Power Modes and Energy Consumption for the iMote2 Sensor Node

September 12, 2006

Abstract

This document describes the many power modes of the iMote2 sensor node. The energy consumption of the node is measured for each power mode and configuration.

1 Power Modes

The iMote2 sensor node[**?**]. The power consumption of the iMote2 is shown for different power modes of the CPU and the PMIC. The operating frequency in run mode is 104MHz and the core voltage is 0.95V. The power consumption was measured as the voltage across a 1Ω resistor in series with a precision 4.0V supply connected to the battery pads on the iMote2. The power consumption of a certain feature on the iMote2 is computed by subtracting the static power consumption of the iMote2 from the measured power consumption of the iMote2 with the feature enabled. The result is then scaled by the efficiency of the PMIC.

The frequency and voltage of the CPU is adjustable for performance and power-efficiency. The individual clocks for the functional units in the processor may be disabled when the units are not active. The GPIO can be configured to maintain state in standby and sleep, or enter a low-power state. The GPIO is always disabled in deep-sleep mode. The power-modes of the iMote2 are provided by both the CPU and the PMIC. The CPU initiates and signals to the PMIC the transition to a power-mode.

The following list shows the changes that are incrementally applied to the processor to achieve low power consumption.

1. Normal   The CPU and peripherals are active.

2. Idle   The CPU is inactive.

3. Deep-idle   The core PLL is disabled.

4. Standby   The peripheral PLL is disabled.

5. Sleep   The low-voltage power domains and internal SRAM are disabled. [The sleep/deep-sleep DC-D

6. Deep-sleep   The high-voltage power domains are disabled.

2   Configuring the iMote2

The power modes for the PXA271 and the PMIC are configured by software running in SOS. The PXA271 is configured by modifying the registers in Coprocessor 14. The registers in the coprocessor allow software to set the frequency of the CPU, specify the retention of data in the SRAM, configure the conditions for the CPU in standby, sleep and deep-sleep modes, and cause the CPU to change power modes. The PMIC is configured by issuing commands to the PMIC through the power-manager I2C interface. The interface is a standard I2C module reserved for communication with the PMIC. The PMIC commands allow software to enable regulators on the PMIC and configure the sleep and deep-sleep modes of the PMIC.

3   Energy Consumption

The static power consumption of the iMote2 was measured by setting the PMIC to shut-down mode, where all voltage regulators are disabled except for the RTC regulator. The memory was enabled for all power modes but shut-down. The radio was disabled for during the power mode measurements. The values for sleep and deep-sleep power modes are larger than expected, because the PMIC was not configured to put the regulators into sleep mode when the CPU operates in the low-power modes.

$$P_{actual} = [I_{normal+feature} - I_{normal}] * V_{test} \tag{1}$$

$$P_{ideal} = [P_{actual} - P_{deep-sleep}] * PMIC_{efficiency} \tag{2}$$

iMote2	Ideal power consumption (mW)
CPU	
Normal@104MHz	170.20
Idle	137.80
Deep-idle	94.60
Standby	28.36
Sleep	17.56
Deep-sleep	3.29
Camera	
Active	61.84
Standby	20.80
Radio	
Active	71.20

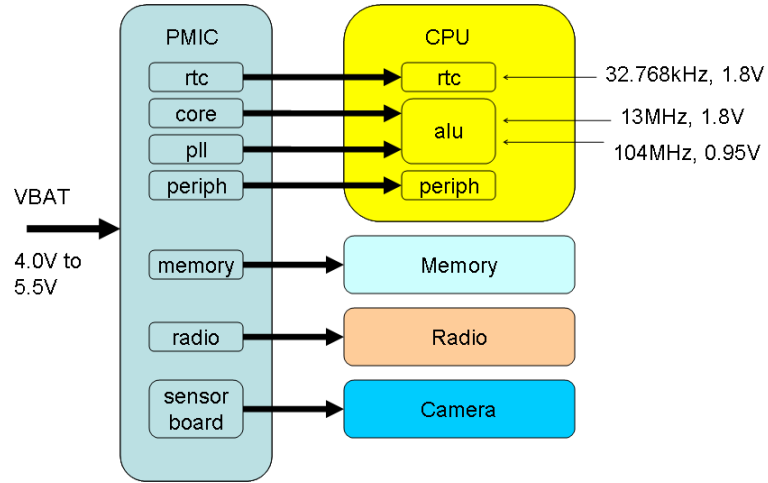Table 1: Simulation parameters (trigger-driven / schedule based)

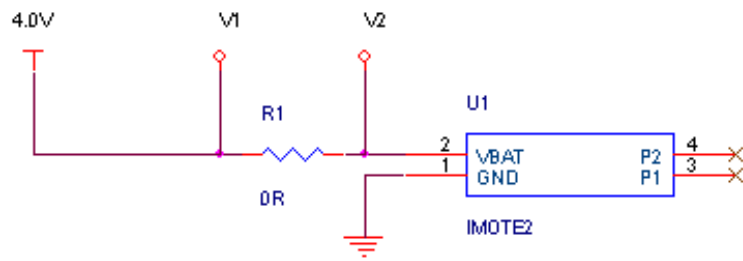Figure 1: The figure shows the power domains supplied by the PMIC to the CPU.

Figure 2: The figure shows the circuit used to measure the power conumption of the iMote2 for different power modes and features.

SOS boot time		
Normal	2.12	sec
Sleep	2.12	sec
Deep-sleep	2.12	sec

Table 2: Table of SOS boot times for different power-modes.

Power domain	Frequency (MHz)	Voltage (V)
RTC	0.032768	1.80
Core	13	1.80
PLL	104	0.95

Table 3: Table of voltages and frequencies for critical power domains.

Test Conditions		
Normal frequency	104	MHz
Normal core voltage	0.95	V
PMIC efficiency (estimated)	90	%
Supply voltage to iMote2	4.00	V
Current sensing resistor	1	Ω

Table 4: Test conditions for power consumption measurements.

iMote2	Measured current (mA)	Total power consumption (mW)
Normal@104MHz	48.10	192.40
Idle	39.10	156.40
Deep-idle	27.10	108.40
Standby	8.70	34.80
Sleep	5.70	22.80
Deep-sleep	0.82	3.29

Table 5: Table of measured power consumption of iMote2 for different power modes.

Feature	Measured current (mA)	Total power consumption (mW)
Camera		
Active	66.10	72.00
Standby	54.70	26.40
Radio		
Active	68.70	82.40

Table 6: Table of measured power consumption of optional features for the iMote2.