USB-6453 and USB-6453 (OEM) Specifications

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Contents

USB-6453 and USB-6453 (OEM) Specifications

USB-6453 and USB-6453 (OEM) Specifications

These specifications apply to the USB-6453 (Revision D, Revision F, and subsequent revisions) and USB-6453 (OEM). Unless Revision D or the OEM version is specified, USB-6453 refers to both versions.

Revision History

Version	Date changed	Description
379044E-01	February 2025	Added 1.8 V, 2.5 V, and 3.3 V logic families and analog triggers.
379044D-01	January 2025	Differentiated between Revision F and earlier revisions.
379044C-01	November 2024	Added USB-6453 (OEM).
379044B-01	October 2024	Updated for the NI mioDAQ 24C3 release.
379044A-01	September 2024	Initial release.

Looking For Something Else?

For information not found in the specifications for your product, such as operating instructions, browse ***Related Information***.

Related information:

- USB-6453 and USB-6453 (OEM) User Manual
- Software and Driver Downloads
- Dimensional Drawings
- Product Certifications
- Letter of Volatility

- Discussion Forums

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- ***Typical*** specifications describe the performance met by a majority of models.
- ***Nominal*** specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are ***Typical*** unless otherwise noted.

Conditions

Specifications are valid at 25 °C unless otherwise noted.

USB-6453 AI Connector Pinout

Use the pinout to connect to analog input terminals on the USB-6453.

Figure 1. USB-6453 AI Connector Pinout

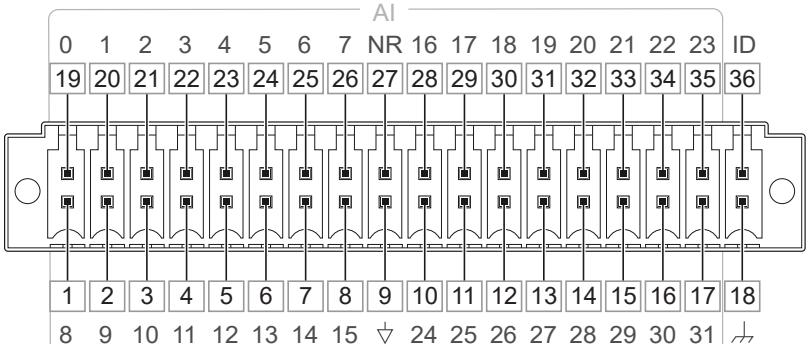


Table 1. USB-6453 AI Connector Pin Assignments

Pin	Signal
1	AI 8
2	AI 9
3	AI 10
4	AI 11
5	AI 12
6	AI 13
7	AI 14
8	AI 15
9	AI GND
10	AI 24
11	AI 25
12	AI 26
13	AI 27
14	AI 28
15	AI 29
16	AI 30
17	AI 31
18	CHSGND
19	AI 0
20	AI 1
21	AI 2
22	AI 3
23	AI 4
24	AI 5
25	AI 6
26	AI 7

Pin	Signal
27	NR (AI SENSE)
28	AI 16
29	AI 17
30	AI 18
31	AI 19
32	AI 20
33	AI 21
34	AI 22
35	AI 23
36	ID 0

Table 2. USB-6453 AI Connector Signal Descriptions

Signal	Function	Reference	Direction	Description
AI <0..7> AI <16..23>	Analog input channels	Varies	Input	Supports differential or single-ended measurement modes. The default configuration is differential mode. In differential mode, these channels are the positive input for the differential pair. The negative input of the differential pair is located directly beneath the positive input. In single-ended mode, each signal is a separate analog input voltage channel. The ground reference in single-ended mode is configurable. In referenced single-ended (RSE) mode, AI GND is the reference for the voltage measurement. In non-referenced single-ended (NRSE) mode, the NR pin is the reference. **Note** You can configure the input mode per channel.

Signal	Function	Reference	Direction	Description
AI <8..15> AI <24..31>	Analog input channels	Varies	Input	Supports single-ended measurements only. The default configuration is (RSE) mode. In RSE mode, AI GND is the reference for the voltage measurement. In NRSE mode, the NR pin is the reference. For differential measurements, refer to the descriptions for AI <0..7> and AI <16..23>.
AI GND	Analog input ground	—	—	The reference point for single-ended measurements in RSE mode and the bias current return point for differential measurements. AI GND, AO GND, D GND, and CHSGND are all connected internally.
NR (AI SENSE)	AI SENSE for NRSE mode	—	Input	The AI SENSE pin is labeled "NR" because it is used when the input terminal is configured to NRSE mode. In NRSE mode, AI SENSE acts as a remote sense of a reference voltage that can be at a different voltage potential than AI GND.
CHSGND	Chassis ground	—	—	Connects directly to the chassis ground of the USB-6453 enclosure. It can be used as a termination point for shielded cables to help improve measurement quality.
ID 0	—	—	—	This feature is not supported yet.

USB-6453 AO/DIO Connector Pinout

Use the pinout to connect to analog output and digital input/output terminals on the USB-6453.

Figure 2. USB-6453 AO/DIO Connector Pinout

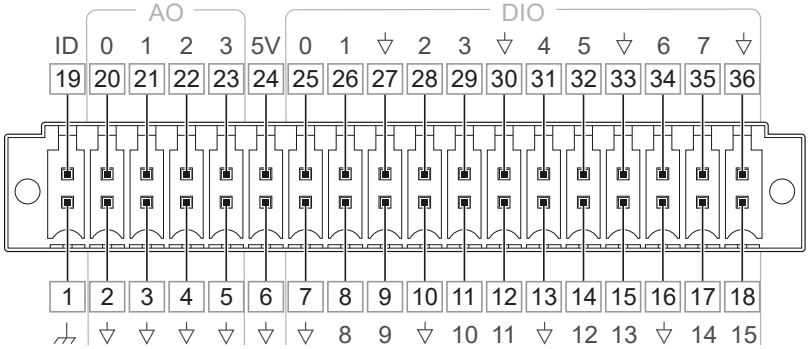


Table 3. USB-6453 AO/DIO Connector Pin Assignments

Pin	Signal
1	CHSGND
2	AO GND
3	AO GND
4	AO GND
5	AO GND
6	D GND
7	D GND
8	PFI 8/P0.8 (port0/line8)
9	PFI 9/P0.9 (port0/line9)
10	D GND
11	PFI 10/P0.10 (port0/line10)
12	PFI 11/P0.11 (port0/line11)
13	D GND
14	PFI 12/P0.12 (port0/line12)
15	PFI 13/P0.13 (port0/line13)
16	D GND
17	PFI 14/P0.14 (port0/line14)
18	PFI 15/P0.15 (port0/line15)
19	ID 1

Pin	Signal
20	AO 0
21	AO 1
22	AO 2
23	AO 3
24	+5 V
25	PFI 0/P0.0 (port0/line0)
26	PFI 1/P0.1 (port0/line1)
27	D GND
28	PFI 2/P0.2 (port0/line2)
29	PFI 3/P0.3 (port0/line3)
30	D GND
31	PFI 4/P0.4 (port0/line4)
32	PFI 5/P0.5 (port0/line5)
33	D GND
34	PFI 6/P0.6 (port0/line6)
35	PFI 7/P0.7 (port0/line7)
36	D GND

Table 4. USB-6453 AO/DIO Connector Signal Descriptions

Signal	Function	Reference	Direction	Description
AO <0..3>	Analog output channels	AO GND	Output	Supplies the voltage output of the AO channels.
AO GND	Analog output ground	—	—	AO GND is the reference for the AO channels. AI GND, AO GND, D GND, and CHSGND are all connected internally.
+5 V	+5 V power	D GND	Output	Provides current limited +5 V power output that can be used to power external circuitry.

Signal	Function	Reference	Direction	Description
	source			Refer to the ***+5 V Power Source*** section for more information. Leave this pin open if you do not use it.
PFI <0..15>/P0.<0..15>	Port 0 digital I/O channels	D GND	Input or output	Digital channels that can be individually configured as input or output. These channels are referred to as port0/line0:15 in software when used as digital I/O. They are referred to as PFI 0:15 when used for other purposes, like timing I/O. Can also be individually configured for the following uses. • Digital I/O • Counter/timer input • Counter/timer output • External timing or trigger signal input for AI, AO, DI, DO, counter, or timers • Timing or trigger signal output from AI, AO, DI, DO, counter, or timers
D GND	Digital ground	—	—	Supplies the reference for the P0.<0..15> pins and +5 V pin. AI GND, AO GND, D GND, and CHSGND are all connected internally.
CHSGND	Chassis ground	—	—	Connects directly to the chassis ground of the USB-6453 enclosure. It can be used as a termination point for shielded cables to help improve measurement quality.
ID 1	—	—	—	This feature is not supported yet.

Related information:

- +5 V Power Source

USB-6453 (OEM) AI Connector Pinout

Use the pinout to connect to analog input terminals on the USB-6453 (OEM).

Figure 3. USB-6453 (OEM) AI Connector Pinout

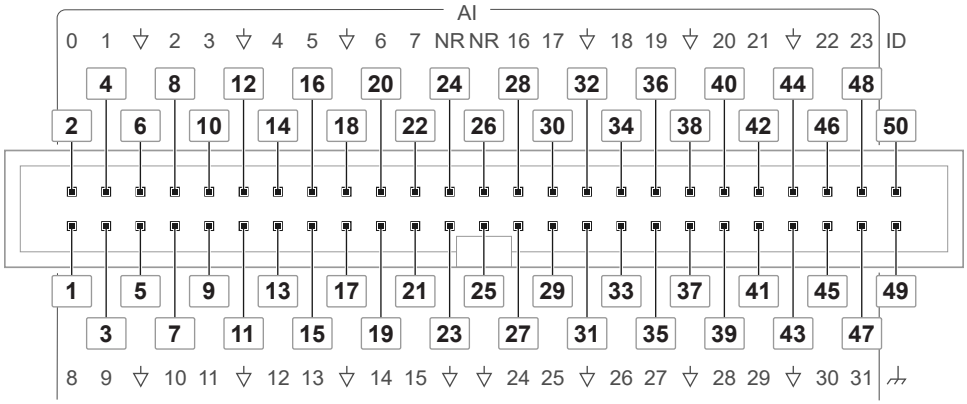


Table 5. USB-6453 (OEM) AI Connector Pin Assignments

Pin	Signal
1	AI 8
2	AI 0
3	AI 9
4	AI 1
5	AI GND
6	AI GND
7	AI 10
8	AI 2
9	AI 11
10	AI 3
11	AI GND
12	AI GND
13	AI 12
14	AI 4
15	AI 13

Pin	Signal
16	AI 5
17	AI GND
18	AI GND
19	AI 14
20	AI 6
21	AI 15
22	AI 7
23	AI GND
24	NR (AI SENSE)
25	AI GND
26	NR (AI SENSE)
27	AI 24
28	AI 16
29	AI 25
30	AI 17
31	AI GND
32	AI GND
33	AI 26
34	AI 18
35	AI 27
36	AI 19
37	AI GND
38	AI GND
39	AI 28
40	AI 20
41	AI 29
42	AI 21

Pin	Signal
43	AI GND
44	AI GND
45	AI 30
46	AI 22
47	AI 31
48	AI 23
49	CHSGND
50	ID 0

Table 6. USB-6453 (OEM) AI Connector Signal Descriptions

Signal	Function	Reference	Direction	Description
AI <0..7> AI <16..23>	Analog input channels	Varies	Input	Supports differential or single-ended measurement modes. The default configuration is differential mode. In differential mode, these channels are the positive input for the differential pair. The negative input of the differential pair is located directly beneath the positive input. In single-ended mode, each signal is a separate analog input voltage channel. The ground reference in single-ended mode is configurable. In referenced single-ended (RSE) mode, AI GND is the reference for the voltage measurement. In non-referenced single-ended (NRSE) mode, the NR pin is the reference. **Note** You can configure the input mode per channel.
AI <8..15>	Analog input channels	Varies	Input	Supports single-ended measurements only. The default configuration is RSE mode. In RSE mode, AI GND is the reference for the voltage measurement. In

Signal	Function	Reference	Direction	Description
AI <24..31>				NRSE mode, the NR pin is the reference. For differential measurements, refer to the descriptions for AI <0..7> and AI <16..23>.
AI GND	Analog input ground	—	—	The reference point for single-ended measurements in RSE mode and the bias current return point for differential measurements. AI GND, AO GND, D GND, and CHSGND are all connected internally.
NR (AI SENSE)	AI SENSE for NRSE mode	—	Input	The AI SENSE pin is labeled "NR" because it is used when the input terminal is configured to NRSE mode. In NRSE mode, AI SENSE acts as a remote sense of a reference voltage that can be at a different voltage potential than AI GND.
CHSGND	Chassis ground	—	—	Connects directly to the chassis ground lug of the USB-6453 (OEM). It can be used as a termination point for shielded cables to help improve measurement quality.
ID 0	—	—	—	This feature is not supported yet.

USB-6453 (OEM) AO/DIO Connector Pinout

Use the pinout to connect to analog output and digital input/output terminals on the USB-6453 (OEM).

Figure 4. USB-6453 (OEM) AO/DIO Connector Pinout

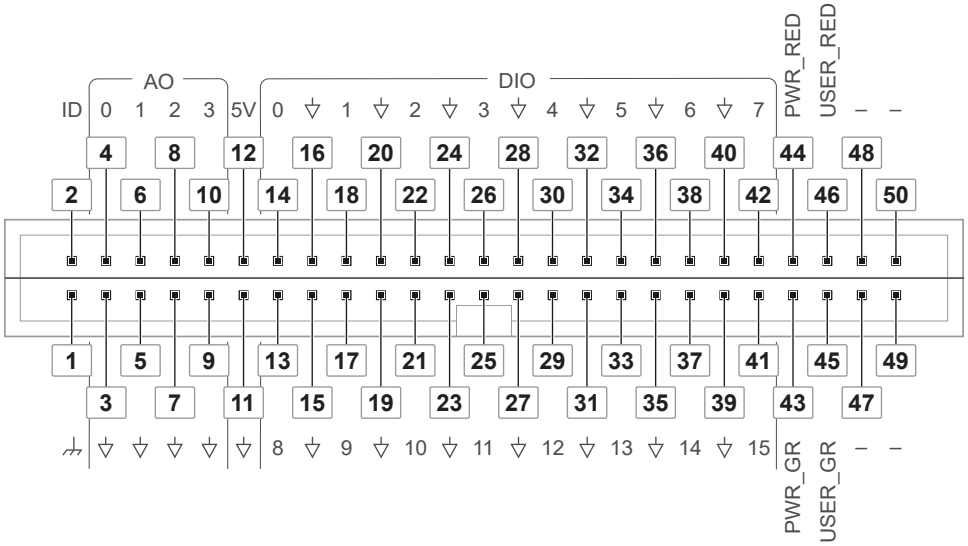


Table 7. USB-6453 (OEM) AO/DIO Connector Pin Assignments

Pin	Signal
1	CHSGND
2	ID 1
3	AO GND
4	AO 0
5	AO GND
6	AO 1
7	AO GND
8	AI 2
9	AO GND
10	AI 3
11	D GND
12	+5 V
13	PFI 8/P0.8 (port0/line8)
14	PFI 0/P0.0 (port0/line0)
15	D GND
16	D GND

Pin	Signal
17	PFI 9/P0.9 (port0/line9)
18	PFI 1/P0.1 (port0/line1)
19	D GND
20	D GND
21	PFI 10/P0.10 (port0/line10)
22	PFI 2/P0.2 (port0/line2)
23	D GND
24	D GND
25	PFI 11/P0.11 (port0/line11)
26	PFI 3/P0.3 (port0/line3)
27	D GND
28	D GND
29	PFI 12/P0.12 (port0/line12)
30	PFI 4/P0.4 (port0/line4)
31	D GND
32	D GND
33	PFI 13/P0.13 (port0/line13)
34	PFI 5/P0.5 (port0/line5)
35	D GND
36	D GND
37	PFI 14/P0.14 (port0/line14)
38	PFI 6/P0.6 (port0/line6)
39	D GND
40	D GND
41	PFI 15/P0.15 (port0/line15)
42	PFI 7/P0.7 (port0/line7)
43	PWR_GR

Pin	Signal
44	PWR_RED
45	USER_GR
46	USER_RED
47	No connect
48	No connect
49	No connect
50	No connect

Table 8. USB-6453 (OEM) AO/DIO Connector Signal Descriptions

Signal	Function	Reference	Direction	Description
AO <0..3>	Analog output channels	AO GND	Output	Supplies the voltage output of the AO channels.
AO GND	Analog output ground	—	—	AO GND is the reference for the AO channels. AI GND, AO GND, D GND, and CHSGND are all connected internally.
+5 V	+5 V power source	D GND	Output	Provides current limited +5 V power output that can be used to power external circuitry. Refer to the ***+5 V Power Source*** section for more information. Leave this pin open if you do not use it.
PFI <0..15>/P0.<0..15>	Port 0 digital I/O channels	D GND	Input or output	Digital channels that can be individually configured as input or output. These channels are referred to as port0/line0:15 in software when used as digital I/O. They are referred to as PFI 0:15 when used for other purposes, like timing I/O. Can also be individually configured for the

Signal	Function	Reference	Direction	Description
				following uses. • Digital I/O • Counter/timer input • Counter/timer output • External timing or trigger signal input for AI, AO, DI, DO, counter, or timers • Timing or trigger signal output from AI, AO, DI, DO, counter, or timers
D GND	Digital ground	—	—	Supplies the reference for the P0.<0..15> pins and +5 V pin. AI GND, AO GND, D GND, and CHSGND are all connected internally.
CHSGND	Chassis ground	—	—	Connects directly to the chassis ground of the USB-6453 (OEM) enclosure. It can be used as a termination point for shielded cables to help improve measurement quality.
PWR_GR	USB PWR LED green color	DGND	Output	Digital logic control signal that is high when the USB PWR LED is green or yellow. You can use this signal to drive an external LED. Leave this pin open if you do not use it.
PWR_RED	USB PWR LED red color	DGND	Output	Digital logic control signal that is high when the USB PWR LED is red or yellow. You can use this signal to drive an external LED. Leave this pin open if you do not use it.
USER_GR	User LED green color	DGND	Output	Digital logic control signal that is high when the USER LED is green or yellow. You can use this signal to drive an external LED.

Signal	Function	Reference	Direction	Description
				Leave this pin open if you do not use it.
USER_RED	User LED red color	DGND	Output	Digital logic control signal that is high when the USER LED is red or yellow. You can use this signal to drive an external LED. Leave this pin open if you do not use it.
ID 1	—	—	—	This feature is not supported yet.

Analog Input

Number of channels	32 single-ended or 16 differential
Number of ADC	16
Simultaneous sampling channels	Up to 16 channels
ADC resolution	20 bits
DNL	No missing codes guaranteed
INL	Refer to ***AI Absolute Accuracy***

Sample rate	
Simultaneous sampling	1 MS/s/ch for all 16 differential channels

	1 MS/s/ch for up to 16 single-ended channels
Single-ended channel scan sampling[1]	500 kS/s per channel
Minimum	No minimum
Timing resolution	10 ns
Timing accuracy	50 ppm of sample rate

Input coupling	DC
Input range	±0.2 V ±2.5 V ±5 V ±10 V
Power on state	Differential Mode at 10 V Range

1. Pairs of single-ended channels are connected to a single ADC. (For example, AI0 and AI8, AI1 and AI9, etc.). When sampling any two single-ended channels connected to the same ADC, the channels are scanned in banks, and the maximum rate decreases to 500 kS/s/ch. In this case, AI0:7 are sampled simultaneously, then AI8:15 are sampled later after a delay controlled by the AIConv.Rate property.

Table 9. Maximum Working Voltage

Input Range	Product Version	Maximum Working Voltage for Analog Inputs (Signal + Common Mode)
±2.5 V, ±5 V, ±10 V	USB-6453 and USB-6453 (OEM)	±10.5 V to AI GND
±0.2 V	USB-6453 (Revision D)	±3.5 V to AI GND
	USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM)	±8.0 V to AI GND

Table 10. Input Impedance

Device on	AI+ to AI GND	>10 GΩ in parallel with 35 pF
	AI- to AI GND	>10 GΩ in parallel with 35 pF
Device off	AI+ to AI GND	1,290 Ω
	AI- to AI GND	1,290 Ω

Input bias current	±10 pA typical ±2 nA maximum over full temperature range

Crosstalk (at 100 kHz)	
Differential channels	-75 dB
Single-ended channels	-63 dB

Table 11. Small Signal Bandwidth

Input Range	Product Version	Small Signal Bandwidth (-3 dB)
±2.5 V, ±5 V, ±10 V	USB-6453 and USB-6453 (OEM)	1.3 MHz
±0.2 V	USB-6453 (Revision D)	800 kHz

Input Range	Product Version	Small Signal Bandwidth (-3 dB)
	USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM)	360 kHz

Figure 5. USB-6453 (Revision D) Small Signal Bandwidth versus Frequency

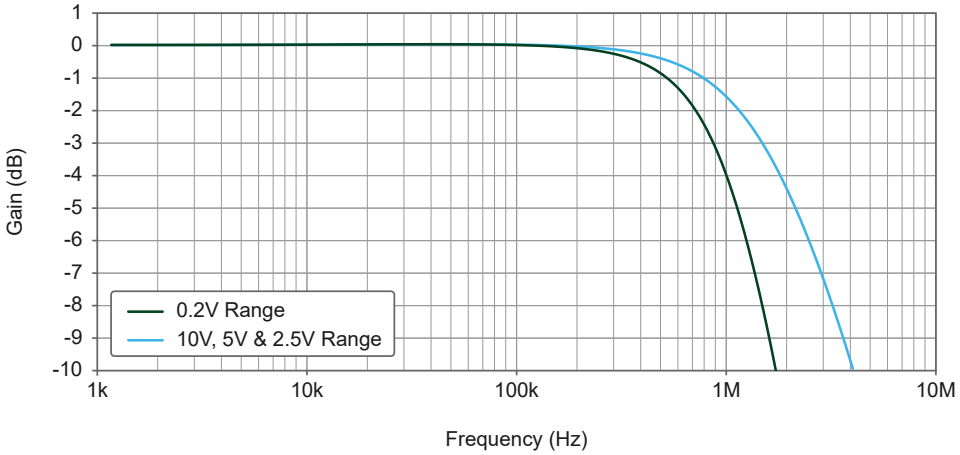
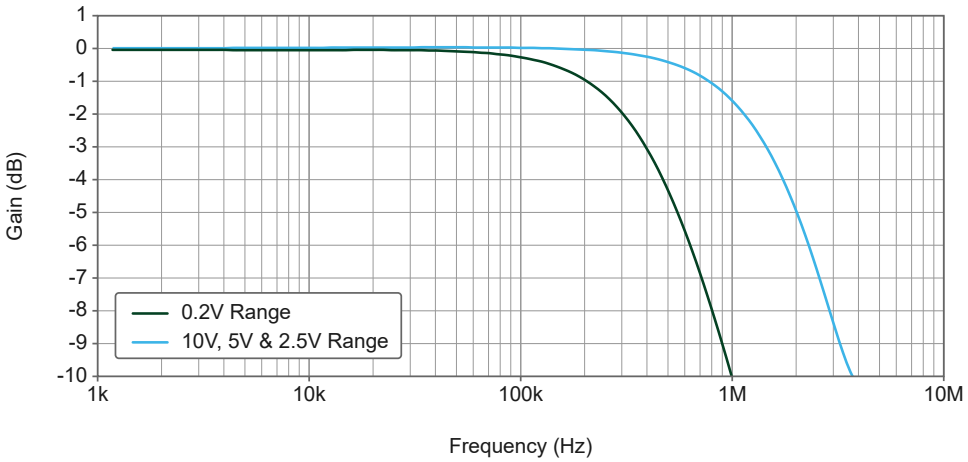


Figure 6. USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM) Small Signal Bandwidth versus Frequency



Common-mode rejection ratio (CMRR) (DC to 60 Hz)[2]	
Differential mode	100 dB
Non-referenced single-ended (NRSE) mode	100 dB

2. The CMRR for the USB-6453 (Revision D) is >90 dB on the ±0.2 V range when the common-mode voltage is above +2 V and >95 dB on the ±5 V range when the common-mode voltage is above +7 V.

Figure 7. USB-6453 (Revision D) CMRR versus Frequency

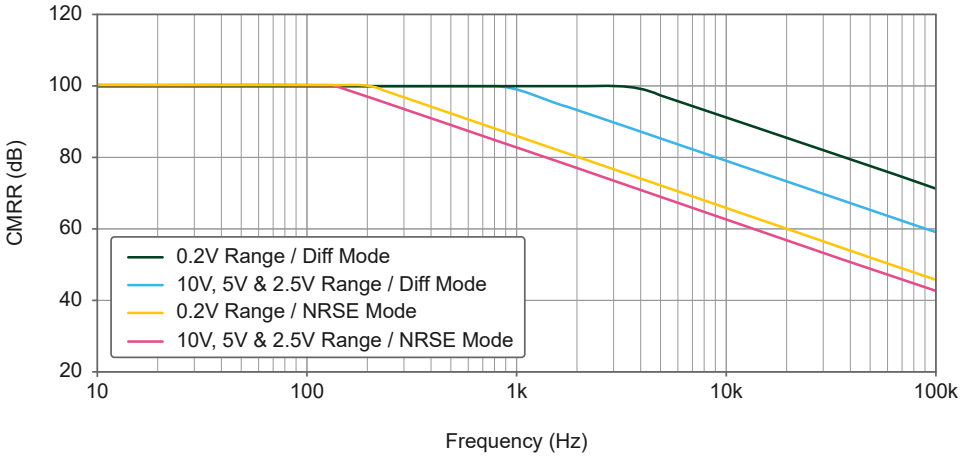
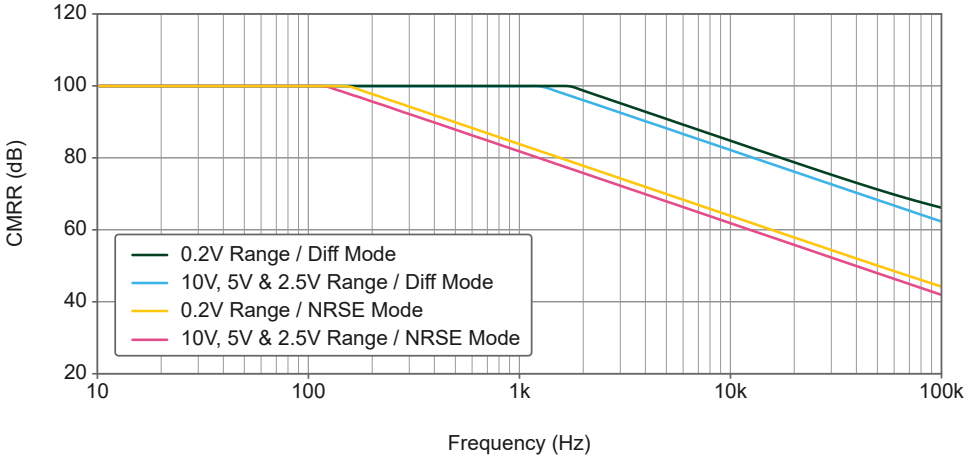


Figure 8. USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM) CMRR versus Frequency



Input FIFO size	8,191 samples shared among channels used
Data transfers	USB Signal Stream, programmed I/O

Overvoltage protection for AI<0..31> and NR (AI Sense) pins	
Device on	±30 V for up to two AI pins

The CMRR for the USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM) is >95 dB on the ±5 V range when the common-mode voltage is above +7 V.

Device off	±20 V for up to two AI pins
Input current during overvoltage condition	±14 mA maximum per AI pin ±45 µA maximum per NR pin

Table 12. Settling Time to Accuracy for Single-Ended Scan Multi-Channel Measurements at Full Scale Step

Input Range	Product Version	±450 ppm	±90 ppm	±30 ppm	±15 ppm	±4 ppm
±2.5 V, ±5 V, ±10 V	USB-6453 and USB-6453 (OEM)	1.0 µs	2.7 µs	6.2 µs	11.0 µs	40.0 µs
±0.2 V	USB-6453 (Revision D)	1.7 µs	2.1 µs	2.5 µs	4.0 µs	50.0 µs
	USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM)	3.2 µs	4.0 µs	6.2 µs	8.0 µs	16.0 µs

Note The ***AI Absolute Accuracy*** table excludes the settling error from this Scan Mode measurement.

Note For applications that require a settling time greater than 10 µs, configure the AIConv.Rate property.

Figure 9. USB-6453 Settling Error versus Time for Different Source Impedances at 10 V, 5 V, and 2.5 V Input Ranges

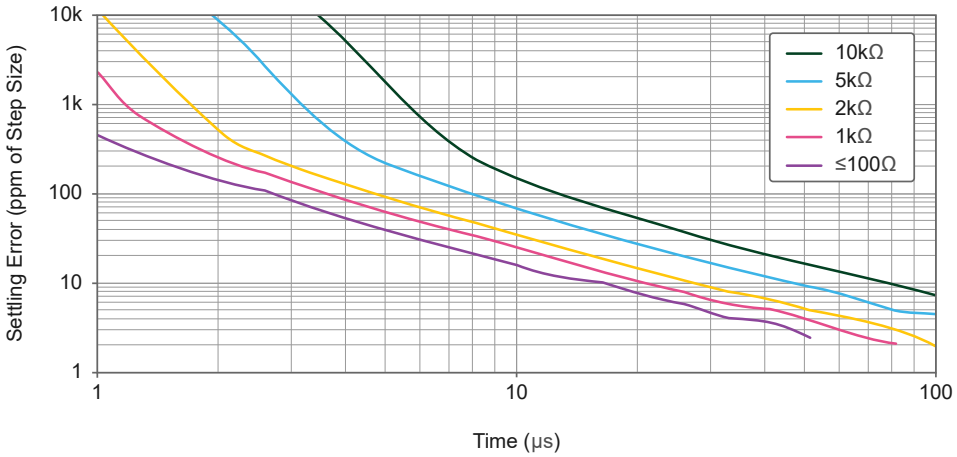


Figure 10. USB-6453 (Revision D) Settling Error versus Time for Different Source Impedances at the 0.2 V Input Range

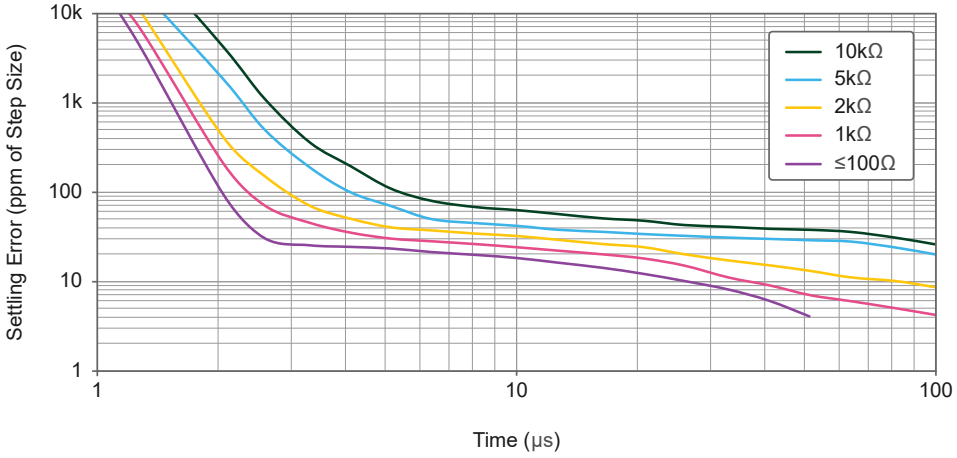


Figure 11. USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM) Settling Error versus Time for Different Source Impedances at the 0.2 V Input Range

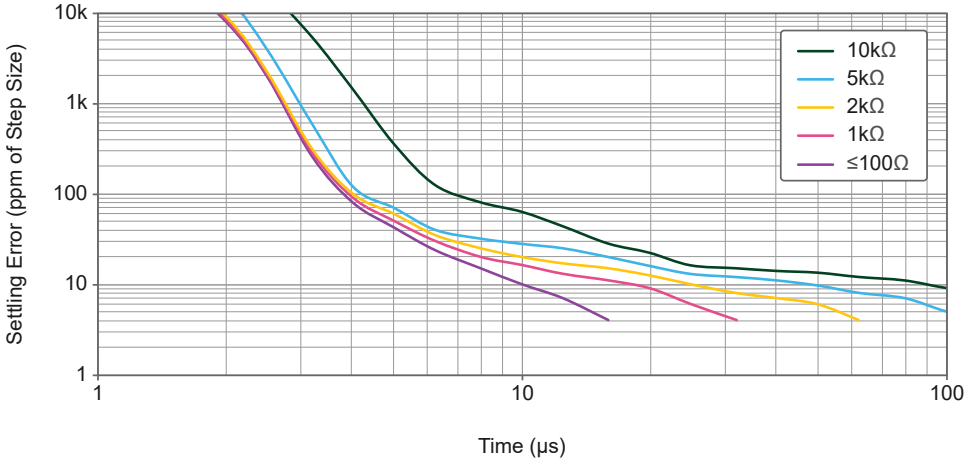


Table 13. Total Harmonic Distortion (THD) at 1 MS/s

Input Level	Product Versions	Input Range	1 kHz	10 kHz	100 kHz
-1 dBFS	USB-6453 and USB-6453 (OEM)	±10 V	-102 dBc	-82 dBc	-62 dBc
		±5 V	-106 dBc	-88 dBc	-68 dBc
		± 2.5 V	-106 dBc	-99 dBc	-79 dBc
	USB-6453 (Revision D)	±0.2 V	-105 dBc	-97 dBc	-68 dBc
	USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM)	±0.2 V	-105 dBc	-92 dBc	-55 dBc
-10 dBFS	USB-6453 and USB-6453 (OEM)	±10 V	-106 dBc	-92 dBc	-72 dBc
		±5 V	-106 dBc	-103 dBc	-84 dBc
		± 2.5 V	-103 dBc	-103 dBc	-83 dBc

Table 14. USB-6453 Zero-scale Noise Specifications

Input Range	Idle Channel Noise (µV RMS)
±2.5 V, ±5 V, ±10 V	88
±0.2 V	23

Analog Triggers

Source	AI<0..31>
Purpose	Reference trigger only
Level	Full scale (depending on AI input range for the selected trigger channel)

Resolution	20-bit
Accuracy	Same as ***AI Absolute Accuracy***
Modes	Rising-edge, rising-edge with hysteresis, falling-edge, falling-edge with hysteresis, entering window, leaving window

AI Absolute Accuracy (Warranted)

Notice The input channels of the USB-6453 are sensitive to electromagnetic interference (EMI). As a result, you might experience reduced measurement accuracy or temporary performance degradation with cables routed through strong EMI environments. To ensure optimal performance, either avoid such environments, or carefully select and route cables or probes connected to the USB-6453. This notice does not apply to the USB-6453 (OEM).

Table 15. USB-6453 AI Absolute Accuracy

Nominal Range, Positive Full Scale (V)	Nominal Range, Negative Full Scale (V)	2 Years Residual Gain Error (ppm of Reading)	10 Years Residual Gain Error (ppm of Reading)	Gain Tempco (ppm of Range/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	Full Scale Random Noise, σ (µV RMS)	2 Years Absolute Accuracy at Full Scale (µV)	10 Years Absolute Accuracy at Full Scale (µV)
10	-10	81	133	2	6	0.3	197	1,299	1,819
5	-5	86	138	2	9	0.6	138	692	952
2.5	-2.5	114	166	2	18	1.2	134	442	572
0.2	-0.2	152	204	16	96	9	24	63	74

Note Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

- ***Temp Change From Last External Cal*** = 10 °C

- ***Temp Change From Last Internal Cal*** = 1 °C
- ***Number of readings*** = 10,000
- ***Coverage Factor*** = 3σ

Note Accuracies listed are valid for up to 2 and 10 years from the device external calibration.

Reference Tempco	3 ppm/°C
INL error	10 ppm of range

AI Absolute Accuracy Equation

$$Absolute\ Accuracy = Reading * (Gain\ Error) + Range * (Offset\ Error) + Full\ Scale\ Noise\ Uncertainty$$

- $Gain\ Error = Residual\ Gain\ Error + Gain\ Tempco * (Temp\ Change\ From\ Last\ Internal\ Cal) + Reference\ Tempco * (Temp\ Change\ From\ Last\ External\ Cal)$
- $Offset\ Error = Residual\ Offset\ Error + Offset\ Tempco * (Temp\ Change\ From\ Last\ Internal\ Cal) + INL\ Error$
- $Noise\ Uncertainty = \frac{Random\ Noise * 3}{\sqrt{10,000}}$

For a coverage factor of 3 σ and averaging 10,000 points

AI Absolute Accuracy Example

For example, on the 10 V range for 2 years calibration interval, the absolute accuracy at full scale is as follows:

- $Gain\ Error: 81\ ppm + 2\ ppm * 1 + 3\ ppm * 10 = 113\ ppm$
- $Offset\ Error: 6\ ppm + 0.3\ ppm * 1 + 10\ ppm = 16.3\ ppm$
- $Noise\ Uncertainty: \frac{197\ \mu V * 3}{\sqrt{10,000}} = 5.91\ \mu V$
- $Absolute\ Accuracy: 10\ V * (Gain\ Error) + 10\ V * (Offset\ Error) + Noise\ Uncertainty = 1,299\ \mu V$

Analog Output

Number of channels	4
DAC resolution	16 bits
DNL	±1 LSB
Monotonicity	16 bits guaranteed

Maximum update rate (simultaneous)	
All channels	250 kS/s
Timing accuracy	50 ppm of sample rate
Timing resolution	10 ns

Output range	±10 V
Output coupling	DC
Output impedance[3]	0.05 Ω

3. Output impedance excludes cabling impedance.

Output current drive	±2 mA
Overdrive protection during power on/off	±30 V
Overdrive current	2.8 mA
Power on state	Less than ±5 mV
Output FIFO size	16,383 samples shared among channels used
Data transfers	USB Signal Stream, programmed I/O
AO waveform modes	Non-periodic waveform Periodic waveform regeneration mode from onboard FIFO Periodic waveform regeneration from host buffer, including dynamic update
Settling time, full-scale step, 15 ppm (1 LSB)	25 µs with 50 pF load
Slew rate	8 V/µs

AO glitch	
Device power up or reset	±0.8 V peak for 8 ms

Device power down	±0.8 V peak for 16 ms
USB cable hot unplug	-2.8 V peak for 4 ms

Glitch energy mid-scale code transition	±5 mV for 5 µs
Crosstalk (at 10 kHz)	< -100 dB

AO Absolute Accuracy (Warranted)

Notice The output channels of the USB-6453 are sensitive to electromagnetic interference (EMI). As a result, you might experience reduced measurement accuracy or temporary performance degradation with cables routed through strong EMI environments. To ensure optimal performance, either avoid such environments, or carefully select and route cables or probes connected to the USB-6453. This notice does not apply to the USB-6453 (OEM).

Absolute accuracy at full-scale numbers is valid immediately following internal calibration and assumes the device is operating within 10 °C of the last external calibration.

Table 16. AO Absolute Accuracy

Nominal Range, Positive Full Scale (V)	Nominal Range, Negative Full Scale (V)	2 Years Residual Gain Error (ppm of Reading)	10 Years Residual Gain Error (ppm of Reading)	Gain Tempco (ppm of Range/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	2 Years Absolute Accuracy at Full Scale (µV)	10 Years Absolute Accuracy at Full Scale (µV)
10	-10	77	129	4	21	1	1,640	2,160

Note Accuracies listed are valid for up to 2 and 10 years from the device external calibration.

Reference Tempco	3 ppm/°C
INL error	31 ppm of range

AO Absolute Accuracy Equation

$$Absolute\ Accuracy = Output\ Value * (Gain\ Error) + Range * (Offset\ Error)$$

- $Gain\ Error = Residual\ Gain\ Error + Gain\ Tempco * (Temp\ Change\ From\ Last\ Internal\ Cal) + Reference\ Tempco * (Temp\ Change\ From\ Last\ External\ Cal)$
- $Offset\ Error = Residual\ Offset\ Error + Offset\ Tempco * (Temp\ Change\ From\ Last\ Internal\ Cal) + INL\ Error$

Digital I/O (PFI)

Number of channels	16
Capabilities	Static Digital I/O, Waveform Digital I/O, PFI, Counter, Timer, or Trigger I/O (configurable per line)
Direction control	Each terminal can be programmed individually as input or output
Logic family	Selectable in software. All lines share the same setting. 5 V (LVCMOS) 3.3 V 2.5 V

	1.8 V
Default logic family setting	5.5 V (LVCMOS)

Electrical Characteristics

Ground reference	D GND
Direction control	Program each as input or output individually
Pull-down resistor	47 kΩ
Input voltage protection	±20 V per line, up to two lines simultaneously

Notice Stresses beyond those listed under the Input voltage protection specification may cause permanent damage to the USB-6453.

Static Digital I/O Capabilities

Channel names in software	Port0/line0:15

Waveform Digital I/O Capabilities

Channel names in software	Port0/line0:15

Port/sample size	Up to 16 bits
Waveform generation (DO) FIFO	8,191 samples
Waveform acquisition (DI) FIFO	1,023 samples
DO or DI sample clock frequency	0 MHz to 10 MHz, system and bus activity dependent
Data transfers	USB Signal Stream, programmed I/O
Digital line filter settings	160 ns 10.24 µs 5.12 ms Disable

PFI Functionality

Channel names in software	PFI0:15
Functionality	Timing input Timing output
Timing output sources	Many AI, AO, counter, DI, and DO timing signals

Recommended Operating Conditions

Output high current (I_{OH})	
DIO<0..15>	-10 mA maximum per channel

Output low current (I_{OL})	
DIO<0..15>	10 mA maximum per channel

Note The maximum output current is shared between all channels and the +5 V power source.

Table 17. Digital Input Logic Levels

Logic Family	Input Low Voltage (V_{IL})		Input High Voltage (V_{IH})	
	Minimum	Maximum	Minimum	Maximum
1.8 V	-0.5 V	0.62 V	1.19 V	5.25 V
2.5 V	-0.5 V	0.70 V	1.76 V	5.25 V
3.3 V	-0.5 V	0.80 V	2.00 V	5.25 V
5.0 V	-0.5 V	1.46 V	3.66 V	5.25 V

Table 18. Digital Output Logic Level

Logic Family	Current	Output Low Voltage (V_{OL}) Maximum	Output High Voltage (V_{OH}) Minimum
1.8 V	4 mA	0.36 V	1.39 V
2.5 V	4 mA	0.32 V	2.16 V
3.3 V	4 mA	0.31 V	2.97 V
5.0 V	4 mA	0.30 V	4.59 V

Digital I/O Characteristics

I_{IL} input low current (V_{IN} = 0 V)	-1 µA maximum
I_{IH} input low current (V_{IN} = 5 V)	110 µA maximum

Figure 12. I_{OH} versus V_{OH}, 1.8 V Logic Family

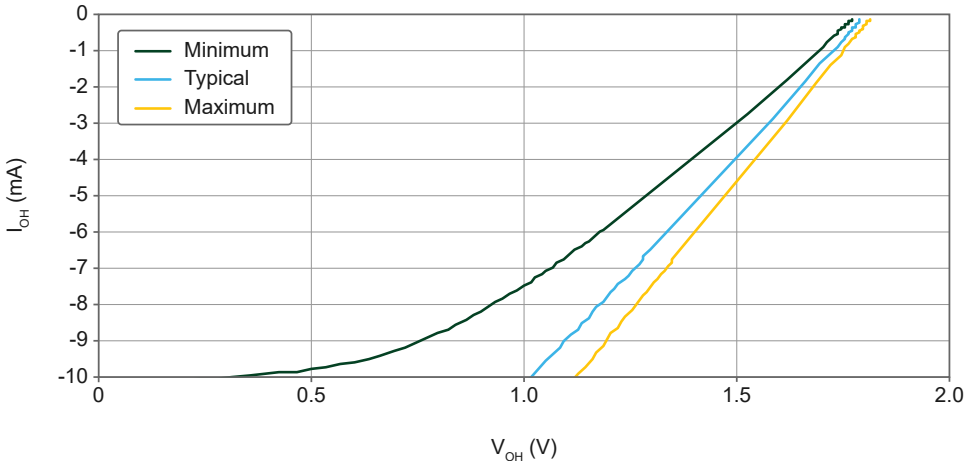


Figure 13. I_{OL} versus V_{OL}, 1.8 V Logic Family

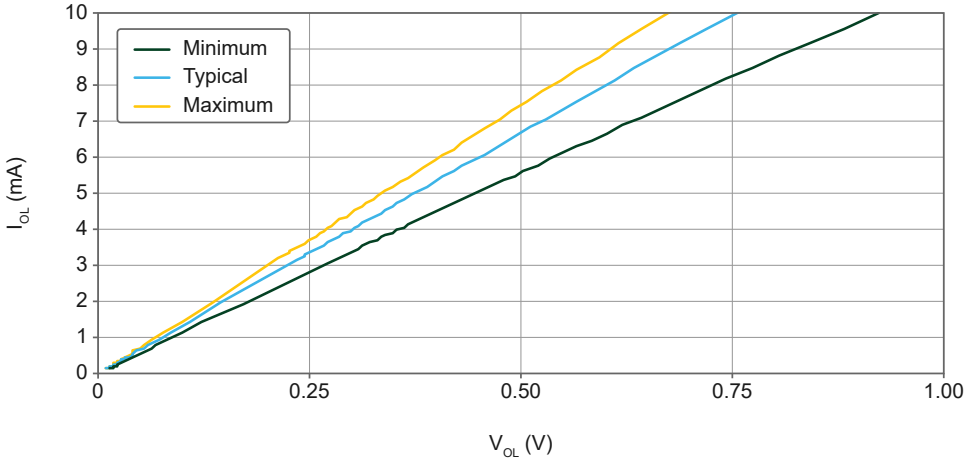


Figure 14. I_{OH} versus V_{OH}, 2.5 V Logic Family

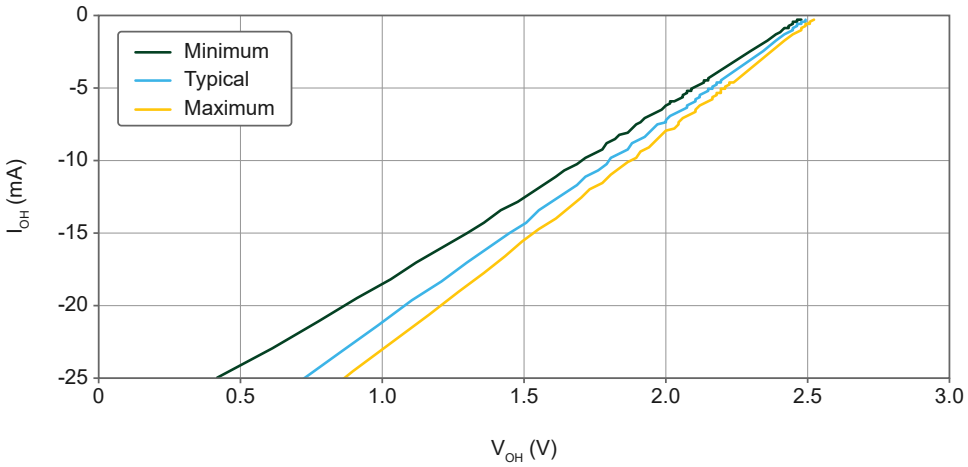


Figure 15. I_{OL} versus V_{OL}, 2.5 V Logic Family

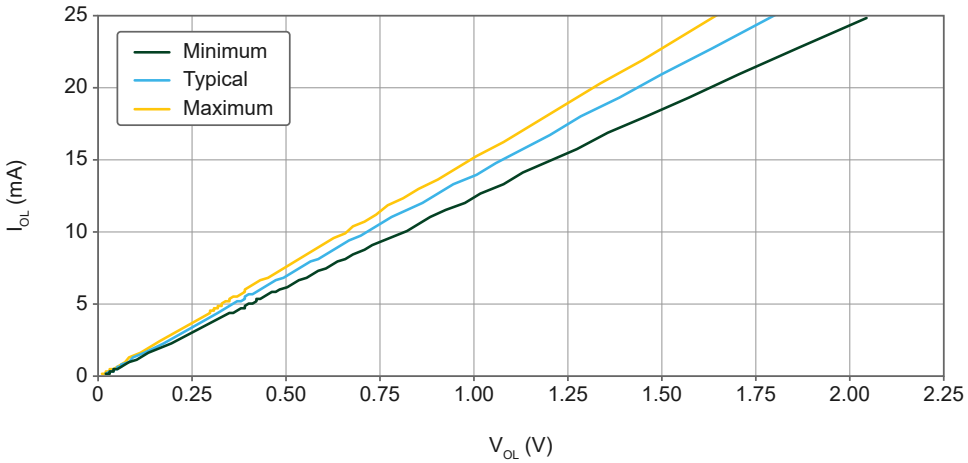


Figure 16. I_{OH} versus V_{OH}, 3.3 V Logic Family

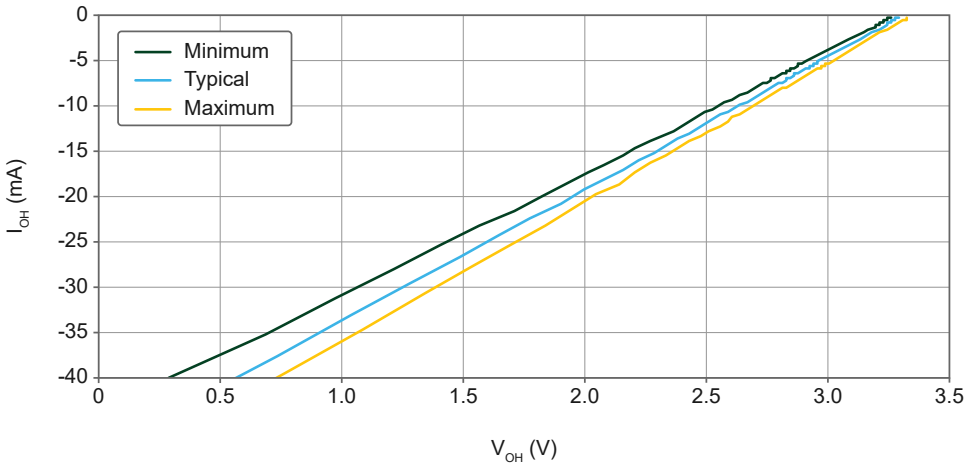


Figure 17. I_{OL} versus V_{OL}, 3.3 V Logic Family

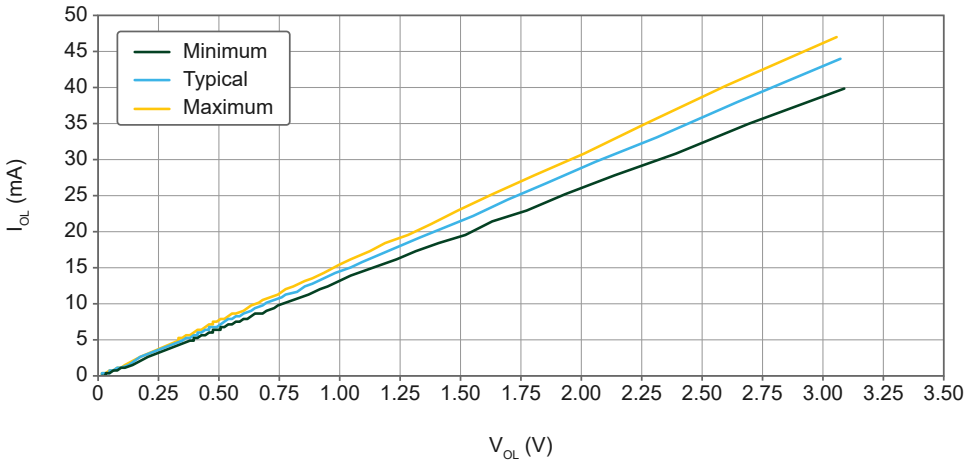


Figure 18. I_{OH} versus V_{OH}, 5.0 V Logic Family

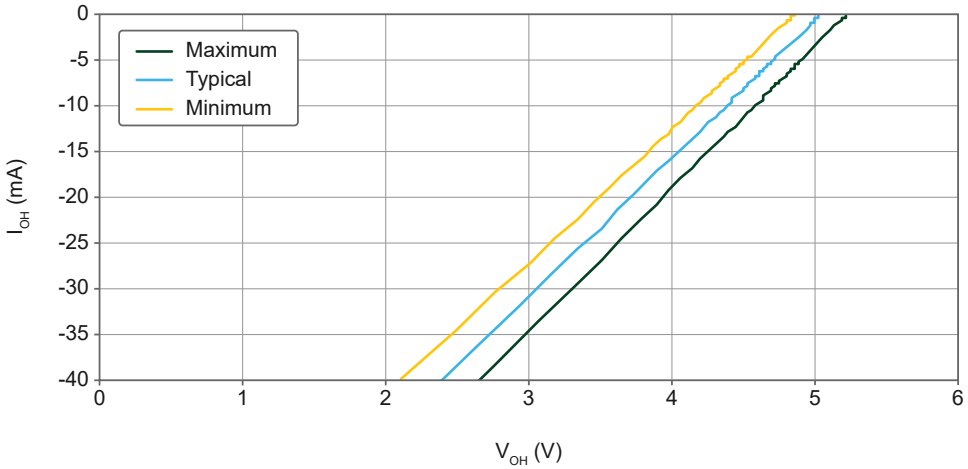
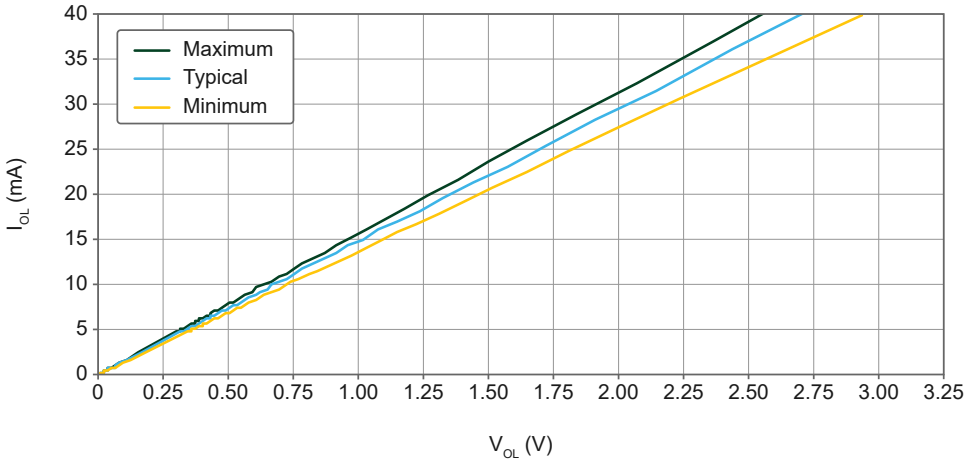


Figure 19. I_{OL} versus V_{OL}, 5.0 V Logic Family



General-Purpose Counters

Number of counters/timers	4
Resolution	32 bits
Counter measurements	Edge counting Pulse Pulse width Semi-period Period Two-edge separation
Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading Two-pulse encoding
Output applications	Pulse Pulse train Frequency division Equivalent time sampling
Internal base clocks	100 MHz 20 MHz 100 kHz

External base clock frequency	0 MHz to 25 MHz
Base clock accuracy	50 ppm
Inputs	Gate Source HW_Arm Aux A B Z Up_Down Sample Clock
Routing options for inputs	Any PFI, many internal signals
FIFO	1,023 samples per counter
Data transfers	USB Signal Stream, Programmed I/O

Frequency Generator

Number of channels	1

Base clocks	100 MHz 20 MHz 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any PFI terminal.

External Digital Triggers

Source	Any PFI
Polarity	Software-selectable for most signals
Analog input function	Start Trigger Reference Trigger Pause Trigger Sample Clock Sample Clock Timebase
Analog output function	Start Trigger Pause Trigger

	Sample Clock Sample Clock Timebase
Counter/timer functions	Gate Source HW_Arm Aux A B Z Up_Down Sample Clock
Digital waveform generation (DO) function	Start Trigger Pause Trigger Sample Clock Sample Clock Timebase
Digital waveform acquisition (DI) function	Start Trigger Reference Trigger Pause Trigger Sample Clock Sample Clock Timebase

Bus Interface

USB compatibility	USB 3.0/USB 3.1 Gen 1/USB 3.2 Gen 1 SuperSpeed
USB Signal Stream	8, can be used for analog input, analog output, digital input, digital output, or counter input
USB connector	USB Type-C

USB-6453 (OEM) LED Color Control Status

Logic level	3.3 V
Output resistance	470 Ω
Protection	±20 V

+5 V Power Source

Voltage accuracy	No load	+4.87 V to +5.22 V
	Maximum current	+4.76 V to 5.17 V

Maximum load current[4]	
Connected to USB 3.0 SuperSpeed Type-A port with 4.5 W power	50 mA
Connected to USB 3.0 SuperSpeed Type-C port with ≥7.5 W power	280 mA

4. The USB-6453 will self-detect the power capability of USB host to configure the current limit. If the USB-6453 is at 280 mA limit, it will lower the current limit to 50 mA if there is overdrive or fault condition. The current limit will be reset back to the default 280 mA limit when the fault or load is removed.

Power on state	Always on (no user control)
Overdrive protection during power on/off	±30 V

Power Requirements

> **Caution** The protection provided by the USB-6453 can be impaired if it is used in a manner not described in the ***USB-6453 and USB-6453 (OEM) User Manual***.

Some USB ports do not provide enough power to operate the USB-6453 with full functionality. Refer to the ***Confirming USB Port Power Rating*** section of the ***USB-6453 User Manual*** for more information. Do not connect the USB-6453 to a USB 2.0 or lower port. The USB-6453 requires more than 2.5 W to power on.

Table 19. USB Power Rating

Product Version	USB Power Rating
USB-6453 (Revision D)	5.6 W (1,120 mA at nominal 5 V)
USB-6453 (Revision F and subsequent revisions) and USB-6453 (OEM)	6.1 W (1,220 mA at nominal 5 V)

Power input mating connector	USB Type-C plug for power and data

Related information:

- USB-6453 and USB-6453 (OEM) User Manual
- Confirming USB Port Power Rating

Current Limit

DIO and +5 V terminals	Connected to USB 3.0	50 mA

combined[5]	SuperSpeed Type-A port with 4.5 W power	
	Connected to USB 3.0 SuperSpeed Type-C port with ≥7.5 W power	280 mA

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel to earth	10.5 V, Measurement Category I

Measurement Category

This product is rated for Measurement Category I.

Caution Do not connect the product to signals or use for measurements within Measurement Categories II, III, or IV.

Remarque Ne pas connecter le produit à des signaux dans les catégories de mesure II, III ou IV et ne pas l'utiliser pour effectuer des mesures dans ces catégories.

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of

5. The USB-6453 will self-detect the power capability of the USB host to configure the current limit. If the USB-6453 is at 280 mA limit, it will lower the current limit to 50 mA if there is an overdrive or fault condition. The current limit will be reset back to the default 280 mA limit when the fault or load is removed.

equipment, circuits powered by regulated low-voltage sources, and electronics.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are for other circuits not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Physical Characteristics

Product Version	I/O Connector
USB-6453	2x 36-position spring terminals
USB-6453 (OEM)	2x 50-pin, 0.100 in. x 0.100 in. ribbon cable header

Product Version	Dimensions
USB-6453	116.7 mm x 177.0 mm x 30.4 mm (4.59 in. x 6.97 in. x 1.20 in.)
USB-6453 (OEM)	109.22 mm x 167 mm x 13.6 mm (4.3 in. x 6.58 in. x 0.14 in.)

Product Version	Weight
USB-6453	598 g (1.32 lb)
USB-6453 (OEM)	103.1 g (0.23 lb)

Field Wiring Specifications

The following field wiring specifications do not apply to the USB-6453 (OEM).

Use copper wiring for all connections unless otherwise stated.

Gauge	0.14 mm^2 to 1.5 mm^2 (26 AWG to 16 AWG) copper conductor wire

Wire strip length	10 mm (0.394 in.) of insulation stripped from the end
Temperature rating	-25 °C to 120 °C
Wires per terminal	One wire per spring terminal; two wires per spring terminal using a 2-wire ferrule

Ferrules	
Single ferrule, uninsulated	0.14 mm^2 to 1.5 mm^2 (26 AWG to 16 AWG) 10 mm barrel length
Single ferrule, insulated	0.14 mm^2 to 1.0 mm^2 (26 AWG to 18 AWG) 12 mm barrel length
Two-wire ferrule, insulated	2x 0.34 mm^2 (22 AWG) 12 mm barrel length

Connector securement	
Securement type	Screw flanges
Torque for screw flanges	0.2 N · m (1.80 lb · in.)

USB-6453 (OEM) Connectors

You can connect the following I/O connectors on the USB-6453 (OEM) using a 0.100 in. x 0.100 in. pitch ribbon cable or PCB socket. Refer to the manufacturer's data sheet for compatibility information.

Table 20. USB-6453 (OEM) Connectors

Connector	Component	Reference Designator(s) on PCB	Manufacturer	Manufacturer Part Number
AI	50-pin header	P1	3M	N2550-6002RB
AO/DIO	50-pin header	P2	3M	N2550-6002RB

Environmental Characteristics

Temperature	
Operating temperature	0 °C to 55 °C
Storage temperature	-20 °C to 70 °C

Humidity	
Operating humidity[6]	10% RH to 90% RH, noncondensing
Storage humidity	5% RH to 95% RH, noncondensing

Pollution Degree	2

6. The USB-6453 will perform at the full accuracy specification up to 90% RH operating humidity at ≤40 °C.

Maximum altitude	2,000 m

The following shock and vibration specifications do not apply to the USB-6453 (OEM).

Shock and vibration	
Operating vibration	5 Hz to 500 Hz, 0.3 g RMS
Non-operating vibration	5 Hz to 500 Hz, 2.4 g RMS
Operating shock	30 g, half-sine, 11 ms pulse

Calibration

Recommended warm-up time	15 minutes
Recommended calibration interval	2 years