USB-2401

24-bit 2kS/s USB 2.0-Based Universal Input
DAQ Module

User's Manual



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Revision History

Revision	Release Date	Description of Change(s)
2.00	Apr 27, 2012	Initial release

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Preface

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Conventions

Take note of the following conventions used throughout this manual to make sure that users perform certain tasks and instructions properly.



Additional information, aids, and tips that help users perform tasks.



Information to prevent ***minor*** physical injury, component damage, data loss, and/or program corruption when trying to complete a task.



Information to prevent ***serious*** physical injury, component damage, data loss, and/or program corruption when trying to complete a specific task.

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1 Introduction

1.1 Overview

The USB-2401 is a 24-bit, 4-channel simultaneous-sampling universal input USB DAQ module featuring built-in signal conditioning and direct measurement of commonly used sensors, including current output transducers, thermocouple, RTD, load cell, strain gauge, and resistance. Individual channels can be programmed to measure different signal types.

The USB-powered USB-2401 is equipped with removable screw-down terminals for easy device connectivity, and the included multi-functional stand fully supports desktop, rail, or wall mounting.

The USB-2401 is suitable for basic measurement applications requiring high resolution and accuracy, laboratory research and material testing environments, and industrial temperature measurement. U-Test, a free ready-to-use testing program is included to enable operation or testing of all ADLINK USB DAQ series functions with no programming requirements.

1.2 Features

- High-speed USB 2.0
- USB powered
- 4-CH simultaneous-sampling analog input
- Built-in signal conditioning for high voltage/current/thermocouple/RTD/strain gauge/load cell/resistance measurement
- Sample rate from 20 S/s to 2 kS/s
- Functional digital I/O
- Removable screw-down terminal
- Lockable USB cable for secure connectivity
- Ready-to-use testing application (U-Test) provided

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1.3 Applications

- Automotive testing
- Laboratory research
- Biotech measurement
- I/O control

1.4 Specifications

1.4.1 General Specifications

Physical, Power, and Operating Environment	
Interface	High speed USB 2.0 compatible, mini-USB connector
Dimensions	156 (L) x 114 (W) x 41 (H) mm (6.14 X 4.49 X 1.61 in.)
I/O Connector	Two 20-pin removable screw-down terminals
Power requirement	USB power (5 V @ 400 mA)
Operating environment	**Ambient temperature:** 0 to 55°C **Relative humidity:** 10% to 90%, non-condensing
Storage environment	**Ambient temperature:** -20 to 70 °C **Relative humidity:** 5% to 95%, non-condensing

1.4.2 General Analog Input

General		
Number of channels:	4 differential input (simultaneous-sampling)	
Sampling rate (sample/sec)	20, 40, 80, 160, 320, 500, 1000, 2000	
Resolution	24-bit	
Input coupling	DC	
Input mode and range		
	Input range or supporting type	Actual input range

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Voltage	±25V ±12.5V ±2.5V ±312.5mV	±25V ±12.5V ±2.5V ±312.5mV
Current	±20mA	2.5V
Thermocouple	K, J, N, R, S, B, T, E	78.125mV
RTD (3-wire, 4-wire)	Pt 100, Pt 1000	2.5V
Half-Bridge (120Ω, 350Ω)	Max. 30mV/V	78.125mV
Full-Bridge (120Ω, 350Ω)	Max. 30mV/V	78.125mV
2-Wire Resistance	30kΩ	2.5V
Excitation voltage	2.5V (for half/full-bridge mode only)	
Excitation current	0.5mA for RTD mode 0.05mA for Resistance mode	
Cold junction compensation (CJC) accuracy	± 0.5°C (after 15 minute warmup)	
Operational common mode voltage range	Voltage input mode: Vcm+Vpp/2 ≦ input range (25V/12.5V/2.5V/ 0.3125V) Current input mode: Vcm ≦ 24V	
Overvoltage protection	Power on: Voltage input mode: 30V Current input mode: 60mA Sensor input mode enable: no protection Sensor input mode disable: 30V Excitation voltage (EX+) and AGND: no protection	
FIFO buffer size	4k samples	
Data transfers	Programmed I/O, continuous (bulk transfer mode)	
Input impedance	1.009MΩ for voltage input mode 249.5Ω for current input mode	

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1.4.3 Analog Input Electrical

Temperature Draft @20SPS, in ppm/°C

Mode	Gain drift	Offset drift
Voltage (±25V)	1.389055871	0.043023355
Voltage (±12.5V)	1.37552178	0.075556565
Voltage (±2.5V)	1.662727273	0.030882956
Voltage (±312.5mV)	21.92878977	0.110084412
Current (±20mA)	3.270369091	0.282946284
Full-bridge	28.00370355	30.90013157
Half-bridge	33.48025514	1.750342188
Thermocouple	62.9978196	0.164409864
2-wire RTD	2.842575758	0.522492944
3-wire RTD	2.879839489	0.258840329
4-wire RTD	2.902723485	0.018656382
2-wire resistance	3.026166667	0.03246755

Temperature Draft @160SPS, in ppm/°C

Mode	Gain drift	Offset drift
Voltage (±25V)	1.533312973	0.084457938
Voltage (±12.5V)	1.520465436	0.134715279
Voltage (±2.5V)	1.732148674	0.054557101
Voltage (±312.5mV)	20.94809375	0.130828487
Current (±20mA)	3.488472439	0.305882921
Full-bridge	26.72626394	17.74701205
Half-bridge	35.27328612	1.748929398

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Mode	Gain drift	Offset drift
Thermocouple	105.3142618	0.193622785
2-wire RTD	2.965409564	0.512440163
3-wire RTD	2.996320076	0.240909456
4-wire RTD	2.854513258	0.086721521
2-wire resistance	3.40709375	0.06209485

Temperature Draft @2000SPS, in ppm/°C

Mode	Gain drift	Offset drift
Voltage (±25V)	1.620950284	0.105635778
Voltage (±12.5V)	1.584251894	0.11027477
Voltage (±2.5V)	1.701225379	0.067356314
Voltage (±312.5mV)	20.52684091	0.113061874
Current (±20mA)	3.771356399	0.338399386
Full-bridge	30.71138027	50.00179464
Half-bridge	35.58911174	1.862124485
Thermocouple	117.7077884	0.435895845
2-wire RTD	3.047327178	0.452466872
3-wire RTD	3.124556345	0.189605804
4-wire RTD	3.216423295	0.088365093
2-wire resistance	3.386921402	0.04574323

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System Noise, in LSB (Typical, 25°C): 20 SPS to 160 SPS

Mode	Sampling Rate (SPS)			
	20	40	80	160
Voltage (±25V)	9.443641	13.58713513	22.225423	47.06011713
Voltage (±12.5V)	10.45022375	15.55506725	23.934448	50.668689
Voltage (±2.5V)	8.941254375	12.75718938	19.522499	46.11391238
Voltage (±312.5mV)	11.115466	15.1842875	19.108748	39.44412825
Current (±20mA)	29.50086975	33.76906888	39.179197	53.86180763
Full/Half-bridge	58.669068	33.97045388	41.628525	67.98029188
Thermocouple	28.24161013	41.73502813	51.59679	76.21635225
2-wire RTD	8.00126525	11.64115513	16.869046	33.30653975
3-wire RTD	8.407154625	12.01619113	16.528028	33.69525963
4-wire RTD	9.043779125	12.47814688	16.762287	45.44077163
2-wire resistance	9.318955625	13.208205	18.829651	43.74764375

System Noise, in LSB (Typical, 25°C): 320 SPS to 2000 SPS

Mode	Sampling Rate (SPS)			
	320	640	1000	2000
Voltage (±25V)	72.508028	142.60307	71.11201	119.26144
Voltage (±12.5V)	81.44560913	139.01469	77.924207	128.36732
Voltage (±2.5V)	66.64280488	136.24263	71.915341	122.92882
Voltage (±312.5mV)	48.83473638	79.888989	86.157589	128.4315
Current (±20mA)	77.58907738	131.06695	80.416917	126.239
Full/Half-bridge	92.8294875	144.14509	175.67111	202.15501

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Mode	Sampling Rate (SPS)			
Thermocouple	107.9735725	143.46202	198.49927	202.17693
2-wire RTD	44.53668125	77.870435	71.369319	127.45831
3-wire RTD	42.00570563	87.738238	72.70806	123.21166
4-wire RTD	72.2785775	155.50389	72.168651	123.65813
2-wire resistance	72.76746238	153.9091	71.566314	122.28421

1.4.4 Digital Input/Output

I/O Specifications	
Number of channels	4-CH programmable function digital input (DI) 2-CH programmable function digital output (DO)
Compatibility	TTL (single-end) (supports 3.3V and 5 V DI but 3.3V DO)
Input voltage	Logic low: VIL = 0.8 V max; IIL = 0.2 mA max. Logic high: VIH = 2.0 V min.; IIH = 0.2 mA max.
Output voltage	Logic low: VOL = 0.5 V max; IOL = 10 mA max. Logic high: VOH = 2.6V min.; IIH = 10 mA max.
Supporting modes (only one can be selected and function at the same time, please see Section 4.6: Programmable Function I/O)	▶ 4-CH TTL DI and 2-CH TTL DO ▶ 1-CH 32-bit general-purpose timer/counters: ▷ Clock source: internal or external ▷ Max source frequency: internal: 80 MHz; external: 10 MHz ▶ 1-CH PWM outputs: ▷ Duty cycle:1-99% (please see Section 4.6.3: Mode 10: PWM Output) Modulation frequency: 20 MHz to 0.005Hz

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I/O Specifications	
Data transfers	Programmed I/O

1.5 Software Support

ADLINK provides comprehensive software drivers and packages to suit various user approaches to system building. In addition to programming libraries, such as DLLs, for most Windows-based systems, ADLINK also provides drivers for other application environments such as LabVIEW® and MATLAB®. ADLINK also provides ActiveX component ware for measurement and SCADA/HMI, and breakthrough proprietary software. All software options are included in the ADLINK All-in-One CD.

Be sure to install the driver & utility before using the USB-2401 module.

1.6 Driver Support for Windows

1.6.1 UD-DASK

UD-DASK is composed of advanced 32/64-bit kernel drivers for customized DAQ application development. USB-DASK enables you to perform detailed operations and achieve superior performance and reliability from your data acquisition system. DASK kernel drivers now support Windows 7/Vista® OS.

1.6.2 DAQPilot

DAQPilot is a SDK with a graphics-driven interface for various application development environments. DAQPilot represents ADLINK's commitment to full support of its comprehensive line of data acquisition products and is designed for the novice to the most experienced programmer.

As a task-oriented DAQ driver, SDK and wizard for Windows systems, DAQPilot helps you shorten development time while accelerating the learning curve for data acquisition programming.

You can download and install DAQPilot at:

http://www.adlinktech.com/TM/DAQPilot.html

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Please note that only DAQPilot versions 2.3.0.712 and later can support the USB-2401.

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1.7 Utilities for Windows

1.7.1 U-Test

U-Test is a free and ready-to-use utility which can assist instant testing and operation of all ADLINK USB DAQ series functions with no programming. In addition to providing data collection and monitoring functions, U-Test also supports basic FFT analysis and provides direct control of analog output and digital I/O with a user-friendly interface.

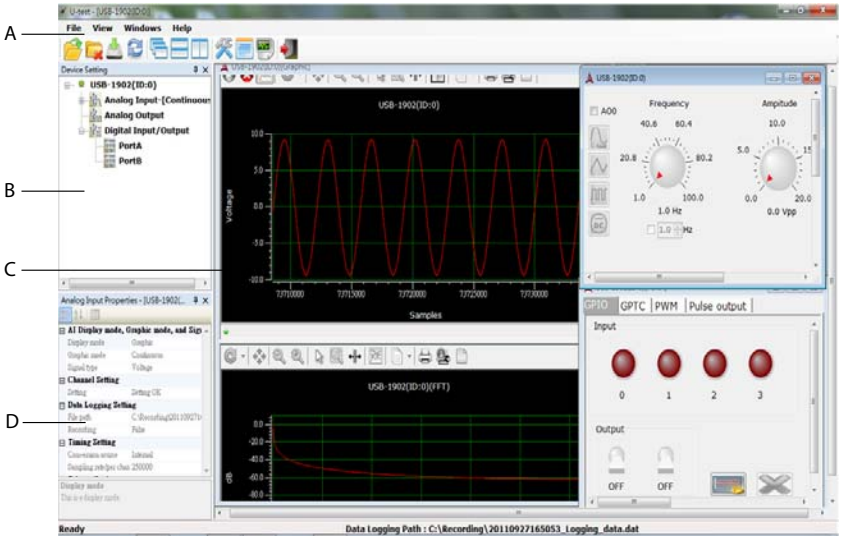


Figure 1-1: U-Test Interface

A	Main Menu
B	Device Viewer
C	AI Data View & AO, DIO Control Panel
D	Analog Input Configuration

Table 1-1: U-Test Interface Legend

You can download and install U-Test at: http://www.adlink-tech.com/

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1.8 Overview and Dimensions

NOTE:

All dimensions shown are in millimeters (mm)

1.8.1 Module

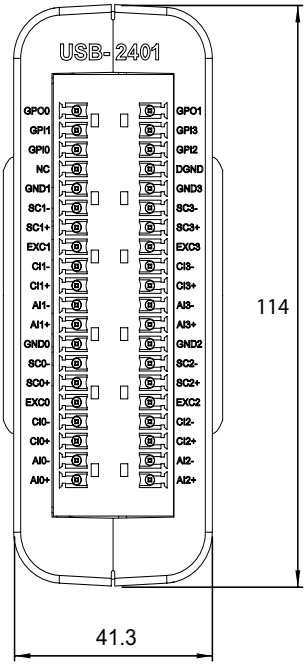


Figure 1-2: USB-2401 Module Rear View

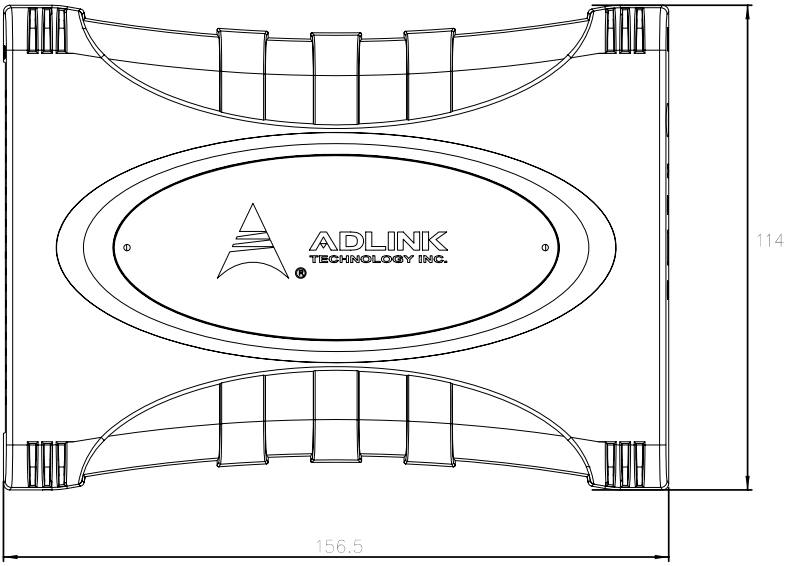


Figure 1-3: USB-2401 Module Side View

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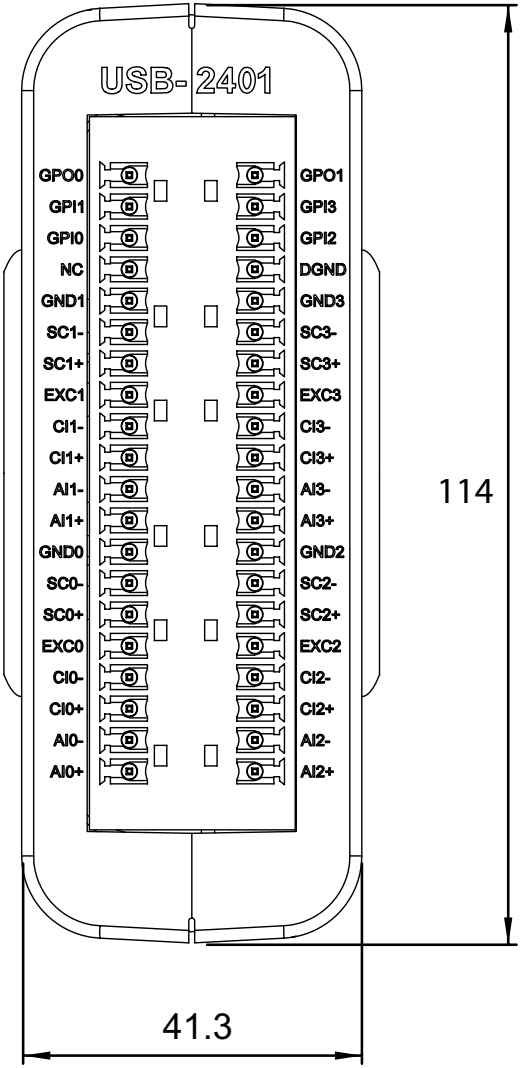


Figure 1-4: USB-2401 Module Front View

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1.8.2 Module Stand

The multi-function USB-2401 stand is compatible with desk, rail, or wall mounting. To fix the module in the stand, slide the module body into the stand until a click is heard. To remove the module from the stand, twist the bottom of the stand in a back-and forth motion and separate from the module.

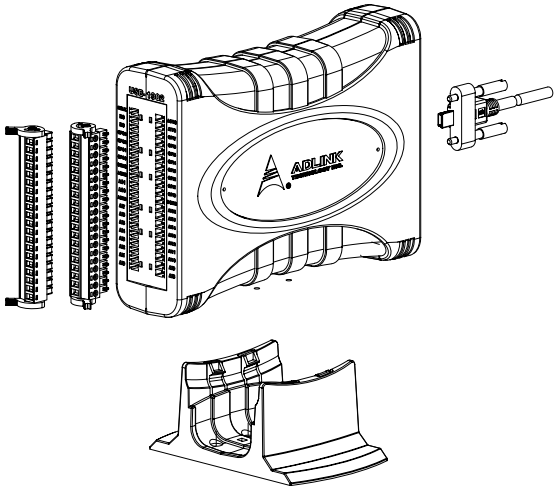


Figure 1-5: Module, Stand, Connector, and USB Cable

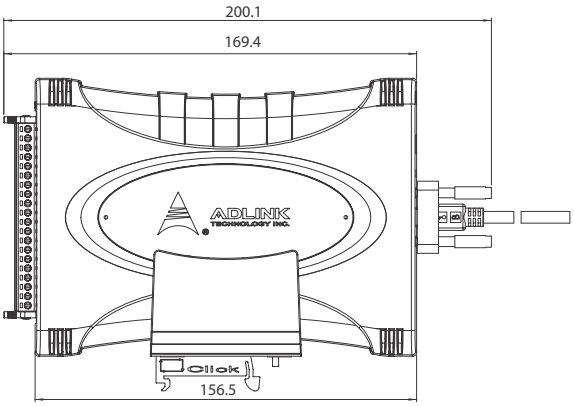


Figure 1-6: Module, Stand, & Wall Mount Kit Side View (w/ Connections)

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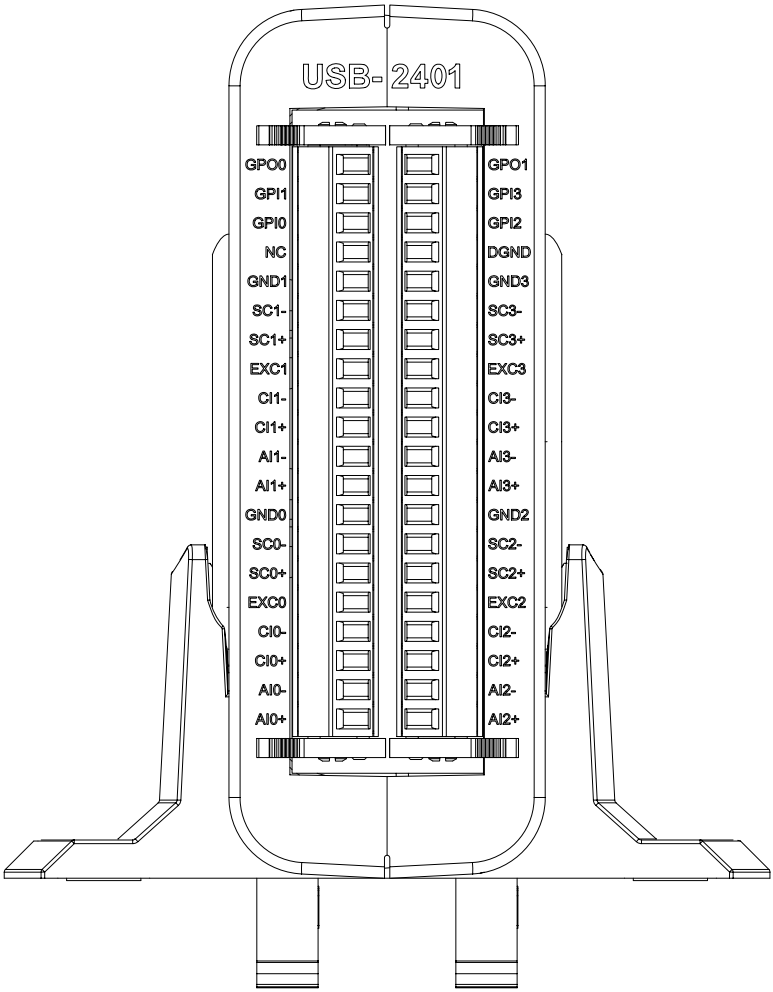


Figure 1-7: Module In Stand Front View

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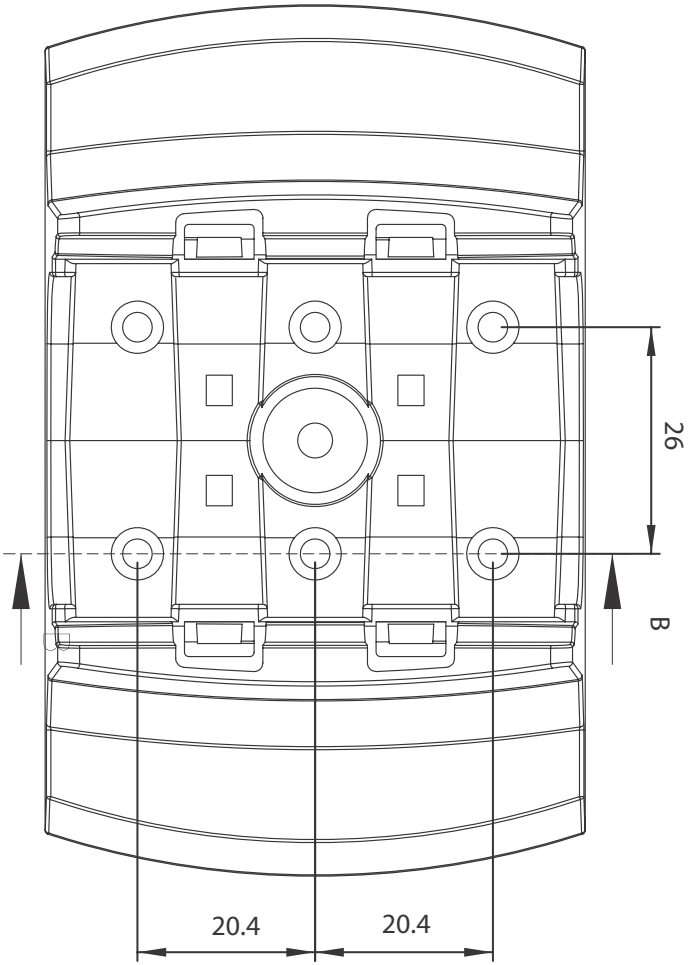


Figure 1-8: Module Stand Top View

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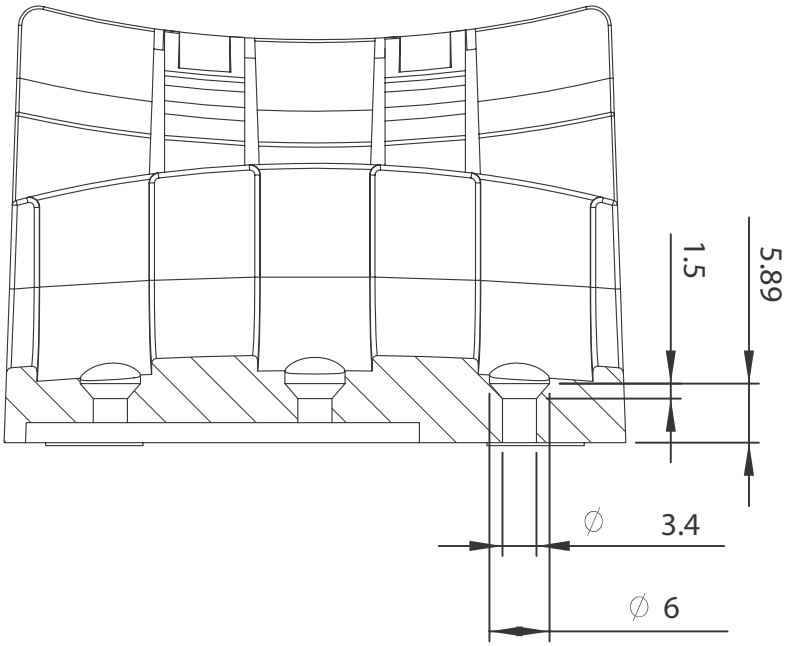


Figure 1-9: Module Stand Side Cutaway View

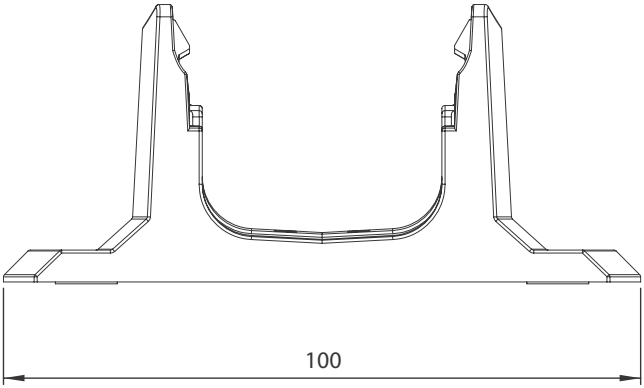


Figure 1-10: Module Stand Front View

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1.9 Connector Information

The USB-2401 module is equipped with 40-pin removable screw-down terminal connectors, with pin assignment and signal description as follows.

Pin	Function	Pin	Function
20	GPO0	40	GPO1
19	GPI1	39	GPI3
18	GPI0	38	GPI2
17	NC	37	DGND
16	GND1	36	GND3
15	SC1-	35	SC3-
14	SC1+	34	SC3+
13	EXC1	33	EXC3
12	CI1-	32	CI3-
11	CI1+	31	CI3+
10	AI1-	30	AI3-
9	AI1+	29	AI3+
8	GND0	28	GND2
7	SC0-	27	SC2-
6	SC0+	26	SC2+
5	EXC0	25	EXC2
4	CI0-	24	CI2-
3	CI0+	23	CI2+
2	AI0-	22	AI2-
1	AI0+	21	AI2+

Table 1-2: USB-2401 Pin Assignment

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Signal Name	Reference	Direction	Description
GND<0..3>	--------		Ground of excitation voltage/current, with GND<0..3> and DGND connected on board
DGND	--------		Digital ground, DGND and GND<0..3> are connected on board
AI<0..4>	GND	I	Differential analog Input channels 0~3
CI<0..4>	GND	I	Current input channel 0~3.
EXC<0..3>	GND	O	Excitation output for channel 0~3; can be configured to voltage output (2.5V) or current output (1mA) by software, with corresponding ground pin GND<0..3>
SC<0..3>	GND	I	Sensor (small signal) input channel 0~3
GPI<0..3>	DGND	I	Function digital input <0..3>
GPO<0..3>	DGND	O	Function digital output <0,1>
N/C	N/C	N/C	No connection

Table 1-3: I/O Signal Description

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2 Getting Started

WARNING:

The appropriate driver must be installed before you can connect the USB DAQ to the computer system. Refer to Section 1.6: Driver Support for Windows for driver support information.

2.1 Connecting the USB-2401 Module

1. Turn on the computer.
2. Connect the USB-2401 module to one USB 2.0 port on the computer using the included USB cable.
3. The first time the USB-2401 module is connected, a New Hardware message appears. It will take around 6 seconds to load the firmware. When loading is complete, the LED indicator on the rear of the USB DAQ module changes from amber to green and the New Hardware message closes.
4. The USB-2401 module can now be located in the hardware Device Manager, as shown.

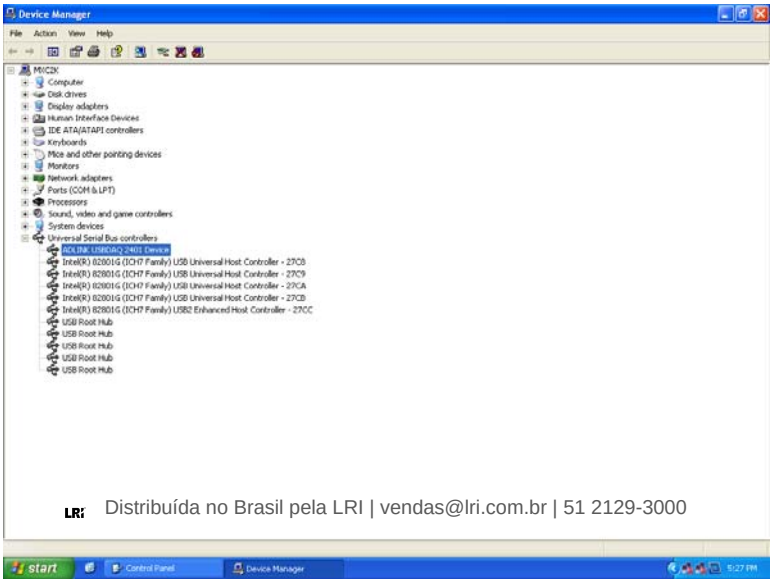


Figure 2-1: USB-2401 Module in Windows Device Manager

If the USB-2401 module cannot be detected, the power provided by the USB port may be insufficient. The USB-2401 module is exclusively powered by the USB port and requires 400 mA @ 5 V.

2.2 Device ID

A rotary control on the rear of the module (as shown) controls device ID setting and can be set from 1 to 8. The device ID allows dedicated control of the USB-2401 module irrespective of the connected USB port. When more than one USB module of the same type is connected, each must be set to a different ID to avoid conflicts and errors in operation.

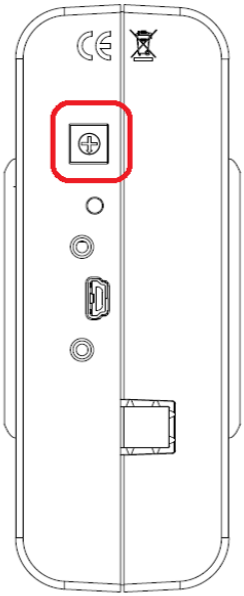


Figure 2-2: Device ID Selection Control

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2.3 Hardware Configuration

All remaining hardware configurations are software programmable, including sampling/update rate, input/output channel, input range, and others. Please see the UD-DASK Function Reference manual for details.

2.4 Device Mounting

2.4.1 Rail Mounting

The multi-function stand can be mounted on the DIN rail using the rail-mount kit as shown.

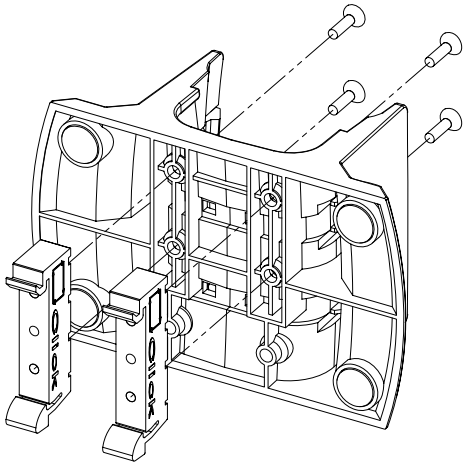


Figure 2-3: Rail Mount Kit

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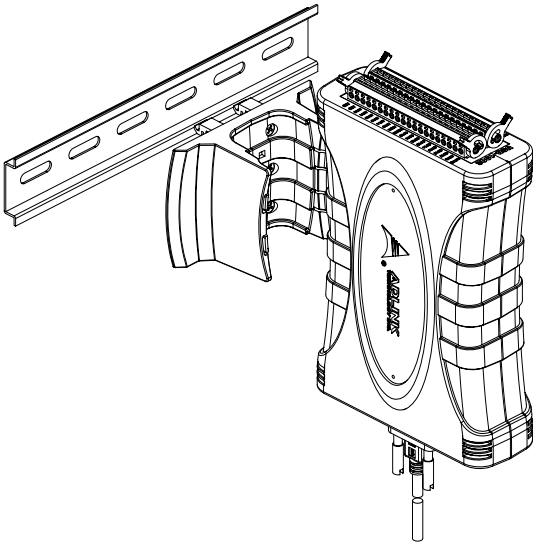


Figure 2-4: Module Pre-Rail Mounting

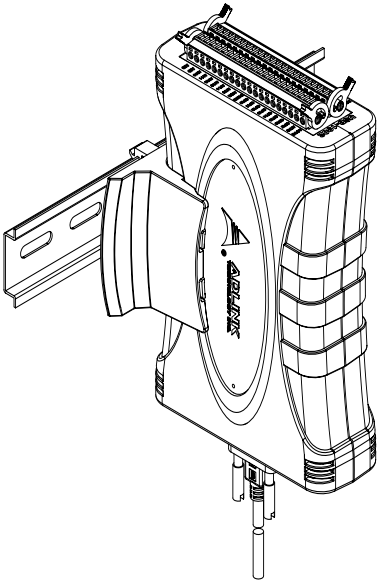


Figure 2-5: Module Rail-Mounted

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2.4.2 Wall Mounting

The multi-function stand can be fixed to a wall using four flush head screws as shown. The four screw holes should be approximately 3.4 mm in diameter.

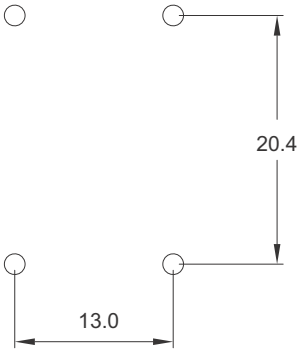


Figure 2-6: Wall Mount Holes

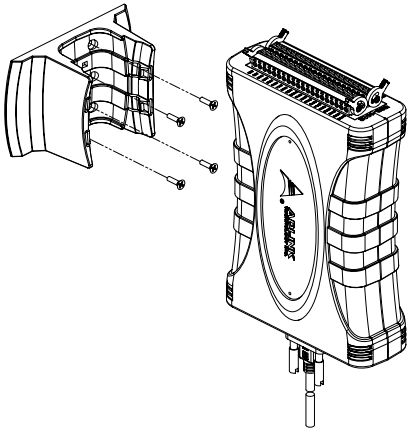


Figure 2-7: Module with Wall Mount Apparatus

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3 Operation

Operation of the USB-2401 is described here to assist in configuration and programming of the module. Functions described include A/D conversion, programmable function I/O, and others

3.1 Functional Layout

The USB-2401 provides 4-channel 24-bit universal analog inputs and supports seven input modes, including voltage input, current input, thermocouple, RTD, full bridge, half bridge, and resistance measurement. The four channels sample simultaneously, and while each can be configured to a different input mode, all active channels must be configured to the same sampling rate. In addition, the USB-2401 also provides 6-channel programmable digital I/O and can be configured to GPIO, GPTC, or PWM mode.

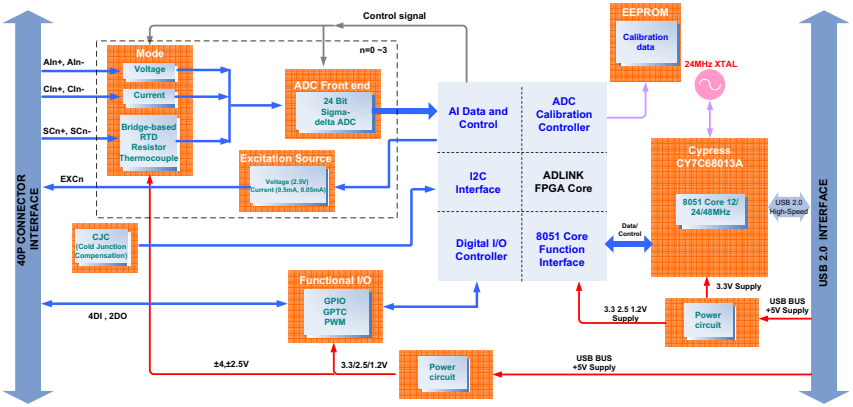


Figure 3-1: USB-2401 Functional Block Diagram

3.2 Signal Sources

3.2.1 Floating Signal Source

Not connected in any way to the existing ground system. Devices with isolated output are floating signal sources, such as optical isolator outputs, transformer outputs, and thermocouples.

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3.2.2 Ground-Referenced Signal Source

Connected in some way to the existing ground system, to a common ground point with respect to the USB DAQ, when the computer is connected to the same power system. Non-isolated output of instruments and devices connected to the existing power systems are ground-referenced signal sources.

3.3 Signal Connection

Each analog input channel can be configured to different input modes by the software API. Details of signal connection in different input modes follow.

3.3.1 Voltage Input Mode

The properties of the signal to be measured must be considered. The differential input mode provides two inputs that respond to signal voltage difference between them. If the signal source is ground-referenced, the differential mode can be used for the common-mode noise rejection.

Connection of ground-referenced signal sources under differential input mode is as shown.

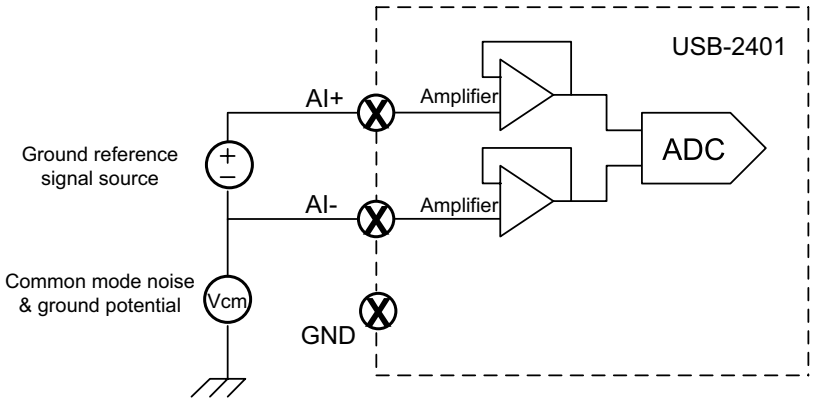


Figure 3-2: Ground-Referenced Source and Differential Input

For floating signal sources, addition of a resistor at each channel provides a bias return path. The resistor value should be about

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100 times the equivalent source impedance, such that if the source impedance is less than 100Ω, the negative side of the signal needs only be connected to GND as well as the negative input of the Instrumentation Amplifier without any resistors. Connection of a floating signal source to the USB-2401 in differential input mode is as shown.

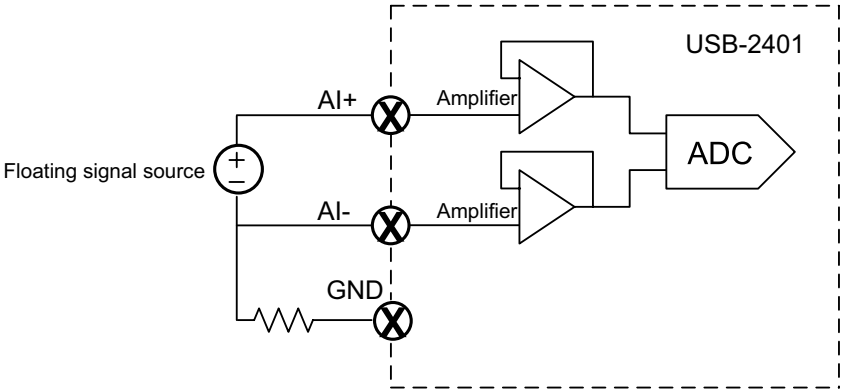


Figure 3-3: Floating Source and Differential Input

3.3.2 Current Input Mode

Current signal source can be floating or grounded reference, converted to voltage through a precision 249.5Ω resistor. Cross-voltage on the precision resistor is considered differential signal. The differential signal pair passes through differential amplifier buffers and is measured by the analog-to-digital converter chip (ADC) with ±2.5 V input range.

The formula to calculate voltage-to-current conversion is:

$$Current(mA) = \frac{V(volt)}{18.6701527}$$

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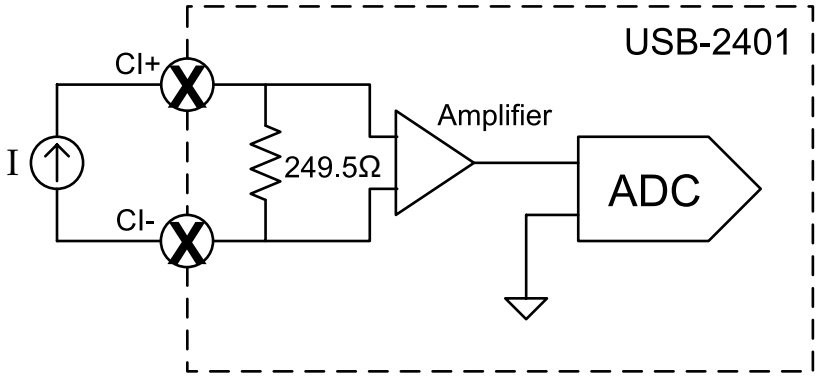


Figure 3-4: Current Source Connection

3.3.3 Full Bridge and Half Bridge Input Mode

A bridge-based transducer is a passive device, requiring voltage excitation to convert the resistive change to an electrical signal. The USB-2401 provides a steady 2.5V excitation voltage for each analog input channel in full bridge and half bridge modes. For half-bridge transducer, USB-2401 has built-in precision 20kΩ resistors to compensate the circuit as a full-bridge transducer measurement.

Also provided is a moving average function, a common and useful digital filtering method of smoothing fluctuation caused by noise. The averaging number for data can be set to 0, 2, 4, 8, or 16, where 0 represents disabling the moving average function.

A typical four-wire connection is shown.

NOTE:

A dotted line represents the connection and circuit of full-bridge mode.

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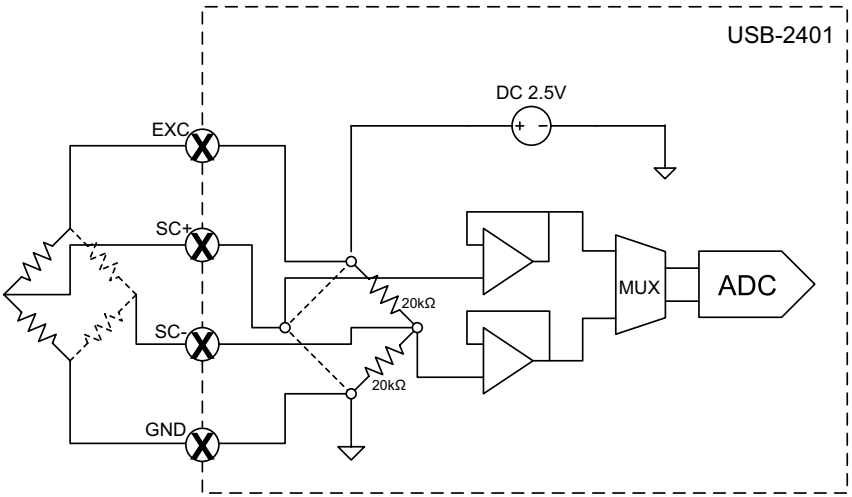


Figure 3-5: Full Bridge and Half Bridge Connection

3.3.4 Thermocouple Input Mode

A thermocouple consists of two different conductors that produce a voltage proportional to a temperature difference between either end of the pair of conductors. The USB-2401 uses 78.125mV input range to acquire the thermocouple signal, and provides a precision built-in digital temperature sensor for cold junction compensation (CJC). CJC reading is available by software API with data in °C. The CJC is in the USB-2401 module.

NOTE: The CJC temperature sensor is housed in the USB-2401 and requires 15 minutes' warmup to stabilize.

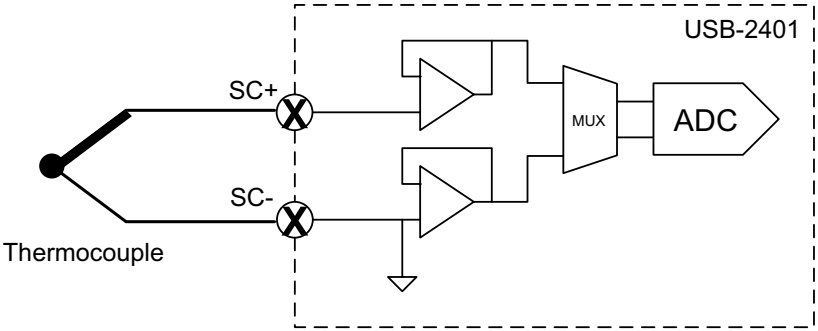


Figure 3-6: Thermocouple Connection

3.3.5 RTD Input Mode

The resistance temperature detector (RTD) measures temperature by correlating the resistance of the RTD element with temperature. The USB-2401 can generate a steady 0.5 mA excitation current source to each channel in RTD input mode to measure cross-voltage on the RTD. The actual input range is ±2.5V with a formula of voltage to RTD resistance conversion of:

$$RTD(\Omega) = \frac{\mathrm{V(volt)}}{0.0005}$$

Since the excitation current can only drive cross-voltage up to 1.5V with good linearity, the maximum equivalent value of the RTD resistor is limited to 3kΩ.

The USB-2401 can support two, three, and four-wire RTD measurement. Adopting three- and four-wire connections rather than two-wire can eliminate connection lead resistance effects from measurement. Three-wire connection is sufficient for most purposes and most universal industrial applications. Four-wire connections are used for the most precise application requirements.

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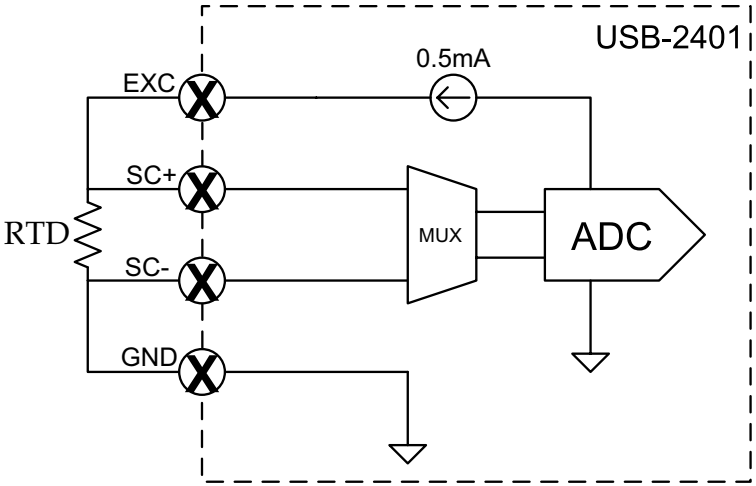


Figure 3-7: 4-Wire RTD Connection

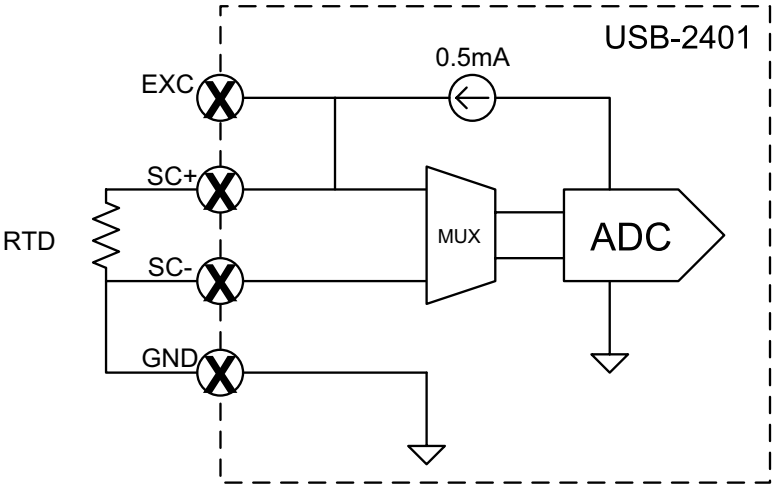


Figure 3-8: 3-Wire RTD Connection

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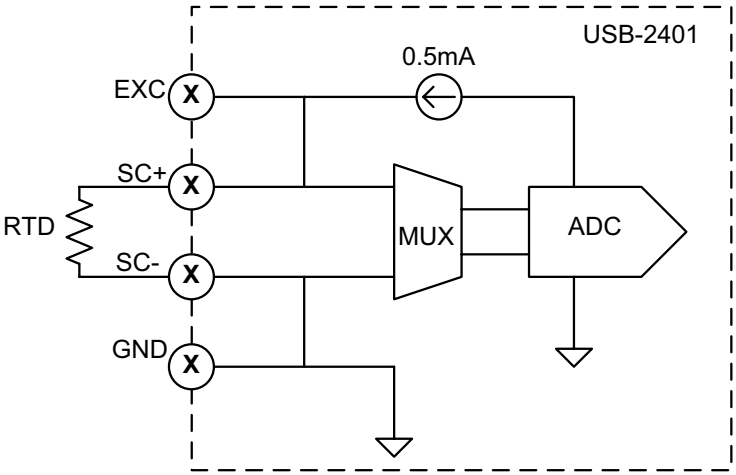


Figure 3-9: 2-wire RTD Connection

3.3.6 Wire Resistance Mode

The USB-2401 can source precision 0.05 mA excitation current to the resistor to be measured and use a 2.5V input range to acquire cross-voltage on the resistor. The formula of voltage to resistance conversion is:

$$R(\Omega) = \frac{\mathrm{V(volt)}}{0.00005}$$

Since the excitation current can only drive the cross-voltage up to 1.5V with good linearity, the maximum equivalent value of the resistor is limited to 30kΩ.

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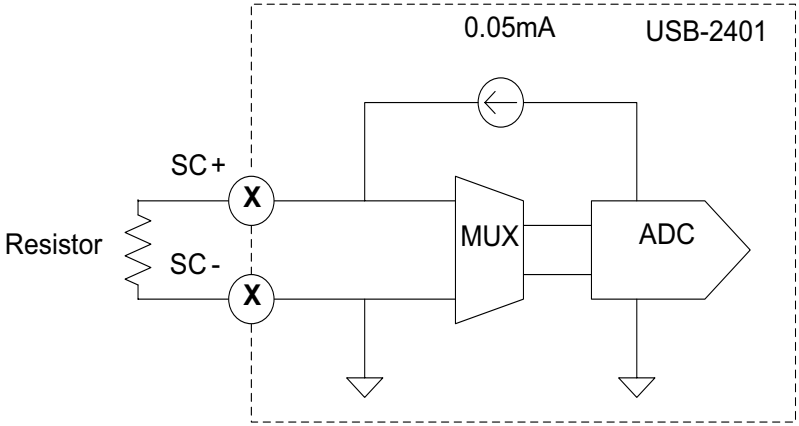


Figure 3-10: 2-Wire Resistance Connection

3.4 AI Data Format

The acquired 24-bit A/D data is 2's complement coded data format. Valid input ranges and optimum transfer characteristics are as shown.

Description	Bipolar Analog Input Range				Digital Code
Full-scale range	±25 V	±12.5 V	±2.5 V	±0.3125V	N/A
Least significant bit	2.98uV	1.49uV	0.298uV	0.037uV	N/A
FSR-1LSB	24.999997 V	12.4999985 V	2.4999997 V	0.3124999V	7FFFFF
Midscale +1LSB	2.98uV	1.49uV	0.298uV	0.037 uV	000001
Midscale	0 V	0 V	0 V	0 V	000000
Midscale -1LSB	-2.98uV	-1.49uV	-0.298uV	-0.3124999uV	FFFFFF
-FSR	-25 V	-12.5 V	-2.5 V	-0.3125V	800000

Table 3-1: Analog Input Range and Output Digital Code

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Description	Bipolar Analog Input Range	Digital Code
Full-scale range	±78.125 mV	N/A
Least significant bit	9.313nV	N/A
FSR-1LSB	78.1249907 mV	7FFFFF
Midscale +1LSB	9.313nV	000001
Midscale	0 V	000000
Midscale -1LSB	-9.313nV	FFFFFF
-FSR	-78.125mV	800000

Table 3-2: Analog Input Range and Output Digital Code (cont'd)

3.5 ADC Sampling Rate

Sampling Rate refers to ADC internal conversion speed as set by the user. When programming through a software API, the desired ADC sampling rate must be set, whether for single value, using a software polling command, or block data in continuous buffer mode. Available sampling rates are 20SPS, 40SPS, 80SPS, 160SPS, 320SPS, 500SPS, 1000SPS, and 2000SPS.


NOTE:

Accuracy frequently deteriorates with increased ADC sampling rate.

3.5.1 Software Polling Data Transfer (Non-Buffering Programmed I/O)

Polling mode benefits flexible timing and is suitable for retrieving the latest data without FIFO buffering latency. The USB-2401 continuously updates the latest acquired data onto a data port for specific channels. Data not retrieved in time is overwritten with new data without notice. As the software polling rate (here equaling data rate) of a PC may exceed the ADC sampling rate, it is possible to receive multiple identical data before a new conversion has

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completed. Please refer to UD-DASK function reference for the details of corresponding software API instruction.

3.5.2 Continuous Acquisition Mode

Differs from software polling mode only in the generation of block data in continuous acquisition mode without the need to consider data overwriting or acquiring repeat data in software polling mode. This mode is suitable for when continuous data is to be acquired in a fixed and precise time interval. Please note the data buffer size must be a multiple of 128 in continuous acquisition mode. Please refer to UD-DASK function reference for details of corresponding software API instruction.

3.6 Programmable Function I/O

The USB-2401 supports powerful programmable I/O function provided by an FPGA chip, configurable as TTL DI/DO, 32-bit timer/counters, and PWM output. These signals are single-ended and 5V TTL-compliant.

3.6.1 TTL DI/DO

Programmable function I/O can be used as static TTL-compliant 4-CH digital input and 2-CH digital output. The I/O lines can be updated by software polling, with sample and update rate fully controlled by software timing.

Pin	Function	Pin	Function
20	GPO0	40	GPO1
19	GPI1	39	GPI3
18	GPI0	38	GPI2
17	NC	37	DGND

Table 3-3: TTL Digital I/O Pin Definition

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3.6.2 General Purpose Timer/Counter

The USB-2401 is equipped with one general purpose timer/counter featuring:

- Count up/down controllable by hardware or software
- Programmable counter clock source (internal clock up to 80MHz, external clock up to 10 MHz)
- Programmable gate selection (hardware or software control)
- Programmable input and output signal polarities (high active or low active)
- Initial Count loaded from a software API
- Current count value readable by software without affecting circuit operation.

Pin	Function	Pin	Function
20	GPTC_OUT0 (GPO0)	40	GPTC_OUT1 (GPO1)
19	GPTC_UD (GPI1)	39	GPTC_AUX (GPI3)
18	GPTC_CLK (GPI0)	38	GPTC_GATE (GPI2)
17	NC	37	DGND

Table 3-4: Timer/Counter Pin Definition

The timer/counter has three inputs that can be controlled via hardware or software, clock input (GPTC_CLK), gate input (GPTC_GATE), and up/down control input (GPTC_UD). The GPTC_CLK input provides a clock source input to the timer/counter. Active edges on the GPTC_CLK input increment or decrement the counter. The GPTC_UD input directs the counter to count up or down (high: count up; low: count down), while the GPTC_GATE input is a control signal acting as a counter enable or counter trigger signal in different applications. The GPTC_OUT then generates a pulse signal based on the timer/counter mode set.

All input/output signal polarities can be programmed by software application. For brevity, all GPTC_CLK, GPTC_GATE, and GPTC_OUT in the following illustrations are assumed to be active high or rising-edge triggered.

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3.6.3 General Purpose Timer/Counter Modes

Ten programmable timer/counter modes are available. All initialize following a software-start signal set by the software. The GPTC software reset initializes the status of the counter and reloads the initial value to the counter. The operation remains halted until software start is executed again. Operations under different modes are as follows.

Mode 1: Simple Gated-Event Counting

In this mode, the counter calculates the number of pulses on the GPTC_CLK after a software start. Initial count can be loaded from the software application. Current count value can be read back by software any time with no influence on calculation. GPTC_GATE enables/disables calculation. When GPTC_GATE is inactive, the counter halts the current count value. Operation in which initial count = 5, countdown mode is shown.

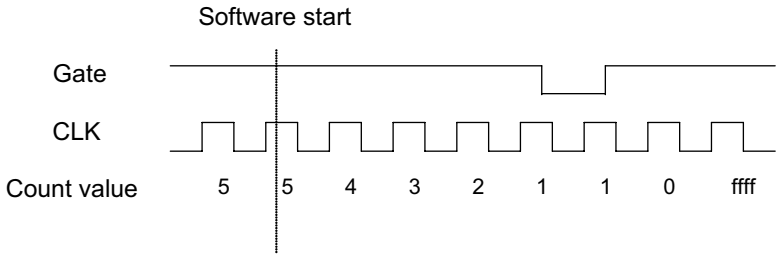


Figure 3-11: Mode 1-Simple Gated-Event Calculation

Mode 2: Single Period Measurement

The counter calculates the period of the signal on GPTC_GATE in terms of GPTC_CLK. The initial count can be loaded from the software application. After software start, the counter calculates the number of active edges on GPTC_CLK between two active edges of GPTC_GATE. After the completion of the period interval on GPTC_GATE, GPTC_OUT outputs high and then current count value can be read by the

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software application. Operation in which initial count = 0, count-up mode is shown.

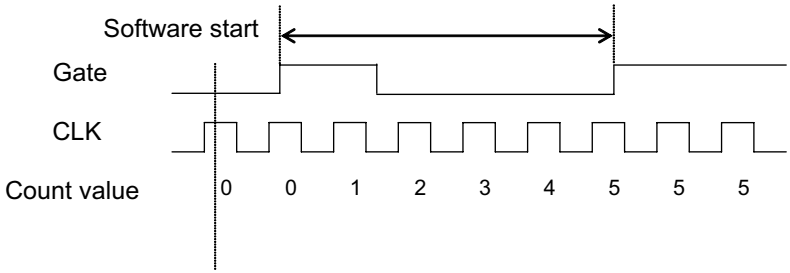


Figure 3-12: Mode 2-Single Period Measurement

Mode 3: Single Pulse-Width Measurement

The counter calculates the pulse-width of the signal on GPTC_GATE in terms of GPTC_CLK. Initial count can be loaded from the software application. After software start, the counter calculates the number of active edges on GPTC_CLK when GPTC_GATE is in its active state.

After the completion of the pulse-width interval on GPTC_GATE, GPTC_OUT outputs high and current count value can be read by the software application. Operation in which initial count = 0, count-up mode is shown.

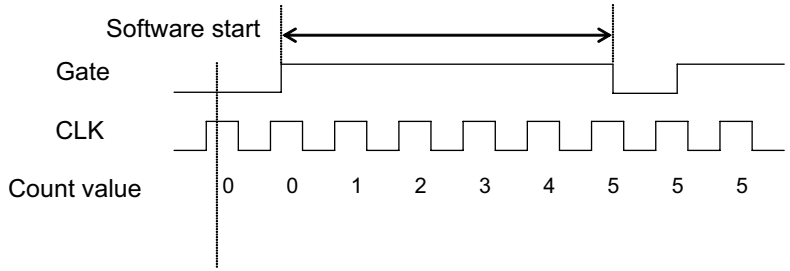


Figure 3-13: Mode 3-Single Pulse-Width Measurement

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Mode 4: Single-Gated Pulse Generation

This mode generates a single pulse with programmable delay and programmable pulse-width following software start. The two programmable parameters can be specified in terms of periods of the GPTC_CLK input by the software application. GPTC_GATE enables/disables calculation. When GPTC_GATE is inactive, the counter halts the current count value. Generation of a single pulse with a pulse delay of two and a pulse-width of four is shown.

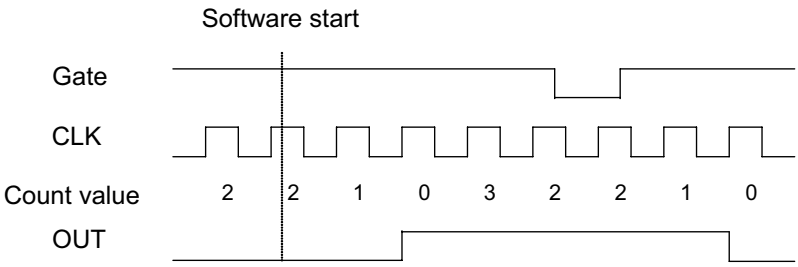


Figure 3-14: Mode 4-Single-Gated Pulse

Mode 5: Single-Triggered Pulse

This mode generates a single pulse with programmable delay and programmable pulse-width following an active GPTC_GATE edge. These programmable parameters can be specified in terms of periods of the GPTC_CLK input. When the first GPTC_GATE edge triggers the single pulse, GPTC_GATE has no effect until software start is executed again. Generation of a single pulse with a pulse delay of two and a pulse-width of four is shown.

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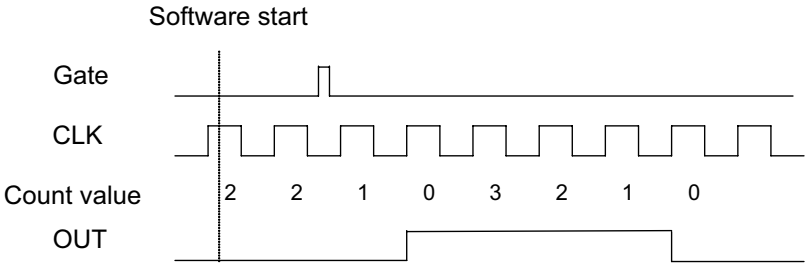


Figure 3-15: Mode 5-Single-Triggered Pulse

Mode 6: Re-Triggered Single Pulse Generation

This mode is similar to Mode 5 except that the counter generates a pulse following every active edge of GPTC_GATE. After software start, every active GPTC_GATE edge triggers a single pulse with programmable delay and pulse width. Any GPTC_GATE triggers that occur when the prior pulse is not completed are ignored. Generation of two pulses with a pulse delay of two and a pulse width of four is shown.

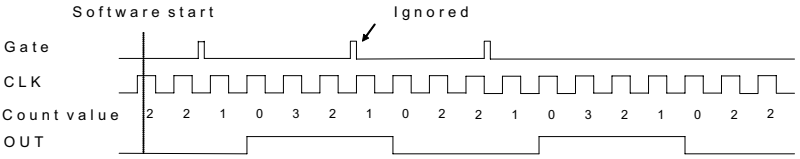


Figure 3-16: Mode 6-Re-Triggered Single Pulse

Mode 7: Single-Triggered Continuous Pulse Generation

This mode is similar to Mode 5 except that the counter generates continuous periodic pulses with programmable pulse interval and pulse-width following the first active edge of GPTC_GATE. When the first GPTC_GATE edge triggers the counter, GPTC_GATE has no effect until software start is executed again. Generation of two pulses with a pulse delay of four and a pulse-width of three is shown.

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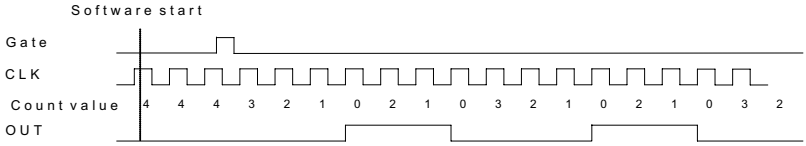


Figure 3-17: Mode 7-Single-Triggered Continuous Pulse

Mode 8: Continuous Gated Pulse Generation

This mode generates periodic pulses with programmable pulse interval and pulse-width following software start. GPTC_GATE enables/disables calculation. When GPTC_GATE is inactive, the counter halts the current count value. Generation of two pulses with a pulse delay of four and a pulse-width of three is shown.

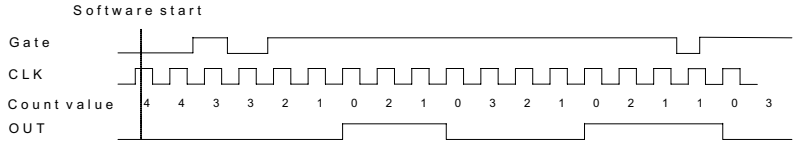


Figure 3-18: Mode 8-Continuous Gated Pulse

Mode 9: Edge Separation Measurement

Measures the time differentiation between two different pulse signals. The first pulse signal is connected to GPTC_GATE and the second signal is connected to GPTC_AUX. Clocks that pass between the rising edge signal of two different pulses through the 40 MHz internal clock or external clock are calculated. You can calculate the time period via the known clock frequency. The maximum counting width is 32-bit. Decrease of

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the counter value in Edge Separation Measurement mode is shown.

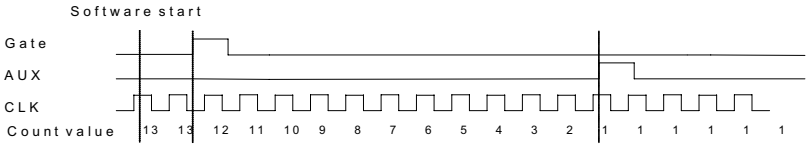


Figure 3-19: Mode 9-Edge Separation Measurement

Mode 10: PWM Output

The USB-1900 Series timer/counter can also simulate a PWM (Pulse Width Modulation) output. By setting a varying amount of Pulse_initial_cnt and Pulse_length_cnt, varying pulse frequencies (Fpwm) and duty cycles (Dutypwm) can be obtained. PWM output is shown.

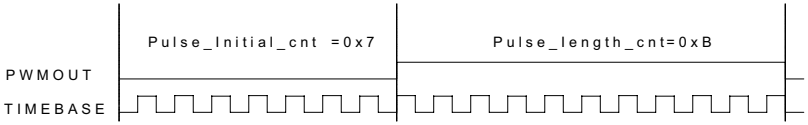


Figure 3-20: Mode 10-PWM Output

Calculation of the PWM frequency and duty cycle is as follows.

$$F_{PWM} = \frac{F_{Timebase}}{Pulse_initial_cnt + Pulse_length_cnt}$$

$$Duty_{PWM} = \frac{Pulse_length_cnt}{Pulse_initial_cnt + Pulse_length_cnt}$$

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4 Calibration

The USB-2401 is factory-calibrated before shipment. The associated calibration constants of the TrimDACs firmware are written to the onboard EEPROM. TrimDACs firmware is the algorithm in the FPGA. Loading calibration constants entails loading the values of TrimDACs firmware stored in the onboard EEPROM.

The recommended re-calibration interval is one year. Please contact your local dealer to request calibration service.

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Important Safety Instructions

For user safety, please read and follow all **instructions**, **WARNINGS**, **CAUTIONS,** and **NOTES** marked in this manual and on the associated equipment before handling/operating the equipment.

- Read these safety instructions carefully.
- Keep this user's manual for future reference.
- Read the specifications section of this manual for detailed information on the operating environment of this equipment.
- When installing/mounting or uninstalling/removing equipment:
  - Turn off power and unplug any power cords/cables.
- To avoid electrical shock and/or damage to equipment:
  - Keep equipment away from water or liquid sources;
  - Keep equipment away from high heat or high humidity;
  - Keep equipment properly ventilated (do not block or cover ventilation openings);
  - Make sure to use recommended voltage and power source settings;
  - Always install and operate equipment near an easily accessible electrical socket-outlet;
  - Secure the power cord (do not place any object on/over the power cord);
  - Only install/attach and operate equipment on stable surfaces and/or recommended mountings; and,
  - If the equipment will not be used for long periods of time, turn off and unplug the equipment from its power source.

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- Never attempt to fix the equipment. Equipment should only be serviced by qualified personnel.

A Lithium-type battery may be provided for uninterrupted, backup or emergency power.



Risk of explosion if battery is replaced with an incorrect type; please dispose of used batteries appropriately.

- Equipment must be serviced by authorized technicians when:
  - The power cord or plug is damaged;
  - Liquid has penetrated the equipment;
  - It has been exposed to high humidity/moisture;
  - It is not functioning or does not function according to the user's manual;
  - It has been dropped and/or damaged; and/or,
  - It has an obvious sign of breakage.

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Getting Service

Contact us should you require any service or assistance.

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