Appendix A - ATmega88/168 Automotive Specification at 150°C

This document contains information specific to devices operating at temperatures up to 150°C. Only deviations are covered in this appendix, all other information can be found in the complete Automotive datasheet. The complete Automotive datasheet can be found on www.atmel.com

8-bit AVR® Microcontroller with 8K Bytes In-System Programmable Flash

ATmega88/168 Automotive

Appendix A

7607H–AVR–02/10

1. Electrical Characteristics

1.1 Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Test Conditions	Unit
Operating Temperature	–55 to +150	°C
Storage Temperature	–65 to +175	°C
Voltage on any Pin except $\overline{\text{RESET}}$ with respect to Ground	–0.5 to V_{CC}+0.5	V
Voltage on $\overline{\text{RESET}}$ with respect to Ground	–0.5 to +13.0	V
Maximum Operating Voltage	6.0	V
DC Current per I/O Pin DC Current V_{CC} and GND	30 200.0	mA

1.2 DC Characteristics

T_A = –40°C to +150°C, V_{CC} = 2.7V to 5.5V (unless otherwise noted)

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Input Low Voltage, except XTAL1 and $\overline{\text{RESET}}$ pin	V_{CC} = 2.7V to 5.5V	V_{IL}	–0.5		$+0.3V_{CC}$ (1)	V
Input High Voltage, except XTAL1 and $\overline{\text{RESET}}$ pins	V_{CC} = 2.7V to 5.5V	V_{IH}	$0.6V_{CC}$ (2)		V_{CC} + 0.5	V
Input Low Voltage, XTAL1 pin	V_{CC} = 2.7V to 5.5V	V_{IL1}	–0.5		$+0.1V_{CC}$ (2)	V
Input High Voltage, XTAL1 pin	V_{CC} = 2.7V to 5.5V	V_{IH1}	$0.7V_{CC}$ (2)		V_{CC} + 0.5	V
Input Low Voltage, $\overline{\text{RESET}}$ pin	V_{CC} = 2.7V to 5.5V	V_{IL2}	–0.5		$+0.2V_{CC}$ (1)	V
Input High Voltage, $\overline{\text{RESET}}$ pin	V_{CC} = 2.7V to 5.5V	V_{IH2}	$0.9V_{CC}$ (2)		V_{CC} + 0.5	V

Notes:
1. “Max” means the highest value where the pin is guaranteed to be read as low
2. “Min” means the lowest value where the pin is guaranteed to be read as high
3. Although each I/O port can sink more than the test conditions (20 mA at V_{CC} = 5V) under steady state conditions (non-transient), the following must be observed:
   1] The sum of all IOL, for all ports, should not exceed 400 mA.
   2] The sum of all IOL, for ports C0 - C5, should not exceed 200 mA.
   3] The sum of all IOL, for ports C6, D0 - D4, should not exceed 300 mA.
   4] The sum of all IOL, for ports B0 - B7, D5 - D7, should not exceed 300 mA.
   If IOL exceeds the test condition, VOL may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test condition.
4. Although each I/O port can source more than the test conditions (20 mA at V_{CC} = 5V) under steady state conditions (non-transient), the following must be observed:
   1] The sum of all IOH, for all ports, should not exceed 400 mA.
   2] The sum of all IOH, for ports C0 - C5, should not exceed 200 mA.
   3] The sum of all IOH, for ports C6, D0 - D4, should not exceed 300 mA.
   4] The sum of all IOH, for ports B0 - B7, D5 - D7, should not exceed 300 mA.
   If IOH exceeds the test condition, VOH may exceed the related specification. Pins are not guaranteed to source current greater than the listed test condition.
5. Minimum V_{CC} for Power-down is 2.5V

1.2 DC Characteristics (Continued)

T_A = –40°C to +150°C, V_{CC} = 2.7V to 5.5V (unless otherwise noted)

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Input Low Voltage, $\overline{\text{RESET}}$ pin as I/O	V_{CC} = 2.7V to 5.5V	V_{IL3}	–0.5		$+0.3V_{CC}$ (1)	V
Input High Voltage, $\overline{\text{RESET}}$ pin as I/O	V_{CC} = 2.7V to 5.5V	V_{IH3}	$0.6V_{CC}$ (2)		V_{CC} + 0.5	V
Output Low Voltage(3), I/O pin except RESET	I_{OL} = 20 mA, V_{CC} = 5V I_{OL} = 5 mA, V_{CC} = 3V	V_{OL}			0.8 0.5	V
Output High Voltage(4) I/O pin except RESET	I_{OH} = –20 mA, V_{CC} = 5V I_{OH} = –10 mA, V_{CC} = 3V	V_{OH}	4.0 2.2			V
Input Leakage Current I/O Pin	V_{CC} = 5.5V, pin low (absolute value)	I_{IL}			1	µA
Input Leakage Current I/O Pin	V_{CC} = 5.5V, pin high (absolute value)	I_{IH}			1	µA
Reset Pull-up Resistor		R_{RST}	30		60	kΩ
I/O Pin Pull-up Resistor		R_{PU}	20		50	kΩ
Power Supply Current(5)	Active 4 MHz, V_{CC} = 3V Active 8MHz, V_{CC} = 5V	I_{CC}			8 16	mA
	Active 16 MHz, V_{CC} = 5V	$I_{CC\ IDLE}$			25	mA
	Idle 4 MHz, V_{CC} = 3V Idle 8 MHz, V_{CC} = 5V				6 12	mA
	Idle 16 MHz, V_{CC} = 5V				14	mA
Power-down mode	WDT enabled, V_{CC} = 3V WDT enabled, V_{CC} = 5V	$I_{CC\ PWD}$			90 140	µA
	WDT disabled, V_{CC} = 3V WDT disabled, V_{CC} = 5V				80 120	µA
Analog Comparator Input Offset Voltage	V_{CC} = 5V V_{in} = V_{CC}/2	V_{ACIO}		< 10	40	mV
Analog Comparator Input Leakage Current	V_{CC} = 5V V_{in} = V_{CC}/2	I_{ACLK}	–50		+50	nA
Analog Comparator Propagation Delay	V_{CC} = 4.0V	t_{ACPD}		500		ns

Notes:
1. “Max” means the highest value where the pin is guaranteed to be read as low
2. “Min” means the lowest value where the pin is guaranteed to be read as high
3. Although each I/O port can sink more than the test conditions (20 mA at V_{CC} = 5V) under steady state conditions (non-transient), the following must be observed:
   1] The sum of all IOL, for all ports, should not exceed 400 mA.
   2] The sum of all IOL, for ports C0 - C5, should not exceed 200 mA.
   3] The sum of all IOL, for ports C6, D0 - D4, should not exceed 300 mA.
   4] The sum of all IOL, for ports B0 - B7, D5 - D7, should not exceed 300 mA.
   If IOL exceeds the test condition, VOL may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test condition.
4. Although each I/O port can source more than the test conditions (20 mA at V_{CC} = 5V) under steady state conditions (non-transient), the following must be observed:
   1] The sum of all IOH, for all ports, should not exceed 400 mA.
   2] The sum of all IOH, for ports C0 - C5, should not exceed 200 mA.
   3] The sum of all IOH, for ports C6, D0 - D4, should not exceed 300 mA.
   4] The sum of all IOH, for ports B0 - B7, D5 - D7, should not exceed 300 mA.
   If IOH exceeds the test condition, VOH may exceed the related specification. Pins are not guaranteed to source current greater than the listed test condition.
5. Minimum V_{CC} for Power-down is 2.5V

1.3 Memory Endurance

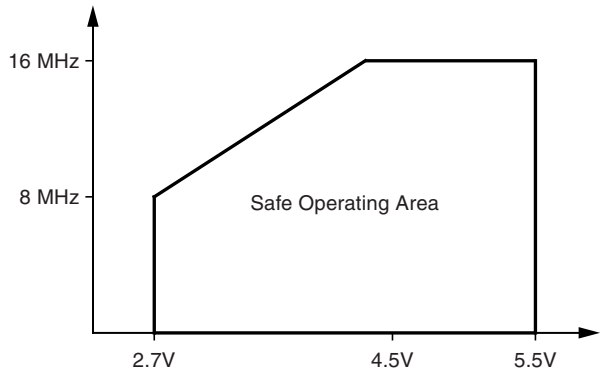
EEPROM endurance: 50,000 Write/Erase cycles.

Flash endurance: 10,000 Write/Erase cycles.

1.4 Maximum Speed versus V_{CC}

Maximum frequency is dependent on V_{CC}. As shown in Figure 1-1, the Maximum Frequency vs. V_{CC} curve is linear between $2.7V < V_{CC} < 4.5V$.

Figure 1-1. Maximum Frequency vs. V_{CC}



1.5 ADC Characteristics(1)

T_A = –40°C to +150°C, V_{CC} = 4.5V to 5.5V (unless otherwise noted)

Parameters	Test Conditions	Symbol	Min	Typ	Max	Unit
Resolution				10		Bits
Absolute accuracy (Including INL, DNL, quantization error, gain and offset error)	V_{REF} = 4V, V_{CC} = 4V, ADC clock = 200 kHz			2	3.5	LSB
	V_{REF} = 4V, V_{CC} = 4V, ADC clock = 200 kHz Noise Reduction Mode			2	3.5	LSB
Integral Non-Linearity (INL)	V_{REF} = 4V, V_{CC} = 4V, ADC clock = 200 kHz			0.6	2.5	LSB
Differential Non-Linearity (DNL)	V_{REF} = 4V, V_{CC} = 4V, ADC clock = 200 kHz			0.30	1.0	LSB
Gain Error	V_{REF} = 4V, V_{CC} = 4V, ADC clock = 200 kHz		–3.5	–1.3	+3.5	LSB
Offset Error	V_{REF} = 4V, V_{CC} = 4V, ADC clock = 200 kHz			1.8	3.5	LSB
Conversion Time	Free Running Conversion		13 cycles			µs
Clock Frequency			50		200	kHz
Analog Supply Voltage		AV_{CC}	V_{CC} – 0.3		V_{CC} + 0.3	V
Reference Voltage		V_{REF}	1.0		AV_{CC}	V
Input Voltage		V_{IN}	GND		V_{REF}	V
Input Bandwidth				38.5		kHz
Internal Voltage Reference		V_{INT}	1.0	1.1	1.2	V
Reference Input Resistance		R_{REF}	25.6	32	38.4	kΩ
Analog Input Resistance		R_{AIN}		100		MΩ

Note: 1. Based on standard voltage range (2.7V to 5.5V) characterization results. To be confirmed after actual silicon characterization.

2. ATmega88/168 Typical Characteristics

2.1 Active Supply Current

Figure 2-1. Active Supply Current versus Frequency (1 MHz to 20 MHz)

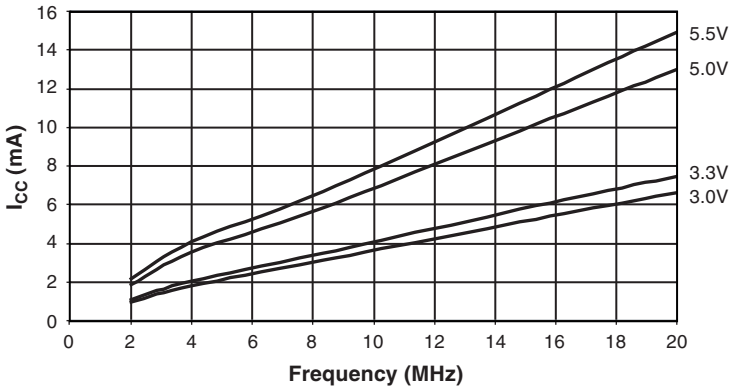
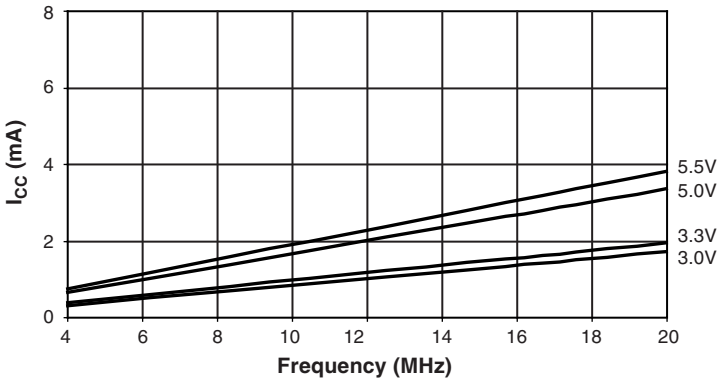


Figure 2-2. Idle Supply Current versus Frequency (1 MHz to 20 MHz)



2.2 Power-Down Supply Current

Figure 2-3. Power-down Supply Current versus V_{CC} (Watchdog Timer Disabled)

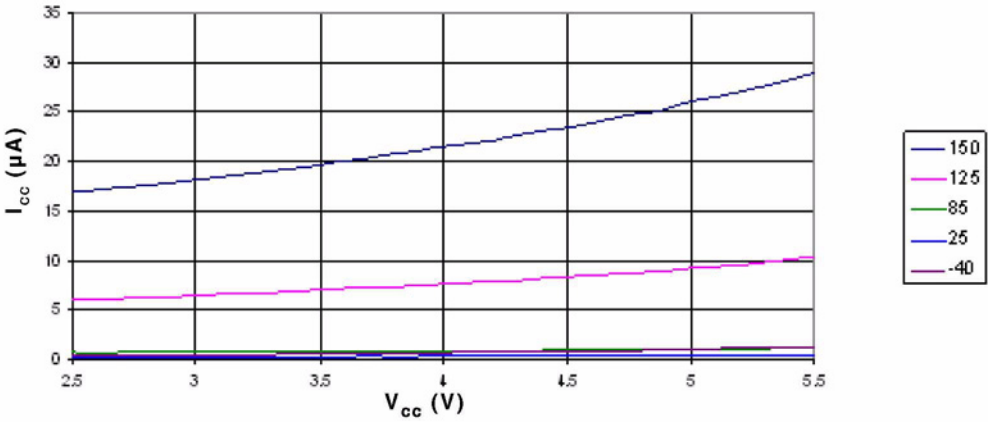
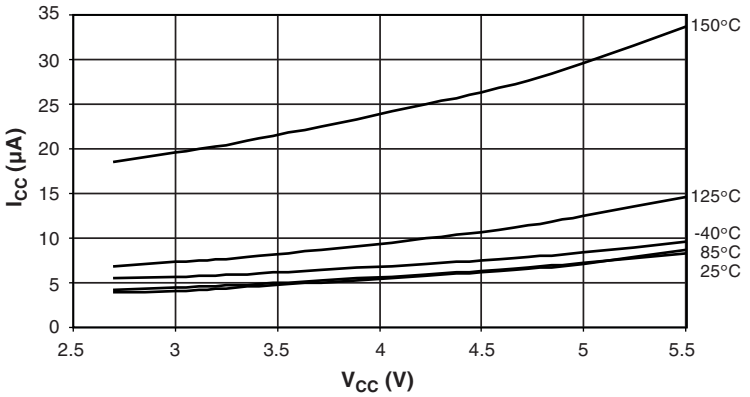


Figure 2-4. Power-down Supply Current versus V_{CC} (Watchdog Timer Enabled)



2.3 Pin Pull-up

Figure 2-5. I/O Pin Pull-up Resistor Current versus Input Voltage (V_{CC} = 5V)

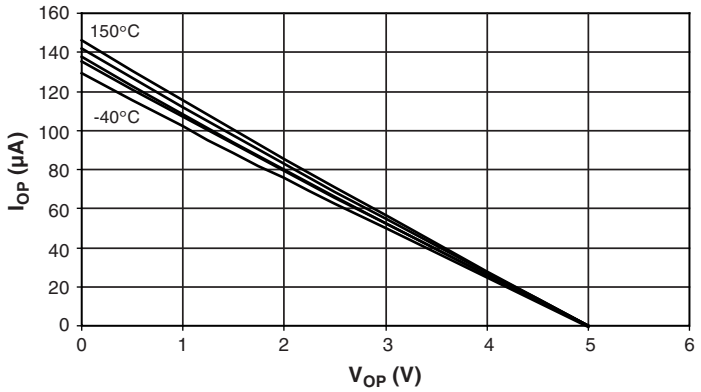


Figure 2-6. Output Low Voltage versus Output Low Current (V_{CC} = 5V)

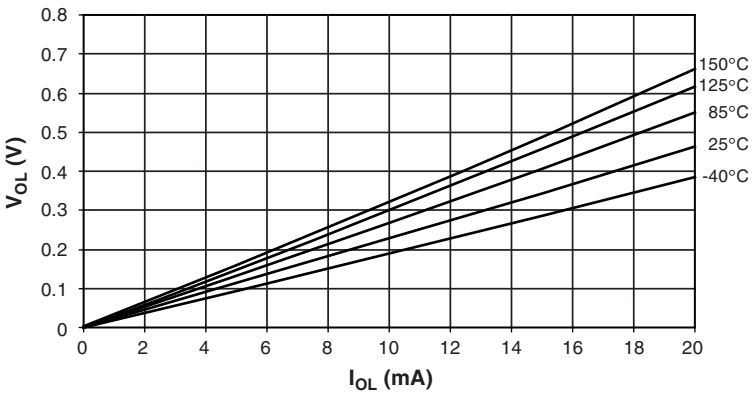


Figure 2-7. Output Low Voltage versus Output Low Current (V_{CC} = 3V)

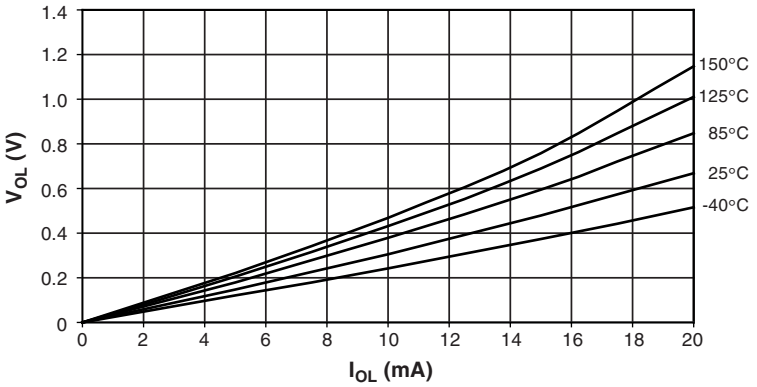


Figure 2-8. Output High Voltage versus Output High Current (V_{CC} = 5V)

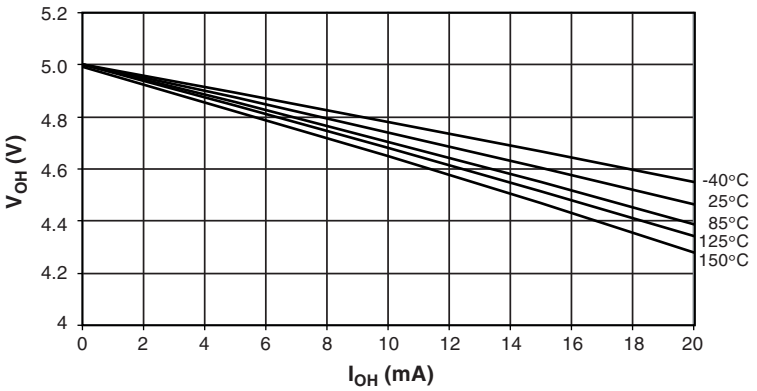


Figure 2-9. Output High Voltage versus Output High Current (V_{CC} = 3V)

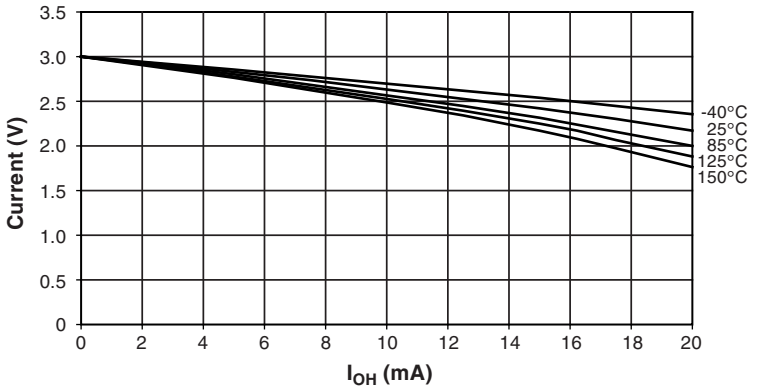
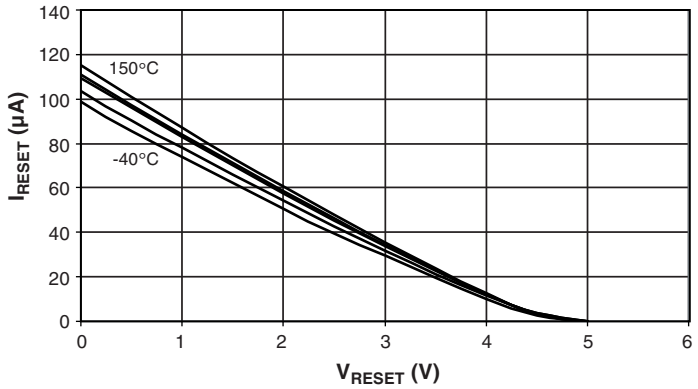


Figure 2-10. Reset Pull-up Resistor Current versus Reset Pin Voltage (V_{CC} = 5V)



2.4 Pin Thresholds and Hysteresis

Figure 2-11. I/O Pin Input Threshold versus V_{CC} (VIH, I/O Pin Read as '1')

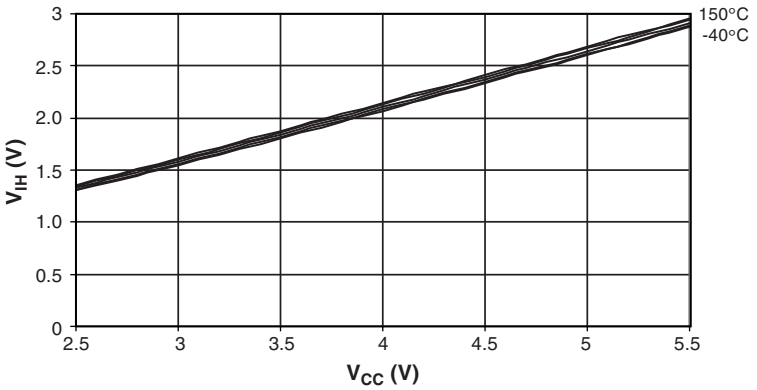


Figure 2-12. I/O Pin Input Threshold versus V_{CC} (VIL, I/O Pin Read as '0')

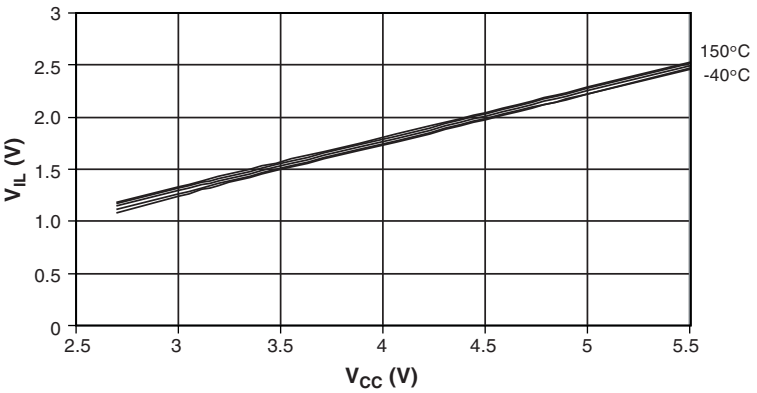


Figure 2-13. Reset Input Threshold Voltage versus V_{CC} (VIH, Reset Pin Read as '1')

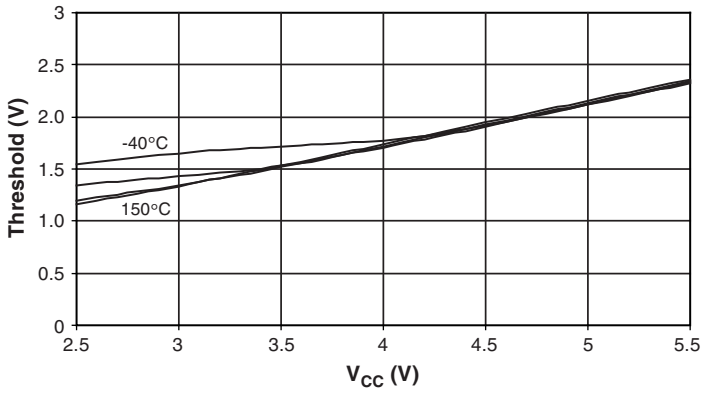
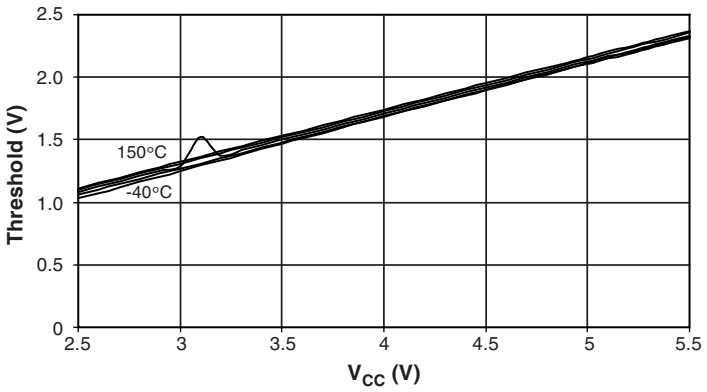


Figure 2-14. Reset Input Threshold Voltage versus V_{CC} (VIL, Reset Pin Read as '0')



2.5 Internal Oscillator Speed

Figure 2-15. Watchdog Oscillator Frequency versus V_{CC}

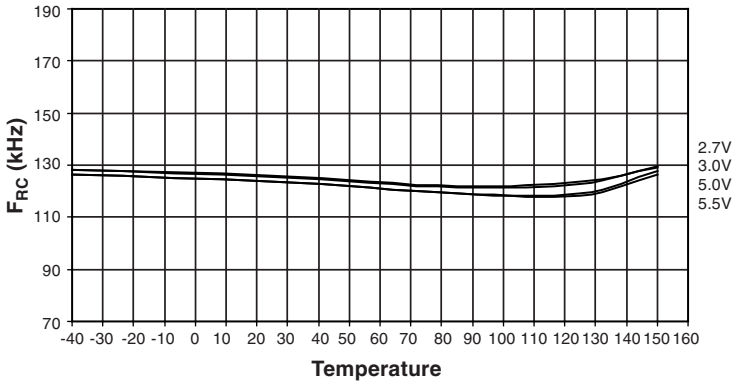


Figure 2-16. Calibrated 8 MHz RC Oscillator Frequency versus Temperature

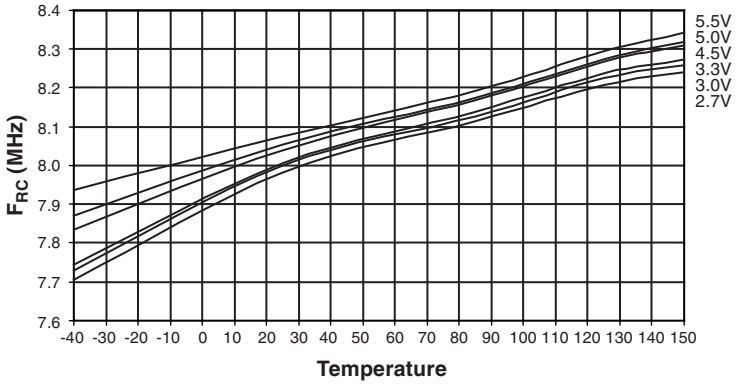


Figure 2-17. Calibrated 8 MHz RC Oscillator Frequency versus V_{CC}

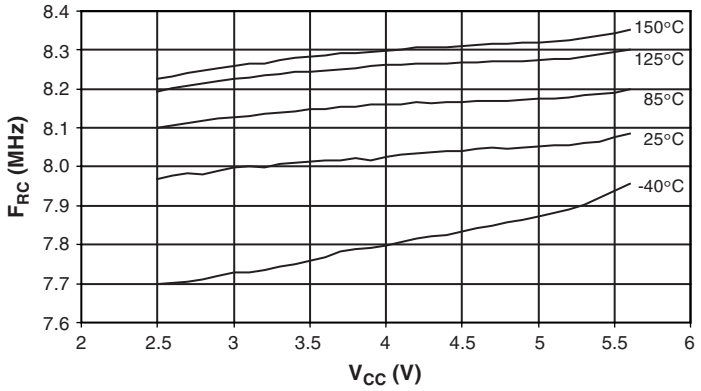
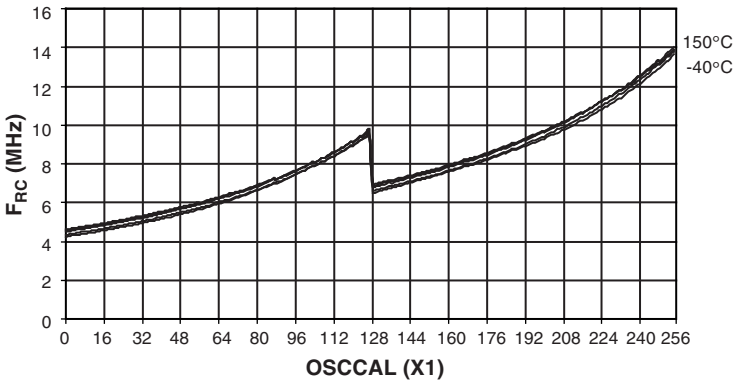


Figure 2-18. Calibrated 8 MHz RC Oscillator Frequency versus OSCCAL Value



2.6 BOD Thresholds and Analog Comparator Offset

Figure 2-19. BOD Threshold versus Temperature (BODLEVEL is 4.0V)

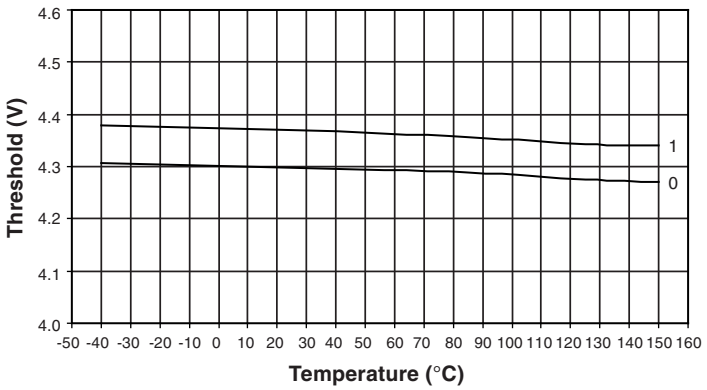


Figure 2-20. BOD Threshold versus Temperature (BODLEVEL is 2.7V)

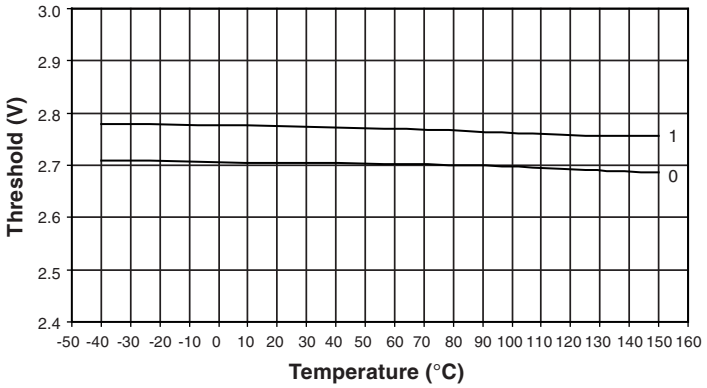
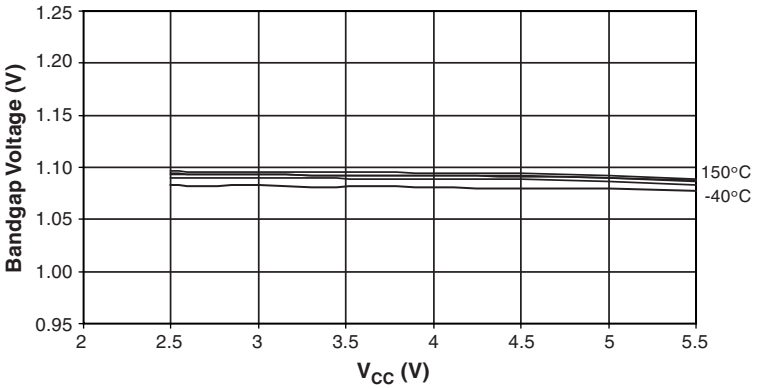


Figure 2-21. Bandgap Voltage versus V_{CC}



2.7 Peripheral Units

Figure 2-22. Analog to Digital Converter GAIN versus V_{CC}

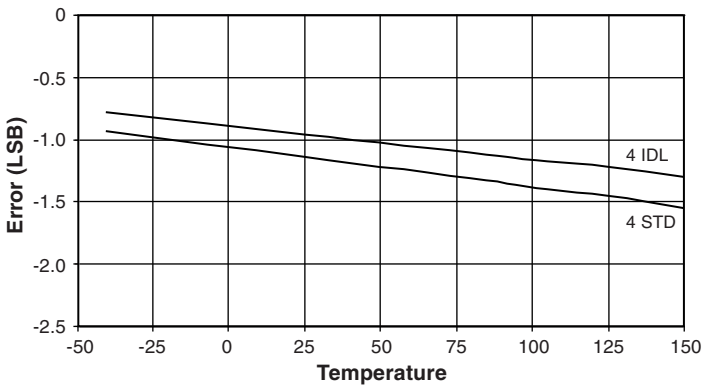


Figure 2-23. Analog to Digital Converter OFFSET versus V_{CC}

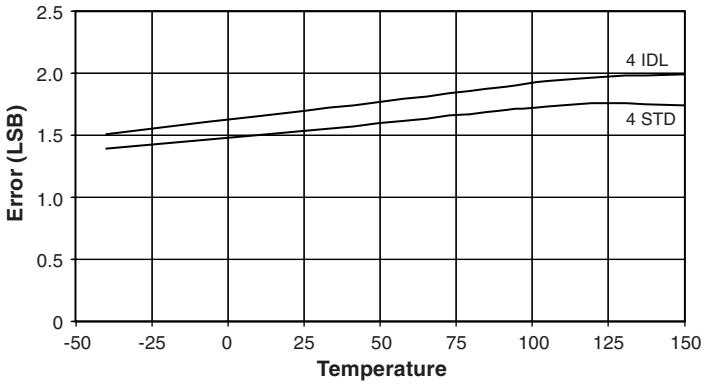


Figure 2-24. Analog to Digital Converter DNL versus V_{CC}

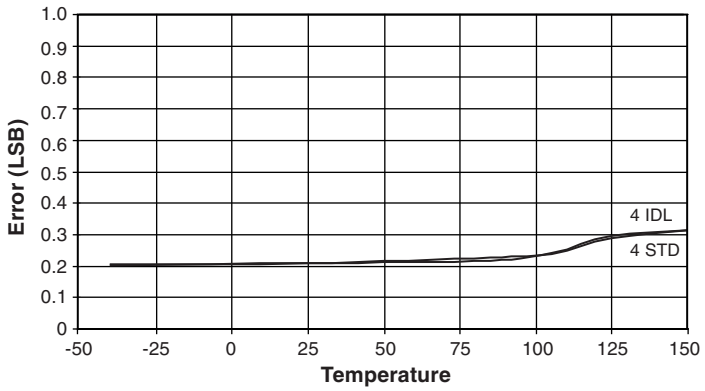
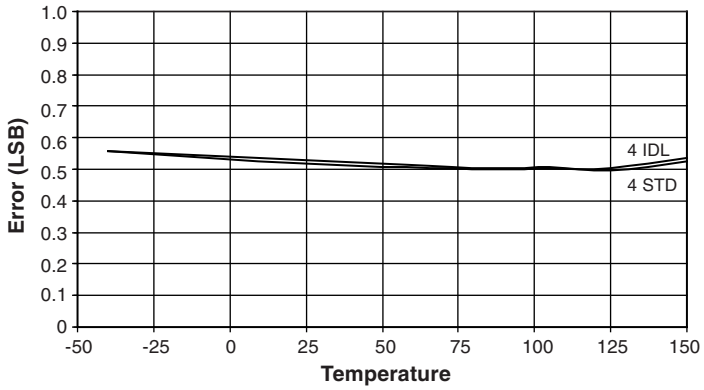


Figure 2-25. Analog to Digital Converter INL versus V_{CC}



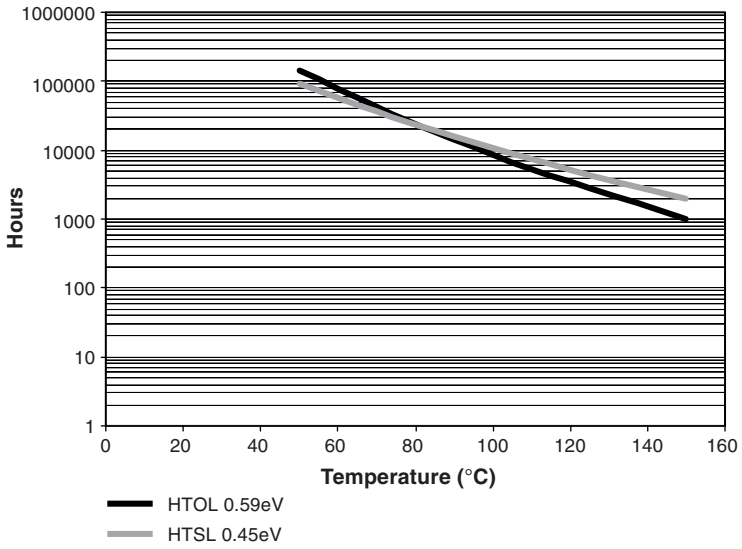
2.8 Grade 0 Qualification

The ATmega88/168 has been developed and manufactured according to the most stringent quality assurance requirements of ISO-TS-16949 and verified during product qualification as per AEC-Q100 grade 0.

AEC-Q100 qualification relies on temperature accelerated stress testing. High temperature field usage however may result in less significant stress test acceleration. In order to prevent the risk that ATmega88/168 lifetime would not satisfy the application end-of-life reliability requirements, Atmel® has extended the testing, whenever applicable (High Temperature Operating Life Test, High Temperature Storage Life, Data Retention, Thermal Cycles), far beyond the AEC-Q100 requirements. Thereby, Atmel verified the ATmega88/168 has a long safe lifetime period after the grade 0 qualification acceptance limits.

The valid domain calculation depends on the activation energy of the potential failure mechanism that is considered. Examples are given in Figure 2-26. Therefore any temperature mission profile which could exceed the AEC-Q100 equivalence domain shall be submitted to Atmel for a thorough reliability analysis

Figure 2-26. AEC-Q100 Lifetime Equivalence



3. Ordering Information

Table 3-1. ATmega88/168

Speed (MHz)	Power Supply	Ordering Code	Package[1]	Operation Range
16[2]	2.7V to 5.5V	ATmega88-15MT2	PN	Extended (–40° C to +150° C)
16[2]	2.7V to 5.5V	ATmega88-15AD	MA	Extended (–40° C to +150° C)
16[2]	2.7V to 5.5V	ATmega168-15MD	PN	Extended (–40° C to +150° C)
16[2]	2.7V to 5.5V	ATmega168-15AD	MA	Extended (–40° C to +150° C)

Notes: 1. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.

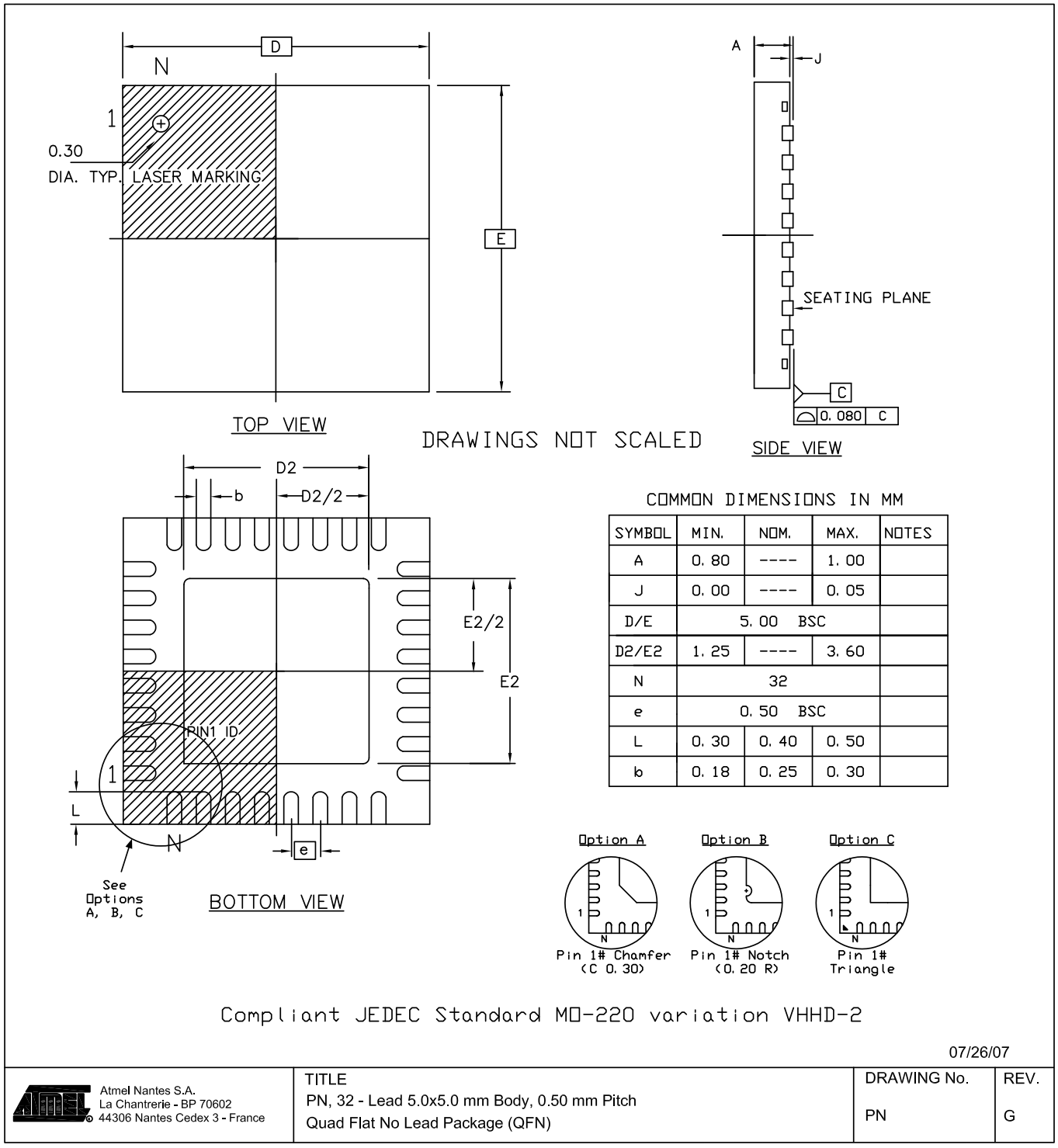
2. For Speed vs. V_{cc}, see complete datasheet.

4. Package Information

Table 4-1. Package Types

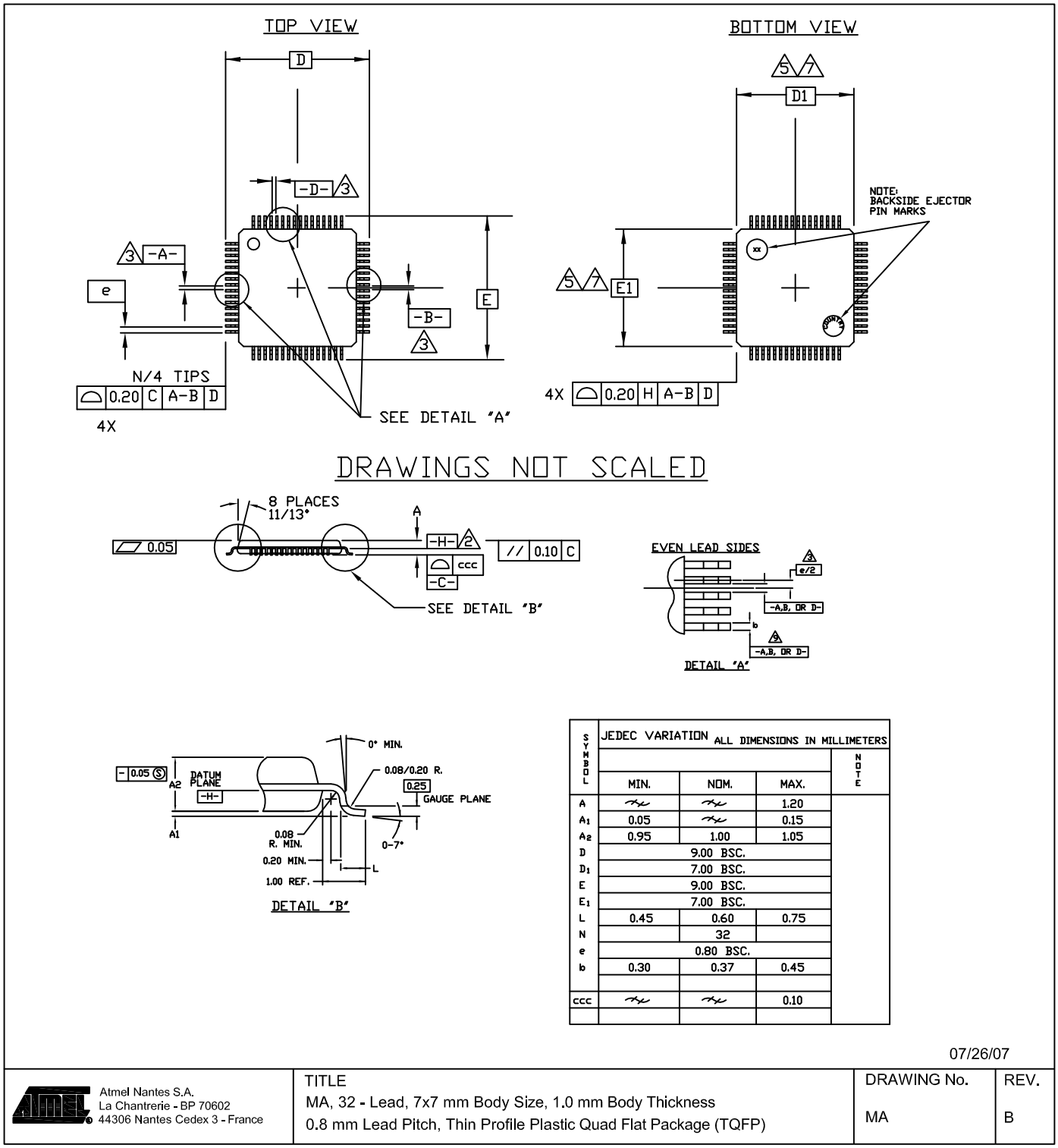
Package Type	
PN	32-pad, 5 × 5 × 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF): E2/D2 3.1 ±0.1 mm
MA	32 - Lead, 7 × 7 mm Body Size, 1.0 mm Body Thickness 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)

Figure 4-1. PN



SYMBOL	MIN.	NOM.	MAX.	NOTES
A	0.80	----	1.00	
J	0.00	----	0.05	
D/E		5.00 BSC		
D2/E2	1.25	----	3.60	
N		32		
e		0.50 BSC		
L	0.30	0.40	0.50	
b	0.18	0.25	0.30	

Figure 4-2. MA



SYMBOL	JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			NOTE
	MIN.	NOM.	MAX.	
A			1.20	
A_1	0.05		0.15	
A_2	0.95	1.00	1.05	
D		9.00 BSC.		
D_1		7.00 BSC.		
E		9.00 BSC.		
E_1		7.00 BSC.		
L	0.45	0.60	0.75	
N		32		
e		0.80 BSC.		
b	0.30	0.37	0.45	
ccc			0.10	

07/26/07

	TITLE	DRAWING No.	REV.
Atmel Nantes S.A. La Chantrerie - BP 70602 44306 Nantes Cedex 3 - France	MA, 32 - Lead, 7x7 mm Body Size, 1.0 mm Body Thickness 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	MA	B

5. Revision History

Please note that the following page numbers referred to in this section refer to the specific revision mentioned, not to this document.

Revision No.	History
7607H-AVR-02/10	• Table 4-1 “Package Types” on page 15 changed
7607G-AVR-07/09	• Package MA updated
7607F-AVR-01/08	• Added memory endurance. See Section 1.3 “Memory Endurance” on page 4
7607E-AVR-11/07	• Added ATMega168 product offering • Added MA package offering
7607D-AVR-03/07	• Updated electrical characteristics • Removed Grade0 qualification section • Updated product part number in ordering information
7607C-AVR-09/06	• Ordering and package information updated
7607B-AVR-08/06	• Added typical characteristics
7607A-AVR-01/06	• Document Creation

Headquarters

Atmel Corporation
2325 Orchard Parkway
San Jose, CA 95131
USA
Tel: 1(408) 441-0311
Fax: 1(408) 487-2600

International

Atmel Asia
Unit 1-5 & 16, 19/F
BEA Tower, Millennium City 5
418 Kwun Tong Road
Kwun Tong, Kowloon
Hong Kong
Tel: (852) 2245-6100
Fax: (852) 2722-1369

Atmel Europe
Le Krebs
8, Rue Jean-Pierre Timbaud
BP 309
78054
Saint-Quentin-en-Yvelines Cedex
France
Tel: (33) 1-30-60-70-00
Fax: (33) 1-30-60-71-11

Atmel Japan
9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chuo-ku, Tokyo 104-0033
Japan
Tel: (81) 3-3523-3551
Fax: (81) 3-3523-7581

Product Contact

Web Site
www.atmel.com

Technical Support
avr@atmel.com

Sales Contact
www.atmel.com/contacts

Literature Requests
www.atmel.com/literature

Disclaimer: The information in this document is provided in connection with Atmel products. No license, express or implied, by estoppel or otherwise, to any intellectual property right is granted by this document or in connection with the sale of Atmel products. **EXCEPT AS SET FORTH IN ATMEL'S TERMS AND CONDITIONS OF SALE LOCATED ON ATMEL'S WEB SITE, ATMEL ASSUMES NO LIABILITY WHATSOEVER AND DISCLAIMS ANY EXPRESS, IMPLIED OR STATUTORY WARRANTY RELATING TO ITS PRODUCTS INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. IN NO EVENT SHALL ATMEL BE LIABLE FOR ANY DIRECT, INDIRECT, CONSEQUENTIAL, PUNITIVE, SPECIAL OR INCIDENTAL DAMAGES (INCLUDING, WITHOUT LIMITATION, DAMAGES FOR LOSS OF PROFITS, BUSINESS INTERRUPTION, OR LOSS OF INFORMATION) ARISING OUT OF THE USE OR INABILITY TO USE THIS DOCUMENT, EVEN IF ATMEL HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.** Atmel makes no representations or warranties with respect to the accuracy or completeness of the contents of this document and reserves the right to make changes to specifications and product descriptions at any time without notice. Atmel does not make any commitment to update the information contained herein. Unless specifically provided otherwise, Atmel products are not suitable for, and shall not be used in, automotive applications. Atmel's products are not intended, authorized, or warranted for use as components in applications intended to support or sustain life.

© 2010 Atmel Corporation. All rights reserved. Atmel®, Atmel logo and combinations thereof, AVR®, AVR® logo and others are registered trademarks or trademarks of Atmel Corporation or its subsidiaries. Other terms and product names may be trademarks of others.