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Appendix A - Specifications [U3 Datasheet]

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Table A-1. Specifications at 25 degrees C and Vusb/Vext = 5.0V, except where noted.

Parameter	Conditions	Min	Typical	Max	Units
General					
USB Cable Length				5	meters
Supply Voltage		4	5	5.25	volts
Supply Current (1)	Hardware V1.21+		50		mA
Operating Temperature		-40		85	°C
Clock Error	-40 to 85 °C			1.5	%
Typ. Command Execution Time (2)	USB high-high	0.6			ms
	USB other	4			ms
VS Outputs					
Typical Voltage (3)	Self-Powered	4.75	5	5.25	volts
	Bus-Powered	4	5	5.25	
Maximum Currrent (3)	Self-Powered		450		mA
	Bus-Powered		50		mA
(1) Typical current drawn by the U3 itself, not including any user connections.					
(2) Total typical time to execute a single Feedback function with no analog inputs. Measured by timing a Windows application that performs 1000 calls to the Feedback function. See Section 3.1 for more timing information.					
(3) These specifications are related to the power provided by the host/hub. Self- and bus-powered describes the host/hub, not the U3. Self-powered would apply to USB hubs with a power supply, all known desktop computer USB hosts, and some notebook computer USB hosts. An example of bus-powered would be a hub with no power supply, or many PDA ports. The current rating is the maximum current that should be sources through the U3 and out of the Vs terminals.					

Parameter	Conditions	Min	Typical	Max	Units
Analog Inputs					
Typical input Range (4)	Single-Ended, LV	0		2.44	volts
	Differential, LV	-2.44		2.44	volts
	Special, LV	0		3.6	volts
	Single-Ended, HV	-10.3		10.3	volts
	Special, HV	-10.3		20.1	volts
Max AIN Voltage to GND (5)	Valid Readings, LV	-0.3		3.6	volts
	Valid Readings, HV	-12.8		20.1	volts
Max AIN Voltage to GND (6)	No Damage, FIO	-10		10	volts
	No Damage, EIO	-6		6	volts
	No Damage, HV	-40		40	volts
Input Impedance (7)	LV		40		MΩ
	HV		1.3		MΩ
Source Impedance (7)	Long Settling Off, LV			10	kΩ
	Long Settling On, LV			200	kΩ
	Long Settling Off, HV			1	kΩ
	Long Settling On, HV			1	kΩ
Resolution	All Ranges		12		bits
	Single-Ended, LV, 0-2.44		0.6		mV
	Differential, LV, ±2.44		1.2		mV
	Special, LV, 0-3.6		1.2		mV
	Single-Ended, HV, ±10		5.0		mV
	Special, HV, -10 to +20		10.0		mV
Integral Linearity Error			±0.05		% FS
Differential Linearity Error			±1		counts
Absolute Accuracy (8)	Single-Ended %		±0.13		% FS
	Single-Ended LV volts		±3.2		mV
	Single-Ended HV volts		±26.8		mV
	Differential %		±0.25		% FS
	Differential LV volts		±6.4		mV
	Differential HV volts		N/A		
	Special 0-3.6 %		±0.25		% FS
	Special LV volts		±6.4		mV
	Special HV volts		±53.6		mV
Temperature Drift			15		ppm/°C
Noise (Peak-To-Peak) (9)	Quick Sample Off		±1		counts
	Quick Sample On		±2		counts
Effective Resolution (RMS) (10)	Quick Sample Off		>12		bits
Noise-Free Resolution (9)	Quick Sample Off		11		bits
Command/Response Speed	See Section 3.1				

Stream Performance	See Section 3.2				
* LV specs refer to low voltage analog inputs which are available on the U3-LV and U3-HV. HV specs refer to high voltage analog inputs which are available on the U3-HV only.					
(4) Note that these are typical input ranges. The actual minimum on the low voltage inputs might not go all the way to 0.0 as discussed in Section 2.6.3.9. These are with DAC1 disabled on hardware version < 1.30.					
(5) This is the maximum voltage on any AIN pin compared to ground for valid measurements. Note that a differential channel has a minimum voltage of -2.44 volts, meaning that the positive channel can be 2.44 volts less than the negative channel, but no low-voltage AIN pin can go more than 0.3 volts below ground.					
(6) Maximum voltage, compared to ground, to avoid damage to the device. Protection level is the same whether the device is powered or not.					
(7) The low-voltage analog inputs essentially connect directly to a SAR ADC on the U3, presenting a capacitive load to the signal source. The high-voltage inputs connect first to a resistive level-shifter/divider. The key specification in both cases is the maximum source impedance. As long as the source impedance is not over this value, there will be no substantial errors due to impedance problems.					
(8) Absolute error includes INL, DNL, and all other sources of internal error at 25 C and VS=5.0V. To equate the percentage to voltage, multiply the full voltage span by the percentage. For a single-ended low voltage input using the normal range the span is about 2.4 volts, so 2.4 * 0.0013 gives ±0.003 volts. For a single-ended high voltage input using the normal range the span is about 20 volts, so 20 * 0.0013 gives ±0.026 volts. Differential readings are not calibrated on high voltage channels.					
(9) Measurements taken with AIN connected to a 2.048 reference (REF191 from Analog Devices) or GND. All "counts" data are aligned as 12-bit values. Noise-free data is determined by taking 128 readings and subtracting the minimum value from the maximum value.					
(10) Effective (RMS) data is determined from the standard deviation of 128 readings. In other words, this data represents _most_ readings, whereas noise-free data represents all readings.					
Parameter	**Conditions**	**Min**	**Typical**	**Max**	**Units**
Analog Outputs (DAC)					
Nominal Output Range (11)	No Load	0.04		4.95	volts
	@ ±2.5 mA	0.225		4.775	volts
Resolution			10		bits
Absolute Accuracy	5% to 95% FS		±5		% FS
Integral Linearity Error			±1		counts
Differential Linearity Error			±1		counts
Max Output Current (12)	@ 2.0V		30		mA

Error Due To Loading (12)	@ 100 µA		0.1		%
	@ 1 mA		1		%
Source Impedance (12)			50		Ω
Short Circuit Current (12,13)	5V to GND		50		mA
Cutoff Frequency (14)	-3 dB		16		Hz
Time Constant (14)			10		ms
Digital I/O, Timers, Counters					
Low Level Input Voltage		-0.3		0.8	volts
Hight Level Input Voltage		2		5.8	volts
Maximum Input Voltage (15)	FIO	-10		10	volts
	EIO/CIO	-6		6	volts
Output Low Voltage (16)	No Load		0		volts
--- FIO	Sinking 1 mA		0.55		volts
--- EIO/CIO	Sinking 1 mA		0.18		volts
--- EIO/CIO	Sinking 5 mA		0.9		volts
Output High Voltage (16)	No Load		3.3		volts
--- FIO	Sourcing 1 mA		2.75		volts
--- EIO/CIO	Sourcing 1 mA		3.12		volts
--- EIO/CIO	Sourcing 5 mA		2.4		volts
Short Circuit Current (16)	FIO		6		mA
	EIO/CIO		18		mA
Input Impedance	Pull-up to 3.3V		100		kΩ
Output Impedance (16)	FIO		550		Ω
	EIO/CIO		180		Ω
Counter Input Frequency (17)	Hardware V1.21+			8	MHz
Input Timer Total Edge Rate (18)	No Stream, V1.21+			30000	edges/s
	While Streaming			7000	edges/s

(11) Maximum and minimum analog output voltage is limited by the supply voltages (Vs and GND). The specifications assume Vs is 5.0 volts. Also, the ability of the DAC output buffer to driver voltages close to the power rails, decreases with increasing output current, but in most applications the output is not sinking/sourcing much current as the output voltage approaches GND.

(12) If the output is set to 3.5 volts and sourcing 30 mA, there will be about 2.0 volts at the DAC pin due to the 50 ohms of series impedance. Each DAC output is driven by a channel on an AD8544 op-amp, powered by VS & GND, and then goes through protection circuitry that includes 50 ohms of series impedance. The max output current is determined by 3 main factors: short circuit current, ability of AD8544 to sink/source near power rails (Figure 22 of AD8544 datasheet), and the 50 ohms of series impedance.

(13) Continuous short circuit will not cause damage.

(14) The DAC outputs are creating by filtering PWM signals, and the 2nd order 16 Hz output filter works great for the default PWM frequency of 732 Hz, but with lower

frequency timer clocks the DAC outputs will be noisier. See Section 2.7 for more details. Time constant is the time it take for the output to settle 63% of the way towards a new value.
(15) Maximum voltage to avoid damage to the device. Protection works whether the device is powered or not, but continuous voltages over 5.8 volts or less than -0.3 volts are not recommended when the U3 is unpowered, as the voltage will attempt to supply operating power to the U3 possible causing poor start-up behavior.
(16) These specifications provide the answer to the question: "How much current can the digital I/O sink or source?". For instance, if EIO0 is configured as output-high and shorted to ground, the current sourced by EIO0 into ground will be about 18 mA (3.3/180). If connected to a load that draws 5 mA, EIO0 can provide that current but the voltage will droop to about 2.4 volts instead of the nominal 3.3 volts. If connected to a 180 ohm load to ground, the resulting voltage and current will be about 1.65 volts @ 9 mA.
(17) Hardware counters. 0 to 3.3 volt square wave. Limit 2 MHz with older hardware versions.
(18) To avoid missing edges, keep the total number of applicable edges on all applicable timers below this limit. See Section 2.9 for more information. Limit 10000 with older hardware versions.