Appendix A – ATtiny4/5/9/10 Specification at 125°C

This document contains information specific to devices operating at temperatures up to 125°C. Only deviations are covered in this appendix, all other information can be found in the complete datasheet. The complete datasheet can be found at www.atmel.com.

8-bit AVR® Microcontroller with 512/1024 Bytes In-System Programmable Flash

ATtiny4/5/9/10

Appendix A

Rev. 8127D–Appendix A–AVR–02/10

1. Electrical Characteristics

1.1 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.

1.2 DC Characteristics

Table 1-1. DC Characteristics. T_A = -40°C to +125°C

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
V_{IL}	Input Low Voltage	V_{CC} = 1.8V - 2.4V V_{CC} = 2.4V - 5.5V	-0.5		$0.2V_{CC}$ $0.3V_{CC}$	V
V_{IH}	Input High-voltage Except $\overline{\text{RESET}}$ pin	V_{CC} = 1.8V - 2.4V V_{CC} = 2.4V - 5.5V	$0.7V_{CC}$(1) $0.6V_{CC}$(1)		V_{CC} +0.5(2)	V
	Input High-voltage $\overline{\text{RESET}}$ pin	V_{CC} = 1.8V to 5.5V	$0.9V_{CC}$(1)		V_{CC} +0.5(2)	V
V_{OL}	Output Low Voltage(3) Except $\overline{\text{RESET}}$ pin(5)	I_{OL} = 10 mA, V_{CC} = 5V I_{OL} = 5 mA, V_{CC} = 3V			0.7 0.6	V
V_{OH}	Output High-voltage(4) Except $\overline{\text{RESET}}$ pin(5)	I_{OH} = -10 mA, V_{CC} = 5V I_{OH} = -5 mA, V_{CC} = 3V	4.2 2.4			V
I_{LIL}	Input Leakage Current I/O Pin	Vcc = 5.5V, pin low (absolute value)		<0.05	2	µA
I_{LIH}	Input Leakage Current I/O Pin	Vcc = 5.5V, pin high (absolute value)		<0.05	2	µA
R_{RST}	Reset Pull-up Resistor	Vcc = 5.5V, input low	30		60	kΩ
R_{PU}	I/O Pin Pull-up Resistor	Vcc = 5.5V, input low	20		50	kΩ

Table 1-1. DC Characteristics. T_A = -40°C to +125°C (Continued)

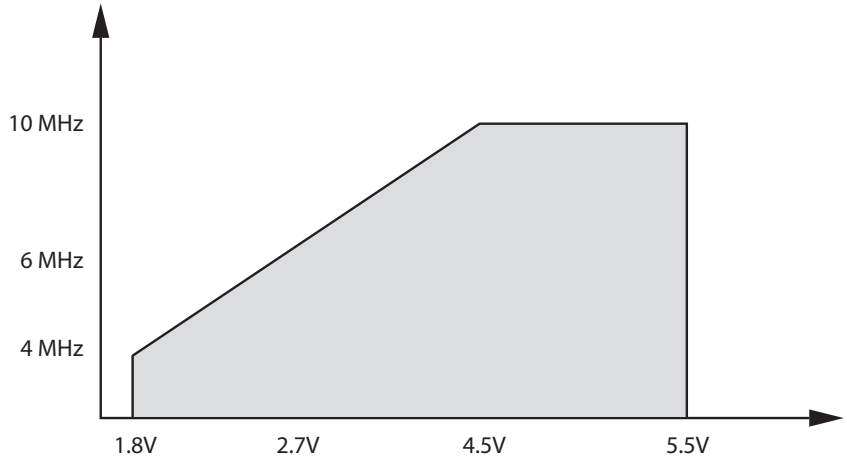
Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
I_{CC}	Power Supply Current[6]	Active 1MHz, V_{CC} = 2V		0.2	0.5	mA
		Active 4MHz, V_{CC} = 3V		0.8	1.5	mA
		Active 8MHz, V_{CC} = 5V		2.7	5	mA
		Idle 1MHz, V_{CC} = 2V		0.02	0.2	mA
		Idle 4MHz, V_{CC} = 3V		0.13	0.5	mA
		Idle 8MHz, V_{CC} = 5V		0.6	1.5	mA
	Power-down mode[7]	WDT enabled, V_{CC} = 3V		4.5	20	µA
		WDT disabled, V_{CC} = 3V		0.15	10	µA

Notes:
1. "Min" means the lowest value where the pin is guaranteed to be read as high.
2. "Max" means the highest value where the pin is guaranteed to be read as low.
3. Although each I/O port can sink more than the test conditions (10 mA at V_{CC} = 5V, 5 mA at V_{CC} = 3V) under steady state conditions (non-transient), the sum of all I_{OL} (for all ports) should not exceed 60 mA. If I_{OL} exceeds the test conditions, V_{OL} 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 (10 mA at V_{CC} = 5V, 5 mA at V_{CC} = 3V) under steady state conditions (non-transient), the sum of all I_{OH} (for all ports) should not exceed 60 mA. If I_{OH} exceeds the test condition, V_{OH} may exceed the related specification. Pins are not guaranteed to source current greater than the listed test condition.
5. The $\overline{\text{RESET}}$ pin must tolerate high voltages when entering and operating in programming modes and, as a consequence, has a weak drive strength as compared to regular I/O pins.
6. Values are with external clock. Power Reduction is enabled (PRR = 0xFF) and there is no I/O drive.
7. BOD Disabled.

1.3 Speed

The maximum operating frequency of the device depends on V_{CC} . As shown in Figure 1-1, the relationship between maximum frequency vs. V_{CC} is linear between 1.8V < V_{CC} < 4.5V.

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



1.4 Clock Characteristics

1.4.1 Accuracy of Calibrated Internal Oscillator

It is possible to manually calibrate the internal oscillator to be more accurate than default factory calibration. Note that the oscillator frequency depends on temperature and voltage. Voltage and temperature characteristics can be found in Figure 2-32 on page 24 and Figure 2-33 on page 24.

Table 1-2. Calibration Accuracy of Internal RC Oscillator

Calibration Method	Target Frequency	V_{CC}	Temperature	Accuracy at given Voltage & Temperature[1]
Factory Calibration	8.0 MHz	3V	25°C	±10%
User Calibration	Fixed frequency within: 7.3 – 8.1 MHz	Fixed voltage within: 1.8V – 5.5V	Fixed temp. within: -40°C – 125°C	±1%

Note: 1. Accuracy of oscillator frequency at calibration point (fixed temperature and fixed voltage).

1.4.2 External Clock Drive

Figure 1-2. External Clock Drive Waveform

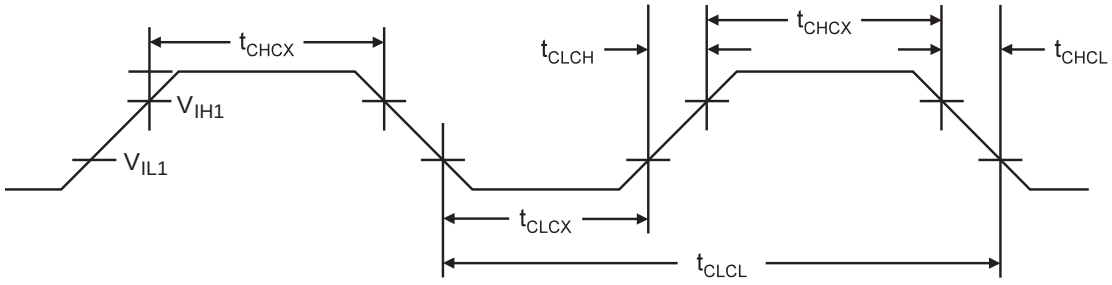


Table 1-3. External Clock Drive Characteristics

Symbol	Parameter	V_{CC} = 1.8 - 5.5V		V_{CC} = 2.7 - 5.5V		V_{CC} = 4.5 - 5.5V		Units
		Min.	Max.	Min.	Max.	Min.	Max.	
$1/t_{CLCL}$	Clock Frequency	0	4	0	8	0	10	MHz
t_{CLCL}	Clock Period	250		125		100		ns
t_{CHCX}	High Time	100		50		33		ns
t_{CLCX}	Low Time	100		50		33		ns
t_{CLCH}	Rise Time		2.0		1		0.6	µs
t_{CHCL}	Fall Time		2.0		1		0.6	µs
Δt_{CLCL}	Change in period from one clock cycle to the next		2		2		2	%

1.5 System and Reset Characteristics

Table 1-4. Reset and Internal Voltage Characteristics

Symbol	Parameter	Condition	Min(1)	Typ(1)	Max(1)	Units
V_{RST}	$\overline{\text{RESET}}$ Pin Threshold Voltage		0.2 V_{CC}		0.9V_{CC}	V
t_{RST}	Minimum pulse width on $\overline{\text{RESET}}$ Pin	V_{CC} = 1.8V V_{CC} = 3V V_{CC} = 5V		2000 700 400		ns
t_{TOUT}	Time-out after reset			64	128	ms

Note: 1. Values are guidelines, only

1.5.1 Power-On Reset

Table 1-5. Characteristics of Enhanced Power-On Reset. T_A = -40 - 125°C

Symbol	Parameter	Min(1)	Typ(1)	Max(1)	Units
V_{POR}	Release threshold of power-on reset (2)	1.1	1.4	1.7	V
V_{POA}	Activation threshold of power-on reset (3)	0.6	1.3	1.7	V
SR_{ON}	Power-On Slope Rate	0.01			V/ms

Notes: 1. Values are guidelines, only
2. Threshold where device is released from reset when voltage is rising
3. The Power-on Reset will not work unless the supply voltage has been below V_{POT} (falling)

1.5.2 V_{CC} Level Monitor

Table 1-6. Voltage Level Monitor Thresholds

Parameter	Min	Typ(1)	Max	Units
Trigger level VLM1L	1.1	1.4	1.7	V
Trigger level VLM1H	1.4	1.6	1.9	
Trigger level VLM2	2.0	2.5	2.7	
Trigger level VLM3	3.0	3.7	4.5	
Settling time VMLM2,VLM3 (VLM1H,VLM1L)		5 (50)		µs

Note: 1. Typical values at room temperature

1.6 Analog Comparator Characteristics

Table 1-7. Analog Comparator Characteristics, T_A = -40°C - 125°C

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{AIO}	Input Offset Voltage	V_{CC} = 5V, V_{IN} = V_{CC} / 2		< 10	40	mV
I_{LAC}	Input Leakage Current	V_{CC} = 5V, V_{IN} = V_{CC} / 2	-0.5		0.5	µA
t_{APD}	Analog Propagation Delay (from saturation to slight overdrive)	V_{CC} = 2.7V		750		ns
		V_{CC} = 4.0V		500		
	Analog Propagation Delay (large step change)	V_{CC} = 2.7V		100		
		V_{CC} = 4.0V		75		
t_{DPD}	Digital Propagation Delay	V_{CC} = 1.8V - 5.5		1	2	CLK

Note: All parameters are based on simulation results. None are tested in production

1.7 ADC Characteristics (ATtiny5/10, only)

Table 1-8. ADC Characteristics. T = -40°C – 125°C. V_{CC} = 2.5V – 5.5V

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Resolution				8	Bits
	Absolute accuracy (Including INL, DNL, and Quantization, Gain and Offset Errors)	V_{REF} = V_{CC} = 4V, ADC clock = 200 kHz		1.0		LSB
		V_{REF} = V_{CC} = 4V, ADC clock = 1 MHz		2.0		LSB
		V_{REF} = V_{CC} = 4V, ADC clock = 200 kHz Noise Reduction Mode		1.0		LSB
		V_{REF} = V_{CC} = 4V, ADC clock = 1 MHz Noise Reduction Mode		2.0		LSB
	Integral Non-Linearity (INL) (Accuracy after Offset and Gain Calibration)	V_{REF} = V_{CC} = 4V, ADC clock = 200 kHz		1.0		LSB
	Differential Non-linearity (DNL)	V_{REF} = V_{CC} = 4V, ADC clock = 200 kHz		0.5		LSB
	Gain Error	V_{REF} = V_{CC} = 4V, ADC clock = 200 kHz		1.0		LSB
	Offset Error	V_{REF} = V_{CC} = 4V, ADC clock = 200 kHz		1.0		LSB
	Conversion Time	Free Running Conversion	65		260	µs
	Clock Frequency		50		200	kHz
V_{IN}	Input Voltage		GND		V_{REF}	V
	Input Bandwidth			7.7		kHz
R_{AIN}	Analog Input Resistance			100		MΩ
	ADC Conversion Output		0		255	LSB

1.8 Serial Programming Characteristics

Figure 1-3. Serial Programming Timing

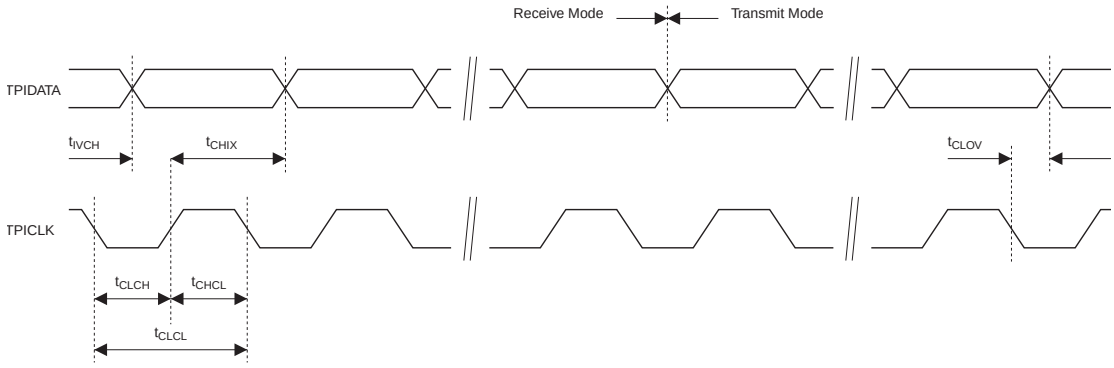


Table 1-9. Serial Programming Characteristics, T_A = -40°C to 125°C, V_{CC} = 5V (Unless Otherwise Noted)

Symbol	Parameter	Min	Typ	Max	Units
$1/t_{CLCL}$	Clock Frequency			2	MHz
t_{CLCL}	Clock Period	500			ns
t_{CLCH}	Clock Low Pulse Width	200			ns
t_{CHCH}	Clock High Pulse Width	200			ns
t_{IVCH}	Data Input to Clock High Setup Time	50			ns
t_{CHIX}	Data Input Hold Time After Clock High	100			ns
t_{CLOV}	Data Output Valid After Clock Low Time			200	ns

2. Typical Characteristics

The data contained in this section is largely based on simulations and characterization of similar devices in the same process and design methods. Thus, the data should be treated as indications of how the part will behave.

The following charts show typical behavior. These figures are not tested during manufacturing. During characterisation devices are operated at frequencies higher than test limits but they are not guaranteed to function properly at frequencies higher than the ordering code indicates.

All current consumption measurements are performed with all I/O pins configured as inputs and with internal pull-ups enabled. 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.

A sine wave generator with rail-to-rail output is used as clock source but current consumption in Power-Down mode is independent of clock selection. 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.

The current drawn from pins with a capacitive load may be estimated (for one pin) as follows:

$I_{CP} \approx V_{CC} \times C_L \times f_{SW}$

where V_{CC} = operating voltage, C_L = load capacitance and f_{SW} = average switching frequency of I/O pin.

2.1 Active Supply Current

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

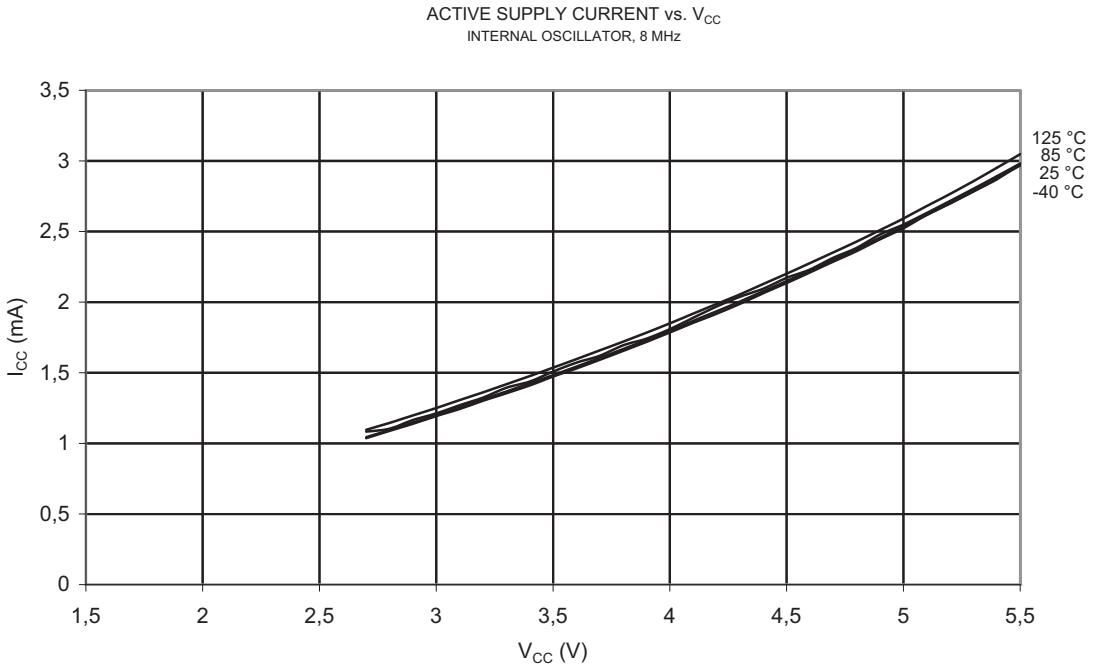


Figure 2-2. Active Supply Current vs. V_{CC} (Internal Oscillator, 1 MHz)

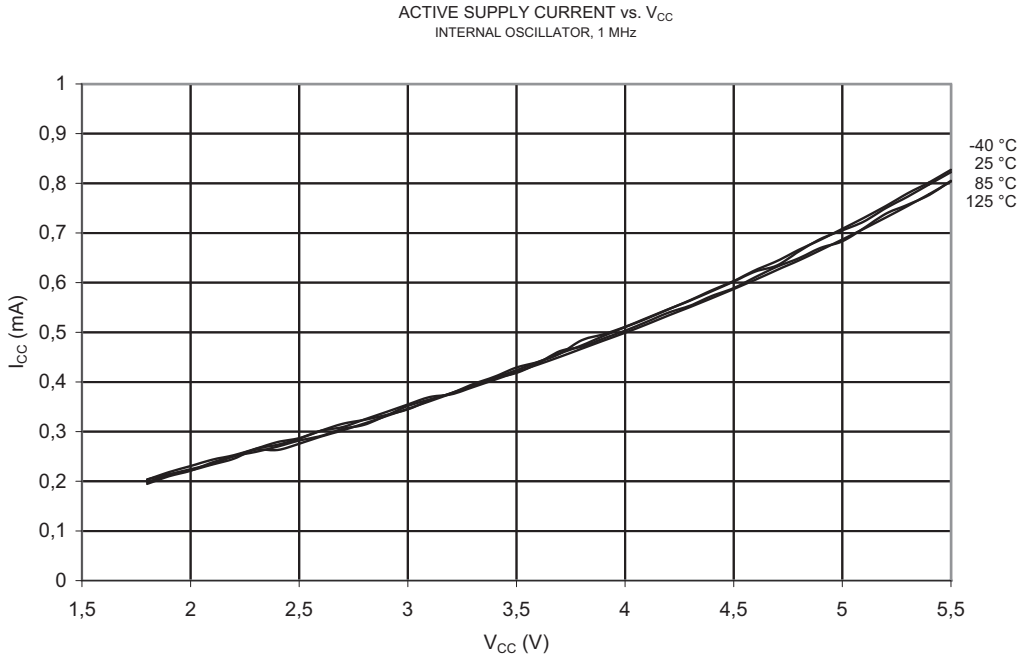


Figure 2-3. Active Supply Current vs. V_{CC} (Internal Oscillator, 128 kHz)

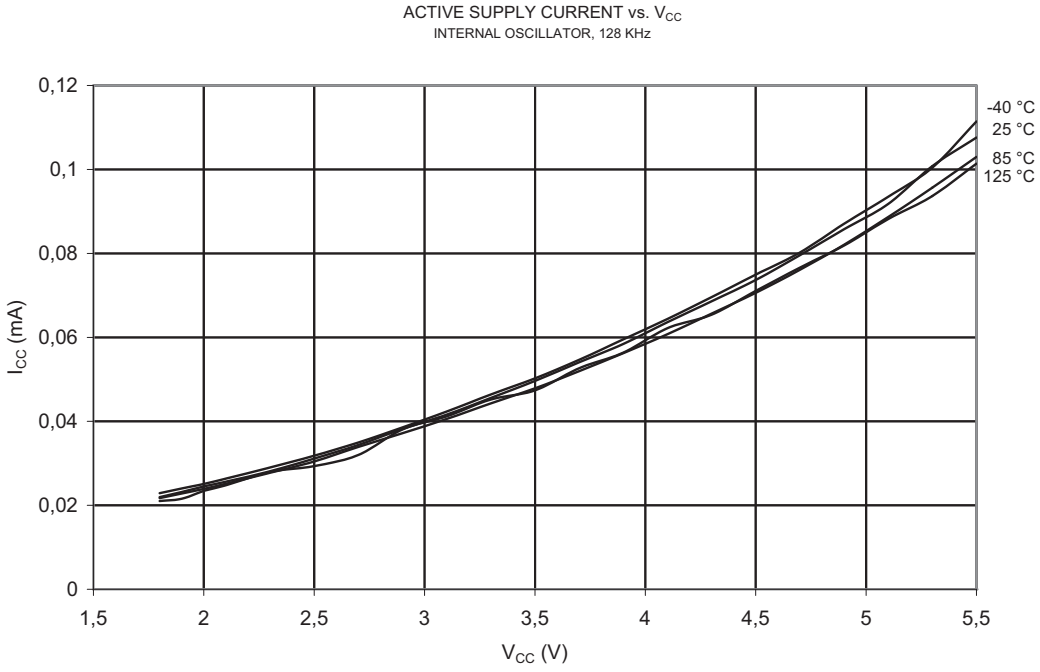
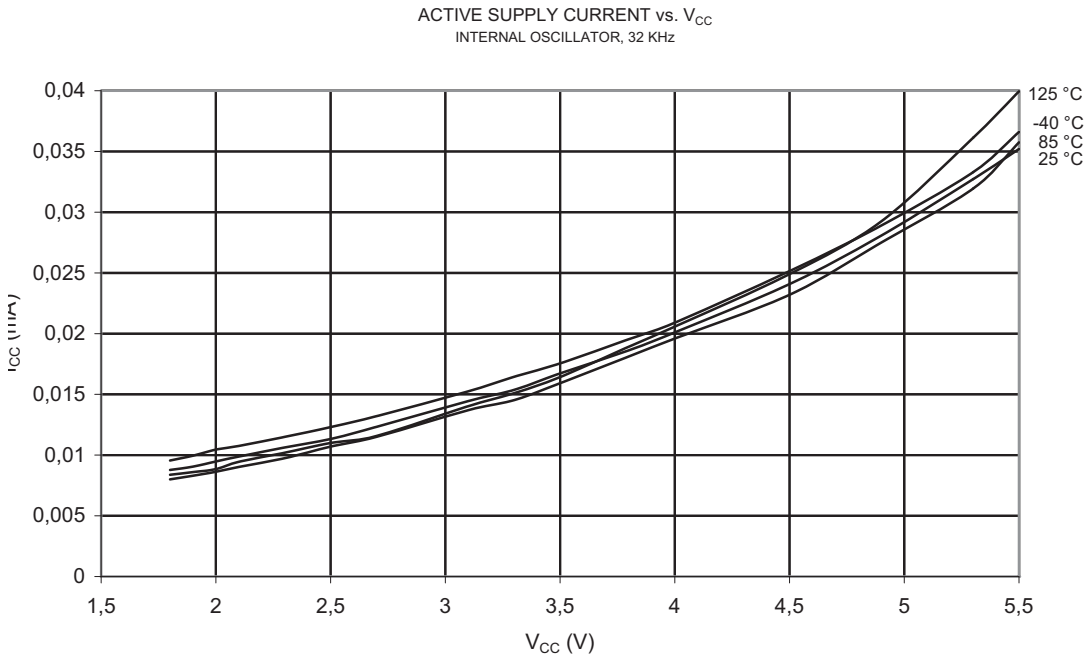


Figure 2-4. Active Supply Current vs. V_{CC} (External Clock, 32 kHz)



2.2 Idle Supply Current

Figure 2-5. Idle Supply Current vs. V_{CC} (Internal Oscillator, 8 MHz)

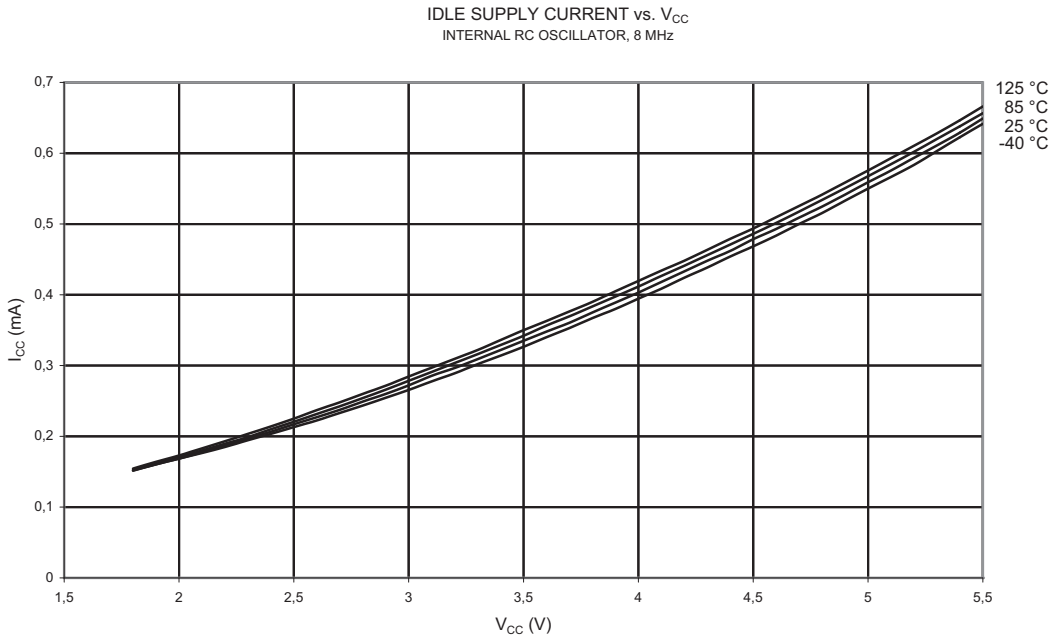
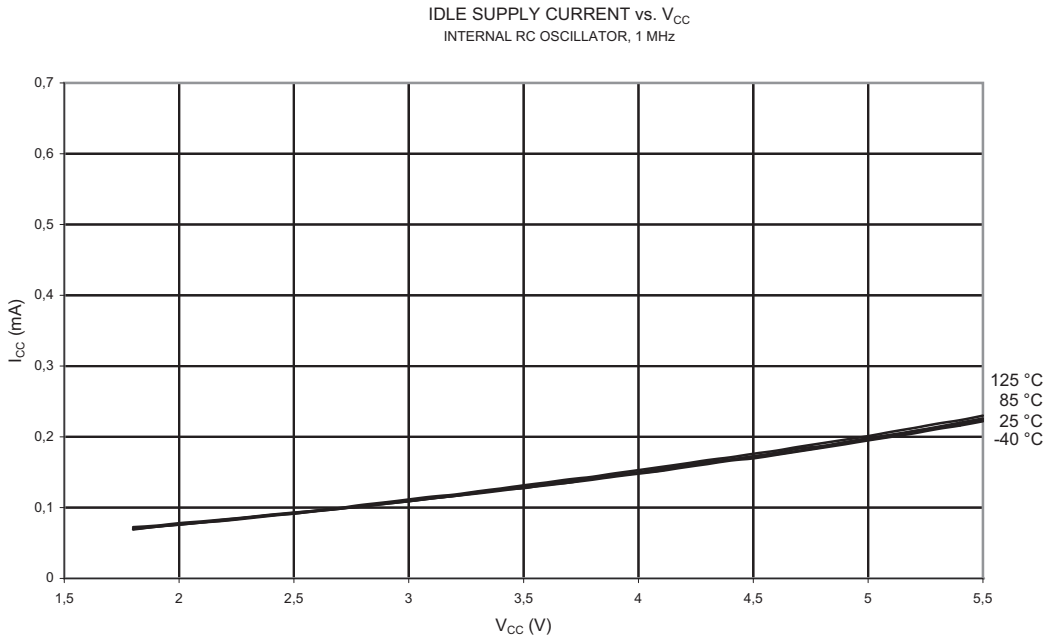


Figure 2-6. Idle Supply Current vs. V_{CC} (Internal Oscillator, 1 MHz)



2.3 Power-down Supply Current

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

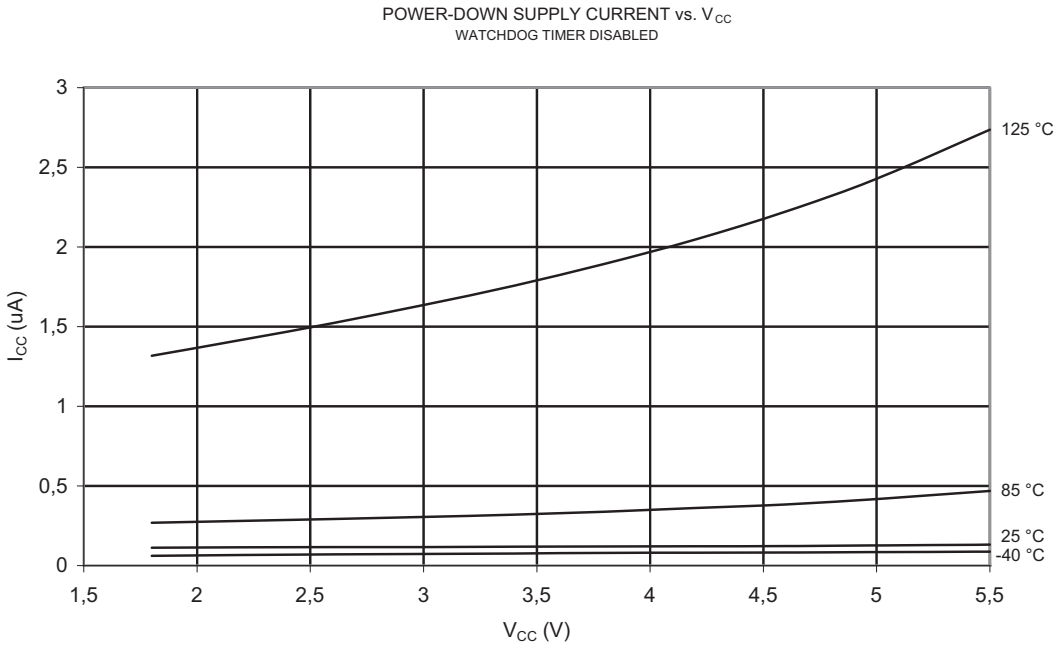
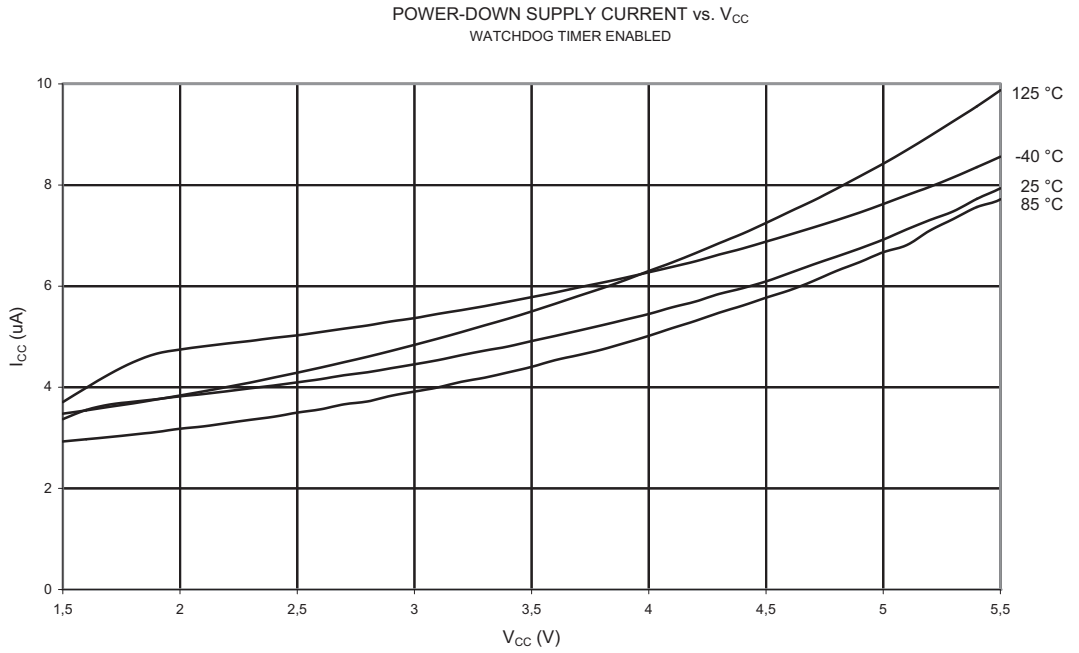


Figure 2-8. Power-down Supply Current vs. V_{CC} (Watchdog Timer Enabled)



2.4 Pin Pull-up

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

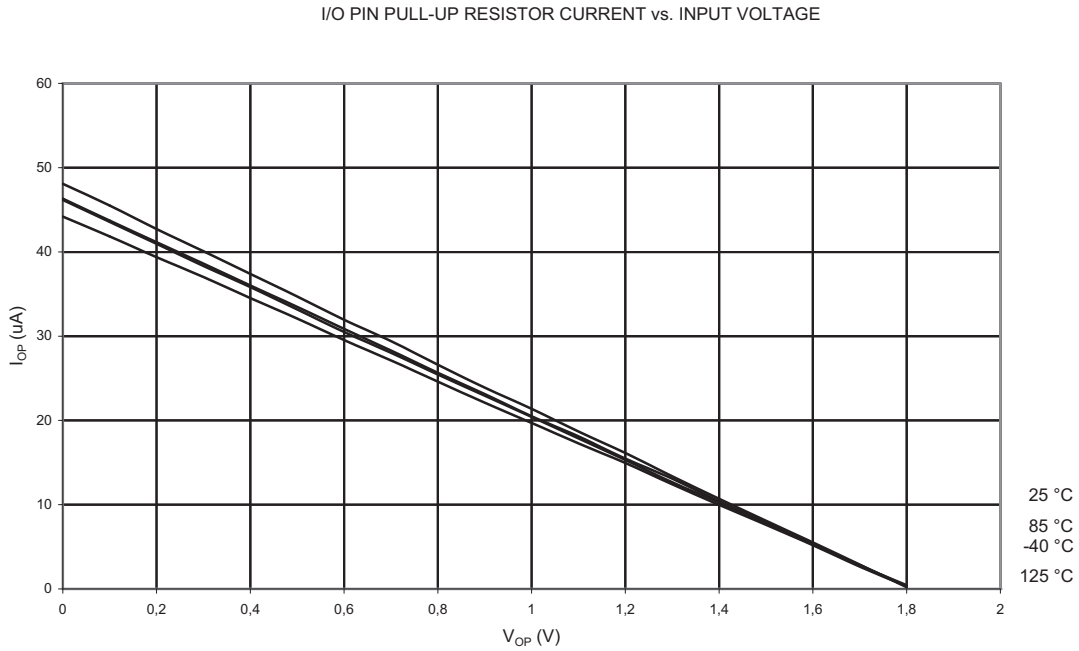


Figure 2-10. I/O Pin Pull-up Resistor Current vs. input Voltage (V_{CC} = 2.7V)

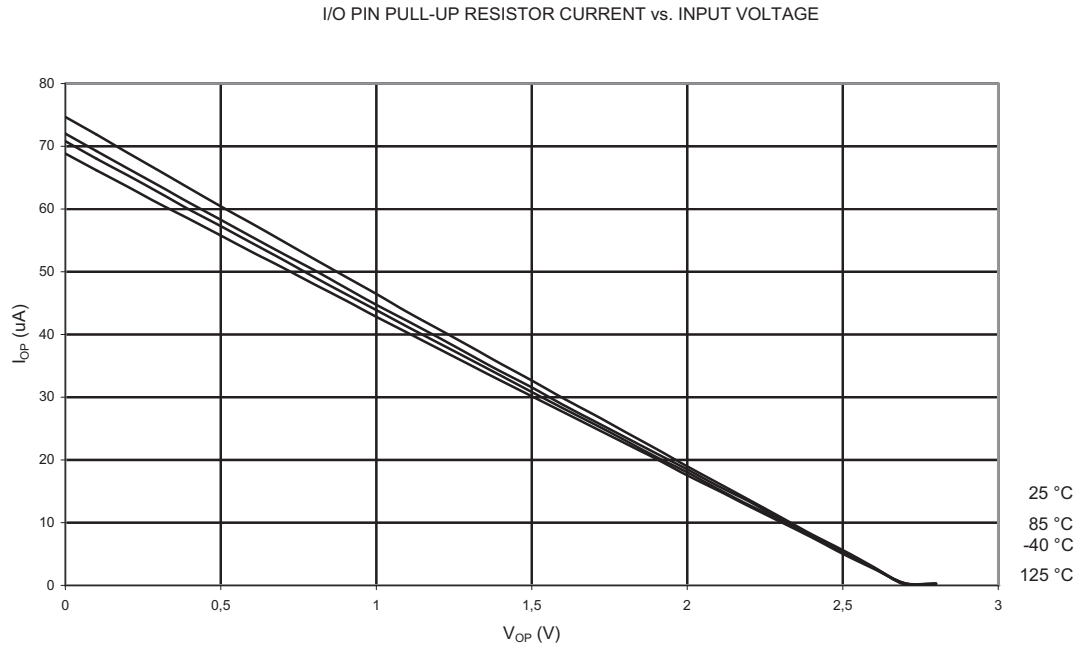


Figure 2-11. I/O pin Pull-up Resistor Current vs. Input Voltage (V_{CC} = 5V)

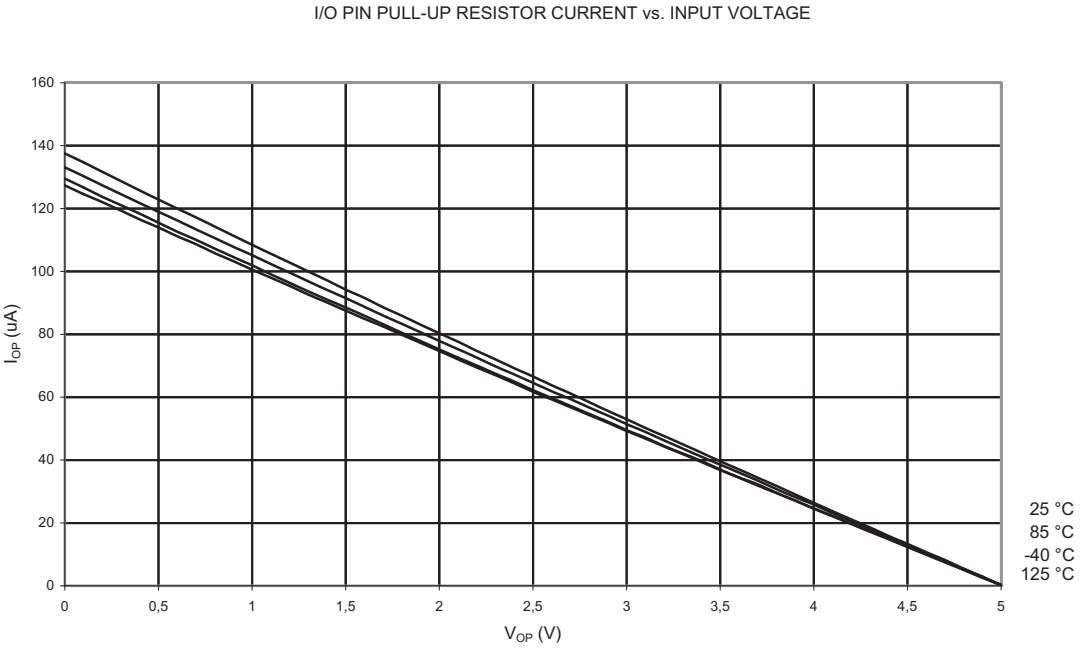


Figure 2-12. Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 1.8V)

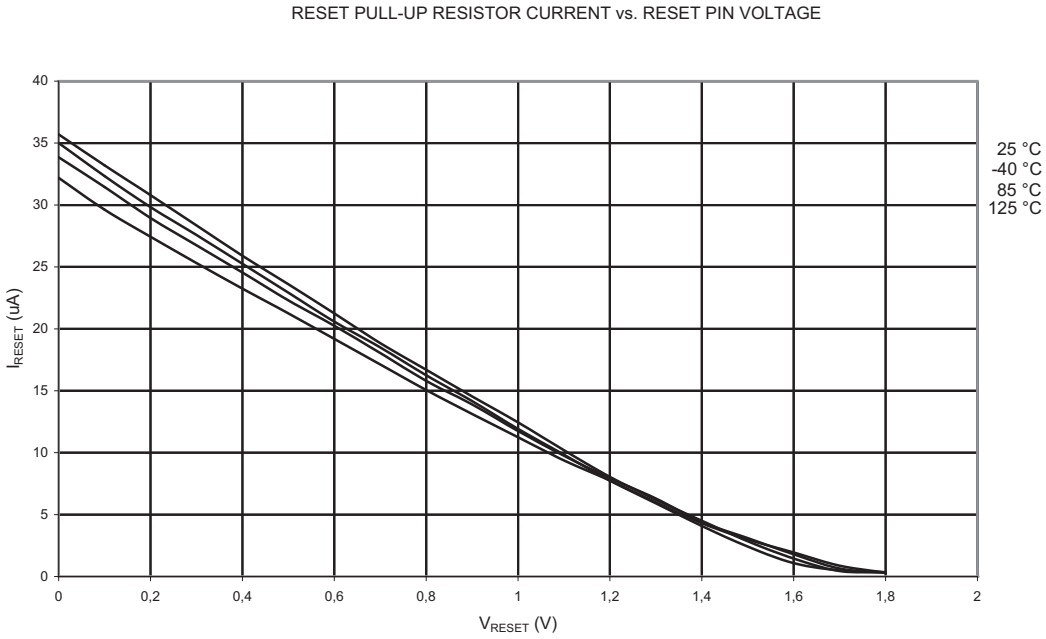


Figure 2-13. Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 2.7V)

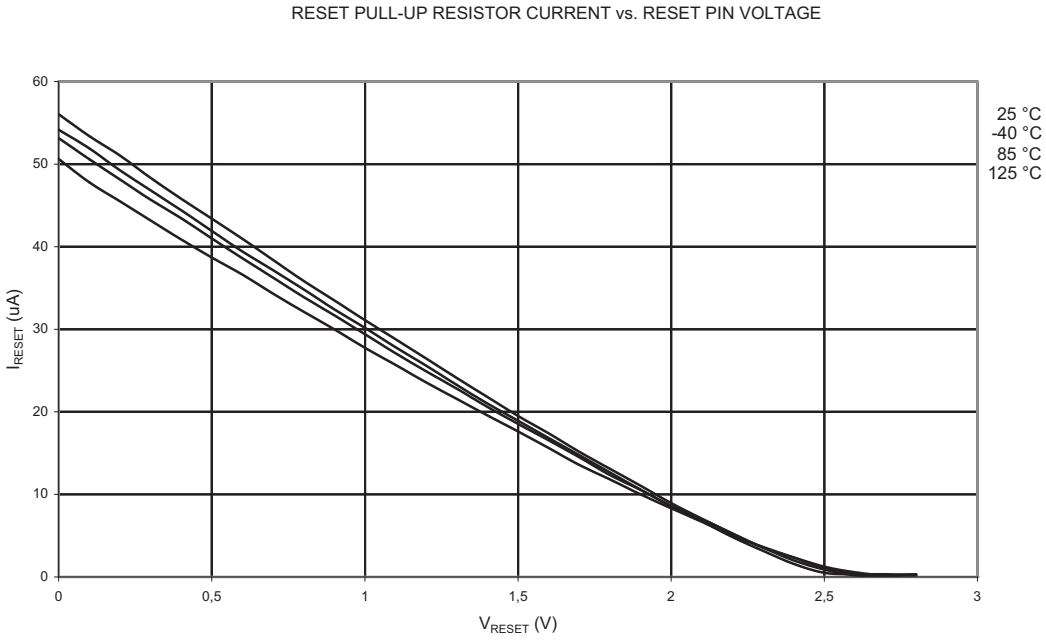
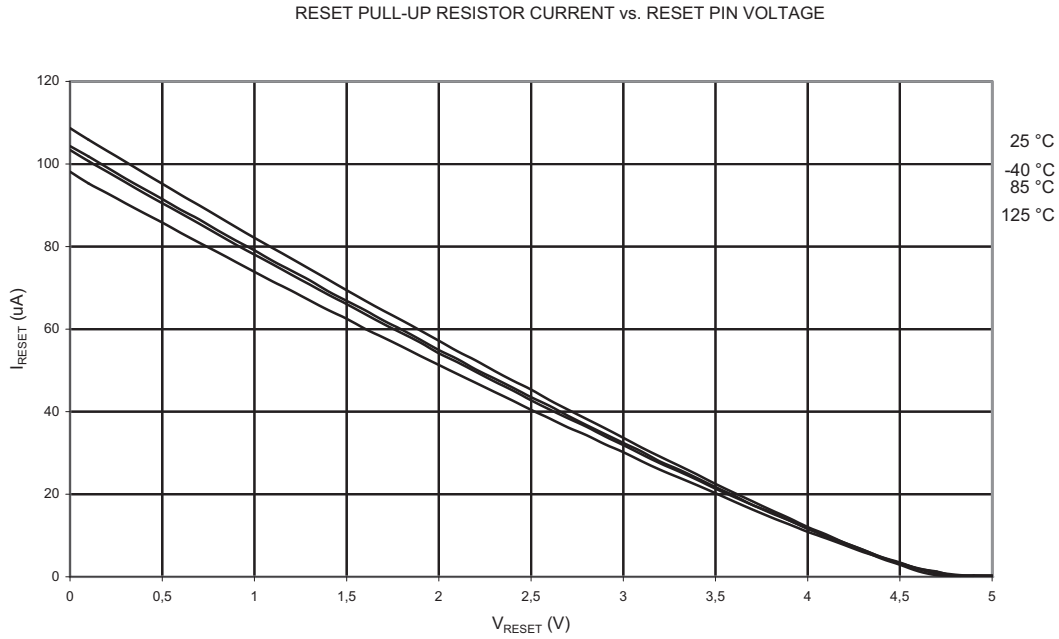


Figure 2-14. Reset Pull-up Resistor Current vs. Reset Pin Voltage (V_{CC} = 5V)



2.5 Pin Driver Strength

Figure 2-15. I/O Pin Output Voltage vs. Sink Current (V_{CC} = 1.8V)

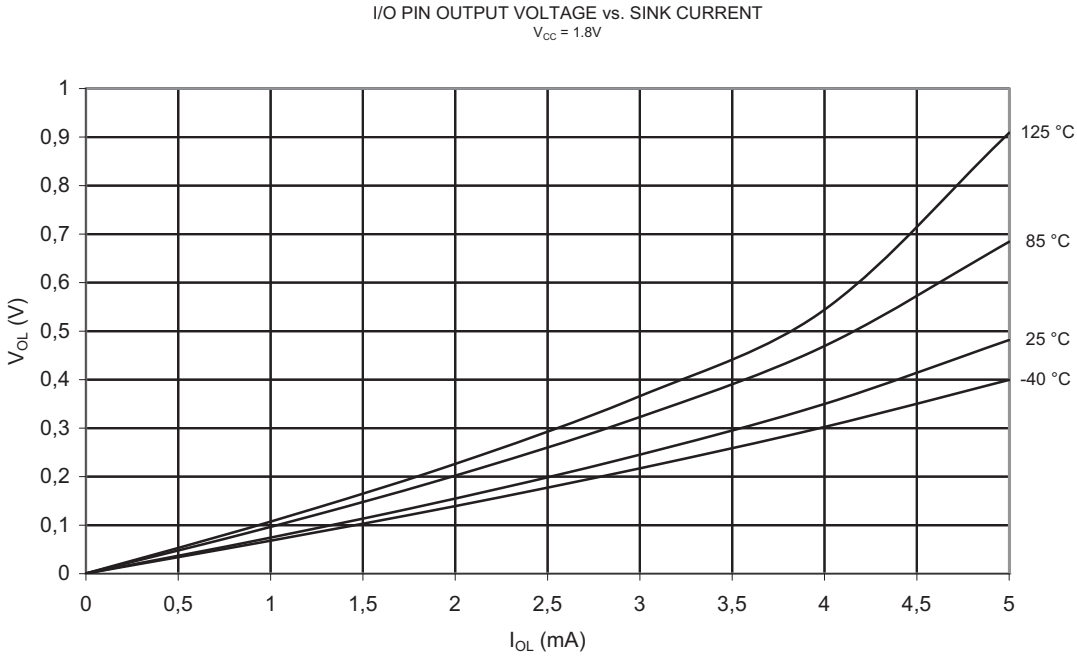


Figure 2-16. I/O Pin Output Voltage vs. Sink Current (V_{CC} = 3V)

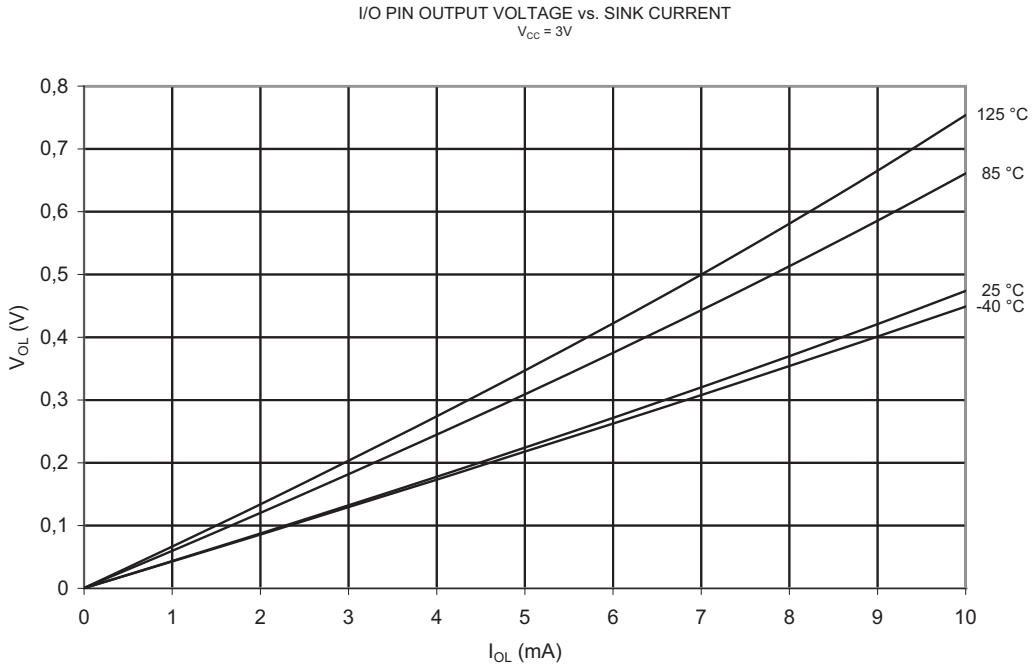


Figure 2-17. I/O pin Output Voltage vs. Sink Current (V_{CC} = 5V)

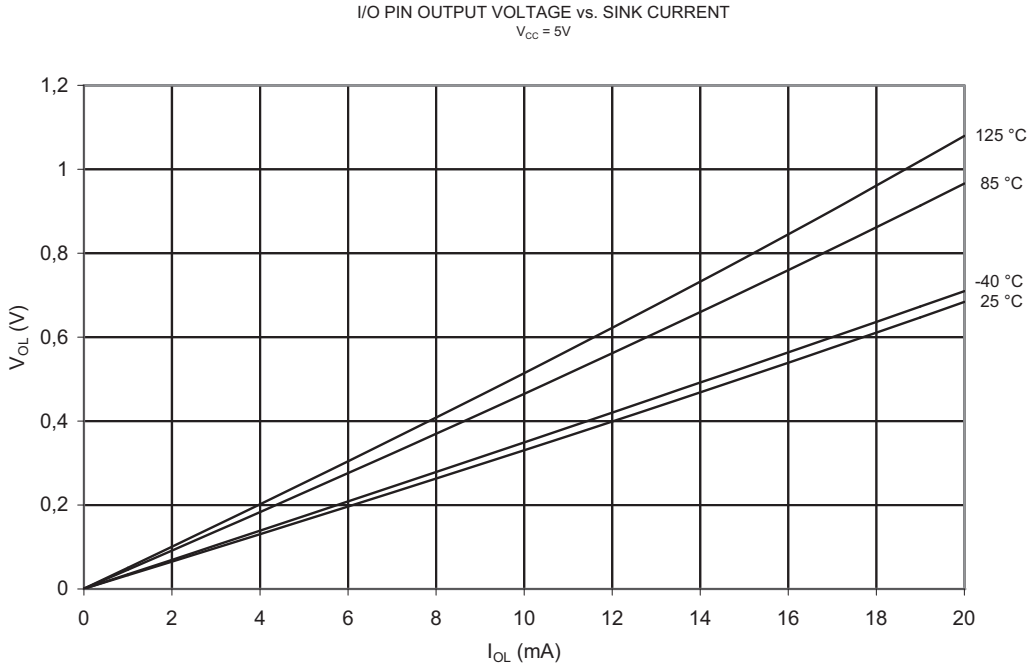


Figure 2-18. I/O Pin Output Voltage vs. Source Current (V_{CC} = 1.8V)

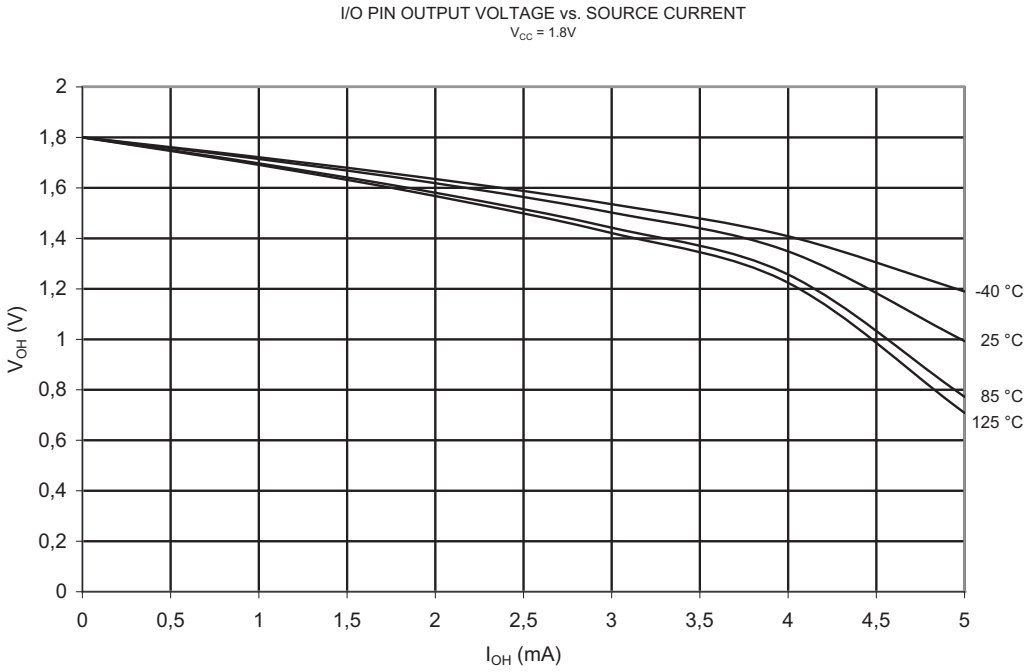


Figure 2-19. I/O Pin Output Voltage vs. Source Current (V_{CC} = 3V)

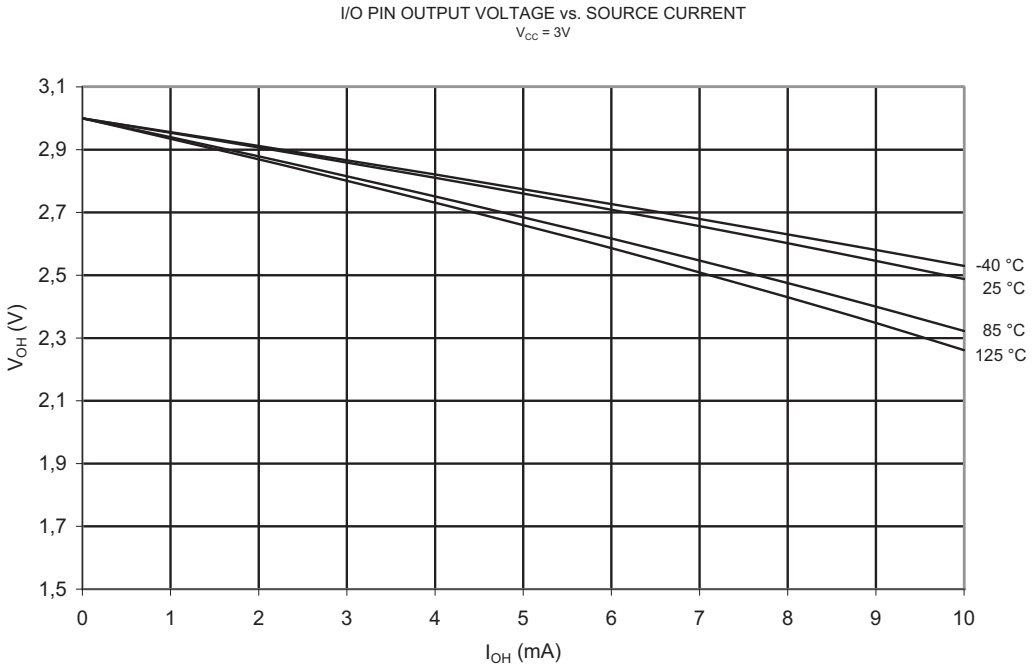
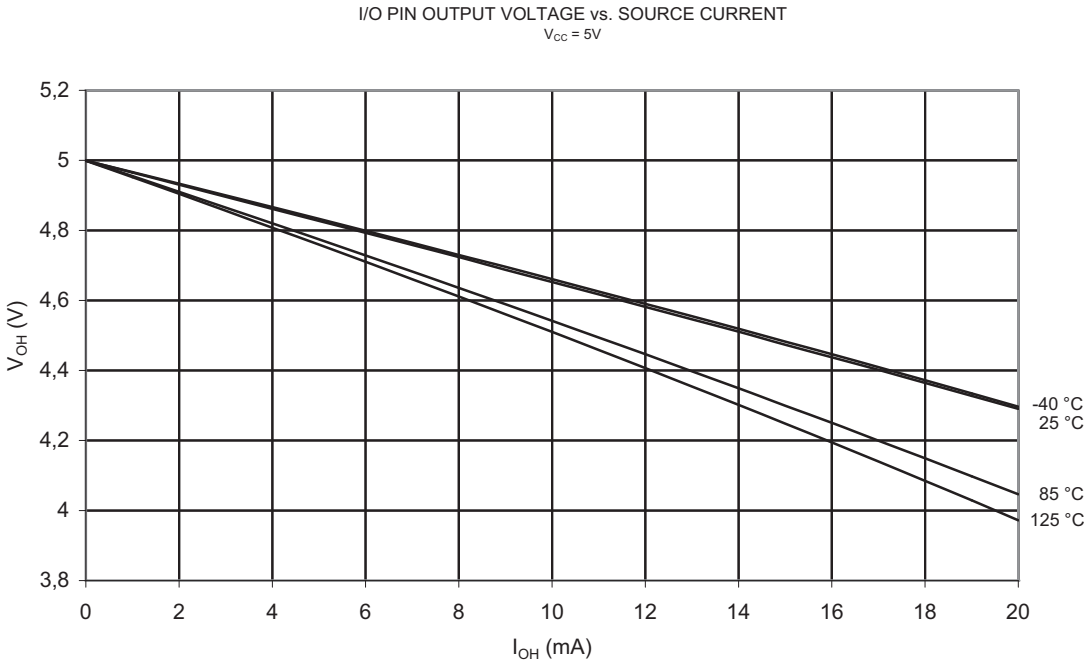


Figure 2-20. I/O Pin output Voltage vs. Source Current (V_{CC} = 5V)



2.6 Pin Threshold and Hysteresis

Figure 2-21. I/O Pin Input Threshold Voltage vs. V_{CC} (V_{IH}, IO Pin Read as '1')

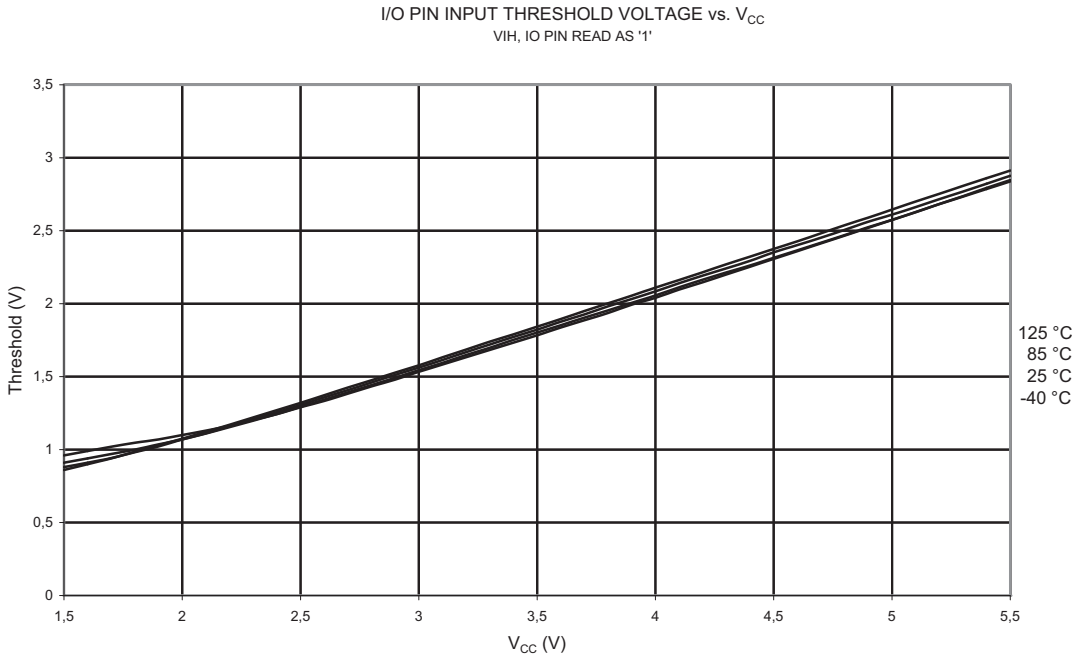


Figure 2-22. I/O Pin Input threshold Voltage vs. V_{CC} (V_{IL}, IO Pin Read as '0')

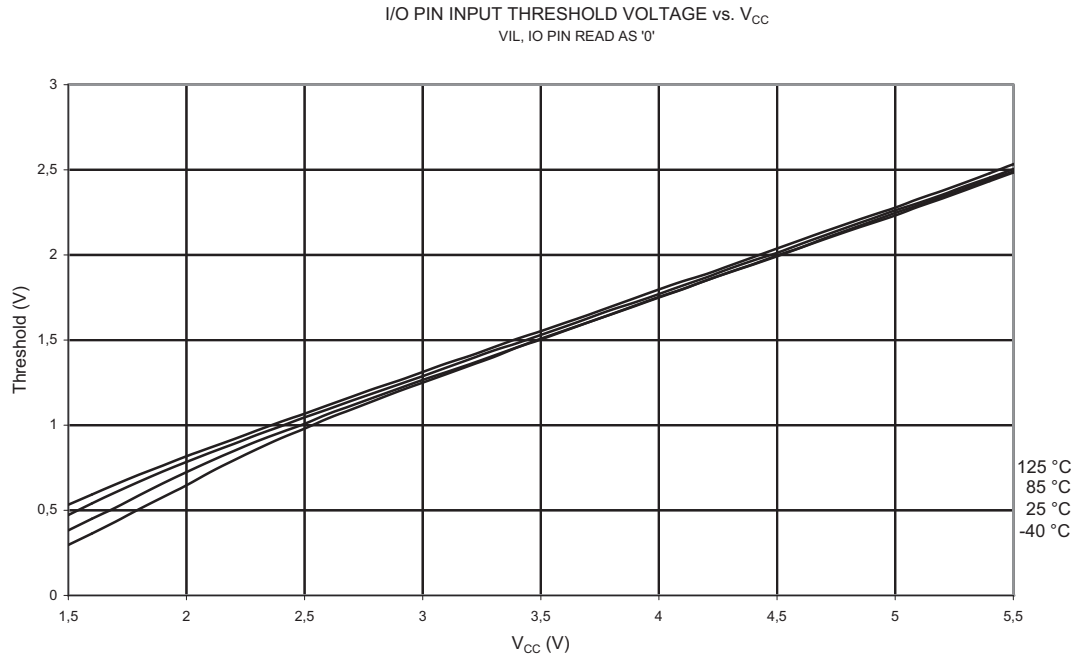


Figure 2-23. I/O Pin Input Hysteresis vs. V_{CC}

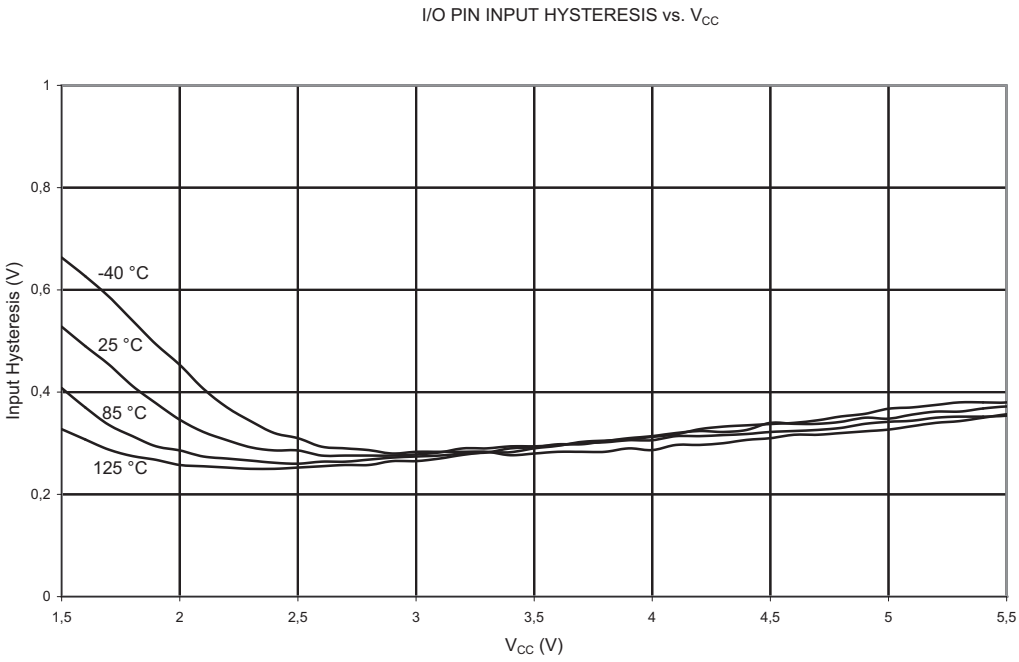


Figure 2-24. Reset Pin as I/O, Input Threshold Voltage vs. V_{CC} (V_{IH}, I/O Pin Read as ‘1’)

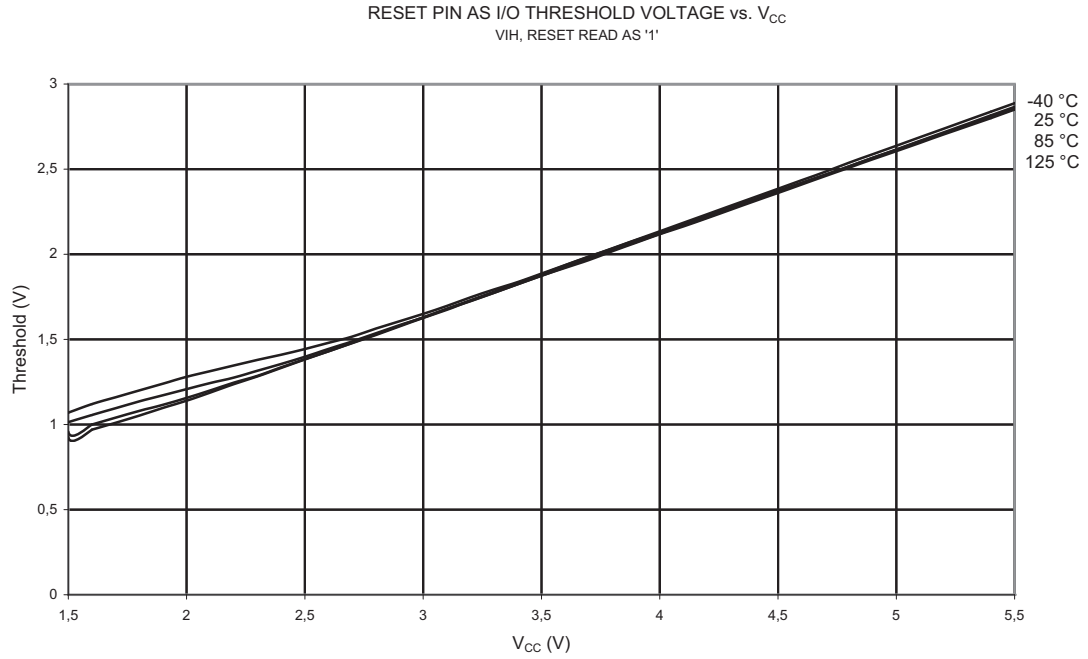


Figure 2-25. Reset Pin as I/O, Input Threshold Voltage vs. V_{CC} (V_{IL}, I/O pin Read as ‘0’)

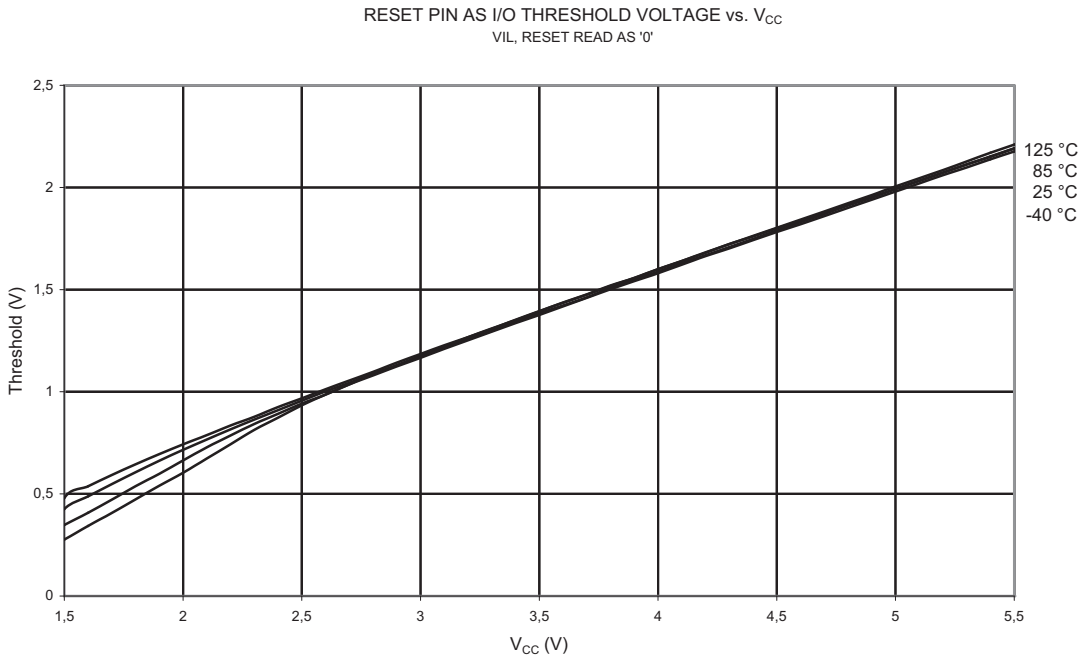


Figure 2-26. Reset Input Hysteresis vs. V_{CC} (Reset Pin Used as I/O)

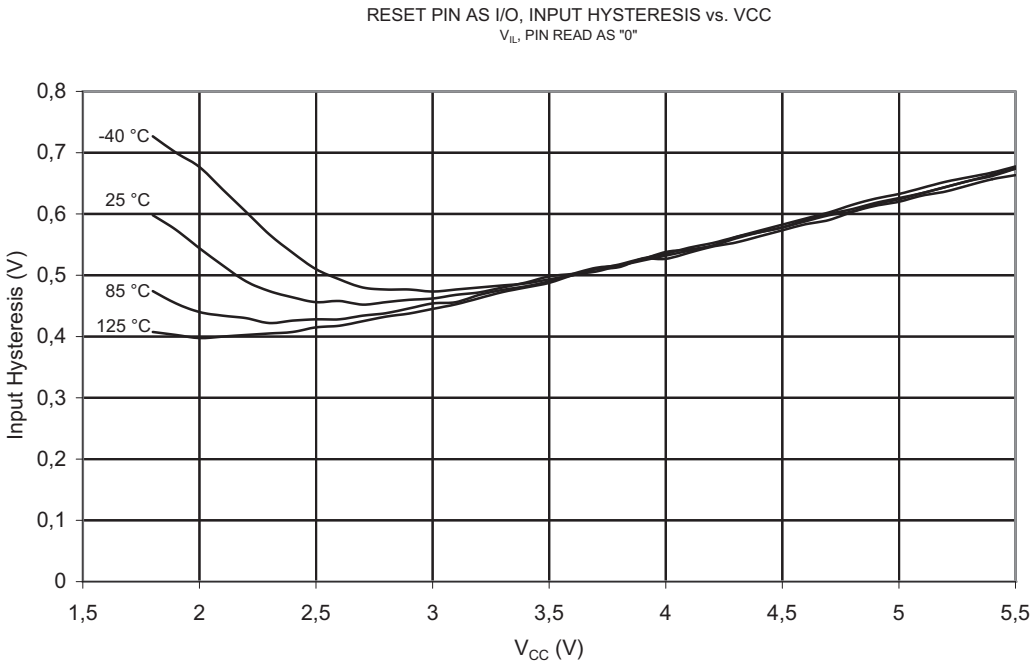


Figure 2-27. Reset Input Threshold Voltage vs. V_{CC} (V_{IH}, I/O Pin Read as '1')

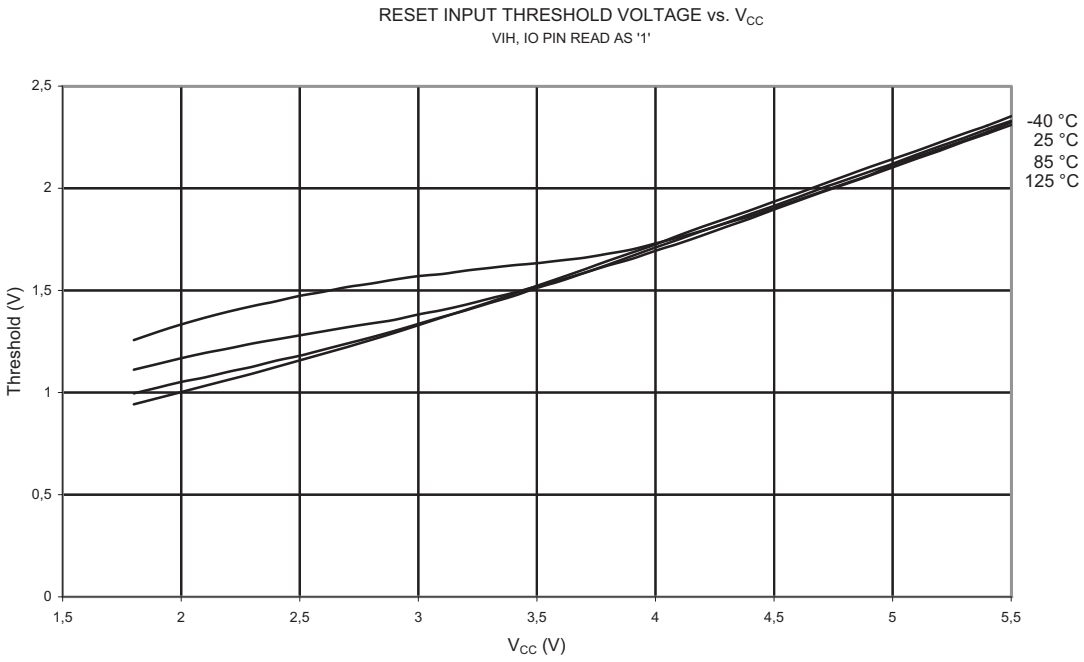


Figure 2-28. Reset Input Threshold Voltage vs. V_{CC} (V_{IL}, I/O pin Read as '0')

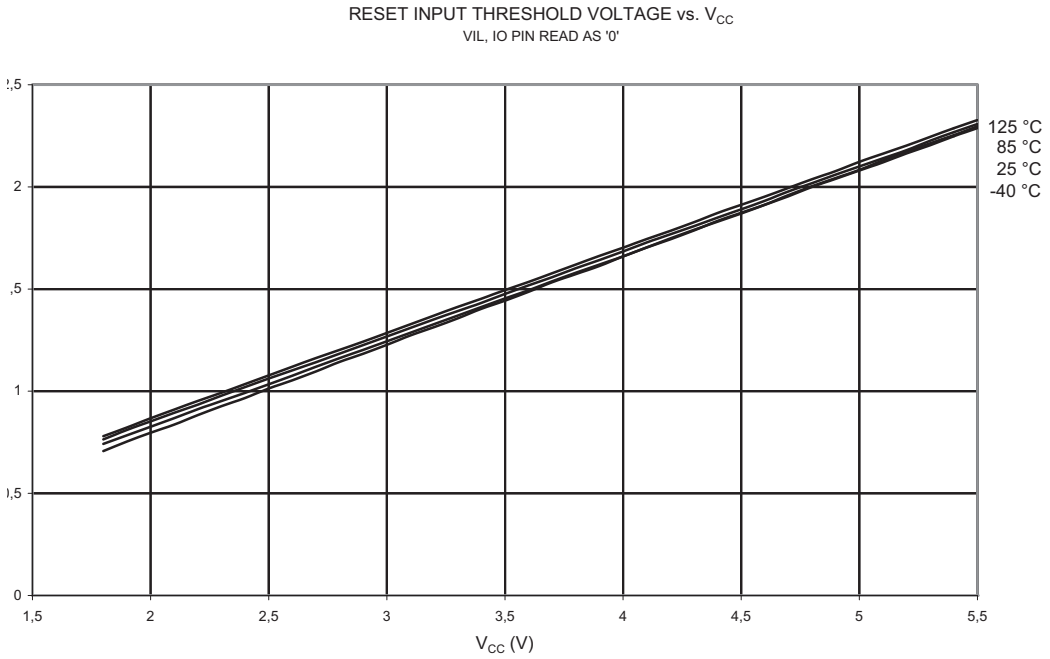
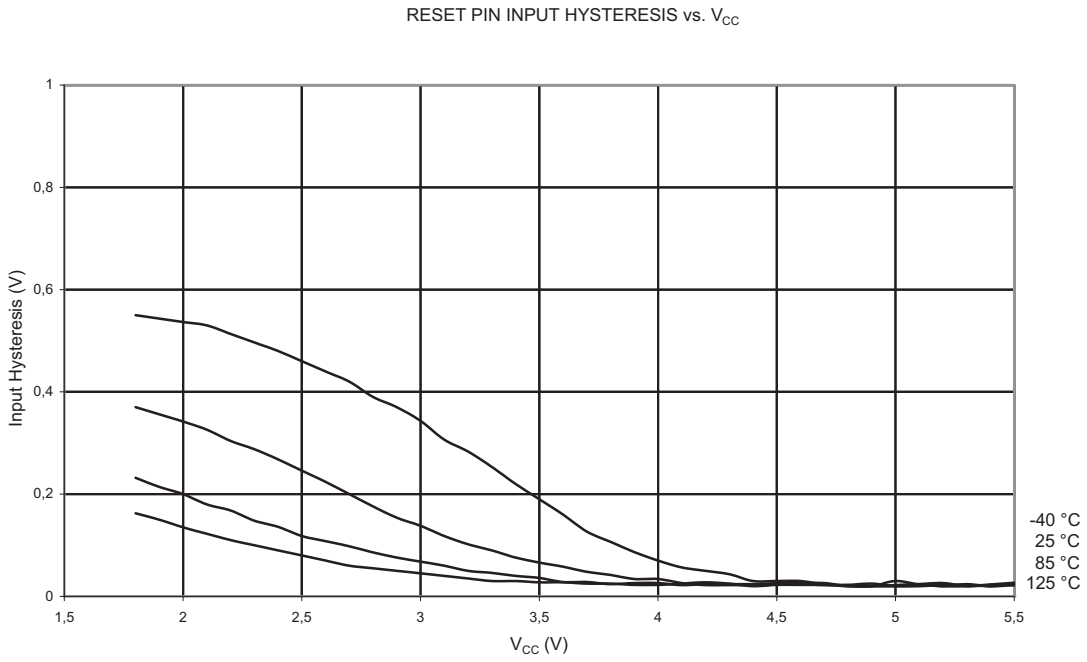
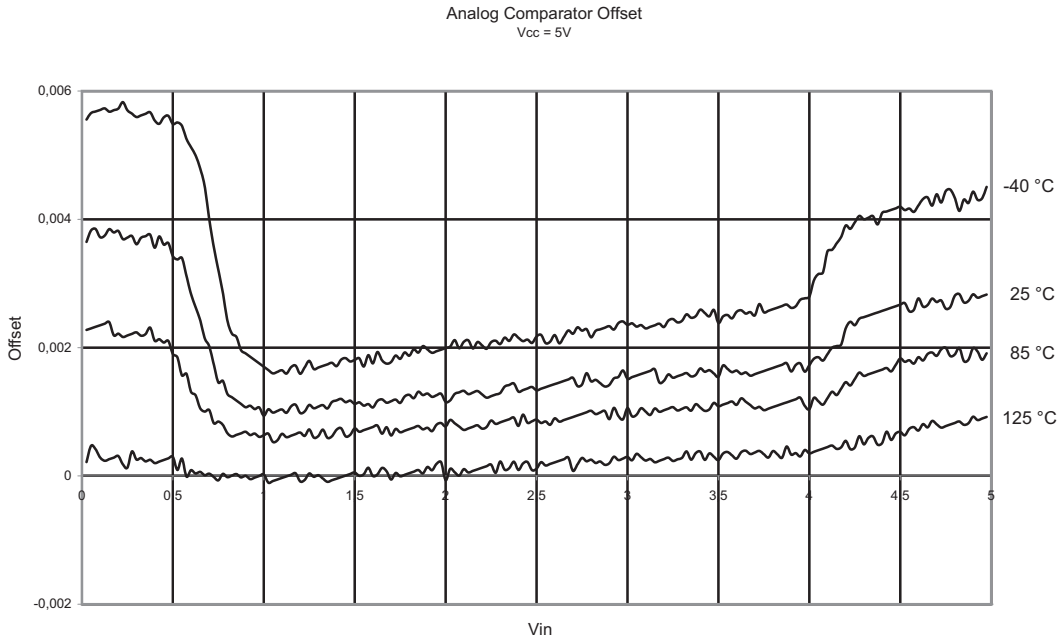


Figure 2-29. Reset Pin, Input Hysteresis vs. V_{CC}



2.7 Analog Comparator Offset

Figure 2-30. Analog Comparator Offset



2.8 Internal Oscillator Speed

Figure 2-31. Watchdog Oscillator Frequency vs. V_{CC}

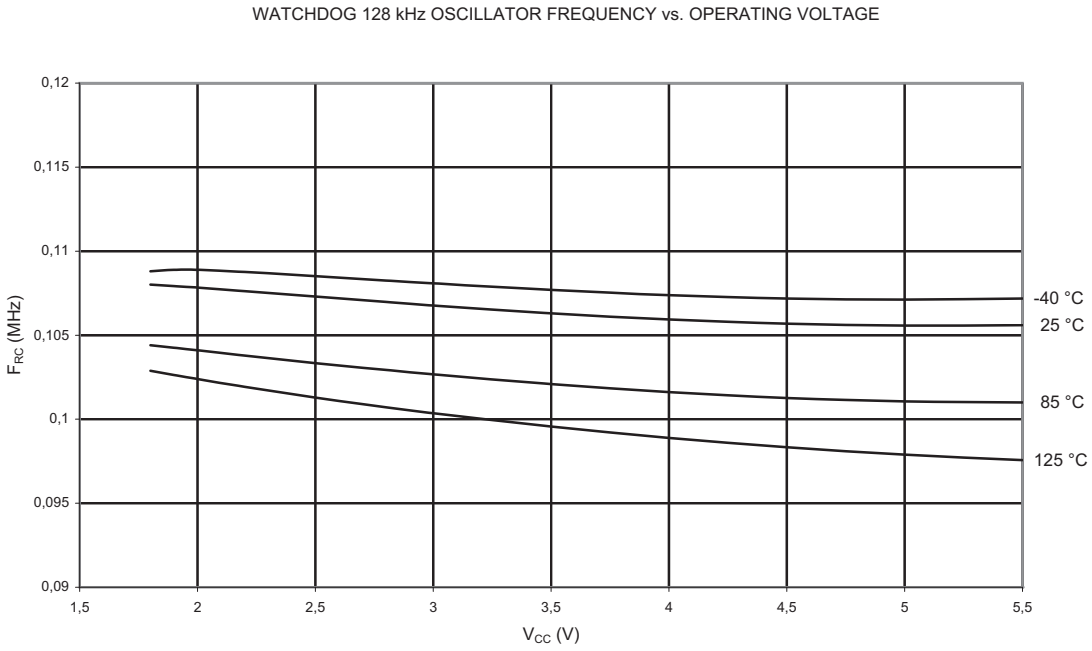


Figure 2-32. Calibrated Oscillator Frequency vs. V_{CC}

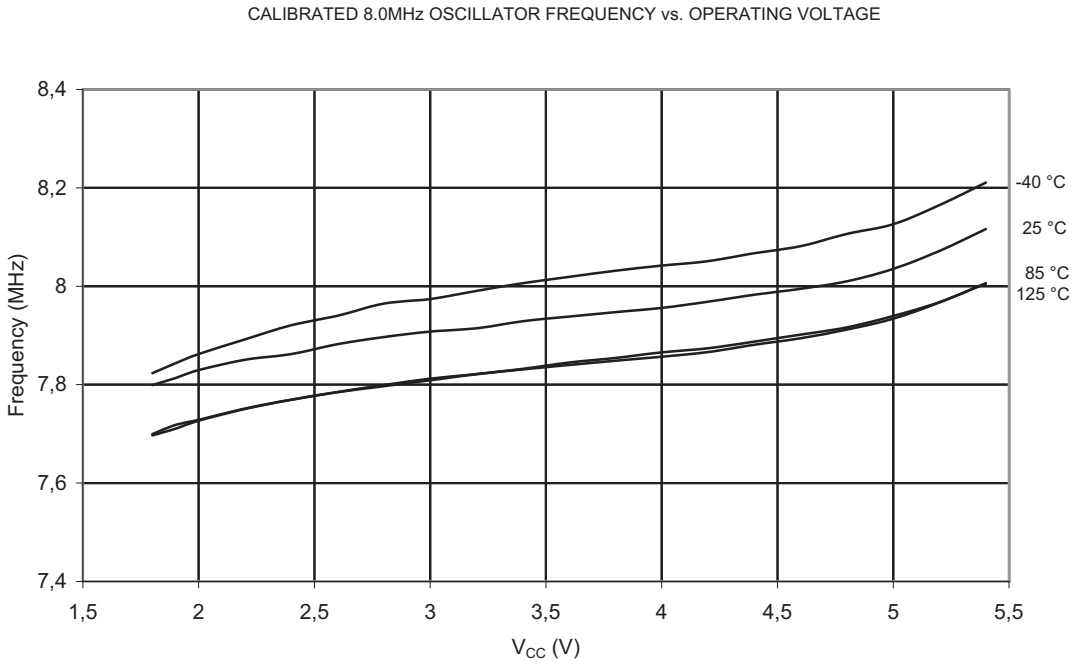


Figure 2-33. Calibrated Oscillator Frequency vs. Temperature

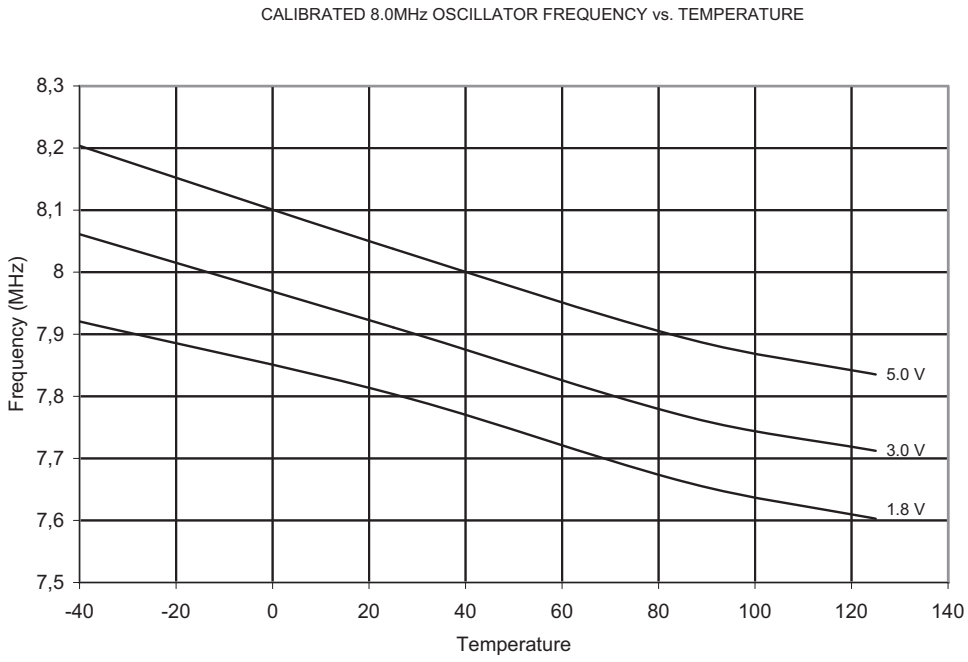
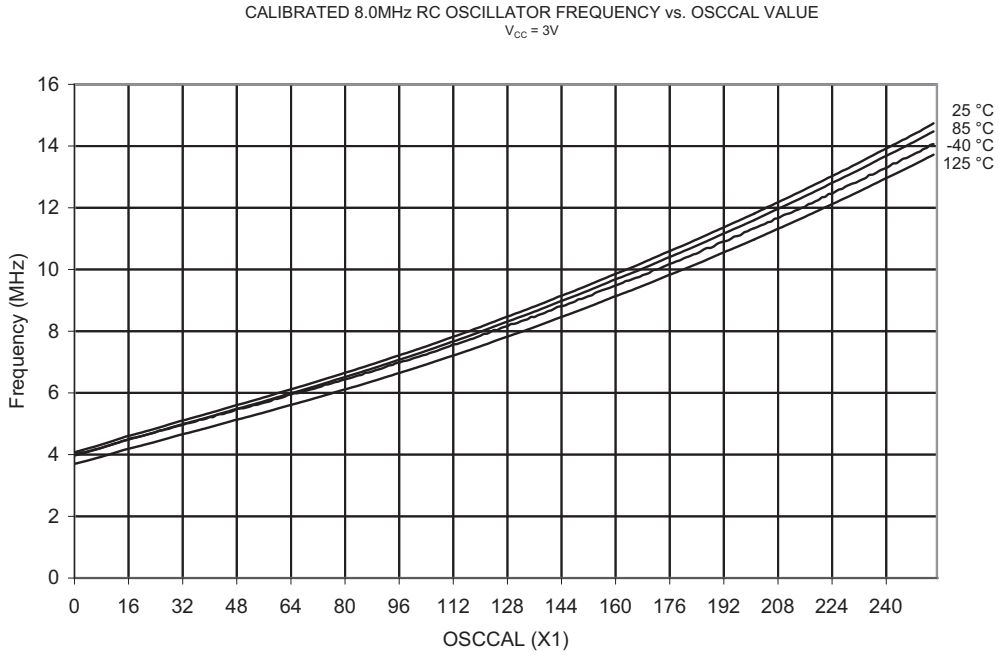


Figure 2-34. Calibrated Oscillator Frequency vs, OSCCAL Value



2.9 VLM Thresholds

Figure 2-35. VLM1L Threshold of V_{CC} Level Monitor

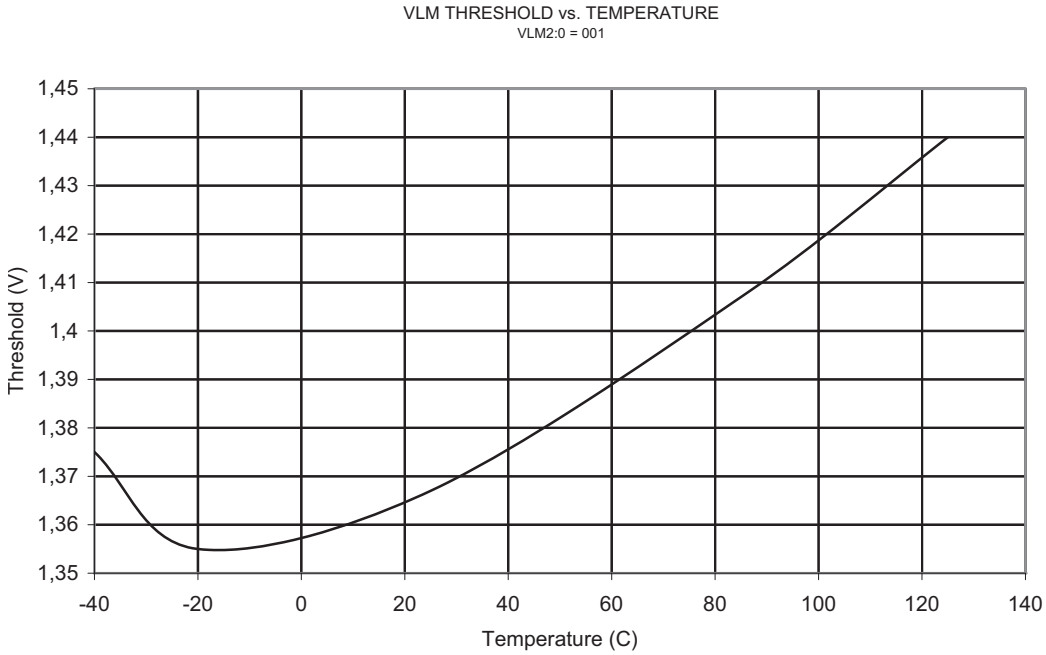


Figure 2-36. VLM1H Threshold of V_{CC} Level Monitor

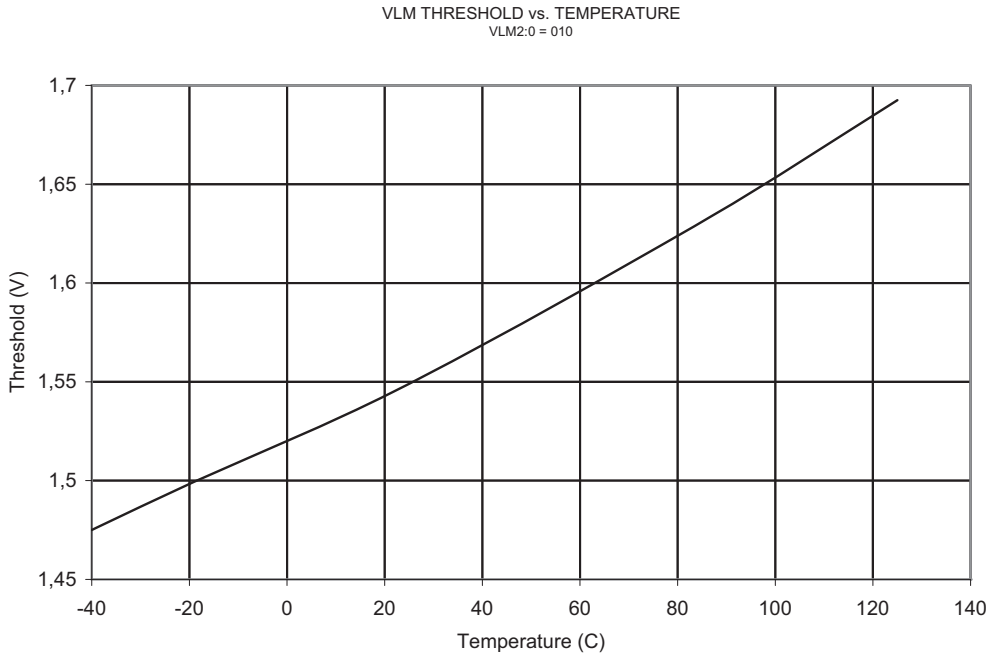


Figure 2-37. VLM2 Threshold of V_{CC} Level Monitor

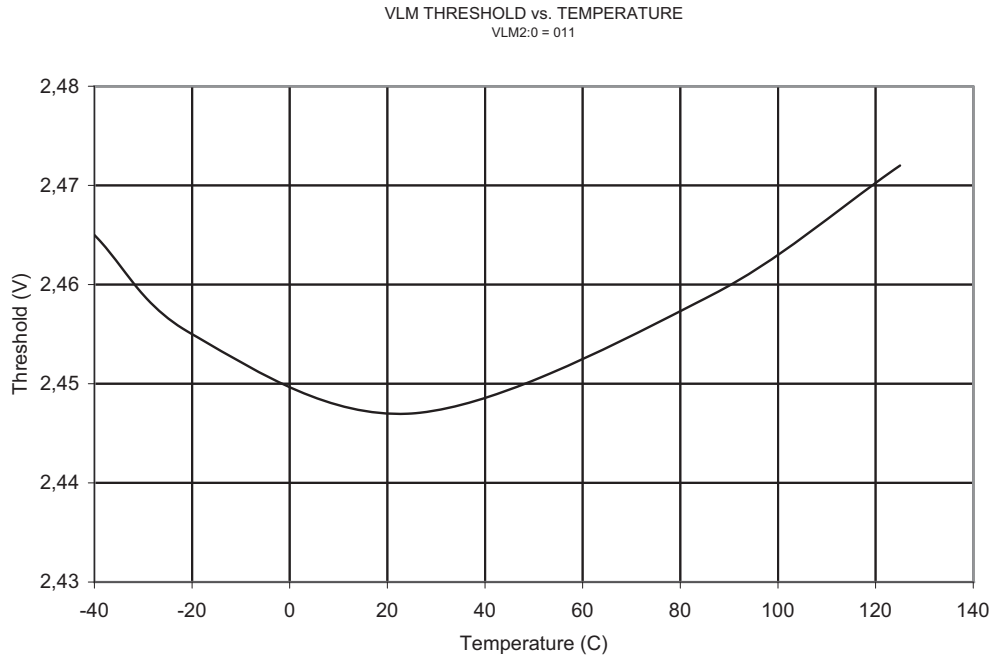
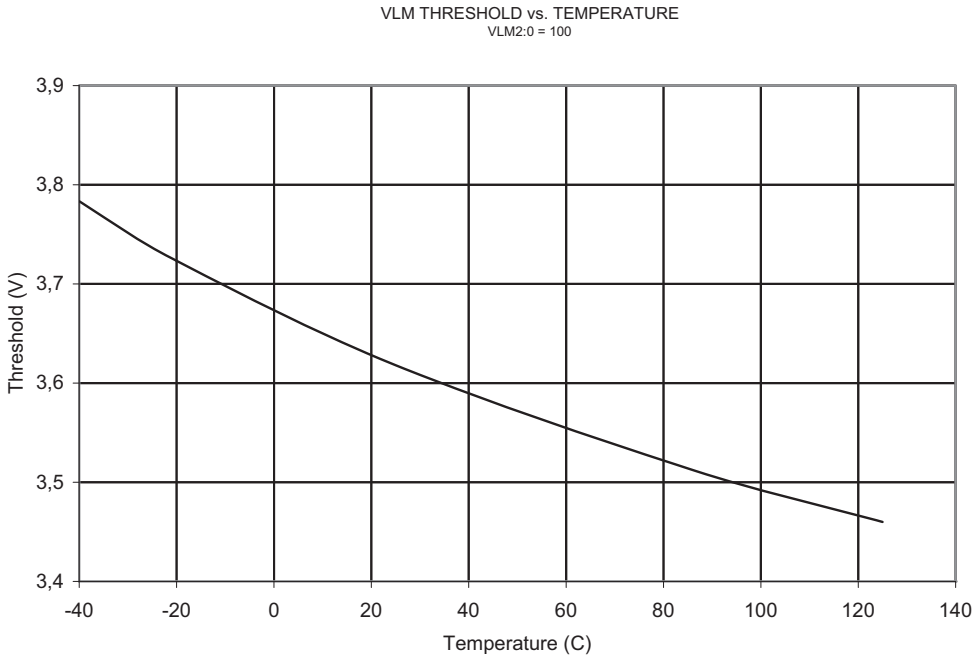


Figure 2-38. VLM3 Threshold of V_{CC} Level Monitor



2.10 Current Consumption of Peripheral Units

Figure 2-39. Temperature Dependence of VLM Current vs. V_{CC}

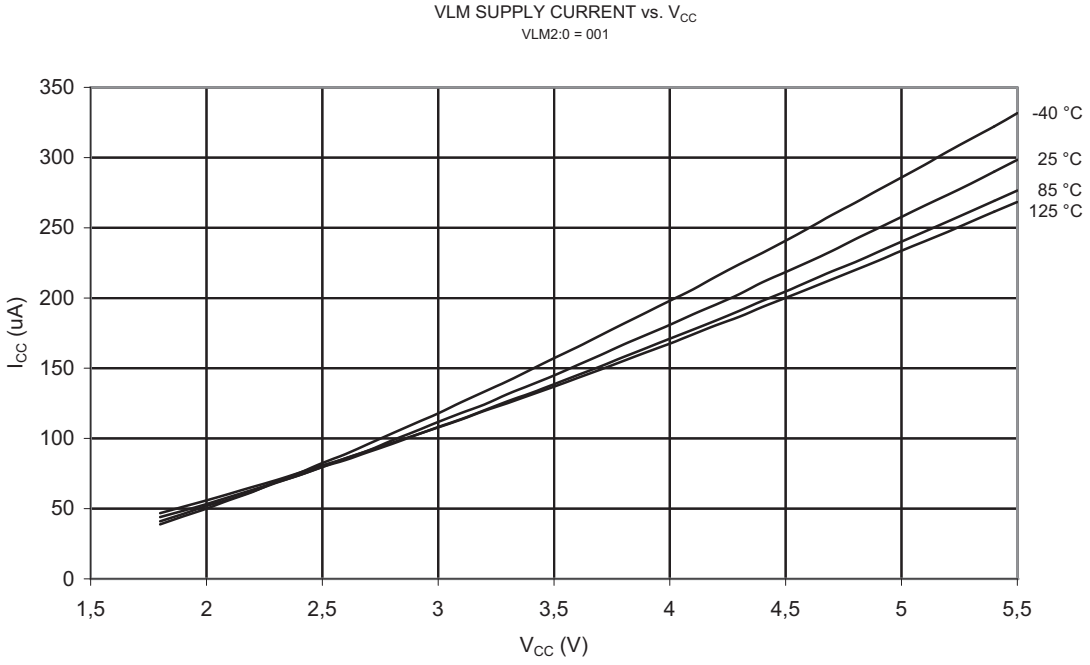
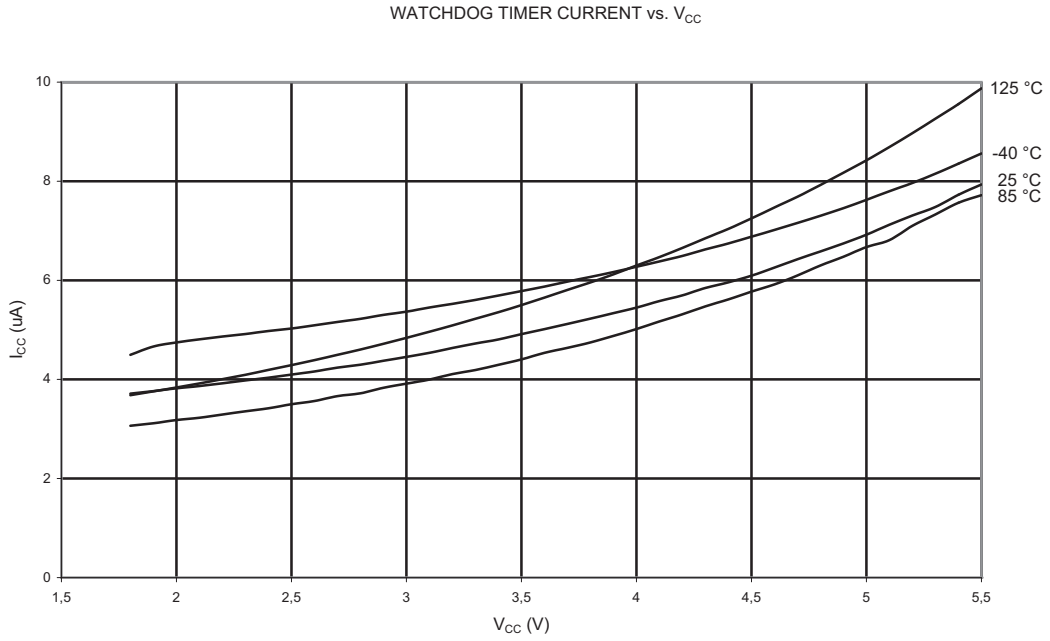
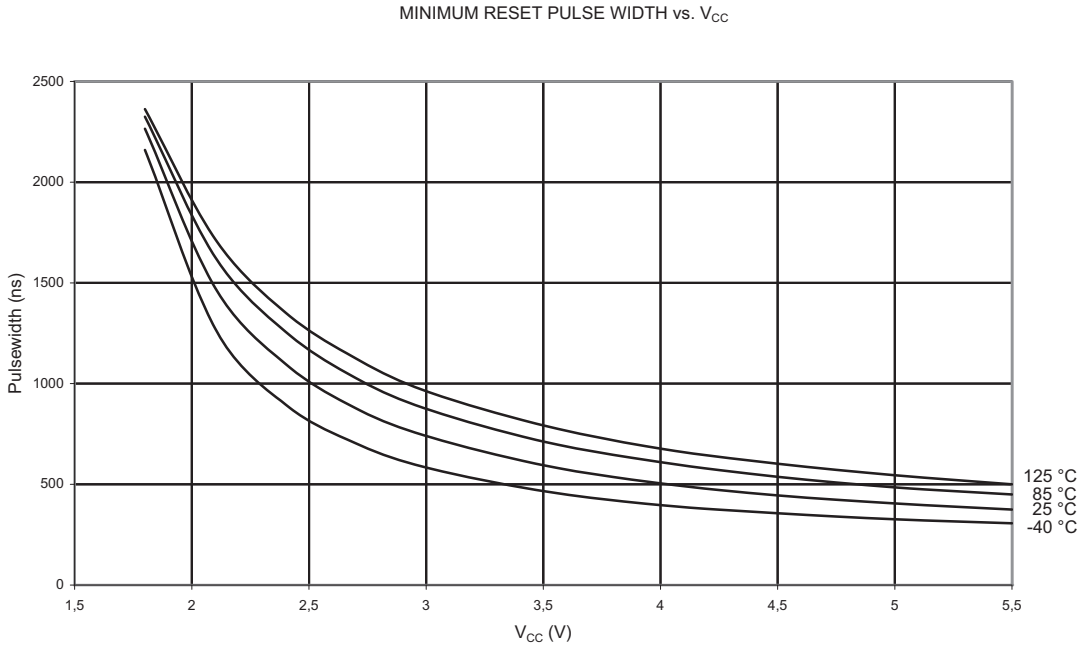


Figure 2-40. Watchdog Timer Current vs. V_{CC}



2.11 Reset Pulsewidth

Figure 2-41. Minimum Reset Pulse Width vs. V_{CC}



3. Ordering Information

3.1 ATtiny4

Speed (MHz)	Power Supply	Ordering Code[1]	Package[2]	Operational Range
10	1.8 - 5.5V	ATtiny4-TS8R[3]	6ST1	Industrial (-40°C to 125°C)

Notes:
1. Tape and reel.
2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS). NiPdAu finish.
3. Top/bottomside markings for ATtiny4:
   - Topside: T4**x** (**x** stands for “die revision”)
   - Bottomside: z**8**zzz [**8** stands for (-40°C to 125°C)]

Package Type	
6ST1	6-lead, 2.90 x 1.60 mm Plastic Small Outline Package (SOT23)

3.2 ATtiny5

Speed (MHz)	Power Supply	Ordering Code[1]	Package[2]	Operational Range
10	1.8 - 5.5V	ATtiny5-TS8R[3]	6ST1	Industrial (-40°C to 125°C)

Notes:
1. Tape and reel.
2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS). NiPdAu finish.
3. Top/bottomside markings for ATtiny5:
   - Topside: T5**x** (**x** stands for “die revision”)
   - Bottomside: z**8**zzz [**8** stands for (-40°C to 125°C)]

Package Type	
6ST1	6-lead, 2.90 x 1.60 mm Plastic Small Outline Package (SOT23)

3.3 ATtiny9

Speed (MHz)	Power Supply	Ordering Code[1]	Package[2]	Operational Range
10	1.8 - 5.5V	ATtiny9-TS8R[3]	6ST1	Industrial (-40°C to 125°C)

Notes:
1. Tape and reel.
2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS). NiPdAu finish.
3. Top/bottomside markings for ATtiny9:
   - Topside: T9**x** (**x** stands for “die revision”)
   - Bottomside: z**8**zzz [**8** stands for (-40°C to 125°C)]

Package Type	
6ST1	6-lead, 2.90 x 1.60 mm Plastic Small Outline Package (SOT23)

3.4 ATtiny10

Speed (MHz)	Power Supply	Ordering Code[1]	Package[2]	Operational Range
10	1.8 - 5.5V	ATtiny10-TS8R[3]	6ST1	Industrial (-40°C to 125°C)

Notes:
1. Tape and reel.
2. All packages are Pb-free, halide-free and fully green and they comply with the European directive for Restriction of Hazardous Substances (RoHS). NiPdAu finish.
3. Top/bottomside markings for ATtiny10:
   - Topside: T10**x** (**x** stands for “die revision”)
   - Bottomside: z**8**zzz [**8** stands for (-40°C to 125°C)]

Package Type	
6ST1	6-lead, 2.90 x 1.60 mm Plastic Small Outline Package (SOT23)

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