Application Note

PowerSage Integration into a PDA

Energy Savings with On-Demand Power®

Executive Summary

Packet Digital has developed and patented On-Demand Power®, a dynamic power management technology that provides real-time, system-wide energy savings for computers, radios, and other portable electronics. Using Packet Digital's On-Demand Power technology, designers can shorten their design cycle and reduce the non-recurring engineering costs to integrate dynamic power savings. Systems using On-Demand Power benefit from lower energy usage, extended battery life, reduced heat, and in certain designs, lighter/smaller systems.

Packet Digital integrated this On-Demand Power technology into a Personal Digital Assistant (PDA) platform, specifically targeting the processor core, flash memory, and I/O supplies. The IP was implemented in an FPGA and applied to the existing power management circuitry. The system was tested using a variety of typical PDA tasks. During active use power savings of 10-19% were observed for the various tasks. A three minute demonstration sequence was constructed showing 32% savings on the PowerSage controlled rails and a system power savings of 17-20%.

1 Overview of PowerSage® Power Management Integrated Circuits

Packet Digital's PowerSage® power management integrated circuits (PMICs) perform the critical task of providing a stable power supply voltage for circuitry. Like other voltage regulators, the PowerSage family of integrated circuits provides high efficiency, with adjustable outputs, soft-start, over-voltage and under-voltage protection, and over-current protection. Unlike any other voltage regulator, the PowerSage power management integrated circuit provides autonomous operation and does not require processor commands or software to provide voltage scaling, standby and sleep operation, and power gating to unneeded peripherals. Packet Digital's technology provides unprecedented performance over any other voltage regulator or power management technology.

Traditionally, dynamic power management for electronics has been treated as a software issue. Code is written and continuously executed to provide bookkeeping of the functions and procedures that are operating at any time. This bookkeeping system is combined with a tabular entry that will report on the amount of energy consumed. There are many issues with this approach, such as the extensive amount of energy consumed by the processor to execute this bookkeeping code.

Packet Digital has elegantly solved this problem in hardware (see Figure 1). Instead of using code to record the functions operating, Packet Digital has developed monitoring circuits that detect activity within the electronics. For example, if memory integrated circuits are rapidly corresponding with the processor via the data bus, Packet Digital's PowerSage PMIC unobtrusively detects the high degree of activity and determines that the memory integrated circuits require high amounts of energy. Conversely, if the memory integrated circuits have little to no activity on the data bus with the processor, the PowerSage PMIC determines that the memory integrated circuits require less energy.

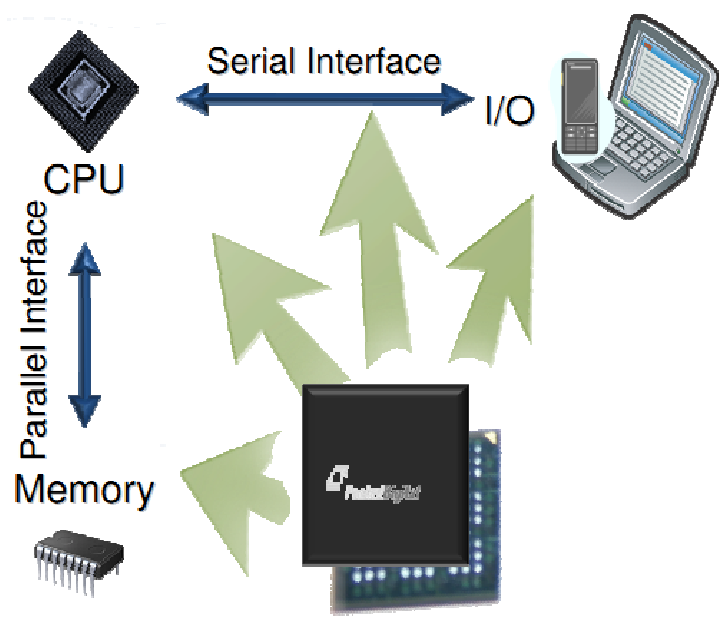

Figure 1: PowerSage PMICs Scan Memory, CPU, I/O and Communication Links to Adjust Supply Voltages

1.1 Review of PowerSage Integrated Circuitry® and On-Demand Power® Technology

Packet Digital's patented On-Demand Power technology and patented PowerSage integrated circuitry takes a real-time systems approach to power management issues. PowerSage PMICs perform real-time power management by:

1) Monitoring activity intelligently across an entire system
2) Calculating and distributing only the minimum power required to perform an operation, only when needed
3) Controlling the clock and supply voltages in real-time, outside the microprocessor
4) Providing just-in-time, just-enough, power management

Packet Digital has applied our patented On-Demand Power technology to multiple applications with significant results:

- Working with the Office of Naval Research (ONR), Packet Digital demonstrated a 67% battery life improvement of a radio, with a 16°F reduction on the heat fins.
- Working with the Defense Microelectronics Activity (DMEA), Packet Digital improved battery life of a wireless sensor by 400%.
- Working with industry leaders, Packet Digital developed a power management integrated circuit for laptop computers that reduces the amount of energy used by hard drives and optical drives. This PowerSage offering was tested and validated on Intel's 2012 Customer Reference Board (CRB) design for notebook computers.

PowerSage PMICs uniquely provide dynamic power management to all types of components, including solid-state, RF, electro-optical, and electro-mechanical. PowerSage PMICs, compared to any other voltage regulator, save power and simultaneously improve performance.

2 System Description

A PDA development system consisting of a Spectrum Digital OMAP5912-OSK for the memory and processing with the mating Mistral Q-VGA LCD module providing the user interface was chosen for the test platform. The OSK contains a TI OMAP 5912 processor, 32MB DDR memory and 32MB Flash memory. The LCD module provides the rest of the hardware you would expect in a PDA: a four button keypad, joystick, LED backlight, touch interface, and 320x240 pixel (QVGA) TFT LCD.

The operating system and desktop environment are based on an open source embedded Linux distribution called Angstrom. The interface is very PDA-like and includes all the programs you would expect to find like a lightweight web browser, media player, calculator, contact list, and several simple games.

Power management for the OMAP processor, Flash, and RAM is provided by the TI TPS65010. The Flash memory and processor I/O run at a fixed 3.3V and the processor core is powered with a fixed 1.6V. These are the rails that will be controlled by PowerSage with On-Demand Power.

3 On-Demand Power Integration

3.1 Hardware

Packet Digital's On-Demand Power technology was implemented in an FPGA which controls the TPS65010. In this implementation three voltages are supported for both the bulk 3.3V rail and the processor core rail: nominal and two lower levels. These three voltages correspond to the voltages required to support idle, low activity, and high system activity.

The FPGA running On-Demand Power is connected as a daughter card to the board marked Burleigh-090-A in Figures 2 and 3. The main power consumers on the bulk rail are the flash memory and the OMAP I/O that is used to talk to that memory. The On-Demand Power inputs for this rail come from the Flash memory bus. When the system is idle the voltage is dropped to a lower-than-nominal level, as determined by the algorithm in PowerSage. After long periods of inactivity the voltage is dropped. At the next memory access the voltage is raised to an active state to resume normal operation.

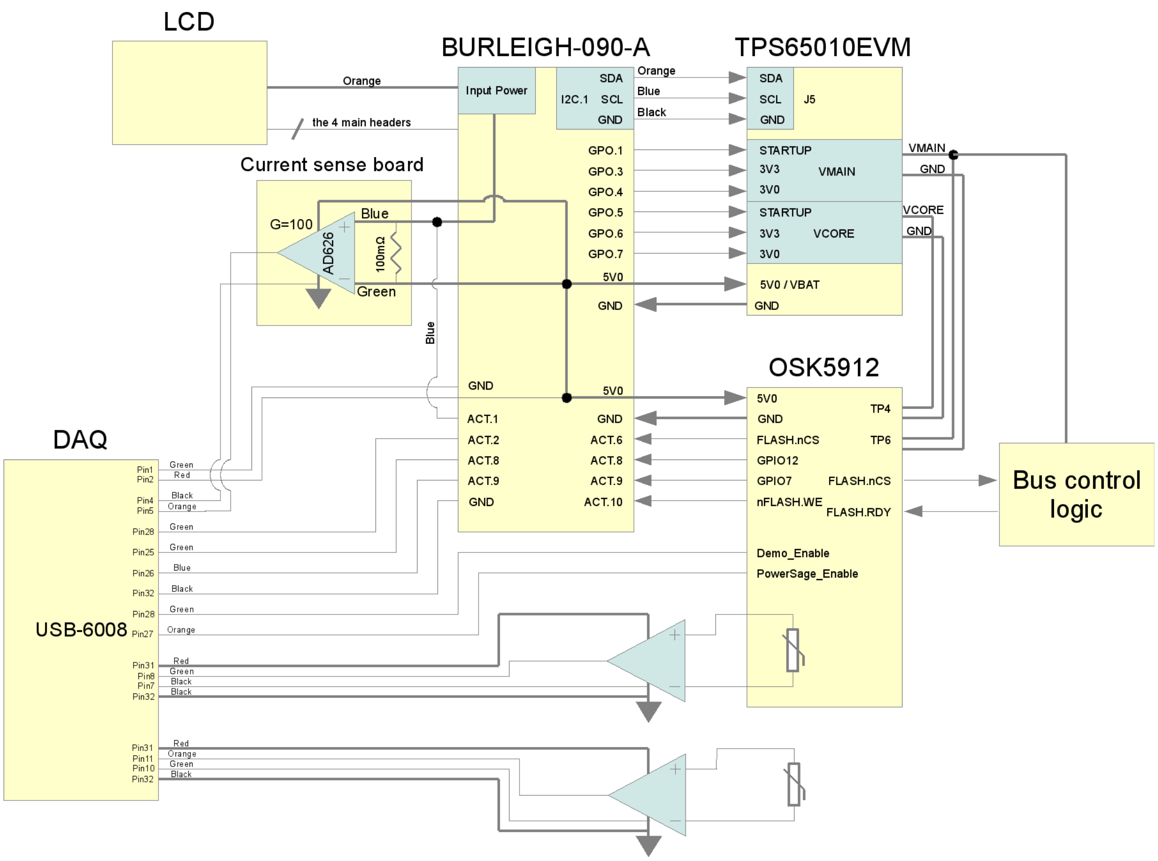

Figure 2: System Integration and Instrumentation

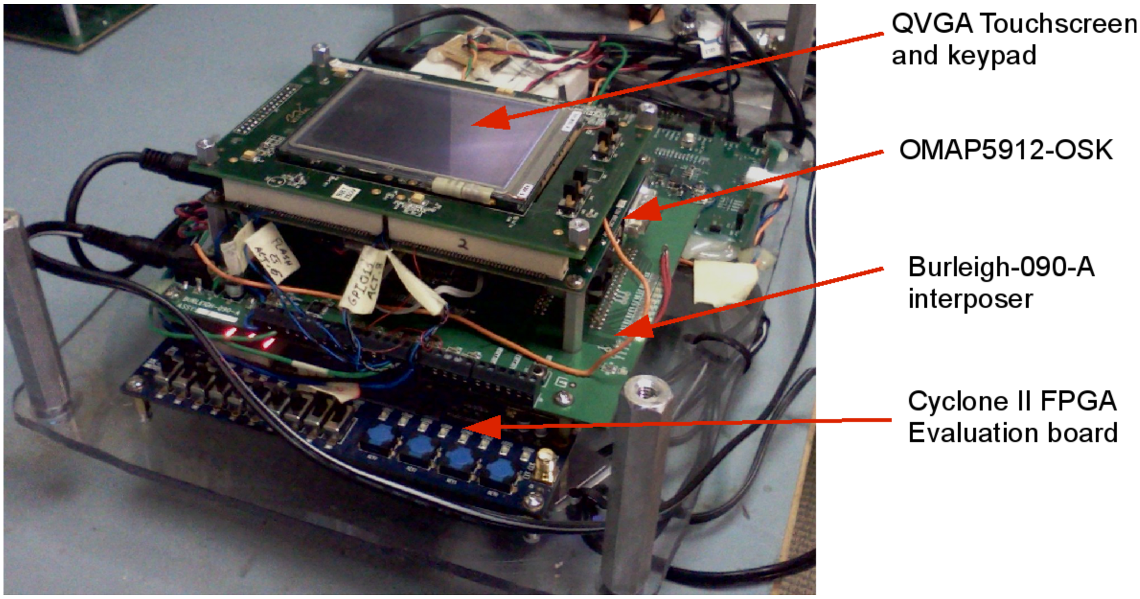

Figure 3: PDA Assembly Diagram

4 Benchmarks

The following tests were selected as typical PDA tasks that represent a broad range of user activity:

- calculator
- calendar entry
- contact list entry
- MP3 playback
- notepad entry
- photo viewing

Additionally, a test that combines a few common tasks was created to be used as a live demonstration. This test utilizes the calculator, MP3 playback, and a simple game entitled *The Game of Life*. Each subtest was played for 30 seconds with 30 second idle periods following them for a total of three minutes. These results are shown in Table 2.

As part of the test configuration, the backlight was set to 160 (default setting) and the Linux Kernel Frequency Scaling was enabled while the governor was set to aggressive for all of these tasks.

5 Test Results

Table 1 shows the average power and savings for each type of PDA task. Run duration was chosen to provide consistent, repeatable results.

Table 1: Average Benchmark Power Savings

Test	Duration (m)	Baseline (mW)	PowerSage (mW)	Savings
Calculator	5	675	605	10.4%
Calendar Entry	10	680	594	12.6%
Contact List Entry	5	678	596	12.1%
Play MP3	5	697	564	19.1%
Notepad Entry	10	615	521	15.3%
Photo Viewing	5	651	572	12.1%

Table 2 shows the power savings measurements for the two On-Demand Power controlled rails for several runs of the three minute demonstration test. These runs include idle periods to emulate more realistic user activity.

Table 2: Average On-Demand Power Savings Per Rail (3-minute demonstration test)

Run	3V3 Baseline (mW)	3V3 PowerSage (mW)	Core Baseline (mW)	Core PowerSage (mW)
Average Savings	120.46	81.31	121.97	83.70
ODP Savings		39.15		38.21
ODP Savings %		32.50%		31.34%

Table 3 shows the power savings for the entire system, with and without the Mistral LCD board connected for several runs. The backlight was off for these tests.

Table 3: Average System Power Savings (with and without Mistral LCD board)

Run	Baseline (mW)	PowerSage (mW)	Baseline no LCD (mW)	PowerSage no LCD (mW)
Average	458.91	380.99	396.13	315.58
Savings		77.93		80.55
Savings %		16.98%		20.33%

6 Conclusion

PowerSage can significantly reduce power in PDA's and other mobile devices. For individual application runs with no idle periods, savings of 10-19% was observed. When combined into a short sequence with 50% idle time, which is a more typical usage scenario, the average power savings was 17% for the system or 32% for the two rails controlled by On-Demand Power.

7 Contact info

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