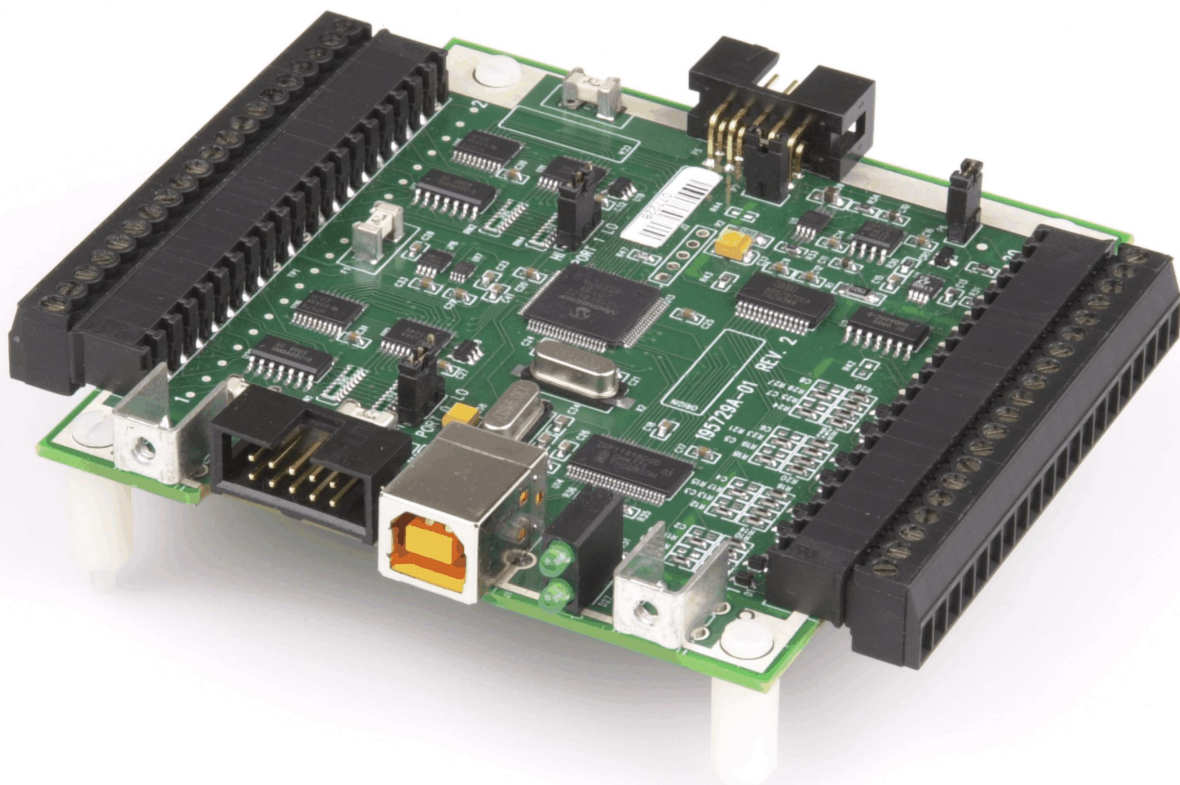


USB-7204

USB-based Analog and Digital I/O

User's Guide



USB-7204

USB-based Analog and Digital I/O Board

User's Guide



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About this User's Guide

What you will learn from this user's guide

This user's guide explains how to install, configure, and use the USB-7204 so that you get the most out of its USB data acquisition features.

This user's guide also refers you to related documents available on our web site, and to technical support resources.

Conventions in this user's guide

For more information on ...

Text presented in a box signifies additional information and helpful hints related to the subject matter you are reading.

Caution! Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

bold text **Bold** text is used for the names of objects on the screen, such as buttons, text boxes, and check boxes.

italic text *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase.

Introducing the USB-7204

This user's guide contains all of the information you need to connect the USB-7204 to your computer and to the signals you want to measure.

The USB-7204 is supported under the following operating systems:

- Microsoft Windows 7/Vista/XP (32-bit or 64-bit)
- Microsoft Windows CE
- Macintosh (32-bit or 64-bit)
- Linux (32-bit or 64-bit)

The USB-7204 is a USB 2.0 full-speed device. It is designed for USB 1.1 ports, and was tested for full compatibility with both USB 1.1 and USB 2.0 ports.

The USB-7204 features eight analog inputs, two 12-bit analog outputs, 16 digital I/O connections, and one 32-bit external event counter. The USB-7204 is powered by the +5 volt USB supply from your computer. No external power is required.

The analog inputs are software configurable for either eight 11-bit single-ended inputs (represented as 12-bit data — even values only) or four 12-bit differential inputs. Sixteen digital I/O lines are provided in two 8-bit ports. Each port is independently selectable as input or output.

A 32-bit counter can count TTL pulses. The counter increments when the TTL levels transition from low to high (rising-edge).

A SYNC (synchronization) input / output line lets you pace the analog input acquisition of one USB-7204 whose SYNC terminal is configured for input (Slave) from another USB-7204 whose SYNC terminal is configured for output (Master).

The USB-7204 is shown in Figure 1. I/O connections are made to the screw terminals located along each side of the USB-7204.

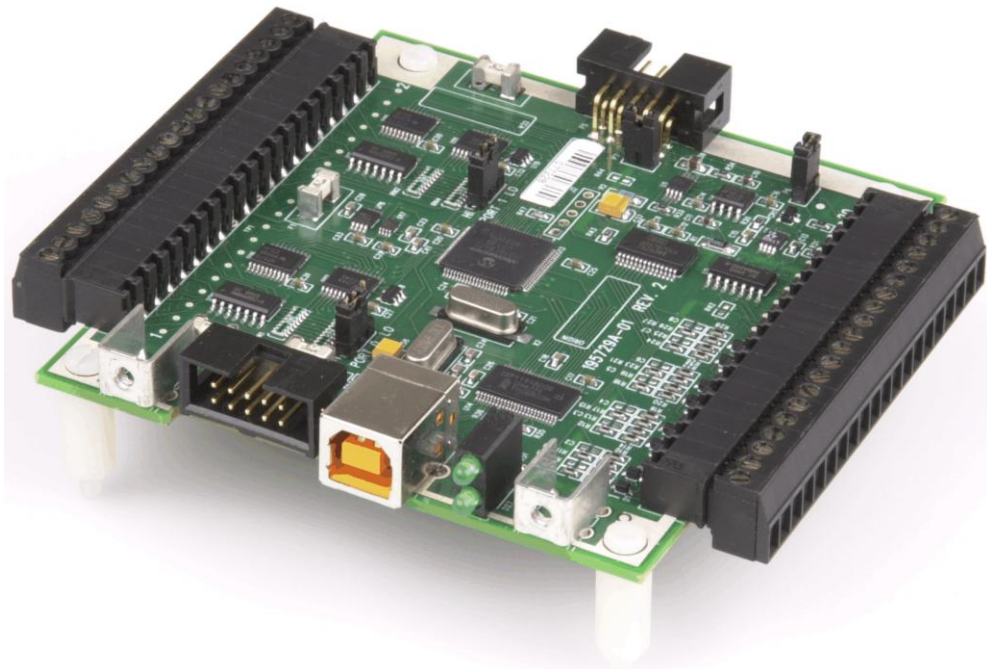


Figure 1. USB-7204

USB-7204 block diagram

USB-7204 functions are illustrated in the block diagram shown here.

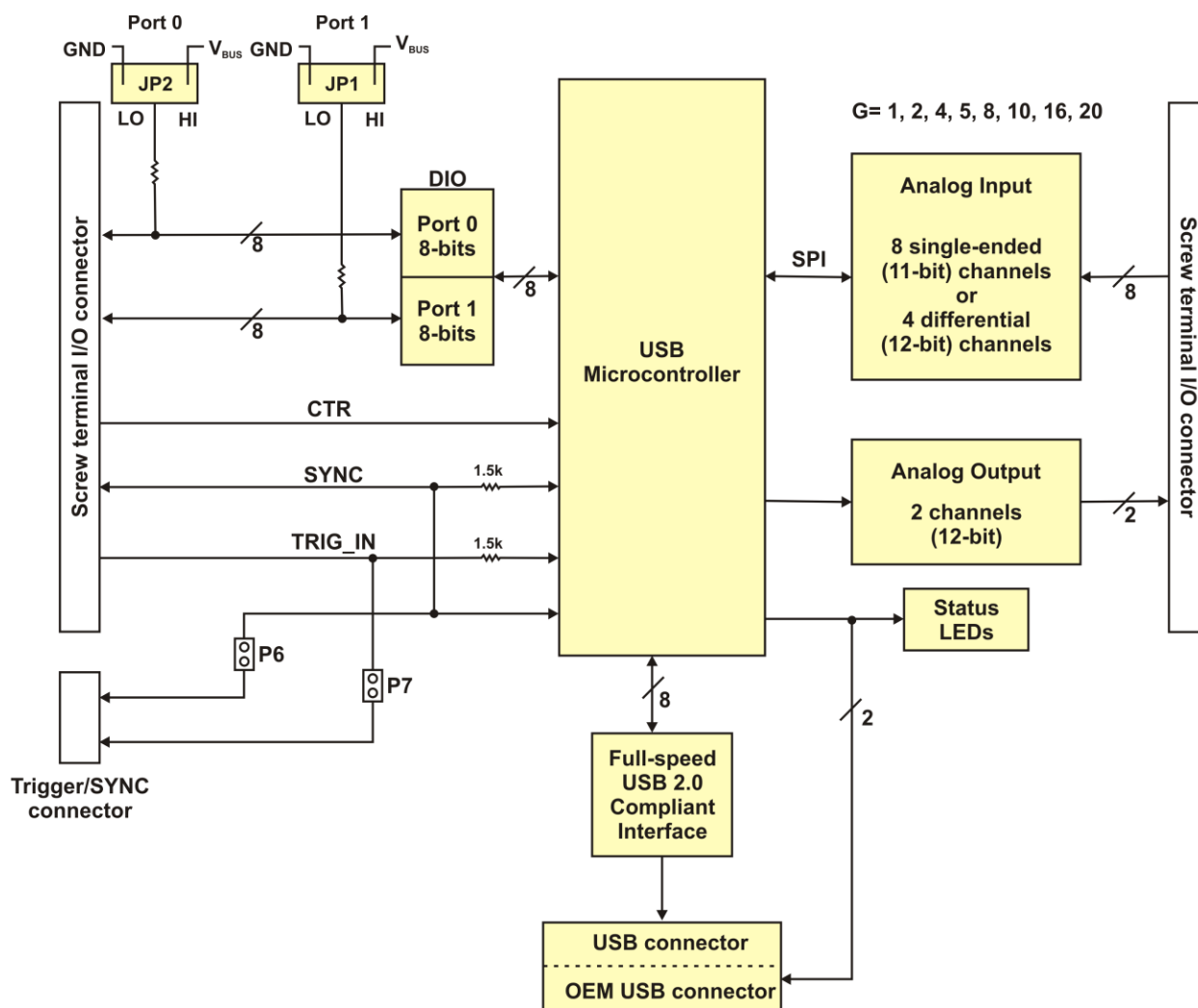


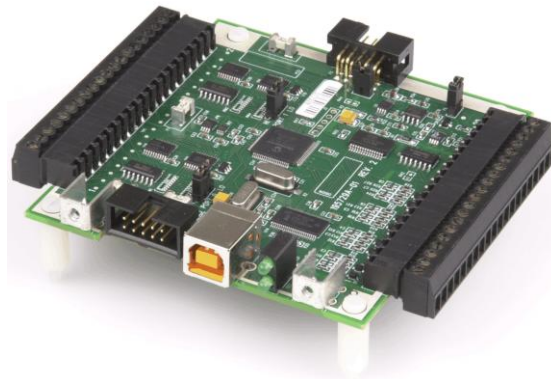
Figure 2. USB-7204 functional block diagram

Installing the USB-7204

What comes with your USB-7204 shipment?

As you unpack your USB-7204, verify that the following components are included.

- USB-7204



- USB cable (2 meter length)



Unpacking the USB-7204

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the USB-7204 from its packaging, ground yourself using a wrist strap or by simply touching the computer chassis or other grounded object to eliminate any stored static charge.

If any components are missing or damaged, notify Measurement Computing Corporation immediately by phone, fax, or e-mail:

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support.
- Fax: 508-946-9500 to the attention of Tech Support
- Email: techsupport@mccdaq.com

Installing the software

DAQFlex software for each supported operating system is available for download from the DAQFlex download page at www.mccdaq.com/DAQFlexDL. Refer to the *DAQFlex Software User's Guide* for instructions on installing the DAQFlex software.

Installing the hardware

Install the DAQFlex software before you install your board

The driver needed to run your board is installed with the DAQFlex software. Therefore, you need to install the DAQFlex software before you install your board.

There are two ways to connect the USB-7204 to your system.

- Connect a USB cable from the **USB** connector to either a USB port on the computer or external USB hub connected to the computer

or

- Use a 0.1" box header to connect with the OEM connector. The connector pin out is shown below:

Pin	Signal Name	Pin	Signal Name
1	N/C	2	VBUS
3	N/C	4	D-
5	N/C (do not connect anything to this pin)	6	D+
7	N/C (do not connect anything to this pin)	8	GND
9	N/C (do not connect anything to this pin)	10	SHIELD

When you connect the USB-7204 for the first time on Windows, a **Found New Hardware** message opens as the device is detected. The installation is complete when the message closes.

After the USB-7204 is installed, the **Power** LED remains lit to indicate that communication is established between the USB-7204 and your computer.

Caution! Do not disconnect **any** device from the USB bus while the computer is communicating with the USB-7204, or you may lose data and/or your ability to communicate with the USB-7204.

If the Power LED turns off

If the Power LED is lit but then turns off, the computer has lost communication with the USB-7204. To restore communication, disconnect the USB cable from the computer, and then reconnect it. This should restore communication, and the Power LED should turn back *on*.

Programming and developing applications

Refer to the *Programming and developing applications* topic in the [Message-based Firmware Specification](#) for information on how to communicate with the USB-7204 using either the device software or firmware API.

Functional Details

Theory of operation

Analog input acquisition modes

The USB-7204 can acquire analog input data in software paced and continuous scan modes.

Software paced mode

You can acquire one analog sample at a time in software paced mode. You initiate the A/D conversion by calling a software command. The analog value is converted to digital data and returned to the computer. You can repeat this procedure for each channel desired until you have the total number of samples that you want from each channel. The maximum throughput sample rate in software paced mode is system-dependent.

Continuous scan mode

You can acquire data from up to eight channels simultaneously in continuous scan mode. The analog data is continuously acquired and converted to digital values until you stop the scan. Data is transferred in blocks of up to 32 samples from the USB-7204 to the memory buffer on your computer.

The maximum continuous scan rate of 50 kS/s is an aggregate rate. You can acquire data from one channel at 50 kS/s, two channels at 25 kS/s, and four channels at 12.5 kS/s. You can start a continuous scan with either a software command or with an external hardware trigger event.

SYNC

The **SYNC** terminal is a bidirectional I/O signal that can be configured as an input or an output:

- Configure as an external clock input to externally pace the A/D conversions from an external source or another USB-7204. The SYNC terminal supports TTL-level input signals of up to 50 kHz.
- Configure as an output to pace the conversions on another USB-7204.

The SYNC pin is available on both the screw terminal connector and on the Trigger/SYNC connector.

Synchronized operations

You can connect the SYNC pin of two USB-7204 units together in a master/slave configuration and acquire data from the analog inputs of both devices using one clock. When the SYNC pin is configured as an output, the internal A/D pacer clock is sent to the screw terminal. You can use this signal as a clock input to a second USB-7204 by connecting it to the SYNC pin and Trig/SYNC connector of the second device.

When used as a clock input, the SYNC pin operates in one of two modes – slave or gated slave.

- In slave mode, the USB-7204 ignores the first clock pulse in order to ensure adequate setup time. Use this mode when the USB-7204 is being paced from a continuous clock source, such as a generator.
- In gated slave mode, it is assumed that the clock signal is held off for an adequate amount of time for setup to occur. No clock pulses are ignored. Use this mode when the source of the external clock is another USB-7204.

The SYNC pin (pin 19) is set for pacer output by default.

Trigger

A separate digital trigger input line (**TRIG_IN**) allows an acquisition to start when a signal's rising or falling edge is detected.

The TRIG_IN pin is available on both the screw terminal connector and on the Trigger/SYNC connector.

Components

The USB-7204 components are shown in Figure 3.

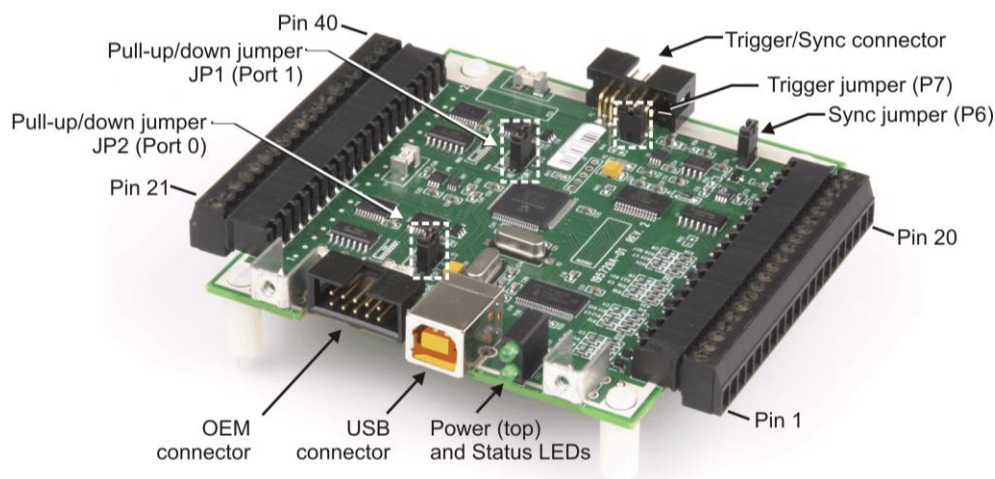


Figure 3. USB-7204 external components

USB connector

The USB connector provides +5 V power and communication. The voltage supplied through the USB connector is system-dependent, and may be less than 5 V. No external power supply is required.

This connector operates in parallel with the OEM connector — do not connect to both the USB connector and the OEM connector.

OEM connector

The OEM connector operates in parallel with the USB connector — do not connect to both the USB connector and the OEM connector.

The OEM connector is a 0.1" box header. Pins 2, 4, 6, 8, and 10 provide a USB connection, as listed in the connector pin out below:

OEM connector pin out

Pin	Signal Name	Pin	Signal Name
1	N/C	2	VBUS
3	N/C	4	D-
5	N/C (do not connect anything to this pin)	6	D+
7	N/C (do not connect anything to this pin)	8	GND
9	N/C (do not connect anything to this pin)	10	SHIELD

Modifications are required in order to use the OEM connector

We recommend that you return the device to the factory for this modification.

Should you have the capabilities to perform the modifications, the following change is required: in order to create a USB connection via the OEM connector, locations R48 and R49 must be populated. We recommend that you populate with 0603 size 0 Ω resistors or provide solder bridges to close the gaps.

LED indicators

The USB-7204 has LEDs for power and communication status. See Figure 3 for the location of each LED.

LED type	Indication
Power	Steady green: The device's microcontroller is connected to a computer or external USB hub.
Status	Blinking green: data is being transferred over the USB bus.

Trigger/Sync connector

The SYNC and TRIG_IN connections are available on the Trigger/Sync connector as well as on the screw terminal. Refer to the connector pin out below.

Trigger/Sync connector pin out

Pin	Signal Name	Pin	Signal Name
1	TRIG_IN	2	GND
3	N/C	4	GND
5	SYNC	6	GND
7	N/C	8	GND
9	N/C	10	N/CD

Use a 0.1" box header when making connections to the Trigger/Sync connector.

The Trigger/Sync connector internally connects its SYNC and TRIG_IN pins to the screw terminal via jumpers **P6** and **P7**.

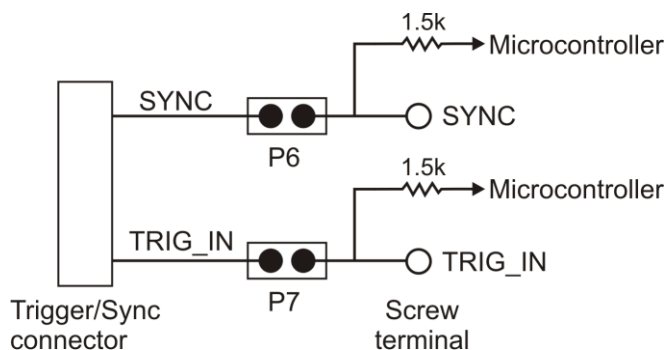


Figure 4. Jumper P6 and P7 schematic

Sync jumper (P6)

The Sync jumper internally connects the SYNC pin on the Trigger/Sync connector to the SYNC pin on the screw terminal. Remove this jumper on boards that will not send/receive the SYNC signal through the SYNC/TRIG connector. Refer to Figure 3 on page 12 for the location of this jumper.

Trigger jumper (P7)

The Trigger jumper internally connects the TRIG_IN pin on the Trigger/Sync connector to the TRIG_IN pin on the screw terminal. Remove this jumper on boards that will not send/receive the TRIG signal through the SYNC/TRIG connector. Refer to Figure 3 on page 12 for the location of this jumper.

Screw terminals

The device's two screw terminal blocks each provide 20 pins. Screw terminal pins 1 to 20 provide the following connections:

- Eight analog input connections (**CH0 IN** to **CH7 IN**)
- Two analog output connections (**D/A OUT 0** to **D/A OUT 1**)
- One external trigger source (**TRIG_IN**)
- One SYNC terminal for external clocking and multi-unit synchronization (**SYNC**)
- One external event counter connection (**CTR**)
- Five analog ground connections (**AGND**)
- One ground connection (**GND**)

Screw terminal pins 21 to 40 provide the following connections:

- 16 digital I/O connections (**Port 0 Bit 0** to **Port 0 Bit 7**, and **Port 1 Bit 0** to **Port 1 Bit 7**)
- One output power connection (**PC+5 V**)
- Three ground connections (**GND**)

Signal I/O connections

Use 16 AWG to 30 AWG when making screw terminal connections. The pin out for each screw terminal is shown in Figure 5.

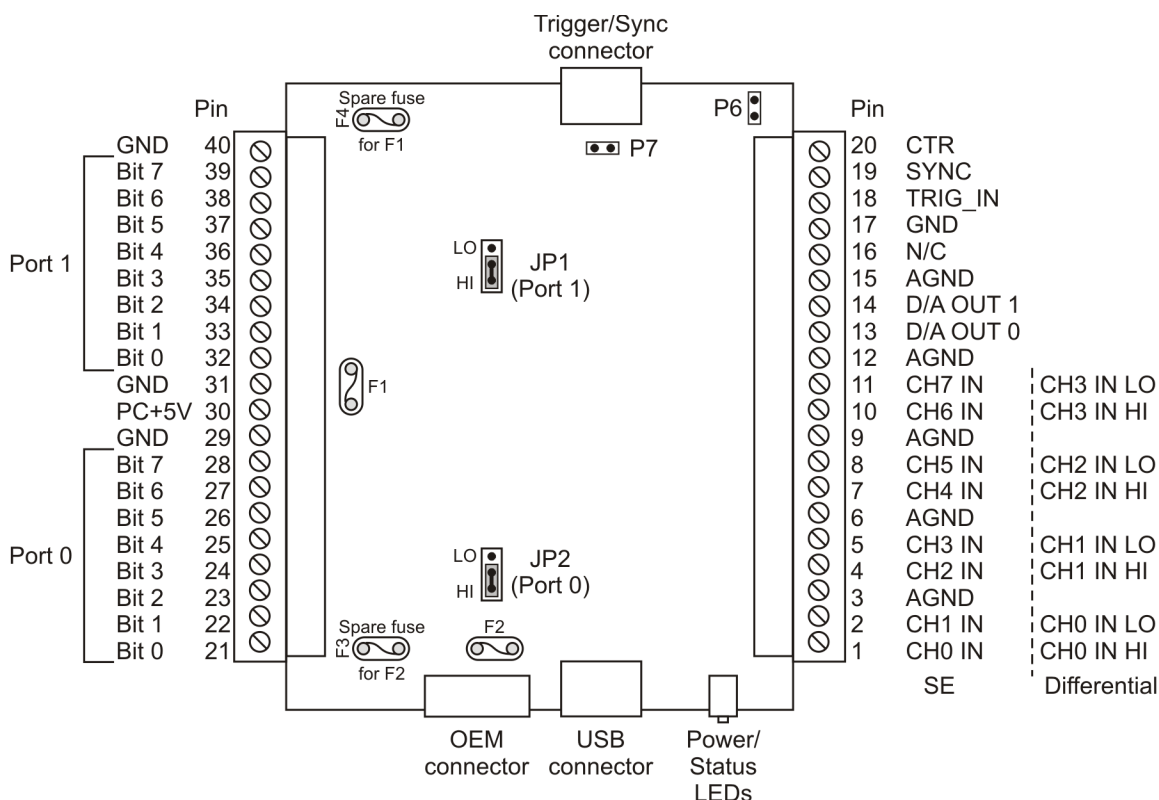


Figure 5. USB-7204 pin orientation

Analog input terminals (CH0 IN - CH7 IN)

You can connect up to eight analog input connections to the screw terminal containing pins 1 to 20 (**CH0 IN** through **CH7 IN**.) Refer to Figure 5 above for the location of the analog input pins.

You can configure the analog input channels as eight single-ended channels or four differential channels. By default, differential mode is configured at power-up. When configured for differential mode, each analog input has 12-bit resolution. When configured for single-ended mode, each analog input has 11-bit resolution shifted as 12-bit data, due to restrictions imposed by the A/D converter.

Single-ended configuration

When all of the analog input channels are configured for single-ended input mode, eight analog channels are available. The input signal is referenced to signal ground (GND), and delivered through two wires:

- The wire carrying the signal to be measured connects to CH# IN.
- The second wire connects to AGND.

The input range for single-ended mode is ± 10 V. No other ranges are supported in single-ended mode.

Single-ended measurements using differential channels

To perform a single-ended measurement using differential channels, connect the signal to "CHn IN HI" input, and ground the associated "CHn IN LO" input.

Differential configuration

When all of the analog input channels are configured for differential input mode, four analog channels are available. In differential mode, the input signal is measured with respect to the low input.

The input signal is delivered through three wires:

- The wire carrying the signal to be measured connects to CH0 IN HI, CH1 IN HI, CH2 IN HI, or CH3 IN HI.
- The wire carrying the reference signal connects to CH0 IN LO, CH1 IN LO, CH2 IN LO, or CH3 IN LO.
- The third wire connects to GND.

A low-noise precision programmable gain amplifier (PGA) is available on differential channels to provide gains of up to 20 and a dynamic range of up to 12-bits. Differential mode input voltage ranges are ± 20 V, ± 10 V, ± 5 V, ± 4 V, ± 2.5 V, ± 2.0 V, ± 1.25 V, and ± 1.0 V.

In differential mode, the following two requirements must be met for linear operation:

- Any analog input must remain in the -10 V to $+20$ V range with respect to ground at all times.
- The maximum differential voltage on any given analog input pair must remain within the selected voltage range.

The input [*common-mode voltage* + *signal*] of the differential channel must be in the -10 V to $+20$ V range in order to yield a useful result. For example, you input a 4 V pp sine wave to CHHI, and apply the same sine wave 180° out of phase to CHLO. The common mode voltage is 0 V. The differential input voltage swings from 4 V $-$ (-4 V) = 8 V to -4 V $-$ 4 V = -8 V. Both inputs satisfy the -10 V to $+20$ V input range requirement, and the differential voltage is suited for the ± 10 V input range (see Figure 6).

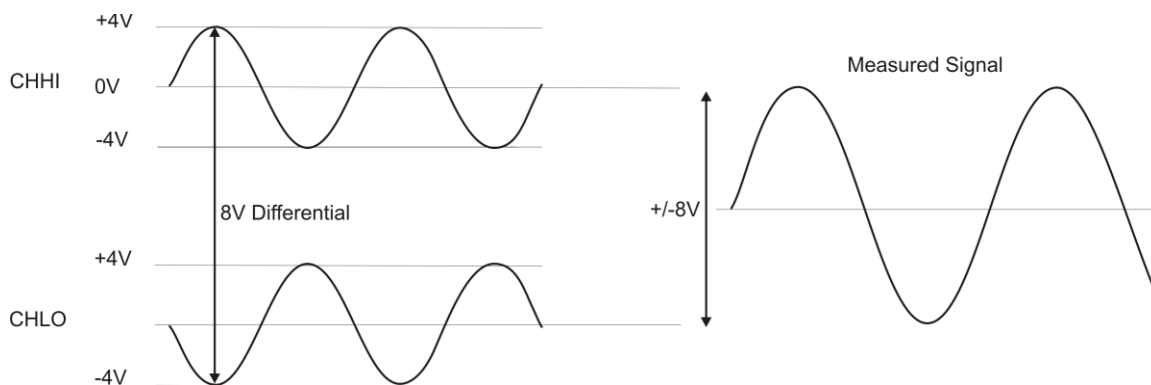


Figure 6. Differential voltage example: common mode voltage of 0 V

If you increase the common mode voltage to 11 V, the differential remains at ± 8 V. Although the [*common-mode voltage* + *signal*] on each input now has a range of +7 V to +15 V, both inputs still satisfy the -10 V to $+20$ V input requirement (see Figure 7).

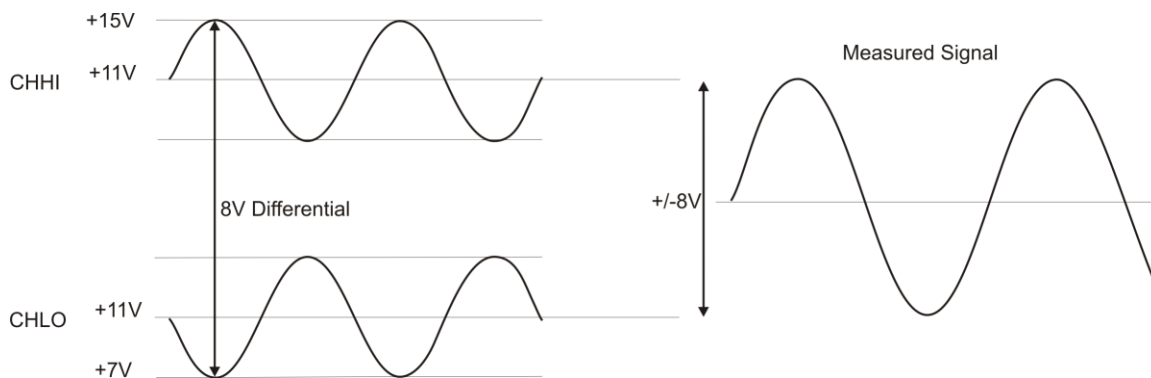


Figure 7. Differential voltage example: common mode voltage of 11 V

If you decrease the common-mode voltage to -7 V, the differential stays at ± 8 V. However, the solution now violates the input range condition of -10 V to +20 V. The voltage on each analog input now swings from -3 V to -11 V. Voltages between -10 V and -3 V are resolved, but those below -10 V are clipped (see Figure 8).

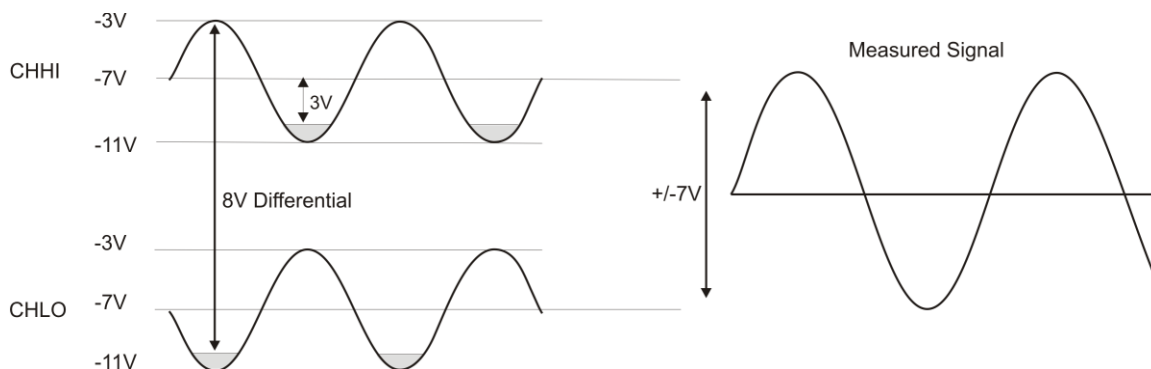


Figure 8. Differential voltage example: common mode voltage of -7 V

Since the analog inputs are restricted to a -10 V to +20 V signal swing with respect to ground, all ranges *except* ± 20 V can realize a linear output for any differential signal with zero common mode voltage and full scale signal inputs. The ± 20 V range is the exception. You cannot put -20 V on CHHI and 0 V on CHLO since this violates the input range criteria.

The following table below shows some possible inputs and the expected results.

Sample inputs and differential results

CHHI	CHLO	Result
-20 V	0 V	Invalid
-15 V	+5 V	Invalid
-10 V	0 V	-10 V
-10 V	+10 V	-20 V
0 V	+10 V	-10 V
0 V	+20 V	-20 V
+10 V	-10 V	+20 V
+10 V	0 V	+10 V
+15 V	-5 V	+20 V
+20 V	0	+20 V

Analog output terminals

You can connect up to two analog output connections to the screw terminal pins 13 and 14 (**D/A OUT 0** and **D/A OUT 1**). Refer to Figure 5 on page 14 for the location of the analog output pins.

Each channel can be paced individually at rates up to 10,000 updates per second. Both channels can be paced simultaneously using the same time base at 5000 updates per channel. The 0-4.096 V output range provides a convenient 1 mV per LSB when setting the output voltage levels.

Digital I/O terminals

The USB-7204 has two eight-bit ports (**Port 0** and **Port 1**). You can connect up to eight DIO lines to screw terminal pins 21 to 28 (**Port 0 Bit 0 to Bit 7**), and up to eight DIO lines to pins 32 to 39 (**Port 1 Bit 0 to Bit 7**). Each port is configurable as either input or output. Refer to Figure 5 on page 14 for the location of the DIO pins.

Pull up/down configuration

The digital pins are configurable via jumpers for pull-up to USB +5 V (HI) or pull-down to ground (LO). Jumper JP2 configures Port 0, and JP1 configures Port 1. On power up and reset the DIO pins are configured as input and pulled by JP1/JP2.

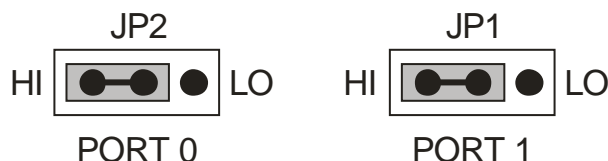


Figure 9. Jumper JP0 and JP1 configuration

When configured for input, the digital I/O terminals can be used to detect the state of any TTL level input.

For more information on digital signal connections

For more information on digital signal connections and digital I/O techniques, refer to the *Guide to Signal Connections* (available on our web site at www.mccdaq.com/signals/signals.pdf).

Trigger terminal

The external digital trigger input **TRIG_IN** connection (pin 18) is internally connected to the TRIG_IN pin on the Trigger/Sync connector (see page 13). Refer to the *Trigger* discussion on page 11 for more information about this connection.

SYNC terminal

The bidirectional **SYNC** connection (pin 19) is internally connected to the SYNC pin on the Trigger/Sync connector (see page 13).

Refer to the SYNC discussion on page 11 for more information about this connection.

Counter terminal

The **CTR** connection (pin 20) is a TTL-level input to a 32-bit event counter. Refer to Figure 5 on page 14 for the location of this pin. The internal counter increments when the TTL level transitions from low to high. The counter can count frequencies of up to 1 MHz.

Power terminal

The **PC +5V** connection (pin 30) draws power from the USB connector. Refer to Figure 5 on page 14 for the location of this pin. The +5 V screw terminal is a 5 volt output that is supplied by the host computer.

Caution! The +5 V terminal is an output. Do not connect to an external power supply or you may damage the USB-7204 and possibly the computer.

The maximum total output current that can be drawn from all USB-7204 connections (power, analog and digital outputs) is 420 mA. This maximum applies to most personal computers and self-powered USB hubs. Bus-powered hubs and notebook computers may limit the maximum available output current to 100 mA.

Just connecting the USB-7204 to your computer draws 80 mA of current from the USB +5 V supply. Once you start running applications with the USB-7204, each DIO bit can draw up to 2.5 mA, and each analog output can draw 15 mA. The maximum amount of +5 V current available for experimental use, over and above that required by the USB-7204, is the difference between the *total current requirement* of the USB (based on the application) and the *allowed current draw* of the PC platform (500 mA for desktop PCs and self-powered hubs, or 100 mA for bus-powered hubs and notebook computers). It shall not exceed 375 mA, based on the Slo-Blo Fuse current rating connected to the +5V terminal.

With all outputs at their maximum output current, you can calculate the total current requirement of the USB-7204 USB +5 V as follows:

$$(\text{USB-7204 @ 80 mA}) + (16 \text{ DIO @ 2.5 mA ea}) + (2 \text{ AO @ 15 mA ea}) = 150 \text{ mA}$$

For an application running on a PC or powered hub, the maximum available excess current is 500 mA–150 mA = 350 mA. This number is the total maximum available current at the PC +5 V screw terminals. Measurement Computing highly recommends that you figure in a safety factor of 20% below this maximum current loading for your applications. A conservative, safe user maximum in this case would be in the 350-375 mA range (fused).

Since laptop computers typically allow up to 100 mA, the USB-7204 in a fully-loaded configuration may be above that allowed by the computer. In this case, you must determine the per-pin loading in the application to ensure that the maximum loading criteria is met. The per-pin loading is calculated by simply dividing the +5 V by the load impedance of the pin in question.

Ground terminals

Four analog ground (**AGND**) connections provide a common ground for all USB-7204 input channels. Four ground (**GND**) connections provide a common ground for the **DIO**, **TRIG_IN**, **CTR**, **SYNC** and **PC +5V** connections. Refer to Figure 5 on page 14 for the location of the **AGND** and **GND** pins.

Accuracy

The overall accuracy of any instrument is limited by the error components within the system. Quite often, resolution is incorrectly used to quantify the performance of a measurement product. While "12-bits" or "1 part in 4096" does indicate what can be resolved, it provides little insight into the quality of an absolute measurement. Accuracy specifications describe the actual results that can be realized with a measurement device.

There are three types of errors which affect the accuracy of a measurement system:

- offset
- gain
- nonlinearity

The primary error sources in the USB-7204 are offset and gain. Nonlinearity is small in the USB-7204, and is not significant as an error source with respect to offset and gain.

Figure 10 shows an ideal, error-free, USB-7204 transfer function. The typical calibrated accuracy of the USB-7204 is range-dependent, as explained in the *Specifications* chapter on page 23. We use a ± 10 V range here as an example of what you can expect when performing a measurement in this range.

The accuracy plots in Figure 10 are drawn for clarity and are not drawn to scale.

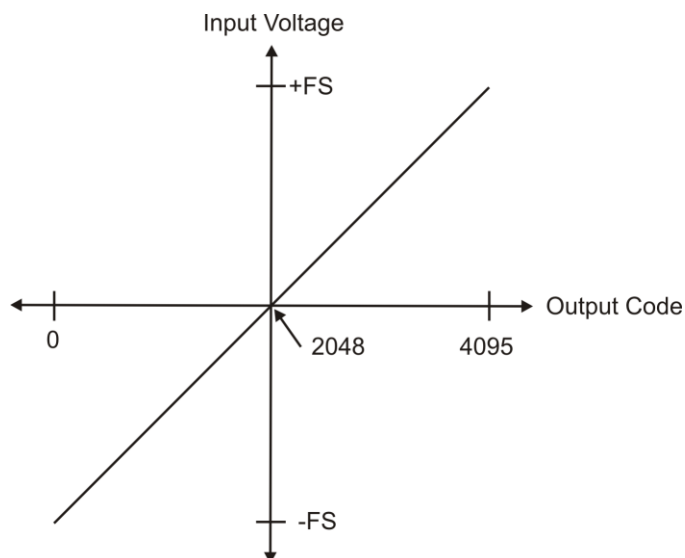


Figure 10. Ideal ADC transfer function

The USB-7204 offset error is measured at mid-scale. Ideally, a zero volt input should produce an output code of 2048. Any deviation from this is an offset error. Figure 11 shows the USB-7204 transfer function with an offset error. The typical offset error specification on the ± 10 V range is ± 9.77 mV. Offset error affects all codes equally by shifting the entire transfer function up or down along the input voltage axis.

The accuracy plots in Figure 11 are drawn for clarity and are not drawn to scale.

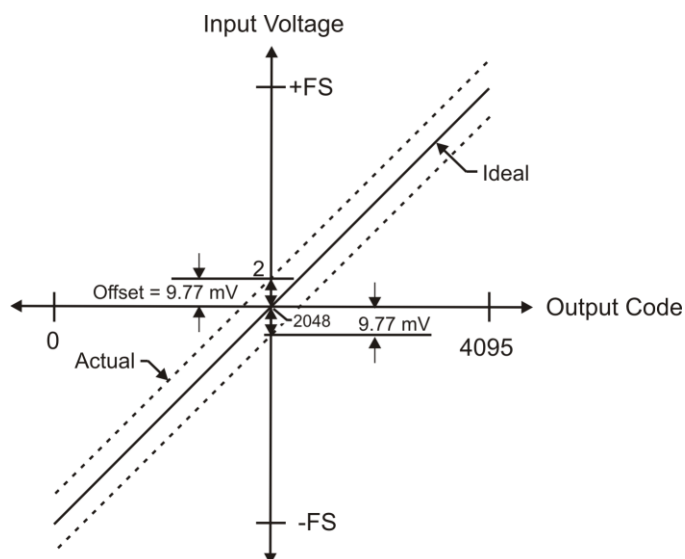


Figure 11. ADC transfer function with offset error

Gain error is a change in the slope of the transfer function from the ideal, and is typically expressed as a percentage of full-scale. Figure 12 shows the USB-7204 transfer function with gain error. Gain error is easily converted to voltage by multiplying the full-scale (**FS**) input by the error.

The accuracy plots in Figure 12 are drawn for clarity and are not drawn to scale.

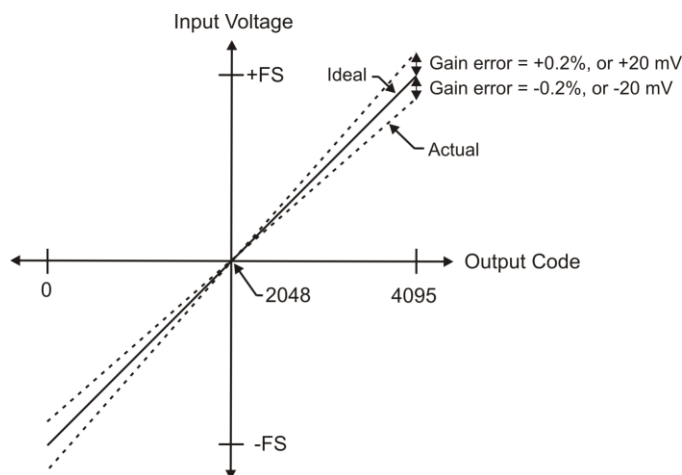


Figure 12. ADC Transfer function with gain error

For example, the USB-7204 exhibits a typical calibrated gain error of $\pm 0.2\%$ on all ranges. For the $\pm 10\text{ V}$ range, this would yield $10\text{ V} \times \pm 0.002 = \pm 20\text{ mV}$. This means that at full scale, neglecting the effect of offset for the moment, the measurement would be within 20 mV of the actual value. Note that gain error is expressed as a ratio. Values near $\pm\text{FS}$ are more affected from an absolute voltage standpoint than are values near mid-scale, which see little or no voltage error.

Combining these two error sources in Figure 13, we have a plot of the error band of the USB-7204 for the $\pm 10\text{ V}$ range. This is a graphical version of the typical accuracy specification of the product.

The accuracy plots in Figure 13 are drawn for clarity and are not drawn to scale

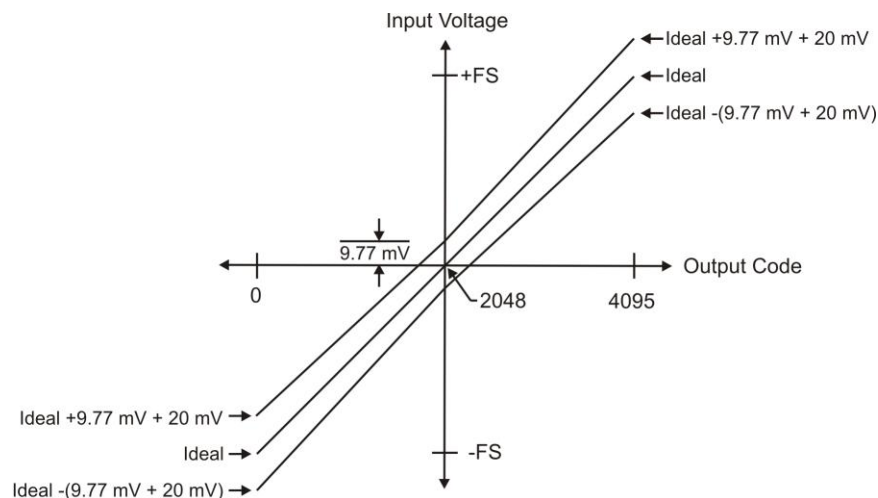


Figure 13. Error band plot

Channel gain queue

Use the device's channel gain queue to set up a scan sequence with a unique per-channel gain setting and channel sequence. The queue is large enough for up to 16 channel configurations limited to either single-ended or differential mode.

The channel gain queue feature removes the restriction of using an ascending channel sequence at a fixed gain. This feature creates a channel list which is written to local memory on the USB-7204. The channel list is made up of a channel number and range setting. An example of a four-element list is shown in the table below.

Sample channel gain queue list

Element	Channel	Range
0	CH0	BIP10V
1	CH0	BIP5V
2	CH7	BIP10V
3	CH2	BIP1V

When a scan begins with the gain queue enabled, the USB-7204 reads the first element, sets the appropriate channel number and range, and then acquires a sample. The properties of the next element are then retrieved, and another sample is acquired. This sequence continues until all elements in the gain queue have been selected. When the end of the channel list is detected, the sequence returns to the first element in the list.

This sequence repeats until the specified number of samples is gathered. You must carefully match the gain to the expected voltage range on the associated channel — otherwise, an over range condition can occur. Although this condition does not damage the USB-7204, it does produce a useless full-scale reading. It can also introduce a long recovery time from saturation, which can affect the next measurement in the queue.

Synchronizing multiple units

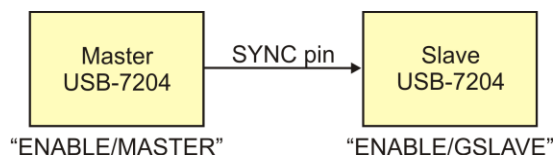
You can connect the SYNC pin of two USB-7204 units together in a master/slave configuration and acquire data synchronously from 16 channels single-ended or 8 channels differential. The SYNC pin is available on both the screw terminal connector and on the Trigger/SYNC connector.

When the SYNC pin is configured as an output (default), the internal A/D pacer clock signal is sent to the screw terminal. If jumper P6 is installed, this signal is also routed to the Trigger/Sync box header.

You set the function of the SYNC pin for pacer input or pacer output with a software command. By default, the SYNC pin is set for pacer output.

For example, when running the DAQFlex API library, follow the steps below to synchronize a master USB-7204 with a slave USB-7204 and acquire data from up to 16 channels:

1. Configure the SYNC pin of the master USB-7204 for pacer output:
 - Send the message "AISCAN:EXTPACER=ENABLE/MASTER".
2. Configure the SYNC pin of the slave USB-7204 for pacer input:
 - Send the message "AISCAN:EXTPACER=ENABLE/GSLAVE".
3. Connect the SYNC pin on the master USB-7204 to the SYNC pin on the slave USB-7204.



When operating one USB-7204, do not set the EXTPACER option unless you are using an external clock for A/D pacing.

Mechanical drawings

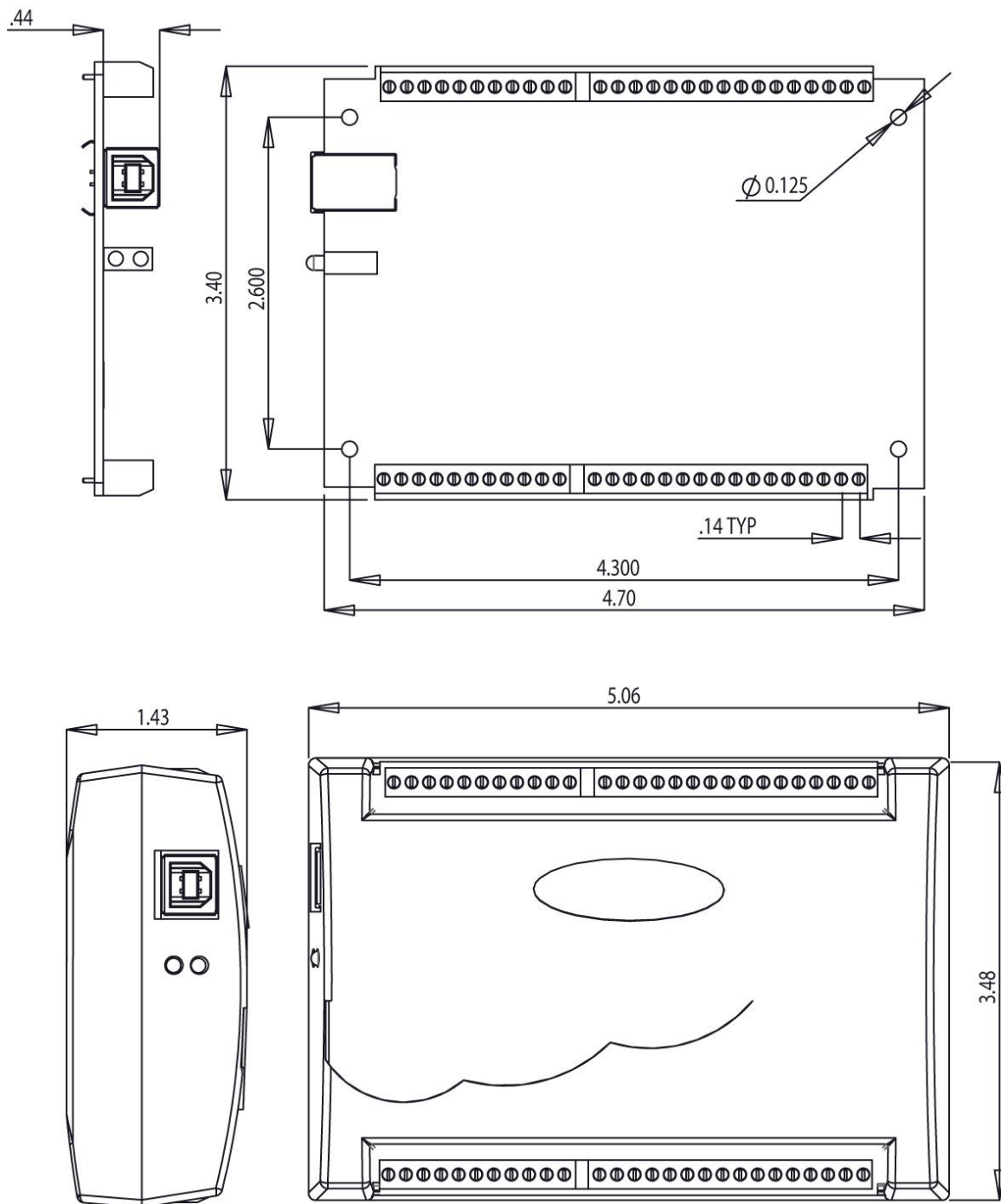


Figure 14. Circuit board (top) and housing dimensions

Specifications

All specifications are subject to change without notice.

Typical for 25°C unless otherwise specified.

Specifications in *italic text* are guaranteed by design.

Analog input

Table 1. Analog input specifications

Parameter	Conditions	Specification
A/D converter type		Successive approximation type
Input modes		Single-ended or differential (default)
Input voltage range for linear operation, single-ended mode	CHx to GND	±10 volts (V) maximum
Input common-mode voltage range for linear operation, differential mode	CHx to GND	-10 V minimum, +20 V maximum
<i>Absolute maximum input voltage</i>	<i>CHx to GND</i>	<i>±28 V maximum</i>
<i>Input impedance</i>		<i>122KOhm</i>
Input current (Note 1)	V _{in} = +10 V	70 microamperes (μA) typical
	V _{in} = 0 V	-12 μA typical
	V _{in} = -10 V	-94 μA typical
Number of channels		8 single-ended / 4 differential, software selectable
Configuration		Single A/D
Sampling method		Multiplexed
Input ranges, single-ended mode		±10 V, G=2
Input ranges, differential mode		±20 V, G=1 ±10 V, G=2 (default) ±5 V, G=4 ±4 V, G=5 ±2.5 V, G=8 ±2.0 V, G=10 ±1.25 V, G=16 ±1.0 V, G=20 Software selectable
Throughput (Note 2)	Software paced	250 samples per second (S/s) typical, PC-dependent
	Scan to system memory	0.596 to 50,000 S/s
Channel Gain Queue	Up to 16 elements	Software configurable channel, range.
Resolution (Note 3)	Differential	12 bits, no missing codes
	Single-ended	11 bits
Integral linearity error		±1 least significant bit (LSB) typical
Differential linearity error		±0.5 LSB typical
Repeatability		±1 LSB typical
Trigger source	Software selectable	External digital: TRIG_IN
Pacer source	Software selectable	<ul style="list-style-type: none"> ▪ Internal ▪ External (SYNC), rising edge triggered ▪ External Gated (SYNC), see Note 4 ▪ Programmed IO

Calibration		Factory Cal factors stored in firmware. Cal factors must be applied via application software.
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- Note 1:** Input current is a function of applied voltage on the analog input channels. For a given input voltage, V_{in} , the input leakage is approximately equal to $(8.181 \cdot V_{in} - 12) \mu A$.
- Note 2:** Maximum throughput scanning to PC memory is machine dependent. The rates specified are for Windows XP only.
- Note 3:** The AD7870 converter only returns 11-bits (0-2047 codes) in single-ended mode and 12-bits in differential mode. Firmware versions prior to 2.04 have LSB justified data. Firmware versions from 2.04 on have MSB justified data.
- Note 4:** External Gated Sync holds off the first clock pulse after setting up a scan to ensure adequate setup time for the first conversion.

Table 2. Accuracy, differential mode

Range	Accuracy (LSB)
± 20 V	5.1
± 10 V	6.1
± 5 V	8.1
± 4 V	9.1
± 2.5 V	12.1
± 2 V	14.1
± 1.25 V	20.1
± 1 V	24.1

Table 3. Accuracy, single-ended mode

Range	Accuracy (LSB)
± 10 V	4.0

Table 4. Accuracy components, differential mode - All values are (\pm)

Range	% of Reading	Gain Error at full scale (FS) (millivolts (mV))	Offset (mV)	Accuracy at FS (mV)
± 20 V	0.2	40	9.766	49.766
± 10 V	0.2	20	9.766	29.766
± 5 V	0.2	10	9.766	19.766
± 4 V	0.2	8	9.766	17.766
± 2.5 V	0.2	5	9.766	14.766
± 2 V	0.2	4	9.766	13.766
± 1.25 V	0.2	2.5	9.766	12.266
± 1 V	0.2	2	9.766	11.766

Table 5. Accuracy components, single-ended mode - All values are (\pm)

Range	% of Reading	Gain Error at FS (mV)	Offset (mV)	Accuracy at FS (mV)
± 10 V	0.2	20	19.531	39.531

Table 6. Noise performance, differential mode

Range	Typical counts	Least significant bit _{root mean square} (LSB _{rms})
±20 V	2	0.30
±10 V	2	0.30
±5 V	3	0.45
±4 V	3	0.45
±2.5 V	4	0.61
±2 V	5	0.76
±1.25 V	7	1.06
±1 V	8	1.21

Table 7. Noise performance, single-ended mode

Range	Typical Counts	LSB _{rms}
±10 V	2	0.30

Analog output

Table 8. Analog output specifications

Parameter	Conditions	Specification
Resolution		12-bits, 1 in 4096
Output range		0 – 4.096 V, 1 mV per LSB.
Number of channels		2
Throughput (Note 5)	Software paced	250 S/s single channel typical, PC dependent
	Single channel, continuous scan	10 kS/s
	Dual channel, continuous scan, simultaneous update	5 kS/s
Power on and reset voltage		Initializes to 000h code
Output drive	Each D/A OUT	15 mA
Slew rate		0.8V/microsecond (μs) typical

Note 5: Maximum throughput scanning to PC memory is machine dependent. The rates specified are for Windows XP only. Maximum rates on operating systems that predate XP may be less and must be determined through testing on your machine.

Table 9. Analog output accuracy, all values are (±)

Range	Accuracy (LSB)
0-4.096 V	4.0 typical, 45.0 maximum

Table 10. Analog output accuracy components, all values are (±)

Range	% of FSR	Gain Error at FS (mV)	Offset (mV) (Note 6)	Accuracy at FS (mV)
0-4.096 V	0.1 typical, 0.9 max	4.0 typical, 36.0 max	1.0 typical, 9.0 max	4.0 typical, 45.0 max

Note 6: Negative offsets will result in a fixed zero-scale error or "dead band." At the maximum offset of 9 mV, any input code of less than 0x009 will not produce a response in the output.

Digital input/output

Table 11. Digital I/O specifications

Parameter	Specification
Digital type	CMOS
Number of I/O	16 (Port 0 bit 0 through bit 7, Port 1 bit 0 through bit 7)
Configuration	2 banks of 8
Pull up/pull-down configuration	All pins configurable via jumpers (JP1 and JP2) to Vs or Ground via 47 K resistors. JP1 configures Port 1, and JP2 configures Port 0.
Input high voltage	2.0 V minimum, 5.5 V absolute maximum
Input low voltage	0.8 V maximum, -0.5 V absolute minimum
Output high voltage (IOH = -2.5 mA)	3.8 V minimum
Output low voltage (IOL = 2.5 mA)	0.7 V maximum
Power on and reset state	Input

External trigger

Table 12. Digital trigger specifications

Parameter	Conditions	Specification
Trigger source (Note 7)	External Digital	TRIG_IN
Trigger mode	Software selectable	Edge sensitive: user configurable for CMOS compatible rising or falling edge.
Trigger latency		10 μ s maximum
Trigger pulse width		1 μ s minimum
Input high voltage		4.0 V minimum, 5.5 V absolute maximum
Input low voltage		1.0 V maximum, -0.5 V absolute minimum
Input leakage current		$\pm 1.0 \mu$ A

Note 7: TRIG_IN is a Schmitt trigger input protected with a 1.5 kilohm ($k\Omega$) series resistor.

External clock input/output

Table 13. External clock I/O specifications

Parameter	Conditions	Specification
Pin name		SYNC
Pin type		Bidirectional
Software selectable direction	Output (default)	Outputs internal A/D pacer clock.
	Input	Receives A/D pacer clock from external source.
Input clock rate		50 KHz, maximum
Clock pulse width	Input mode	1 μ s minimum
	Output mode	5 μ s minimum
<i>Input leakage current</i>	<i>Input mode</i>	$\pm 1.0 \mu$ A
Input high voltage		4.0 V minimum, 5.5 V absolute maximum
Input low voltage		1.0 V maximum, -0.5 V absolute minimum
Output high voltage (Note 8)	IOH = -2.5 mA	3.3 V minimum
	No load	3.8 V minimum
Output low voltage (Note 8)	IOL = 2.5 mA	1.1 V maximum
	No load	0.6 V maximum

Note 8: SYNC is a Schmitt trigger input and is over-current protected with a 1.5 k Ω series resistor.

Counter

Table 14. Counter specifications

Parameter	Specification
Pin name (Note 9)	CTR
Counter type	Event counter
Number of channels	1
Input type	TTL, rising edge triggered
<i>Input source</i>	<i>CTR screw terminal</i>
Resolution	32 bits
<i>Schmidt trigger hysteresis</i>	<i>20 mV to 100 mV</i>
<i>Input leakage current</i>	$\pm 1 \mu$ A
Maximum input frequency	1 MHz
<i>High pulse width</i>	<i>500 ns minimum</i>
<i>Low pulse width</i>	<i>500 ns minimum</i>
Input high voltage	4.0 V minimum, 5.5 V absolute maximum
Input low voltage	1.0 V maximum, -0.5 V absolute minimum

Note 9: CTR is a Schmitt trigger input protected with a 1.5K Ω series resistor.

Non-volatile memory

Table 15. Non-volatile memory specifications

Parameter	Specification		
EEPROM	1,024 bytes		
EEPROM Configuration	Address Range	Access	Description
	0x000-0x1FF	Reserved	512 bytes system and cal data
	0x200-0x3FF	Read/write	512 bytes user area

Microcontroller

Table 16. Microcontroller specifications

Parameter	Specification
Type	High performance 8-bit RISC microcontroller
Program Memory	32,768 words
Data Memory	3,936 bytes

Indicator LEDs

Table 17. Indicator LED specifications

Parameter	Specification
Power LED (top)	Indicates that the device's microcontroller has power and is configured.
Status LED	Blinks to indicate USB communications.
OEM power	OEM Connector; LED sink current up to 5 mA per LED @ 5 V _{max}

Power

Table 18. Power specifications

Parameter	Conditions	Specification
Supply current (Note 10)		80 mA
+5V _{USER} power available (Note 11)	<ul style="list-style-type: none"> Connected to self-powered hub Connected to externally-powered root port hub 	4.5 V minimum, 5.25 V maximum
	Connected to bus-powered hub	4.1 V minimum, 5.25 V maximum
Output current (Note 12)	Connected to self-powered hub	420 mA maximum
	Connected to externally-powered root port hub	
	Connected to bus-powered hub	20 mA maximum
Fuse F1, (F4 spare)	0452.500 - Littelfuse 0.5A NANO ² ® Slo-Blo® Subminiature Surface Mount Fuse	
Fuse F2, (F3 spare)	0452.375 - Littelfuse 0.375A NANO ² ® Slo-Blo® Subminiature Surface Mount Fuse	

Note 10: This is the total current requirement for the USB-7204 which includes up to 10 mA for the status LED.

Note 11: *Self-powered hub* refers to a USB hub with an external power supply. Self-powered hubs allow a connected USB device to draw up to 500 mA.

Root port hubs reside in the PC's USB host controller. The USB port(s) on your PC are root port hubs. All externally powered root port hubs (desktop PCs) provide up to 500 mA of current for a USB device. Battery-powered root port hubs provide 100 mA or 500 mA, depending upon the manufacturer. A laptop PC that is not connected to an external power adapter is an example of a battery-powered root port hub.

Bus powered hubs receive power from a self-powered or root port hub. In this case the maximum current available from the USB +5 V is 100 mA. The minimum USB +5 V voltage level can be as low as 4.1 V.

Protected by fuse F2 at 375 mA.

Note 12: This refers to the total amount of current that can be sourced from the USB +5 V, analog outputs and digital outputs.

General

Table 19. General specifications

Parameter	Specification
Device type	USB 2.0 (full-speed)
Device compatibility	USB 1.1, USB 2.0
DEFAULTS for programmable options and "DEV:RESET/DEFAULT" message	AI Channel Mode = Differential Range = ± 10 V
	AInScan Low Channel = 0 High Channel = 0 Samples = 1000 Rate = 1000 Range = ± 10 V Pacer = Master Transfer Mode = BlockIO Trigger = Disabled Queue = Disabled Status = Idle
	AITrig Trigger Polarity = Rising Rearm – Disabled
	AOutScan Low Channel = 0 High Channel = 0 Samples = 1000 Rate = 1000 Trigger = Disabled Status = Idle
	CTR Value = 0

Environmental

Table 20. Environmental specifications

Parameter	Specification
Operating temperature range	0 to 70 °C
Storage temperature range	-40 to 70 °C
Humidity	0 to 90% non-condensing

Mechanical

Table 21. Mechanical specifications

Parameter	Specification
Dimensions	3.55" (L) x 3.75" (W) x 0.5" (H) 4.40" (L) with detachable screw terminals connected
USB cable length	3 meters maximum
User connection length	3 meters maximum

Main connector and pin out

Table 22. Main connector specifications

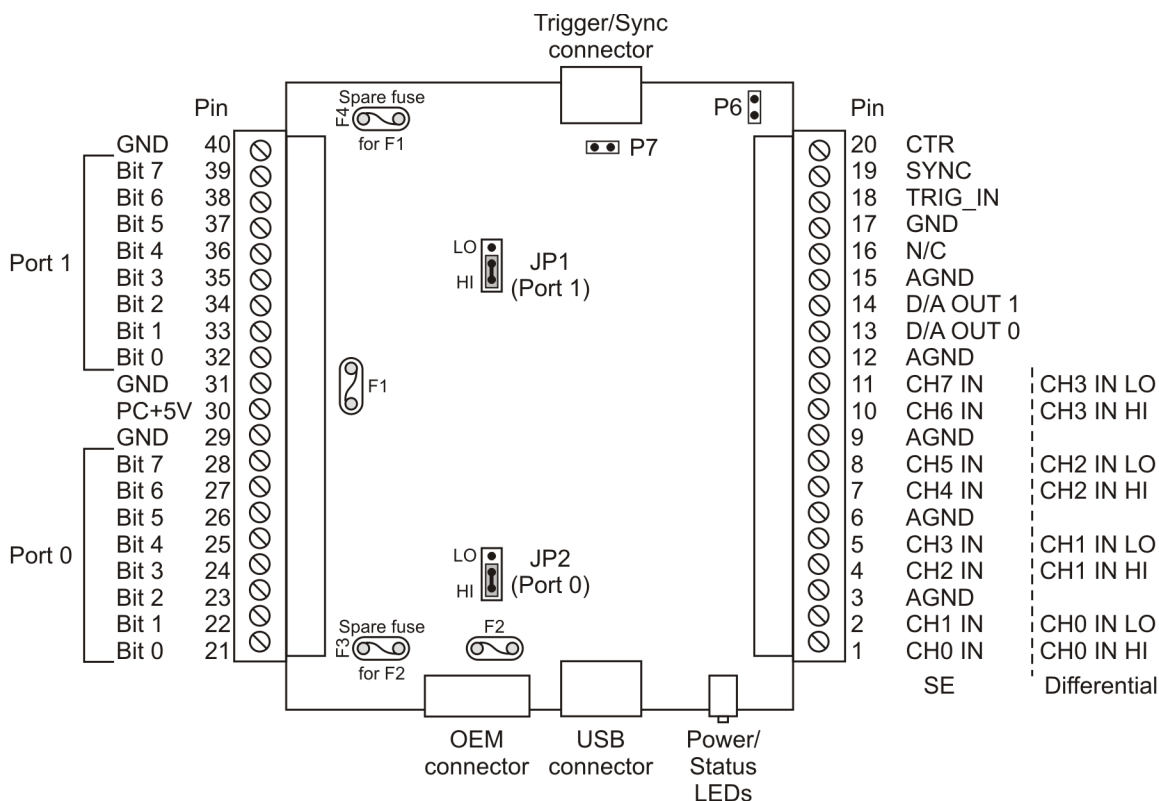
Parameter	Specification
Connector type	Screw terminal
Wire gauge range	16 AWG to 30 AWG

4-channel differential mode

Pin	Signal Name	Pin	Signal Name
1	CH0 IN HI	21	Port 0 Bit 0
2	CH0 IN LO	22	Port 0 Bit 1
3	AGND	23	Port 0 Bit 2
4	CH1 IN HI	24	Port 0 Bit 3
5	CH1 IN LO	25	Port 0 Bit 4
6	AGND	26	Port 0 Bit 5
7	CH2 IN HI	27	Port 0 Bit 6
8	CH2 IN LO	28	Port 0 Bit 7
9	AGND	29	GND
10	CH3 IN HI	30	+5V _{USER} output
11	CH3 IN LO	31	GND
12	AGND	32	Port 1 Bit 0
13	D/A OUT 0	33	Port 1 Bit 1
14	D/A OUT 1	34	Port 1 Bit 2
15	AGND	35	Port 1 Bit 3
16	N/C (do not connect anything to this pin)	36	Port 1 Bit 4
17	GND	37	Port 1 Bit 5
18	TRIG IN	38	Port 1 Bit 6
19	SYNC	39	Port 1 Bit 7
20	CTR	40	GND

8-channel single-ended mode

Pin	Signal Name	Pin	Signal Name
1	CH0 IN	21	Port 0 Bit 0
2	CH1 IN	22	Port 0 Bit 1
3	AGND	23	Port 0 Bit 2
4	CH2 IN	24	Port 0 Bit 3
5	CH3 IN	25	Port 0 Bit 4
6	AGND	26	Port 0 Bit 5
7	CH4 IN	27	Port 0 Bit 6
8	CH5 IN	28	Port 0 Bit 7
9	AGND	29	GND
10	CH6 IN	30	+5V _{USER} output
11	CH7 IN	31	GND
12	AGND	32	Port 1 Bit 0
13	D/A OUT 0	33	Port 1 Bit 1
14	D/A OUT 1	34	Port 1 Bit 2
15	AGND	35	Port 1 Bit 3
16	N/C (do not connect anything to this pin)	36	Port 1 Bit 4
17	GND	37	Port 1 Bit 5
18	TRIG IN	38	Port 1 Bit 6
19	SYNC	39	Port 1 Bit 7
20	CTR	40	GND



OEM connector and pin out (P4)

Table 23. OEM connector specifications

Parameter	Specification
Connector type	10 position 0.1" box header

Table 24. OEM connector pin out

Pin	Signal Name	Pin	Signal Name
1	N/C	2	V _{BUS} (fuse protected)
3	N/C	4	D-
5	N/C (do not connect anything to this pin)	6	D+
7	N/C (do not connect anything to this pin)	8	GND
9	N/C (do not connect anything to this pin)	10	SHIELD

Trigger/Sync connector and pin out (P5)

Table 25. Trigger/Sync connector specifications

Parameter	Specification
Connector type	10 position 0.1" box header

Table 26. Trigger/Sync connector pin out

Pin	Signal Name	Pin	Signal Name
1	TRIG_IN	2	GND
3	N/C	4	GND
5	SYNC	6	GND
7	N/C	8	GND
9	N/C	10	N/C

CE Declaration of Conformity

Manufacturer: Measurement Computing Corporation
Address: 10 Commerce Way
Suite 1008
Norton, MA 02766
USA
Category: Electrical equipment for measurement, control and laboratory use.

Measurement Computing Corporation declares under sole responsibility that the product

USB-7204

to which this declaration relates is in conformity with the relevant provisions of the following standards or other documents:

EC EMC Directive 2004/108/EC: General Requirements, EN 61326-1:2006 (IEC 61326-1:2005).

Emissions:

- EN 55011 (2007) / CISPR 11(2003): Radiated emissions: Group 1, Class A
- EN 55011 (2007) / CISPR 11(2003): Conducted emissions: Group 1, Class A

Immunity: EN 61326-1:2006, Table 3.

- IEC 61000-4-2 (2001): Electrostatic Discharge immunity.
- IEC 61000-4-3 (2002): Radiated Electromagnetic Field immunity.

To maintain compliance to the standards of this declaration, the following conditions must be met.

- The host computer, peripheral equipment, power sources, and expansion hardware must be CE compliant.
- All I/O cables must be shielded, with the shields connected to ground.
- I/O cables must be less than 3 meters (9.75 feet) in length.
- The host computer or embedded system must be properly grounded.
- Equipment must be operated in a controlled electromagnetic environment as defined by Standards EN 61326-1:2006, or IEC 61326-1:2005.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in August, 2004. Test records are outlined in Chomerics Test Report #EMI3948.04. Further testing was conducted by Chomerics Test Services, Woburn, MA. 01801, USA in December, 2008. Test records are outlined in Chomerics Test report #EMI5216.08.

We hereby declare that the equipment specified conforms to the above Directives and Standards.



Carl Haapaoja, Director of Quality Assurance

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