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**Appendix A - ATtiny45 Automotive specification at 150°C**

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**DATASHEET****Description**

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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](http://www.atmel.com)

# 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	Min.	Typ.	Max.	Unit
Operating temperature	-55		+150	°C
Storage temperature	-65		+175	°C
Voltage on any pin except $\overline{\text{RESET}}$ with respect to ground	-0.5		$V_{CC} + 0.5$	V
Voltage on $\overline{\text{RESET}}$ with respect to ground	-0.5		+13.0	V
Maximum operating voltage			6.0	V
DC current per I/O pin		30.0		mA
DC current $V_{CC}$ and GND pins		200.0		mA

## 1.2 DC Characteristics

$T_A = -40^\circ\text{C}$  to  $+150^\circ\text{C}$ ,  $V_{CC} = 2.7\text{V}$  to  $5.5\text{V}$  (unless otherwise noted)<sup>(6)</sup>

Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit
Input low voltage, except XTAL1 and $\overline{\text{RESET}}$ pin	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IL}$	-0.5		$0.3V_{CC}^{(1)}$	V
Input high voltage, except XTAL1 and $\overline{\text{RESET}}$ pins	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IH}$	$0.6V_{CC}^{(2)}$		$V_{CC} + 0.5$	V
Input low voltage, XTAL1 pin	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IL1}$	-0.5		$0.1V_{CC}^{(1)}$	V
Input high voltage, XTAL1 pin	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IH1}$	$0.7V_{CC}^{(2)}$		$V_{CC} + 0.5$	V
Input low voltage, $\overline{\text{RESET}}$ pin	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IL2}$	-0.5		$0.2V_{CC}^{(1)}$	V
Input high voltage, $\overline{\text{RESET}}$ pin	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IH2}$	$0.9V_{CC}^{(2)}$		$V_{CC} + 0.5$	V
Input low voltage, $\overline{\text{RESET}}$ pin as I/O	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IL3}$	-0.5		$0.3V_{CC}^{(1)}$	V
Input high voltage, $\overline{\text{RESET}}$ pin as I/O	$V_{CC} = 2.7\text{V} - 5.5\text{V}$	$V_{IH3}$	$0.6V_{CC}^{(2)}$		$V_{CC} + 0.5$	V
Output low voltage <sup>(3)</sup> , I/O pin except $\overline{\text{RESET}}$	$I_{OL} = 10\text{mA}$ , $V_{CC} = 5\text{V}$ $I_{OL} = 5\text{mA}$ , $V_{CC} = 3\text{V}$	$V_{OL}$			0.8 0.5	V
Output high voltage <sup>(4)</sup> , I/O pin except $\overline{\text{RESET}}$	$I_{OH} = -10\text{mA}$ , $V_{CC} = 5\text{V}$ $I_{OH} = -5\text{mA}$ , $V_{CC} = 3\text{V}$	$V_{OH}$	4.0 2.2			V
Input leakage current I/O pin	$V_{CC} = 5.5\text{V}$ , pin low (absolute value)	$I_{IL}$			1	$\mu\text{A}$
Input leakage current I/O pin	$V_{CC} = 5.5\text{V}$ , pin high (absolute value)	$I_{IH}$			1	$\mu\text{A}$
Reset pull-up resistor		$R_{RST}$	30		60	$\text{k}\Omega$
I/O pin pull-up resistor		$R_{PU}$	20		50	$\text{k}\Omega$

## 1.2 DC Characteristics (Continued)

$T_A = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{CC} = 2.7\text{V}$  to  $5.5\text{V}$  (unless otherwise noted)<sup>(6)</sup>

Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit
Power supply current <sup>(6)</sup>	Active 4MHz, $V_{CC} = 3\text{V}$	$I_{CC}$			8	mA
	Active 8MHz, $V_{CC} = 5\text{V}$				16	
	Active 16MHz, $V_{CC} = 5\text{V}$				25	
Power supply current <sup>(6)</sup>	Idle 4MHz, $V_{CC} = 3\text{V}$	$I_{CC\text{ IDLE}}$			6	mA
	Idle 8MHz, $V_{CC} = 5\text{V}$				12	
	Idle 16MHz, $V_{CC} = 5\text{V}$				14	
Power-down mode	WDT enabled, $V_{CC} = 3\text{V}$	$I_{CC\text{ PWD}}^{(5)}$			90	$\mu\text{A}$
	WDT enabled, $V_{CC} = 5\text{V}$				140	
Power-down mode	WDT disabled, $V_{CC} = 3\text{V}$	$I_{CC\text{ PWD}}^{(5)}$			80	$\mu\text{A}$
	WDT disabled, $V_{CC} = 5\text{V}$				120	
Analog comparator input offset voltage	$V_{CC} = 5\text{V}$ $V_{in} = V_{CC}/2$	$V_{ACIO}$		<10	40	mV
Analog comparator input leakage current	$V_{CC} = 5\text{V}$ $V_{in} = V_{CC}/2$	$I_{ACLK}$	-50		50	nA
Analog comparator propagation delay	$V_{CC} = 4.0\text{V}$	$t_{ACPD}$		500		ns

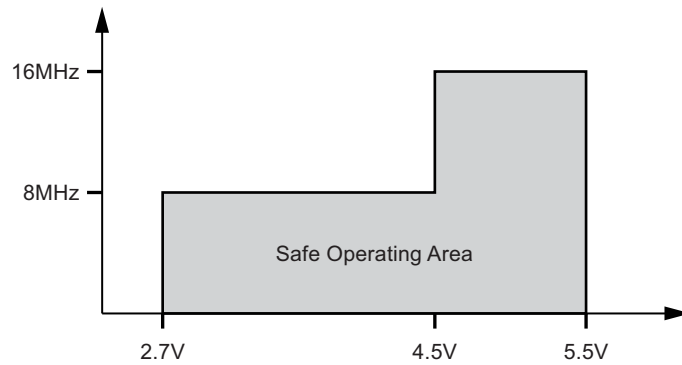
## 2. Memory Endurance

EEPROM endurance: 50,000 Write/Erase cycles

### 2.1 Maximum Speed versus $V_{CC}$

Maximum frequency is dependent on  $V_{CC}$ . As shown in [Figure 2-1](#), the maximum frequency versus  $V_{CC}$  curve is linear between  $2.7V < V_{CC} < 4.5V^{(6)}$ .

**Figure 2-1. Maximum Frequency versus  $V_{CC}$**



### 3. ADC Characteristics<sup>(6)</sup>

$T_A = 125^\circ\text{C}$  to  $150^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$  (unless otherwise noted)

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Resolution				10		Bits
Absolute accuracy (Including INL, DNL, quantization error, gain and offset error)	$V_{REF} = 4\text{V}$ , $V_{CC} = 4\text{V}$ , ADC clock = 200kHz			2	3.5	LSB
	$V_{REF} = 4\text{V}$ , $V_{CC} = 4\text{V}$ , ADC clock = 200kHz Noise reduction mode			2	3.5	LSB
Integral non-linearity (INL)	$V_{REF} = 4\text{V}$ , $V_{CC} = 4\text{V}$ , ADC clock = 200 kHz			0.6	2.5	LSB
Differential non-linearity (DNL)	$V_{REF} = 4\text{V}$ , $V_{CC} = 4\text{V}$ , ADC clock = 200kHz			0.30	1.0	LSB
Gain error	$V_{REF} = 4\text{V}$ , $V_{CC} = 4\text{V}$ , ADC clock = 200kHz		-3.5	-1.3	3.5	LSB
Offset error	$V_{REF} = 4\text{V}$ , $V_{CC} = 4\text{V}$ , ADC clock = 200kHz			1.8	3.5	LSB
Conversion time	Free running conversion		13 cycles			$\mu\text{s}$
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		$V_{REF} - 50\text{mV}$	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	$\text{k}\Omega$
Analog input resistance		$R_{AIN}$		100		$\text{M}\Omega$

- 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 (20mA at  $V_{CC} = 5\text{V}$ ) under steady state conditions (non-transient), the following must be observed:
    - 1] The sum of all IOL, for all ports, should not exceed 400mA.
    - 2] The sum of all IOL, for ports C0 - C5, should not exceed 200mA.
    - 3] The sum of all IOL, for ports C6, D0 - D4, should not exceed 300mA.
    - 4] The sum of all IOL, for ports B0 - B7, D5 - D7, should not exceed 300mA.
 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 (20mA at  $V_{CC} = 5\text{V}$ ) under steady state conditions (non-transient), the following must be observed:
    - 1] The sum of all IOH, for all ports, should not exceed 400mA.
    - 2] The sum of all IOH, for ports C0 - C5, should not exceed 200mA.
    - 3] The sum of all IOH, for ports C6, D0 - D4, should not exceed 300mA.
    - 4] The sum of all IOH, for ports B0 - B7, D5 - D7, should not exceed 300mA.
 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.

## 4. ATtiny45 Typical Characteristics

### 4.1 Active Supply Current

Figure 4-1. Active Supply Current versus Frequency (1 - 20 MHz)

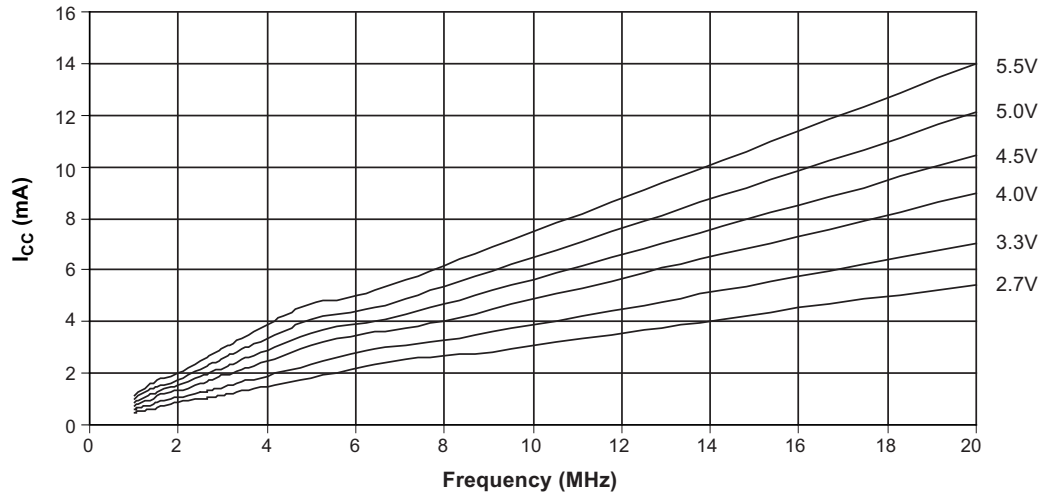
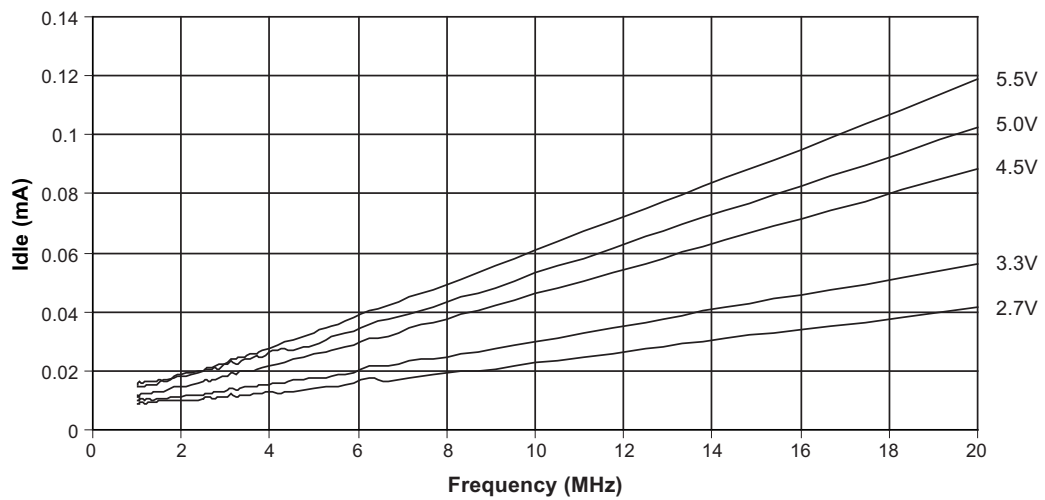


Figure 4-2. Idle Supply Current versus Frequency (1 - 20 MHz)



## 4.2 Power-Down Supply Current

Figure 4-3. Power-down Supply Current versus  $V_{CC}$  (Watchdog Timer Disabled)

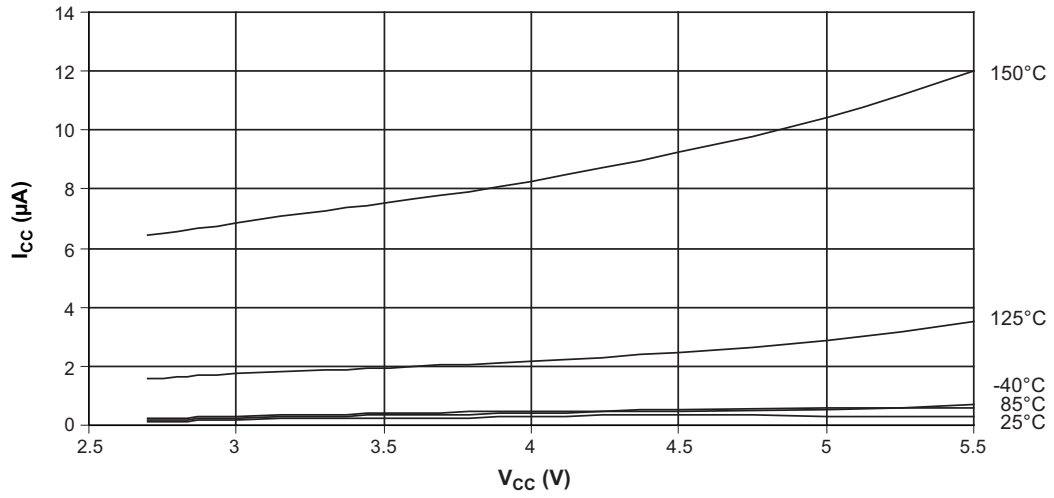
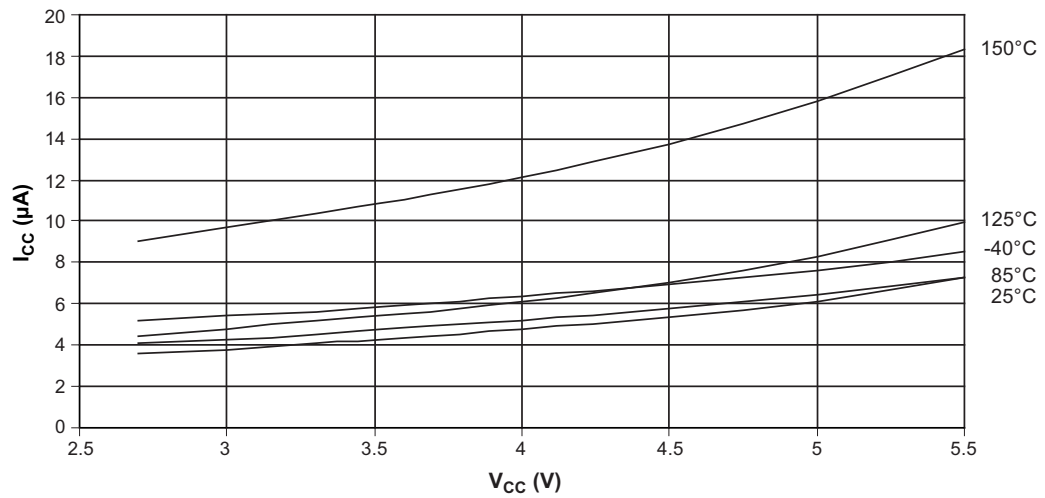


Figure 4-4. Power-down Supply Current versus  $V_{CC}$  (Watchdog Timer Enabled)



### 4.3 Pin Pull-up

Figure 4-5. I/O Pin Pull-up Resistor Current versus Input Voltage ( $V_{CC} = 5V$ )

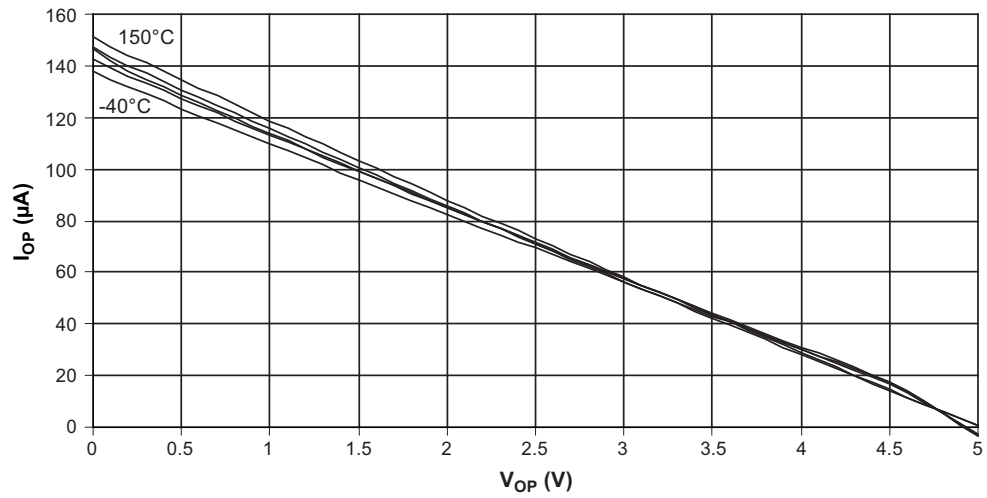


Figure 4-6. Output Low Voltage versus Output Low Current ( $V_{CC} = 5V$ )

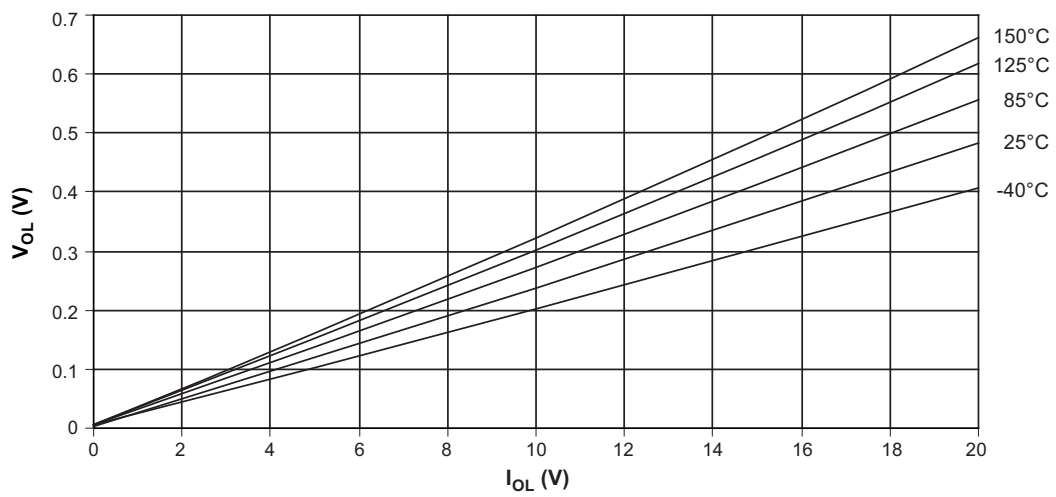




Figure 4-7. Output Low Voltage versus Output Low Current ( $V_{CC} = 3V$ )

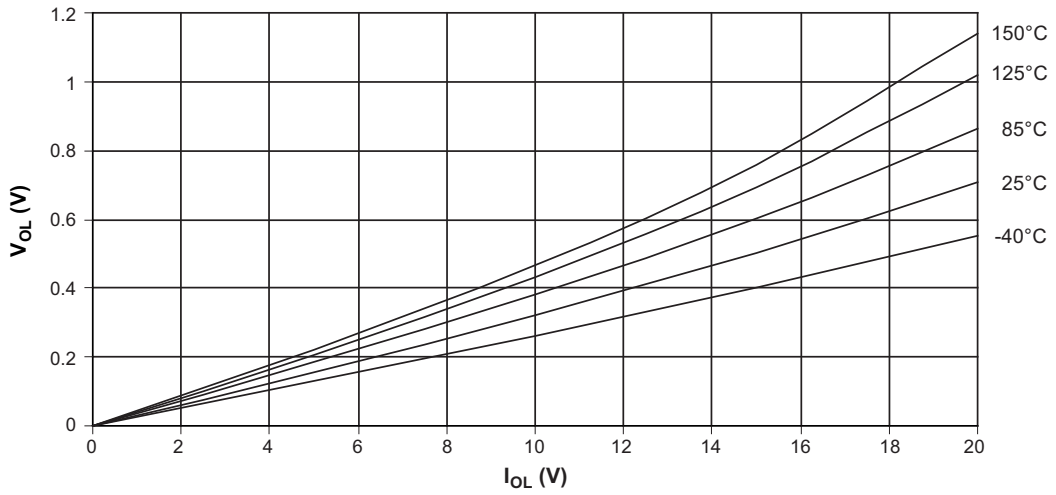


Figure 4-8. Output High Voltage versus Output High Current ( $V_{CC} = 5V$ )

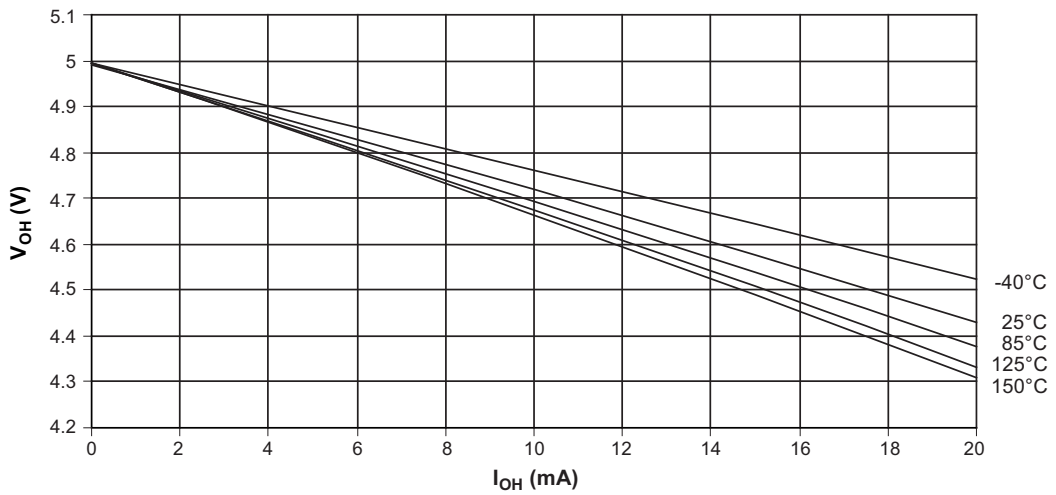


Figure 4-9. Output High Voltage versus Output High Current ( $V_{CC} = 3V$ )

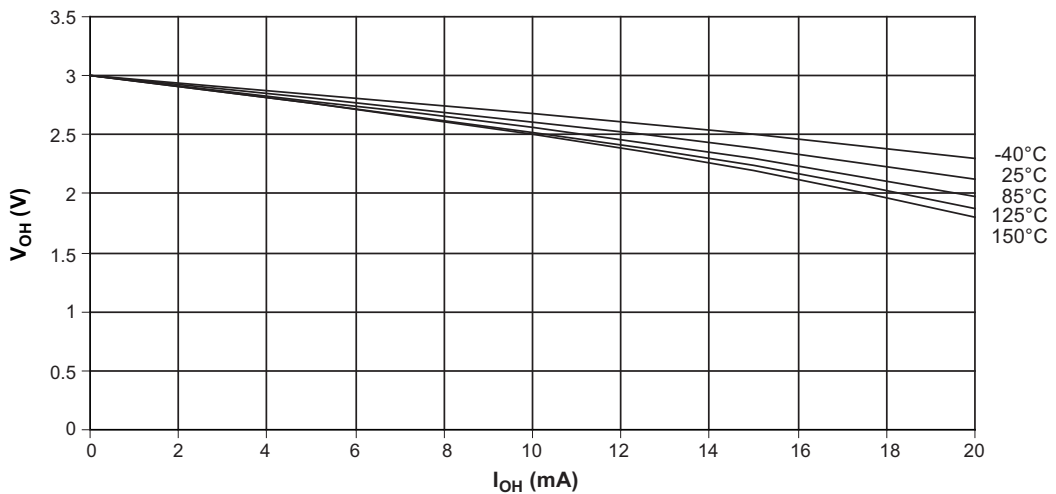
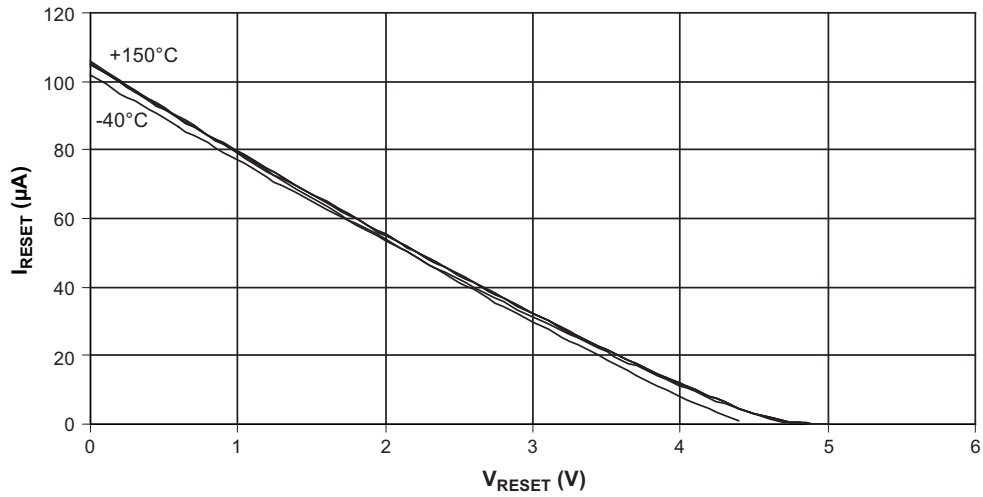


Figure 4-10. Reset Pull-Up Resistor Current versus Reset Pin Voltage ( $V_{CC} = 5V$ )



#### 4.4 Pin Thresholds and Hysteresis

Figure 4-11. I/O Pin Input Threshold versus  $V_{CC}$  ( $V_{IH}$ , I/O Pin Read as '1')

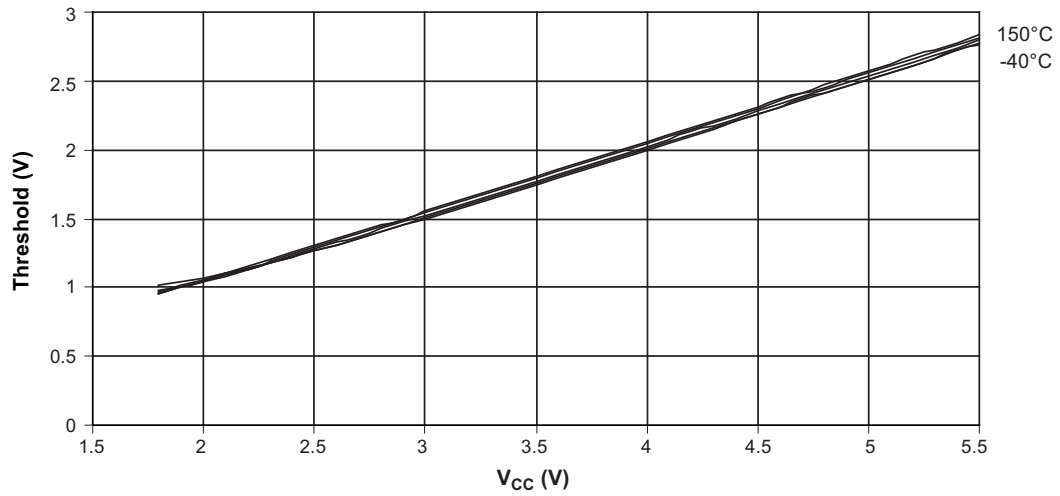


Figure 4-12. I/O Pin Input Threshold versus  $V_{CC}$  (VIL, I/O Pin Read as '0')

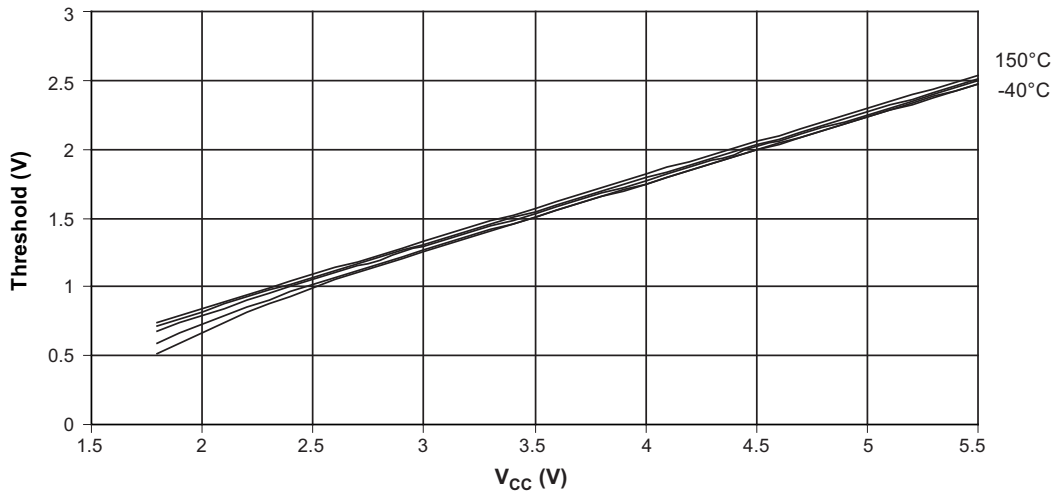


Figure 4-13. Reset Input Threshold Voltage versus  $V_{CC}$  (VIH, Reset Pin Read as '1')

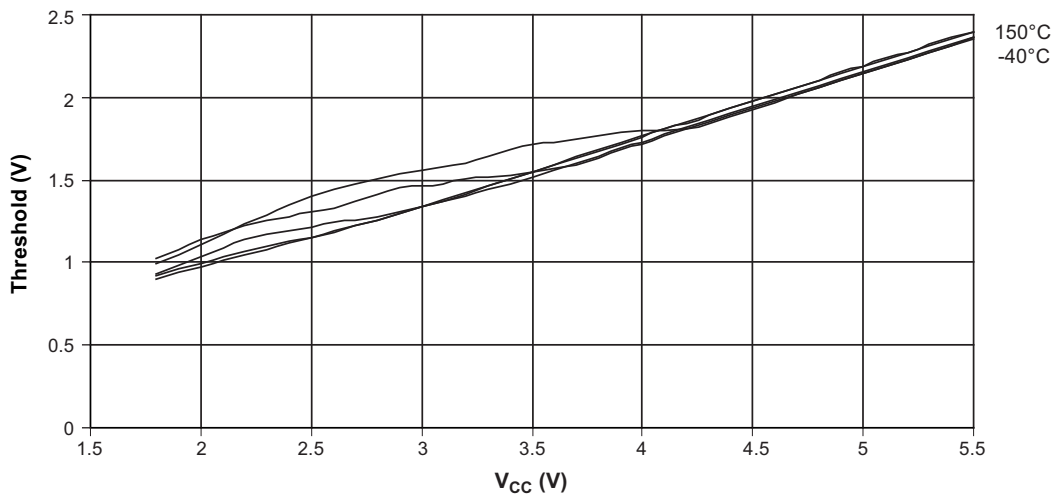
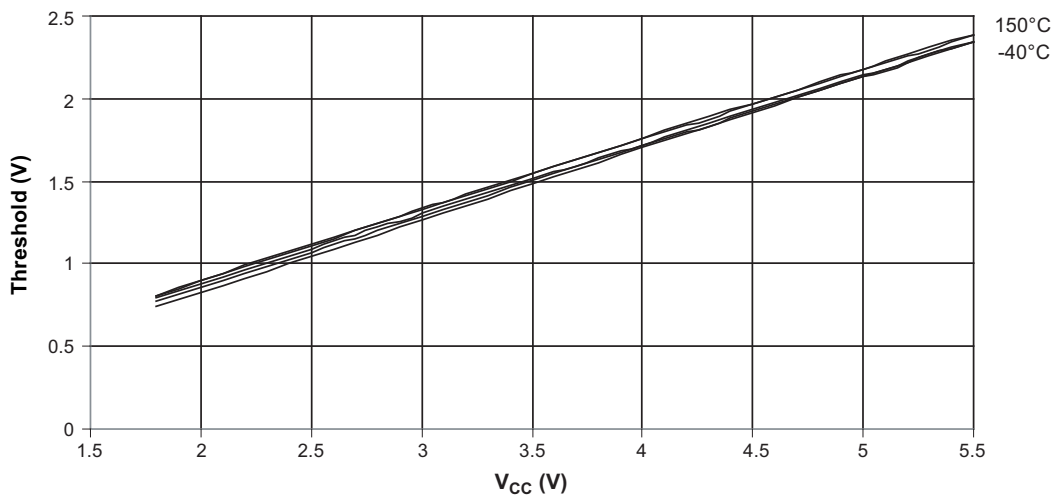


Figure 4-14. Reset Input Threshold Voltage versus  $V_{CC}$  (VIL, Reset Pin Read as '0')



## 4.5 Internal Oscillator Speed

Figure 4-15. Watchdog Oscillator Frequency versus  $V_{CC}$

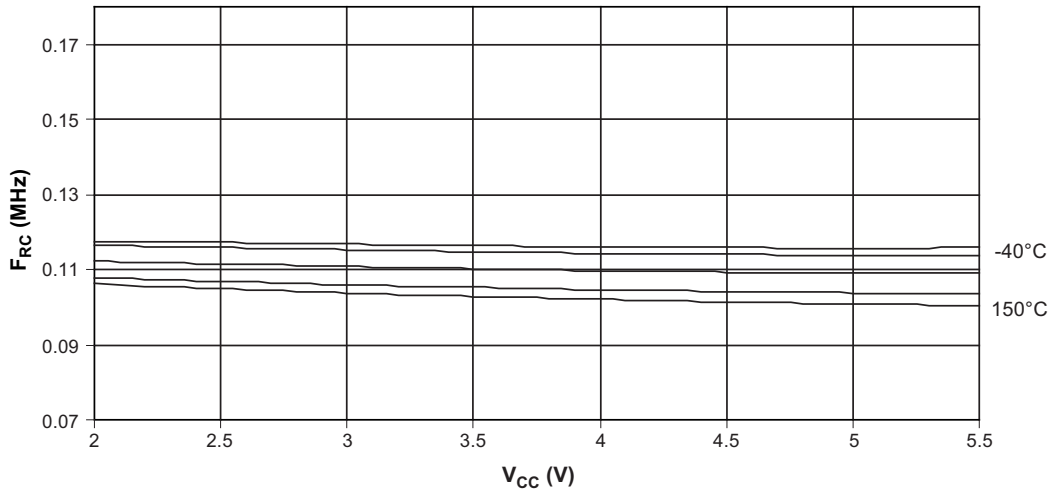
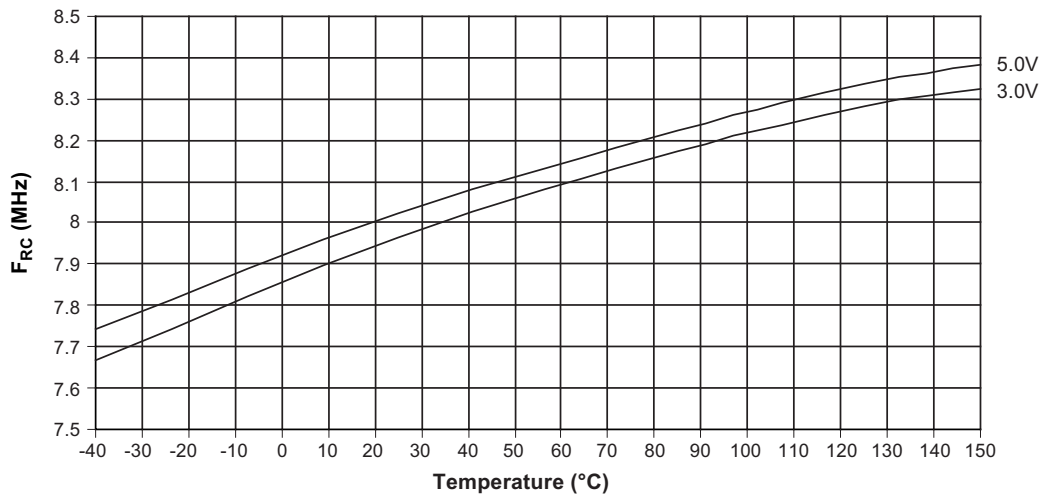
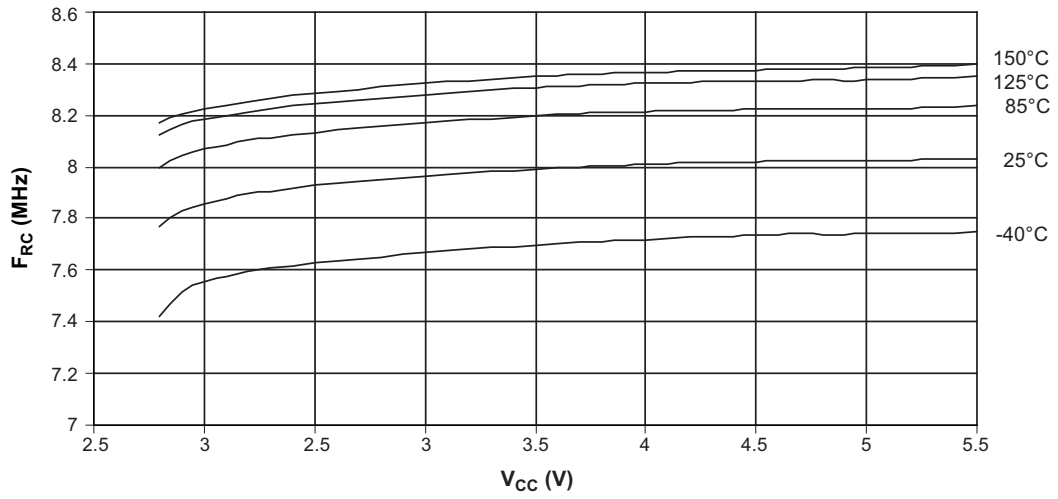


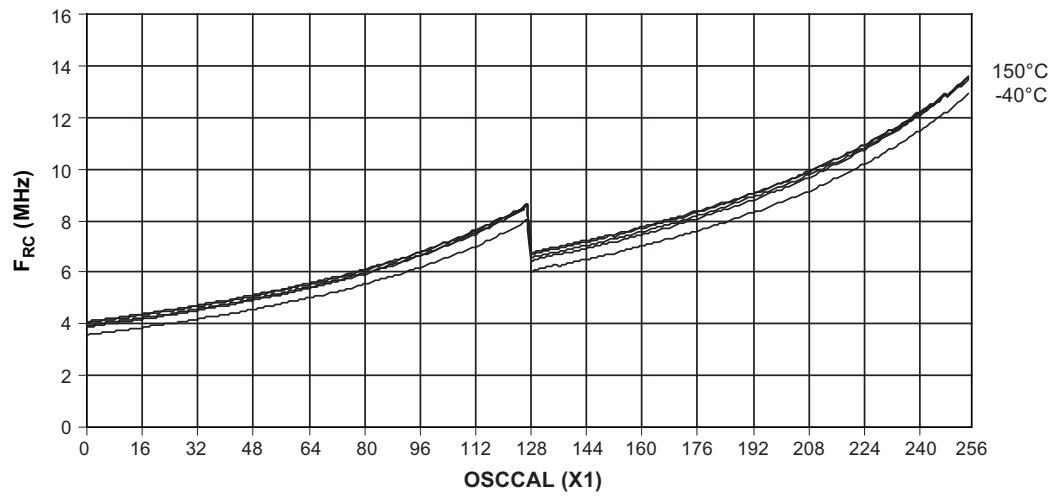
Figure 4-16. Calibrated 8 MHz RC Oscillator Frequency versus Temperature



**Figure 4-17. Calibrated 8 MHz RC Oscillator Frequency versus  $V_{CC}$**



**Figure 4-18. Calibrated 8 MHz RC Oscillator Frequency versus OSCCAL Value**



## 4.6 BOD Thresholds and Analog Comparator Offset

Figure 4-19. BOD Threshold versus Temperature (BODLEVEL is 4.3V)

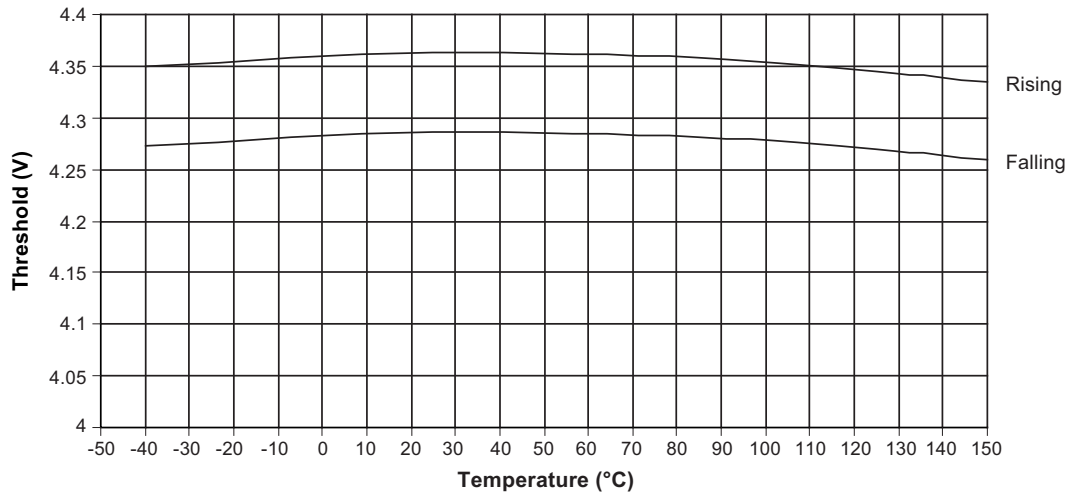


Figure 4-20. BOD Threshold versus Temperature (BODLEVEL is 2.7V)

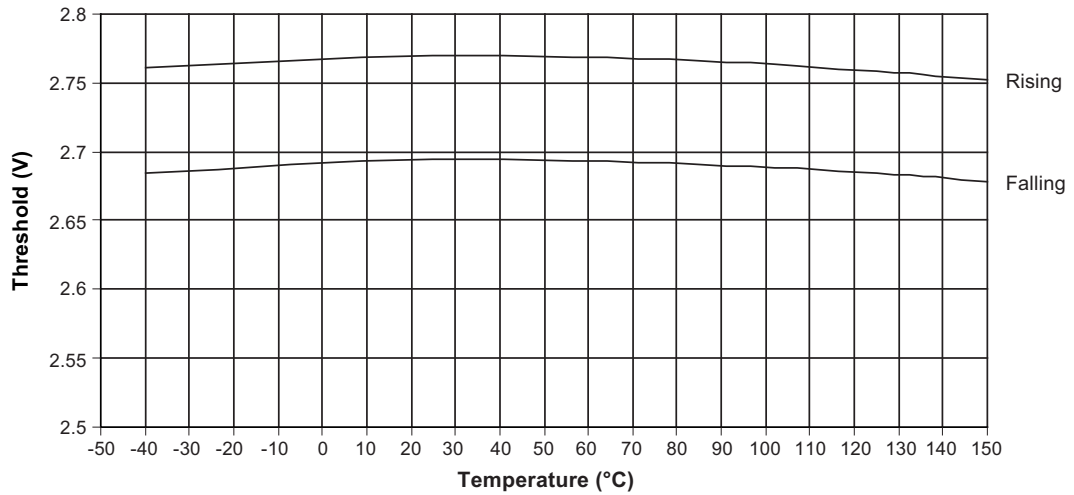
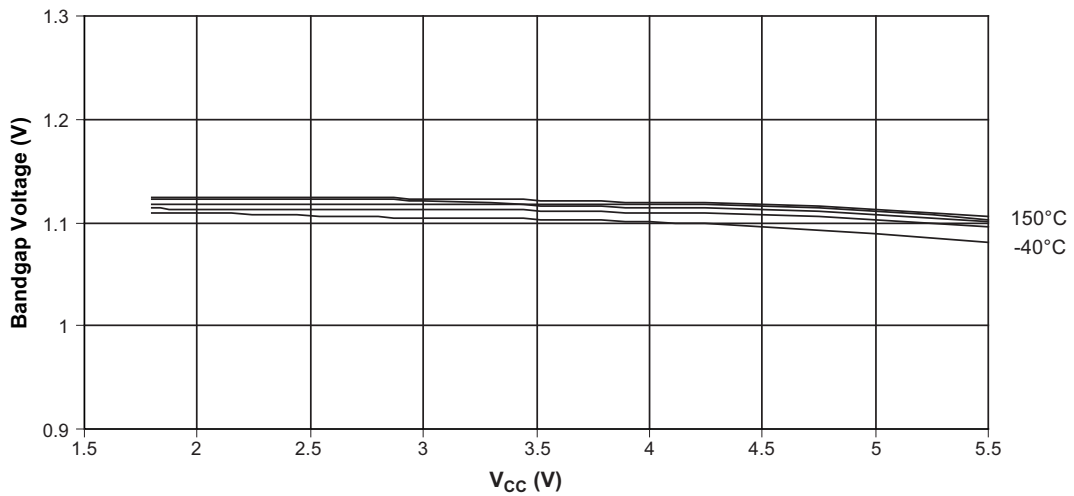


Figure 4-21. Bandgap Voltage versus  $V_{CC}$



## 4.7 Peripheral Units

Figure 4-22. Analog to Digital Converter GAIN versus Temperature, Single Ended

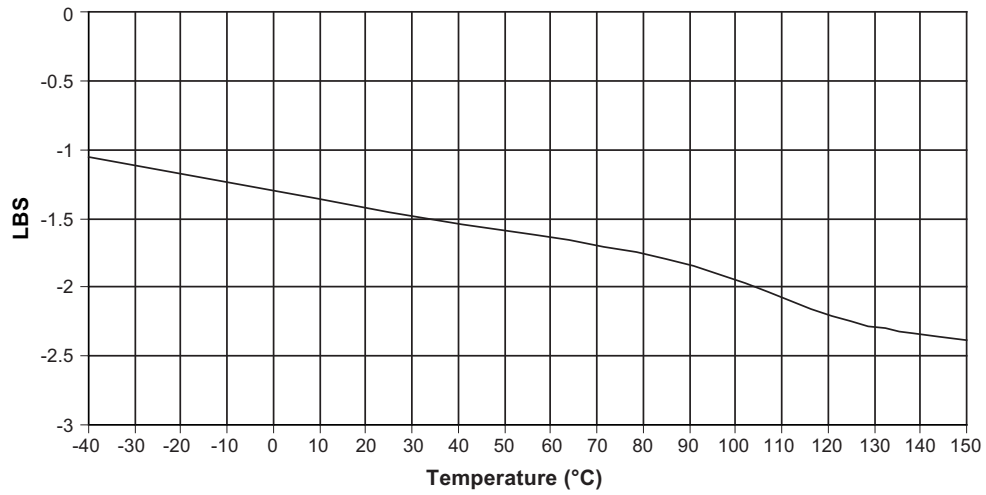


Figure 4-23. Analog to Digital Converter GAIN versus Temperature, Differential Mode

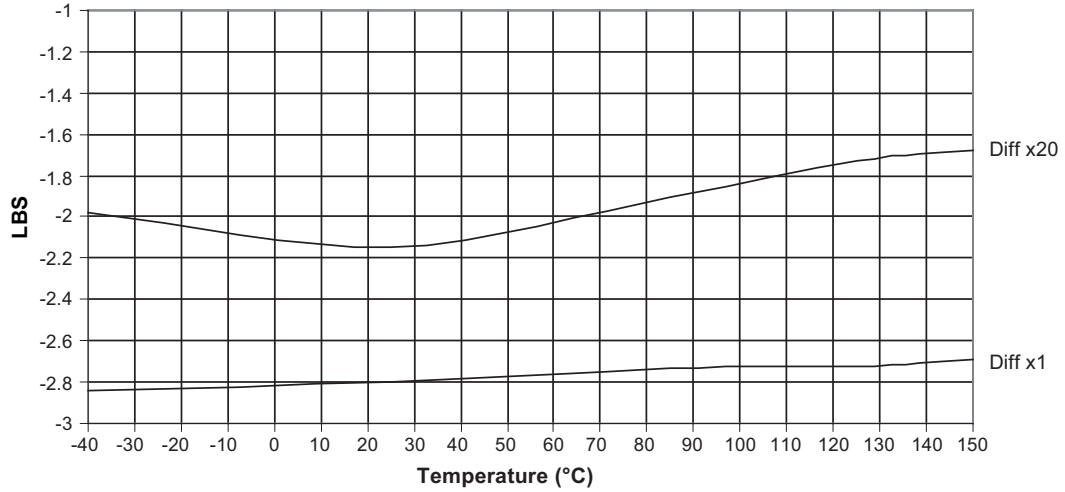
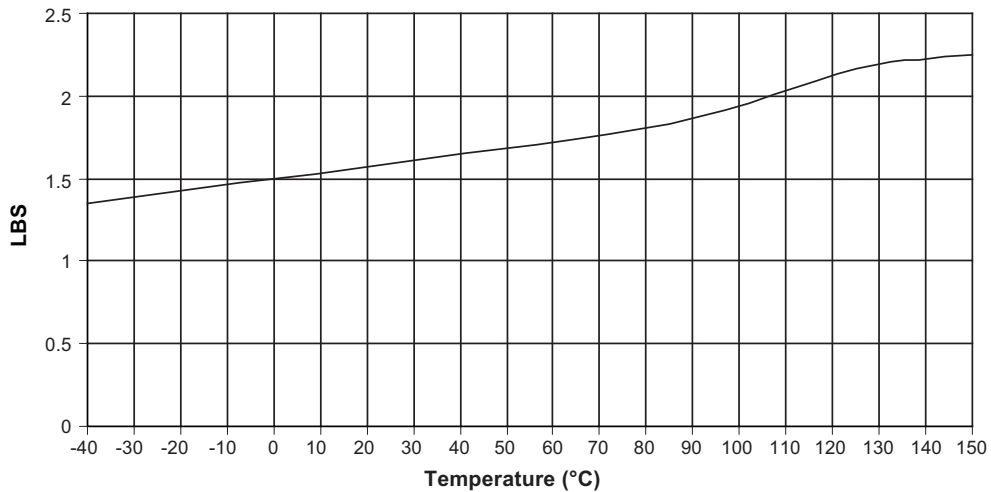
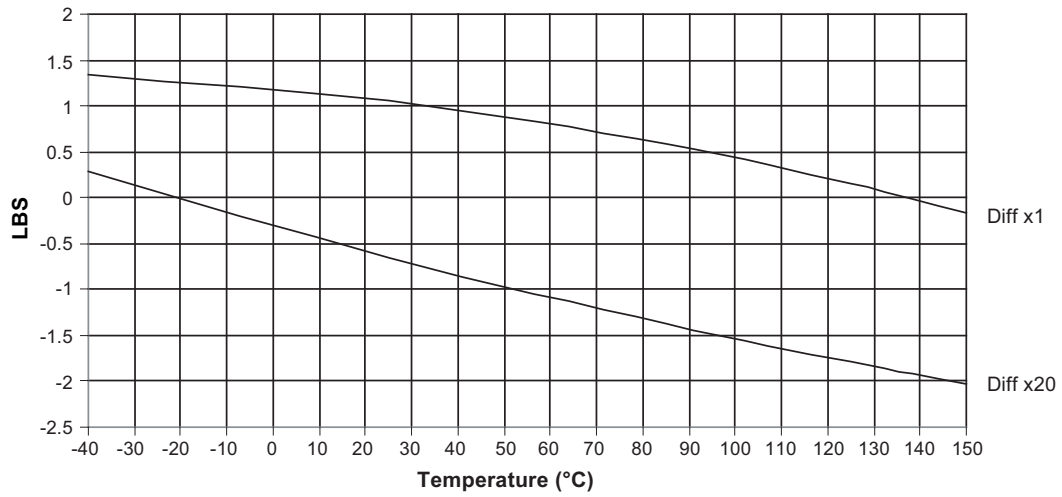


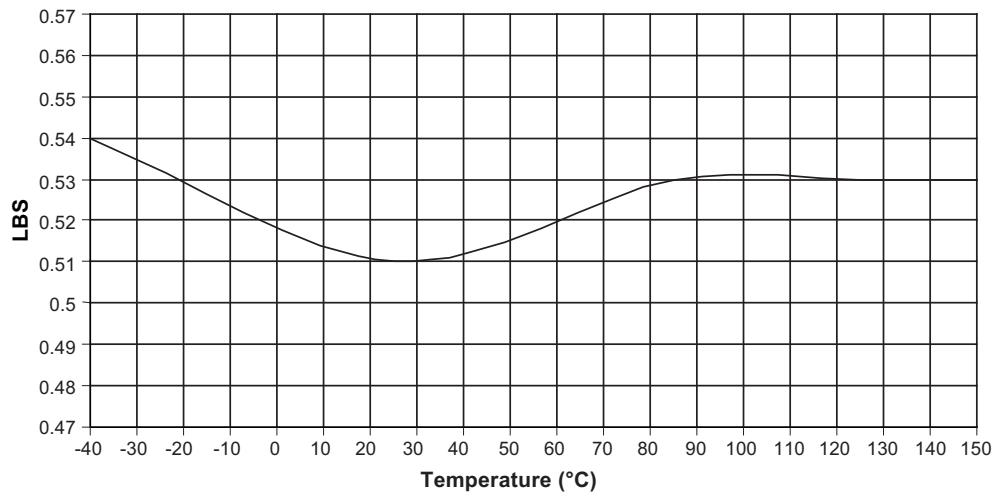
Figure 4-24. Analog to Digital Converter OFFSET versus Temperature, Single Ended



**Figure 4-25. Analog to Digital Converter OFFSET versus Temperature, Differential Mode**



**Figure 4-26. Analog to Digital Converter DNL versus Temperature, Single Ended**



**Figure 4-27. Analog to Digital Converter DNL versus Temperature, Differential Mode**

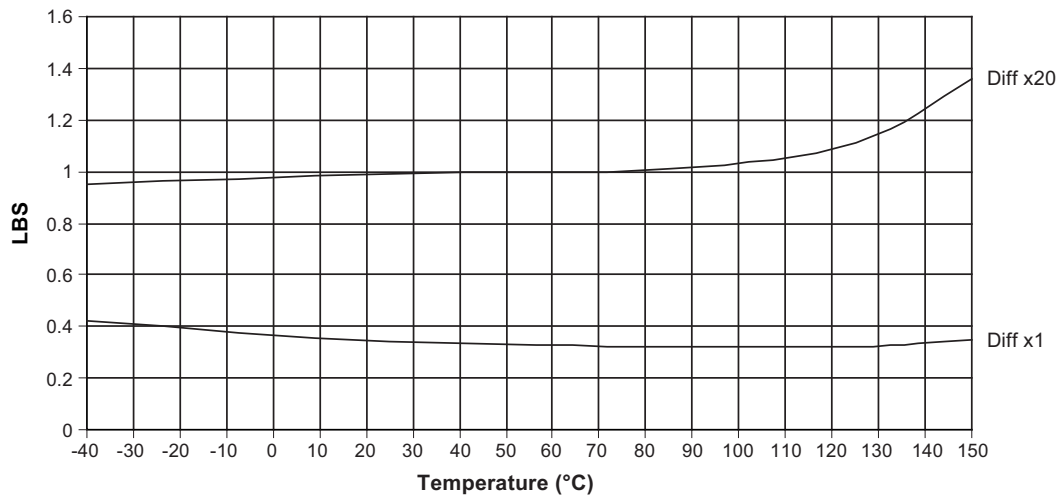




Figure 4-28. Analog to Digital Converter INL versus Temperature, Single Ended

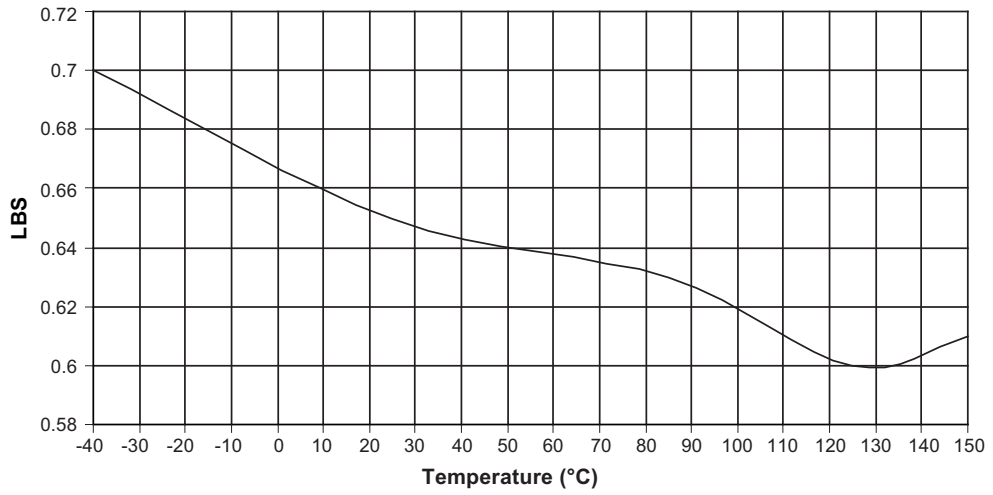
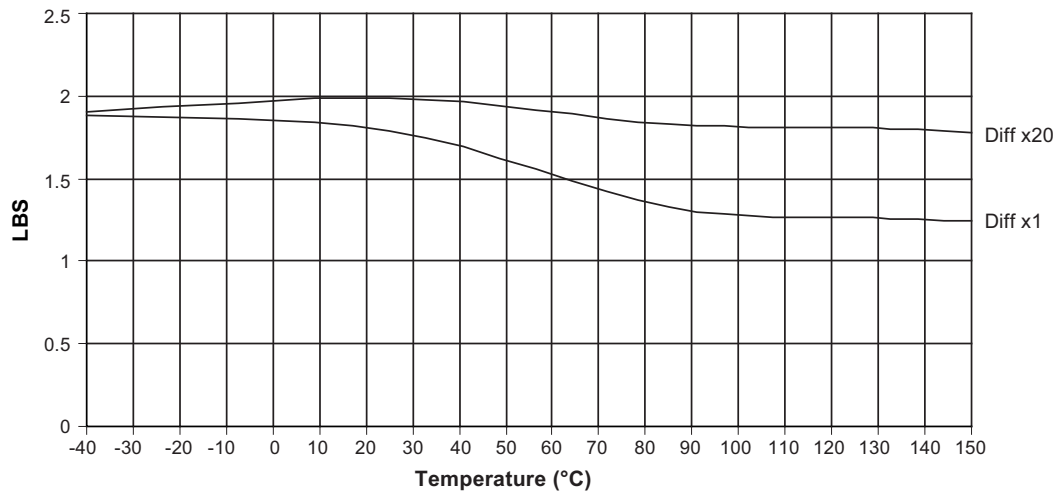


Figure 4-29. Analog to Digital Converter INL versus Temperature, Differential Mode



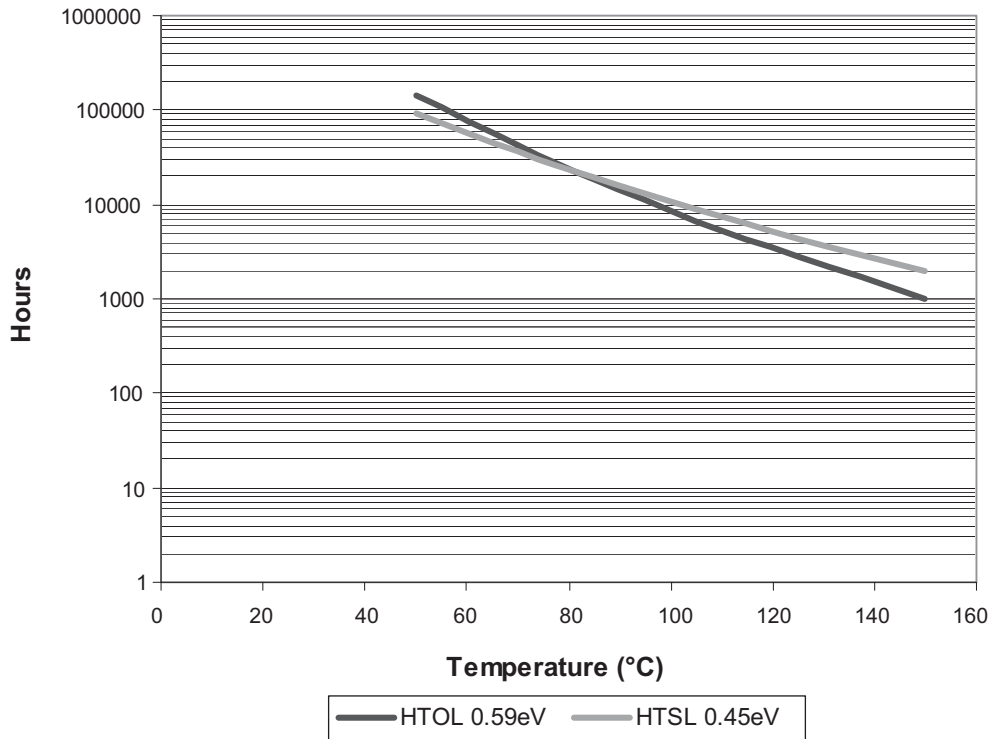
## 5. Grade 0 Qualification

The ATtiny45 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 ATtiny45 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 ATtiny45 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 1. Therefore any temperature mission profile which could exceed the AEC-Q100 equivalence domain shall be submitted to Atmel for a thorough reliability analysis.

**Figure 5-1. AEC-Q100 Lifetime Equivalence**



## 6. Ordering Information

### 6.1 ATtiny45

Table 6-1. ATtiny45

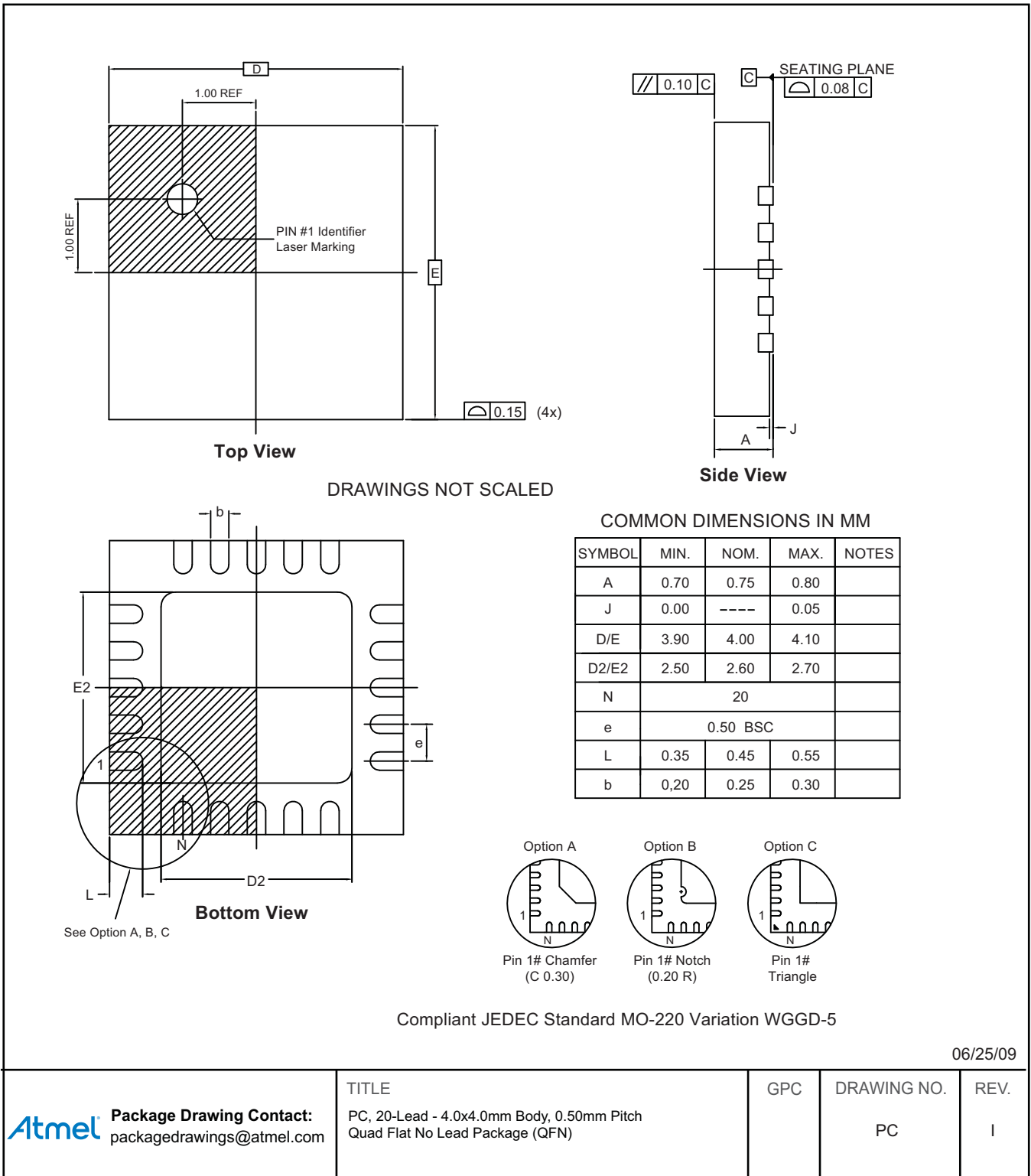
Speed (MHz)	Power Supply	Ordering Code	Package <sup>(1)</sup>	Operation Range
16 <sup>(2)</sup>	2.7 - 5.5V	ATtiny45-15MT2	PC	Extended (-40°C to +150°C)

- 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 versus  $V_{CC}$ , see [Figure 2-1 on page 4](#) and complete product datasheet.

Table 6-2. Package Information

Package Type	
PC	20-lead, 4.0x 4.0mm body, lead pitch 0.60mm, quad flat no-lead package

Figure 6-1. Package PC



## 7. 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
7696D-AVR-06/14	<ul style="list-style-type: none"><li>• Put datasheet in the latest template</li></ul>
7696C-AVR-10/12	<ul style="list-style-type: none"><li>• Figure 6-1 “Package PC” on page 23 updated</li></ul>
7696B-AVR-04/09	<ul style="list-style-type: none"><li>• Added EEPROM endurance. See <a href="#">Section 2. “Memory Endurance”</a> on page 4.</li></ul>



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