Appendix A - ATmega164P, ATmega324P and ATmega644P specification at 105°C

This document contains information specific to devices operating at temperatures up to 105°C. Only deviations are covered in this appendix, all other information can be found in the complete datasheet. The complete datasheet can be found in www.atmel.com.

8-bit AVR® Microcontroller with 16/32/64K Bytes In-System Programmable Flash

ATmega164P/V
ATmega324P/V
ATmega644P/V

Appendix A
Preliminary

8011 - Appendix A–AVR–02/10

1. Electrical Characteristics

Absolute Maximum Ratings*

Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Voltage on any Pin except $\overline{\text{RESET}}$ with respect to Ground	-0.5V to V_{CC}+0.5V
Voltage on $\overline{\text{RESET}}$ with respect to Ground	-0.5V to +13.0V
Maximum Operating Voltage	6.0V
DC Current per I/O Pin	40.0 mA
DC Current V_{CC} and GND Pins	200.0 mA

*NOTICE: 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 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.

1.1 DC Characteristics

T_A = -40°C to 105°C, V_{CC} = 1.8V to 5.5V (unless otherwise noted)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{IL}	Input Low Voltage,Except XTAL1 and Reset pin	V_{CC} = 1.8V - 2.4V V_{CC} = 2.4V - 5.5V	-0.5 -0.5		$0.2V_{CC}$[1] $0.3V_{CC}$[1]	V
V_{IL1}	Input Low Voltage, XTAL1 pin	V_{CC} = 1.8V - 5.5V	-0.5		$0.1V_{CC}$[1]	V
V_{IL2}	Input Low Voltage, RESET pin	V_{CC} = 1.8V - 5.5V	-0.5		$0.1V_{CC}$[1]	V
V_{IH}	Input High Voltage, Except XTAL1 and RESET pins	V_{CC} = 1.8V - 2.4V V_{CC} = 2.4V - 5.5V	$0.7V_{CC}$[2] $0.6V_{CC}$[2]		V_{CC} + 0.5 V_{CC} + 0.5	V
V_{IH1}	Input High Voltage, XTAL1 pin	V_{CC} = 1.8V - 2.4V V_{CC} = 2.4V - 5.5V	$0.8V_{CC}$[2] $0.7V_{CC}$[2]		V_{CC} + 0.5 V_{CC} + 0.5	V
V_{IH2}	Input High Voltage, RESET pin	V_{CC} = 1.8V - 5.5V	$0.9V_{CC}$[2]		V_{CC} + 0.5	V
V_{OL}	Output Low Voltage[3],	I_{OL} =20 mA, V_{CC} = 5V I_{OL} =10 mA, V_{CC} = 3V			1.0 0.7	V
V_{OH}	Output High Voltage[4],	I_{OH} = -20 mA, V_{CC} = 5V I_{OH} = -10 mA, V_{CC} = 3V	4.0 2.1			V
I_{IL}	Input Leakage Current I/O Pin	V_{CC} = 5.5V, pin low (absolute value)			1	µA
I_{IH}	Input Leakage Current I/O Pin	V_{CC} = 5.5V, pin high (absolute value)			1	µA
R_{RST}	Reset Pull-up Resistor		30		60	kΩ
R_{PU}	I/O Pin Pull-up Resistor		20		50	kΩ
V_{ACIO}	Analog Comparator Input Offset Voltage	V_{CC} = 5V V_{in} = V_{CC}/2			40	mV
I_{ACLK}	Analog Comparator Input Leakage Current	V_{CC} = 5V V_{in} = V_{CC}/2	-50		50	nA

Note: 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 VCC = 5V, 10mA at VCC = 3V) under steady state conditions (non-transient), the following must be observed:
1.)The sum of all IOL, for ports PB0-PB7, XTAL2, PD0-PD7 should not exceed 100 mA.
2.)The sum of all IOL, for ports PA0-PA3, PC0-PC7 should not exceed 100 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 (20mA at VCC = 5V, 10mA at VCC = 3V) under steady state conditions (non-transient), the following must be observed:
1.)The sum of all IOH, for ports PB0-PB7, XTAL2, PD0-PD7 should not exceed 100 mA.
2.)The sum of all IOH, for ports PA0-PA3, PC0-PC7 should not exceed 100 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.

1.1.1 ATmega164P DC Characteristics TBD

Table 1-1. T_A = -40°C to 105°C, V_{CC} = 1.8V to 5.5V (unless otherwise noted)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
I_{CC}	Power Supply Current[1]	Active 1 MHz, V_{CC} = 2V				mA
		Active 4 MHz, V_{CC} = 3V				mA
		Active 8 MHz, V_{CC} = 5V				mA
		Idle 1 MHz, V_{CC} = 2V				mA
		Idle 4 MHz, V_{CC} = 3V				mA
		Idle 8 MHz, V_{CC} = 5V)				mA
	Power-down mode[2]	WDT enabled, V_{CC} = 3V				µA
		WDT disabled, V_{CC} = 3V				µA

Notes: 1. All bits set in the "PRR – Power Reduction Register" on page 48
2. The current consumption values include input leakage current.

1.1.2 ATmega324P DC Characteristics

Table 1-2. T_A = -40°C to 105°C, V_{CC} = 1.8V to 5.5V (unless otherwise noted)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
I_{CC}	Power Supply Current[1]	Active 1 MHz, V_{CC} = 2V			0.7	mA
		Active 4 MHz, V_{CC} = 3V			3.0	mA
		Active 8 MHz, V_{CC} = 5V			11	mA
		Idle 1 MHz, V_{CC} = 2V			0.2	mA
		Idle 4 MHz, V_{CC} = 3V			0.85	mA
		Idle 8 MHz, V_{CC} = 5V)			6	mA
	Power-down mode[2]	WDT enabled, V_{CC} = 3V			15	µA
		WDT disabled, V_{CC} = 3V			5	µA

Notes: 1. All bits set in the "PRR – Power Reduction Register" on page 48
2. The current consumption values include input leakage current.

1.1.3 ATmega644P DC Characteristics

Table 1-3. T_A = -40°C to 105°C, V_{CC} = 1.8V to 5.5V (unless otherwise noted)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
I_{CC}	Power Supply Current[1]	Active 1 MHz, V_{CC} = 2V			0.7	mA
		Active 4 MHz, V_{CC} = 3V			3.0	mA
		Active 8 MHz, V_{CC} = 5V			11	mA
		Idle 1 MHz, V_{CC} = 2V			0.2	mA
		Idle 4 MHz, V_{CC} = 3V			0.85	mA
		Idle 8 MHz, V_{CC} = 5V)			6	mA
	Power-down mode[2]	WDT enabled, V_{CC} = 3V			20	µA
		WDT disabled, V_{CC} = 3V			10	µA

Notes: 1. All bits set in the "PRR – Power Reduction Register" on page 48
2. The current consumption values include input leakage current.

2. Typical Characteristics

The following charts show typical behavior. These figures are not tested during manufacturing. All current consumption measurements are performed with all I/O pins configured as inputs and with internal pull-ups enabled. A sine wave generator with rail-to-rail output is used as clock source.

All Active- and Idle current consumption measurements are done with all bits in the PRR registers set and thus, the corresponding I/O modules are turned off. Also the Analog Comparator is disabled during these measurements. The power consumption in Power-down mode is independent of clock selection.

The current consumption is a function of several factors such as: operating voltage, operating frequency, loading of I/O pins, switching rate of I/O pins, code executed and ambient temperature. The dominating factors are operating voltage and frequency.

The current drawn from capacitive loaded pins may be estimated (for one pin) as C_L*V_{CC}*f where C_L = load capacitance, V_{CC} = operating voltage and f = average switching frequency of I/O pin.

The parts are characterized at frequencies higher than test limits. Parts are not guaranteed to function properly at frequencies higher than the ordering code indicates.

The difference between current consumption in Power-down mode with Watchdog Timer enabled and Power-down mode with Watchdog Timer disabled represents the differential current drawn by the Watchdog Timer.

2.1 ATmega164P Typical Characteristics

2.1.1 Active Supply Current

Figure 2-1. ATmega164P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 8 MHz)

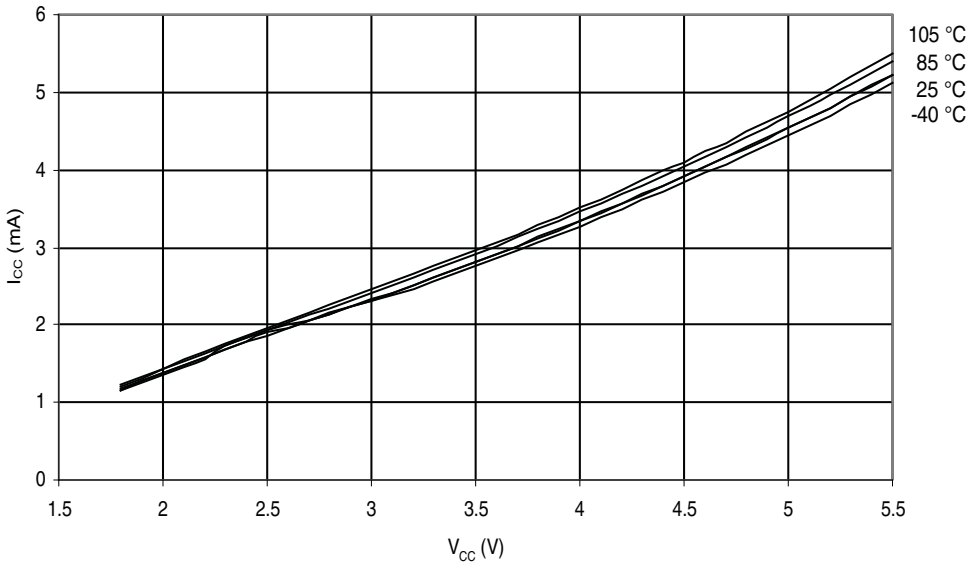


Figure 2-2. ATmega164P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 1 MHz)

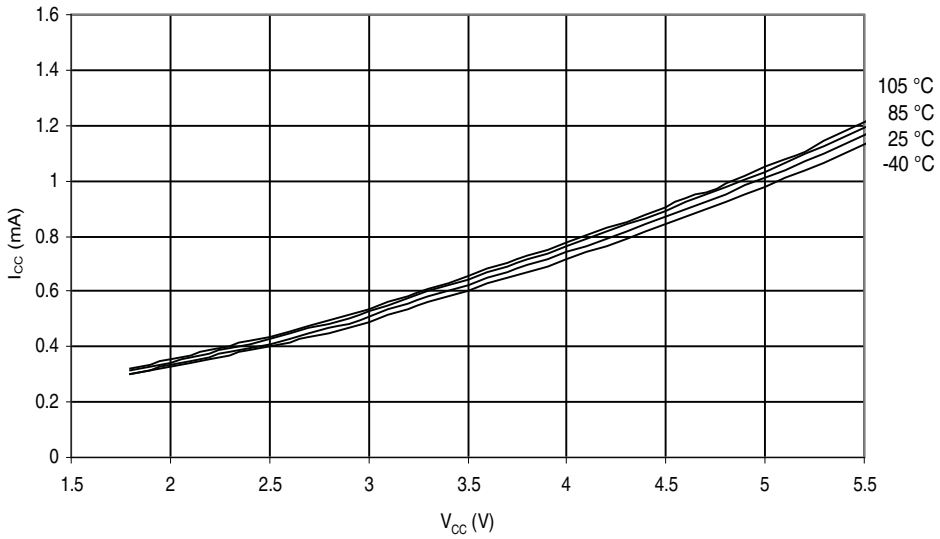
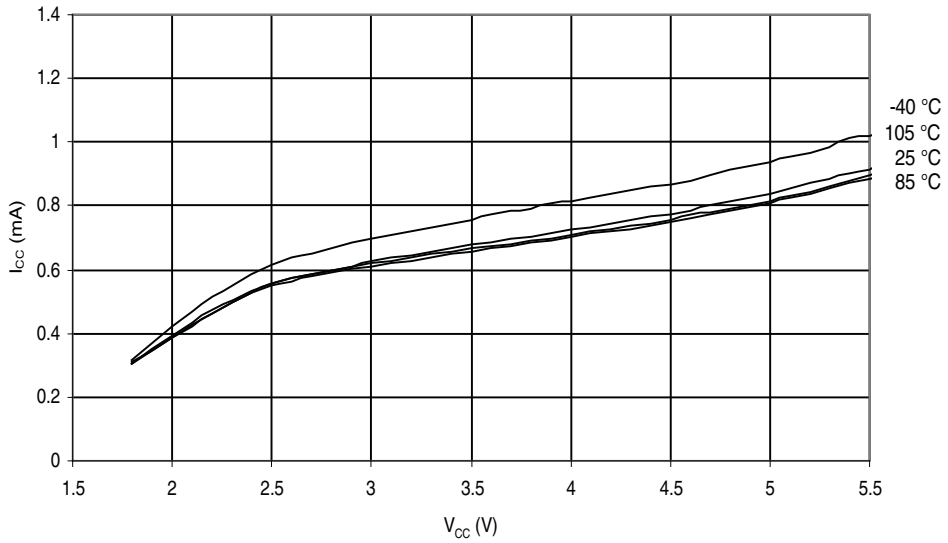


Figure 2-3. ATmega164P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 128 kHz)



2.1.2 Idle Supply Current

Figure 2-4. ATmega164P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 8 MHz)

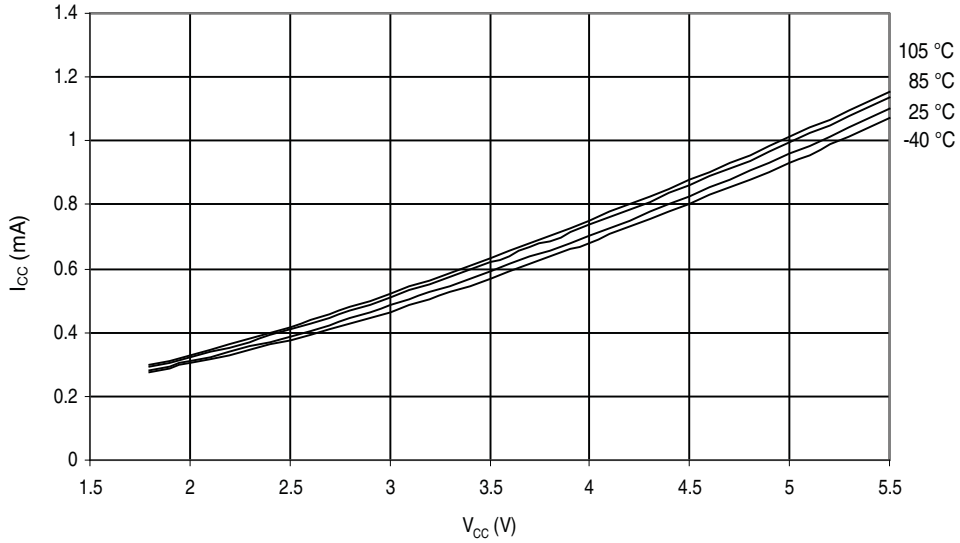


Figure 2-5. ATmega164P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 1 MHz)

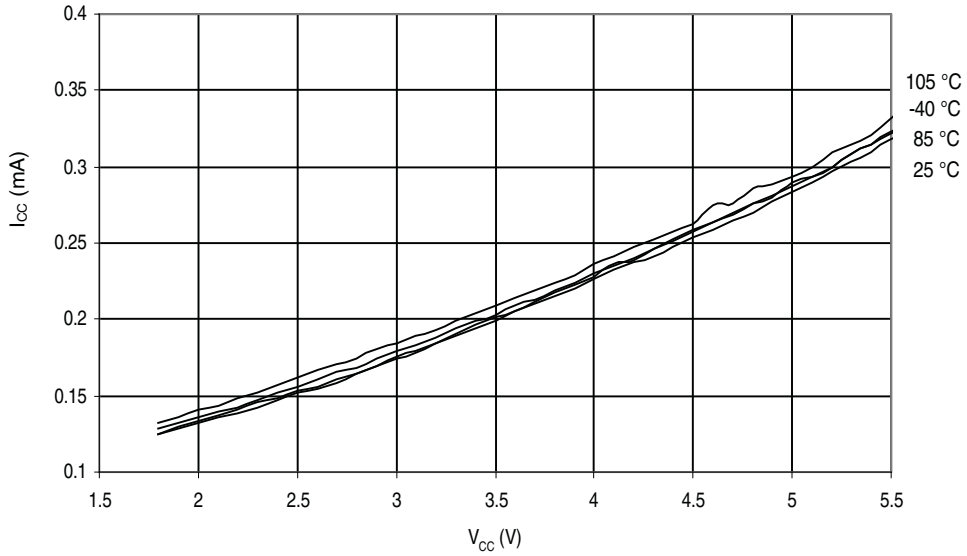
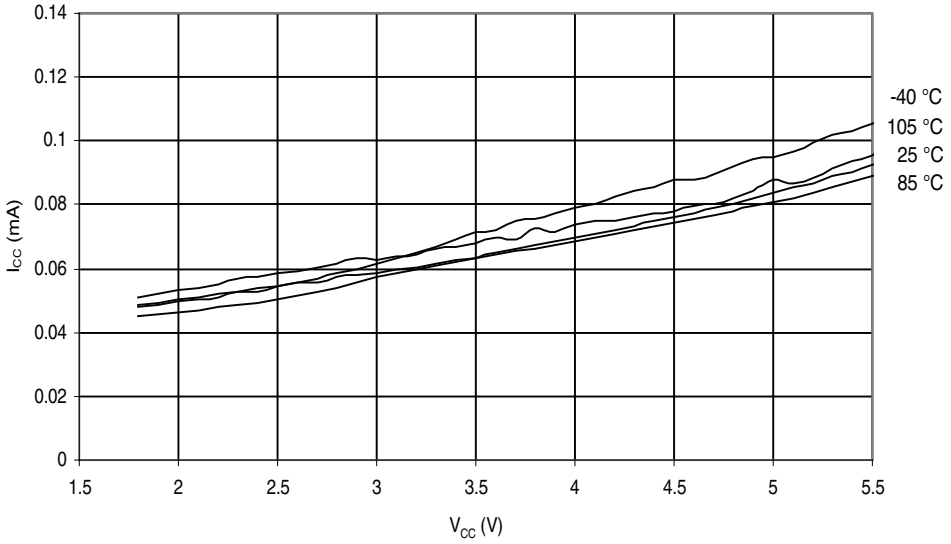


Figure 2-6. ATmega164P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 128 kHz)



2.1.3 Power-down Supply Current

Figure 2-7. ATmega164P: Power-down Supply Current vs. V_{CC} (Watchdog Timer Disabled)

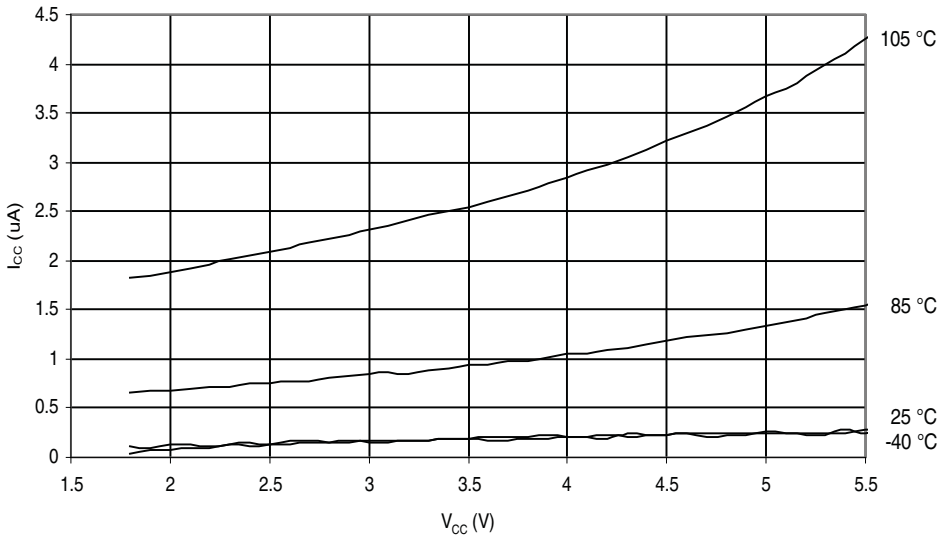
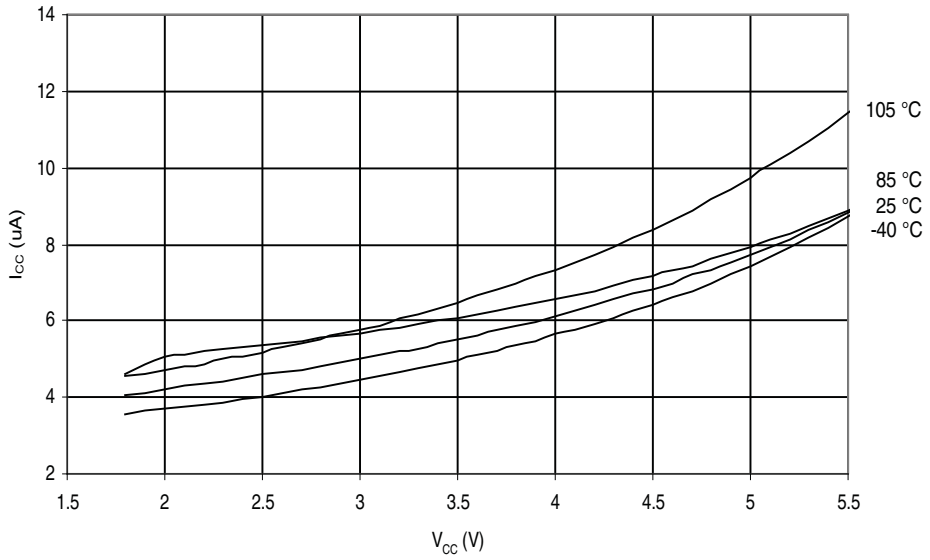


Figure 2-8. ATmega164P: Power-down Supply Current vs. V_{CC} (Watchdog Timer Enabled)



2.1.4 Pin Pull-up

Figure 2-9. ATmega164P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 1.8V)

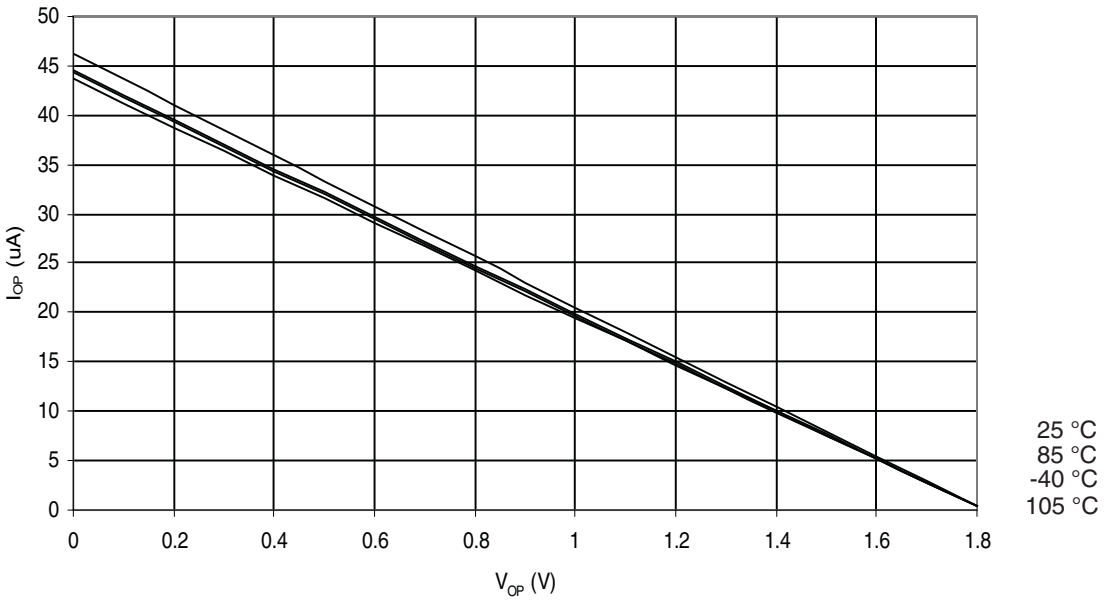


Figure 2-10. ATmega164P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 2.7V)

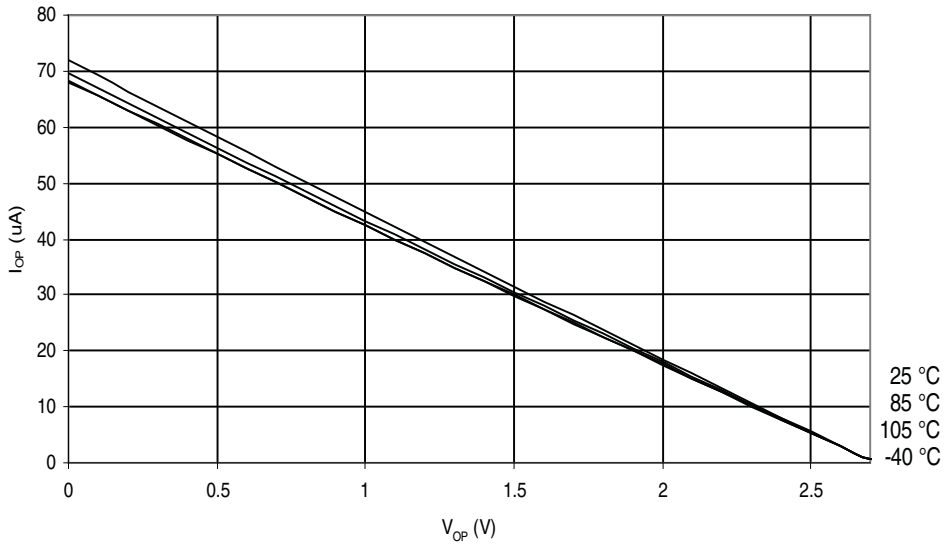


Figure 2-11. ATmega164P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 5V)

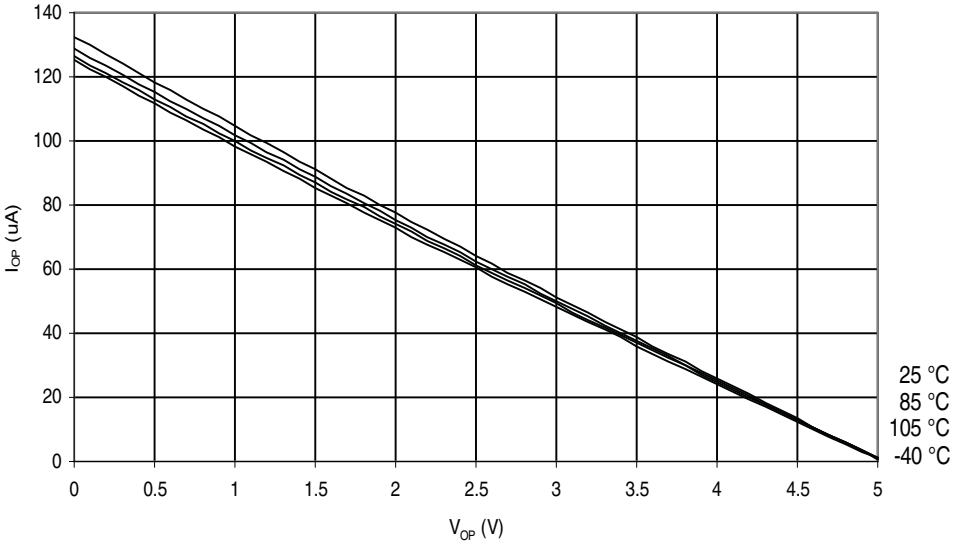


Figure 2-12. ATmega164P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 1.8V)

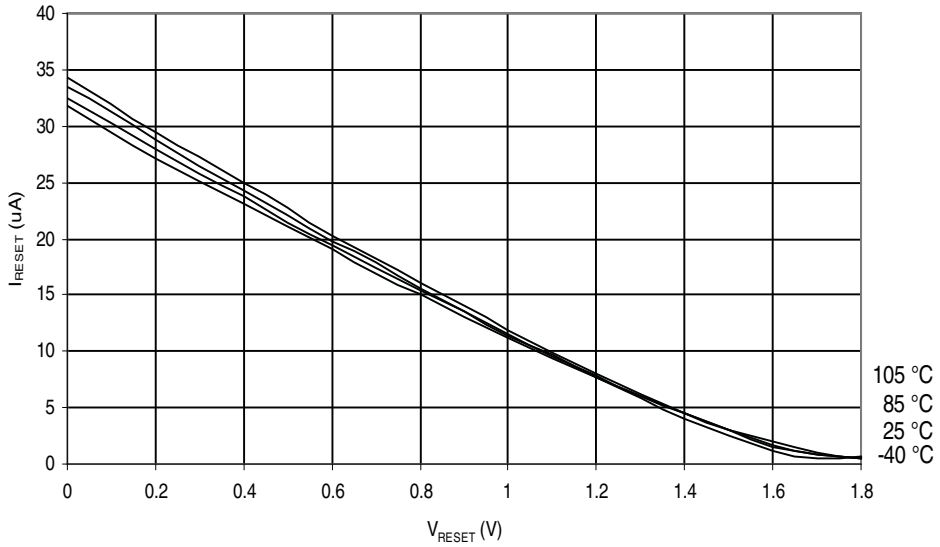


Figure 2-13. ATmega164P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 2.7V)

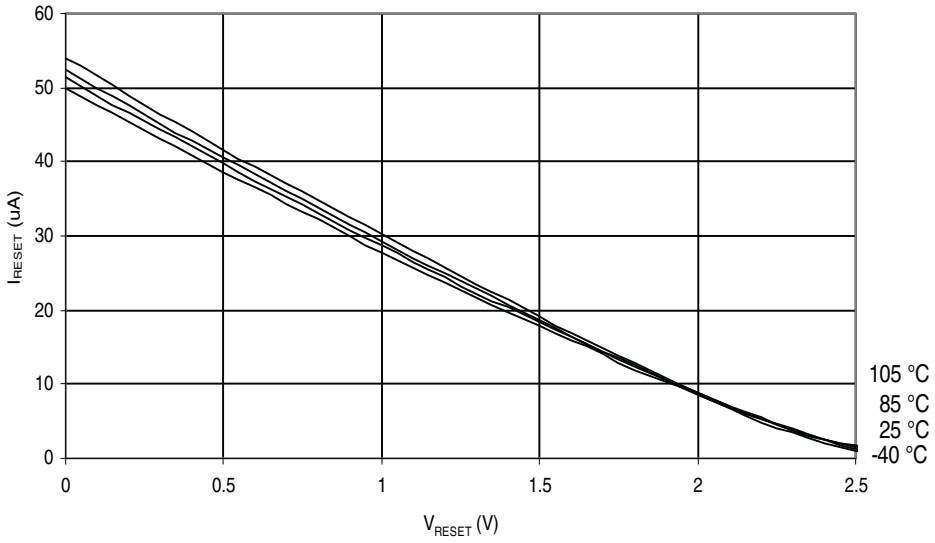
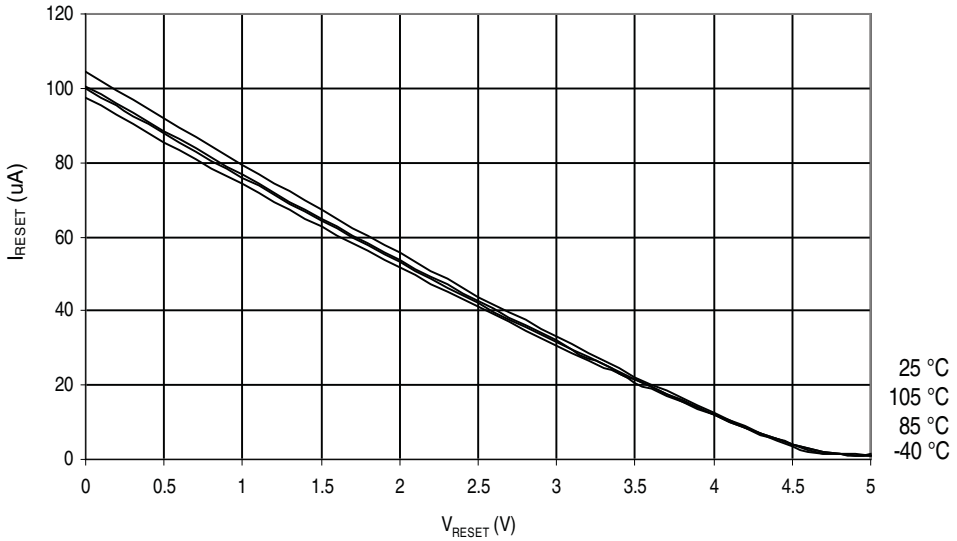


Figure 2-14. ATmega164P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 5V)



2.1.5 Pin Driver Strength

Figure 2-15. ATmega164P: I/O Pin Output Voltage vs. Sink Current (V_{CC} = 3V)

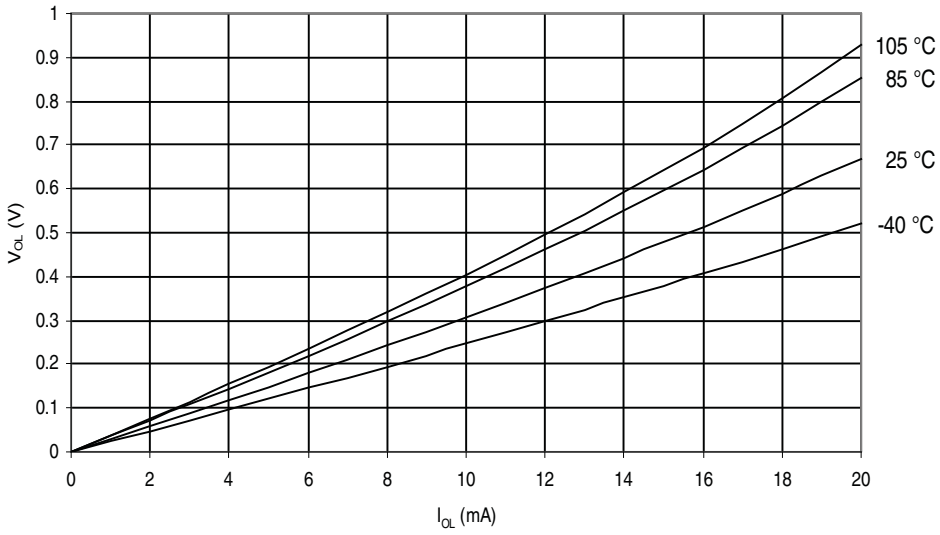


Figure 2-16. ATmega164P: I/O Pin Output Voltage vs. Sink Current (V_{CC} = 5V)

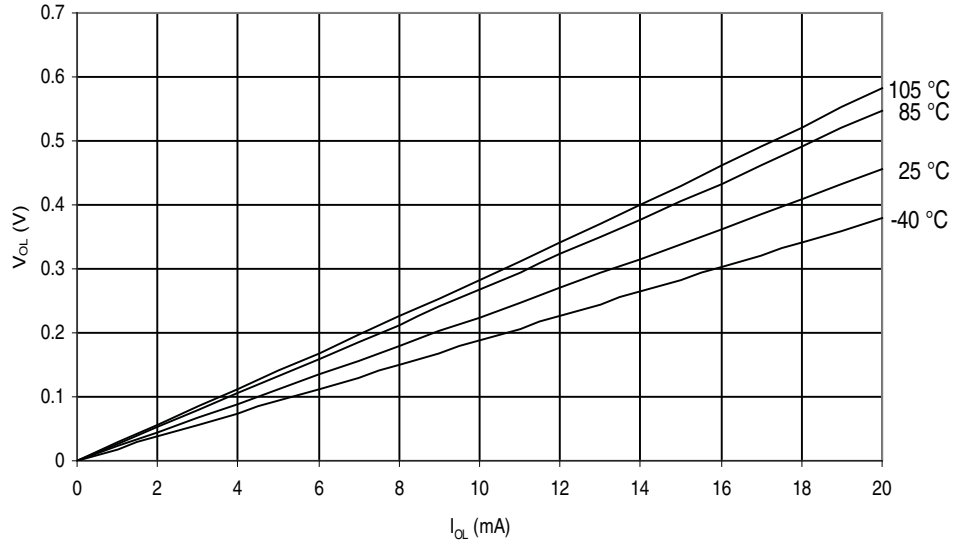


Figure 2-17. ATmega164P: I/O Pin Output Voltage vs. Source Current (V_{CC} = 3V)

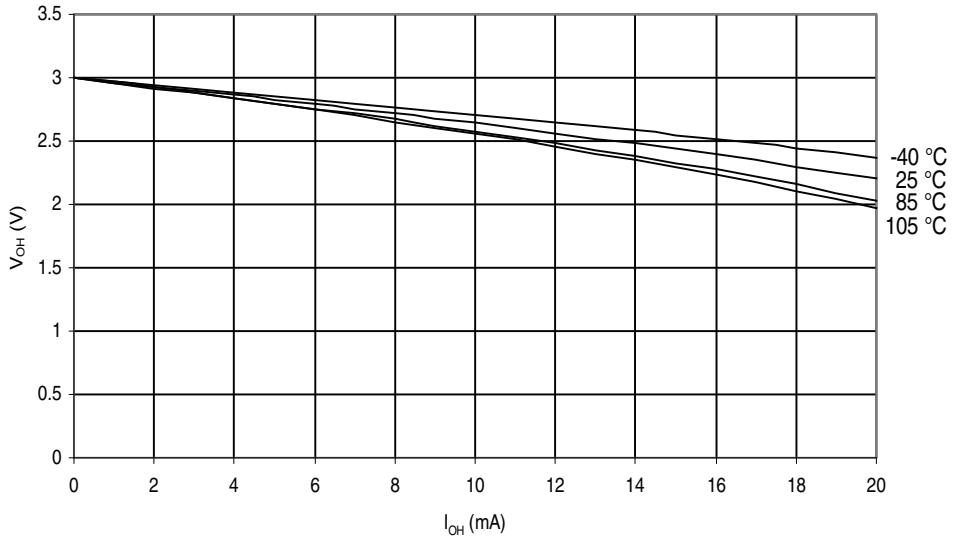
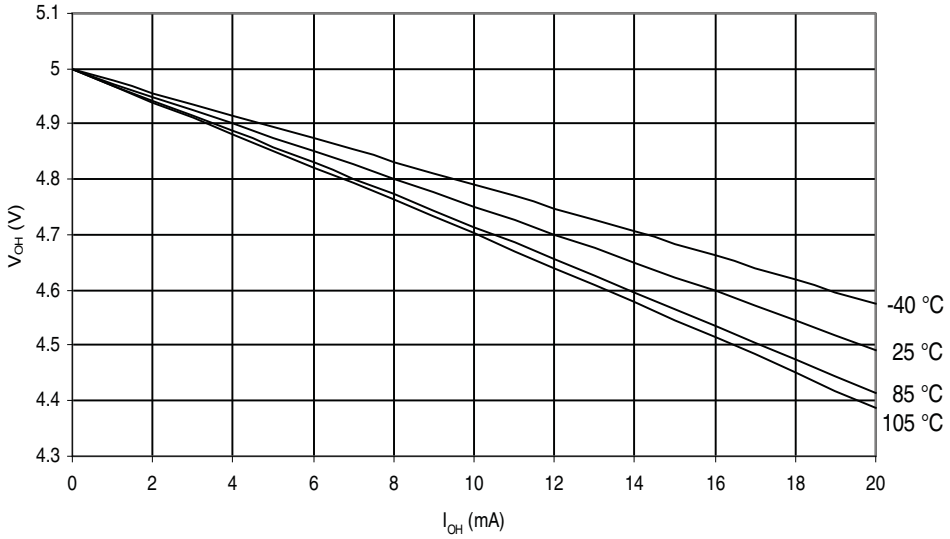


Figure 2-18. ATmega164P: I/O Pin Output Voltage vs. Source Current (V_{CC} = 5V)



2.1.6 Pin Threshold and Hysteresis

Figure 2-19. ATmega164P: I/O Pin Input Threshold vs. V_{CC} (V_{IH} , I/O Pin Read as '1')

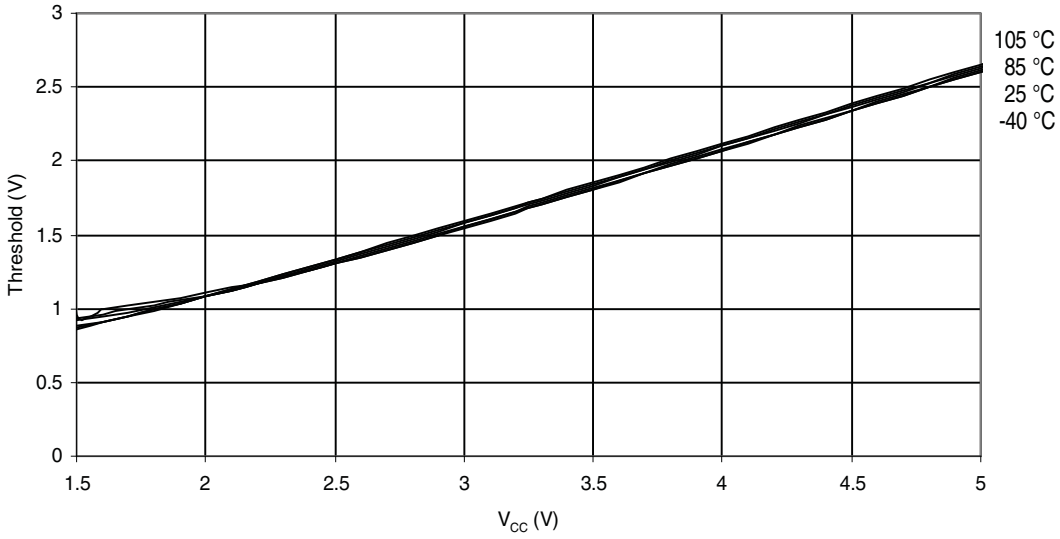


Figure 2-20. ATmega164P: I/O Pin Input Threshold vs. V_{CC} (V_{IL}, I/O Pin Read as '0')

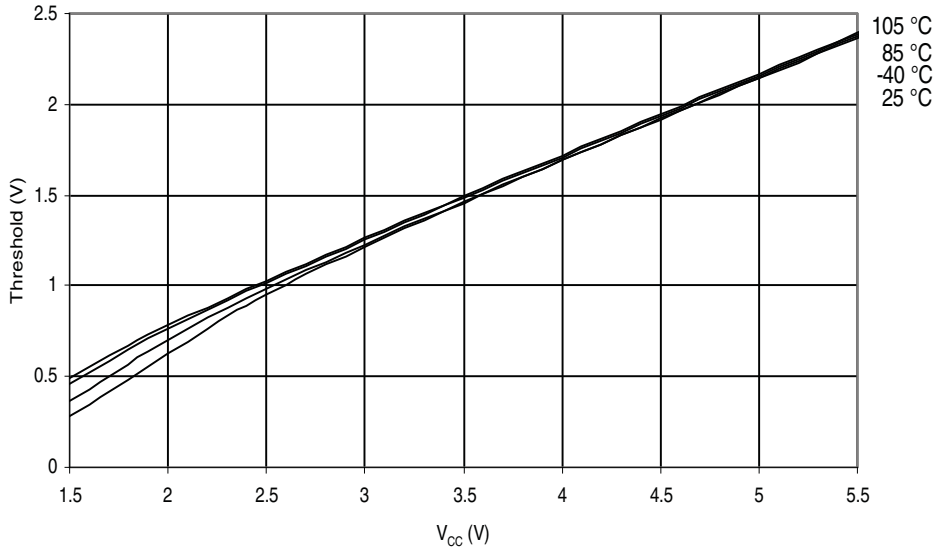


Figure 2-21. ATmega164P: I/O Pin Input Hysteresis vs. V_{CC}

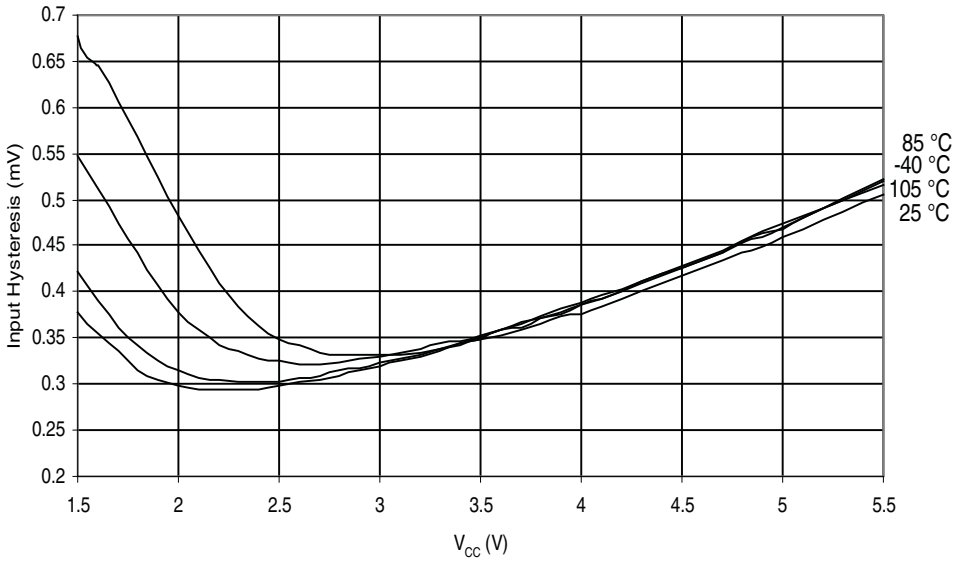


Figure 2-22. ATmega164P: Reset Pin Input Threshold vs. V_{CC} (V_{IH} , I/O Pin Read as '1')

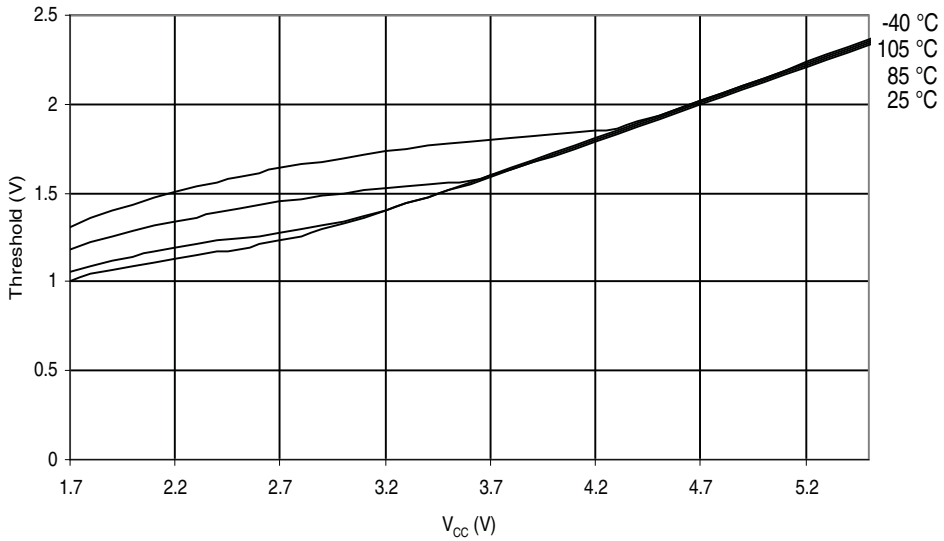


Figure 2-23. ATmega164P: Reset Pin Input Threshold vs. V_{CC} (V_{IL}, I/O Pin Read as '0')

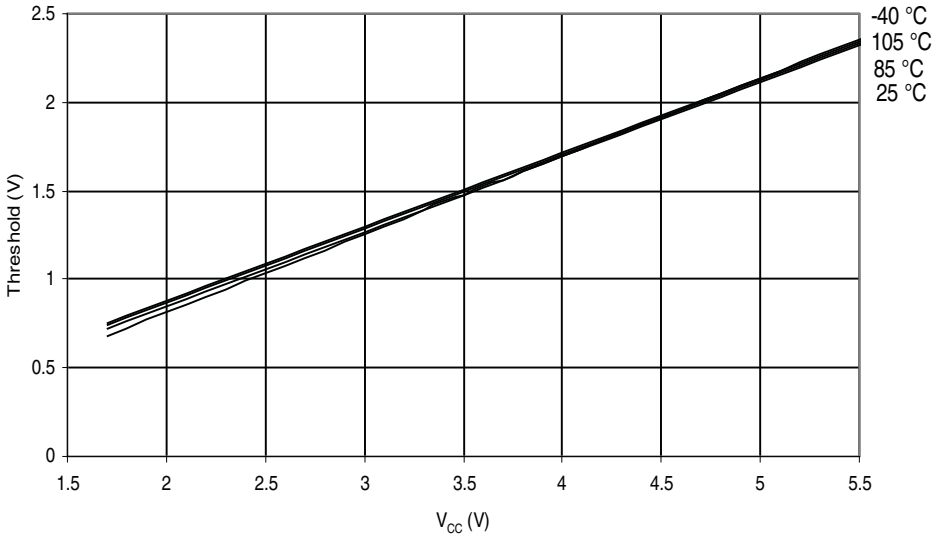
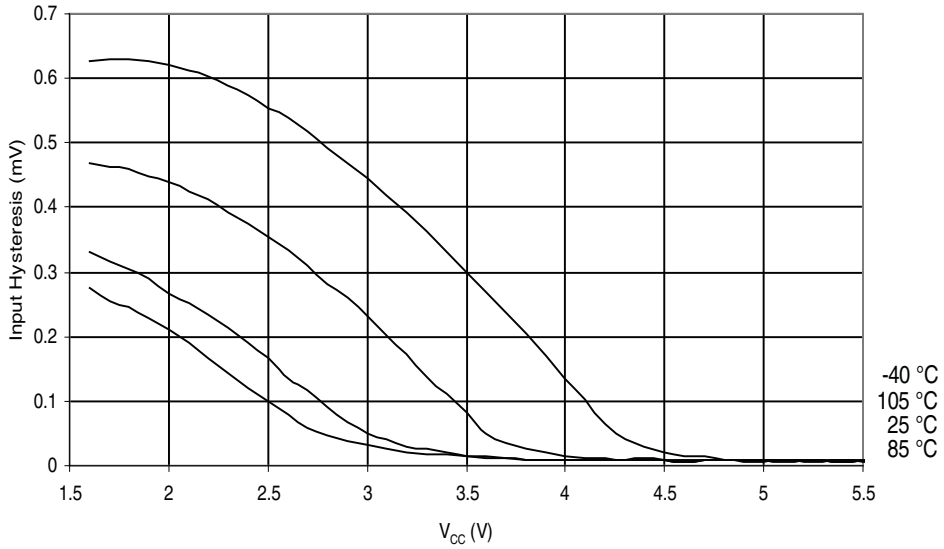


Figure 2-24. ATmega164P: Reset Pin Input Hysteresis vs. V_{CC}



2.1.7 BOD Threshold

Figure 2-25. ATmega164P: BOD Threshold vs. Temperature (V_{CC} = 4.3V)

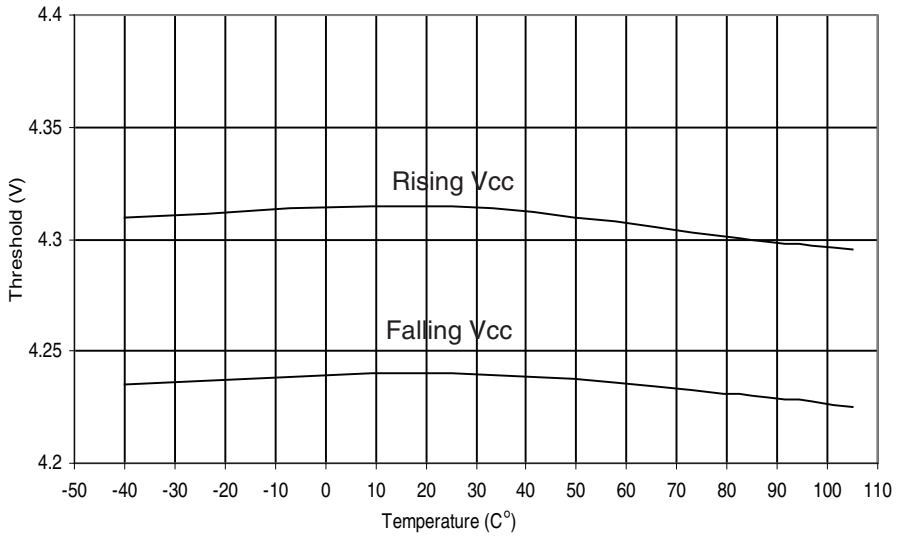


Figure 2-26. ATmega164P: BOD Threshold vs. Temperature (V_{CC} = 2.7V)

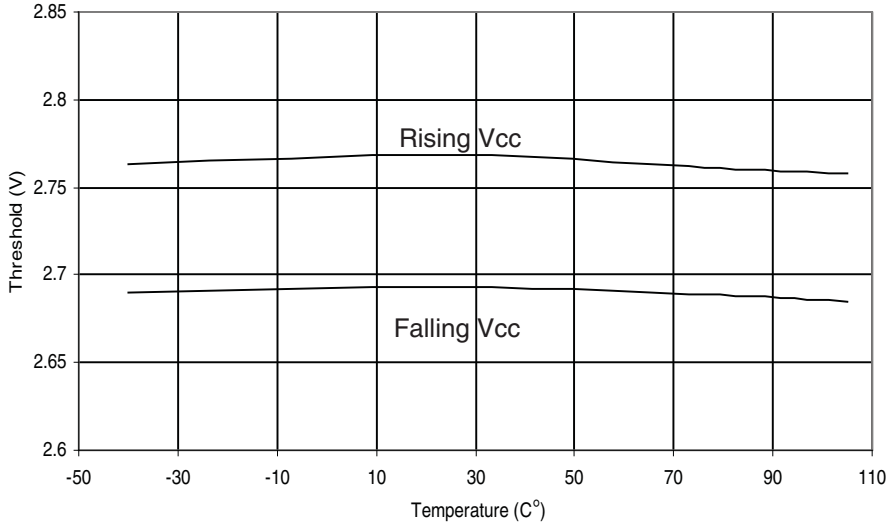
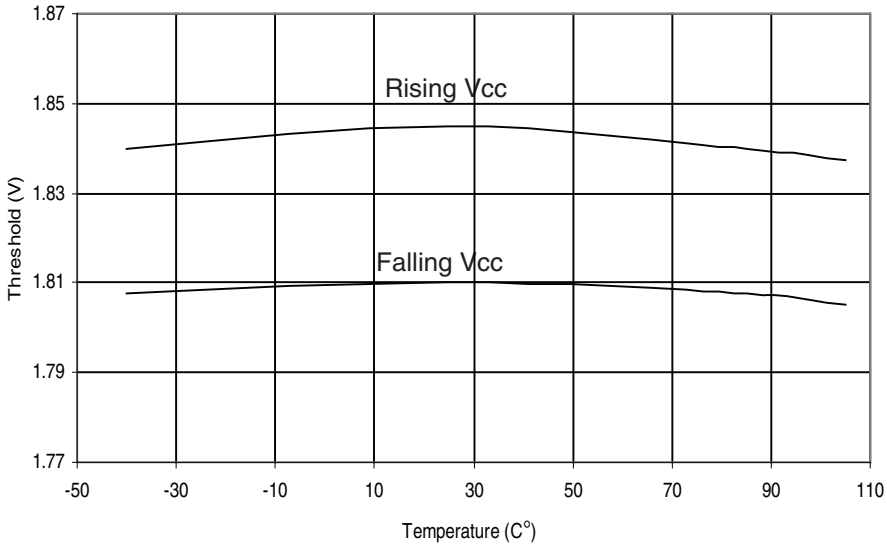


Figure 2-27. ATmega164P: BOD Threshold vs. Temperature (V_{CC} = 1.8V)



2.1.8 Internal Oscillator Speed

Figure 2-28. ATmega164P: Watchdog Oscillator Frequency vs. Temperature

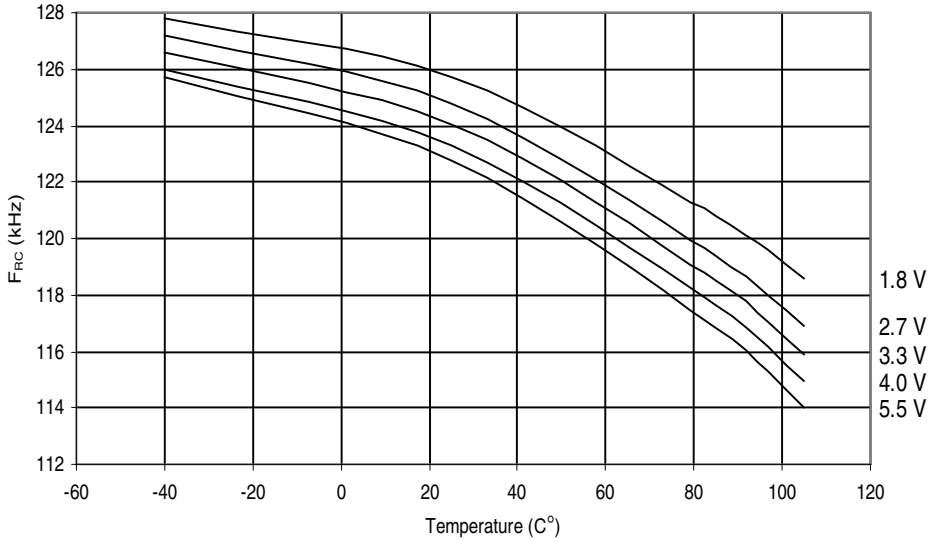


Figure 2-29. ATmega164P: Watchdog Oscillator Frequency vs. V_{CC}

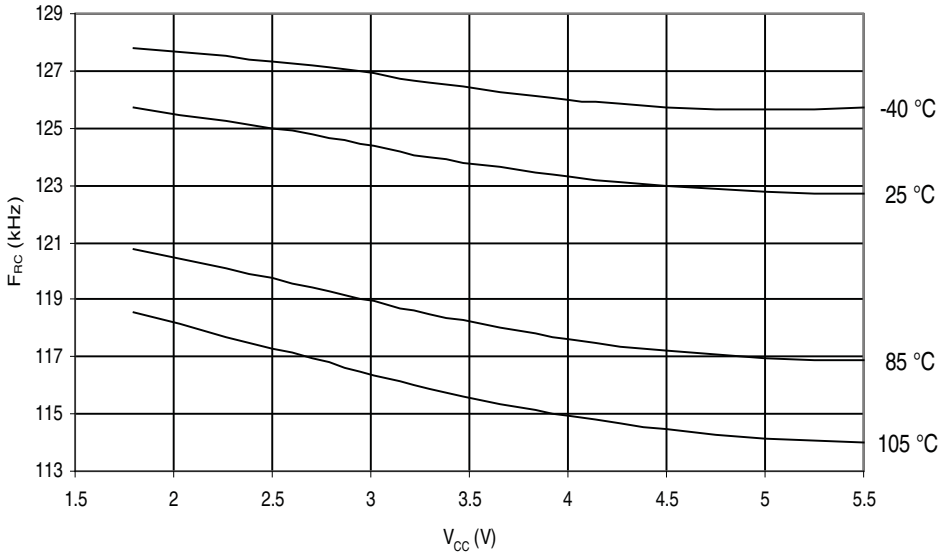


Figure 2-30. ATmega164P: Calibrated 8 MHz RC Oscillator vs. V_{CC}

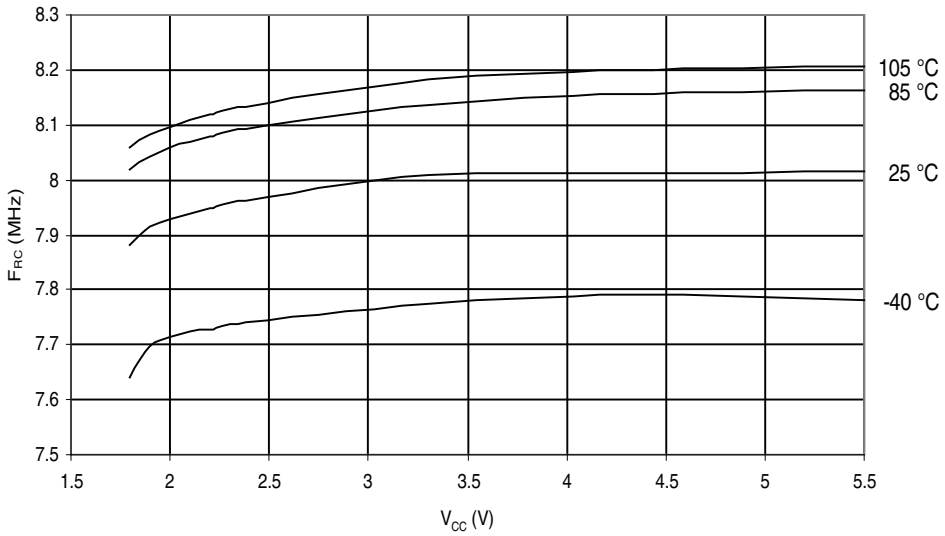


Figure 2-31. ATmega164P: Calibrated 8 MHz RC Oscillator vs. Temperature

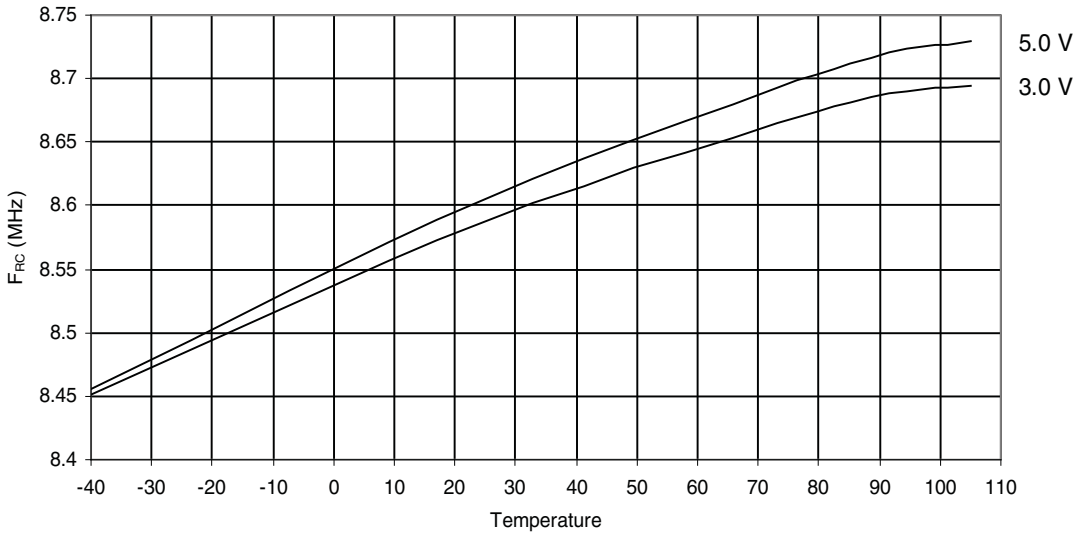
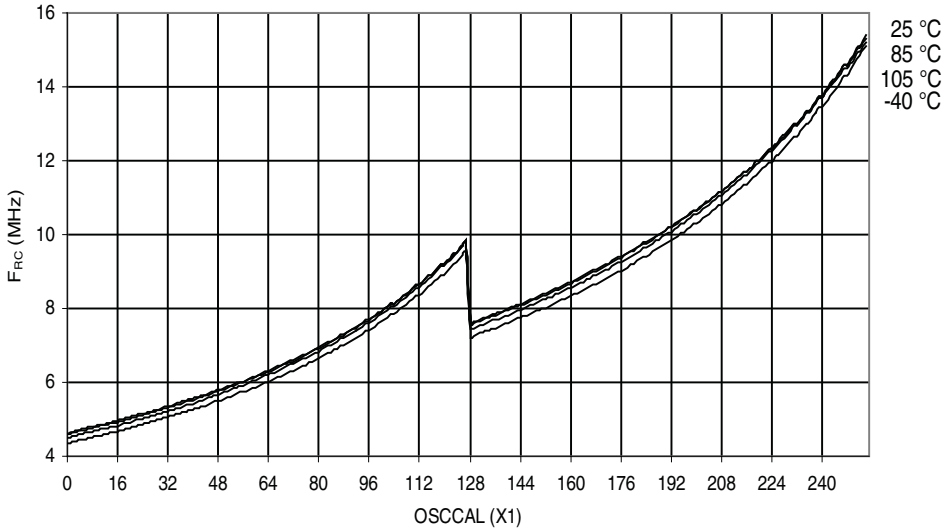


Figure 2-32. ATmega164P: Calibrated 8 MHz RC Oscillator vs. OSCCAL Value



2.1.9 Current Consumption of Peripheral Units

Figure 2-33. ATmega164P: ADC Current vs. V_{CC} (AREF = AV_{CC})

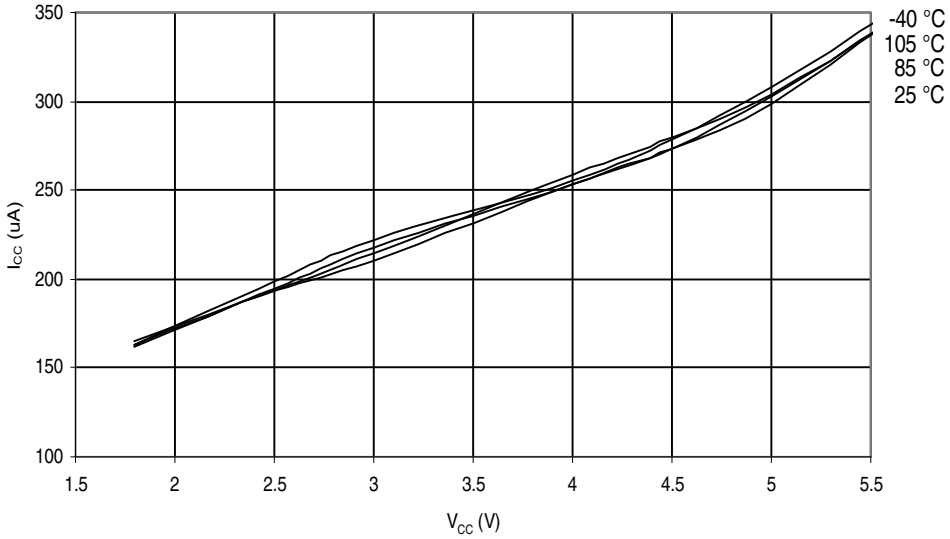


Figure 2-34. ATmega164P: Analog Comparator Current vs. V_{CC}

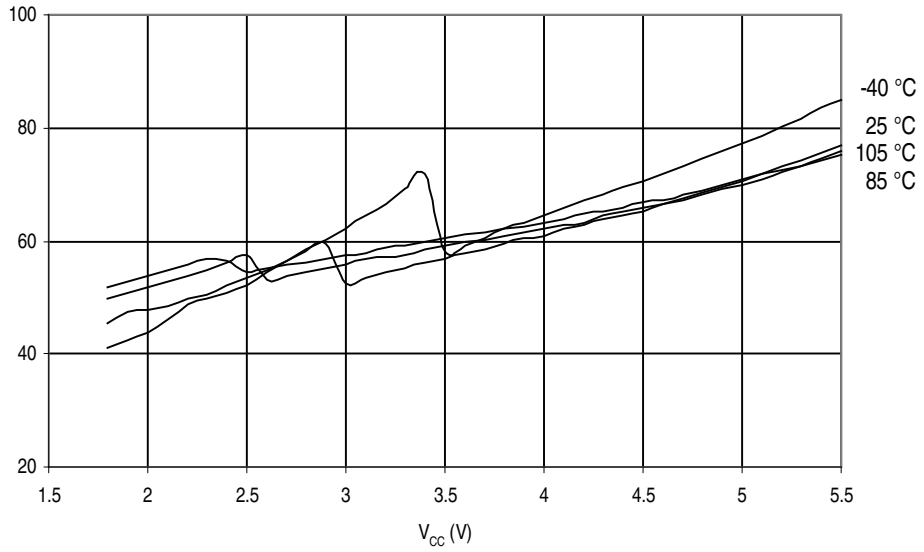


Figure 2-35. ATmega164P: AREF External Reference Current vs. V_{CC}

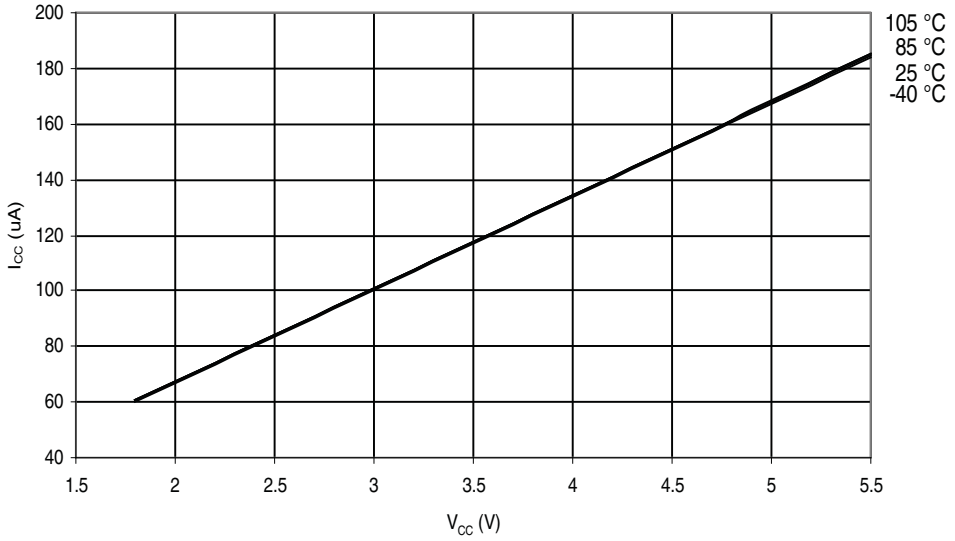


Figure 2-36. ATmega164P: Brownout Detector Current vs. V_{CC}

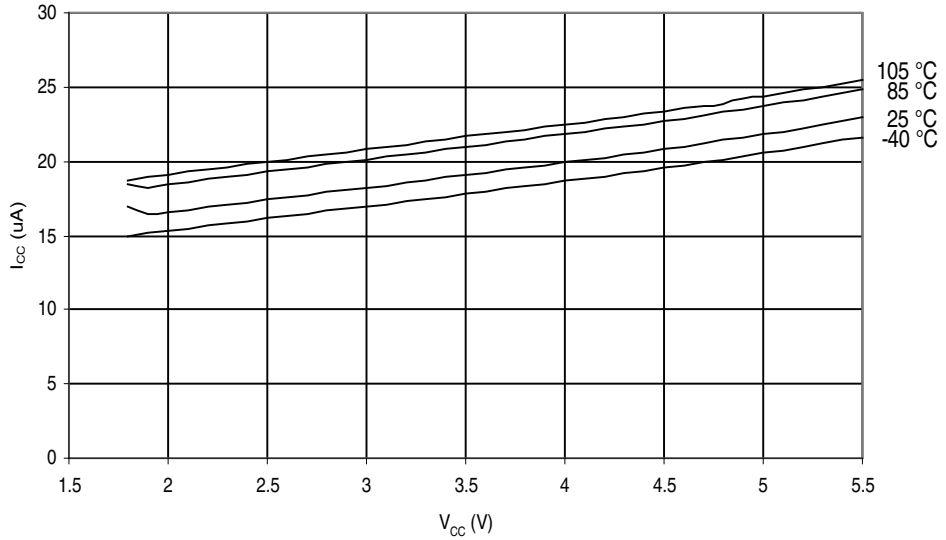


Figure 2-37. ATmega164P: Programming Current vs. V_{CC}

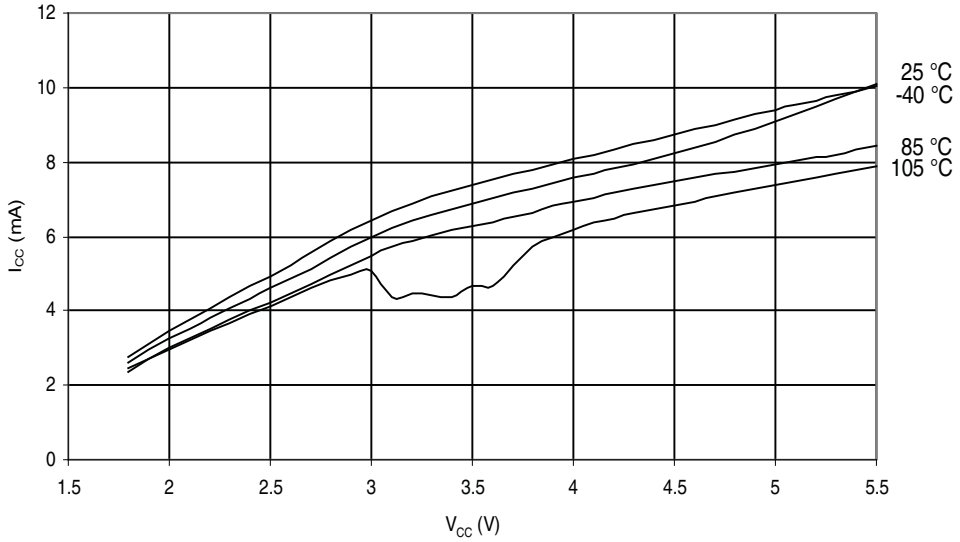
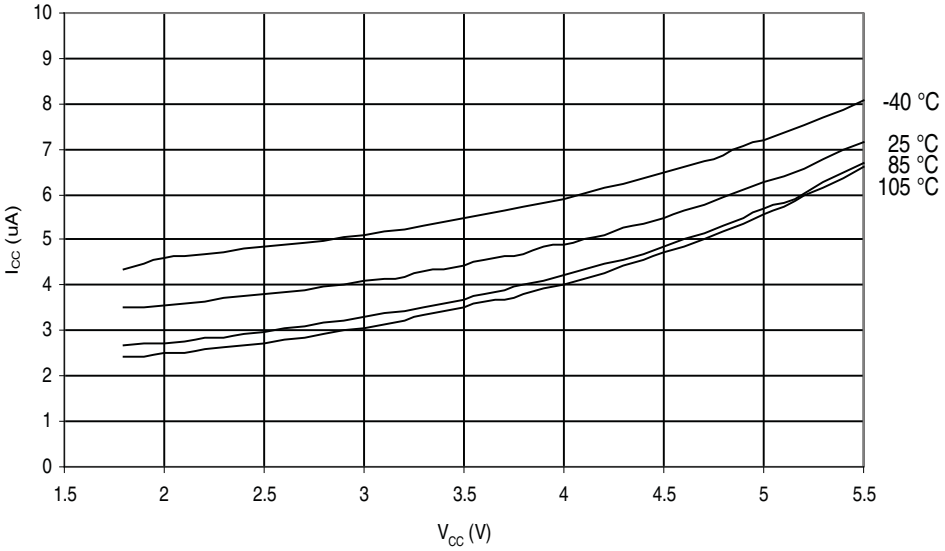


Figure 2-38. ATmega164P: Watchdog Timer Current vs. V_{CC}



2.1.10 Current Consumption in Reset and Reset Pulsewidth

Figure 2-39. ATmega164P: Reset Supply Current vs Vcc 0.1-1.0MHz

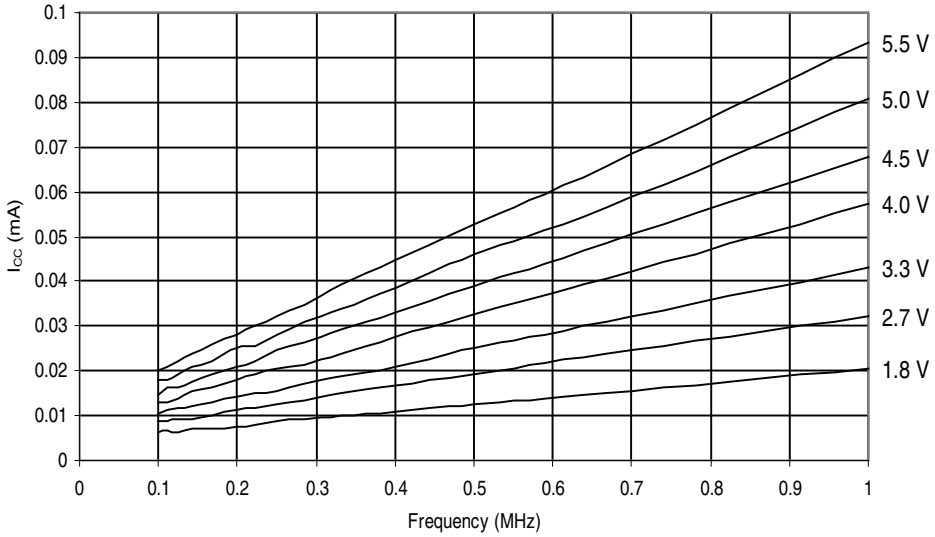


Figure 2-40. ATmega164P: Reset Supply Current vs Vcc 1-20MHz

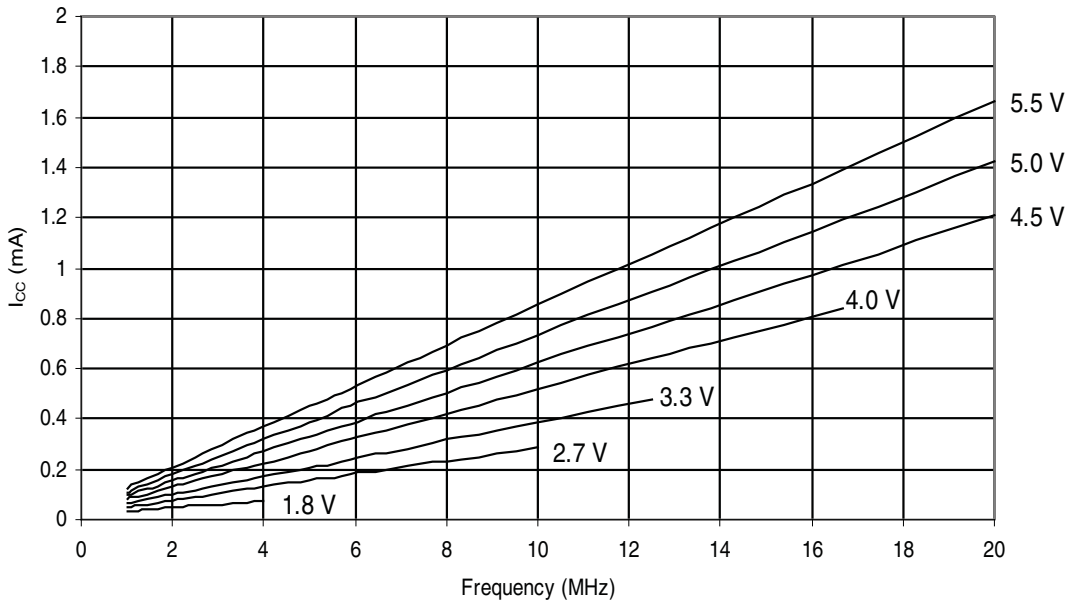
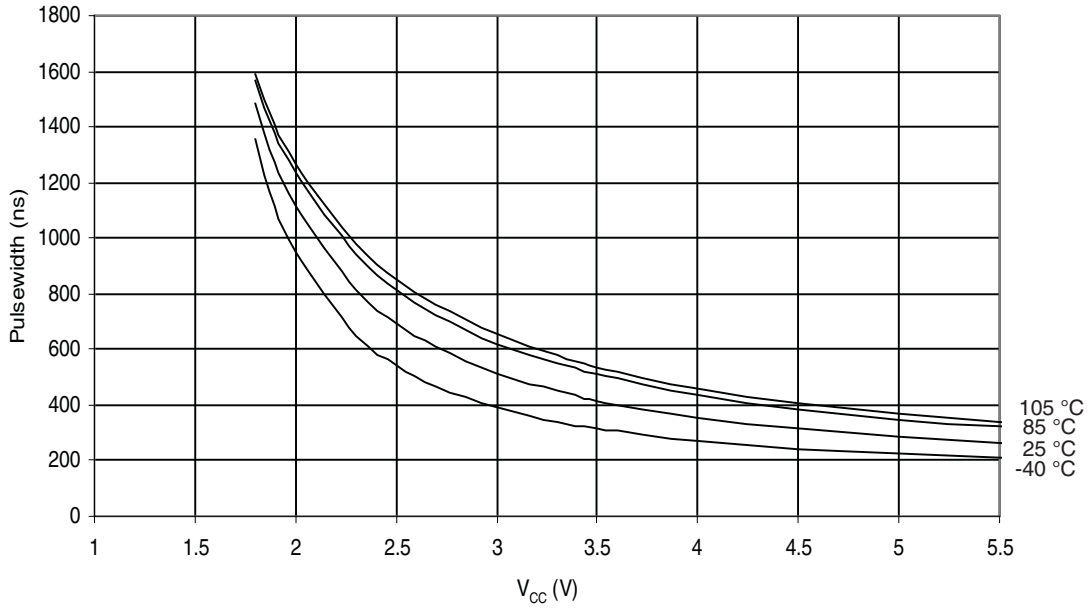


Figure 2-41. ATmega164P: Minimum reset Pulswith vs. Vcc



2.2 ATmega324P Typical Characteristics

2.2.1 Active Supply Current

Figure 2-42. ATmega324P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 8 MHz)

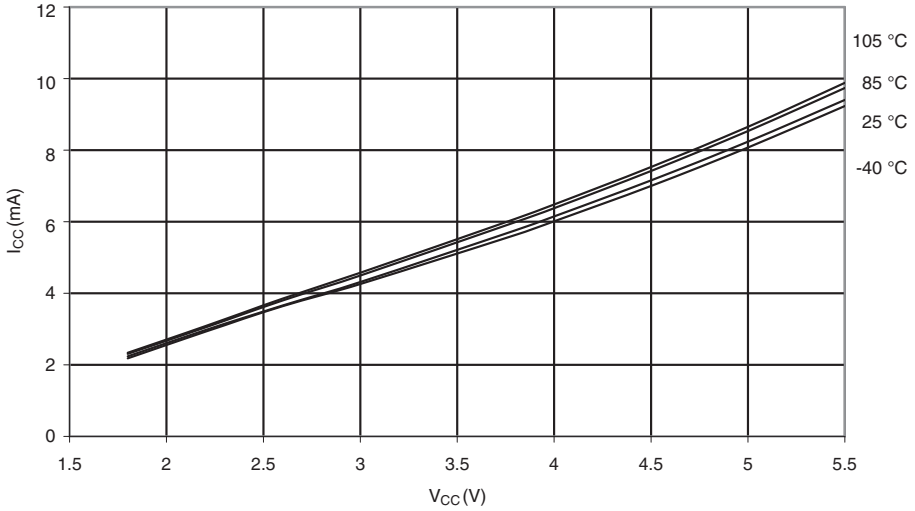


Figure 2-43. ATmega324P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 1 MHz)

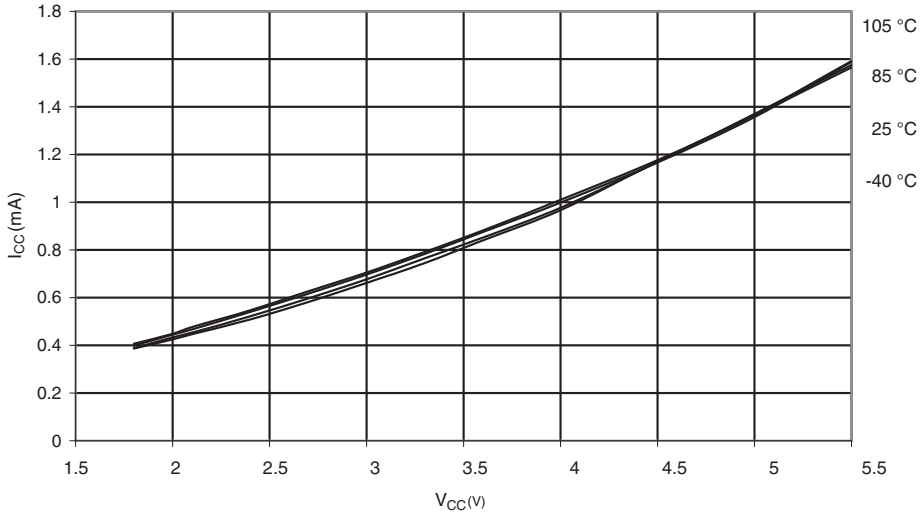
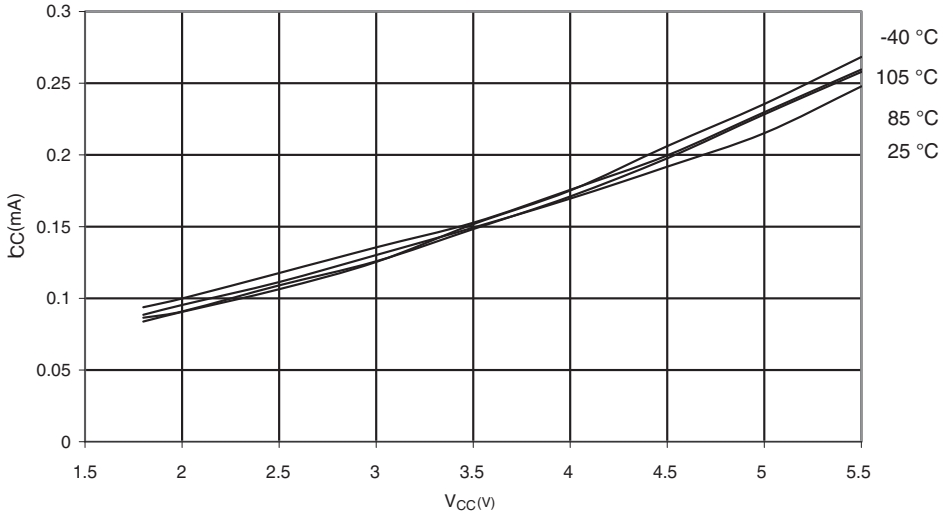


Figure 2-44. ATmega324P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 128 kHz)



2.2.2 Idle Supply Current

Figure 2-45. ATmega324P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 8 MHz)

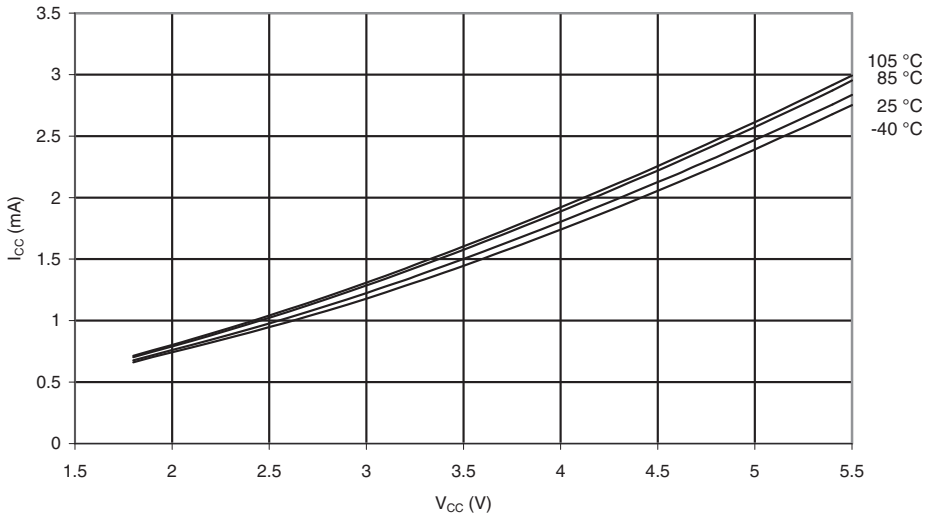


Figure 2-46. ATmega324P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 1 MHz)

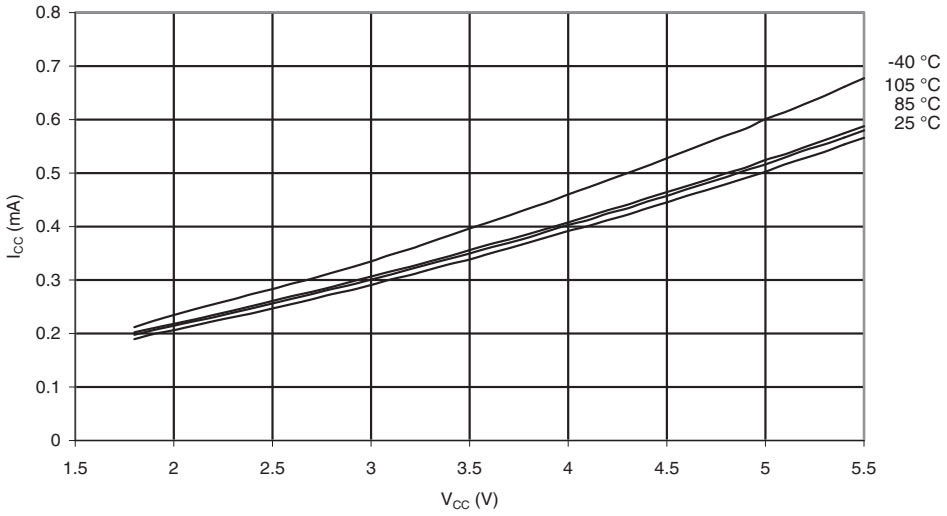
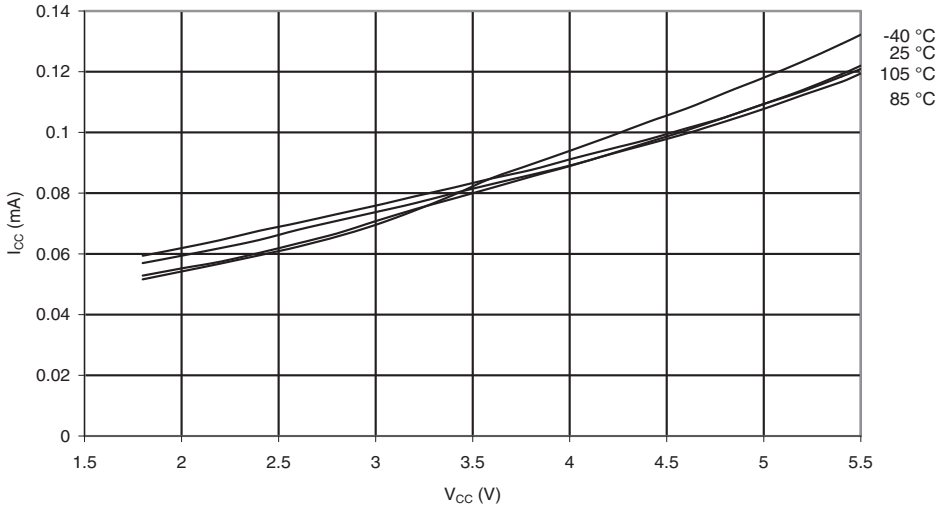


Figure 2-47. ATmega324P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 128 kHz)



2.2.3 Power-down Supply Current

Figure 2-48. ATmega324P: Power-down Supply Current vs. V_{CC} (Watchdog Timer Disabled)

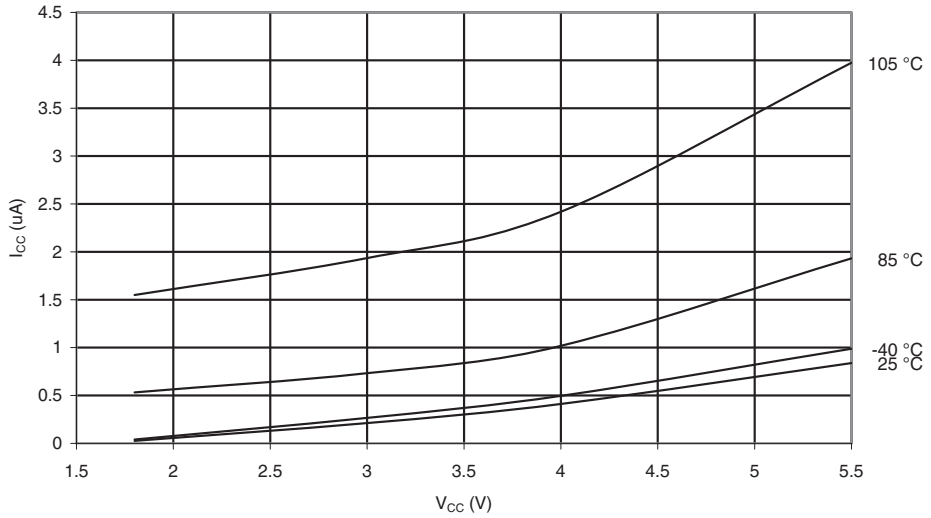
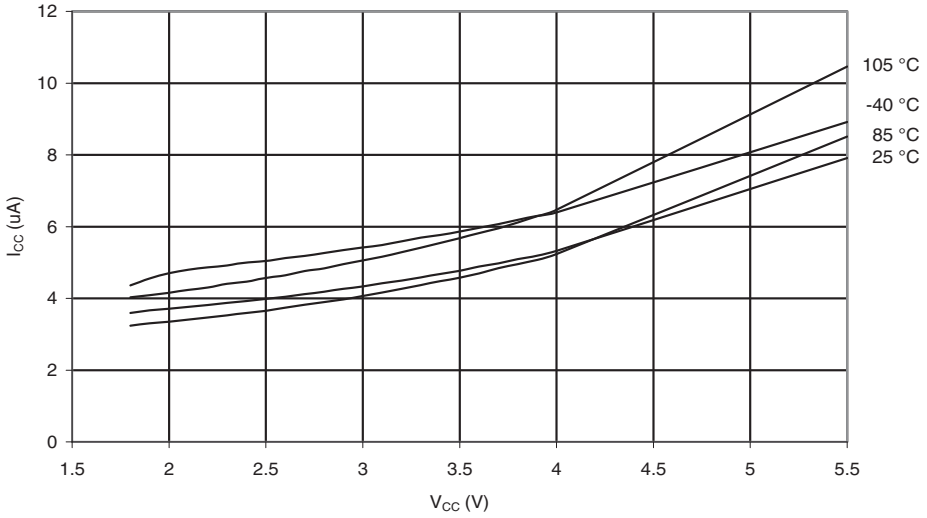


Figure 2-49. ATmega324P: Power-down Supply Current vs. V_{CC} (Watchdog Timer Enabled)



2.2.4 Pin Pull-up

Figure 2-50. ATmega324P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 1.8V)

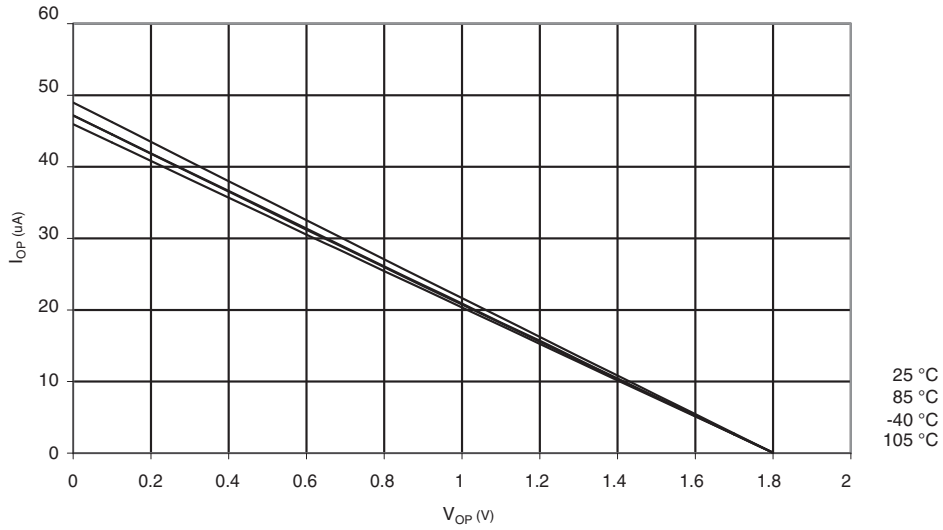


Figure 2-51. ATmega324P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 2.7V)

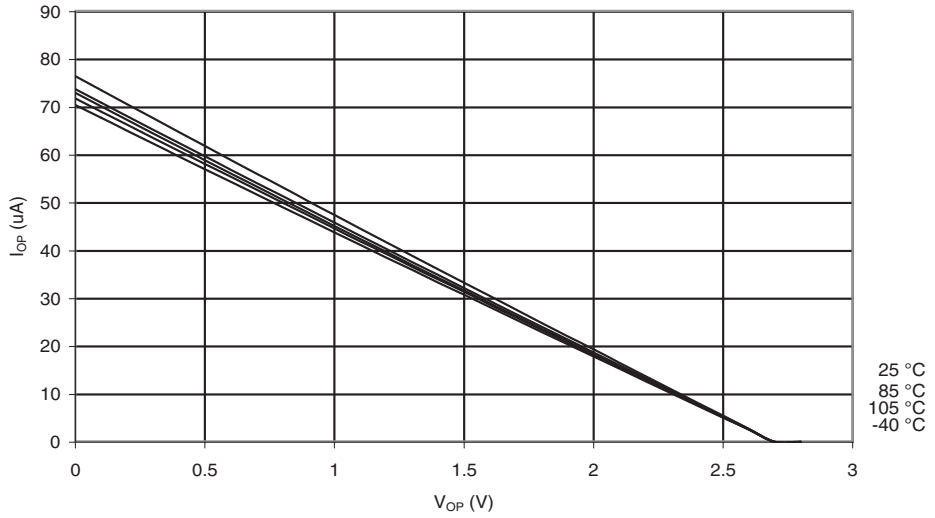


Figure 2-52. ATmega324P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 5V)

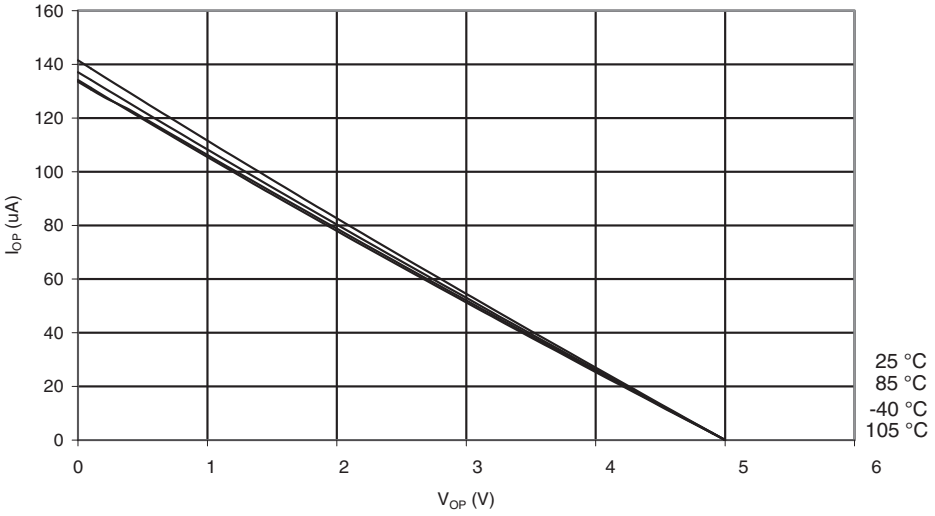


Figure 2-53. ATmega324P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 1.8V)

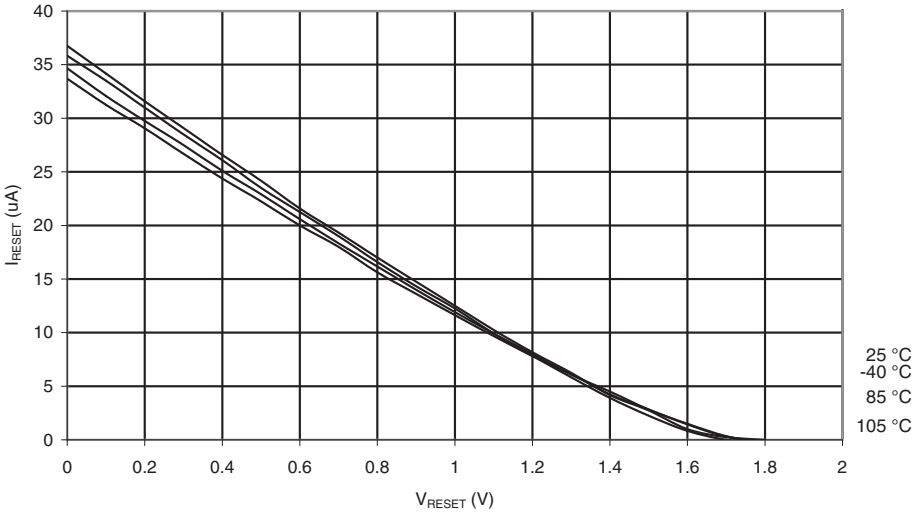


Figure 2-54. ATmega324P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 2.7V)

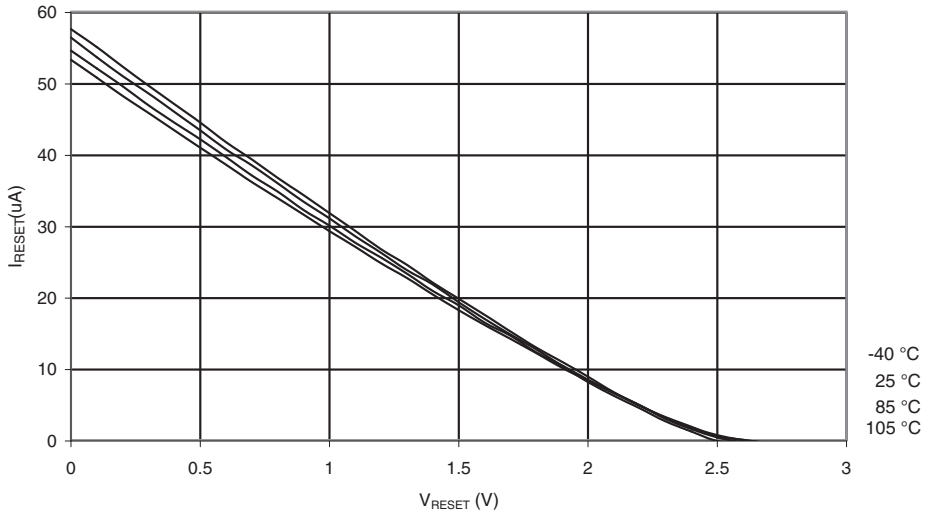
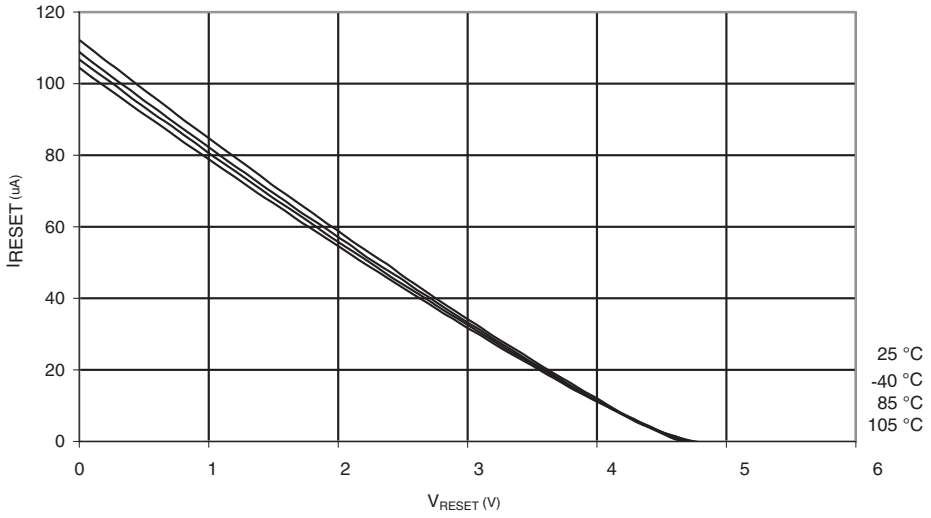


Figure 2-55. ATmega324P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 5V)



2.2.5 Pin Driver Strength

Figure 2-56. ATmega324P: I/O Pin Output Voltage vs. Sink Current (V_{CC} = 3V)

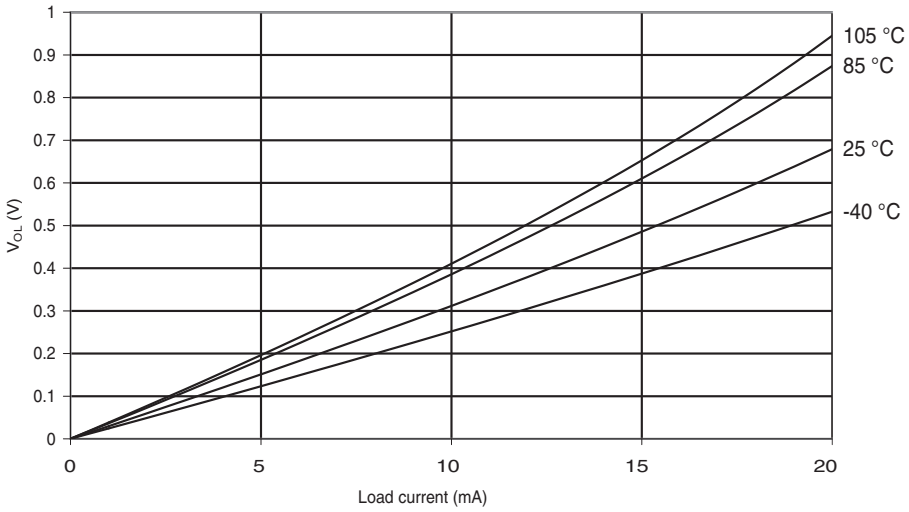


Figure 2-57. ATmega324P: I/O Pin Output Voltage vs. Sink Current (V_{CC} = 5V)

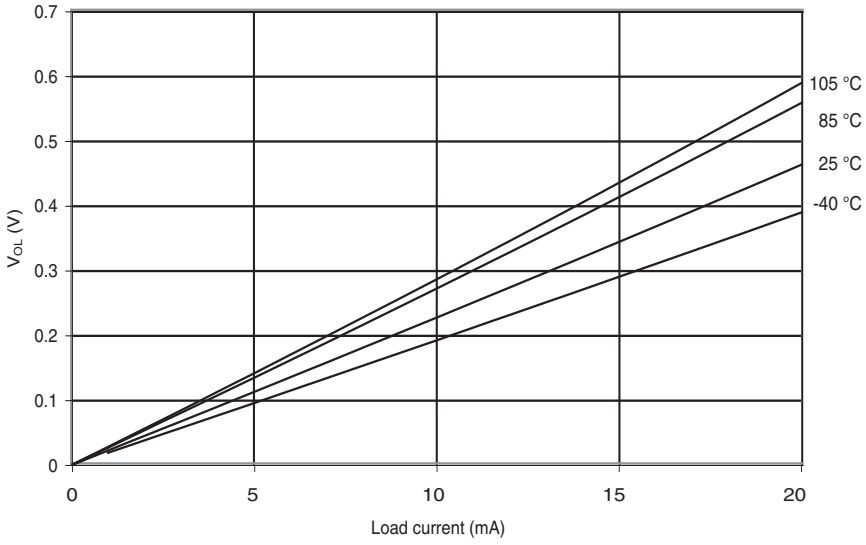


Figure 2-58. ATmega324P: I/O Pin Output Voltage vs. Source Current (V_{CC} = 3V)

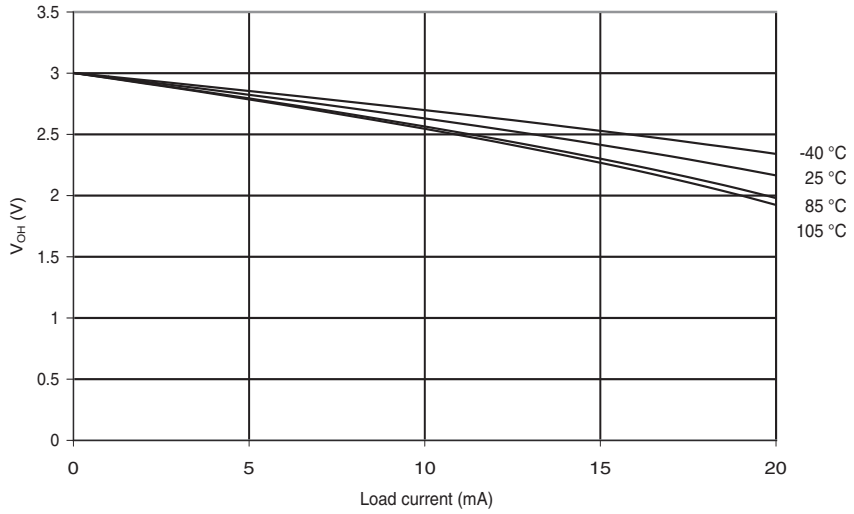
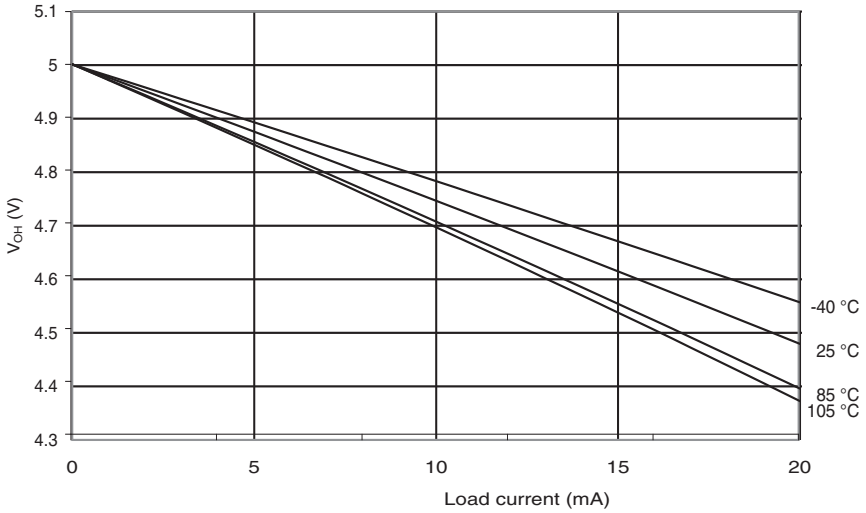


Figure 2-59. ATmega324P: I/O Pin Output Voltage vs. Source Current (V_{CC} = 5V)



2.2.6 Pin Threshold and Hysteresis

Figure 2-60. ATmega324P: I/O Pin Input Threshold vs. V_{CC} (V_{IH} , I/O Pin Read as '1')

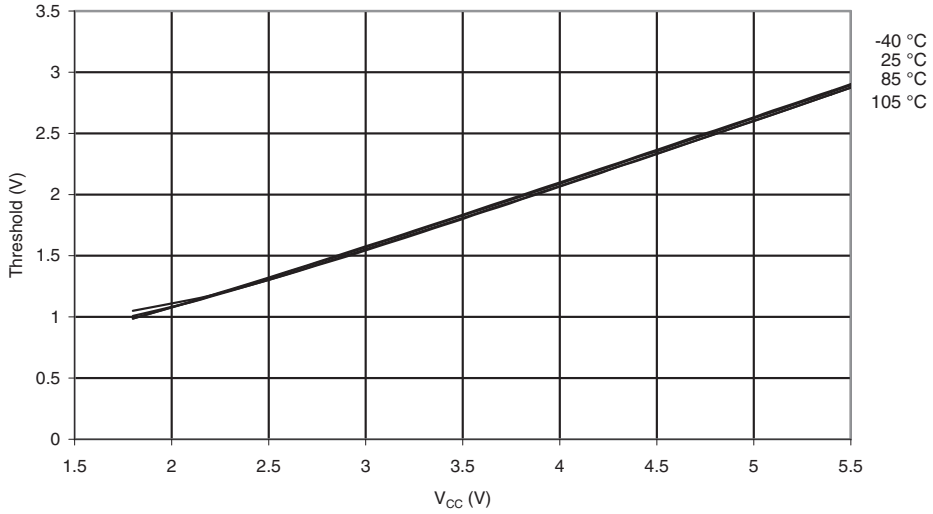


Figure 2-61. ATmega324P: I/O Pin Input Threshold vs. V_{CC} (V_{IL}, I/O Pin Read as '0')

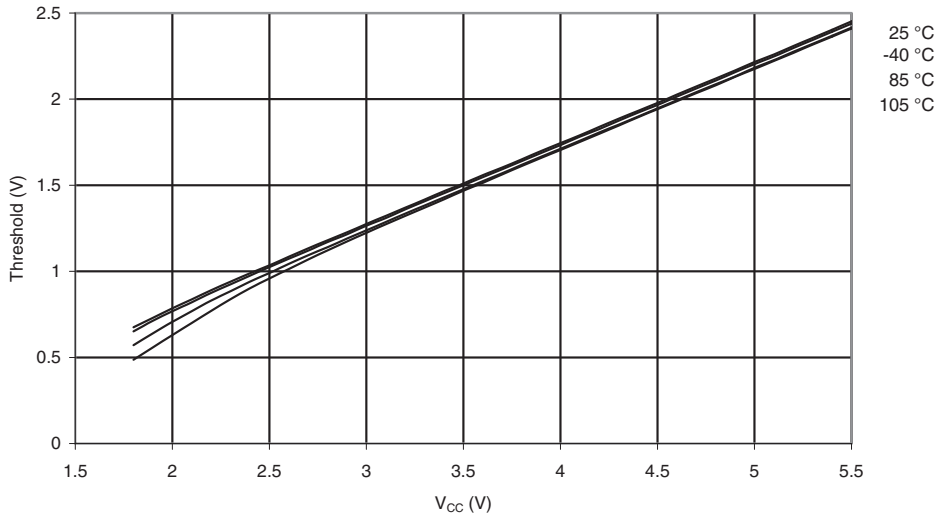


Figure 2-62. ATmega324P: I/O Pin Input Hysteresis vs. V_{CC}

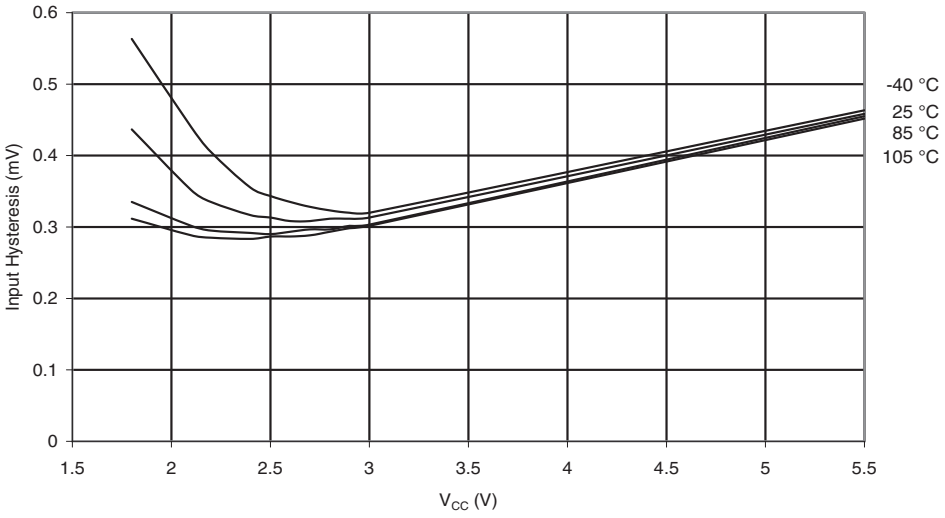


Figure 2-63. ATmega324P: Reset Pin Input Threshold vs. V_{CC} (V_{IH} , I/O Pin Read as '1')

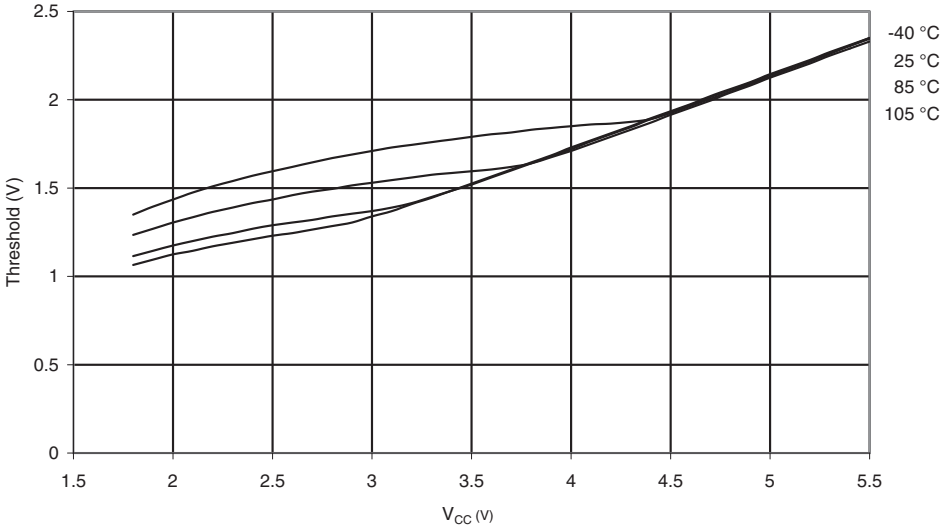


Figure 2-64. ATmega324P: Reset Pin Input Threshold vs. V_{CC} (V_{IL}, I/O Pin Read as '0')

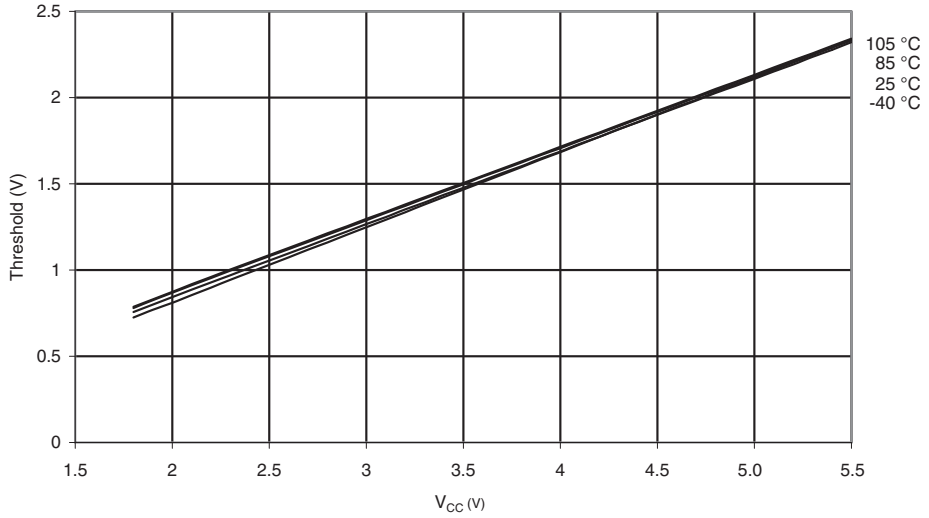
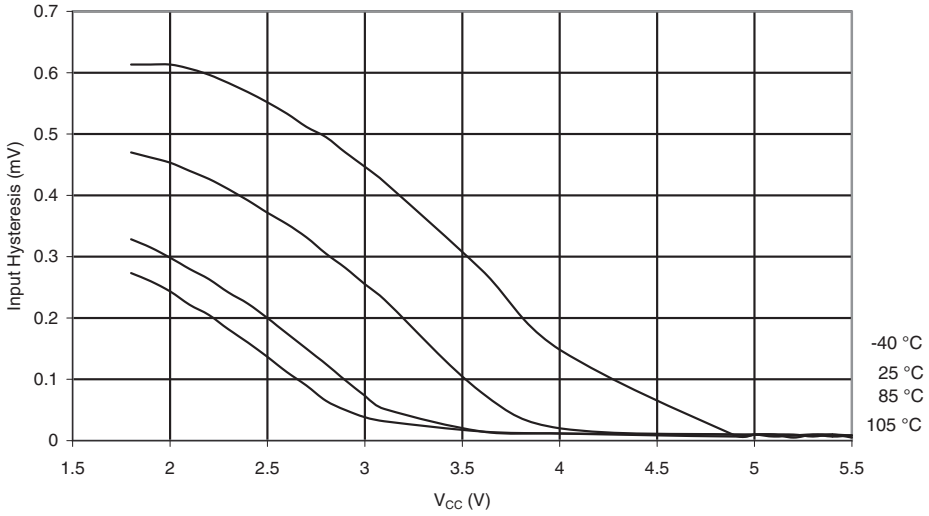


Figure 2-65. ATmega324P: Reset Pin Input Hysteresis vs. V_{CC}



2.2.7 BOD Threshold

Figure 2-66. ATmega324P: BOD Threshold vs. Temperature (V_{CC} = 4.3V)

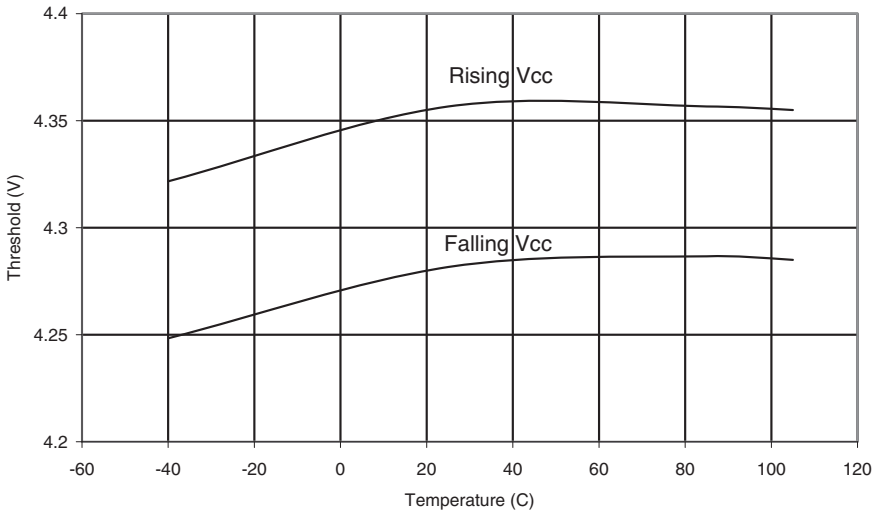


Figure 2-67. ATmega324P: BOD Threshold vs. Temperature (V_{CC} = 2.7V)

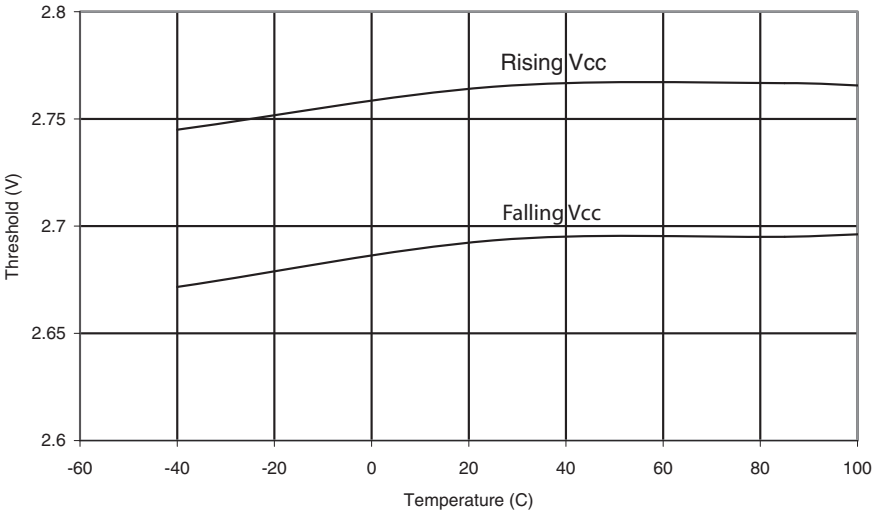
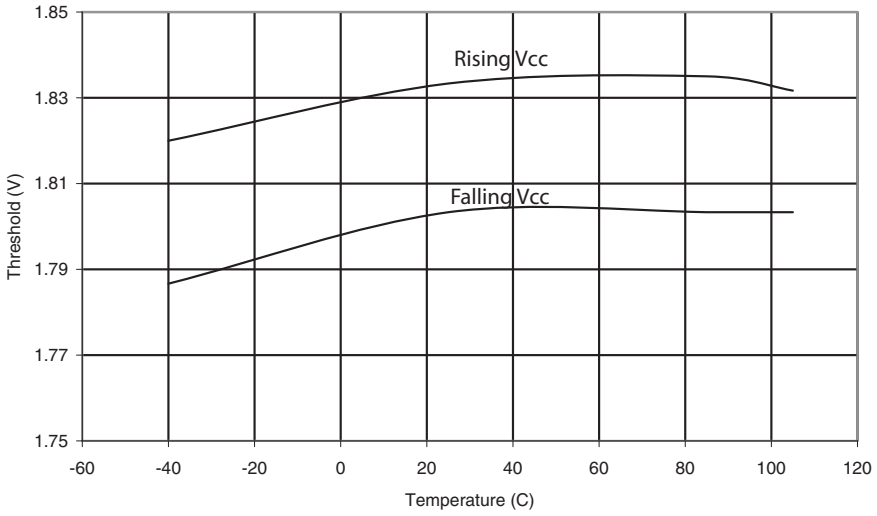


Figure 2-68. ATmega324P: BOD Threshold vs. Temperature (V_{CC} = 1.8V)



2.2.8 Internal Oscillator Speed

Figure 2-69. ATmega324P: Watchdog Oscillator Frequency vs. Temperature

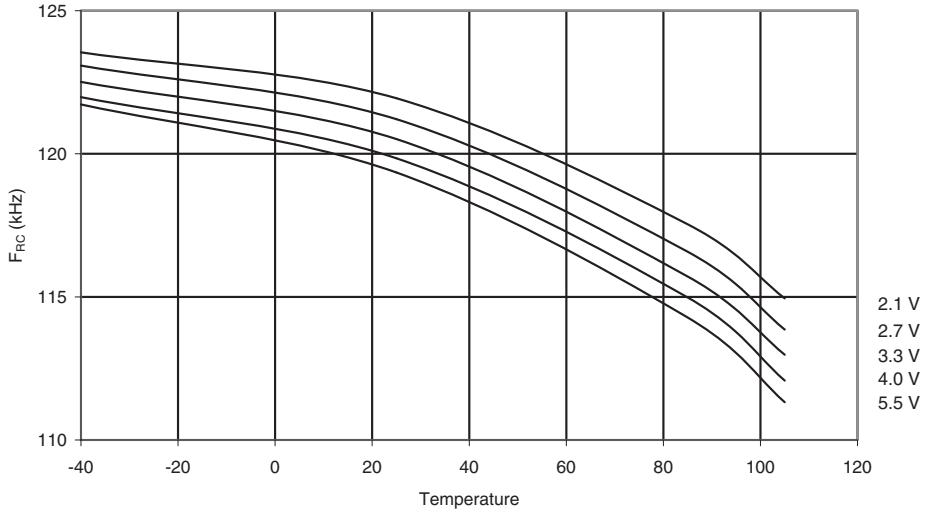


Figure 2-70. ATmega324P: Watchdog Oscillator Frequency vs. V_{CC}

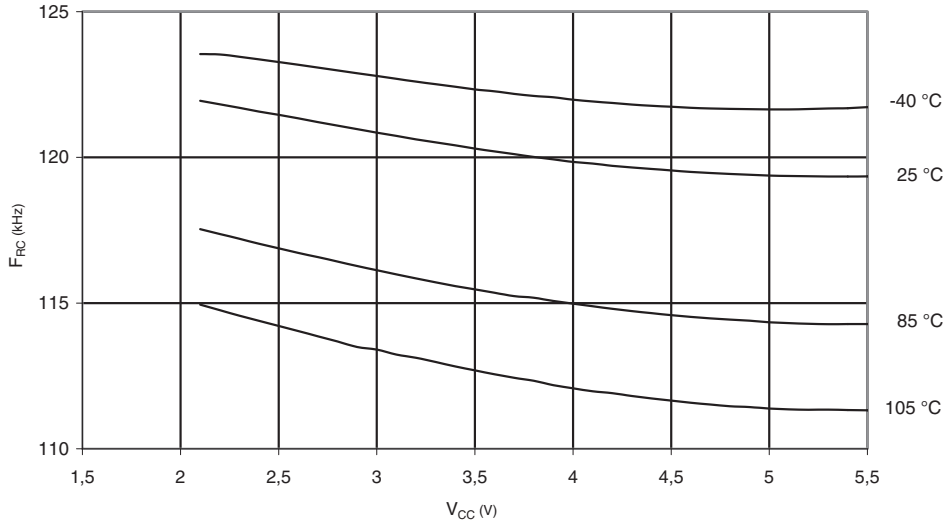


Figure 2-71. ATmega324P: Calibrated 8 MHz RC Oscillator vs. V_{CC}

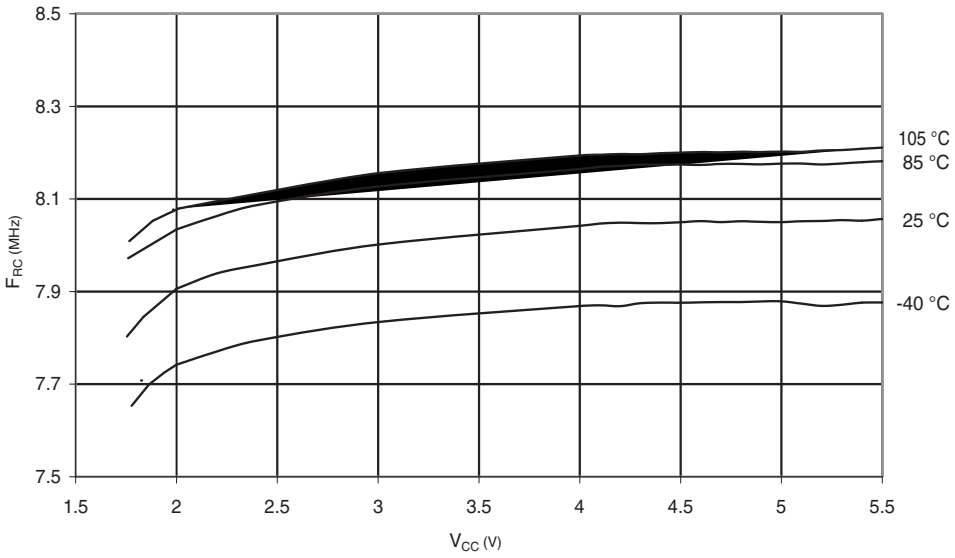


Figure 2-72. ATmega324P: Calibrated 8 MHz RC Oscillator vs. Temperature

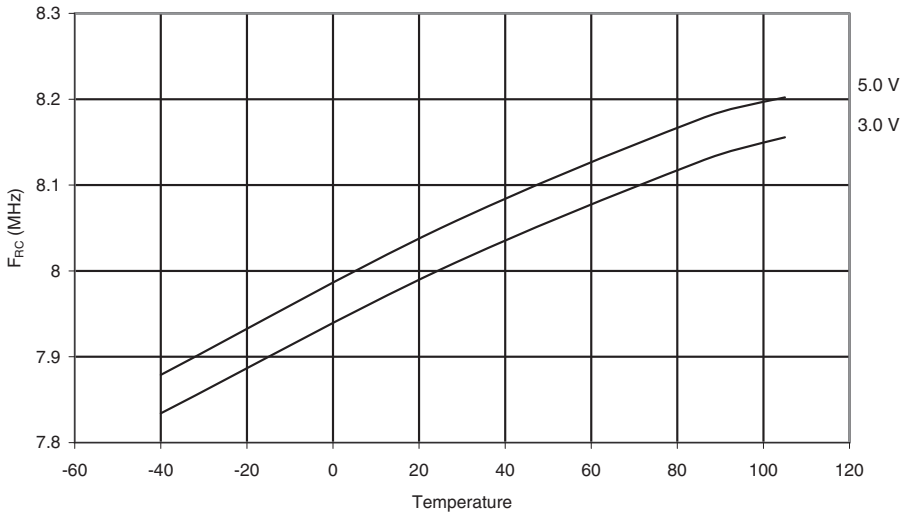
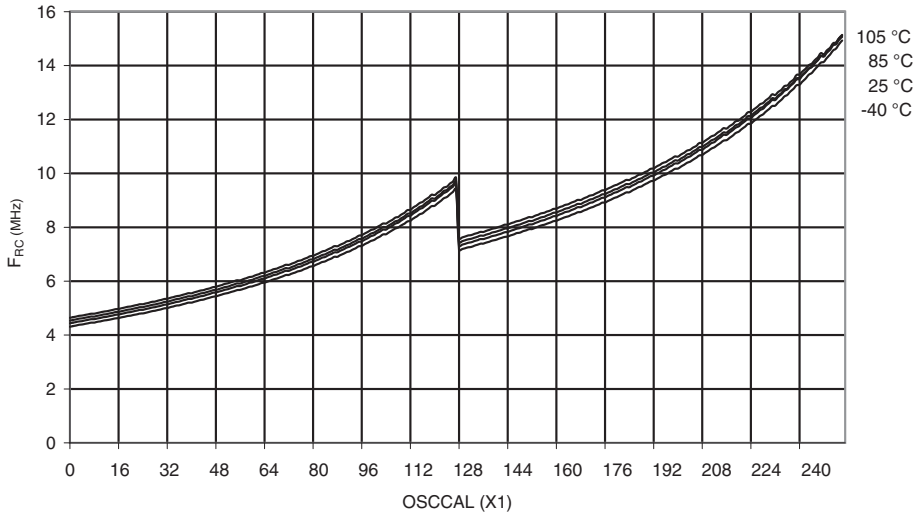


Figure 2-73. ATmega324P: Calibrated 8 MHz RC Oscillator vs. OSCCAL Value



2.2.9 Current Consumption of Peripheral Units

Figure 2-74. ATmega324P: ADC Current vs. V_{CC} ($AREF = AV_{CC}$)

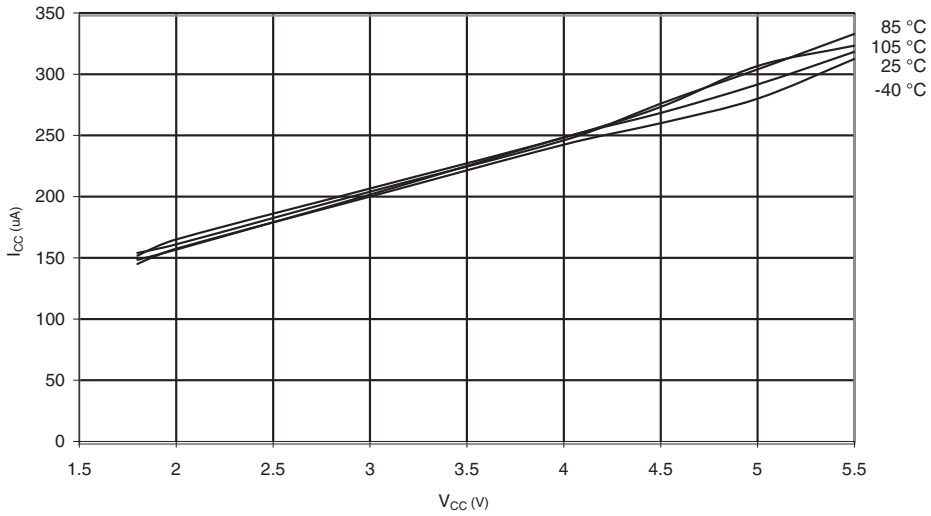


Figure 2-75. ATmega324P: Analog Comparator Current vs. V_{CC}

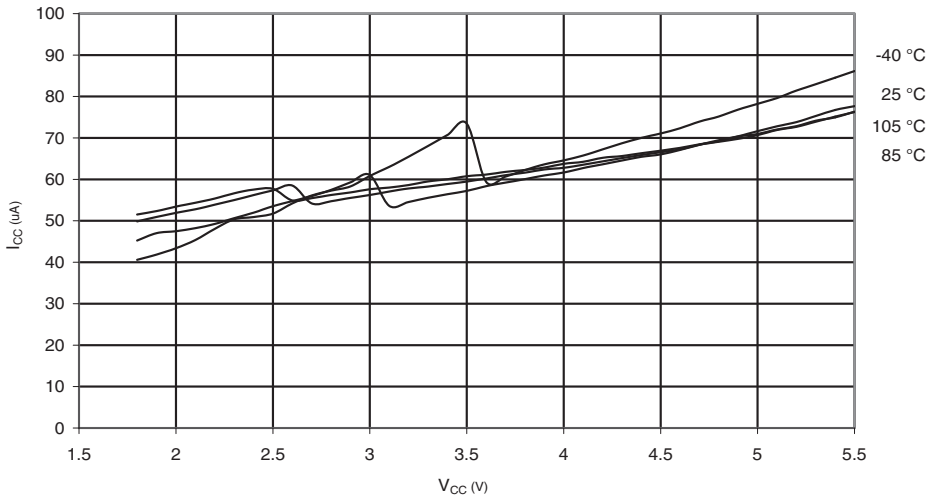


Figure 2-76. ATmega324P: AREF External Reference Current vs. V_{CC}

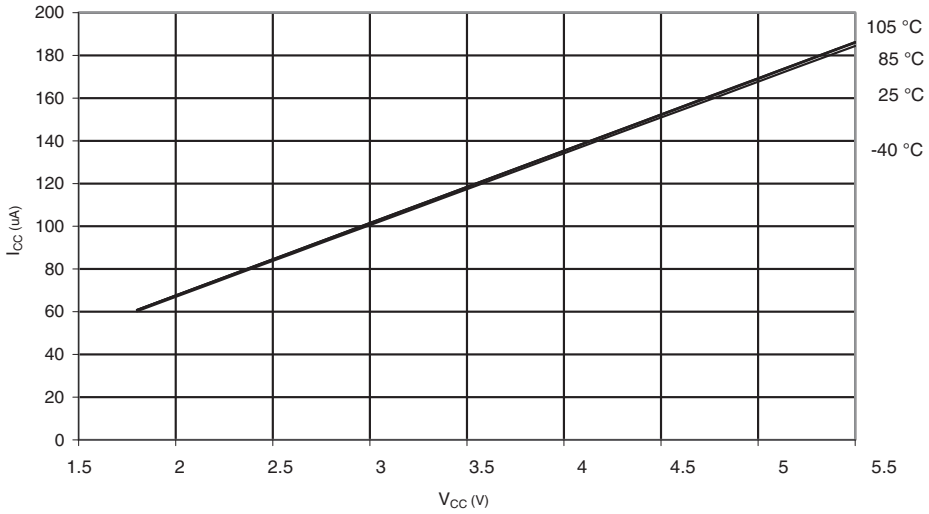


Figure 2-77. ATmega324P: Brownout Detector Current vs. V_{CC}

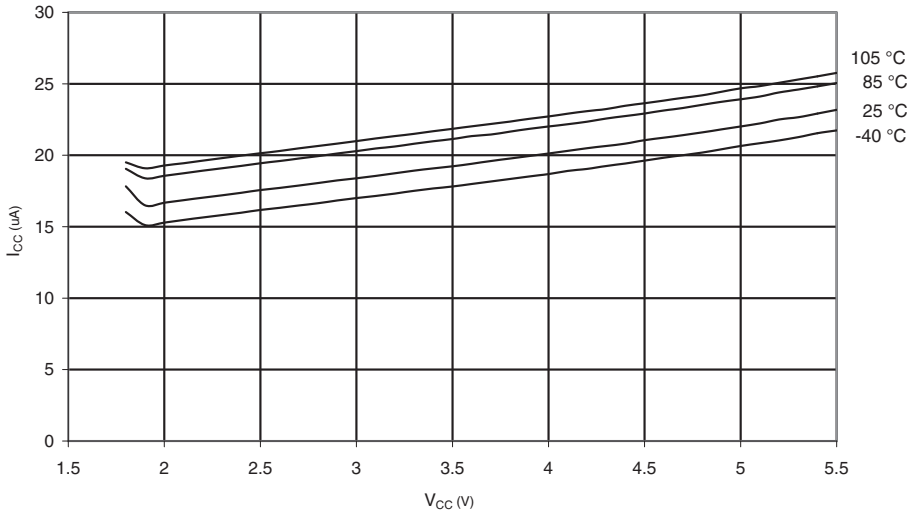


Figure 2-78. ATmega324P: Programming Current vs. V_{CC}

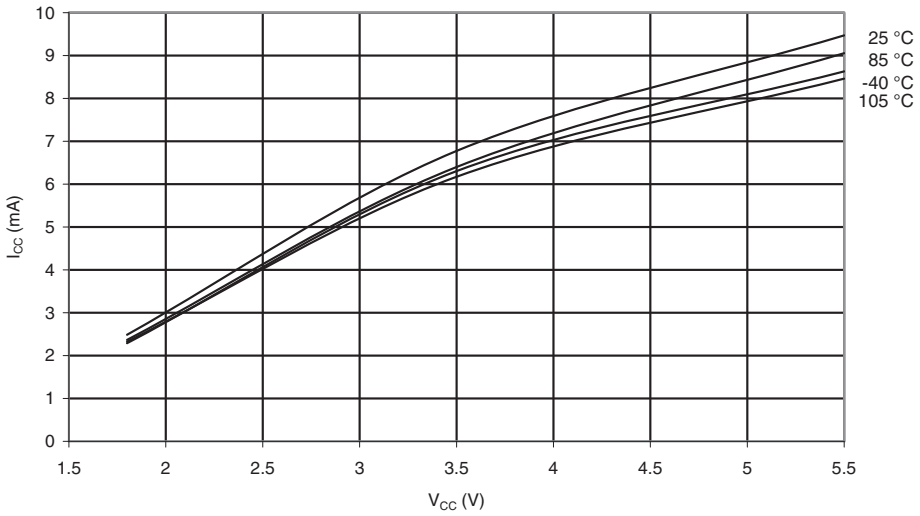
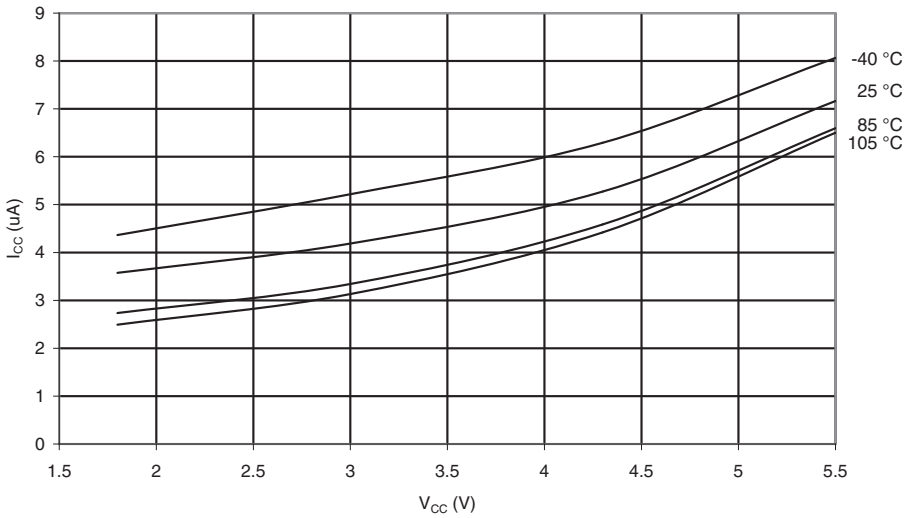


Figure 2-79. ATmega324P: Watchdog Timer Current vs. V_{CC}



2.2.10 Current Consumption in Reset and Reset Pulsewidth

Figure 2-80. ATmega324P: Minimum reset Pulswith vs. Vcc

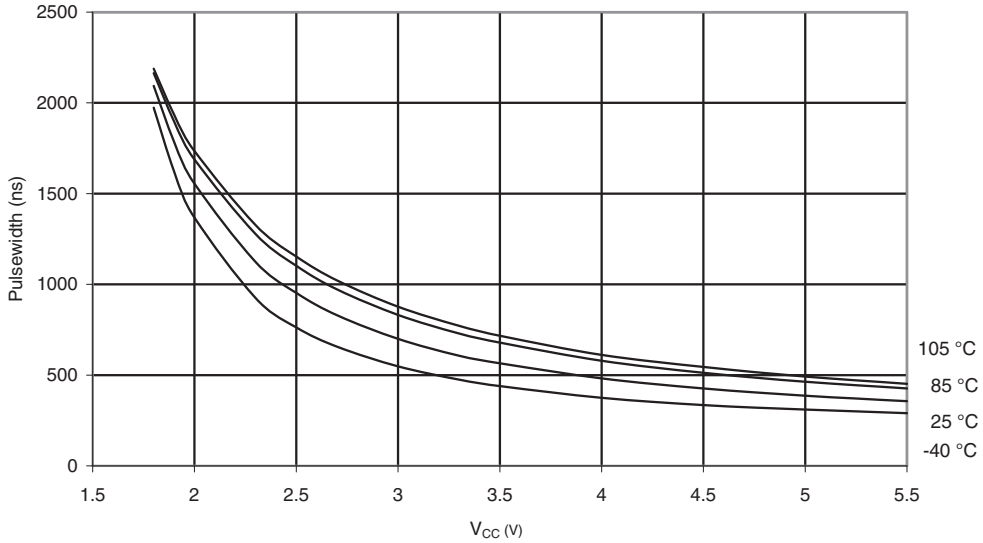


Figure 2-81. ATmega324P:Reset Supply Current vs Vcc 0.1-1.0MHz

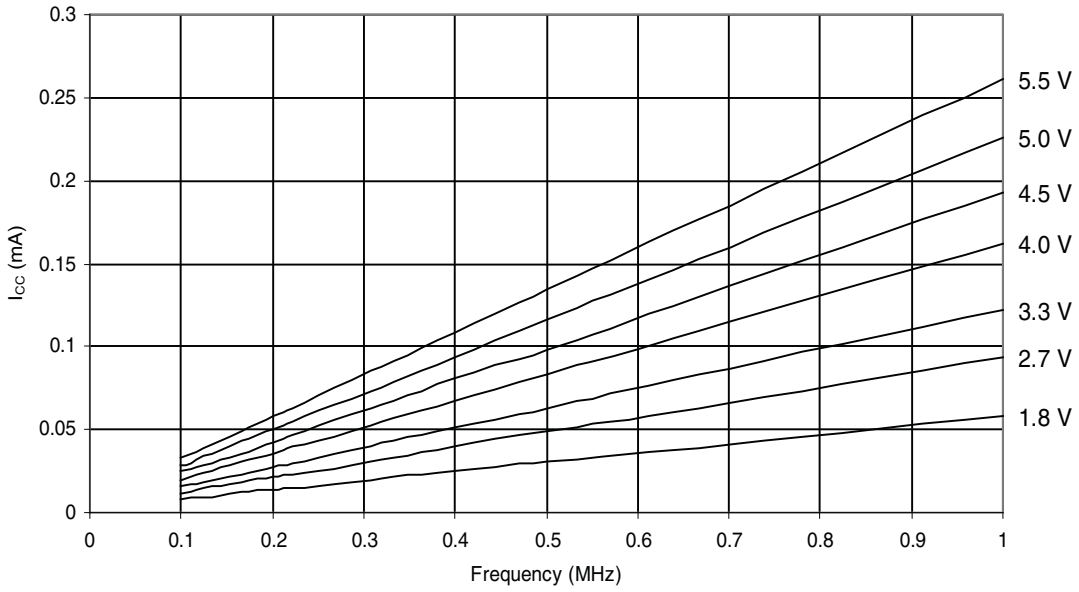
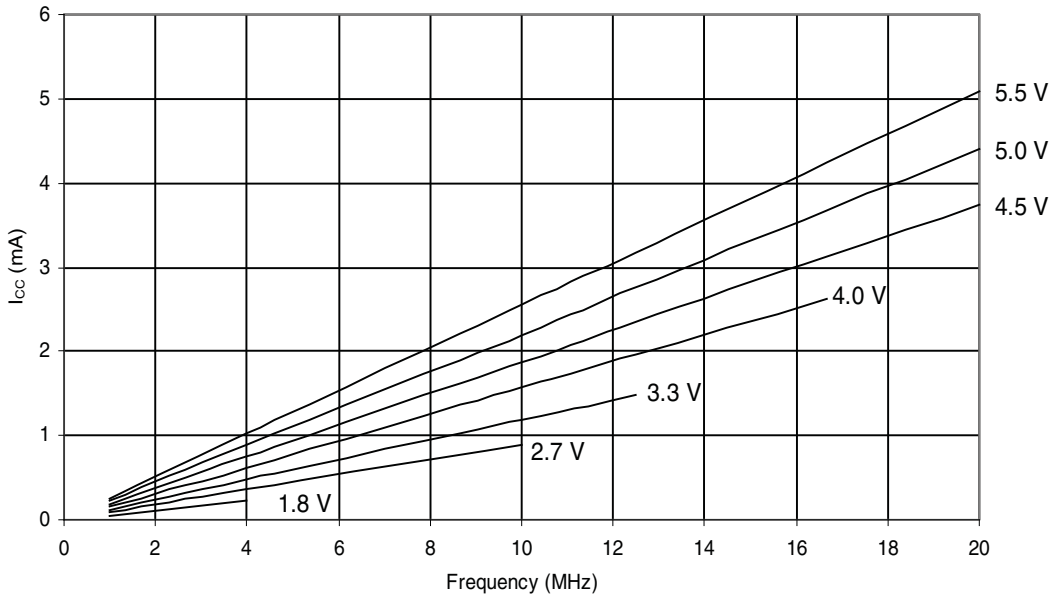


Figure 2-82. ATmega324P:Reset Supply Current vs Vcc 1-20MHz



2.3 ATmega644P Typical Characteristics

2.3.1 Active Supply Current

Figure 2-83. ATmega644P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 8 MHz).

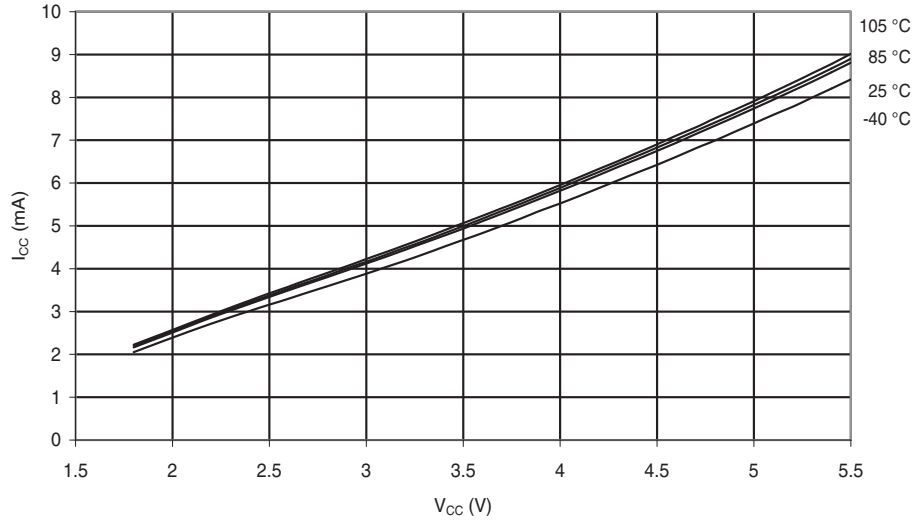


Figure 2-84. ATmega644P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 1 MHz).

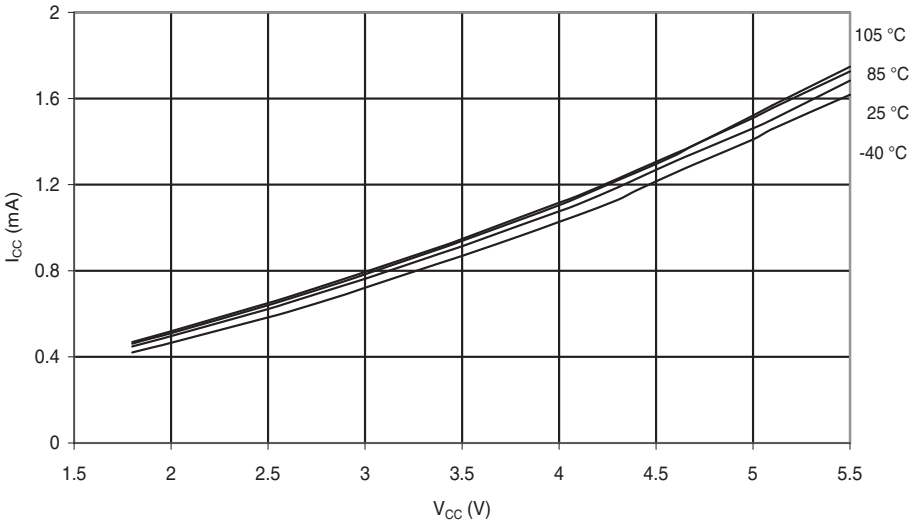
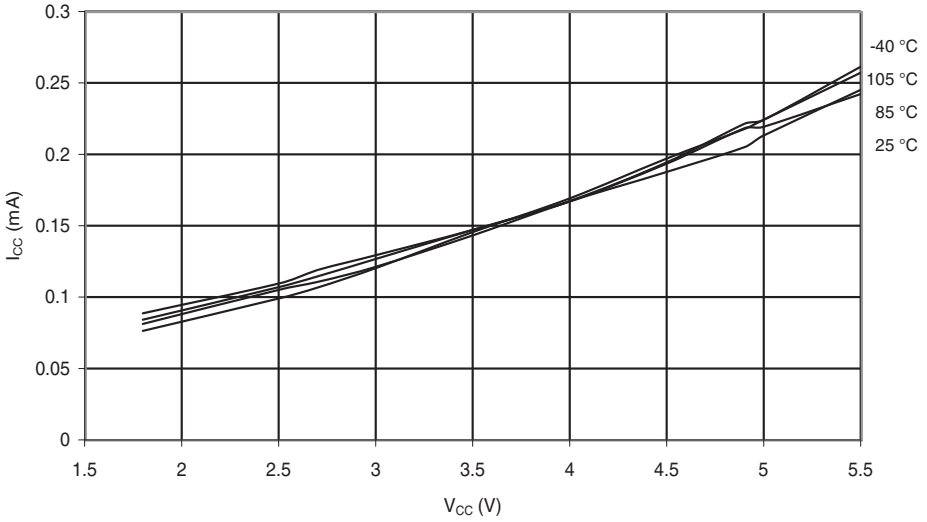


Figure 2-85. ATmega644P: Active Supply Current vs. V_{CC} (Internal RC Oscillator, 128 kHz).



2.3.2 Idle Supply Current

Figure 2-86. ATmega644P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 8 MHz).

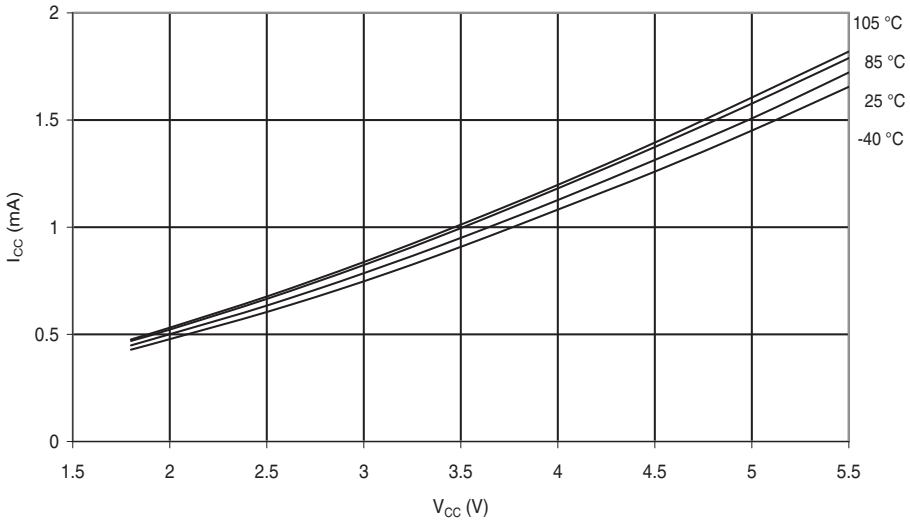


Figure 2-87. ATmega644P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 1 MHz).

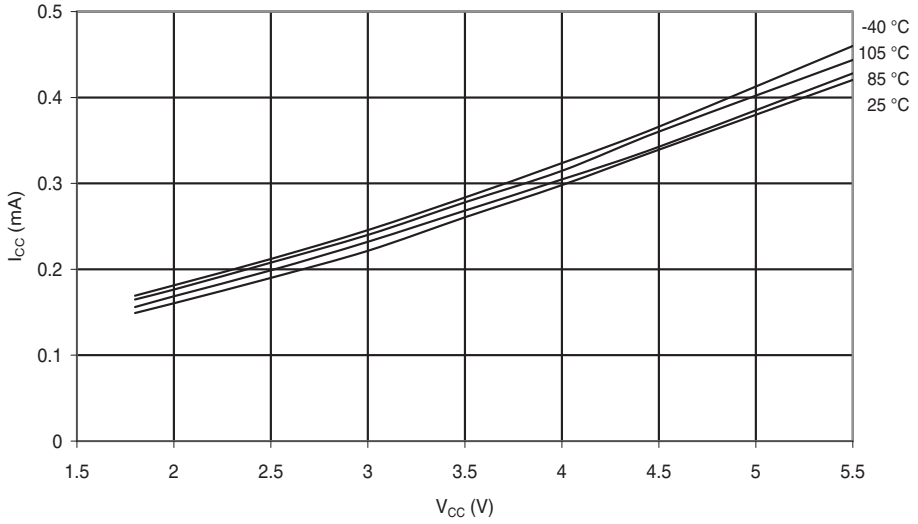
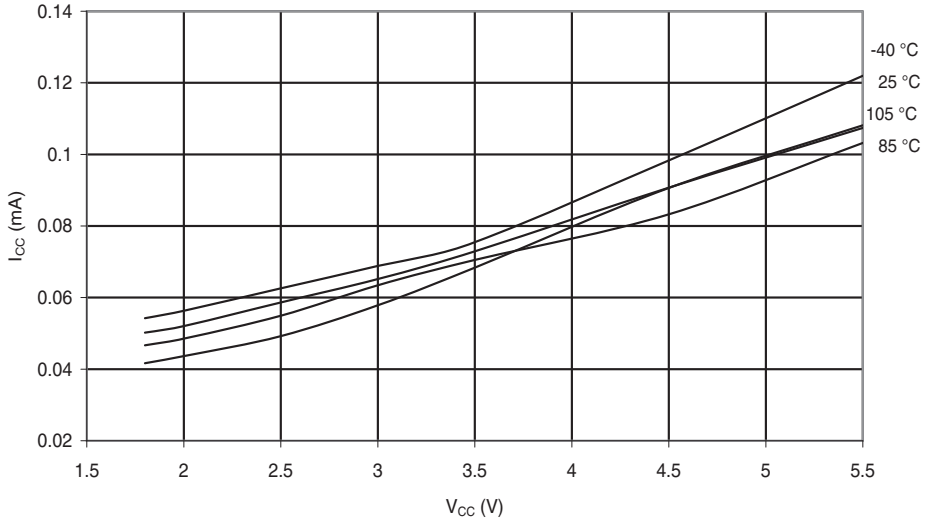


Figure 2-88. ATmega644P: Idle Supply Current vs. V_{CC} (Internal RC Oscillator, 128 kHz).



2.3.3 Power-down Supply Current

Figure 2-89. ATmega644P: Power-down Supply Current vs. V_{CC} (Watchdog Timer Disabled).

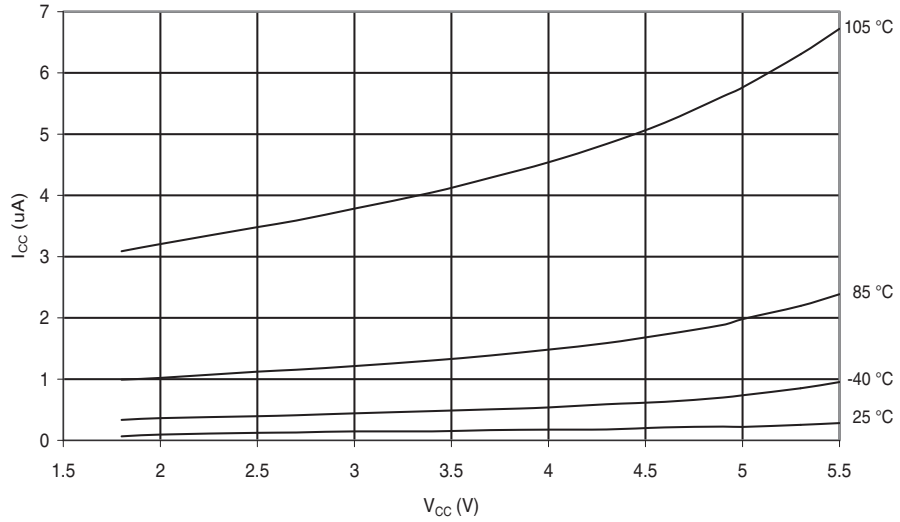
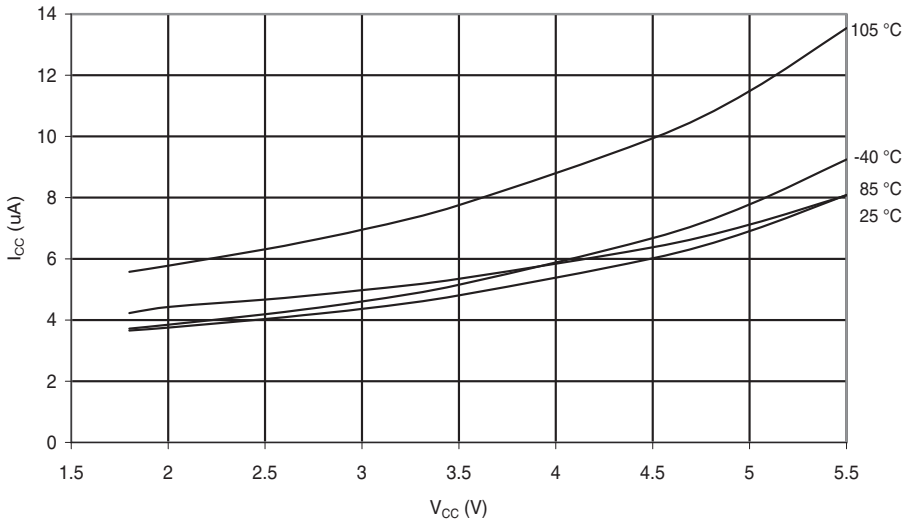


Figure 2-90. ATmega644P: Power-down Supply Current vs. V_{CC} (Watchdog Timer Enabled).



2.3.4 Pin Pull-up

Figure 2-91. ATmega644P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 1.8V).

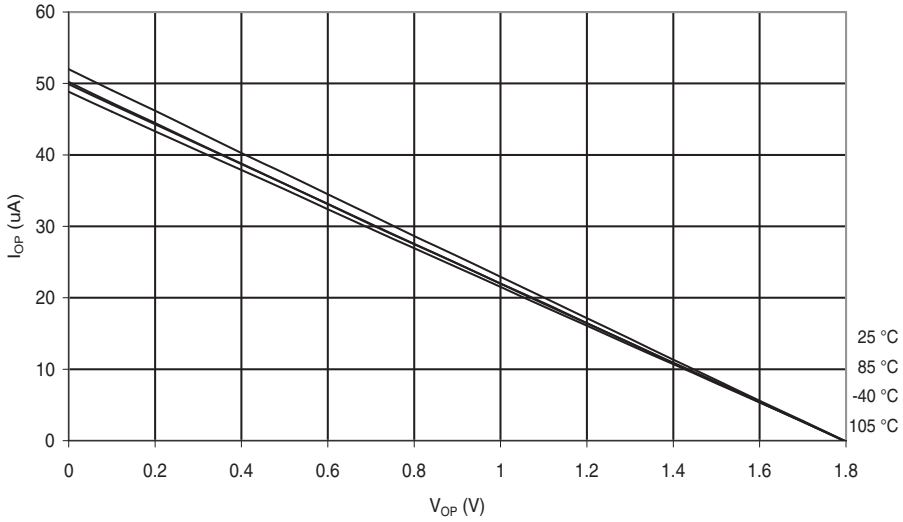


Figure 2-92. ATmega644P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 2.7V).

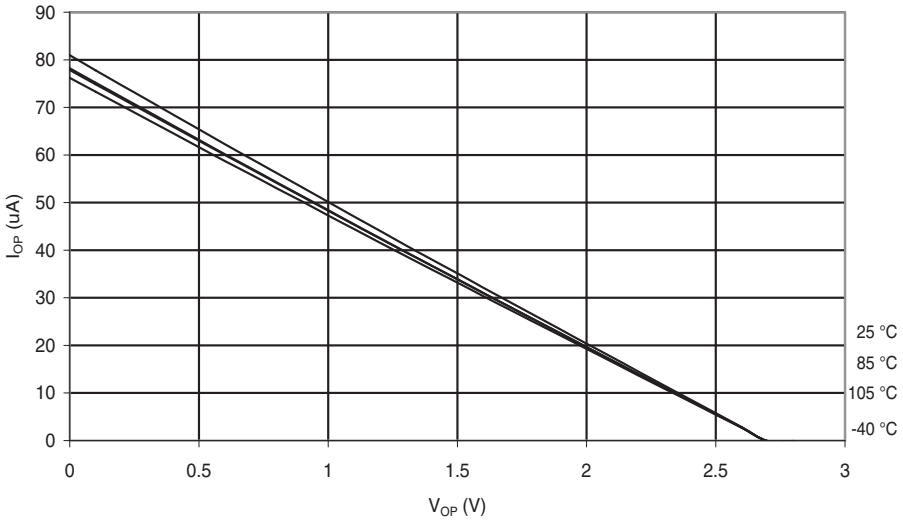


Figure 2-93. ATmega644P: I/O Pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 5V).

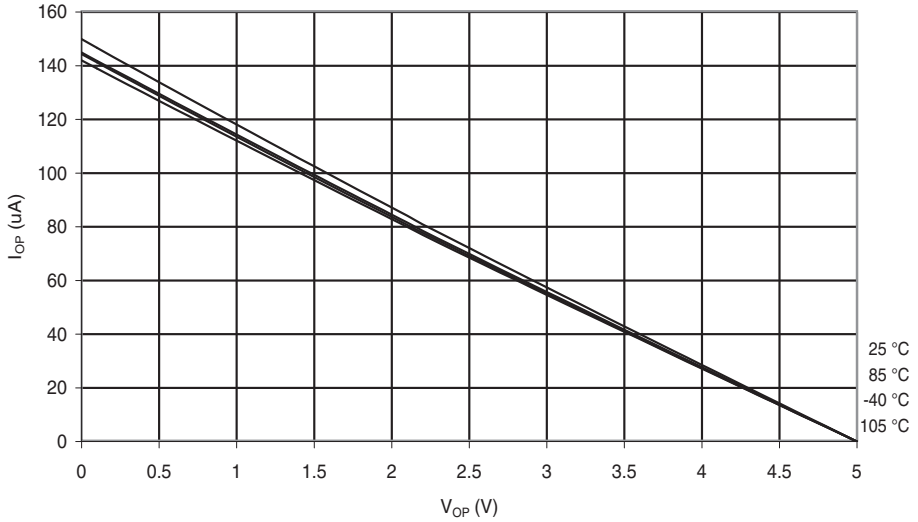


Figure 2-94. ATmega644P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 1.8V).

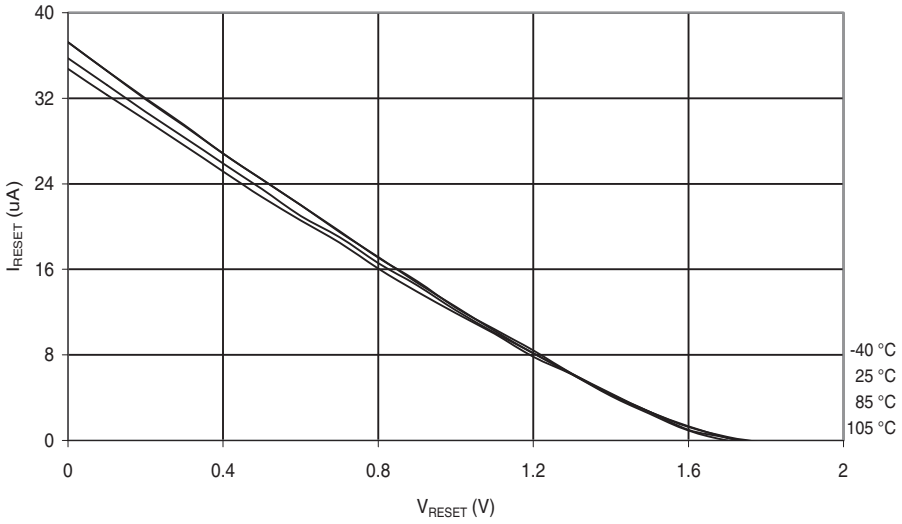


Figure 2-95. ATmega644P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 2.7V).

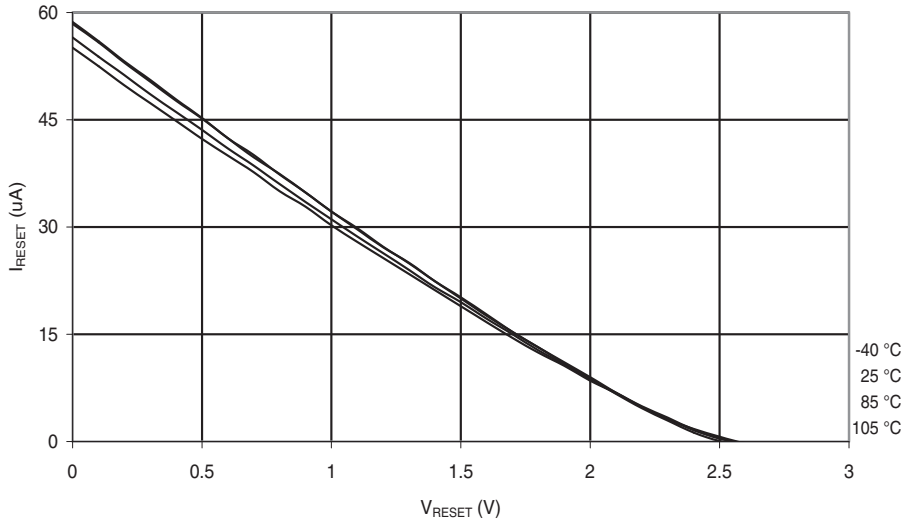
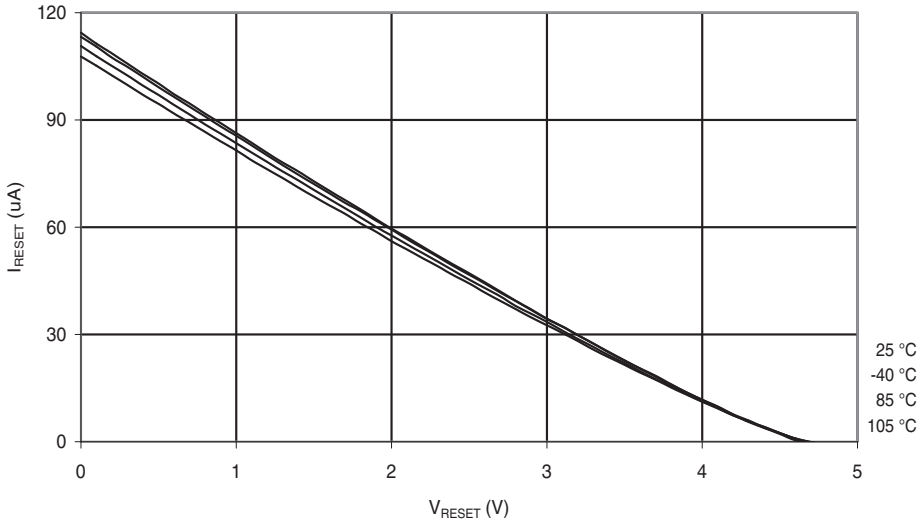


Figure 2-96. ATmega644P: Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 5V).



2.3.5 Pin Driver Strength

Figure 2-97. ATmega644P: I/O Pin Output Voltage vs. Sink Current (V_{CC} = 3V).

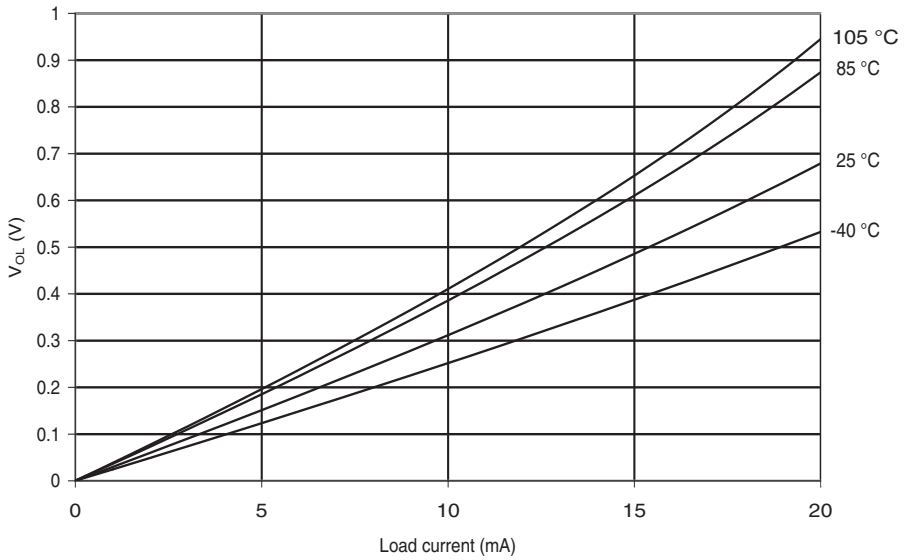


Figure 2-98. ATmega644P: I/O Pin Output Voltage vs. Sink Current (V_{CC} = 5V).

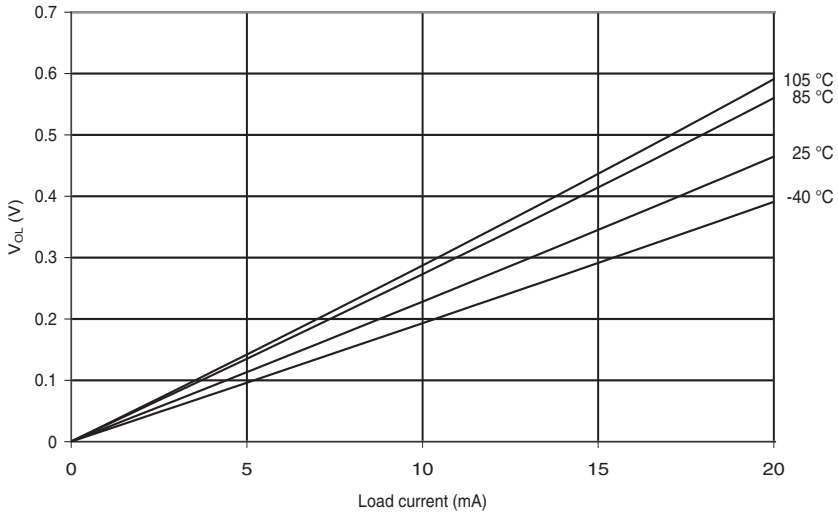


Figure 2-99. ATmega644P: I/O Pin Output Voltage vs. Source Current (V_{CC} = 3V).

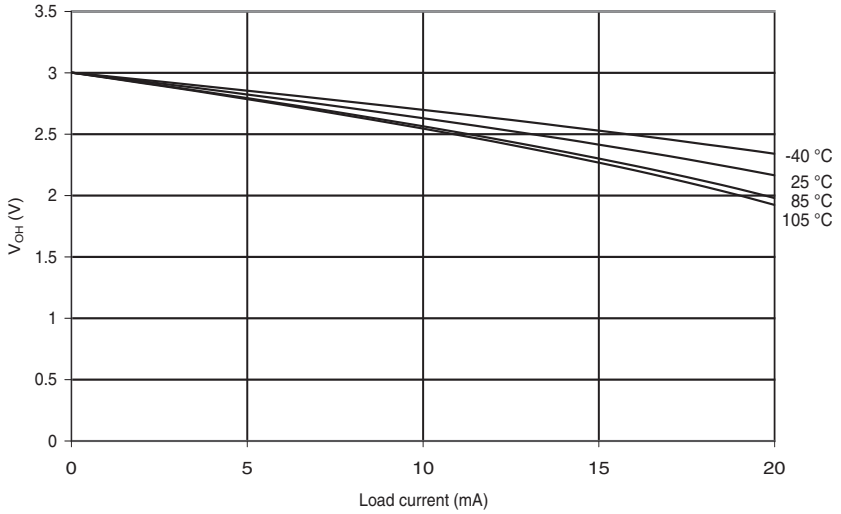
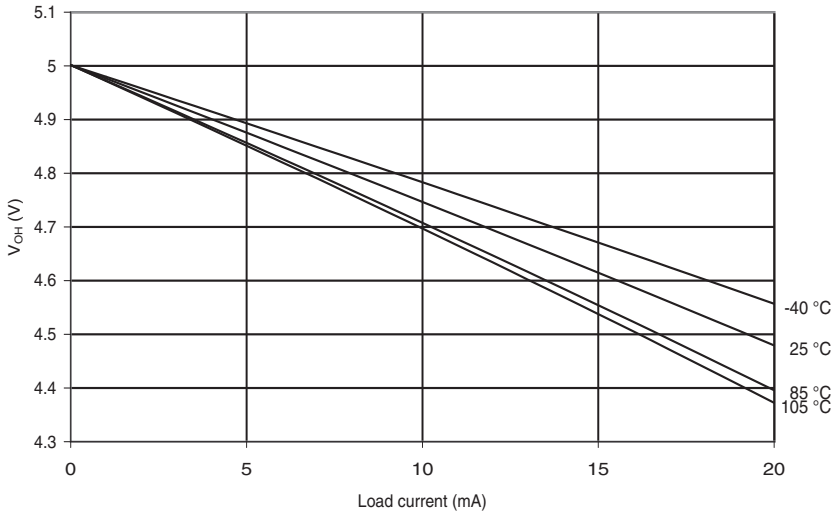


Figure 2-100. ATmega644P: I/O Pin Output Voltage vs. Source Current (V_{CC} = 5V).



2.3.6 Pin Threshold and Hysteresis

Figure 2-101. ATmega644P: I/O Pin Input Threshold vs. V_{CC} (V_{IH} , I/O Pin Read as '1').

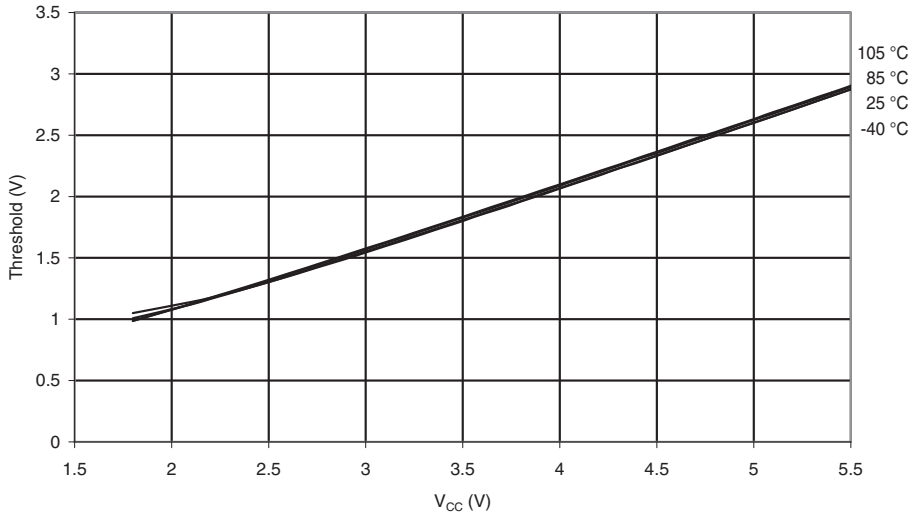


Figure 2-102. ATmega644P: I/O Pin Input Threshold vs. V_{CC} (V_{IL}, I/O Pin Read as '0').

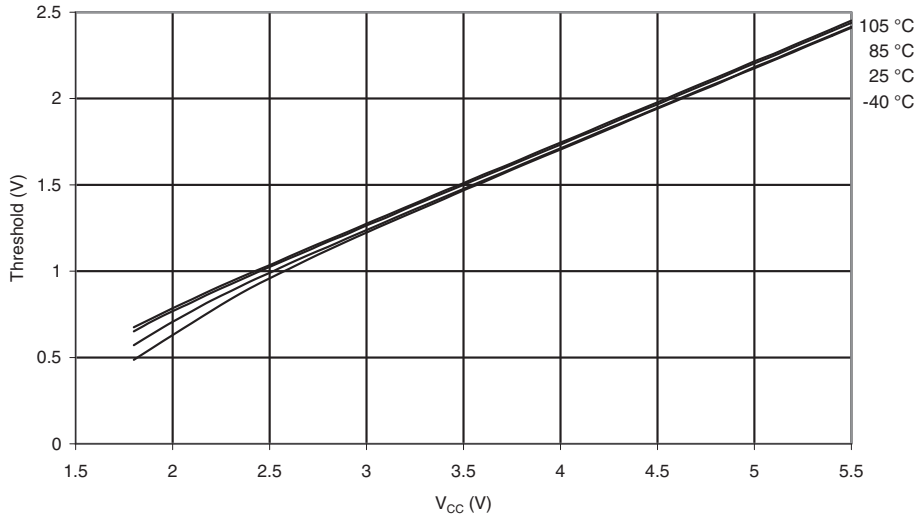


Figure 2-103. ATmega644P: I/O Pin Input Hysteresis vs. V_{CC}

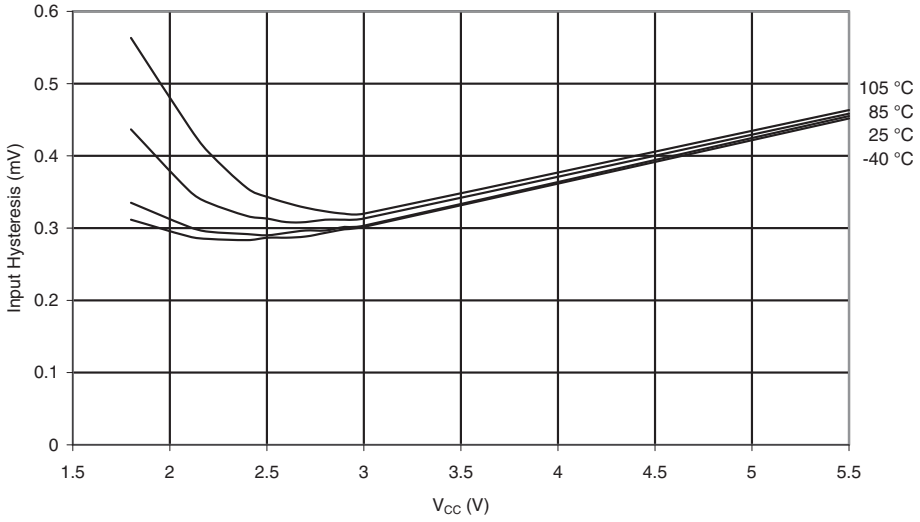


Figure 2-104. ATmega644P: Reset Pin Input Threshold vs. V_{CC} (V_{IH} , I/O Pin Read as '1').

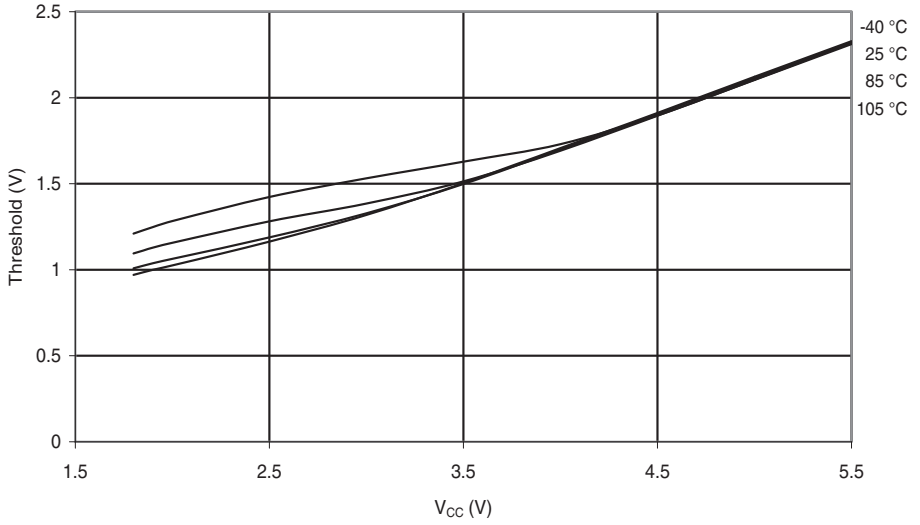


Figure 2-105. ATmega644P: Reset Pin Input Threshold vs. V_{CC} (V_{IL}, I/O Pin Read as '0').

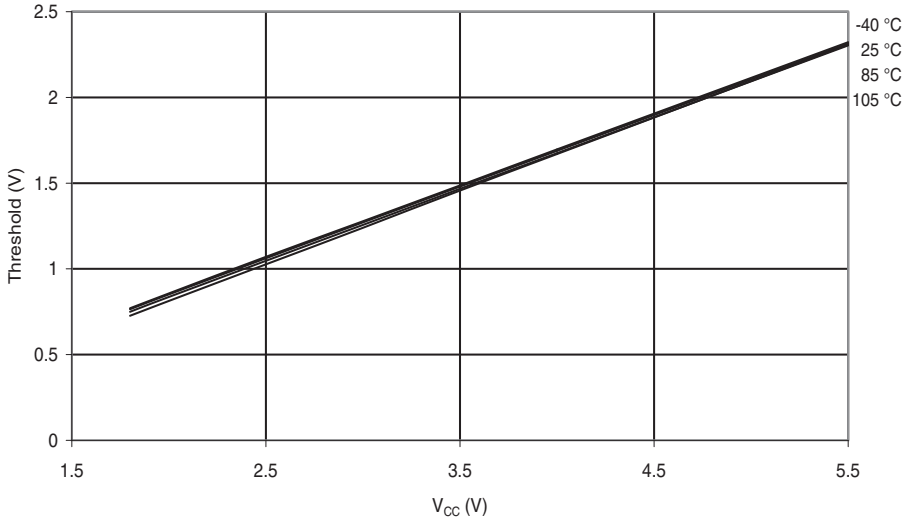
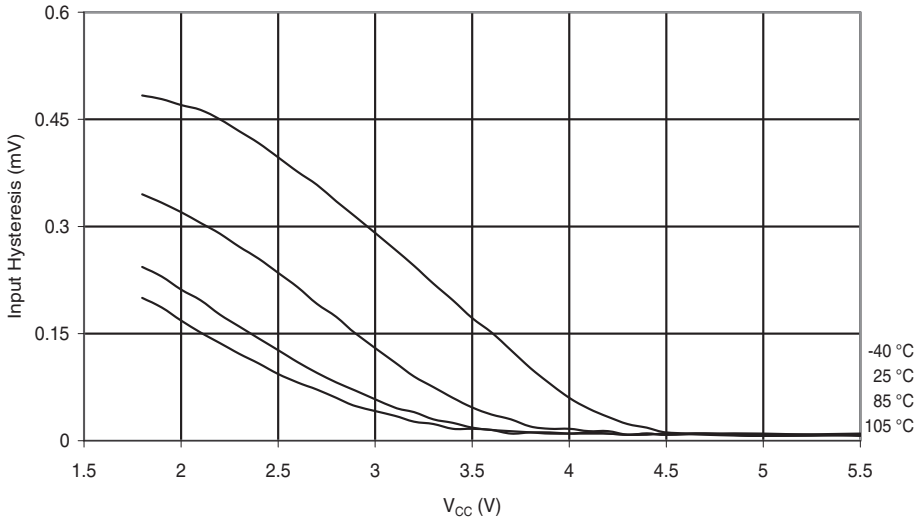


Figure 2-106. ATmega644P: Reset Pin Input Hysteresis vs. V_{CC}



2.3.7 BOD Threshold

Figure 2-107. ATmega644P: BOD Threshold vs. Temperature (V_{CC} = 4.3V)

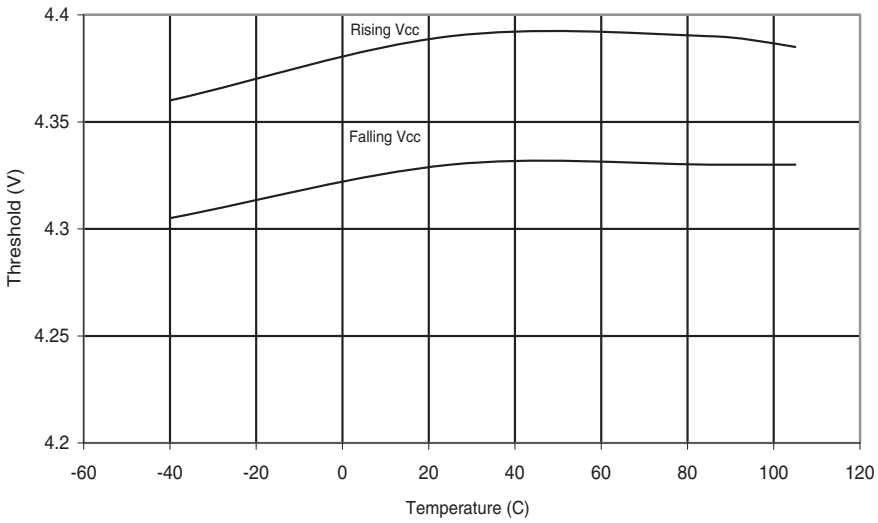


Figure 2-108. ATmega644P: BOD Threshold vs. Temperature (V_{CC} = 2.7V)

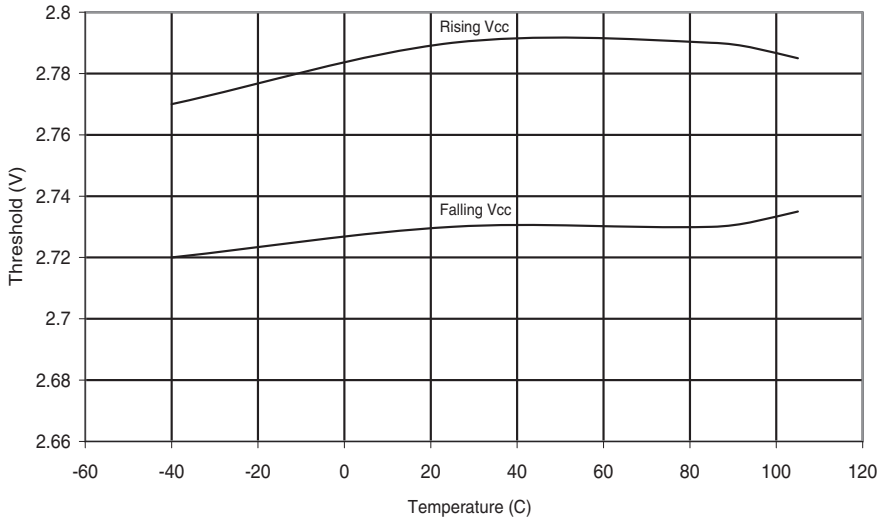
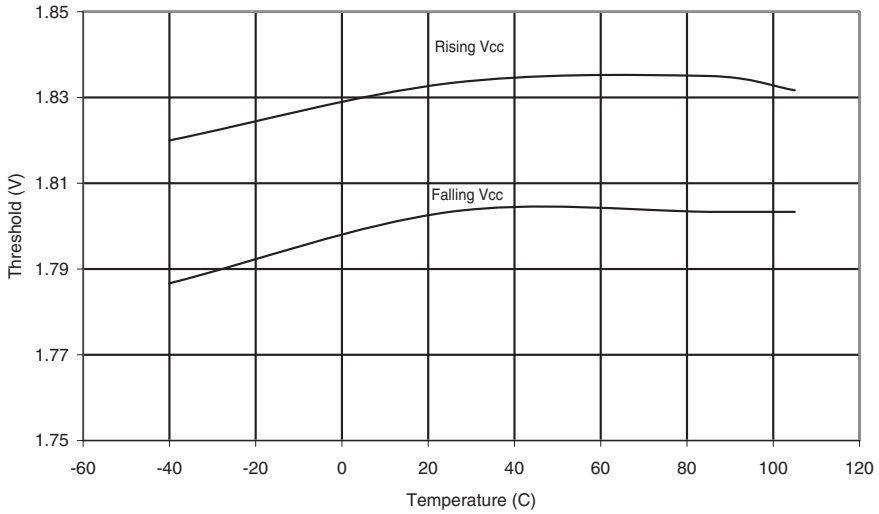


Figure 2-109. ATmega644P: BOD Threshold vs. Temperature (V_{CC} = 1.8V)



2.3.8 Internal Oscillator Speed

Figure 2-110. ATmega644P: Watchdog Oscillator Frequency vs. Temperature

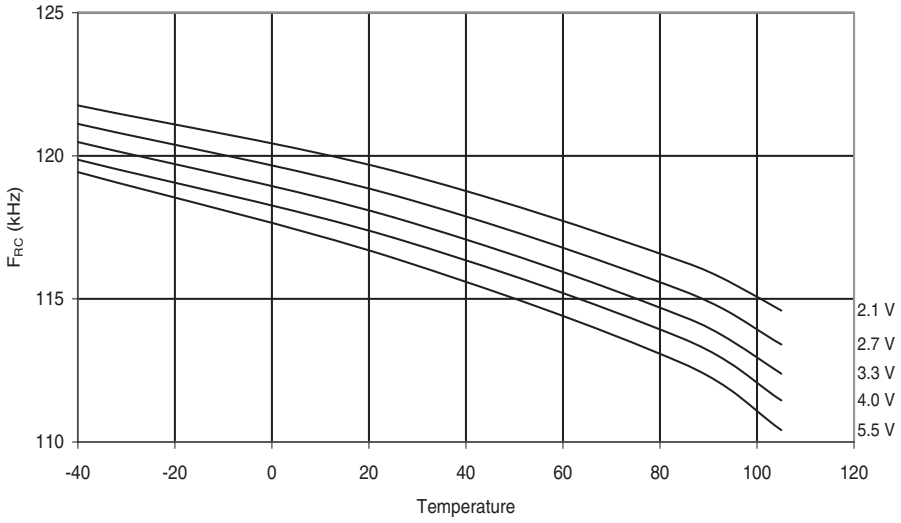


Figure 2-111. ATmega644P: Watchdog Oscillator Frequency vs. V_{CC}

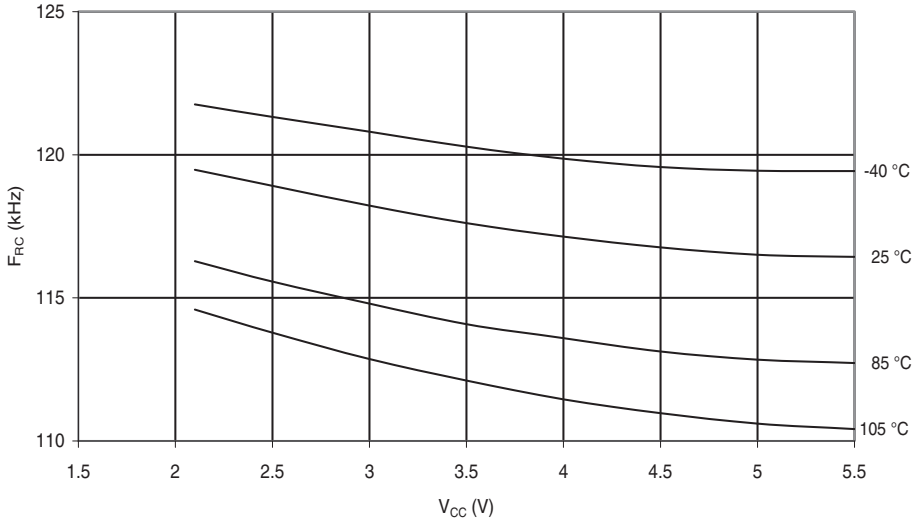


Figure 2-112. ATmega644P: Calibrated 8 MHz RC Oscillator vs. V_{CC}

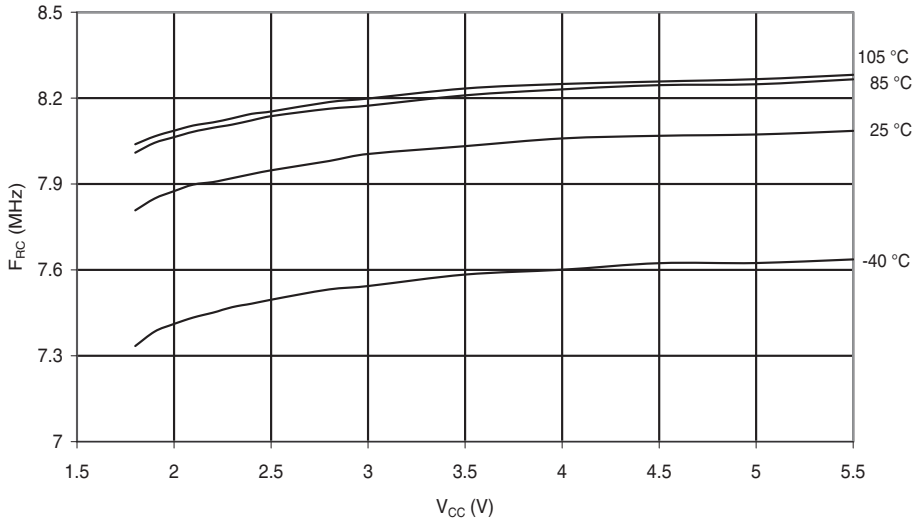


Figure 2-113. ATmega644P: Calibrated 8 MHz RC Oscillator vs. Temperature

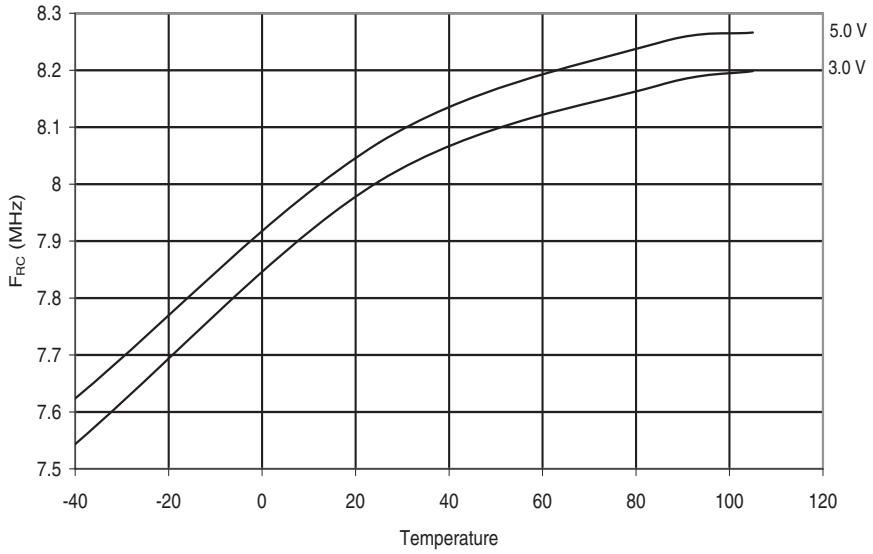
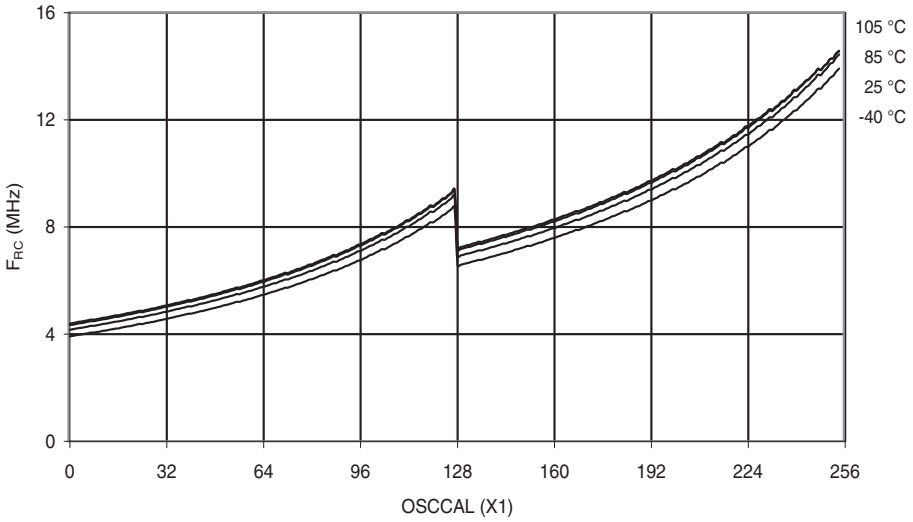


Figure 2-114. ATmega644P: Calibrated 8 MHz RC Oscillator vs. OSCCAL Value



2.3.9 Current Consumption of Peripheral Units

Figure 2-115. ATmega644P: ADC Current vs. V_{CC} ($AREF = AV_{CC}$)

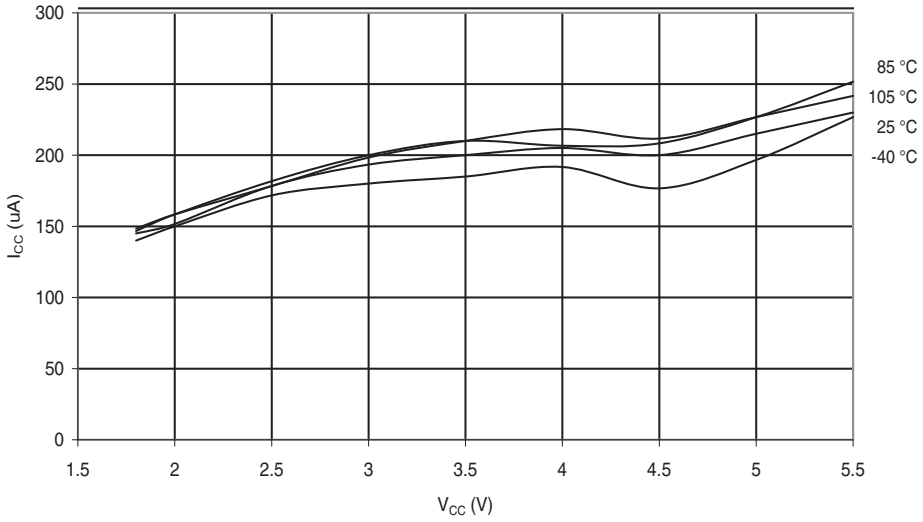


Figure 2-116. ATmega644P: Analog Comparator Current vs. V_{CC}

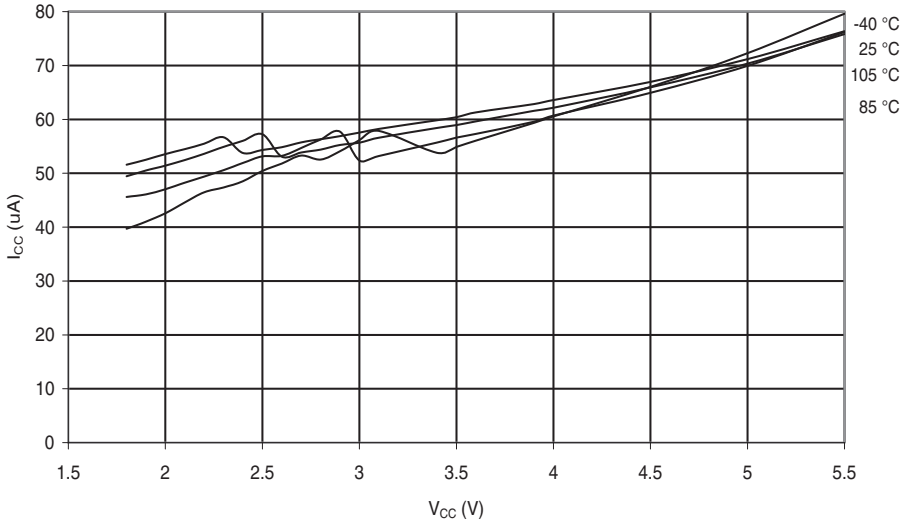


Figure 2-117. ATmega644P: AREF External Reference Current vs. V_{CC}

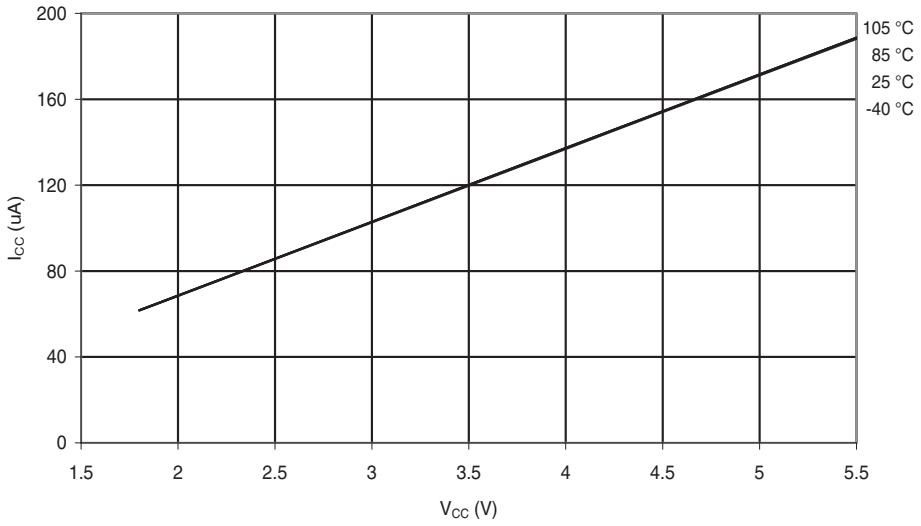


Figure 2-118. ATmega644P: Brownout Detector Current vs. V_{CC}

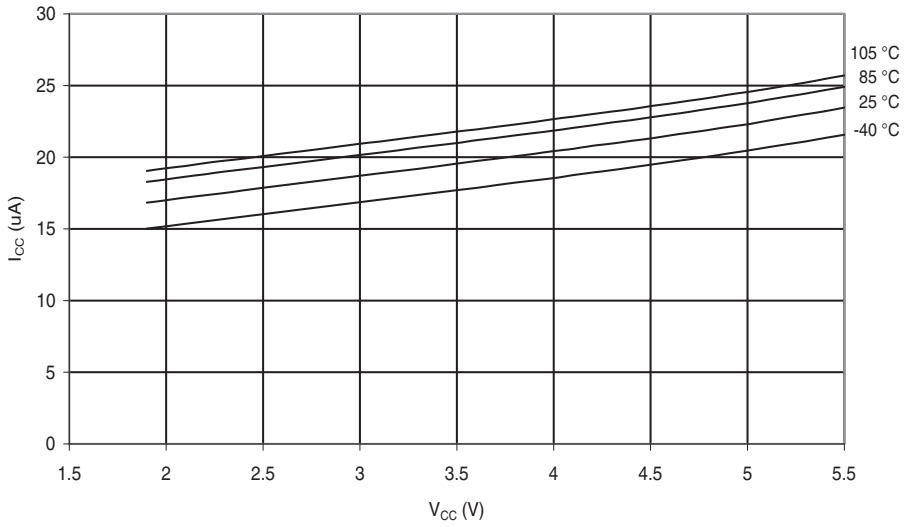


Figure 2-119. ATmega644P: Programming Current vs. V_{CC}

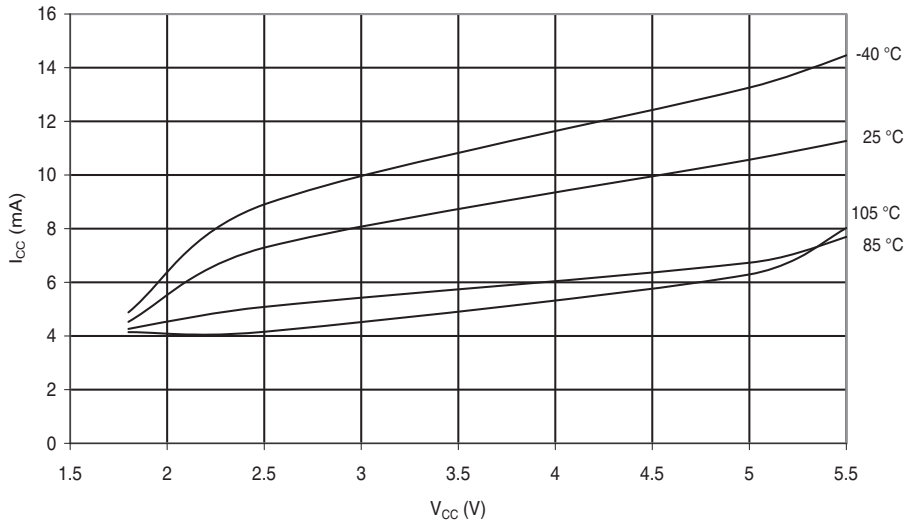
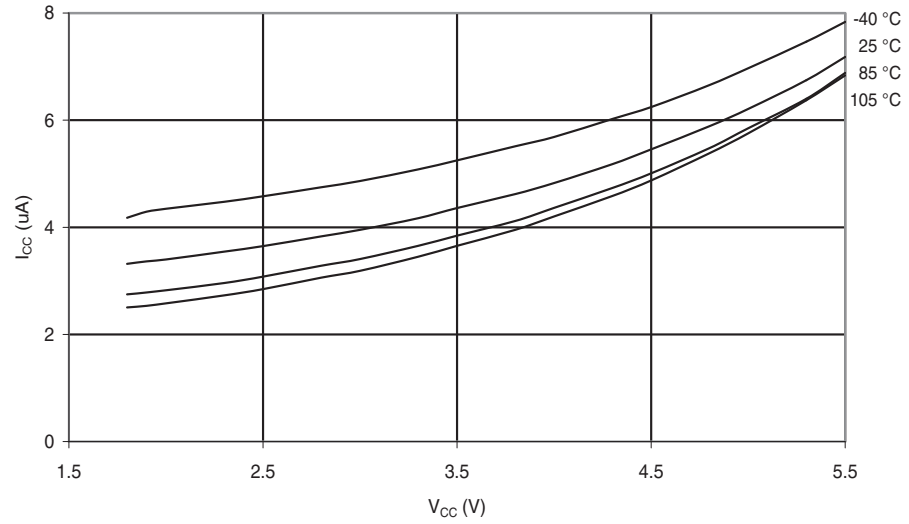


Figure 2-120. ATmega644P: Watchdog Timer Current vs. V_{CC}



2.3.10 Current Consumption in Reset and Reset Pulsewidth

Figure 2-121. ATmega644P: Minimum Reset Pulse Width vs. Vcc

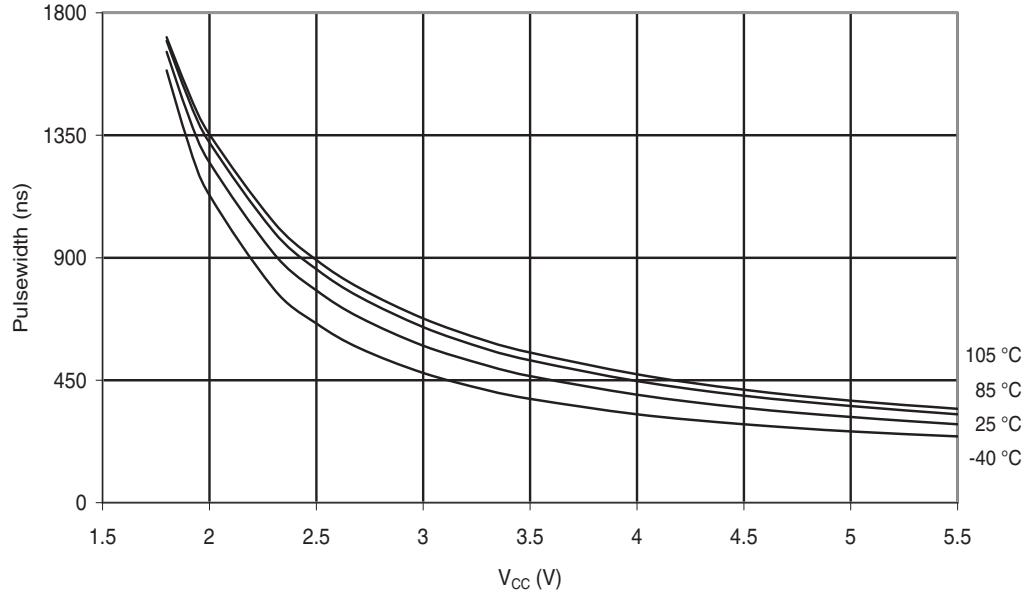


Figure 2-122. ATmega644P: Reset Supply Current vs Vcc 0.1-1.0MHz

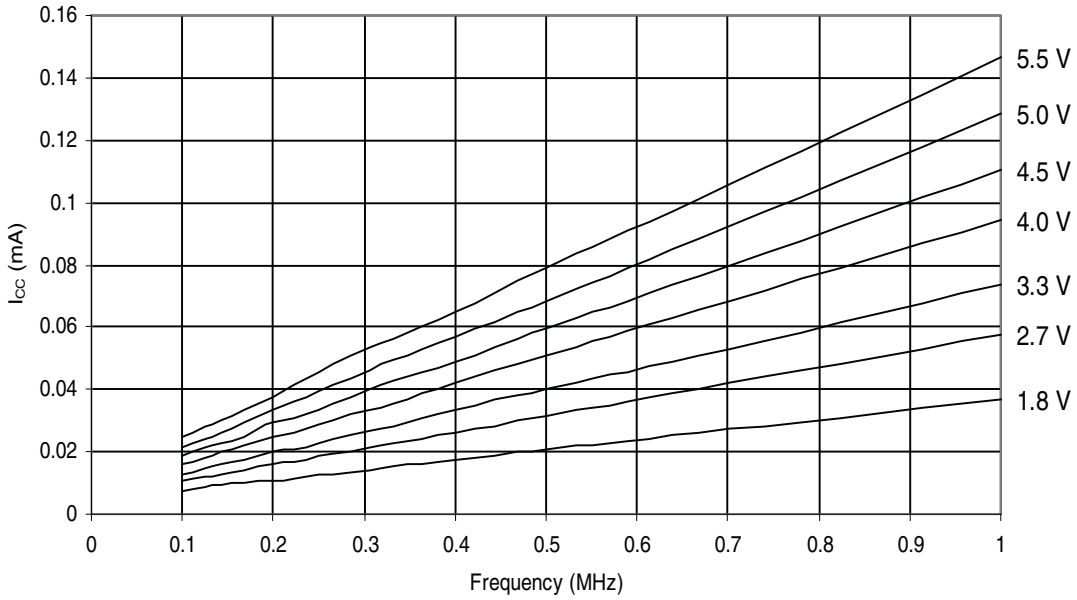
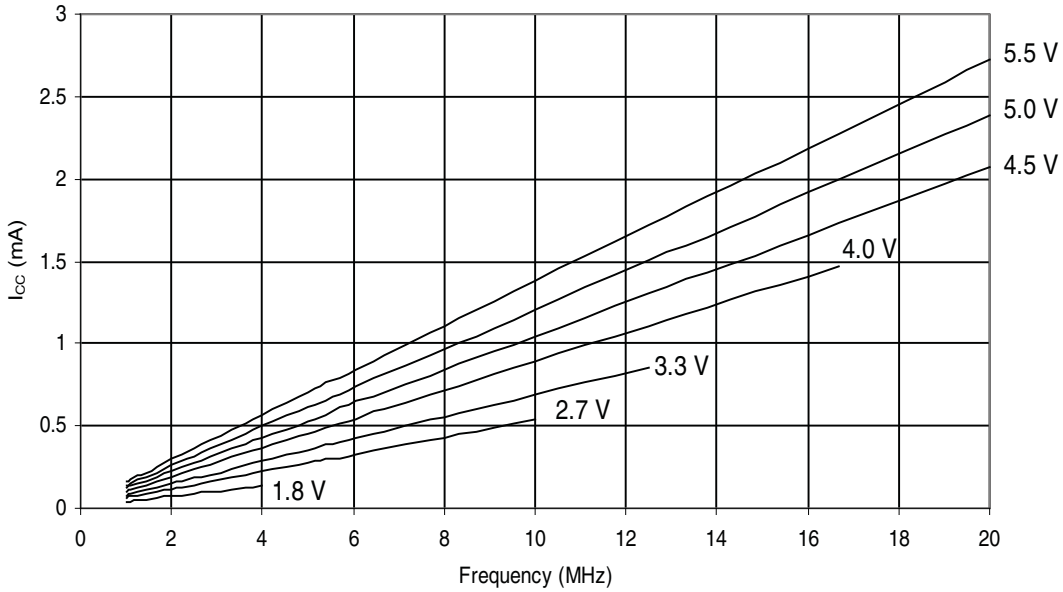


Figure 2-123. ATmega644P: Reset Supply Current vs Vcc 1-20MHz



3. Ordering Information

3.1 ATmega164P

Speed[1] (MHz)	Power Supply	Ordering Code[2]	Package	Operational Range
10	1.8 - 5.5V	ATmega164PV-10AQ ATmega164PV-10AQR[3] ATmega164PV-10PQ	44A 44A 40P6	Extended (-40°C to 105°C)
20	2.7 - 5.5V	ATmega164P-20AQ ATmega164P-20AQR[3] ATmega164P-20PQ ATmega164P-20MQ ATmega164P-20MQR[3]	44A 44A 40P6 44M1 44M1	

Notes:
1. For Speed Grades, see complete datasheets.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Tape & Reel

Package Type	
44A	44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600” Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 x 7 x 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

3.2 ATmega324P

Speed[1] (MHz)	Power Supply	Ordering Code[2]	Package	Operational Range
10	1.8 - 5.5V	ATmega324PV-10AQ	44A	Extended (-40°C to 105°C)
		ATmega324PV-10AQR[3]	44A	
		ATmega324PV-10PQ	40P6	
		ATmega324PV-10MQR[3]	44M1	
		ATmega324PV-10MQR[3]	44M1	
20	2.7 - 5.5V	ATmega324P-20AQ	44A	
		ATmega324P-20AQR[3]	44A	
		ATmega324P-20PQ	40P6	
		ATmega324P-20MQ	44M1	
		ATmega324P-20MQR[3]	44M1	

Notes:
1. For Speed Grades, see complete datasheets.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Tape & Reel

Package Type	
44A	44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600” Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 x 7 x 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

3.3 ATmega644P

Speed[1] (MHz)	Power Supply	Ordering Code[2]	Package	Operational Range
10	1.8 - 5.5V	ATmega644PV-10AQ	44A	Extended (-40°C to 105°C)
		ATmega644PV-10AQR[3]	44A	
		ATmega644PV-10PQ	40P6	
		ATmega644PV-10MQR[3]	44M1	
		ATmega644PV-10MQR[3]	44M1	
20	2.7 - 5.5V	ATmega644P-20AQ	44A	
		ATmega644P-20AQR[3]	44A	
		ATmega644P-20PQ	40P6	
		ATmega644P-20MQ	44M1	
		ATmega644P-20MQR[3]	44M1	

Notes: 1. For Speed Grades, see complete datasheets.
2. Pb-free packaging, complies to the European Directive for Restriction of Hazardous Substances (RoHS directive). Also Halide free and fully Green.
3. Tape & Reel

Package Type	
44A	44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP)
40P6	40-pin, 0.600” Wide, Plastic Dual Inline Package (PDIP)
44M1	44-pad, 7 x 7 x 1.0 mm body, lead pitch 0.50 mm, Quad Flat No-Lead/Micro Lead Frame Package (QFN/MLF)

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