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CA IOUs Report - Impact of RAM Size on Sleep Power

Additional submitted attachment is included below.

Computers

Codes and Standards Enhancement (CASE) Initiative
For PY 2016: Title 20 Standards Development

Impact of RAM Size on Sleep Power
Computers

Docket #16-AAER-2

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1 Objective

The objective of this project was to determine the effect of RAM size on a computer's power consumption while in sleep state. Since RAM size can be changed by either changing the number of modules or changing the size of individual modules, so another objective was to determine which of these methods had a greater impact on the power consumption.

2 System Configuration

Each test was performed using the following hardware setup while varying the type of PSU, the type of RAM, and the size of the RAM.

- MSI Z170-A Pro Motherboard
- Intel i7-6700k CPU
- Intel E97378-007 CPU cooler for LGA 1155/1156/1150 (stock Intel fan bundled with most CPUs)
- Western Digital Green SATA HDD 1TB (WD10EZRX)
- USB Mouse and Keyboard
- Monitor (1600x1200 60Hz) connected via DVI-D

2.1 RAM Under Test

- 16GB HyperX Fury 2133MHz DDR4
- 8GB HyperX Fury 2133Mhz DDR4
- 8GB PNY Anarchy 2400MHz DDR4

2.2 PSU Under Test

- FSP Aurum 400 80+ Gold
- Corsair RM850 80+ Gold
- Corsair CX430 80+ Bronze

3 Test Setup

3.1 Equipment Used:

- Yokogawa WT310 Digital Power Meter
- Agilent Technologies N6705B DC Power Analyzer
- BK Precision 8510 Programmable DC Electronic Load

3.2 Software Used:

- WTViewerFreePlus

The Yokogawa WT310 Digital AC Power Meter was used to measure the AC power consumption of the systems. The AC power meter was used with the Yokogawa WTViewerFreePlus software to record the AC power consumption of the systems at each time interval and to adjust the sampling rate of the measurement. Recorded measurements from the software were saved in a .CSV file. The sampling rate for the AC power measurements was 100ms.

Both the Agilent Technologies N6705B DC Power Analyzer and the BK Precision 8510 Programmable DC Electronic Load were used to determine the DC power consumption of the PSUs at low loads and the efficiency of each PSU. We connected a 50mΩ shunt to the 5V standby wire of the ATX motherboard connector and then attached the Agilent Technologies N6705B DC Power Analyzer to either side of the shunt to measure the voltage drop. We used the BK Precision 8510 Programmable DC Electronic Load to supply a constant load to the wire. With the

known voltage and resistance, we were able to determine the DC power using equations 1 and 2 below.

$$I_{shunt} = V_{shunt} / R_{shunt} \quad (1)$$

$$P = V_{actual} I_{shunt} \quad (2)$$

The DC power was compared against the AC power measured from the Yokogawa Digital Power Meter to determine the efficiency of each PSU using equation 3 below.

$$Efficiency = \frac{DC\ Power\ Consumption}{AC\ Power\ Consumption} \cdot 100\%$$

4 Measurement Results

4.1 RAM Testing

We have used two 8GB HyperX Fury 2133MHz DDR4 RAM modules and two 8GB PNY Anarchy 2400MHz DDR4 RAM modules. To make sure that the configured RAM frequency had no effect on power consumption in the sleep state, we measured the AC power consumption of the computer in sleep state with the PNY RAM in both frequency configurations by manually setting the RAM frequency in the BIOS.

	2133MHz	2400MHz
PNY Anarchy	1.77 W AC	1.77 W AC

Table 1

As shown in Table 1, our measurements confirmed that different RAM frequency configurations have little impact on the power consumption in the sleep state. This is most likely due to the fact that the RAM frequency applies only to the active state, not to the auto-refresh state, in which memories typically run at a much lower frequency.

Next, we determined the AC power consumption differences between the 8GB HyperX Fury and the 8GB PNY, so that we could make more consistent comparisons with RAM configurations that used more than 2 modules.

	1x8GB	2x8GB
HyperX Fury	1.84 W AC	2.01 W AC
PNY Anarchy	1.77 W AC	1.91 W AC
Difference	0.07 W AC	0.10 W AC

Table 2

We then compared every combination of 8GB and 16GB modules that would work on a motherboard with 4 DIMM slots. For the measurements in Table 3 below, the FSP Aurum 400 PSU (rated 80+ Gold) was used.

Test Number	Memory Configuration	Total Memory	Number of Modules	AC Power Consumption
1	4x16GB	64GB	4	2.76 W
2	3x16GB	48GB	3	2.58 W
3	2x16GB	32GB	2	2.22 W
4	1x16GB	16GB	1	1.99 W
5	4x8GB	32GB	4	2.23 W (2.33W)
6	3x8GB	24GB	3	2.11 W (2.19W)
7	2x8GB	16GB	2	2.01 W
8	1x8GB	8GB	1	1.84 W
9	1x8GB + 3x16GB	56GB	4	2.73 W
10	2x8GB + 2x16GB	48GB	4	2.63 W
11	1x8GB + 2x16GB	40GB	3	2.43 W
12	3x8GB + 1x16GB	40GB	4	2.39 W (2.46W)
13	2x8GB + 1x16GB	32GB	3	2.30 W
14	1x8GB + 1x16GB	24GB	2	2.11 W

Table 3

It is important to note that tests 5, 6, and 12 use both the PNY and the HyperX 8GB memory modules. The values in parenthesis represent the power consumption if just HyperX memory modules were used. These values were calculated by adding the found power consumption to the difference value shown

above in Table 2. Figure 1 below graphically shows the AC Power measurements taken in Table 3 with the adjusted values.

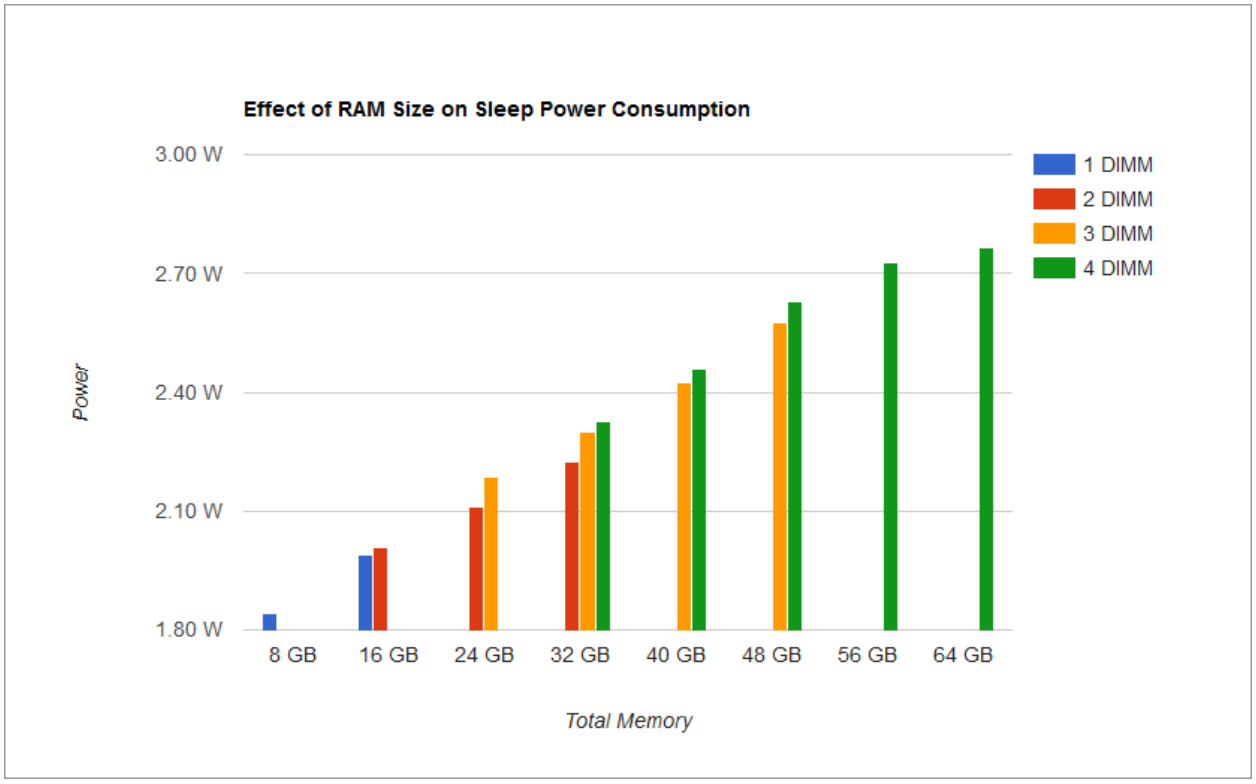

Figure 1: Impact of Total Memory Size on AC Power Consumption in Sleep

The data shown above shows that using multiple smaller DIMMs is less power efficient than using one larger DIMM. But ultimately, the total amount of memory is the biggest factor determining sleep power consumption.

5 PSU Testing

To assess the effect of PSU size and efficiency on the measurement results in sleep, we measured the efficiency of each PSU for 1W, 2W and 3W DC loads using the method described in chapter Test Setup above.

	1W DC	2W DC	3W DC
FSP 400W 80+ Gold	76.45%	80.37%	81.56%
RM850 850W 80+ Gold	77.73%	80.74%	82.18%
CX430 430W 80+ Bronze	74.98%	79.55%	80.55%
Seasonic 400W 80+ Platinum	77.32%	80.02%	81.14%
Enermax 180W 80+ Bronze	76.94%	77.47%	78.91%
Solid Gear 180W	50.42%	62.16%	66.29%
Dell 250W	75.50%	77.73%	78.52%

Table 4

Table 4 shows that at low DC loads, the nominal rating of the PSUs in the 80+ category (bronze, gold, etc) does not seem to have correlation to the PSU's sleep mode efficiency. For all of the measured 80+ rated PSUs, the sleep-mode efficiency at DC loads of 1W, 2W and 3W tends to be very similar. However, for a single PSU without the 80+ rating we have observed a significantly lower sleep-mode efficiency.

Impact of RAM Size on Sleep Power

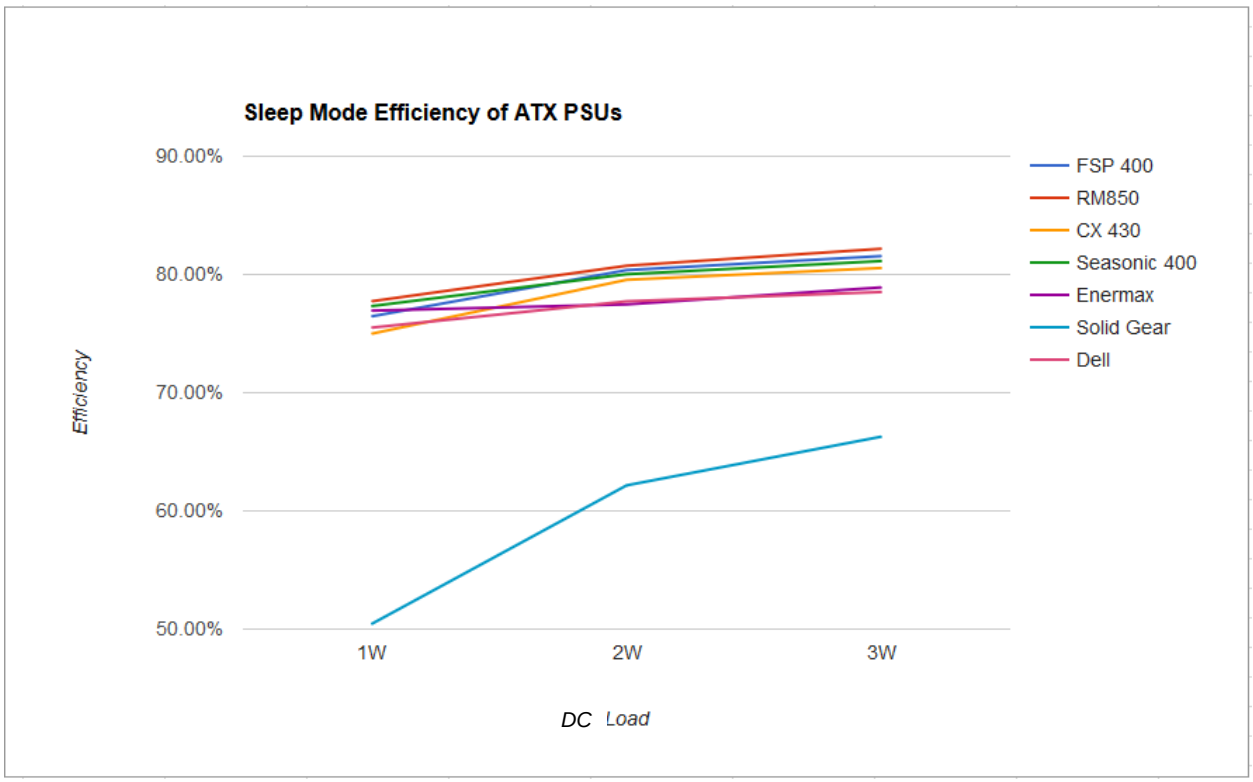

Figure 2

6 Conclusion

The analysis of RAM size impact on sleep power consumption shows that the biggest factor that determines consumption is the total amount of memory. Additionally, we found that an increase in the number of DIMMs used also causes a small increase in sleep-mode power consumption when the total memory size is kept the same.

The PSU efficiency testing in the sleep mode revealed that the size and type of PSU does not affect the sleep mode efficiency, as long as the PSU belongs to the 80+ category of PSUs. We have identified at least one PSU without the 80+ rating that has shown a significantly lower efficiency in the sleep mode.