



MICROCHIP

Section 31. Device Characteristics

HIGHLIGHTS

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31.1 Introduction

Microchip Technology Inc. provides characterization information on the devices that it manufactures. This information becomes available after the devices have undergone a complete characterization and the data has been analyzed. This data is taken on both device testers and on bench setups. The characterization data gives the designer a better understanding of the device characteristics, to better judge the acceptability of the device to the application.

31.2 Characterization vs. Electrical Specification

The difference between this information and the Electrical specifications can be classified as what the user should expect the devices to do vs. what Microchip tests the devices to. The characterization graphs and tables provided are for design guidance and are not tested or guaranteed.

There may be differences between what the characterization shows as the limits vs. that which is tested, as shown in the Electrical Specification section. This results from capabilities of the production tester equipment, plus whatever guard band that may be necessary.

31.3 DC and AC Characteristics Graphs and Tables

Each table gives specific information that may be useful design information. These values are taken under fixed circumstances. Measurements taken in your application may not lead to the same values if your circumstances are not the same.

In some graphs or tables the data presented are outside specified operating range (i.e., outside specified V_{DD} range). This is for information only and devices will operate properly only within the specified range.

Note:	The data presented in the device Data Sheet Characterization section is a statistical summary of data collected on units from different lots over a period of time and matrix samples. 'Typical' represents the mean of the distribution at, 25°C, while 'max' or 'min' represents (mean +3 σ) and (mean -3 σ) respectively where σ is standard deviation.
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31.3.1 IPD vs. VDD

IPD is the current (I) that the device consumes when the device is in sleep mode (power-down), referred to as power-down current. These tests are taken with all I/O as inputs, either pulled high or low. That is, there are no floating inputs, nor are any pins driving an output (with a load).

The characterization shows graphs for both the Watchdog Timer (WDT) disabled and enabled. This is required since the WDT requires an on-chip RC oscillator which consumes additional current.

Since the device may have certain features and modules that can operate while the device is in sleep mode. Some of these modules are:

- Watchdog Timer (WDT)
- Brown-out Reset (BOR) circuitry
- Timer1
- Analog to Digital converter
- LCD module
- Comparators
- Voltage Reference

If these features are operating while the device is in sleep mode, a higher current will be consumed. When all features are disabled, the device will consume the lowest possible current (the leakage current). If more than one feature is enabled then the expected current can easily be calculated as the base current (everything disabled and in sleep mode) plus all delta currents. [Example 31-1](#) shows an example of calculating the typical currents for a device at 5V, with the WDT and Timer1 oscillator enabled.

Example 31-1: IPD Calculations with WDT and TIMER1 Oscillator Enabled (@ 5V)

Base Current	14 nA	; Device leakage current
WDT Delta Current	14 μ A	; 14 μ A - 14 nA = 14 μ A
<u>Timer1 Delta Current</u>	<u>22 μA</u>	; 22 μ A - 14 nA = 22 μ A
Total Sleep Current	36 μ A	;

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Figure 31-1: Example Typical I_{PD} vs. V_{DD} (WDT Disabled, RC Mode)

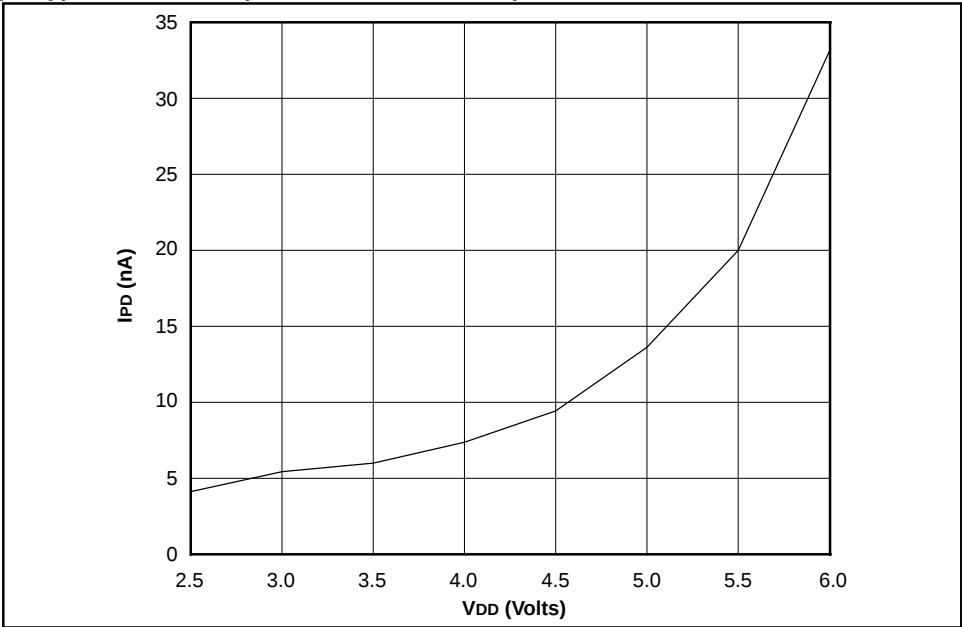


Figure 31-2: Example Maximum I_{PD} vs. V_{DD} (WDT Disabled, RC Mode)

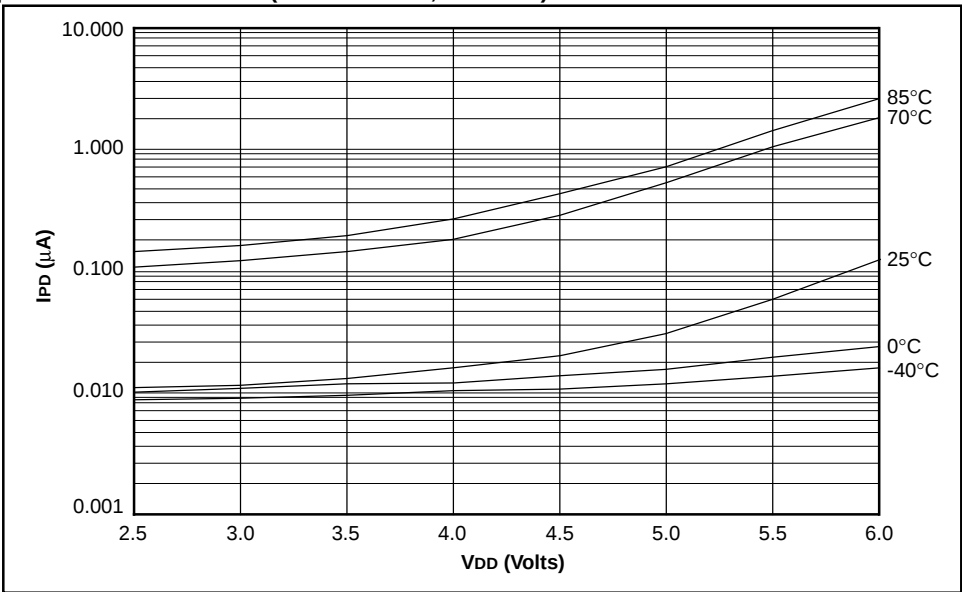


Figure 31-3: Example Typical I_{PD} vs. V_{DD} @ 25°C (WDT Enabled, RC Mode)

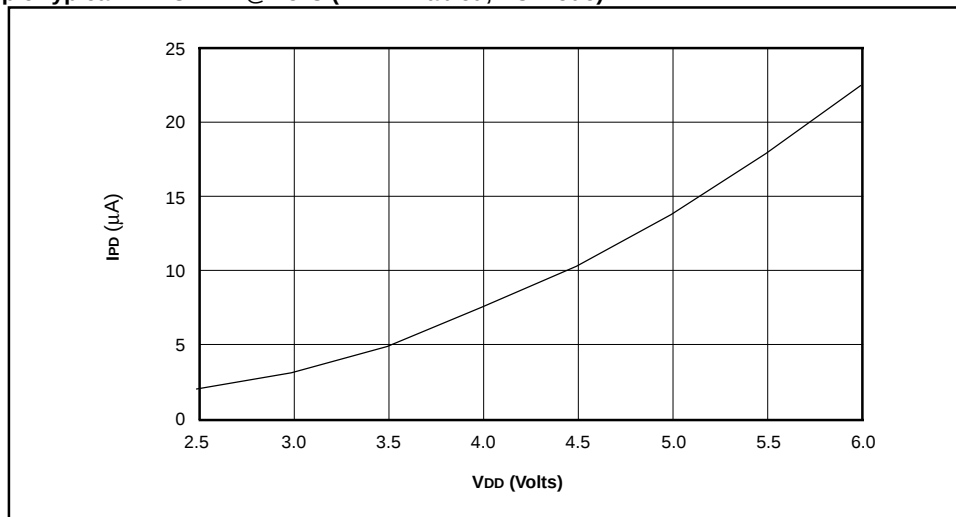
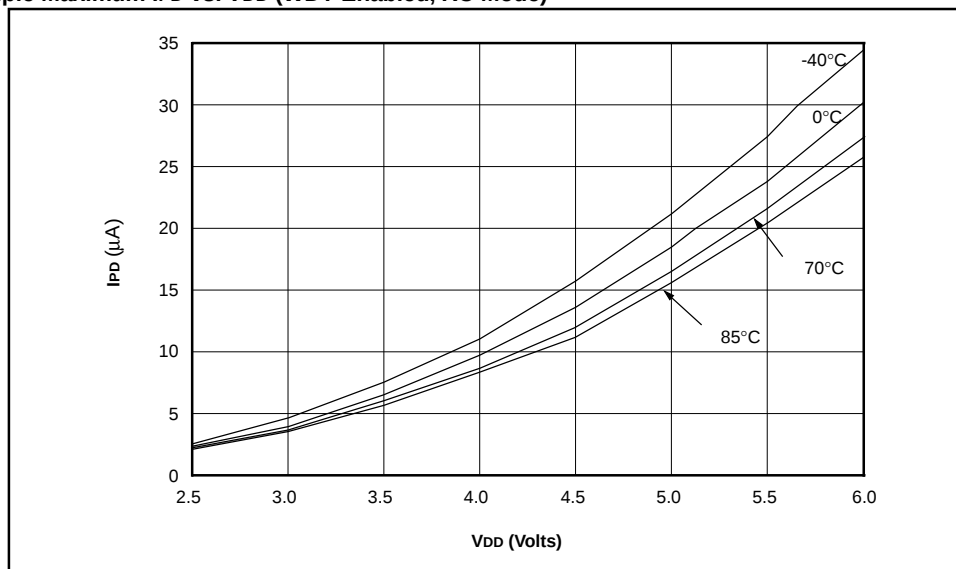


Figure 31-4: Example Maximum I_{PD} vs. V_{DD} (WDT Enabled, RC Mode)



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Figure 31-5: Example Typical IPD vs. VDD Brown-out Detect Enabled (RC Mode)

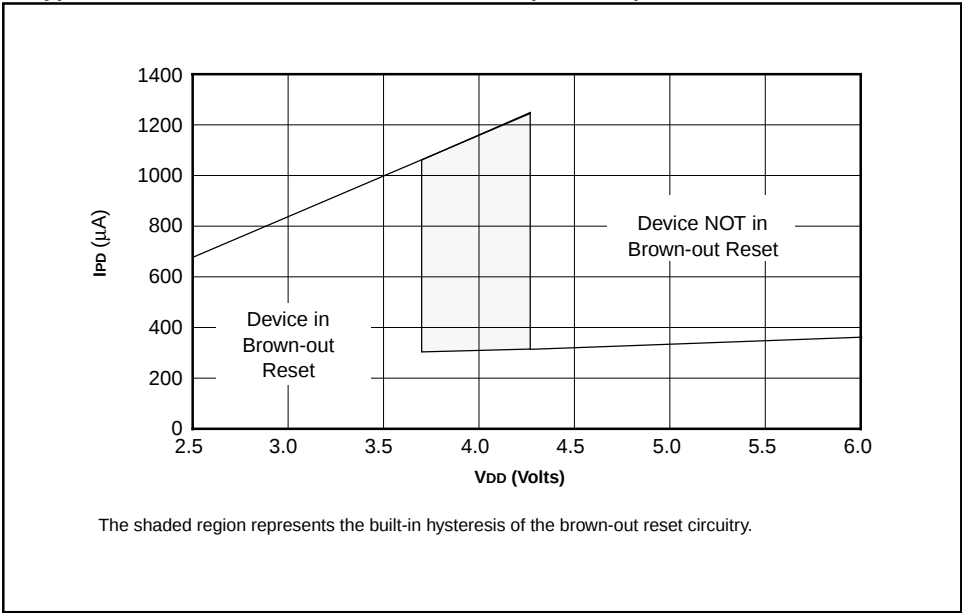


Figure 31-6: Example Maximum IPD vs. VDD Brown-out Detect Enabled (85°C to -40°C, RC Mode)

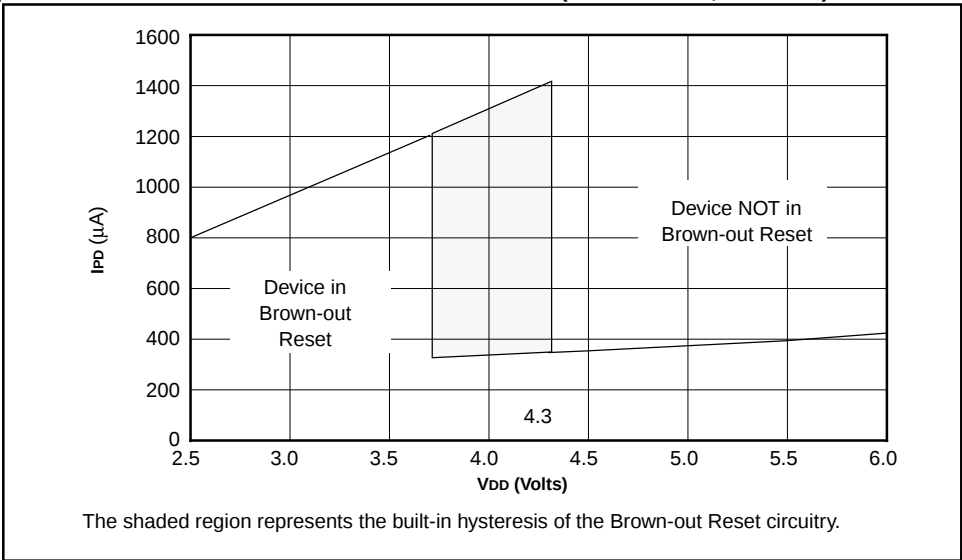


Figure 31-7: Example Typical I_{PD} vs. Timer1 Enabled (32 kHz, RC0/RC1 = 33 pF/33 pF, RC Mode)

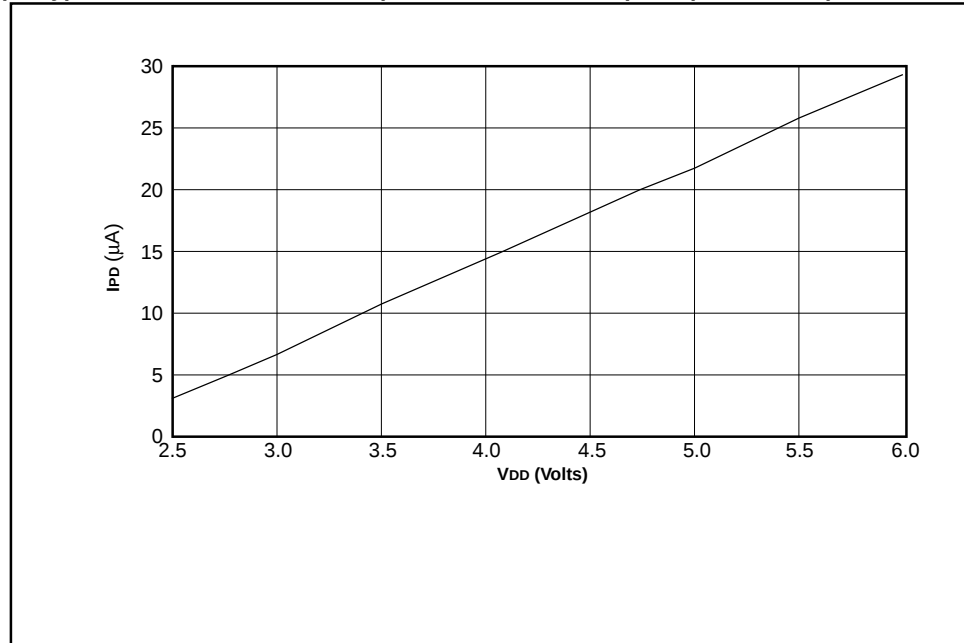
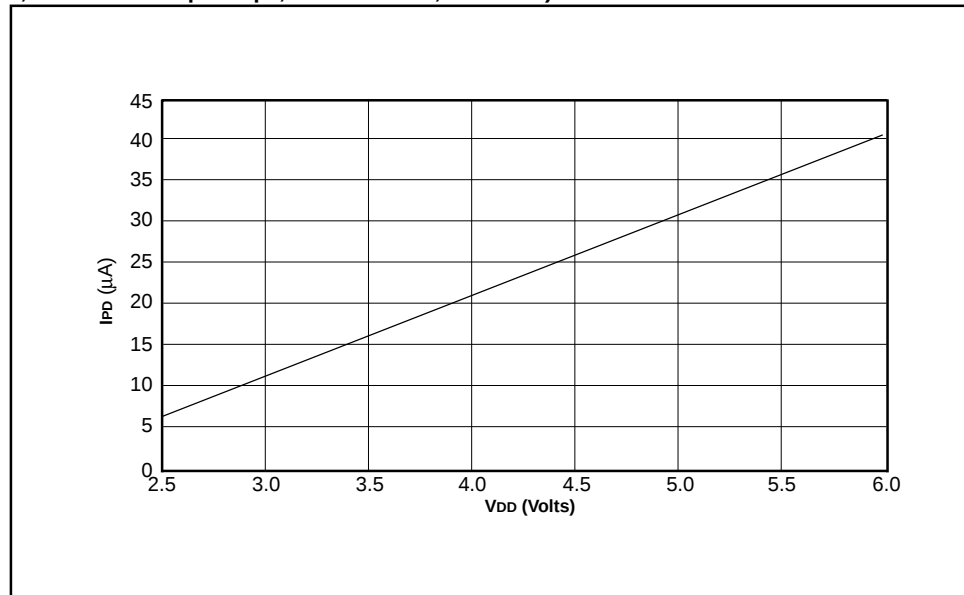


Figure 31-8: Example Maximum I_{PD} vs. Timer1 Enabled
(32 kHz, RC0/RC1 = 33 pF/33 pF, 85°C to -40°C, RC Mode)



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31.3.2 I_{DD} vs. Frequency

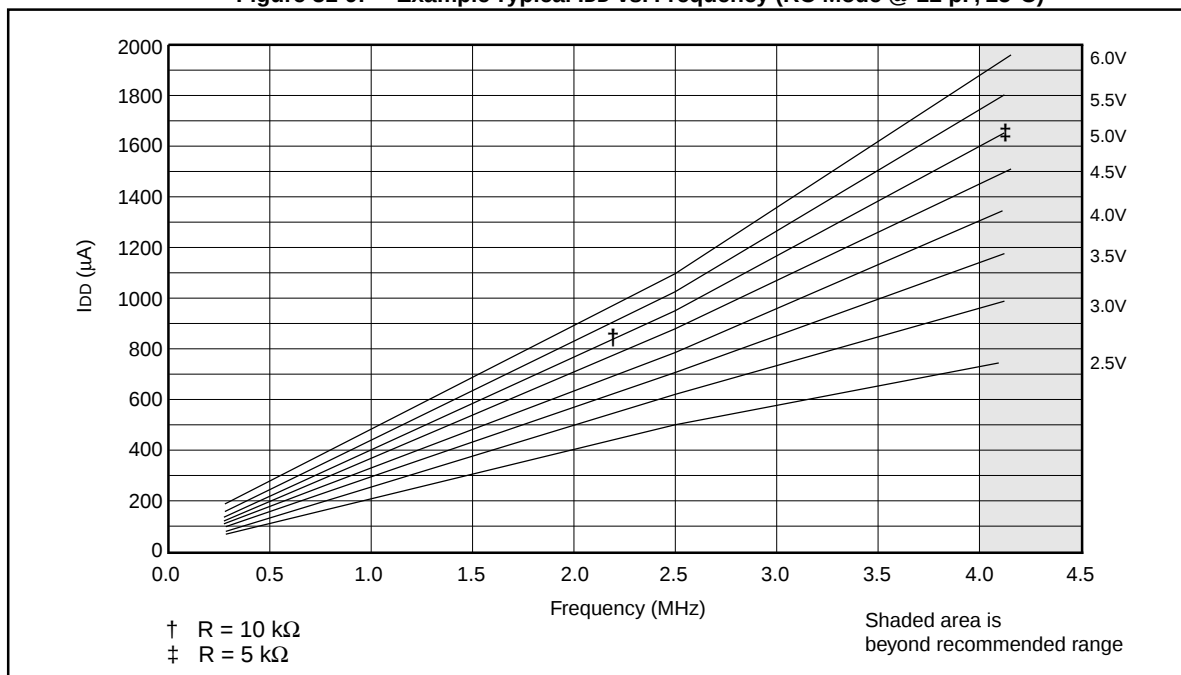
I_{DD} is the current (I) that the device consumes when the device is in operating mode. This test is taken with all I/O as inputs, either pulled high or low. That is, there are no floating inputs, nor are any pins driving an output (with a load).

The I_{DD} vs. Frequency charts measure the results on a Microchip automated bench setup, called the DCS (Data Collection System). The DCS accurately reflects the device and specified component values, that is, it does not add stray capacitance or current.

31.3.2.1 RC Measurements

For the RC measurement, the DCS selects a resistor and capacitor value, and then varies the voltage over the specified range. As the voltage is changed, the frequency of operation changes. For a fixed RC, as V_{DD} increases, the frequency increases. After the measurement, at this RC, has been taken, the RC value is changed and the measurements are taken again. Each point on the graph corresponds to a device voltage, resistor value (R), and capacitor value (C).

Figure 31-9: Example Typical I_{DD} vs. Frequency (RC Mode @ 22 pF, 25°C)



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Figure 31-10: Example Maximum I_{DD} vs. Frequency (RC Mode @ 22 pF, -40°C to 85°C)

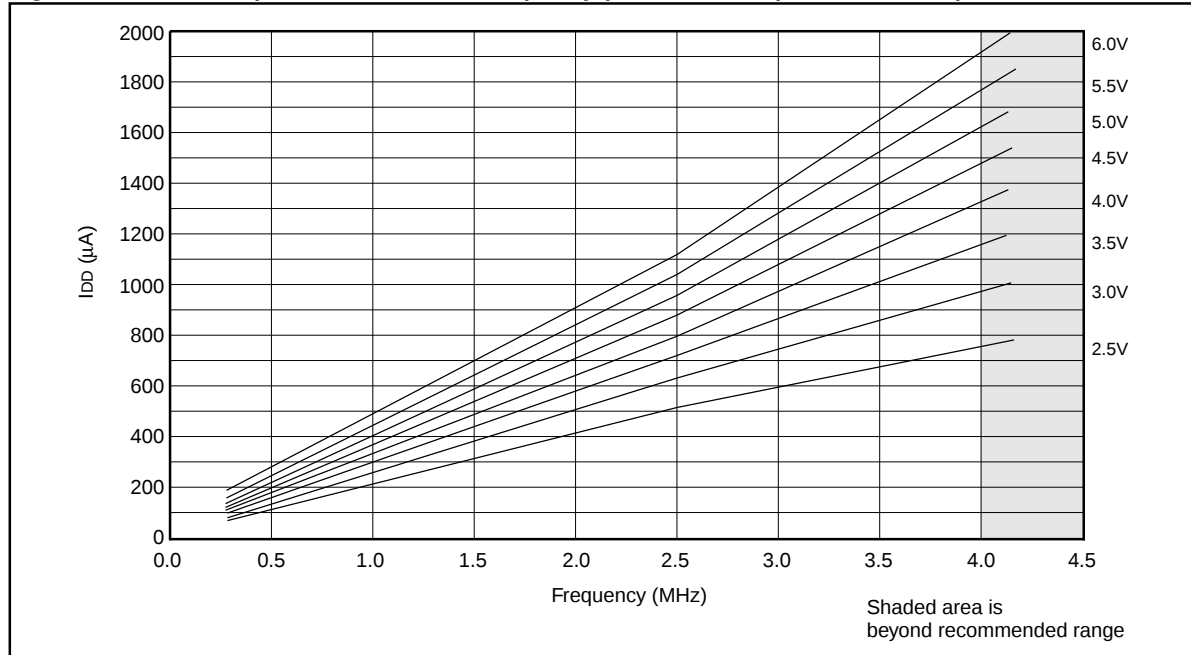
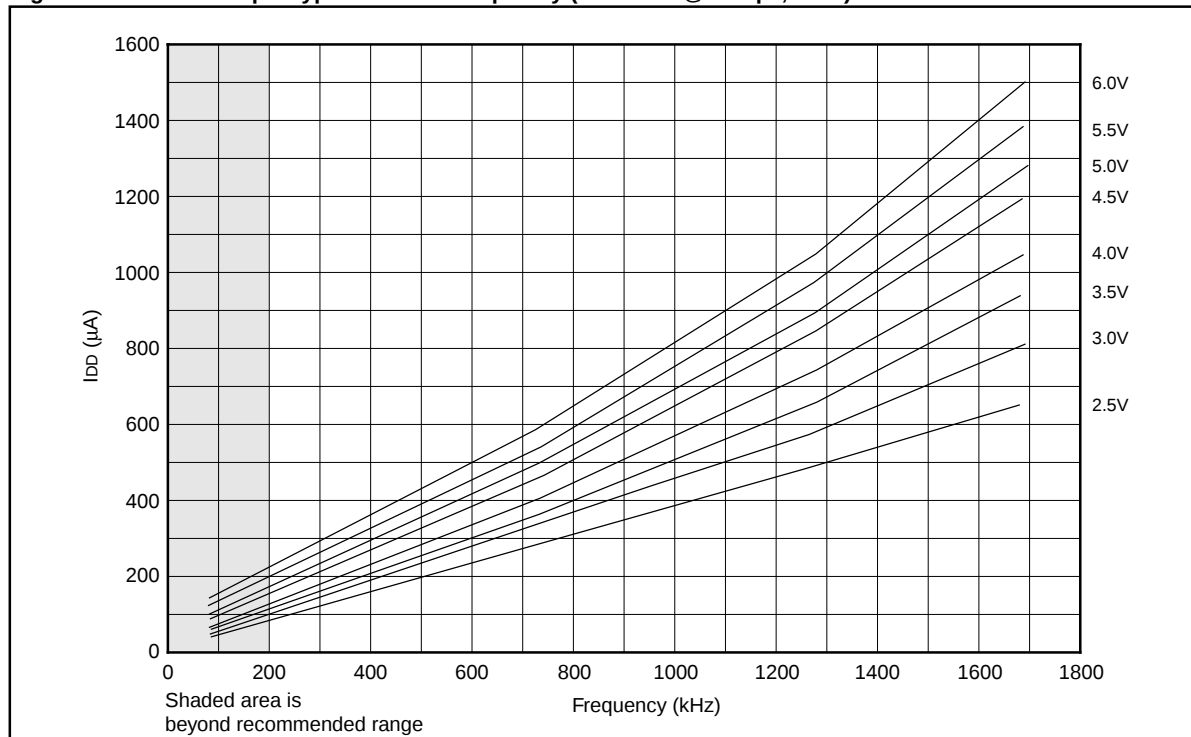


Figure 31-11: Example Typical I_{DD} vs. Frequency (RC Mode @ 100 pF, 25°C)



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Figure 31-12: Example Maximum I_{DD} vs. Frequency (RC Mode @ 100 pF, -40°C to 85°C)

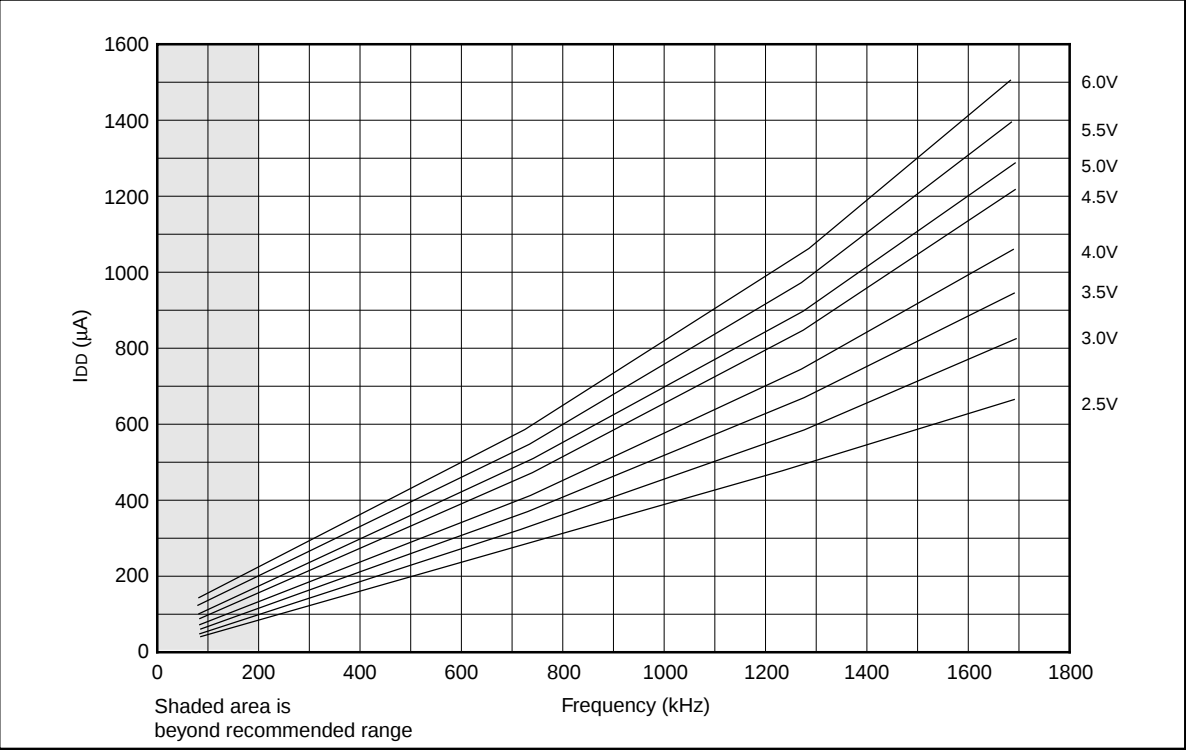
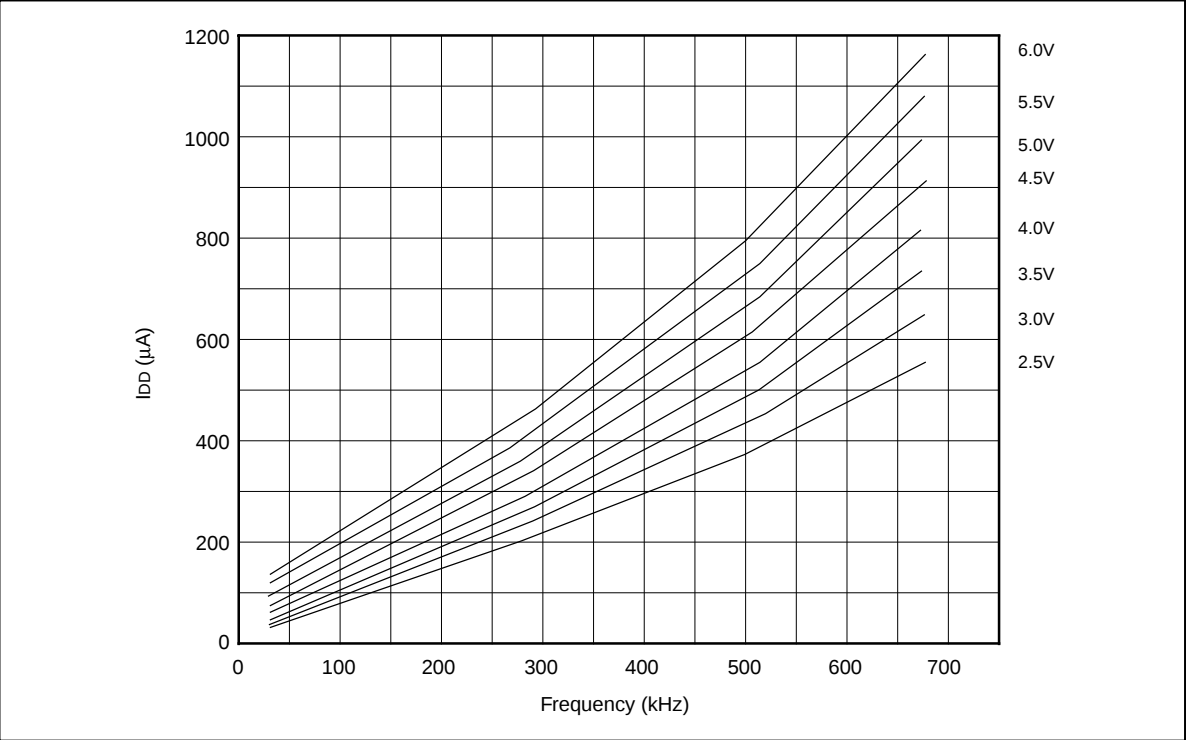


Figure 31-13: Example Typical I_{DD} vs. Frequency (RC Mode @ 300 pF, 25°C)



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Figure 31-14: Example Maximum I_{DD} vs. Frequency (RC Mode @ 300 pF, -40°C to 85°C)

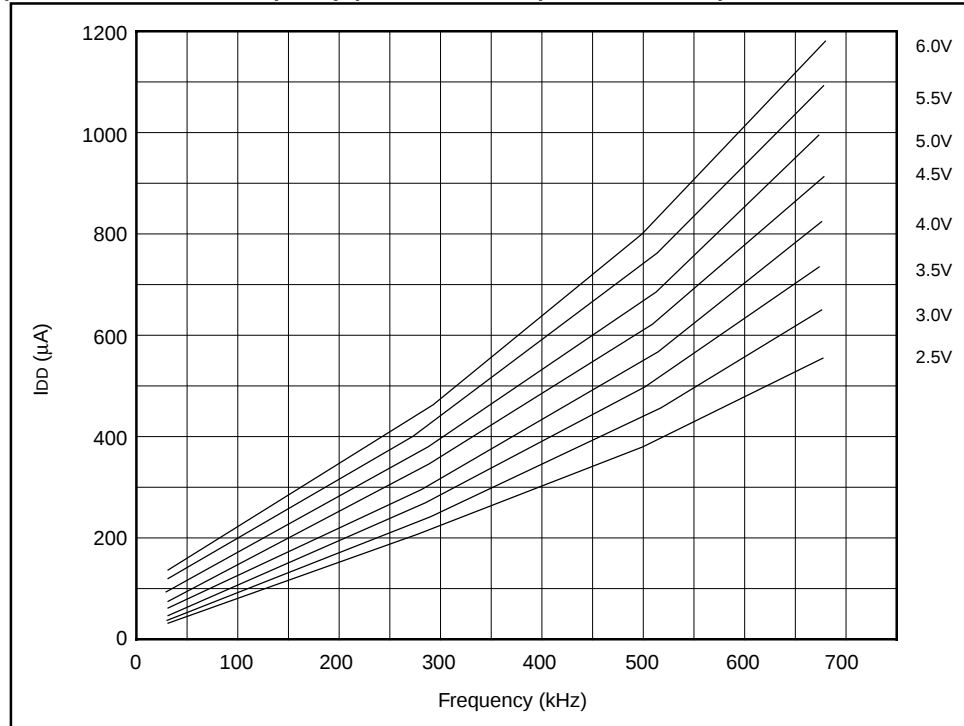
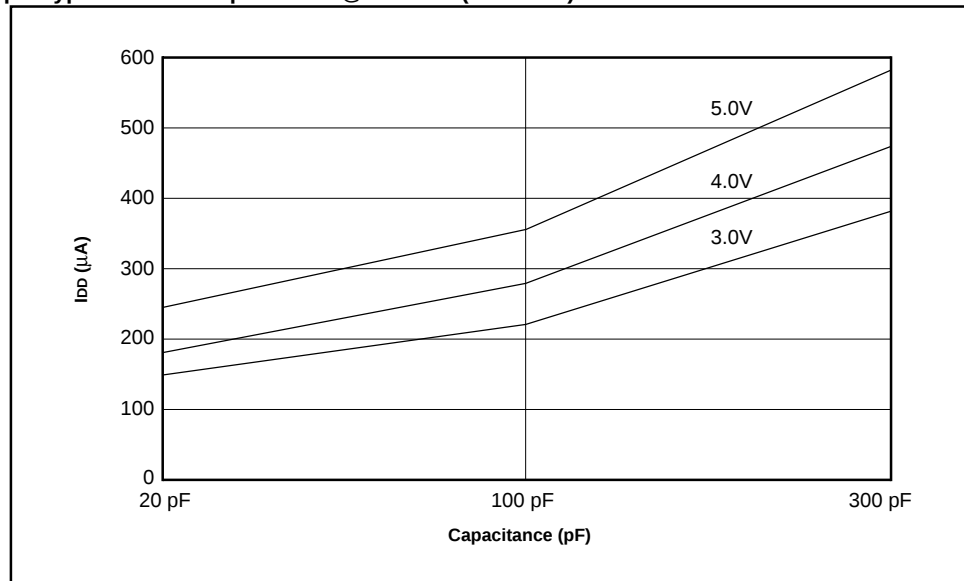


Figure 31-15: Example Typical I_{DD} vs. Capacitance @ 500 kHz (RC Mode)



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31.3.2.2 Crystal Oscillator Measurements

On the Data Collection System, there are several crystals. For this test a crystal is multiplexed into the device circuit, and the crystal's capacitance values can be varied. The capacitance and voltage values are varied to determine the best characteristics (current, oscillator waveform, and oscillator start-up), and then the currents are measured over voltage. The next crystal oscillator is then switched in and the procedure is repeated.

Figure 31-16: Example Typical I_{DD} vs. Frequency (LP Mode, 25°C)

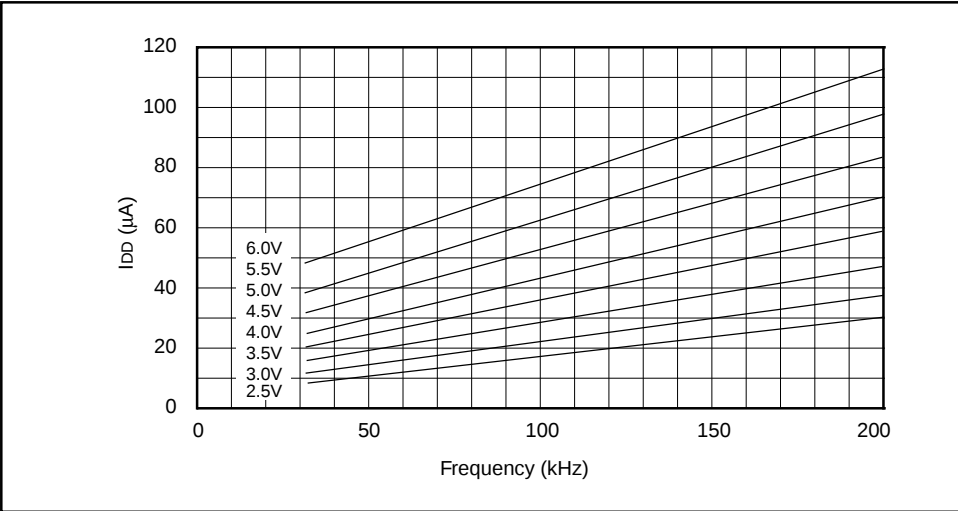
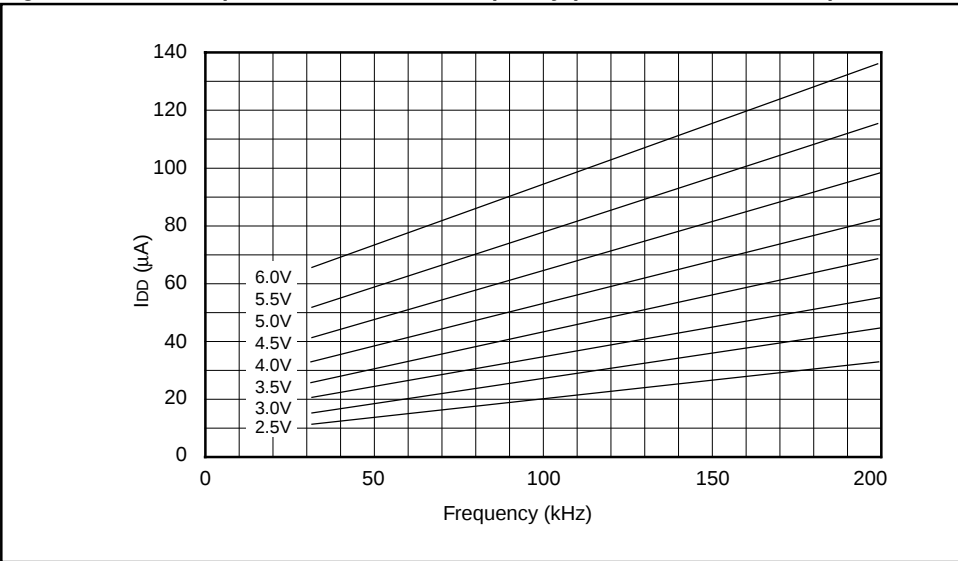


Figure 31-17: Example Maximum I_{DD} vs. Frequency (LP Mode, 85°C to -40°C)



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Figure 31-18: Example Typical I_{DD} vs. Frequency (XT Mode, 25°C)

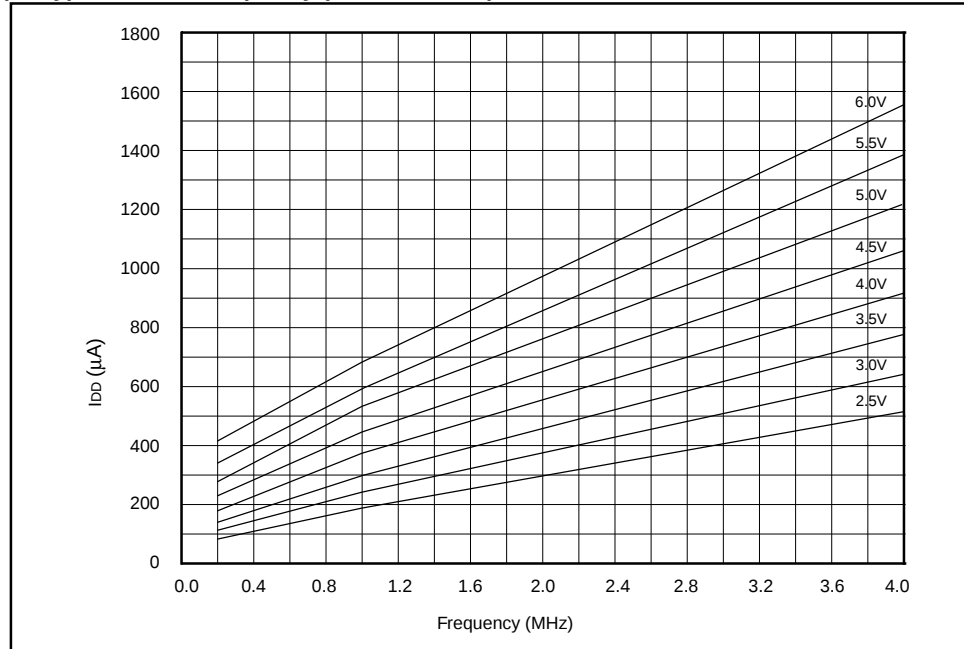
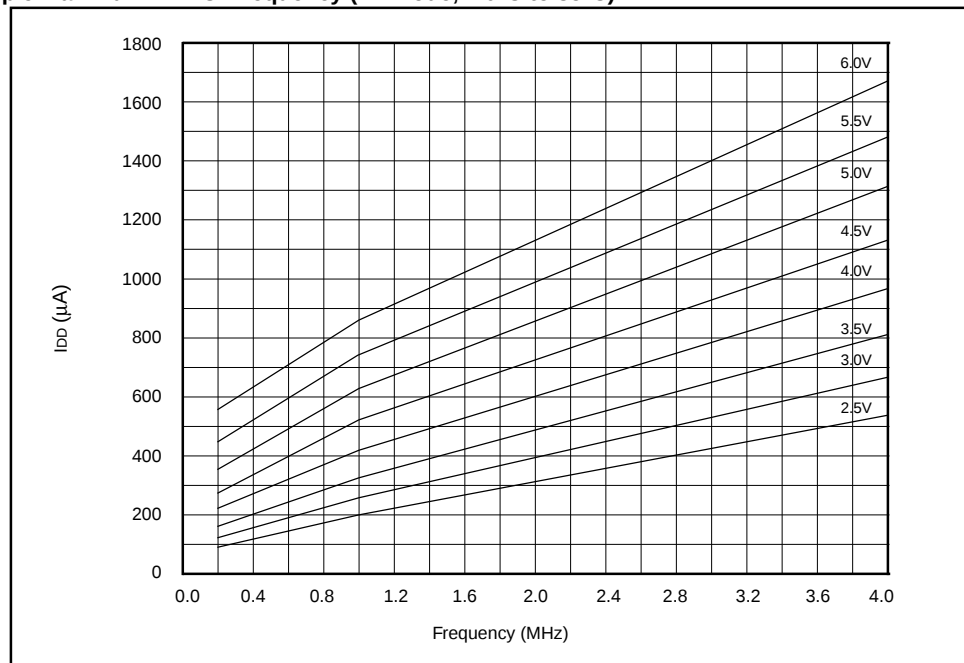


Figure 31-19: Example Maximum I_{DD} vs. Frequency (XT Mode, -40°C to 85°C)



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Figure 31-20: Example Typical I_{DD} vs. Frequency (HS Mode, 25°C)

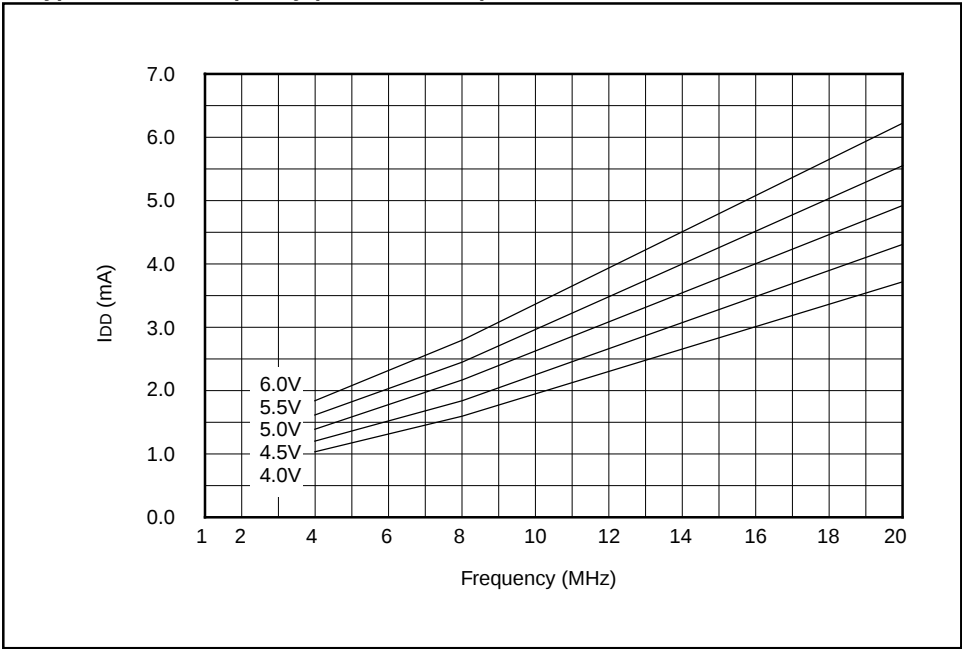
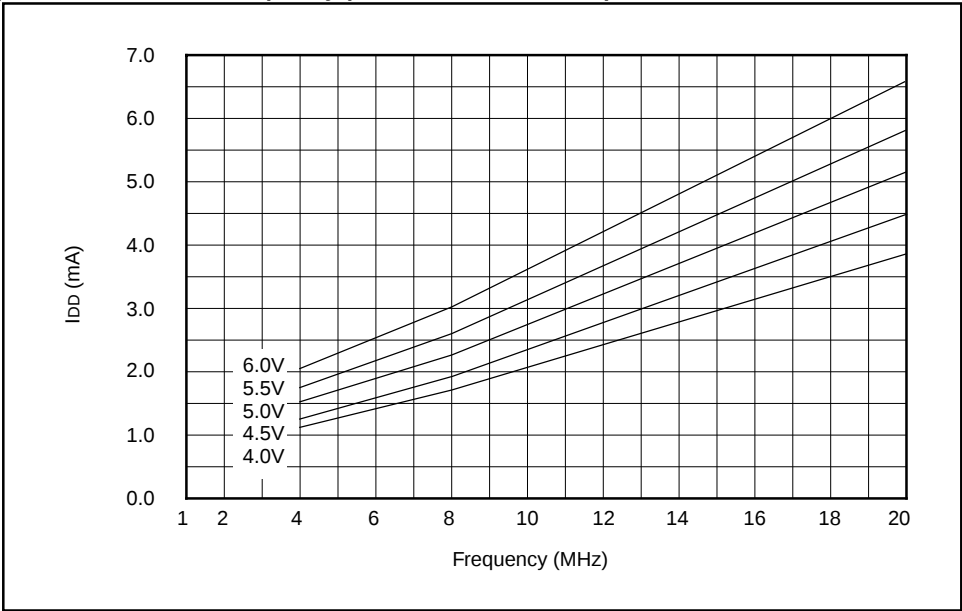


Figure 31-21: Example Maximum I_{DD} vs. Frequency (HS Mode, -40°C to 85°C)



31.3.3 RC Oscillator Frequency

These tables show the effects of the RC oscillator frequency as the device voltage varies. In these measurements a capacitor and resistor value are selected and then the frequency of the RC is measured as the device voltage varies. The table shows the typical frequency for a R and C value at 5V, as well as the variation from this frequency that can be expected due to device processing.

Figure 31-22: Example Typical RC Oscillator Frequency vs. VDD

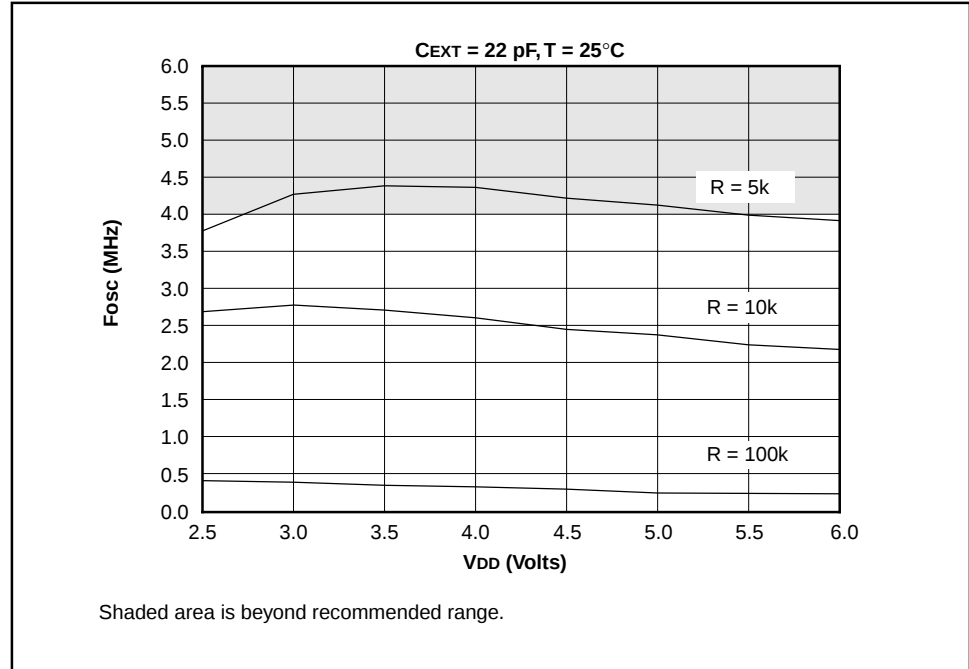
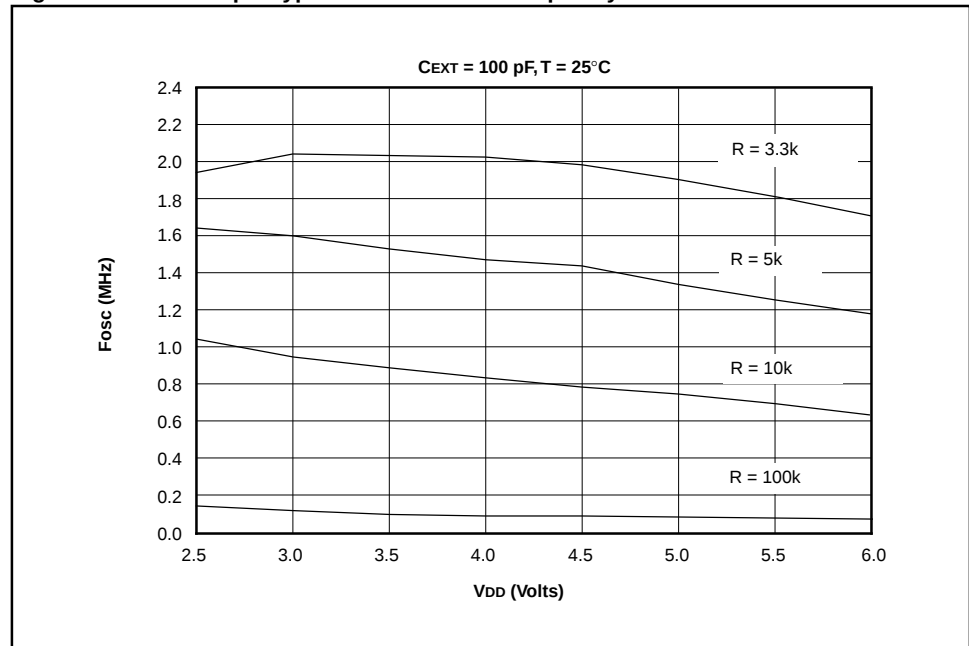


Figure 31-23: Example Typical RC Oscillator Frequency vs. VDD



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Figure 31-24: Example Typical RC Oscillator Frequency vs. VDD

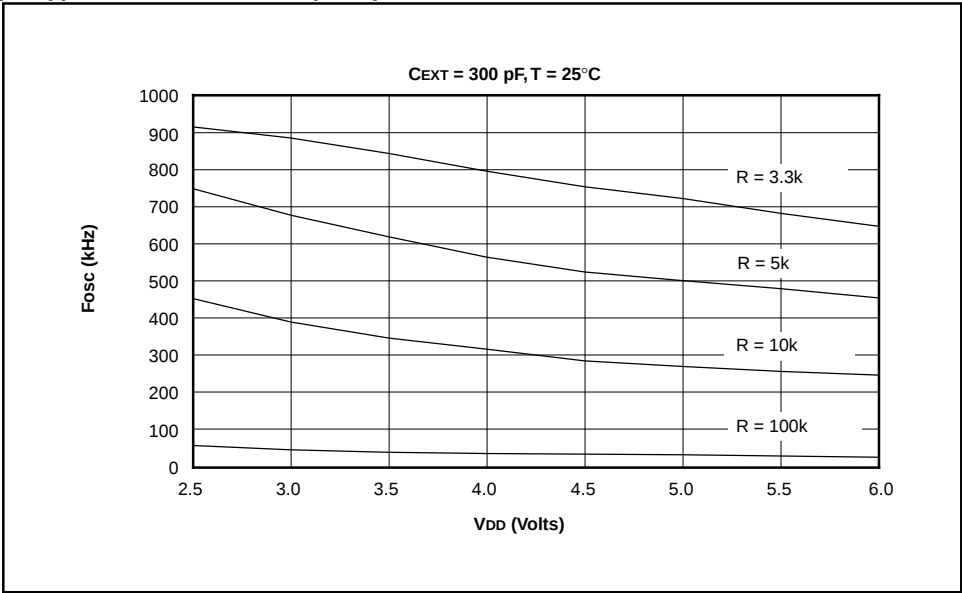


Table 31-1: Example RC Oscillator Frequencies

CEXT	REXT	Average	
		Fosc @ 5V, 25°C	
22 pF	5k	4.12 MHz	± 1.4%
	10k	2.35 MHz	± 1.4%
	100k	268 kHz	± 1.1%
100 pF	3.3k	1.80 MHz	± 1.0%
	5k	1.27 MHz	± 1.0%
	10k	688 kHz	± 1.2%
	100k	77.2 kHz	± 1.0%
300 pF	3.3k	707 kHz	± 1.4%
	5k	501 kHz	± 1.2%
	10k	269 kHz	± 1.6%
	100k	28.3 kHz	± 1.1%

The percentage variation indicated here is part to part variation due to normal process distribution. The variation indicated is ±3 standard deviation from average value for VDD = 5V.

31.3.4 Oscillator Transconductance

Transconductance of the oscillator indicates the gain of the oscillator. As the transconductance increases, the gain of the oscillator circuit increases which causes the current consumption of the oscillator circuit to increase. Also as the transconductance increases the maximum frequency that the oscillator circuit can support also increases, or the start-up time of the oscillator decreases.

Figure 31-25: Example Transconductance (gm) of HS Oscillator vs. VDD

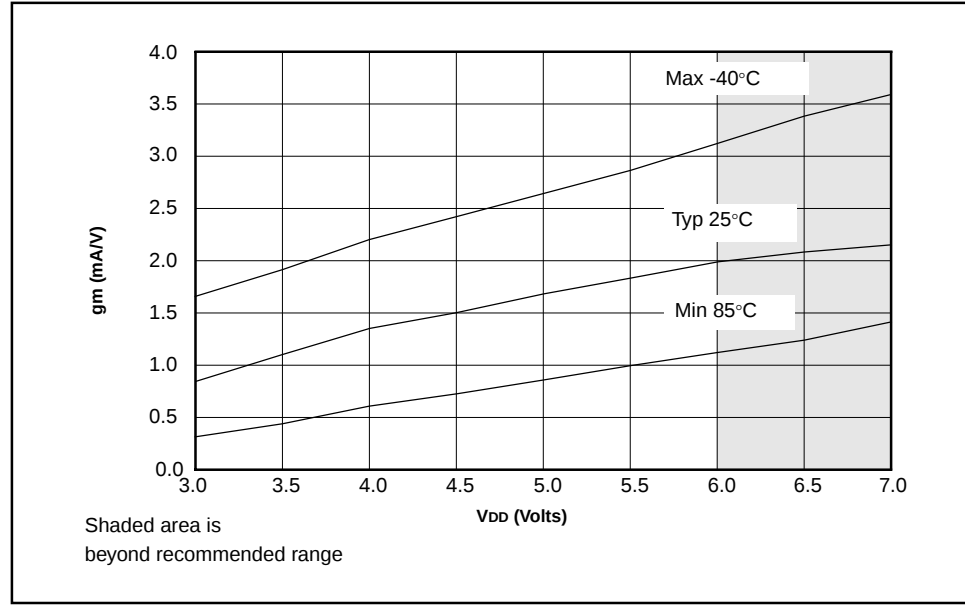
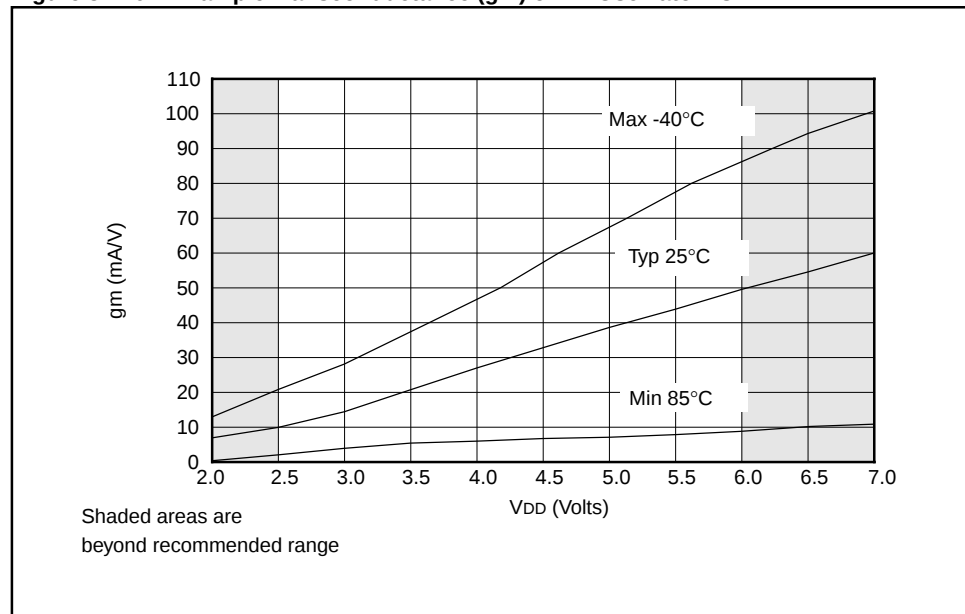
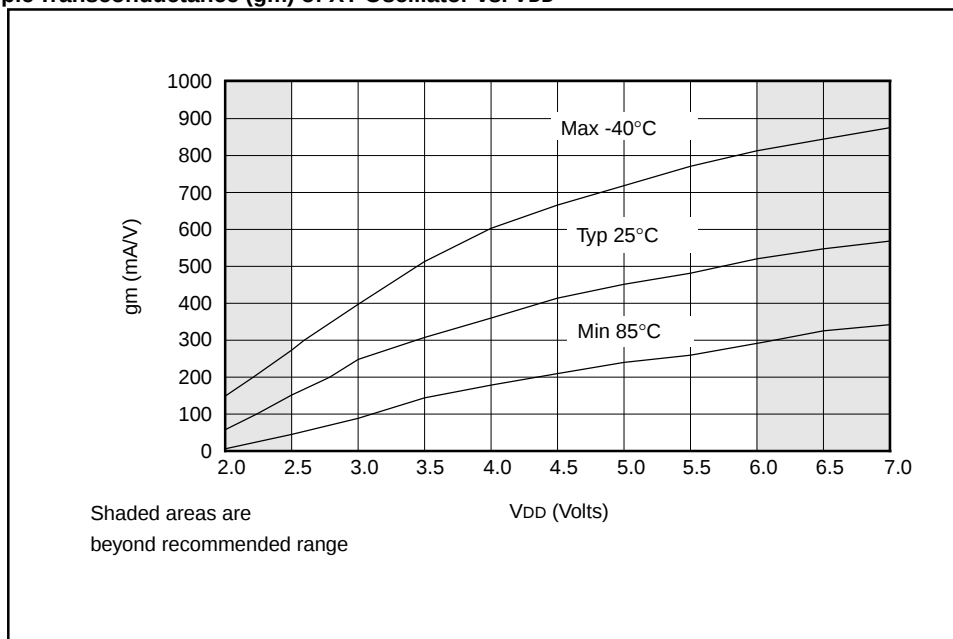


Figure 31-26: Example Transconductance (gm) of LP Oscillator vs. VDD



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Figure 31-27: Example Transconductance (gm) of XT Oscillator vs. VDD



31.3.5 Crystal Start-up Time

These graphs show the start-up time that one should expect to see at the specified voltage level, for a given crystal/capacitor combination.

Figure 31-28: Example Typical XTAL Start-up Time vs. VDD (LP Mode, 25°C)

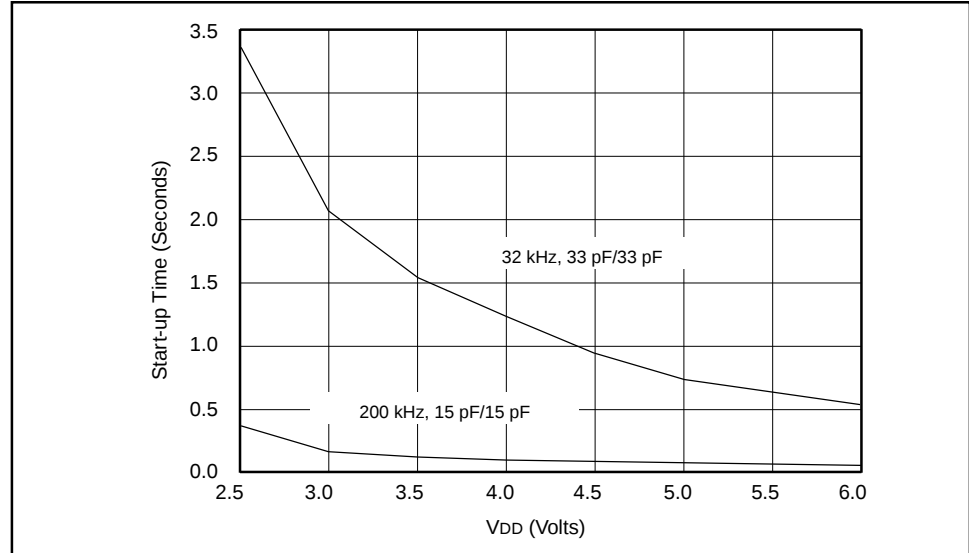
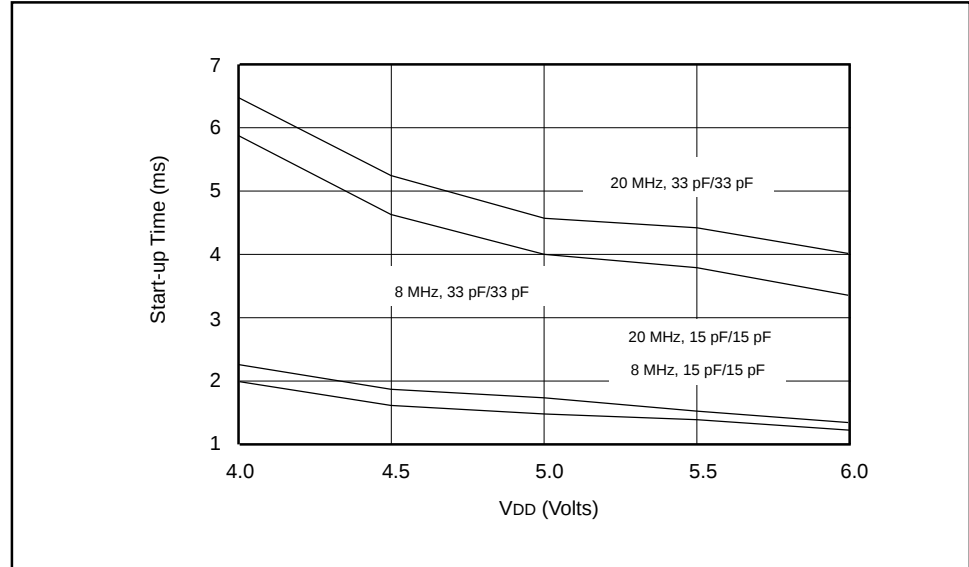
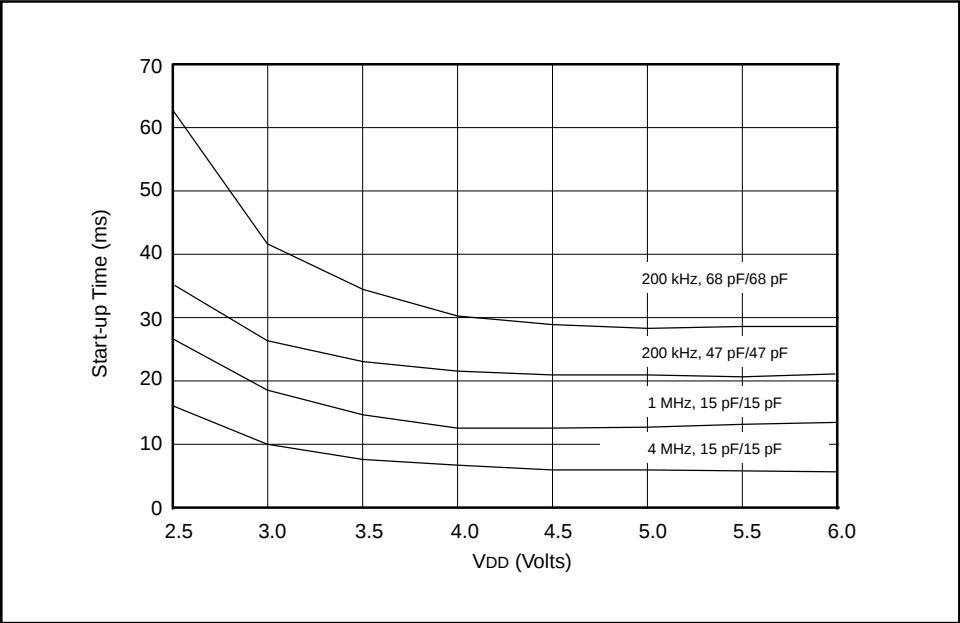


Figure 31-29: Example Typical XTAL Start-up Time vs. VDD (HS Mode, 25°C)



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Figure 31-30: Example Typical XTAL Start-up Time vs. VDD (XT Mode, 25°C)



31.3.6 Tested Crystals and Their Capacitor Values

This table shows the crystal frequency and manufacturer that was used for every tests in this section, as well as the capacitor values/ranges that exhibited the best characteristics.

Table 31-2: Example Capacitor Selection for Crystal Oscillators

Osc Type	Crystal Frequency	Capacitor Range C1	Capacitor Range C2
LP	32 kHz	33 pF	33 pF
	200 kHz	15 pF	15 pF
XT	200 kHz	47-68 pF	47-68 pF
	1 MHz	15 pF	15 pF
	4 MHz	15 pF	15 pF
HS	4 MHz	15 pF	15 pF
	8 MHz	15-33 pF	15-33 pF
	20 MHz	15-33 pF	15-33 pF
Note: Higher capacitance increases the stability of the oscillator but also increases the start-up time. These values are for design guidance only. <i>Rs</i> may be required in HS mode as well as XT mode to avoid overdriving crystals with low drive level specification. Since each crystal has its own characteristics, the user should consult the crystal manufacturer for appropriate values of external components or verify oscillator performance.			
Crystals Used:			
32 kHz	Epson C-001R32.768K-A	± 20 PPM	
200 kHz	STD XTL 200.000KHz	± 20 PPM	
1 MHz	ECS ECS-10-13-1	± 50 PPM	
4 MHz	ECS ECS-40-20-1	± 50 PPM	
8 MHz	EPSON CA-301 8.000M-C	± 30 PPM	
20 MHz	EPSON CA-301 20.000M-C	± 30 PPM	

31.3.7 Example EPROM Memory Erase Times

The UV erase time of an EPROM cell depends on the geometry size of the EPROM cell and the manufacturing technology. Table 31-3 shows some of the expected erase times for each different device.

Table 31-3: Example of Typical EPROM Erase Time Recommendations

Example Device	Wavelength (Angstroms)	Intensity ($\mu\text{W}/\text{cm}^2$)	Distance from UV lamp (inches)	Typical Time ⁽¹⁾ (minutes)
1	2537	12,000	1	15 - 20
2	2537	12,000	1	20
3	2537	12,000	1	40
4	2537	12,000	1	60

Note 1: If these criteria are not met, the erase times will be different.

Table 31-4: Refer to the device data sheet for the typical erase times for a device.

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31.4 Revision History

Revision A

This is the initial released revision of the Device Characteristics description.