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SPECIFICATIONS

USB-6349

500 kS/s/ch, 32 Simultaneous AI, 24 DIO, 2 AO Multifunction I/O Device

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 for 25 °C unless otherwise noted.

Analog Input

Note Floating inputs can cause unnecessary power consumption and higher operating temperatures. NI recommends connecting unused analog input channels to AI GND.

Number of channels	32 differential
ADC resolution	16 bits
DNL	No missing codes, warranted
INL	Refer to the *AI Absolute Accuracy* section.
Sample rate (simultaneous sampling on all channels sampled)	
Maximum	500 kS/s
Minimum	No minimum
Timing resolution	10 ns

NATIONAL INSTRUMENTS

Timing accuracy	50 ppm of sample rate
Input coupling	DC
Input range	±1 V, ±2 V, ±5 V, ±10 V
Maximum working voltage for all analog inputs (AI±)	
Ranges ±10 V, ±5 V	±11 V, Measurement Category I
Ranges ±2 V, ±1 V	±9 V, Measurement Category I

Caution Do not connect the USB-6349 to signals or use for measurements within Measurement Categories II, III, or IV.

Attention Ne connectez pas le USB-6349 à des signaux et ne l'utilisez pas pour effectuer des mesures dans les catégories de mesure II, III ou IV.

CMRR (at 60 Hz)	80 dB
Bandwidth (small signal)	2.0 MHz at ±1 V 2.9 MHz at other ranges
Input impedance	
Device on	
AI+ to AI GND	>1 GΩ in parallel with 18 pF
AI- to AI GND	>1 GΩ in parallel with 18 pF
Device off	
AI+ to AI GND	2.37 kΩ
AI- to AI GND	2.37 kΩ
Input bias current	±6 nA ±90 nA, maximum over full temperature range
Crosstalk (at 100 kHz)	-80 dB
Input FIFO size	32 MS shared among channels used
Data transfers	USB Signal Stream, programmed I/O
Overvoltage protection for AI <0..31>	
Device on	±30 V
Device off	±15 V
Input current during overvoltage conditions	±6.3 mA maximum/AI pin
Maximum AI channels in overvoltage	4 channels on AI <0..15> and 4 channels on AI <16..31>

Notice Exceeding overvoltage specifications may result in data corruption on non-overvoltaged channels.

Analog Triggers

Number of triggers	1
Source	AI <0..31>, APFI 0
Functions	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Source level	
AI <0..31>	±Full scale
APFI 0	±10 V
Resolution	16 bits
Modes	Analog edge triggering, analog edge triggering with hysteresis, and analog window triggering
Bandwidth (large signal, to -3 dB)	
AI <0..31>	600 kHz
APFI 0	3.9 MHz
Accuracy	±1% of range
APFI 0 characteristics	
Input impedance	10 kΩ
Coupling	DC
Protection, power on	±30 V
Protection, power off	±15 V

AI Absolute Accuracy

Table 1. AI Absolute Accuracy

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Offset Tempco (ppm of Range/°C)	Random Noise, σ (μVrms)	Absolute Accuracy at Full Scale (μV)
10	-10	115	2	265	3,225
5	-5	115	2	148	1,613

Table 1. AI Absolute Accuracy (Continued)

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Offset Tempco (ppm of Range/°C)	Random Noise, σ (µVrms)	Absolute Accuracy at Full Scale (µV)
2	-2	117	2	74	650
1	-1	124	3	50	333

Note For more information about absolute accuracy at full scale, refer to the *AI Absolute Accuracy Example* section.

Gain tempco	16.7 ppm/°C
Reference tempco	5 ppm/°C
Residual offset error	12 ppm of range
INL error	126 ppm of range

Note Accuracies listed are warranted for up to one year from the device external calibration when the device is within 10 °C of the external calibration temperature and 1 °C of the last self calibration, when averaging 10,000 DC samples. Other accuracies may be calculated for different temperatures and sample sizes using the given equations.

Notice This product may become more sensitive to electromagnetic disturbances in the operational environment when test leads are attached or when connected to a test object.

AI Absolute Accuracy Equation

$AbsoluteAccuracy = Reading \cdot (GainError) + Range \cdot (OffsetError) + NoiseUncertainty$

$GainError = ResidualGainError + GainTempco \cdot (TempChangeFromLastInternalCal) + ReferenceTempco \cdot (TempChangeFromLastExternalCal)$

$OffsetError = ResidualOffsetError + OffsetTempco \cdot (TempChangeFromLastInternalCal) + INLError$

$NoiseUncertainty = \frac{\text{Random Noise} \cdot 3}{\sqrt{10,000}}$ for a coverage factor of 3 σ and averaging 10,000 points.

AI Absolute Accuracy Example

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

- $TempChangeFromLastExternalCal = 10$ °C
- $TempChangeFromLastInternalCal = 1$ °C

- *number_of_readings* = 10,000
- *CoverageFactor* = 3 σ

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

GainError = 115 ppm + 16.7 ppm · 1 + 5 ppm · 10 = 181.7 ppm

OffsetError = 12 ppm + 2 ppm ·1 + 126 ppm = 140 ppm

$$Noise\ Uncertainty = \frac{265\ \mu V \cdot 3}{\sqrt{10,000}} = 8\ \mu V$$

AbsoluteAccuracy = 10 V · (*GainError*) + 10 V · (*OffsetError*) + *NoiseUncertainty* = 3225 µV

Analog Output

Number of channels	2
DAC resolution	16 bits
DNL	±1 LSB, maximum
Monotonicity	16 bit guaranteed
Accuracy	Refer to the *AO Absolute Accuracy* section.
Maximum update rate (simultaneous)	
1 channel	900 kS/s
2 channels	840 kS/s
Minimum update rate	No minimum
Timing accuracy	50 ppm of sample rate
Timing resolution	10 ns
Output range	±10 V
Output coupling	DC
Output impedance	0.2 Ω
Output current drive	±5 mA
Overdrive protection	±15 V
Overdrive current	15 mA
Power-on state	±20 mV
Power-on/off glitch[1]	2 V peak for 1.5 s
Output FIFO size	8,191 samples shared among channels used
Data transfers	USB Signal Stream, programmed I/O

[1] Typical behavior. Time period may be longer due to host system USB performance. Time period will be longer during firmware updates.

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)	6 µs
Slew rate	15 V/µs
Glitch energy at midscale transition	100 mV · 2.6 µs

AO Absolute Accuracy

Accuracies listed are warranted for up to one year from the device external calibration when the device is within 10 °C of the external calibration temperature and 1 °C of the last self calibration.

Table 2. AO Absolute Accuracy

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco (ppm/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/ °C)	INL Error (ppm of Range)	Absolute Accuracy at Full Scale (µV)
10	-10	130	11.3	5	52	4.8	128	3,761

AO Absolute Accuracy Equation

AbsoluteAccuracy = *OutputValue* · (*GainError*) + *Range* · (*OffsetError*)

GainError = *ResidualGainError* + *GainTempco* · (*TempChangeFromLastInternalCal*) + *ReferenceTempco* · (*TempChangeFromLastExternalCal*)

OffsetError = *ResidualOffsetError* + *OffsetTempco* · (*TempChangeFromLastInternalCal*) + *INLError*

Digital I/O/PFI

Static Characteristics

Number of channels	24 total 8 (P0.<0..7>) 16 (PFI <0..7>/P1, PFI <8..15>/P2)
Ground reference	D GND

Direction control	Each terminal individually programmable as input or output
Pull-down resistor	50 kΩ, typical 20 kΩ, minimum
Input voltage protection	±20 V on up to two pins

Notice Stresses beyond those listed under the *Input voltage protection* specification may cause permanent damage to the device.

Waveform Characteristics (Port 0 Only)

Terminals used	Port 0 (P0.<0..7>)
Port/sample size	Up to 8 bits
Waveform generation (DO) FIFO	2,047 samples
Waveform acquisition (DI) FIFO	255 samples
DI Sample Clock frequency	0 to 1 MHz, system and bus activity dependent
DO Sample Clock frequency	
Regenerate from FIFO	0 to 1 MHz
Streaming from memory	0 to 1 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/Port 1/Port 2 Functionality

Functionality	Static digital input, static digital output, timing input, timing output
Timing output sources	Many AI, AO, counter, DI, DO timing signals
Debounce filter settings	90 ns, 5.12 µs, 2.56 ms, custom interval, disable; programmable high and low transitions; selectable per input

Recommended Operating Conditions

Input high voltage (V_{IH})	
Minimum	2.2 V
Maximum	5.25 V
Input low voltage (V_{IL})	
Minimum	0 V
Maximum	0.8 V

Output high current (I_{OH})	
P0.<0..7>	-24 mA, maximum
PFI <0..15>/P1/P2	-16 mA, maximum
Output low current (I_{OL})	
P0.<0..7>	24 mA, maximum
PFI <0..15>/P1/P2	16 mA, maximum

Digital I/O Characteristics

Positive-going threshold (VT+)	2.2 V, maximum
Negative-going threshold (VT-)	0.8 V, minimum
Delta VT hysteresis (VT+ - VT-)	0.2 V , minimum
I_{IL} input low current (V_{IN} = 0 V)	-10 µA, maximum
I_{IH} input high current (V_{IN} = 5 V)	250 µA, maximum

Figure 1. P0.<0..7>: I_{OH} versus V_{OH}

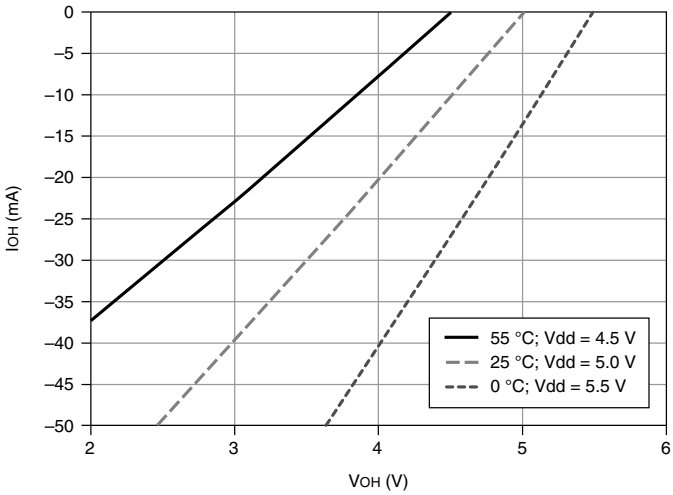


Figure 2. P0.<0..7>: I_{OL} versus V_{OL}

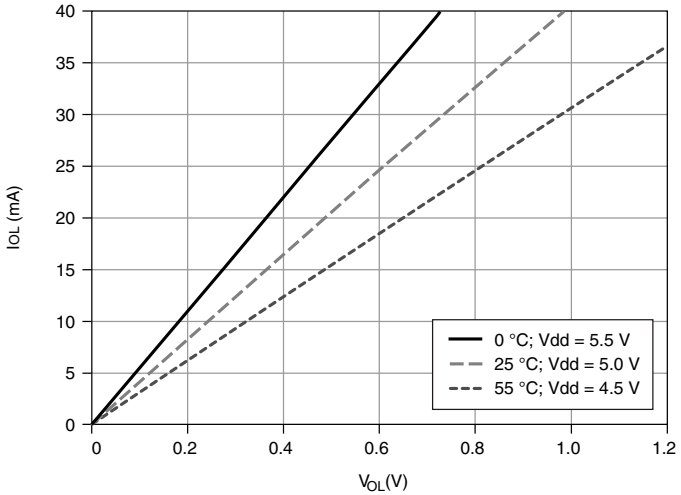


Figure 3. PFI <0..15>/P1/P2: I_{OH} versus V_{OH}

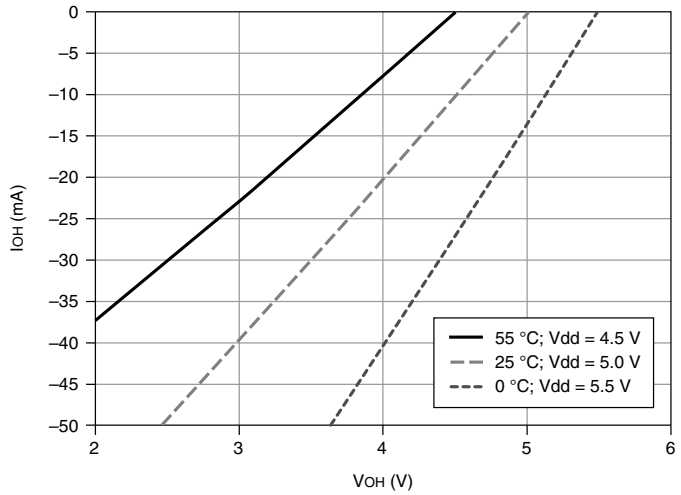
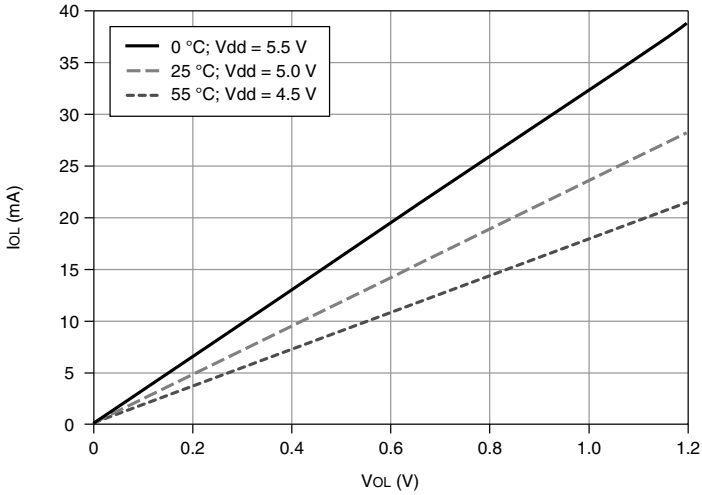


Figure 4. PFI <0..15>/P1/P2: I_{OL} versus V_{OL}



General-Purpose Counters

Number of counter/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 with dynamic updates, 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	127 samples per counter
Data transfers	USB Signal Stream, programmed I/O

Frequency Generator

Number of channels	1
Base clocks	20 MHz, 10 MHz, 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any PFI terminal.

Phase-Locked Loop (PLL)

Number of PLLs	1

Table 3. Reference Clock Locking Frequencies

Reference Signal	USB Locking Input Frequency
PFI <0..15>	10 MHz

Output of PLL	100 MHz Timebase; other signals derived from 100 MHz Timebase including 20 MHz and 100 kHz Timebases

External Digital Triggers

Source	Any PFI
Polarity	Software-selectable for most signals
Analog input function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert 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[2]	USB 2.0 Hi-Speed or full-speed
DMA channels	8 (can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1, counter/timer 2, counter/timer 3)

Power Requirements

Caution The protection provided by the USB-6349 can be impaired if it is used in a manner not described in the user documentation.

Attention La protection apportée par le USB-6349 risque d'être endommagée s'il est utilisé d'une autre façon que celle décrite dans la documentation utilisateur.

Power supply requirements	11 V DC to 30 V DC, 30 W, 2 positions 3.5 mm pitch pluggable screw terminal with screw locks similar to Phoenix Contact MC 1,5/2-STF-3,5 BK
Power input mating connector	Phoenix Contact MC 1,5/2-GF-3,5 BK or equivalent

Caution The USB-6349 must be powered with an AC adapter offered by NI or a National Electric Code (NEC) Class 2 DC source that meets the power requirements for the device and has appropriate safety certification marks for country of use.

Attention Le USB-6349 doit être alimenté par un adaptateur secteur proposé par NI ou une source de courant continu de classe 2, selon la norme NEC (National Electric Code), qui répond aux exigences d'alimentation de l'appareil et possède les marques de certification de sécurité appropriées pour le pays d'utilisation.

Current Limits

Notice Exceeding the current limits may cause unpredictable device behavior.

+5 V terminal (connector 0)	1 A, maximum

[2] Operating on a full-speed bus results in lower performance, and you might not be able to achieve maximum sampling/update rates.

Note Connector 0 has a self-resetting fuse that opens when current exceeds this specification.

P0/PFI/P1/P2 and +5 V terminals combined	1.2 A, maximum

Physical Characteristics

Enclosure dimensions (includes connectors)	26.4 cm × 17.3 cm × 3.6 cm (10.39 in. × 6.81 in. × 1.42 in.)
Weight	1.45 kg (3 lb 3 oz)
I/O connectors	128 screw terminals
Screw terminal wire gauge	0.2 mm^2 to 1.3 mm^2 (24 AWG to 16 AWG)

Calibration

Recommended warm-up time	15 minutes
Calibration interval	1 year

Maximum Working Voltage

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

Channel to earth	11 V, Measurement Category I

Caution Do not connect the USB-6349 to signals or use for measurements within Measurement Categories II, III, or IV.

Attention Ne connectez pas le USB-6349 à des signaux et ne l'utilisez pas pour effectuer des mesures dans les catégories de mesure II, III ou IV.

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 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.

Environmental Guidelines

Notice This model is intended for use in indoor applications only.

Environmental Characteristics

Temperature	
Operating	0 °C to 45 °C
Storage	-40 °C to 70 °C
Humidity	
Operating	10% to 90% RH, noncondensing
Storage	5% to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m (800 mbar) (at 25 °C ambient temperature)

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