USB-2405

USB 2.0-based Dynamic Signal Acquisition Module

User's Manual



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Recycled Paper

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Revision History

Revision	Release Date	Description of Change(s)
2.00	July 5, 2013	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-2405 is a 24-bit high-performance dynamic signal acquisition USB module, equipped with 4 simultaneous-sampling analog input channels sampling up to 128 kS/s per channel. The USB-2405 also features software selectable AC or DC coupling input configuration, and built-in high precision 2 mA excitation current to measure integrated electronic piezoelectric (IEPE) sensors such as accelerometers and microphones.

The USB-2405 delivers high precision DC and dynamic measurement performance with very low temperature drift. The onboard 24-bit Sigma-Delta ADC supports anti-aliasing, which suppresses modulator and signal out-of-band noise and provides usable signal bandwidth of the Nyquist rate, making it ideal for high dynamic range signal measurement in vibration and acoustic applications.

The USB-2405 supports digital and analog trigger sources and flexible trigger modes, including post, delay, middle, gated, and pre-triggering, which acquires data efficiently without post processing. The USB-2405 is USB bus powered and equipped with BNC connectors and removable spring terminals for easy device connectivity.

1.2 Features

- Hi-Speed USB 2.0
- USB bus powered
- 24-bit Sigma-Delta ADC with built-in anti-aliasing filter
- 4-CH simultaneous sampling analog input, up to 128kS/s
- AC or DC input coupling, software selectable
- Analog or digital triggering
- Supports 2mA excitation output on each analog input channel for IEPE sensor measurement
- Full auto-calibration
- Ready-to-use testing application (U-Test) provided

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1.3 Applications

- Vibration testing
- Machine condition monitoring
- Acoustic measurement
- Environmental noise analysis

1.4 Specifications

1.4.1 General Specifications

Physical, Power, and Operating Environment	
Interface	Hi Speed USB 2.0 compatible, mini-USB connector
Dimensions	156.5 (L) x 114 (W) x 41.3 (H) mm (6.16 X 4.49 X 1.63 in.)
I/O Connector	Four BNC connectors and 4-pin removable spring 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 Analog Input (AI)

Channels	4 (simultaneous-sampling)
ADC resolution	24-bit
ADC type	Delta-sigma
Sampling rate	1kHz to 128kHz
Input range	±10V
FIFO buffer size	8kS across all channel
Input configuration	Differential or pseudo-differential
Input impedance	200 kΩ between positive input and negative input 16.93 kΩ between negative input and chassis ground
Input coupling	AC or DC, software selectable

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Integrated electronic piezoelectric (IEPE)	Current: 2 mA or 0 mA, software selectable IEPE compliance: 24V
Over-voltage protection	±60V
Input common mode range	±10V
Trigger source	Analog or digital, software selectable
Trigger mode	Post trigger, delay trigger, middle trigger, gated trigger, pre-trigger, post or delay trigger with re-triggering
Data transfer	Programmed I/O, continuous (bulk transfer mode)

1.4.3 DC accuracy @25°C

	Offset Error (mV)	Gain Error (%)
Typical	±0.15mV	±0.15mV
Maximum	±0.3mV	±0.3%

1.4.4 AC Dynamic Performance (typical, 25°C)

THD, THD+N (Vin = 8.9 Vpk)

Input Configuration	Input Signal Frequency (fin)	THD	THD+N
Differential	20Hz to 20kHz	-94dB	-91 dB
	20Hz to 46.4kHz	-89 dB	-88 dB
Pseudo-differential	20Hz to 20kHz	-92 dB	-88 dB
	20Hz to 46.4kHz	-85 dB	-85 dB

CMRR

AC (20Hz to 1kHz)	60 dB

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Bandwidth

-3dB bandwidth	0.49 x fs (where fs is sampling rate)
AC cut-off frequency (-3dB)	0.4 Hz
AC cut-off frequency (-0.1dB)	2.4 Hz

Flatness

Input Signal Frequency (f_{in})	Flatness
20Hz to 20kHz	±0.01 dB
20Hz to 46.4kHz	±0.15 dB

Crosstalk

Input Signal Frequency (f_{in})	Crosstalk
1kHz	-102 dB
46.4kHz	-95 dB

System Noise

Measurement Bandwidth	AI Noise
High Resolution (< 52.734kHz)	50 µVrms
High Speed Mode (52.734 kHz to 128kHz)	65 µVrms

SFDR (Vin = -1 dBFS)

Input Signal Frequency (f_{in})	SFDR
1kHz	104 dB

Dynamic Range (Vin = -60 dBFS)

Input Signal Frequency (f_{in})	Dynamic Range
1kHz	100 dB

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1.4.5 Digital I/O

Channels	2 programmable function I/O
Compatibility	3.3V / TTL (single-ended)
Initial status	Input (pulled low)
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 = 0.8 V max; IIL = 0.2 mA max. Logic high: VOH = 2.0 V min.; IIH = 24 mA max.
Over-voltage protection	-2V to +7V
Supporting modes (only one can be selected and function at a time, see Section 3.4: Programmable Function I/O	• Static digital input/output • PWM output, max. frequency: 4 MHz • Frequency/Event counter, max. frequency: 4MHz • Digital trigger IN • Synchronization sample clock IN, max. frequency: 128kHz
Data Transfer	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 application environments such as LabVIEW® and MATLAB®. ADLINK also provide ActiveXcomponent 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-2405 module.

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1.6 Driver Support for Windows

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. Please note that only UD-DASK versions 1.2.2.0627 and later can support the USB-2405 module.

DAQPilot

DAQPilot is a task-oriented Software Development Kit, supporting ActiveX Controls/.NET Assembly, Express VI and Polymorphic VI for LabVIEW and DAQ Toolbox for MATLAB.

You can download and install DAQPilot at:

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

Please note that only DAQPilot versions 2.6.1.0628 and later can support the USB-2405.

1.7 Utilities for Windows

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.

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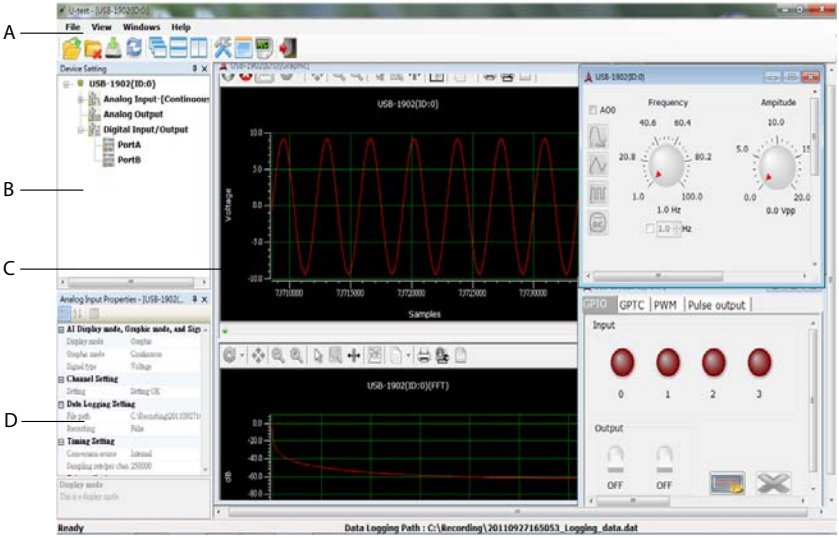


Figure 1-1: U-Test Interface

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/

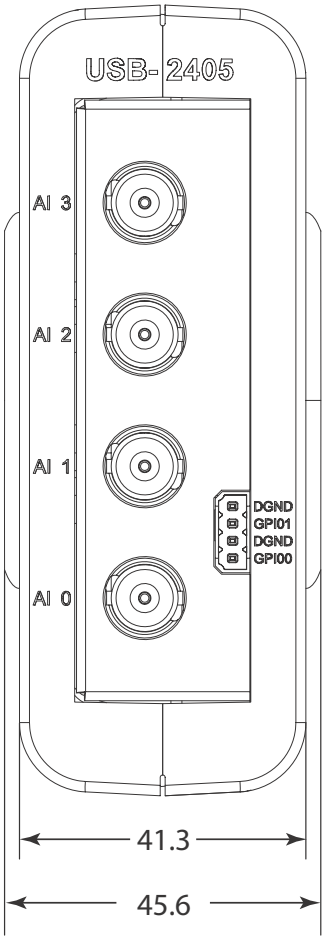
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1.8 Overview and Dimensions

NOTE:

All dimensions shown are in millimeters (mm)

1.8.1 Module



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Figure 1-2: USB-2405 Module Front View

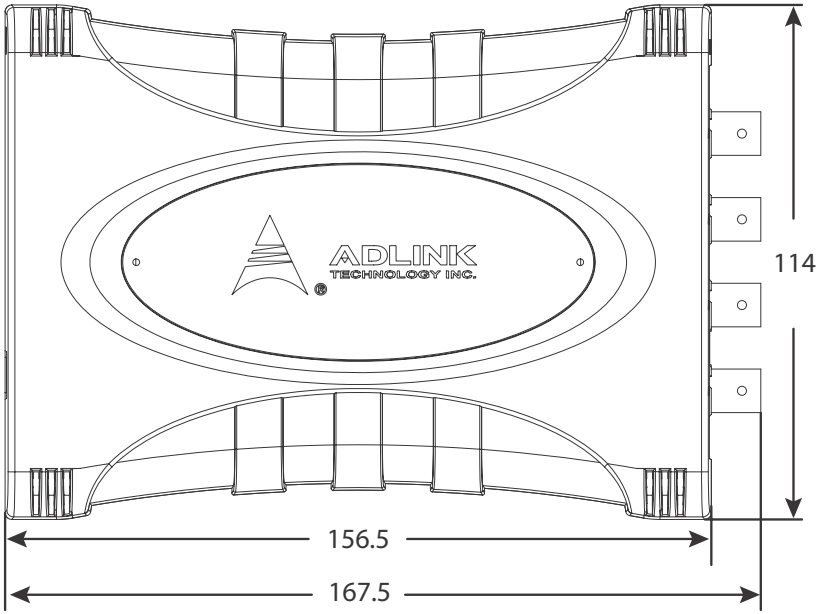


Figure 1-3: USB-2405 Module Side View

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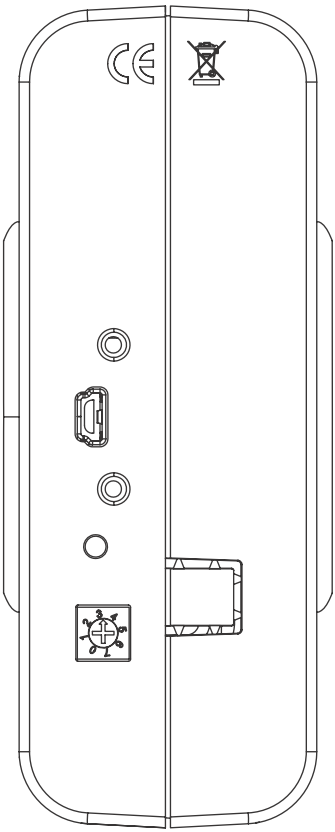


Figure 1-4: USB-2405 Module Rear View

1.8.2 Module Stand

The multi-function USB-2405 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

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from the stand, twist the bottom of the stand in a back-and forth motion and separate from the module.

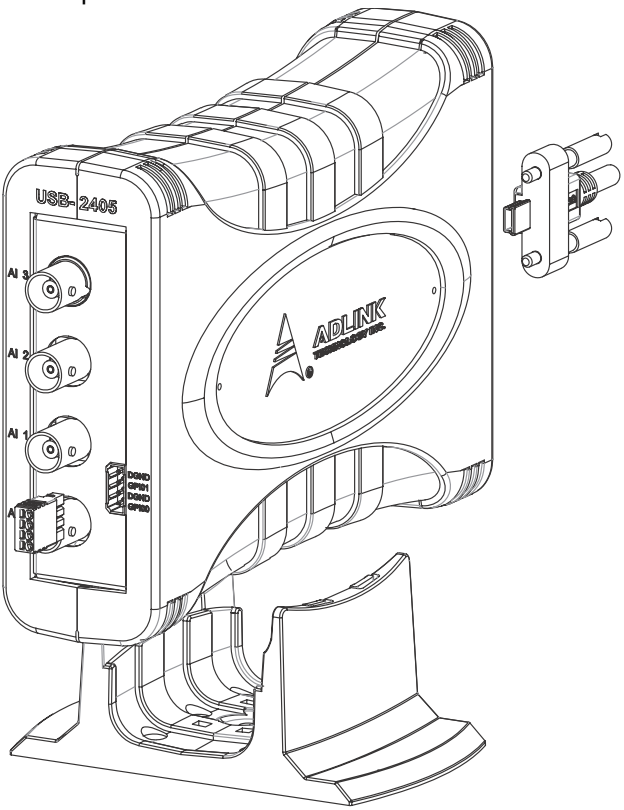


Figure 1-5: Module, Stand, and USB Cable

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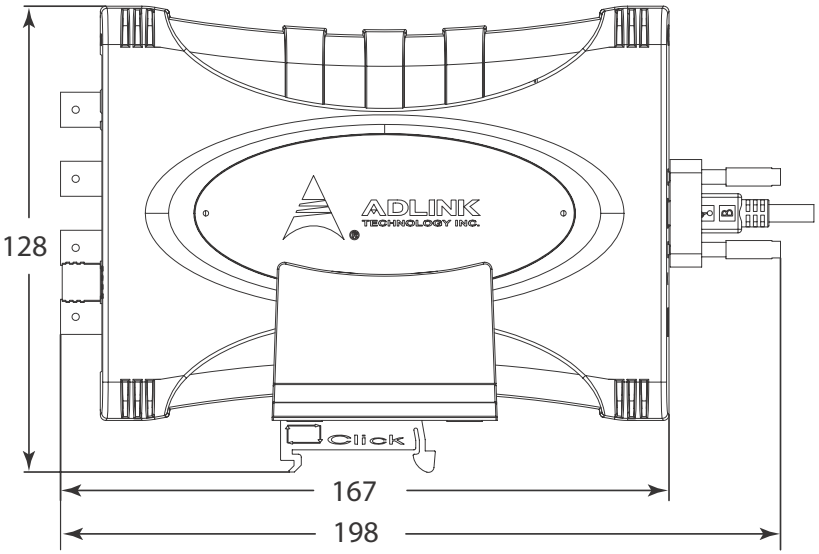


Figure 1-6: Module, Stand, & Wall Mount Kit Side View (w/ Connections)

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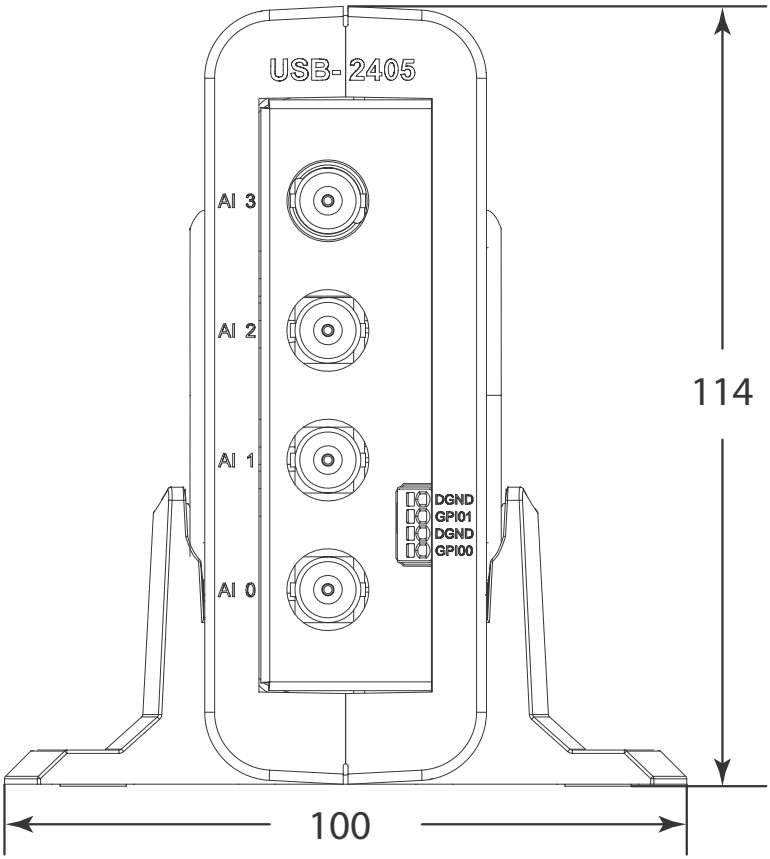


Figure 1-7: Module In Stand Front View

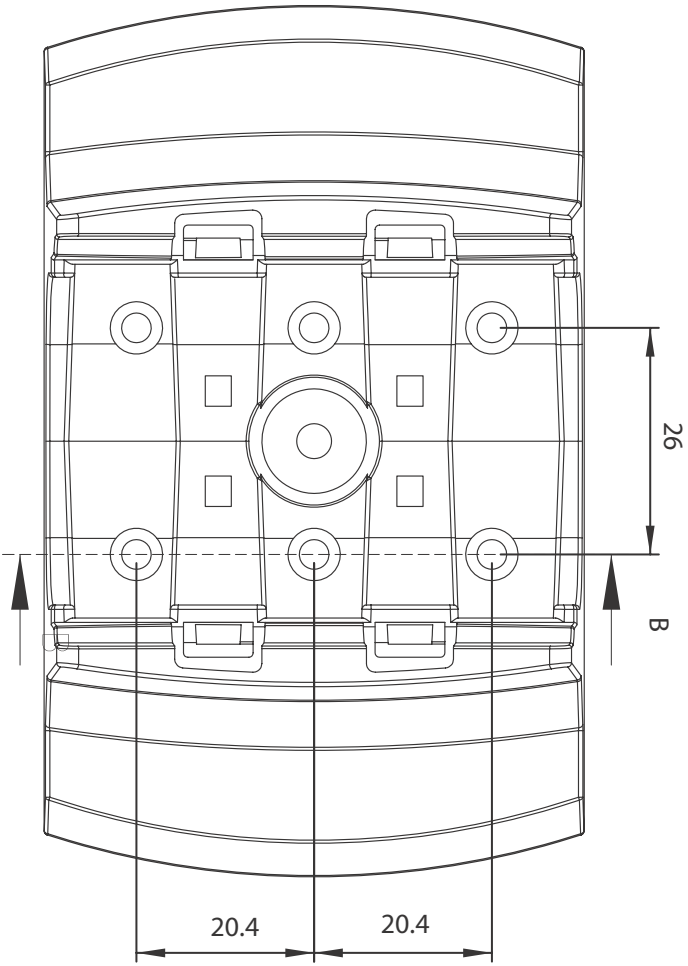


Figure 1-8: Module Stand Top View

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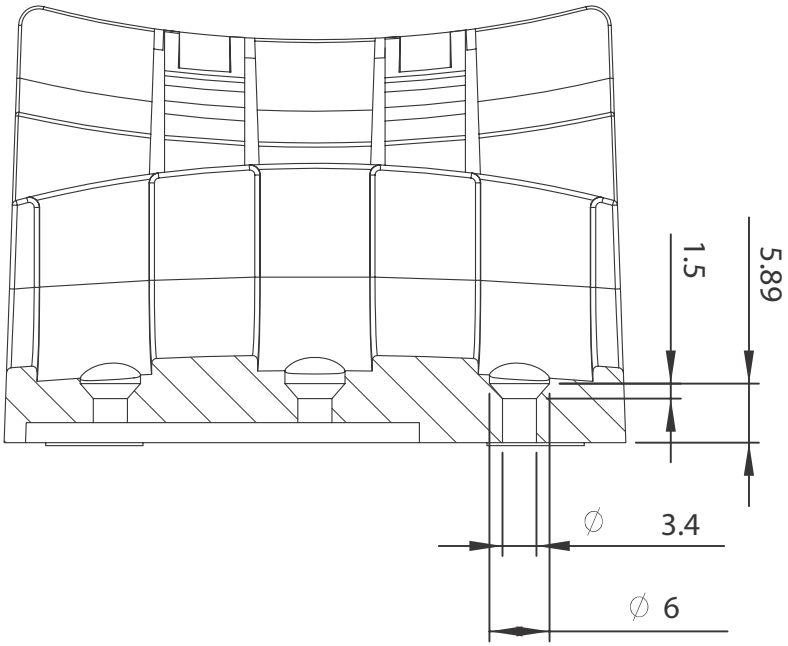


Figure 1-9: Module Stand Side Cutaway View

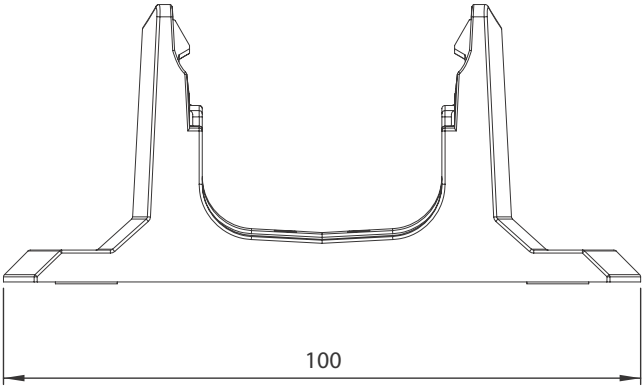


Figure 1-10: Module Stand Front View

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1.9 Connections

The USB-2405 module is equipped with four BNC connectors and one 4-pin removable spring terminal connector, with pin assignment as labeled.

BNC connector polarity is as shown.

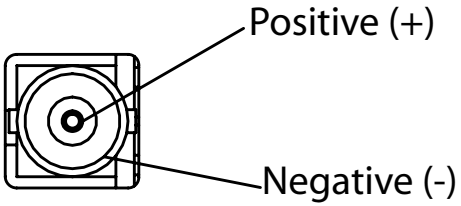


Figure 1-11: BNC Connector Polarity

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2 Getting Started

2.1 Unpacking the USB-2405

Before unpacking, check the shipping carton for any damage. If the shipping carton and/or contents are damaged, inform your dealer immediately. Retain the shipping carton and packing materials for inspection. Obtain authorization from your dealer before returning any product to ADLINK. Ensure that the following items are included in the package.

- ▷ USB-2405
- ▷ Stand
- ▷ USB cable (2 meter)
- ▷ Rail mount kit
- ▷ ADLINK All-in-One CD
- ▷ Quick Start Guide

2.2 Connecting the USB-2405 Module



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.

1. Turn on the computer.
2. Connect the USB-2405 module to one USB 2.0 port on the computer using the included USB cable.
3. The first time the USB-2405 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

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changes from amber to green and the New Hardware message closes.

4. The USB-2405 module can now be located in the hardware Device Manager, as shown.

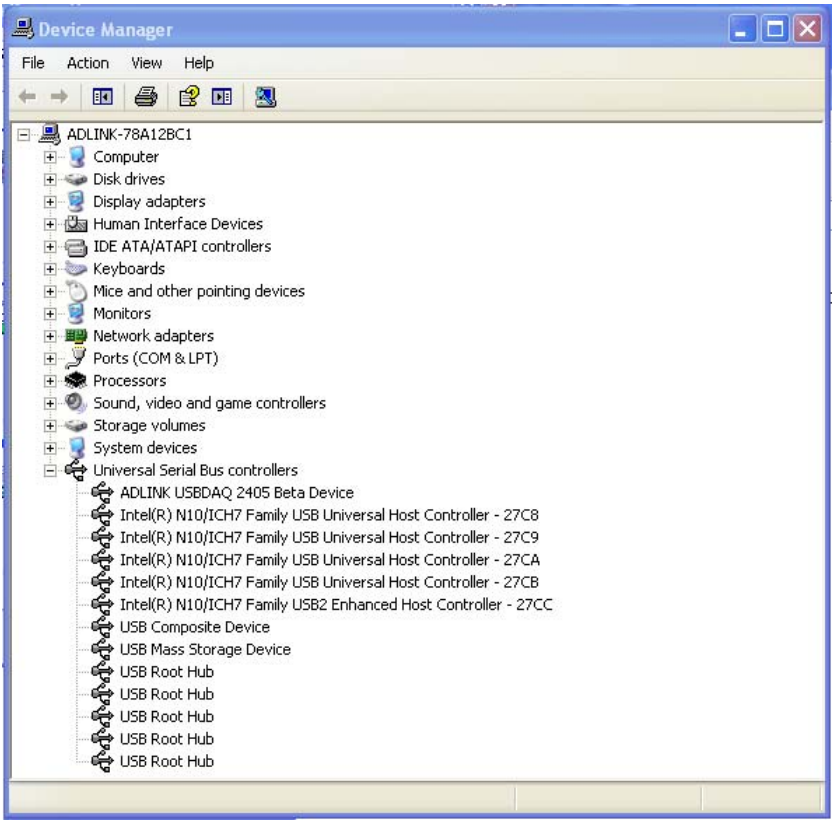


Figure 2-1: USB-2405 Module in Windows Device Manager

If the USB-2405 module cannot be detected, the power provided by the USB port may be insufficient. The USB-2405 module is exclusively powered by the USB port and requires 400 mA @ 5 V.

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2.3 Device ID

A rotary control on the rear of the module (as shown) controls device ID setting and can be set from 0 to 7. The device ID allows dedicated control of the USB-2405 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.

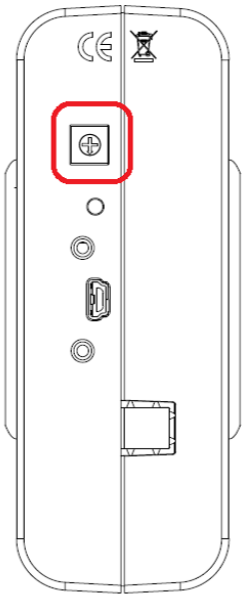


Figure 2-2: Device ID Selection Control

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.

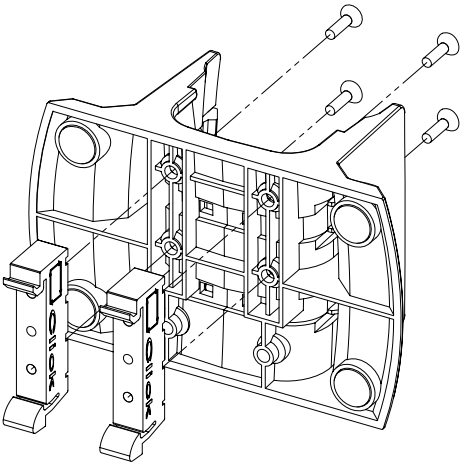


Figure 2-3: Rail Mount Kit

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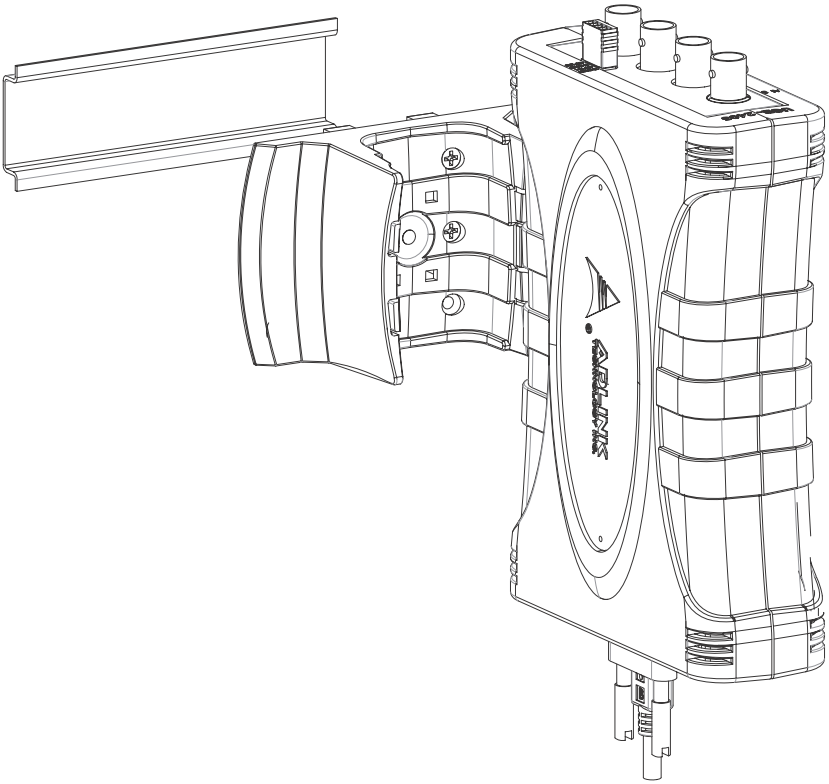


Figure 2-4: Module Pre-Rail Mounting

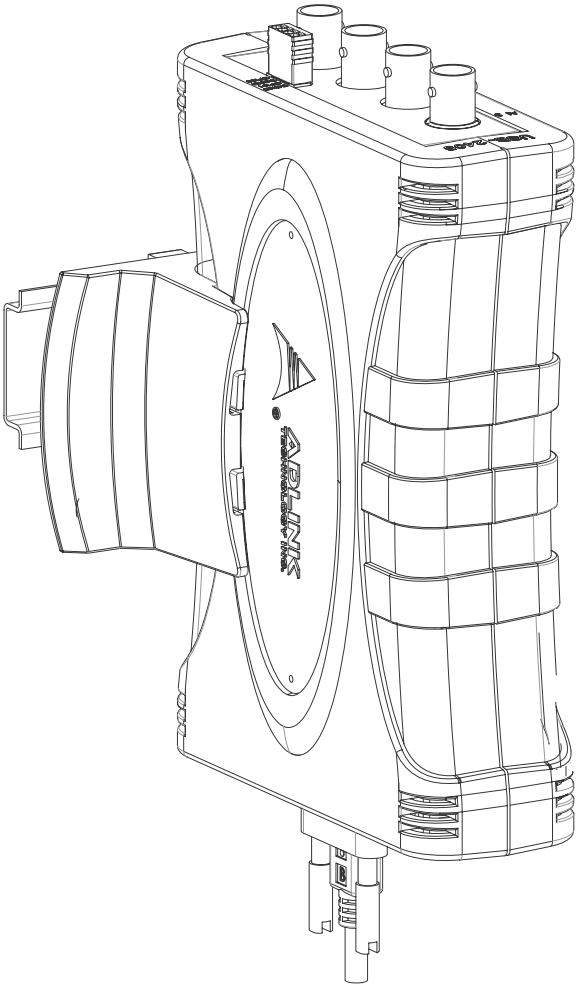


Figure 2-5: Module Rail-Mounted

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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.

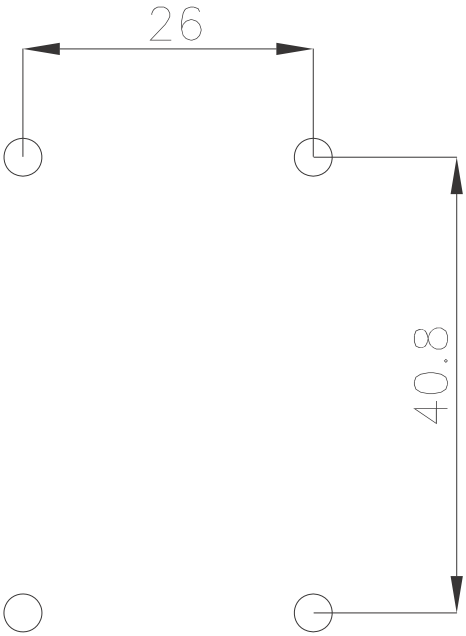


Figure 2-6: Wall Mount Holes

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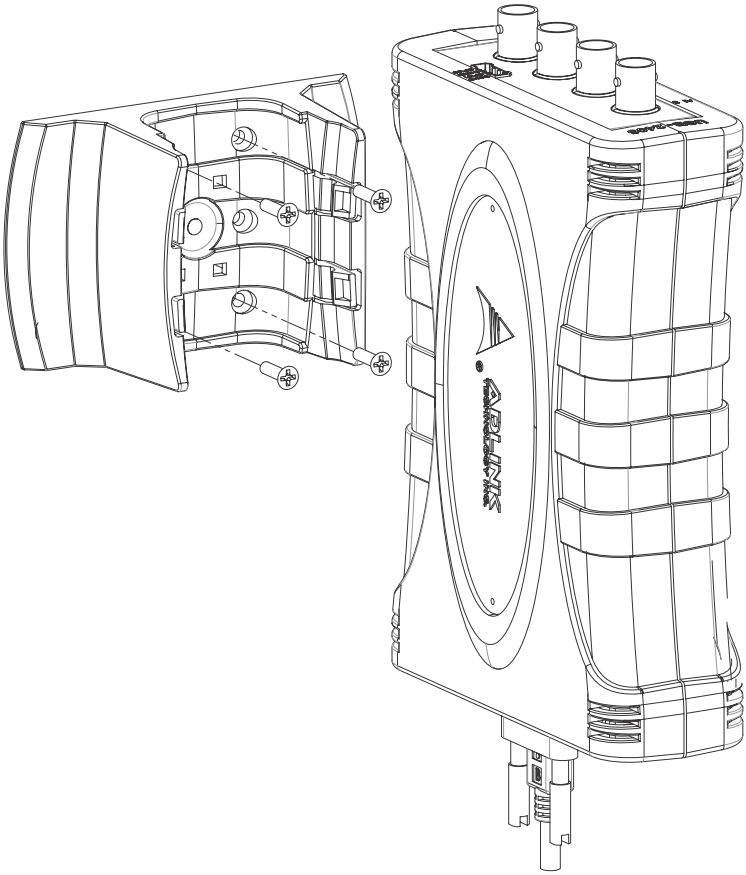


Figure 2-7: USB-2405 Module with Wall Mount Apparatus

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2.5 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.

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3 Operation

Operation of the USB-2405 is described here to assist in configuration and programming of the module. Functions addressed include analog input and GPIO.

3.1 Functional Layout

The USB-2405 is equipped with four simultaneous-sampling analog input channels and two general-purpose digital I/Os (GPIO).

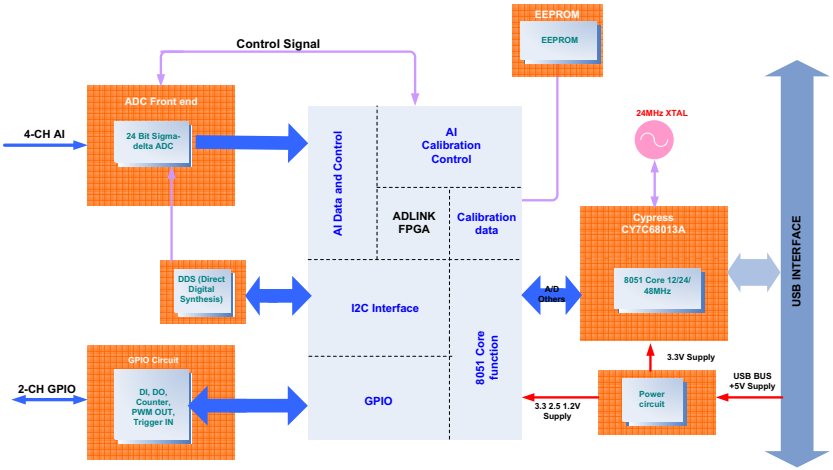


Figure 3-1: USB-2405 Functional Block Diagram

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3.2 Analog Input

3.2.1 Analog Input Front End Configuration

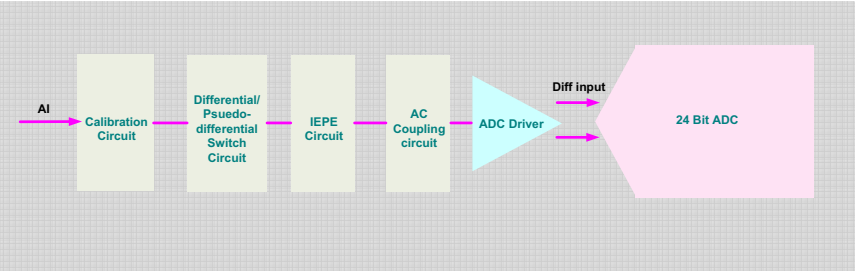


Figure 3-2: USB-2405 Analog Front End

Input Configuration: Differential/Pseudo-Differential

Differential input mode provides anode and cathode inputs of the BNC connector that respond to signal voltage differences therebetween. If the signal source is ground-referenced, the differential input mode can be used for common-mode noise rejection.

If the signal source is a floating signal, setting pseudo-differential input mode will provide a reference ground connected to the cathode input of the BNC through a 20 kΩ resistor.

Recommended configurations for the signal sources are as follows.

Signal Source	Card Configuration
Floating	Pseudo-differential
Ground-reference	Differential

Table 3-1: Signal Source-Card Configuration

Input Coupling

When DC coupling is selected, DC offset present in the input signal is passed to ADC. DC coupling configuration is indicated when the signal source has a small offset voltage or if the DC content of

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the signal is important. When AC coupling is selected, DC offset present in the input signal is removed. AC coupling configuration is indicated when the DC content of the input signals is to be rejected. AC coupling enables a high pass R-C filter through the input signal path, with corner frequency (-3dB) about 0.4 Hz.

IEPE Input

For applications utilizing sensors such as accelerometers or microphones, the USB-2405 provides an excitation current source.

The excitation current is 2 mA for the IEPE sensors, with DC voltage offset generated because of the excitation current and sensor impedance. When enabling IEPE current sources, the USB-2405 automatically sets input configuration to AC coupling.

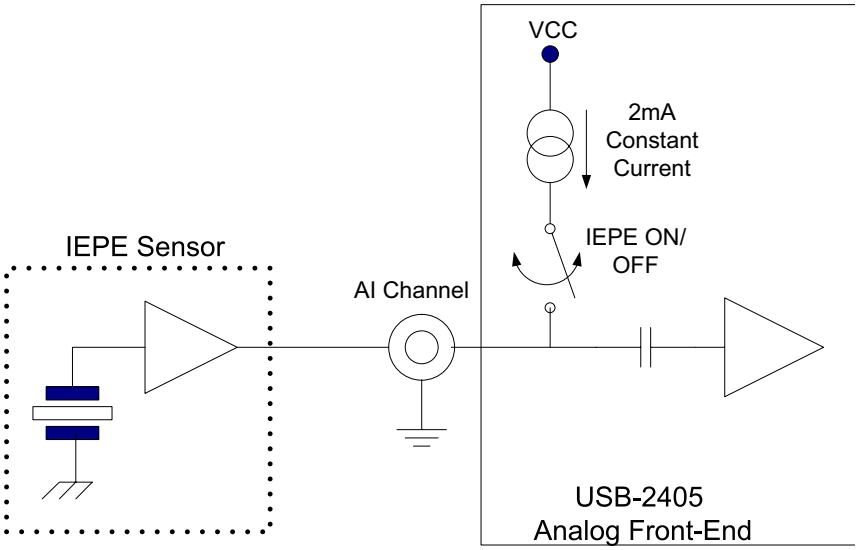


Figure 3-3: Excitation Current for IEPE Sensor Measurement

3.2.2 AI Data Format

When an A/D converter is used, properties of the signal to be measured must be ascertained to determine the channel to be

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used and connections to the card. After A/D conversion, the A/D data is buffered in a Data FIFO, for transfer to memory for further processing. Transfer characteristics of various input ranges of the USB-2405 are as follows, with data format 2's complement.

Description	Bipolar Analog Input Range	Digital Code
Full-scale Range	±10V	
Least significant bit	1.19uV	
FSR-1LSB	9.99999881V	7FFFFFh
Midscale +1LSB	1.19uV	000001h
Midscale	0V	000000h
Midscale –1LSB	-1.19uV	FFFFFFh
-FSR	-10V	800000h

Table 3-2: USB-2405 Input Ranges

3.2.3 Sampling Rate

To drive the sigma-delta ADC, an onboard timebase clock is applied, with frequency exceeding the sampling rate, produced from a DDS (Direct Digital Synthesis) chip. The output frequency of the DDS chip is programmable, with excellent resolution.

DDS Timing/Sampling Rate

Mode	High Resolution	High Speed
Sampling Rate	1 kHz ~ 52.734 kHz	52.734 kHz ~ 128 kHz
fCLK/fDATA	512	256
DDS CLK	512kHz to 26.999808MHz	13.499904 MHz to 2.768 MHz
Sampling Rate Resolution	0.0003 Hz	0.0003 Hz

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3.2.4 Data Transfer

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

Polling mode supports flexible timing and is suitable for retrieving recent data without FIFO buffering latency. The USB-2405 continuously updates the most recently acquired data onto a data port for specific channels. Data not retrieved in time is overwritten with new data without notification. The UD-DASK Function Library Reference provides corresponding software API details.

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 256 in continuous acquisition mode. The UD-DASK Function Library Reference provides corresponding software API details.

3.2.5 Anti-Aliasing Filter and Frequency Response

The filter limits the bandwidth of the signal path and rejects out-of-band noise. The digital filter of the Sigma-Delta ADC sets the overall frequency response, using multi-stage FIR topology to provide linear phase with minimal passband ripple and high stopband attenuation. These image frequencies, if present in the signal and not externally filtered, will fold back (or alias) into the passband, causing errors. The stopband of the ADC provides 100dB attenuation of frequencies that begin just beyond the passband and continue out to ADC over-sampling rate. The USB-2405 provides an anti-aliasing, low-pass, simple RC filter in front of the ADC inputs to limit possible high amplitude out-of-band signals and noise.

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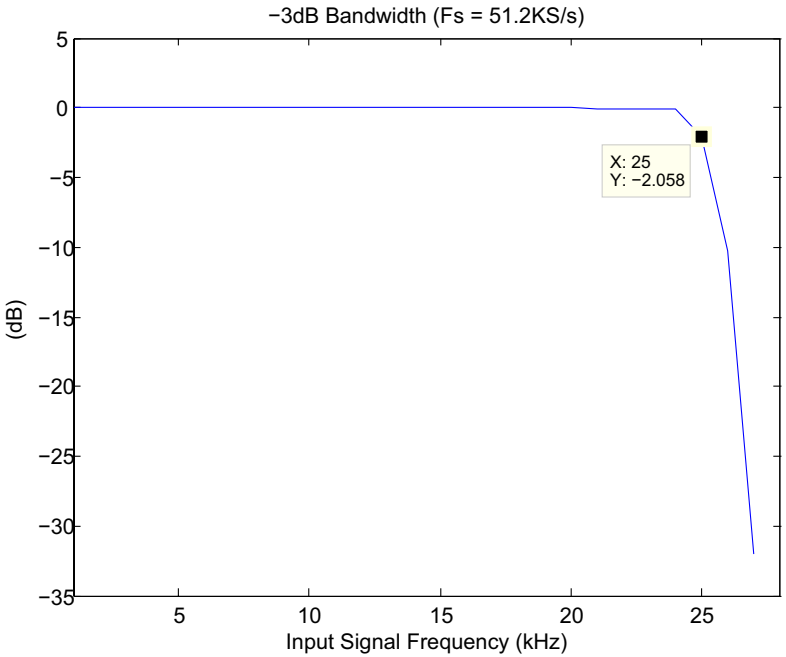


Figure 3-4: Input Frequency Response for High Resolution Mode (Fs=51.2kS/s)

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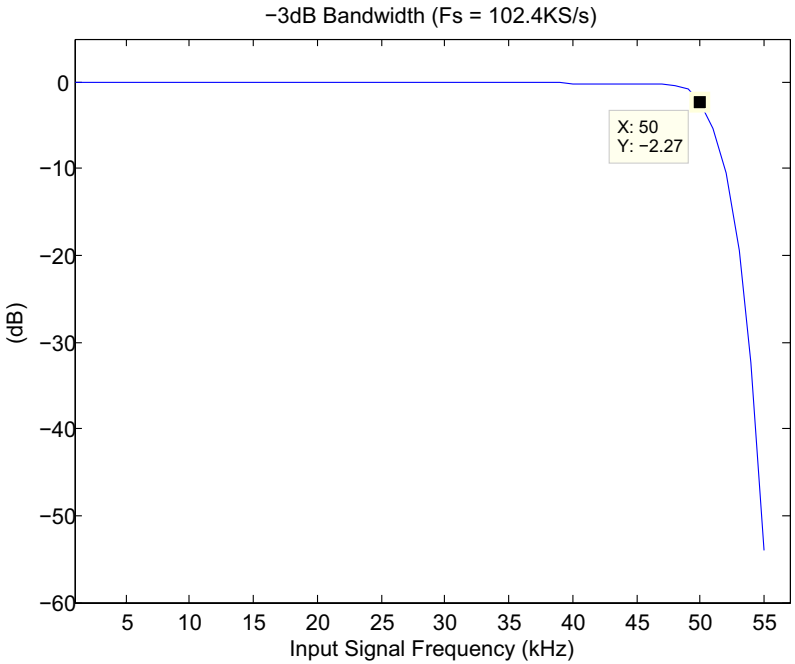


Figure 3-5: Input Frequency Response for High Speed Mode (Fs=102.4kS/s)

3.3 Triggering

The USB-2405 supports flexible trigger sources and trigger modes for analog input functionality. The trigger source can originate with software command, external analog, or external digital signal in continuous analog input mode. Trigger source and mode are programmable by software.

3.3.1 Analog Input Trigger Source

Software Triggering

This trigger mode requires no external trigger signals. The trigger asserts immediately following execution of the specified function calls to begin the operation.

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External Analog Trigger

The analog multiplexer can select one input channel as the analog trigger source. That is, one of 4 input channels can be selected as the analog trigger source. An external analog trigger occurs when the analog trigger signal crosses above (above high) or below (below low) the pre-defined voltage level. The range of trigger level is the full-scale range of the selected input channel and the resolution is 24-bit. In external analog trigger mode, the first acquired data starts with a delay time of 1/(sampling rate).

Below-Low Analog Triggering

As shown, the trigger signal is generated when the input analog signal is less than the Low_Threshold voltage. High_Threshold setting is not used in this triggering situation.

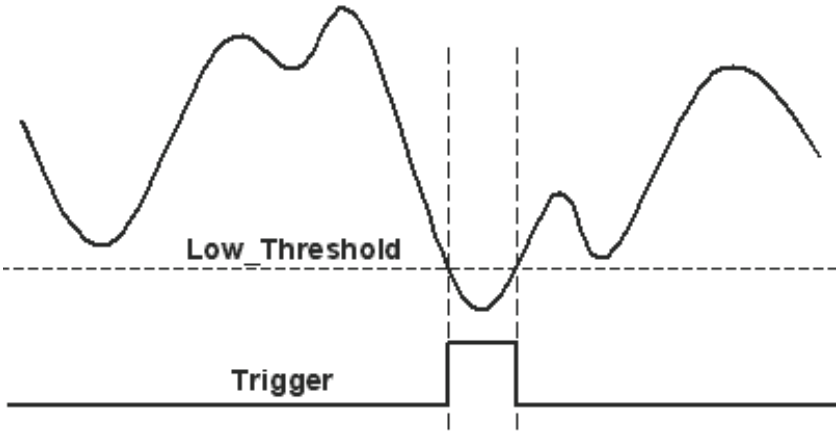


Figure 3-6: Below-Low Analog Triggering

Above-High Analog Triggering

As shown, the trigger signal is generated when the input analog signal exceeds the High_Threshold voltage. Low_Threshold setting is not used in this triggering situation

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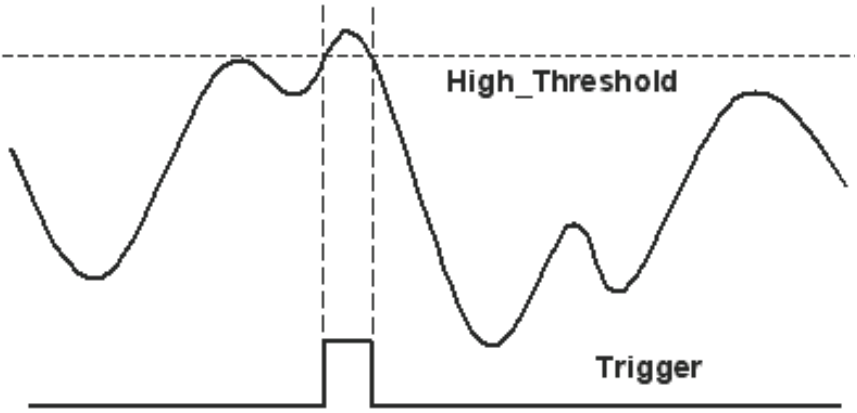


Figure 3-7: Above-High Analog Triggering

External Digital Triggering

An external digital trigger occurs when a rising or falling edge is detected on the digital signal connected to the GPIO pin. Trigger polarity can be programmed using ADLINK software drivers.

NOTE: Signal level of the external digital trigger signals should be 3/3V/TTL-compatible, with a minimum pulse of 20ns.

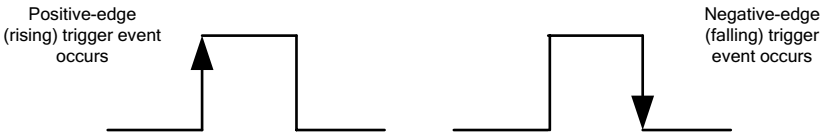


Figure 3-8: Digital Triggering

Trigger Modes

Analog input supports post, delay, middle, gate, post trigger with retrigger, and delay trigger with retrigger modes.

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Post-Trigger Acquisition Mode (no retrigger)

Post-trigger acquisition is indicated in applications where data is to be collected after a trigger event, as shown.

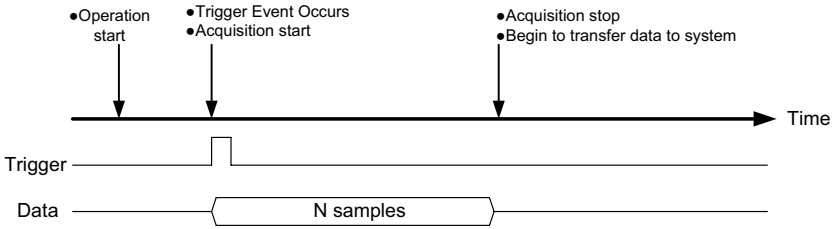


Figure 3-9: Post Trigger without Retrigger

Pre-trigger Acquisition (no retrigger)

Collects data before the trigger event, with acquisition starting once specified function calls are executed to begin the pre-trigger operation, and stopping when the trigger event occurs. If the trigger event occurs after the specified amount of data has been acquired, the system stores only data preceding the trigger event by a specified amount, as shown. Note that N must be equal to or less than 8k samples for all analog input channels.

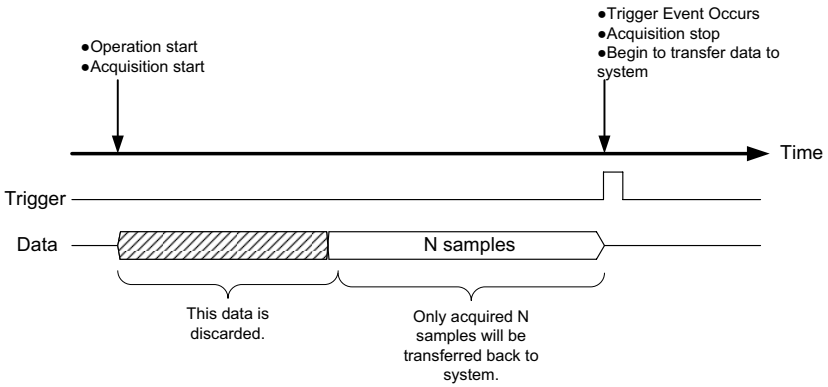


Figure 3-10: Pre-trigger Mode Operation (valid trigger only)

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The trigger event occurs after the specified amount of data has been acquired. However, if the trigger event occurs before the specified amount of data has been acquired, the acquisition engine ignores the trigger signal until the specified amount of data has been acquired, as shown.

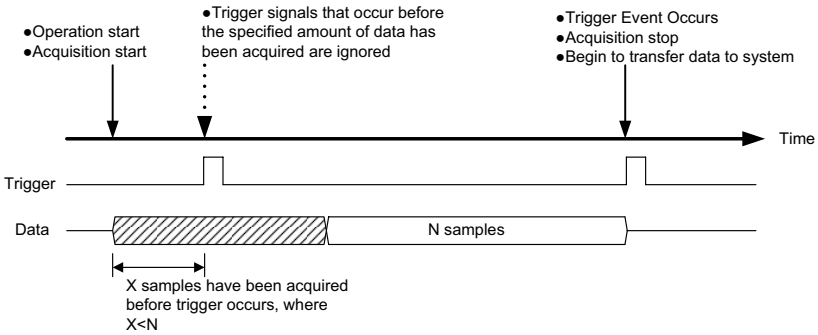


Figure 3-11: Pre-trigger Mode Operation (w/ invalid trigger)

Delay-Trigger Acquisition (no retrigger)

Delays data collection after the trigger event, as shown. The delay count is specified by a 32-bit counter value, such that the maximum delay count is (2^{32}-1) when the minimum delay count is 1.

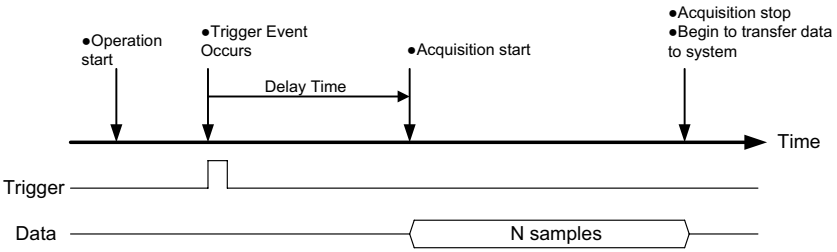


Figure 3-12: Delay-Trigger Mode Operation

Middle-Trigger Acquisition

Middle-trigger acquisition is indicated when data is to be collected before and after the trigger event. The amount of stored data

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before and after trigger event can be set individually (M and N samples), as shown. Please note that M+N must be equal to or less than 8k samples for all analog input channels, and that the trigger event can only be accepted when the specified amount of data has been acquired (M samples), otherwise the trigger event will be ignored.

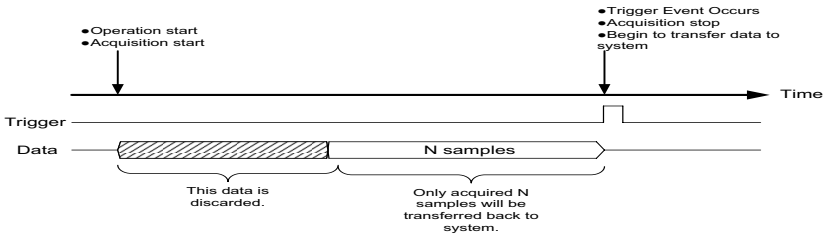


Figure 3-13: Middle-Trigger Acquisition

Gated Trigger

Gated-trigger acquisition is indicated in applications where data is to be collected when trigger events are set to level high/low, and acquisition suspended when trigger events are set to the opposite level. The process repeats until the specified amount of data is acquired.

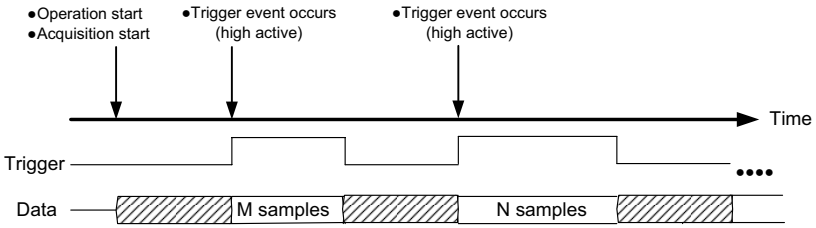


Figure 3-14: Gated Trigger

Post-Trigger or Delay-Trigger Acquisition with Re-Trigger

Post-trigger or delay-trigger acquisition with re-trigger function is indicated in applications where data is to be collected after several trigger events. The number of scans after each trigger and the

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re-trigger number are valid from 1 to the buffer size allocated in kernel space. The process repeats until the specified amount of re-trigger signals is detected.

3.4 Programmable Function I/O

The USB-2405 supports powerful programmable I/O function provided by an FPGA chip, configurable as static digital input/output, 32-bit frequency counters, pulse output, synchronization sample clock IN, and trigger IN. These signals are single-ended and 3.3 V/ TTL-compliant.

3.4.1 Static Digital Input/Output

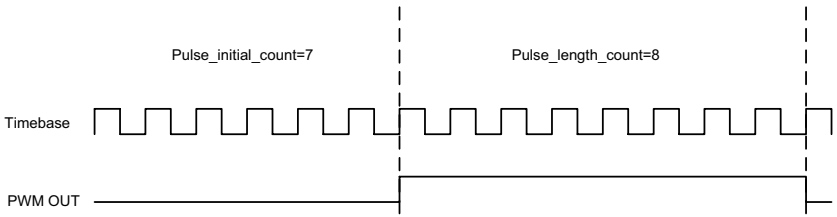
Programmable function I/O can be used as static digital inputs or outputs, with I/O lines readable and writeable by software polling, with sample and update rate fully controlled by software timing.

3.4.2 Frequency Counter

Calculates base clocks occurring within a period (rising edge to rising edge or falling edge to falling edge) of the repetitive input signal, which is then converted to frequency value. Counter polarity can be adjusted to rising edge active or falling edge active, with maximum frequency measurable of 4MHz.

3.4.3 Pulse Output

The GPIO can also simulate a pulse output. By setting a varying amount of Pulse_initial_cnt and Pulse_length_cnt, varying pulse frequencies and duty cycles can be obtained. The maximum output frequency is 4MHz, as shown.



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

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

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

3.4.4 Digital Trigger IN for Continuous Analog Input

The GPIO can be programmed as the digital trigger source for continuous analog input acquisition. Please see External Digital Triggering for details.

3.4.5 Synchronization Sample Clock IN

To synch multiple devices, the GPIO can be programmed as external sample clock input, with the same trigger signal and external sample clock applicable to multiple USB-2405s to achieve more than 4 channel synchronization without phase delay. Note the synchronization sample clock must be continuous, with valid frequency range from 1 kHz to 128 kHz.

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4 Calibration

This chapter introduces the process of calibrating the USB-2405 to optimize AD measurement.

4.1 Loading Calibration Constants

The USB-2405 is factory-calibrated before shipment, with associated calibration constants of the TrimDACs firmware 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.

ADKLINK provides a software utility that automatically reads the calibration constants, if necessary.

Dedicated space for storing calibration constants is provided in the EEPROM. In addition to the default bank of factory calibration constants, there is one user-utilization bank, allowing loading of the TrimDACs firmware values either from the original factory calibration or a subsequently-performed calibration.

Since measurement errors may vary depending on time and temperature, it is recommended that the USB-2405 module be calibrated in the existing testing environment, as follows.

4.2 Auto-Calibration



The USB-2405 module should be warmed up for at least 15 minutes before initiating auto-calibration.

The USB-2405 auto-calibration utility measures and corrects almost all calibration errors with no requirement for external signal connection, reference voltage, or measurement devices. An onboard calibration reference is provided to ensure accuracy of auto-calibration. The reference voltage is measured in the production line by a digital potentiometer and compensated in the software. The calibration constant is stored after auto-calibration.

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4.3 Saving Calibration Constants

Factory-calibrated constants are permanently stored in a bank of the onboard EEPROM and cannot be modified. When the device is recalibrated through auto-calibration, the software stores the new constants in a user-configurable section of the EEPROM. To restore original factory calibration settings, the software can copy the factory-calibrated constants to the user-configurable section of the EEPROM. When auto-calibration is complete, the new calibration constants can be saved to the user-configurable banks in the EEPROM.

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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

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