



DDR2 1.5V Memory

Technical Review

5/11/2007

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Agenda

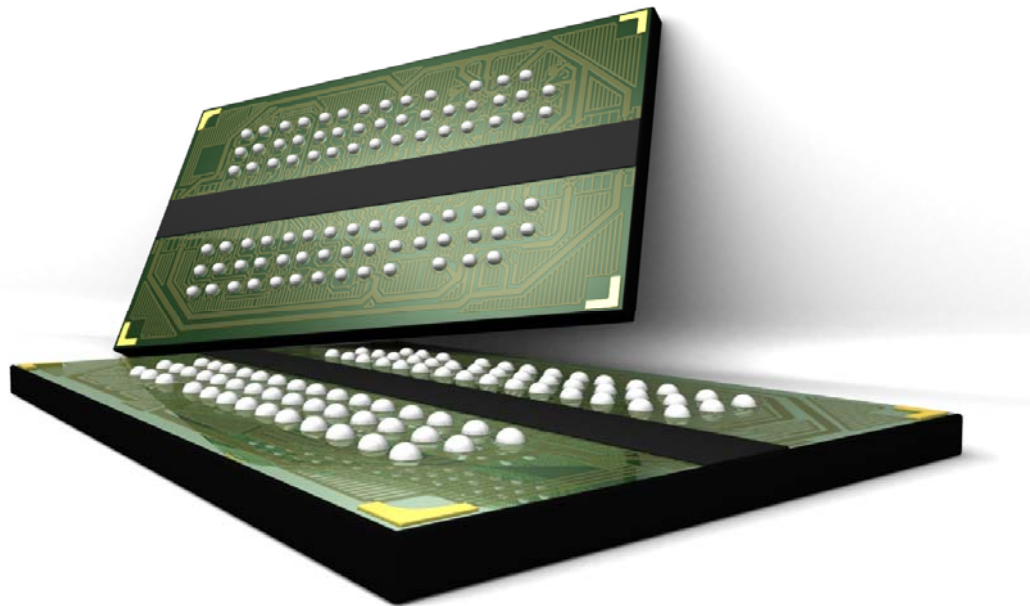
- What is it?
- Power reduction ($P = V \cdot I$)
- Thermal advantage
- Compatibility/design requirements
- Road map/schedule/part numbers

Agenda

- **What is it?**
- Power reduction ($P = V \cdot I$)
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1.5V DDR2 – What Is It?

- Micron is leading the way in low-power DDR2 with our new energy-efficient (1.5V) 1Gb and 2Gb DDR2 SDRAM



1.5V DDR2 – What Is It?

- Our 78nm process enables Micron to run both the DRAM core and I/O at reduced voltage levels for greater power savings
 - ▶ $VDD = VDDQ = 1.8V \pm 100mV$ (standard)
 - ▶ $VDD = VDDQ = 1.55V \pm 50mV$ (regulated)
 - ▶ $VDD = VDDQ = 1.50V \pm 100mV$ (unregulated)

1.5V DDR2 – What Is It?

- The regulated (1.55V) parts are standard 1.8V parts screened to 1.55V limits
- Same form, function, and fit
- Operating range
 - ▶ $V_{DD} \text{ (MIN)} = 1.5V$
 - ▶ $V_{DD} \text{ (NOM)} = 1.55V$
 - ▶ $V_{DD} \text{ (MAX)} = 1.9V$
- Both our 1Gb and 2Gb regulated parts will support DDR2-667 at $V_{DD} = V_{DDQ} = 1.55V$ nominal
- 1.55V is an interim, time-to-market part
 - ▶ See our preliminary data sheet for more details

1.5V DDR2 – What Is It?

- Unregulated (1.5V) parts are a mask option of the standard 1.8V part
 - ▶ Will tolerate $VDD = VDDQ = 1.8V$ for a limited time ($\sim 1s$) without degradation
 - ▶ Will run at 1.8V continuously; lifespan is significantly reduced
 - ▶ Operating range
 - $VDD (MIN) = 1.4V$
 - $VDD (NOM) = 1.5V$
 - $VDD (MAX) = 1.6V$
- Unregulated advantages
 - ▶ Lower $VDD (MIN)$
 - ▶ Wider VDD range
 - ▶ Lower power
 - ▶ Higher frequencies
- Long-term direction for 1.5V standard

Agenda

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- **Power reduction ($P = V \cdot I$)**
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Comparison of IDD Values

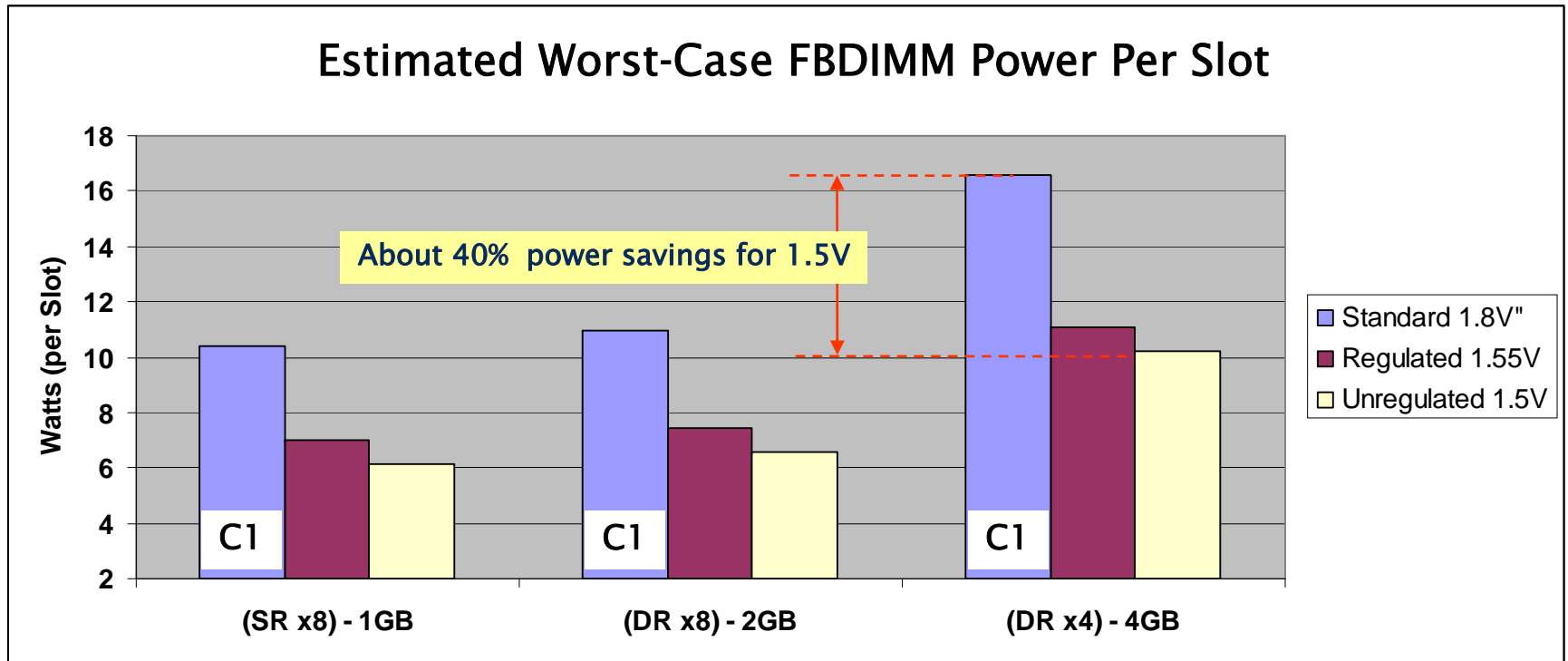
DDR2-667 (1Gb)

| | Standard | Regulated | Unregulated | |
|---------|----------|-----------|-------------|----|
| IDD0 | 70 | 61 | 54 | mA |
| IDD1 | 83 | 76 | 62 | mA |
| IDD2P | 6 | 4 | 3 | mA |
| IDD2Q | 27 | 25 | 22 | mA |
| IDD2N | 31 | 30 | 27 | mA |
| IDD3P-F | 25 | 19 | 16 | mA |
| IDD3P-S | 8 | 4 | 1 | mA |
| IDD3N | 35 | 34 | 31 | mA |
| IDD4W | 111 | 110 | 102 | mA |
| IDD4R | 109 | 107 | 105 | mA |
| IDD5 | 192 | 169 | 137 | mA |
| IDD6 | 6 | 4 | 4 | mA |
| IDD7 | 235 | 214 | 204 | mA |

• Reflects measured backend data for standard and regulated DRAM and simulation data for unregulated DRAM

Theoretical Worst-Case FBDIMM Power

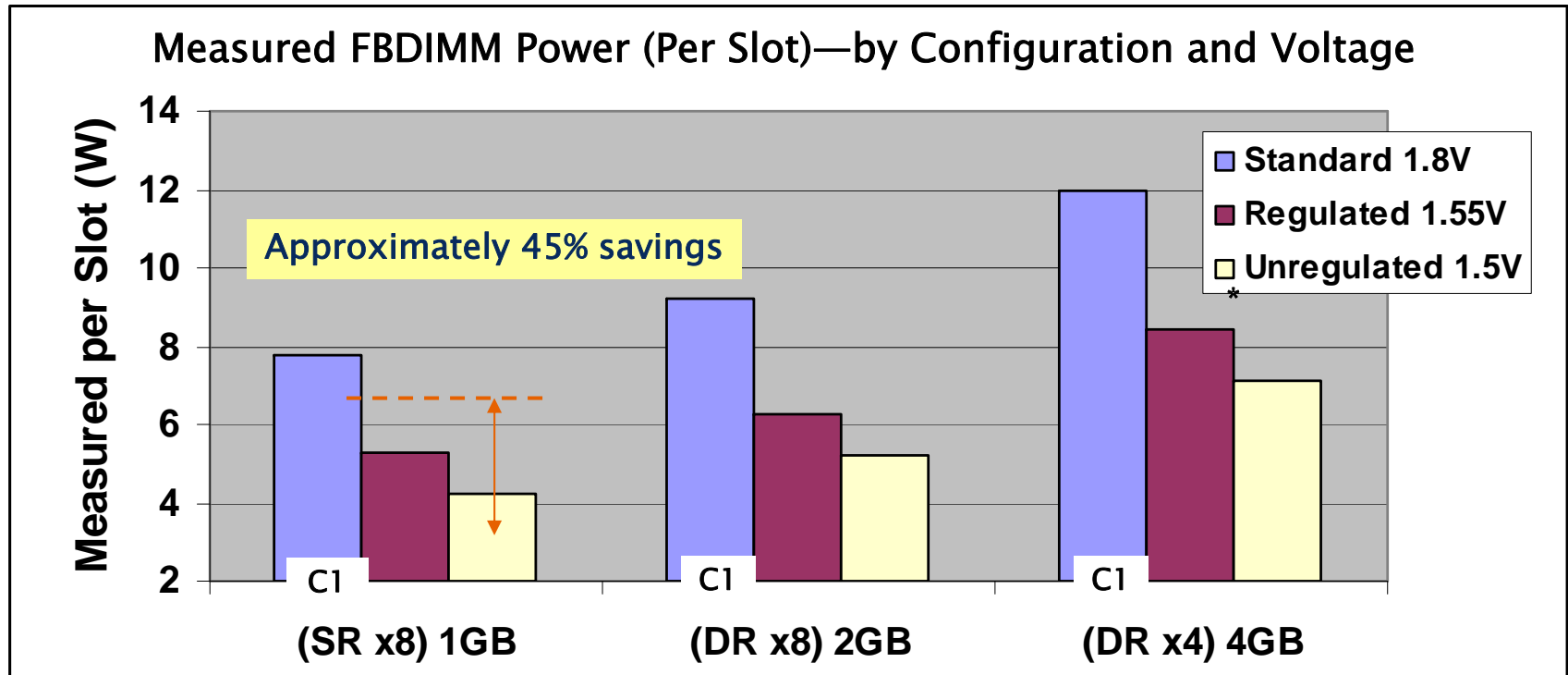
- For the FBDIMM, this equates to watts of power savings!



- Test conditions are for BL = 4, DDR2-667, DIMM BW of 3.60 GB/s, closed page; reflects worst-case DRAM values

Measured FBDIMM Power

- For the FBDIMM, this equates to watts of power savings!

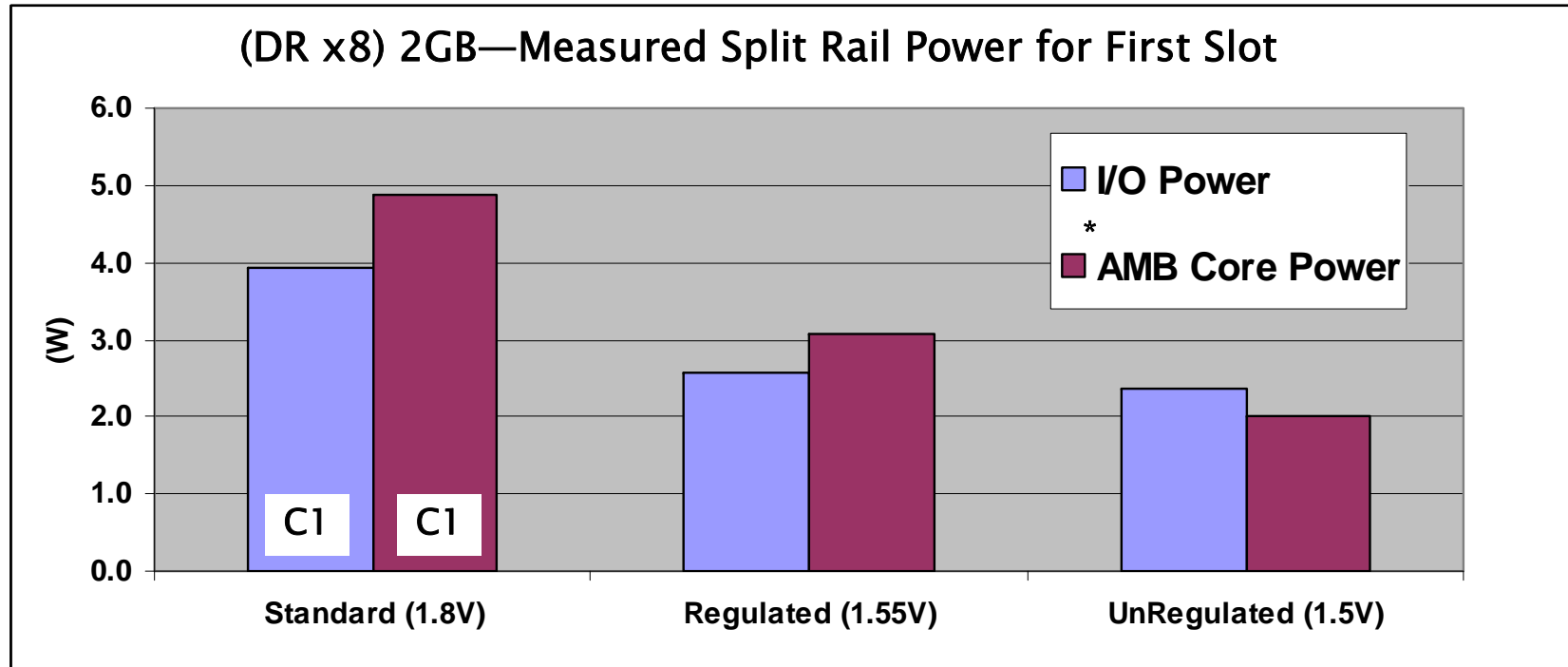


* Regulated running at 1.5V

- Test conditions are for BL = 8, DDR2-667, estimated BW per slot is 2.60 GB/s, single-slot populated

Measured Power for Both FBDIMM Supplies

- For the FBDIMM, this equates to watts of power savings!



* I/O Power = AMB I/O and all DRAM power
** Regulated running at 1.5V

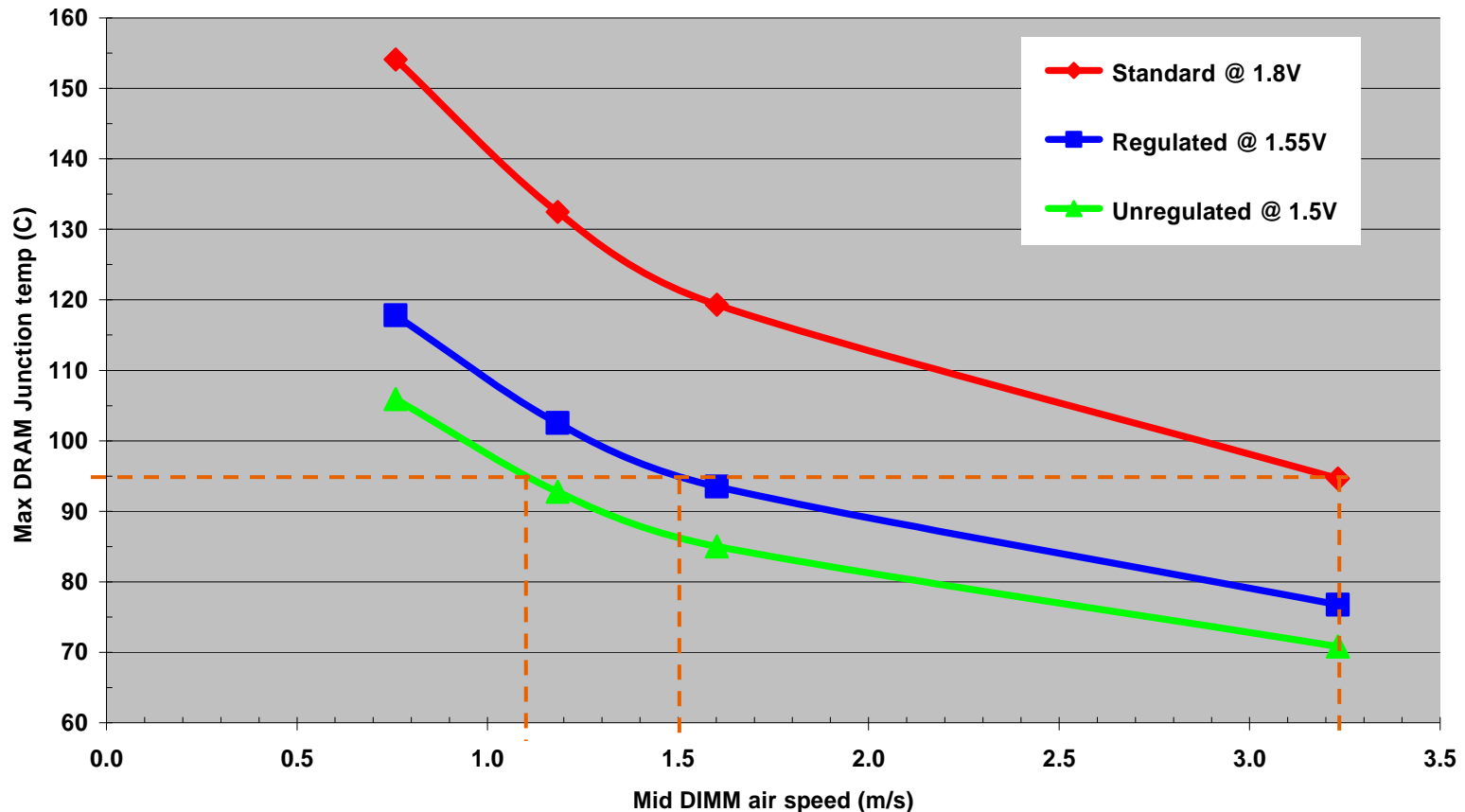
- Test conditions are for BL = 8, DDR2-667, estimated BW per slot is 1.80 GB/s, two slots populated

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DRAM Thermal Advantages

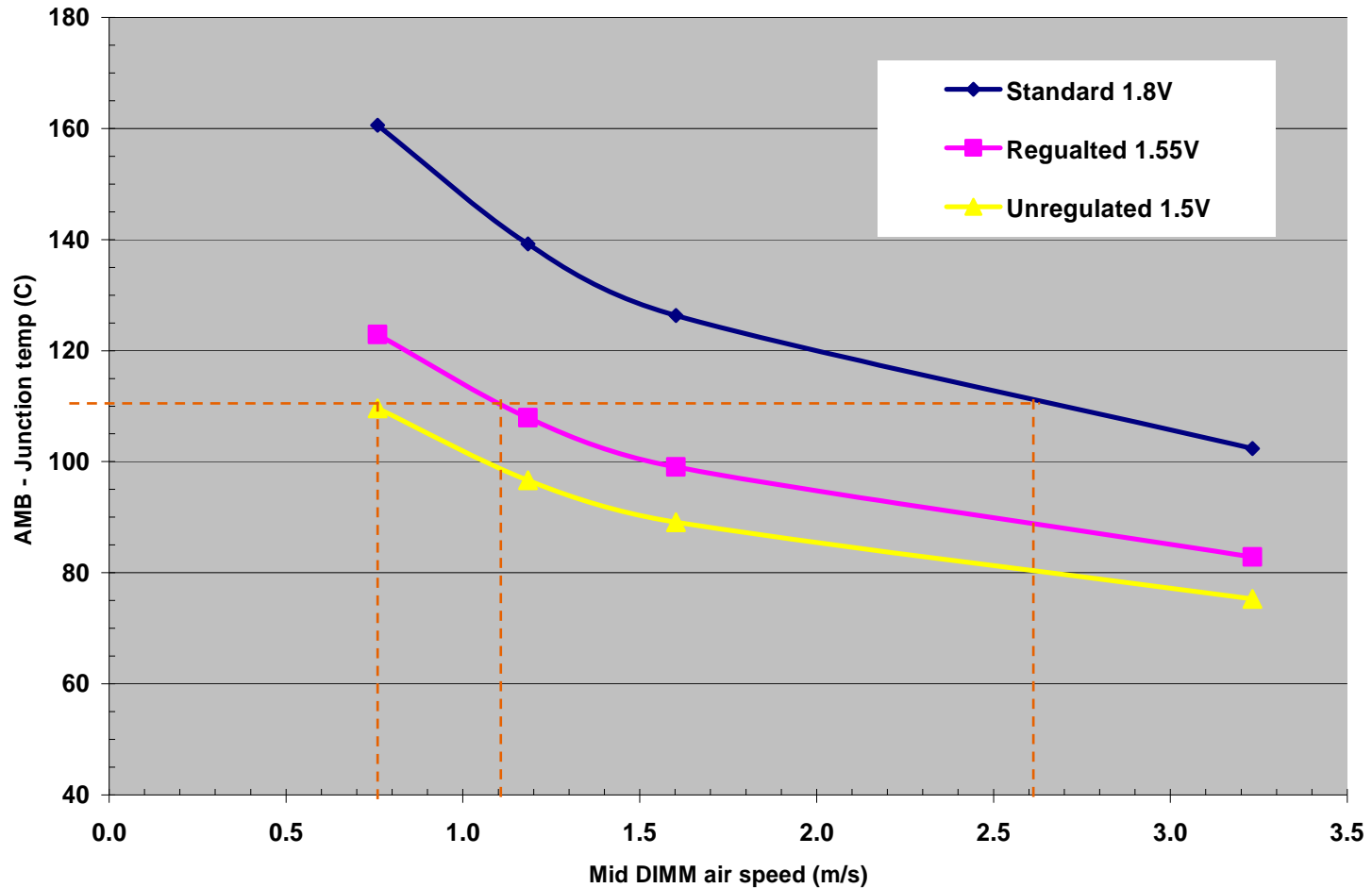
(DRx4) FBDIMM with FMHS, 4 DIMMs, 40C ambient



• Simulations show that FBDIMMs running at 1.5V require significantly less air flow to maintain the same DRAM temperature than FBDIMMs running at 1.8V

DRAM Thermal Advantages (continued)

(DRx4) FBDIMM with FMHS, 4 DIMMs, 40C ambient



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Compatibility

- What is needed for compatibility?
 - ▶ Same module and/or component part number?
 - Micron part numbers must be different
 - Customer part number
 - Possibly the same for 1.5V regulated component/module
 - Different for 1.5V unregulated component/module

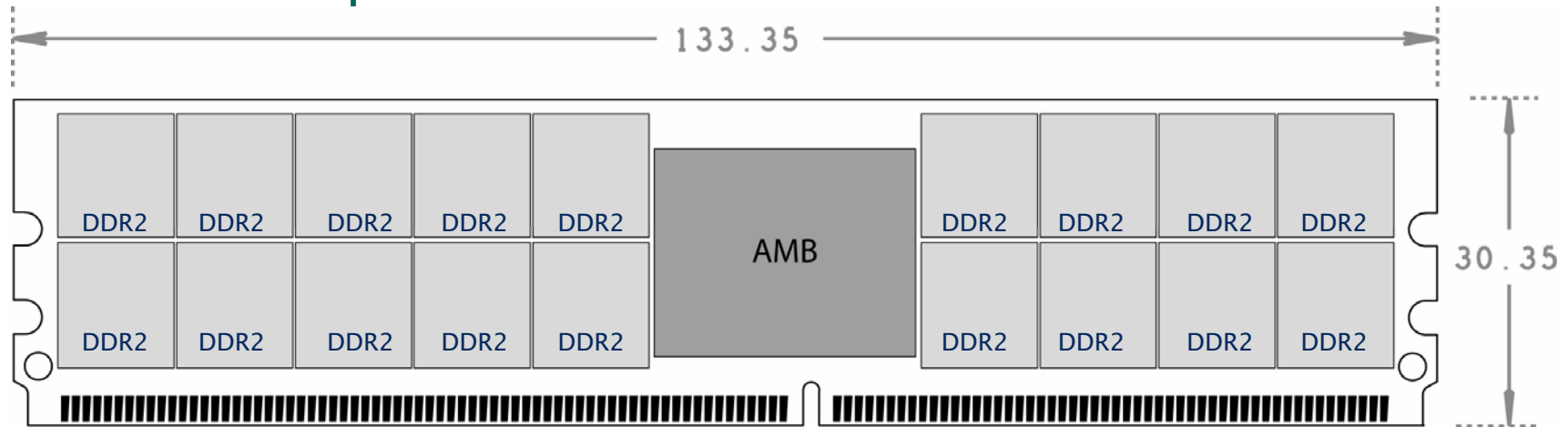
Compatibility (continued)

- ▶ 1.8V usage
 - 1.5V regulated screened part; no issues
 - 1.5V unregulated
 - 1.8V system operation indefinitely
 - ▶ Accelerated wear out; lifespan significantly reduced
 - ▶ 1.8V operation only a short time frame (~1 s)
- ▶ Visual indication of 1.5V
 - Green heat spreader versus blue heat spreader
 - Module label with GREEN 1.5V indication

System Assumptions

- Assumptions

- ▶ The low-power module would have the same pin-out and form factor as the standard FBDIMM
- ▶ DRAM voltage
 - VDD = 1.5V nominal; MIN VDD = 1.4V
 - 1.8V requirement?



DRAM VDD = VDDQ = 1.5V

Module Identification

- System identification
 - ▶ Option 1 (Micron preference)
 - Change SPD byte 3 to indicate 1.5V DRAM power supply
 - Could cause issues with standard 1.8V systems?
 - Also possible to use a location in the manufacture data area to identify the module as 1.5V capable

Module Identification (continued)

▶ Option 2

- Use voltage ID pins on module
 - Requires system power supply modification
 - Requires module modification

| Voltage ID Pins | | | |
|-----------------|-------------------------|------|----------|
| Voltage Rail | Pin Name | Open | Grounded |
| V_{DD} | VID0 – DRAM, AMB I/O | 1.8V | 1.5V |
| V_{CC} | VID1 – AMB | 1.5V | 1.2V |

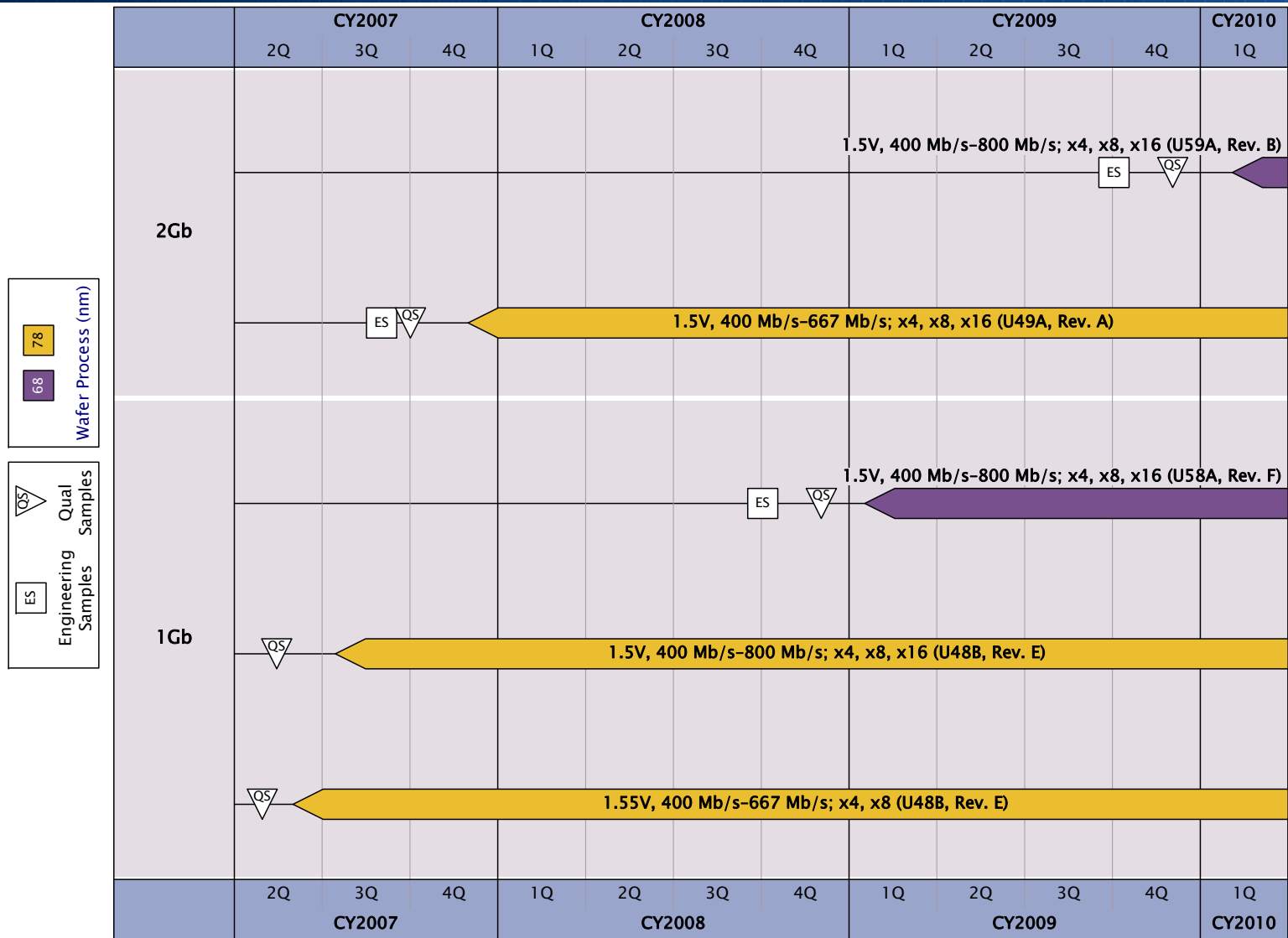
1.5V Design Requirements

- What is required for you to design in 1.5V DDR2?

Agenda

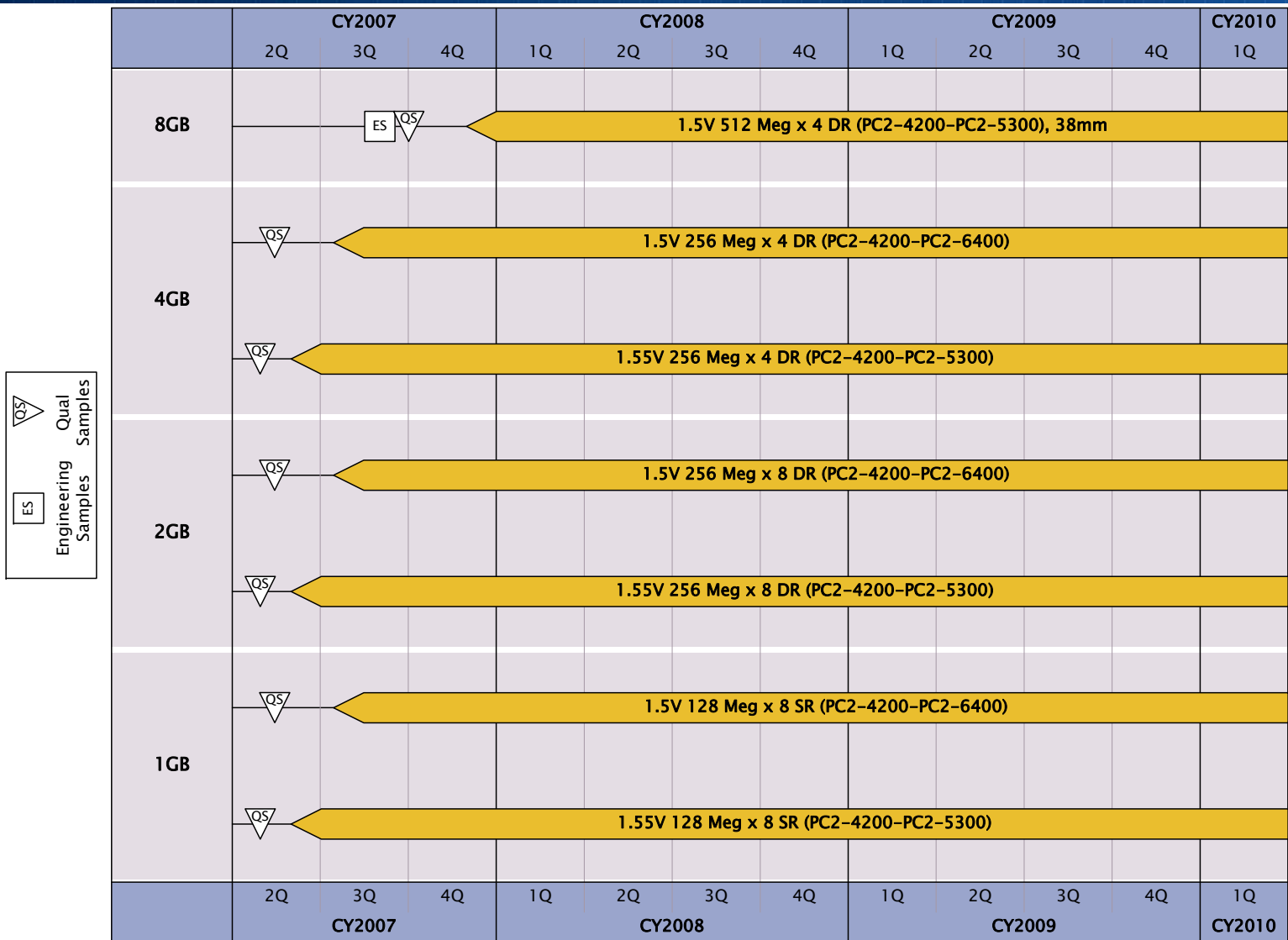
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1.5V DDR2 Road Map



Note: Speeds are shown in data rates

1.5V FBDIMM DDR2 Road Map



 Engineering Samples
 Qual Samples

Note: Speeds are shown in data rates

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Schedule

- 1GB, 2GB, 4GB FBDIMM
 - ▶ 1.5V regulated
 - ES – now in limited quantities
 - QS – 2Q07
 - Production – 2Q07
 - ▶ 1.5V unregulated
 - ES – 2Q07
 - QS – 3Q07
 - Production - 3Q07
- 8GB FBDIMM (1.5V unregulated)
 - ES – 3Q07
 - QS – 3Q07
 - Production – 4Q07

1.5V Regulated Part Numbers

- **Component**
 - ▶ MT47R64M16HR-37E
 - ▶ MT47R64M16HR-3
 - ▶ MT47R64M16HR-25
 - ▶ MT47R128M8HQ-37E
 - ▶ MT47R128M8HQ-3
 - ▶ MT47R128M8HQ-25
 - ▶ MT47R256M4HQ-37E
 - ▶ MT47R256M4HQ-3
 - ▶ MT47R256M4HQ-25
- **FBDIMM**
 - ▶ MT9RTF12872FY-667
 - ▶ MT9RTF12872FY-533
 - ▶ MT18RTF25672FDY-667
 - ▶ MT18RTF25672FDY-533
 - ▶ MT36RTF51272FY-667
 - ▶ MT36RTF51272FY-533

1.5V Unregulated Part Numbers

- **Component**
 - ▶ MT47J64M16HR-37E
 - ▶ MT47J64M16HR-3
 - ▶ MT47J64M16HR-25
 - ▶ MT47J128M8HQ-37E
 - ▶ MT47J128M8HQ-3
 - ▶ MT47J128M8HQ-25
 - ▶ MT47J256M4HQ-37E
 - ▶ MT47J256M4HQ-3
 - ▶ MT47J256M4HQ-25
- **FBDIMM**
 - ▶ MT9GTF12872FY-667
 - ▶ MT9GTF12872FY-533
 - ▶ MT18GTF25672FDY-667
 - ▶ MT18GTF25672FDY-533
 - ▶ MT36GTF51272FY-667
 - ▶ MT36GTF51272FY-533

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