by turning off the entire chip except for its wake-up domain. Known as the "device off mode," this is the lowest power mode from which the chip can wake up automatically and respond to user inputs instantaneously. For example, SLM might shift the processor running in a personal navigation device (PND) into its device off-mode when no user inputs have occurred for 30 seconds. In this state, the PND's operating system is retained in memory so the system can respond immediately to a user input, but significantly less power is consumed.

The Figure 1 on the following page illustrates how these four power-savings techniques relate to each other and how they each contribute to the ultra-low power consumption of a portable, battery-operated device such as a PND.

In other types of applications, the device may be connected to an AC power supply such as the wall power outlet. However, when the AC power is interrupted, for example, in the case of a power outage, the device is still required to operate in low-power mode for a certain number of hours or days. That is the case for some home automation devices such as smart thermostats, fire security panels, industrial automation control panels and others.

TI solutions

TI's Sitara ARM processors offer a broad portfolio of highly capable devices for a wide range of applications. For battery-operated systems where power consumption is particularly critical, Sitara AM37x ARM Cortex-A8 processors provide an optimum solution. In fact, the Sitara AM37x processors consume less power than any other processor in its class in the industry.

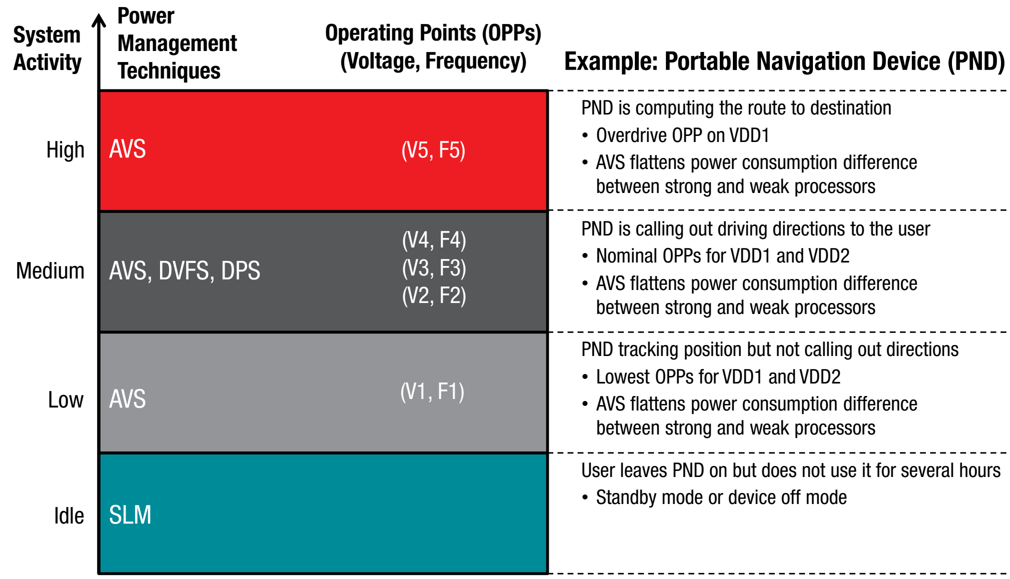

Figure 1: Four power-savings techniques are available to enable ultra-low power consumption in portable navigation devices (PNDs) and other battery-operated devices.

Several features of the AM37x processors contribute to its power-saving capabilities. For example, when it is in its "device off mode," which utilizes SLM to implement low-power standby or idle modes, the processor consumes less than 1 mW. In addition, the power management integrated circuits (PMIC) that are compatible with the AM37x processors make its power consumption scalable to the needs of the application. Eight PMICs work with AM37x processors, offering power options and on-chip PMIC resources ranging from supplying all power rails with high-efficiency DC/DC and low-noise LDO, to battery management, audio codecs

Table 1: TI PMICs that are compatible with TI's Sitara™ AM37x processors

Feature	TPS65950	TPS65951	TPS65930	TPS65920	TPS65921	TPS65910	TPS65023	TPS65073
Integrated battery charger	Yes	No	No	No	No	No	No	Yes
Audio codec and drivers	5 Stereo TX 2 Stereo RX	4 Stereo TX 4 Stereo RX	1 Stereo TX 1 Stereo RX	No	No	No	No	No
USB 2.0 HS PHY	Yes	Yes	Yes	Yes	Yes	No	No	No
V_{DD1} max current	1.2A (A3 version 1.4A)	1.4A	1.2A	1.2A	1.4A	1.5A	1.5A	1.5A
Power	3 DC/DC 10 LDOs	3 DC/DC 8 LDOs	3 DC/DC 4 LDOs	3 DC/Dc 4 LDOs	3 DC/Dc 4 LDOs	3 DC/Dc 9 LDOs	3 DC/Dc 2 LDOs	3 DC/Dc 2 LDOs
SmartReflex™	Class 3	Class 3	Class 3	Class 3	Class 3	Class 3	Class 2	Class 2
Max input voltage	4.5V	4.5V	4.5V	4.5V	4.5V	5.5V	6V	6.3V
Package	209-pin BGA 7×7 mm^2	169-pin BGA 12×12 mm^2	139-pin BGA 10×10 mm^2	139-pin BGA 10×10 mm^2	120-pin µBGA 6×6 mm^2	48-pin QFN 6×6 mm^2	40-pin QFN 5×5 mm^2	48-pin QFN 6×6 mm^2
Ball pitch	0.4 mm	0.8 mm	0.65 mm	0.65 mm	0.5 mm	0.4 mm	0.4 mm	0.4 mm
Targeted devices	All AM37x, DM37x except for OPP1G, only TPS65950A3 for DM37x at OPP1G	All AM37x, all DM37x	All AM37x, DM37x except for OPP1G	All AM37x, DM37x except for OPP1G	Must use TPS65921B1 for DM37x OPP1G, otherwise any TPS65921 can be used	All AM37x, all DM37x	All AM37x, all DM37x	All AM37x, all DM37x

(coder/decoder), USB OTG interfaces, analog-to-digital converters (ADC) and others. The table below lists the PMICs that are compatible with AM37x processors.

The 45-nanometer (nm) process used in the Sitara AM37x processors yields chips that are very power efficient in active modes. In addition, the devices are available in two different types of packages to meet the diverse needs of portable systems. A package-on-package (PoP) option is well suited to compact systems that are space constrained. In a PoP package, mobile DDR and flash memory can be stacked on top of the AM37x processors. In addition to reducing board space, the PoP package simplifies the routing that typically connects the processor to off-chip external memory on a printed circuit board (PCB). In applications where space is not a major issue, the AM37x processors are available in a traditional ball grid array (BGA) package.

Development tools

TI's Sitara ARM processors are supported by a powerful set of development tools, including evaluation modules (EVMs), development platforms, operating systems, software development tools and others. In particular, ultra-low-power AM37x processors offer a host of tools to assist battery-operated device designers. For example, the **AM37x EVM** not only lets developers evaluate the processor, but also start developing applications immediately. On-board resources include power management, memory, USB, Ethernet, audio and video outputs. The AM37x-based **BeagleBoard-xM development board** offers an open-source and lower-cost development option. The BeagleBoard-xM comes with on-board mobile DDR memory as well as a high-capacity microSD slot, a four-port USB hub, video outputs, a camera interface, stereo audio inputs and outputs, and more. Both the EVM and BeagleBoard-xM support Android™ (Ice Cream Sandwich) and Linux™ operating systems.

A unique Sitara tool for the power-conscious designer is the **Power Estimation Tool**. Since power consumption is highly application-dependent, this tool allows designers to model power consumption based on the use cases of their application. With the information provided by the estimation tool, designers may devise alternative architectures to reduce power consumption and perform thermal analyses on their system.

TI's Sitara ARM processors are also supported by the **Code Composer Studio™ integrated development environment**, making it fast and easy to develop and debug a variety of applications.

Conclusions

If the smartphone is any indication, more and more of tomorrow's communications and computing systems will be low-power, battery-operated devices. Of course, the processing engines for these innovative new applications must be powerful enough to execute computationally intense and demanding applications, but even more critically, they must draw as little power as possible from the battery in active, standby and static modes. Longer active usage times and extended standby modes will be competitive advantages in the marketplace.

TI's Sitara AM37x ARM Cortex-A8 processors fit the bill precisely: Powerful processing resources executing on less power than any other processor in its class. By incorporating advanced power-saving techniques like DVFS, DPS, AVS and SLM, AM37x processors have moved to the head of its class.

For more information about TI's Sitara AM37x ARM Cortex-A8 processors, please visit:

- **TI's Sitara AM3715 processor**
- **TI's Sitara AM3703 processor**

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