

USB-2637

Multifunction Measurement and Control

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 describes the Measurement Computing USB-2637 data acquisition device and lists device specifications.

Conventions in this user's guide

For more information

Text presented in a box signifies additional information related to the subject matter.

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 a 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.

Where to find more information

For additional information relevant to the operation of your hardware, refer to the Documents subdirectory where you installed the MCC DAQ software (C:\Program Files\Measurement Computing\DAQ by default), or search for your device on our website at www.mccdaq.com.

Introducing the USB-2637

The USB-2637 is a USB 2.0 high-speed device that is supported under the Microsoft® Windows® operating system.

The USB-2637 is compatible with both USB 1.1 and USB 2.0 ports. The speed of the device may be limited when using a USB 1.1 port due to the difference in transfer rates on the USB 1.1 versions of the protocol (low-speed and full-speed).

The USB-2637 device provides the following features:

- 64 single-ended (SE) analog inputs
- 24 DIO channels; bit configurable for input or output
- Four analog outputs
- Four counter inputs
- Four timer outputs
- Digital trigger input
- External AI scan clock input
- External AO scan clock input
- One 68-pin SCSI connector and four 40-pin header connectors for field wiring connections

The USB-2637 is powered by the USB supply from the computer; external power is not required.

Functional block diagram

USB-2637 functions are illustrated in the block diagram shown in Figure 1.

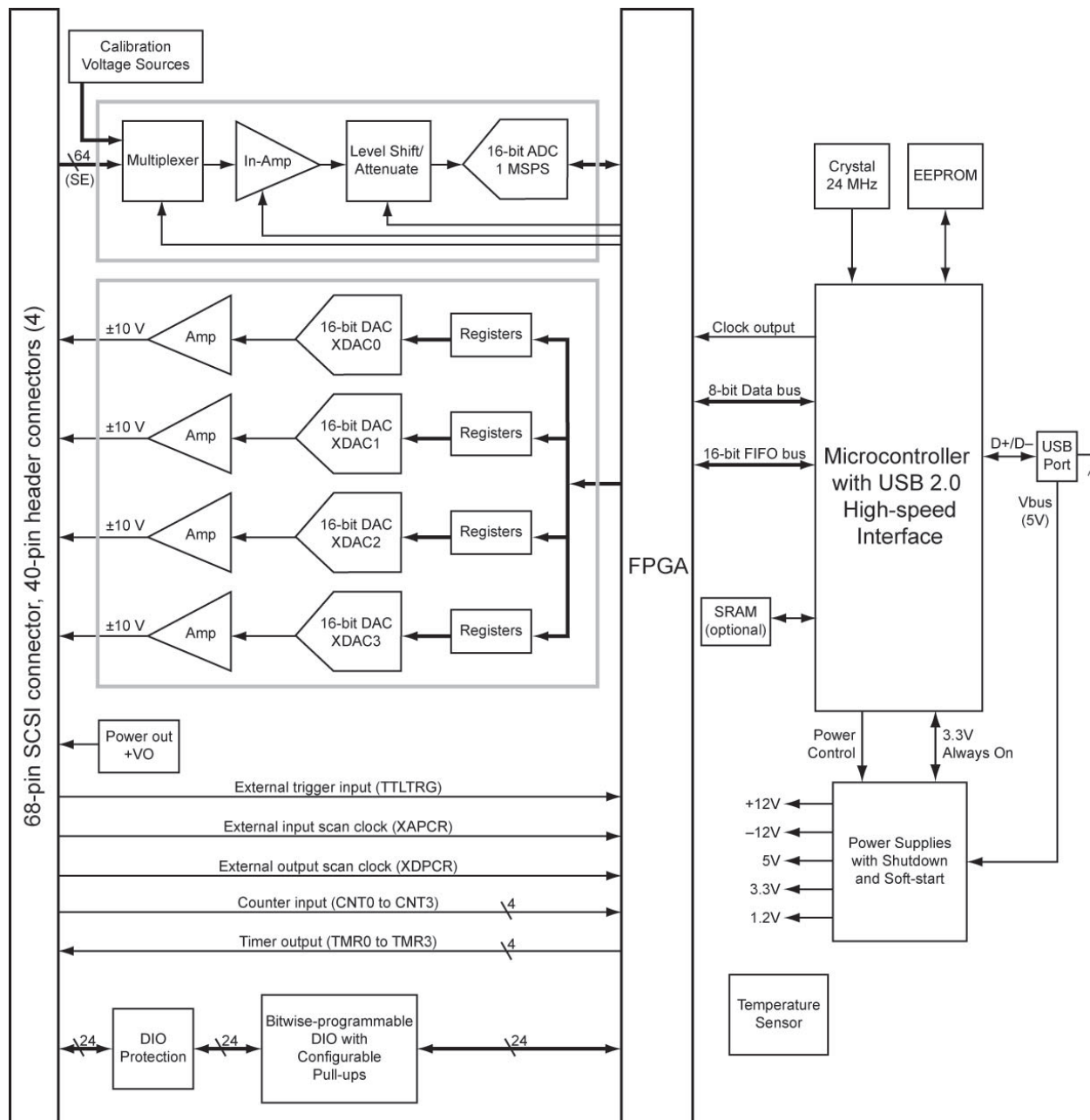


Figure 1. USB-2637 functional block diagram

Installing the USB-2637

Unpacking

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the device 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.

Contact us immediately if any components are missing or damaged.

Installing the software

Refer to the *MCC DAQ Quick Start* and the USB-2637 product page on our website for information about the software that supports the device.

Install the software before you install your device

The driver needed to run the USB-2637 is installed with the software. Therefore, you need to install the software package you plan to use before you install the hardware.

Installing the hardware

To connect a USB-2637 device to your system, turn on your computer and connect the USB cable to an available USB port on the computer or to an externally powered USB hub connected to the computer.

When connected for the first time, a **Found New Hardware** dialog opens when the operating system detects the device. When the dialog box closes, the installation is complete.

The **Power LED** (top LED) blinks during device detection and initialization, and then remains on. When the board is first powered on, there is usually a momentary delay before the Power LED blinks or turns on.

Configuring the hardware

All hardware configuration options are programmable with software.

Caution! Avoid redundant connections. Ensure that there is no signal conflict between the 68-pin SCSI connector (P1) and the 40-pin connectors (J2 to J5). Failure to do so could possibly cause equipment damage and/or personal injury.

Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

Always handle components carefully, and never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD-controlled area. These guidelines include using properly-grounded mats and wrist straps, ESD bags and cartons, and related procedures.

Avoid touching board surfaces and onboard components. Only handle boards by their edges. Make sure that the USB-2637 does not come into contact with foreign elements such as oils, water, and industrial particulate.

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage.

Calibrating the hardware

Field calibration

The USB-2637 supports self-calibration. Run the InstaCal utility to calibrate the USB-2637 whenever the ambient temperature changes by more than ± 10 °C from the last self-calibration. The recommended calibration interval is one year. Calibrate the inputs before calibrating the outputs.

Factory calibration

The Measurement Computing Manufacturing Test department performs the initial factory calibration. Return the device to Measurement Computing Corporation if you want the factory calibration restored.

Signal Connections

Board signals are available on the 68-pin SCSI connector P1 and 40-pin header connectors J2, J3, J4, and J5.

Caution! Avoid redundant connections! Make sure there is no signal conflict between the SCSI connector pins and header connector pins. Failure to do so could possibly cause equipment damage and/or personal injury.

Use the SCSI cable for optimal analog input settling time

To achieve the best analog input channel-channel settling time performance, connect your signals to the SCSI connector (P1). If the J2 to J5 connectors are to be used, keep the interface cable as short as possible to minimize settling errors.

68-pin SCSI connector P1

The SCSI connector provides connections to the board signals listed in Figure 2.

Analog input0	ACH0	68	●	34	ACH8	Analog input 8
Analog ground	AGND	67	●	33	ACH1	Analog input 1
Analog input 9	ACH9	66	●	32	AGND	Analog ground
Analog input 2	ACH2	65	●	31	ACH10	Analog input 10
Analog ground	AGND	64	●	30	ACH3	Analog input 3
Analog input 11	ACH11	63	●	29	AGND	Analog ground
Analog ground	AGND	62	●	28	ACH4	Analog input 4
Analog input 12	ACH12	61	●	27	AGND	Analog ground
Analog input 5	ACH5	60	●	26	ACH13	Analog input 13
Analog Ground	AGND	59	●	25	ACH6	Analog input 6
Analog input 14	ACH14	58	●	24	AGND	Analog ground
Analog input 7	ACH7	57	●	23	ACH15	Analog input 15
Analog output 3	XDAC3	56	●	22	XDAC0	Analog output 0
Analog output 2	XDAC2	55	●	21	XDAC1	Analog output 1
Analog ground	AGND	54	●	20	NC	No connection
Digital ground	DGND	53	●	19	+VO	Power output
Port A bit 1	A1	52	●	18	A0	Port A bit 0
Port A bit 3	A3	51	●	17	A2	Port A bit 2
Port A bit 5	A5	50	●	16	A4	Port A bit 4
Port A bit 7	A7	49	●	15	A6	Port A bit 6
Port B bit 1	B1	48	●	14	B0	Port B bit 0
Port B bit 3	B3	47	●	13	B2	Port B bit 2
Port B bit 5	B5	46	●	12	B4	Port B bit 4
Port B bit 7	B7	45	●	11	B6	Port B bit 6
Port C bit 1	C1	44	●	10	C0	Port C bit 0
Port C bit 3	C3	43	●	9	C2	Port C bit 2
Port C bit 5	C5	42	●	8	C4	Port C bit 4
Port C bit 7	C7	41	●	7	C6	Port C bit 6
Digital Ground	GND	40	●	6	TTLTRIG	External dig. trigger input
Counter input 1	CNT1	39	●	5	CNT0	Counter input 0
Counter input 3	CNT3	38	●	4	CNT2	Counter input 2
Timer input 1	TMR1	37	●	3	TMR0	Timer output 0
Digital ground	GND	36	●	2	XAPCR	External AI scan clock
Digital ground	GND	35	●	1	XDPCR	External AO scan clock

Figure 2. SCSI connector P1 pinout

Cabling

Use a CA-68-3R cable (Figure 3) when connecting signals to the SCSI connector.

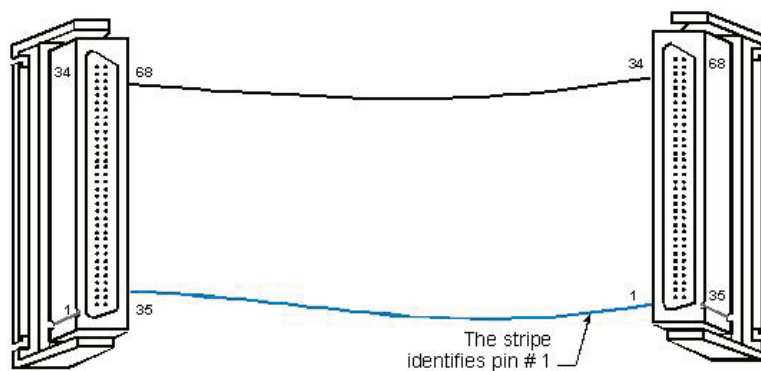


Figure 3. CA-68-3R cable

Signal termination

- **TB-100** screw terminal board – connects to SCSI connector P1 with a CA-68-3R cable. A 19-inch rack mount kit (**RM-TB-100**) is also available.

The following table lists how TB-100 screw terminals are mapped to the SCSI connector pins.

TB-100 to SCSI connector pin map

TB2 terminal	SCSI pin	TB1 terminal	SCSI pin
+5V	19	ACH0	68
GND	GND	ACH8	34
A0	18	AGND	AGND
A1	52	ACH1	33
A2	17	ACH9	66
A3	51	AGND	AGND
A4	16	ACH2	65
A5	50	ACH10	31
A6	15	AGND	AGND
A7	49	ACH3	30
B0	14	ACH11	63
B1	48	AGND	AGND
B2	13	ACH4	28
B3	47	ACH12	61
B4	12	AGND	AGND
B5	46	ACH5	60
B6	11	ACH13	26
B7	45	AGND	AGND
C0	10	ACH6	25
C1	44	ACH14	58
C2	9	AGND	AGND
C3	43	ACH7	57
C4	8	ACH15	23
C5	42	XDAC3	56
C6	7	SGND	62
C7	41	NC (Note 1)	20
TTL TRG	6	XDAC2	55
GND	GND	GND (Note 2)	GND
CNT0	5	AGND	AGND
CNT1	39	XDAC0	22
CNT2	4	AGND	AGND

TB2 terminal	SCSI pin	TB1 terminal	SCSI pin
CNT3	38	XDAC1	21
TMR0	3	AGND	AGND
TMR1	37	XAPCR	2
XDPCR	1	GND	GND
GND	GND	EGND	SCSI shell

Do not make connections to any terminal labeled NC.

Note 1: Labeled POSREF on the TB-100; not supported on the USB-2637.
Note 2: Labeled NEGREF on the TB-100; not supported on the USB-2637.

40-pin header connectors J2, J3, J4, and J5

The 40-pin headers (**J2** through **J5**) provide alternative connections to the 68-pin connector. Pins 1, 2, 39, and 40 are labeled on each connector.

J2 and **J3** provide analog input connections. **J4** provides digital, counter, timer, pacer input, and power output connections. **J5** provides analog output, timer, pacer I/O, and power output connections.

Caution! **Avoid redundant connections!** Make sure there is no signal conflict between the SCSI connector pins and header connector pins. Failure to do so could possibly cause equipment damage and/or personal injury.

Figure 4 shows the pinout for J2 and J3.

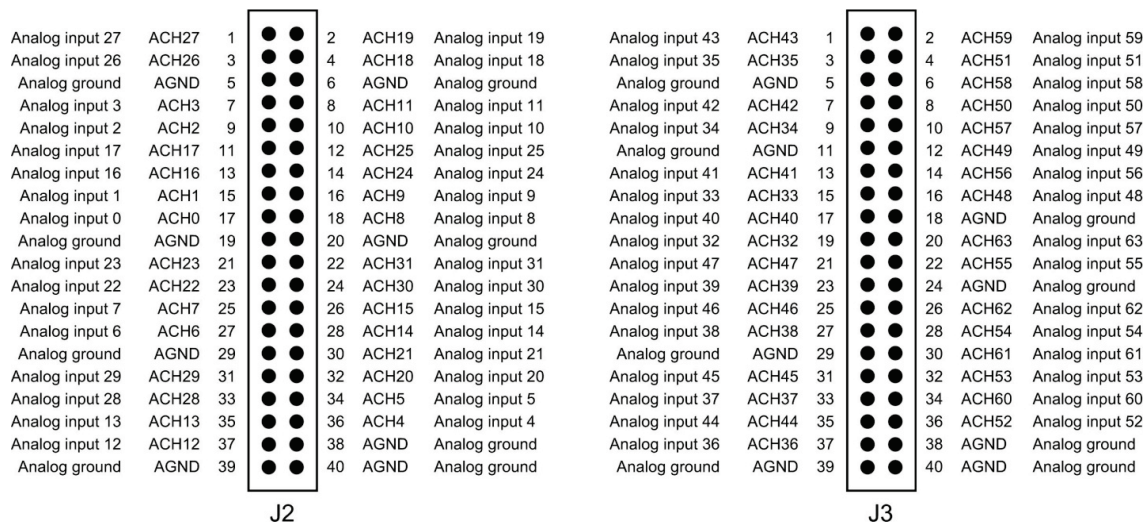


Figure 4. Header connector J2 and J3 pinout

Figure 5 shows the pinout for J4 and J5.

Digital ground	GND	1	● ●	2	XAPCR	AI scan clock	No connection	NC	1	● ●	2	NC	No connection
Port A bit 0	A0	3	● ●	4	A4	Port A bit 4	No connection	NC	3	● ●	4	NC	No connection
Port A bit 1	A1	5	● ●	6	A5	Port A bit 5	Analog ground	AGND	5	● ●	6	AGND	Analog ground
Port A bit 2	A2	7	● ●	8	A6	Port A bit 6	Analog output 0	XDAC0	7	● ●	8	XDAC2	Analog output 2
Port A bit 3	A3	9	● ●	10	A7	Port A bit 7	Analog output 1	XDAC1	9	● ●	10	XDAC3	Analog output 3
Digital ground	GND	11	● ●	12	TTLTRG	Dig. trigger input	Analog ground	AGND	11	● ●	12	AGND	Analog ground
Port B bit 0	B0	13	● ●	14	B4	Port B bit 4	No connection	NC	13	● ●	14	AGND	Analog ground
Port B bit 1	B1	15	● ●	16	B5	Port B bit 5	Analog ground	AGND	15	● ●	16	AGND	Analog ground
Port B bit 2	B2	17	● ●	18	B6	Port B bit 6	Dig. trigger input	TTLTRG	17	● ●	18	XDPCR	AO scan clock
Port B bit 3	B3	19	● ●	20	B7	Port B bit 7	AI scan clock	XAPCR	19	● ●	20	GND	Digital ground
Digital ground	GND	21	● ●	22	+VO	Power output	Digital ground	GND	21	● ●	22	GND	Digital ground
Port C bit 0	C0	23	● ●	24	C4	Port C bit 4	No connection	NC	23	● ●	24	NC	No connection
Port C bit 1	C1	25	● ●	26	C5	Port C bit 5	Power output	+VO	25	● ●	26	NC	No connection
Port C bit 2	C2	27	● ●	28	C6	Port C bit 6	No connection	NC	27	● ●	28	NC	No connection
Port C bit 3	C3	29	● ●	30	C7	Port C bit 7	Digital ground	GND	29	● ●	30	NC	No connection
Digital ground	GND	31	● ●	32	TMR1	Timer output 1	Timer output 2	TMR2	31	● ●	32	NC	No connection
Timer output 0	TMR0	33	● ●	34	CNT1	Counter input 1	Digital ground	GND	33	● ●	34	NC	No connection
Counter input 0	CNT0	35	● ●	36	CNT3	Counter input 3	Timer output 3	TMR3	35	● ●	36	NC	No connection
Counter input 2	CNT2	37	● ●	38	GND	Digital ground	Digital ground	GND	37	● ●	38	NC	No connection
Digital ground	GND	39	● ●	40	GND	Digital ground	No connection	NC	39	● ●	40	NC	No connection

Figure 5. Header connector J4 and J5 pinout

For more information about signal connections

For more information about analog input connections, refer to the *Guide to DAQ Signal Connections* (available for download on our website at www.mccdaq.com/support/DAQ-Signal-Connections.aspx).

Cabling

Use a C40FF-x cable (Figure 6) when connecting signals to a 40-pin header connector.

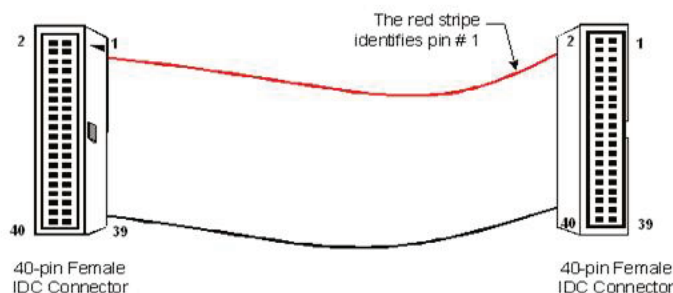


Figure 6. C40FF-x cable

Connecting a C40FF-x cable to each 40-pin connector provides greater signal connectivity than what is provided by the SCSI connector.

Signal termination

- **CIO-MINI40** – 40-pin screw terminal board that connects to the J2, J3, J4, or J5 header connector with the C40FF-x cable.
- **TB-103** – screw terminal board that mounts directly onto the header connectors.

Functional Details

Analog input modes

The USB-2637 can acquire analog input data in two modes – software paced and hardware paced.

Software paced

You can acquire one analog sample at a time in software paced mode. You initiate the A/D conversion with a software command. The analog value is converted to digital data and returned to the computer. Repeat this procedure until you have the total number of samples that you want.

The sample rate in software paced mode is system-dependent and can range from 33 S/s to 4000 S/s.

Hardware paced

You can acquire data from up to 64 channels in hardware paced mode. The analog data is continuously acquired, converted to digital values, and written into the 4k FIFO buffer on the device until you stop the scan. The FIFO buffer is serviced in blocks as the data is transferred from the FIFO buffer to the computer memory buffer. You start a continuous scan with either a software command or with an external hardware trigger event.

The maximum sampling rate in hardware paced mode from one to 64 channels is 1,000 kS/s, max.

Burst mode

Burst mode is an optional scan mode used with the onboard pacer to obtain more precise timing between samples. When burst mode is enabled, each successive channel in a scan is sampled at the maximum A/D rate. This ensures that samples from each channel are taken as close as possible to the same absolute point in time. When burst mode is disabled, data is sampled at evenly spaced intervals, allowing you to increase the sample period time; doing so can improve settling time and overall measurement accuracy.

Multi-channel scanning with burst mode enabled and disabled is shown in Figure 7.

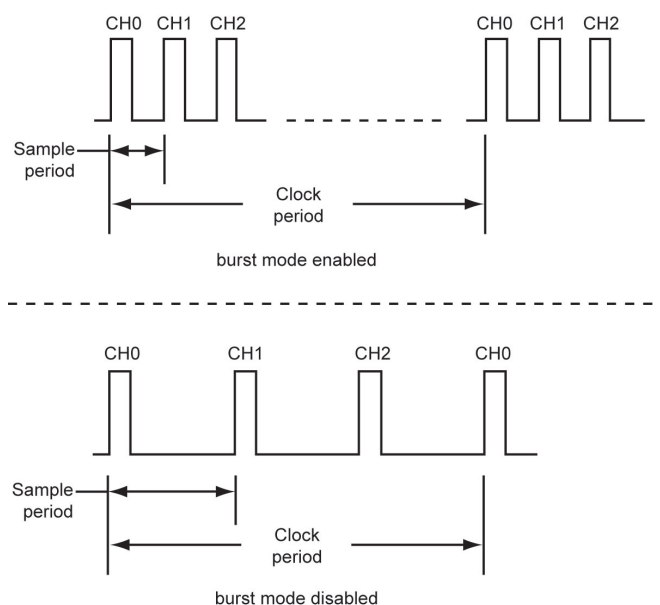


Figure 7. Multi-channel scan with burst mode enabled and disabled

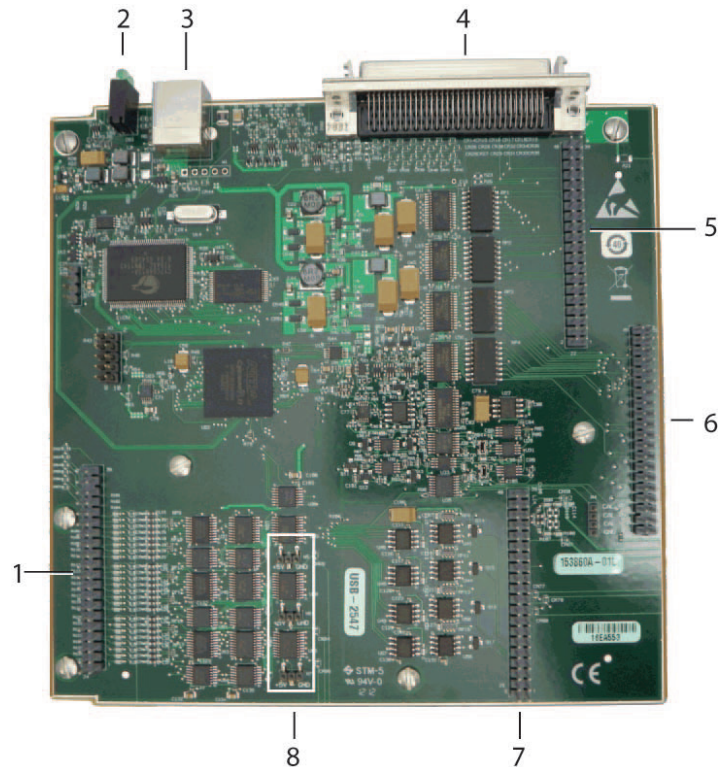
The burst mode sample period is 1 μ s.

You can trigger the acquisition with the external trigger and control the clock period with the internal A/D pacer clock.

USB-2637 components

These USB-2637 components are shown in Figure 8.

- 68-pin SCSI connector (P1)
- 40-pin header connectors (J2, J3, J4, and J5)
- USB connector
- LED indicators (USB and Power)



- | | | | |
|---|--------------------------|---|-----------------------------------|
| 1 | 40-pin connector J4 | 5 | 40-pin connector J2 |
| 2 | LEDs | 6 | 40-pin connector J3 |
| 3 | USB connector | 7 | 40-pin connector J5 |
| 4 | 68-pin SCSI connector P1 | 8 | Pull-up/down jumpers (W5, W6, W7) |

Figure 8. USB-2637 components

68-pin SCSI connector P1

The 68-pin SCSI connector provides the following connections:

- 16 single-ended analog inputs (ACH0 to ACH15)
- Four analog outputs (XDAC0 to XDAC3)
- 24 digital I/O (A0 to A7, B0 to B7, C0 to C7)
- Four counter inputs (CNT0 to CNT3)
- Two timer outputs (TMR0 to TMR1)
- External AI scan clock input (XAPCR)
- External AO scan clock input (XDPCR)
- External digital trigger input (TTLTRG)
- Power output (+VO)
- Analog ground and digital ground (AGND and GND)

Refer to Figure 2 on page 10 for the SCSI connector pinout.

40-pin header connectors J2, J3, J4, and J5

The header connectors provide alternative connections to the SCSI connector.

Connectors **J2** and **J3** provide analog input connections. **J4** provides digital, counter, timer, pacer input, and power output connections. **J5** provides analog output, timer, pacer I/O, and power output connections.

Refer to Figure 4 and Figure 5 on page 12 for header connector pinouts.

USB connector

The USB connector provides +5 V power and communication. No external power supply is required.

LEDs

The USB-2637 has two LEDs – **Power** and **Activity**.

- The **Power** LED (top) turns on when the device is detected and installed on the computer.
- The **Activity** LED (bottom) blinks when data is transferred and is off otherwise.

Standoffs

The board is shipped with standoffs that can be used for mounting onto a metal frame.

Signal descriptions

Analog input

The USB-2637 has a 16-bit A/D converter and provides 64 single-ended analog inputs. The input voltage range is fixed at ± 10 V. AI connections are available on the SCSI connector and on header connectors J2 and J3:

- SCSI connector P1 provides connections for **ACH0** to **ACH15**
- Header connector J2 provides connections for **ACH0** to **ACH15**
- Header connector J3 provides connections for **ACH32** to **ACH63**

Input pacer clock

You can pace input scanning operations using the input scan clock on the board or with an external signal connected to **XAPCR**. The sampling rate is software-selectable for 0.0149 Hz to 1 MHz.

Channel-Gain queue

The USB-2637 channel-gain queue feature allows you to configure a list of channels to scan. The settings are stored in a channel-gain queue list that is written to local memory on the device.

The channel-gain queue list can contain up to 64 elements. The channels can be listed in any order. An example of a 4-element list is shown in the table below.

Sample channel-gain queue list

Element	Channel	Range
0	CH5	BIP10V
1	CH27	BIP10V
2	CH45	BIP10V
3	CH15	BIP10V

Analog output

The USB-2637 has four 16-bit, 1 MHz analog output channels (**XDAC0** to **XDAC3**). The output range is fixed at ± 10 V. All outputs can be updated at 1 MS/s, regardless of the number of channels in a scan.

Analog output connections are available on the SCSI connector and header connector J5.

Output pacer clock

You can pace the output waveform using the DAC scan clock on the board or with an external signal connected to **XDPCR**.

The on-board programmable clock can generate updates ranging from 0.0149 Hz to 1 MHz.

Digital I/O

The USB-2637 has 24 TTL-level digital I/O lines that are configured as three 8-bit ports. Each bit is configurable as either input or output. Digital I/O connections are available on the SCSI connector and header connector J4.

You can read digital input ports asynchronously before, during, or after an analog input scan. Digital outputs can be updated asynchronously before, during, or after an acquisition.

Pull-up/down configuration

Each digital port has 47 k Ω resistors that are jumper configurable as pull-up or pull-down (default). Jumper **W7** configures Port A, **W6** configures Port B, and **W5** configures Port C.

Caution! Turn off power to all devices connected to the system before making connections. Electrical shock or damage to equipment can result even under low-voltage conditions.

Always handle components carefully, and never touch connector pins or circuit components unless you are following ESD guidelines in an appropriate ESD-controlled area. These guidelines include using properly-grounded mats and wrist straps, ESD bags and cartons, and related procedures.

Avoid touching board surfaces and onboard components. Only handle boards by their edges. Make sure that the USB-2637 does not come into contact with foreign elements such as oils, water, and industrial particulate.

The discharge of static electricity can damage some electronic components. Semiconductor devices are especially susceptible to ESD damage.

Figure 9 shows the location of each jumper on the board.

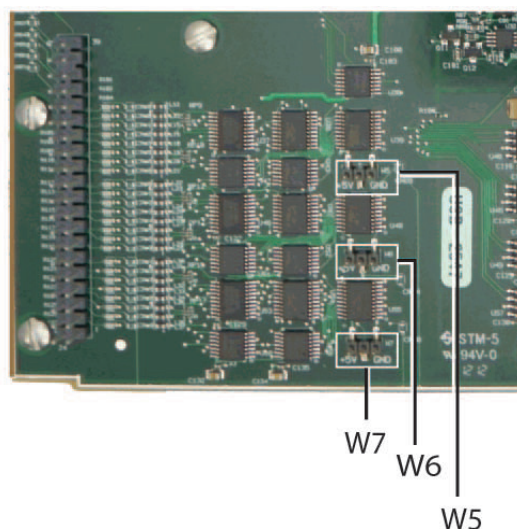


Figure 9. Pull-up/down jumper locations

Figure 10 shows the pull-up and pull-down configuration for each jumper.

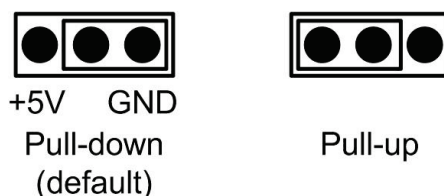


Figure 10. Pull-up/down jumper configurations

For more information about digital signal connections

For general information about digital signal connections and digital I/O techniques, refer to the *Guide to DAQ Signal Connections* (available for download on our website at www.mccdaq.com/support/DAQ-Signal-Connections.aspx).

Counter input

The four counter inputs (**CNT0** to **CNT3**) are 32-bit event counters that can accept frequency inputs up to 20 MHz.

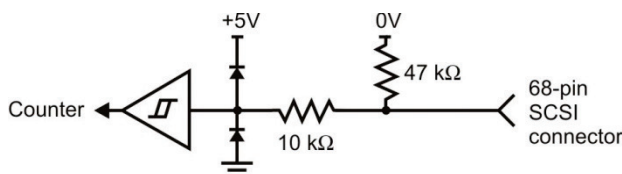


Figure 11. Typical counter input

Counter input connections are available on the SCSI connector and header connector J4.

Trigger input

The external digital trigger input (**TTLTRIG**) is software selectable for edge or level sensitive.

- Edge sensitive mode is configurable for rising or falling edge.
- Level sensitive mode is configurable for high or low level.

The default setting at power up is edge sensitive, rising edge. The trigger input connection is available on the SCSI connector and header connectors J4 and J5.

Timer output

The four timer outputs (**TMR0** to **TMR3**) are pulse width modulation (PWM) outputs that can generate a square wave with a programmable frequency in the range of 0.015 Hz to 32 MHz. Figure 12 shows the timer output schematic.

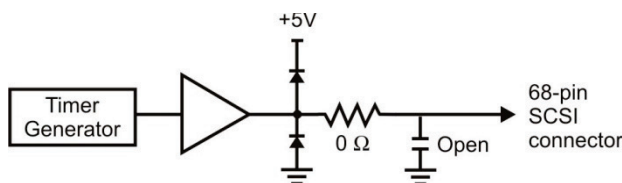


Figure 12. Typical timer output

Timer output connections are available on the 68-pin connector P1 and the 40-pin connectors J4 and J5. TMR0 and TMR1 are available on the SCSI connector and header connector J4. TMR2 and TMR3 are available on header connector J5.

Ground

The analog ground (**AGND**) pins provide a common ground for all analog channels. The digital ground (**GND**) pins provide a common ground for the digital, counter, timer, and clock channels and the power terminal.

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. General analog input specifications

Parameter	Condition	Specification
A/D converter type		Successive approximation
ADC resolution		16 bits
Number of channels		64 single-ended
Input voltage range		± 10 V
<i>Absolute maximum input voltage</i>	<i>CHx relative to AGND</i>	■ ± 25 V max (power on) ■ ± 10.5 V max (power off)
<i>Input impedance</i>		■ $1\text{ G}\Omega$ (power on) ■ $390\text{ }\Omega$ (power off)
<i>Input bias current</i>		± 100 pA
Input bandwidth	Small signal (–3 dB)	3.1 MHz
<i>Input capacitance</i>		40 pf
Maximum working voltage		± 10.1 V max relative to AGND
Crosstalk	Adjacent channels, DC to 10 kHz	–80 dB
Input coupling		DC
Sampling rate		0.0149 Hz to 1,000 kHz; software selectable
Trigger source		TTLTRG
A/D pacing		■ Internal input scan clock ■ External input scan clock (XAPCR)
Burst mode		Burst rate = 1 μ s, software selectable
Throughput	Software paced	33 to 4,000 S/s typ; system dependent
	Hardware paced	1 MS/s max
Channel queue		Up to 64 element list of random channels
Warm-up time		15 minutes min

Accuracy

Analog input DC voltage measurement accuracy

Table 2. DC Accuracy components and specifications. All values are ($\pm$)

Range	Gain error (% of reading)	Offset error (μ V)	INL error (% of range)	Absolute accuracy at Full Scale (μ V)	Gain temperature coefficient (% reading/°C)	Offset temperature coefficient (μ V/°C)
± 10 V	0.031	915	0.0076	4775	0.0013	35

Noise performance

For the peak-to-peak noise distribution test, a single-ended input channel is connected to AGND at the input terminal block, and 32,000 samples are acquired at the maximum rate.

Table 3. Noise performance specifications

Range	Counts	LSBrms
±10 V	8	1.21

Settling time for multichannel measurements

Settling time is defined as the accuracy that can be expected after one conversion when switching from a channel with a DC input at one extreme of full scale to another channel with a DC input at the other extreme of full scale.

Table 4. Input settling time specifications in μ S, typical

Range	1 μ S settling accuracy (% FSR)	5 μ S settling accuracy (% FSR)	10 μ S settling accuracy (% FSR)
±10 V	0.0152	0.0061	0.0015

Analog output

Table 5. Analog output specifications

Parameter	Condition	Specification
Number of channels		4
Resolution		16 bits
Output ranges	Calibrated	±10 V
Output transient	Host computer is reset, powered on, suspended, or a reset command is issued to the device	Duration: 100 ms Amplitude: 2V p-p
	Powered off	Duration: 100 ms Amplitude: 5 V peak
Differential non-linearity		±0.25 LSB typ ±1 LSB max
Output current	XDACx pins	±3.5 mA max
Output short-circuit protection	XDACx connected to AGND	Unlimited duration
Output coupling		DC
Power on and reset state		DACs cleared to zero-scale: 0 V, ±150 mV
Pacer source		Two programmable sources: ■ Internal output scan clock ■ External output scan clock (XDPCR), independent of external input scan clock (XAPCR)
Trigger sources		TTLTRIG (see <i>External trigger</i> on page 23)
Output update rate		1 MS/s max (Note 3)
Settling time	To rated accuracy, 10 V step	2 μ s
Slew rate		20 V/ μ s
Throughput	Software paced	33 S/s to 4,000 S/s typ, system dependent
	Hardware paced	1 MS/s max, system dependent

Note 1: Leave unused XDACx output channels disconnected.

Note 2: XDACx defaults to 0 V whenever the host computer is reset, powered on, suspended, or a reset command is issued to the device.

Note 3: The DAC update rate is not affected by the number of channels in the scan.

Table 6. Calibrated absolute accuracy specifications

Range	Absolute accuracy ($\pm$ LSB)
± 10 V	16.0

Table 7. Calibrated absolute accuracy components specifications

Range	% of reading	Offset ($\pm$ mV)	Offset tempco (μ V/ $^{\circ}$ C)	Gain tempco (ppm of range/ $^{\circ}$ C)
± 10 V	± 0.0183	1.831	12.7	13

Table 8. Relative accuracy specifications ($\pm$ LSB)

Range	Relative accuracy (INL)
± 10 V	4.0 typ

Analog input/output calibration

Table 9. Analog input/output calibration specifications

Parameter	Specification
Recommended warm-up time	15 minutes min
Calibration method	Self-calibration (firmware)
Calibration interval	1 year (factory calibration)
AI calibration reference	+5 V, ± 2.5 mV max. Actual measured values stored in EEPROM.
	Tempco: 5 ppm/ $^{\circ}$ C max
	Long term stability: 15 ppm/1,000 hours
AO calibration procedure	The analog output pins are internally routed to the analog input circuit. For best calibration results, disconnect any XDACx connections at the I/O connectors prior to performing AOUT calibration.

Digital input/output

Table 10. Digital input/output specifications

Parameter	Specification
Digital type	TTL
Number of I/O	24
Configuration	Three banks of 8. Each bit may be configured as input (power on default) or output.
Pull-up configuration	Each port has 47 k Ω resistors that are configurable as pull-up or pull-down (default) using an onboard jumper (W5, W6, W7).
Digital I/O transfer rate (system-paced, asynchronous)	33 to 4,000 port reads/writes or single bit reads/writes per second typ; system dependent.
Input high voltage	2.0 V min 5.0 V absolute max
Input low voltage	0.8 V max 0 V recommended min
Output high voltage	4.4 V min (IOH = -50 μ A) 3.76 V min (IOH = -24 mA)
Output low voltage	0.1 V max (IOL = 50 μ A) 0.44 V max (IOL = 24 mA)
Output current	60 mA max, not to exceed 24 mA for one bit, resulting in 2.5 mA max when all 24 bits are enabled.

External trigger

Table 11. External trigger specifications

Parameter	Specification
Trigger source	TTLTRG
Trigger mode	Software programmable for edge or level sensitive, rising or falling edge, high or low level. Power on default is edge sensitive, rising edge.
Trigger latency	1 μ s + 1 clock cycle max
Trigger pulse width	100 ns min
Input type	33 Ω series resistor and 49.9 k Ω pull-down to GND
Input high voltage	2.2 V min 5.5 V absolute max
Input low voltage	1.5 V max −0.5 V absolute min 0 V recommended min

External clock

Table 12. External clock I/O specifications

Parameter	Specification
Terminal names	XAPCR, XDPCR
Terminal types	Input, active on rising edge
Terminal descriptions	Receives pacer clock from external source
Input clock rate	1 MHz max
Clock pulse width	100 ns min
Input type	33 Ω series resistor, 47 k Ω pull-down to GND
Input high voltage	2.2 V min 5.5 V absolute max
Input low voltage	1.5 V max −0.5 V absolute min 0 V recommended min

Counter

Table 13. Counter specifications

Parameter	Specification
Terminal names	CNT0, CNT1, CNT2, CNT3
Number of channels	4 channels
Resolution	32-bit
Counter type	Event counter
Input type	33 Ω series resistor, 47 k Ω pull-down to GND
Input source	68-pin SCSI: CNT0 (pin 5), CNT1 (pin 39), CNT2 (pin 4), CNT3 (pin 38) 40-pin (J4): CNT0 (pin 35), CNT1 (pin 34), CNT2 (pin 37), CNT3 (pin 36)
Counter read/writes rates (software paced)	33 to 8,000 reads/writes per second typ; system dependent
Input high voltage	2.2 V min
Input low voltage	1.5 V max
Maximum input voltage range	−5 V to +10 V max
Input frequency	20 MHz max
High pulse width	25 ns min
Low pulse width	25 ns min

Timer output

Table 14. Timer output specifications

Parameter	Specification
Terminal name	TMR0, TMR1, TMR2, TMR3
Number of channels	4 channels
Timer type	PWM output with count, period, delay, and pulse width registers
Output value	Default state is idle low with pulses high, software selectable, output invert
Input source	68-pin SCSI: TMR0 (pin 3), TMR1 (pin 37) 40-pin (J4): TMR0 (pin 33), TMR1 (pin 32) 40-pin (J5): TMR2 (pin 31), TMR3 (pin 35)
Internal clock frequency	64 MHz
Register widths	32-bit
High pulse width	10.42 ns min
Low pulse width	10.42 ns min
Output high voltage	4.4 V min (IOH = -50 μ A) 3.76 V min (IOH = -1.0 mA)
Output low voltage	0.1 V max (IOL = 50 μ A) 0.44 V max (IOL = 1.0 mA)
Output waveform	Square wave
Output rate	64 MHz base rate divided by 2^{32} ; software selectable

Memory

Table 15. Memory specifications

Parameter	Specification
Data FIFO	4 kS analog input/2 kS analog output
Non-volatile memory	32 KB (30 KB firmware storage, 2 KB calibration/user data)

Power

Table 16. Power specifications

Parameter	Condition	Specification
Supply current (Note 4, Note 5)	Quiescent current	360 mA
+VO output voltage range		4.25 V to 5.25 V
+VO output current		10 mA max

Note 4: This is the total quiescent current requirement for the device that includes up to 10 mA for the Status LED. This value does not include potential loading of the DIO bits, +VO pin, or the XDACx outputs.

Note 5: USB 2.0 ports are required by USB 2.0 standards to supply 2500 mW (nominal at 5 V, 500 mA). Self-powered hubs and externally-powered root port hubs provide up to 500 mA of current for a USB device. Battery-powered root port hubs, such as in a laptop PC, provide 100 mA or 500 mA, depending on the manufacturer. If your laptop is constrained to the 100 mA maximum, you need to purchase a self-powered hub.

USB

Table 17. USB specifications

Parameter	Specification
USB device type	USB 2.0 (high-speed)
Device compatibility	USB 1.1, USB 2.0
USB cable type	A-B cable, UL type AWM 2725 or equivalent. (min 24 AWG VBUS/GND, min 28 AWG D+/D-)
USB cable length	3 m (9.84 ft) max

Environmental

Table 18. Environmental specifications

Parameter	Specification
Operating temperature range	0 °C to 55 °C max
Storage temperature range	–40 °C to 85 °C max
Humidity	0% to 90% non-condensing max

Mechanical

Table 19. Mechanical specifications

Parameter	Specification
PCB dimensions (L × W)	152.4 × 150.62 mm (6.00 × 5.93 in.)

Signal connections

Table 20. Board connectors, cables, and compatible hardware

Parameter	Specification
Connector type	P1: 68-pin standard SCSI TYPE III female connector J2, J3, J4, J5: Four 40-pin header connectors AMP# 2-103328-0
Compatible cables	P1: CA-68-3R ribbon cable; 3 feet. J2, J3, J4, J5: C40FF-x ribbon cable; x is length in feet.
Compatible terminal boards	TB-100: Connects to a CA-68-3R TB-103: Mounts directly onto the header connectors CIO-MINI40: Connects to a C40FF-x cable

68-pin SCSI connector (P1)

Table 21. P1 connector pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
68	ACH0	Analog input 0	34	ACH8	Analog input 8
67	AGND	Analog ground	33	ACH1	Analog input 1
66	ACH9	Analog input 9	32	AGND	Analog ground
65	ACH2	Analog input 2	31	ACH10	Analog input 10
64	AGND	Analog ground	30	ACH3	Analog input 3
63	ACH11	Analog input 11	29	AGND	Analog ground
62	AGND	Analog ground	28	ACH4	Analog input 4
61	ACH12	Analog input 12	27	AGND	Analog ground
60	ACH5	Analog input 5	26	ACH13	Analog input 13
59	AGND	Analog ground	25	ACH6	Analog input 6
58	ACH14	Analog input 14	24	AGND	Analog ground
57	ACH7	Analog input 7	23	ACH15	Analog input 15
56	XDAC3	Analog output channel 3	22	XDAC0	Analog output 0
55	XDAC2	Analog output channel 2	21	XDAC1	Analog output1
54	AGND	Analog ground	20	NC	No connection
53	GND	Digital ground	19	+VO	Power output
52	A1	Port A bit 1	18	A0	Port A bit 0
51	A3	Port A bit 3	17	A2	Port A bit 2
50	A5	Port A bit 5	16	A4	Port A bit 4
49	A7	Port A bit 7	15	A6	Port A bit 6
48	B1	Port B bit 1	14	B0	Port B bit 0
47	B3	Port B bit 3	13	B2	Port B bit 2
46	B5	Port B bit 5	12	B4	Port B bit 4
45	B7	Port B bit 7	11	B6	Port B bit 6
44	C1	Port C bit 1	10	C0	Port C bit 0
43	C3	Port C bit 3	9	C2	Port C bit 2
42	C5	Port C bit 5	8	C4	Port C bit 4
41	C7	Port C bit 7	7	C6	Port C bit 6
40	GND	Digital ground	6	TTLTRG	External digital trigger input
39	CNT1	Counter input 1	5	CNT0	Counter input 0
38	CNT3	Counter input 3	4	CNT2	Counter input 2
37	TMR1	Timer output 1	3	TMR0	Timer output 0
36	GND	Digital ground	2	XAPCR	External analog input scan clock
35	GND	Digital ground	1	XDPCR	External analog output scan clock

40-pin header connectors (J2 to J5)

Table 22. J2 connector pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	ACH27	Analog input 27	2	ACH19	Analog input 19
3	ACH26	Analog input 26	4	ACH18	Analog input 18
5	AGND	Analog ground	6	AGND	Analog ground
7	ACH3	Analog input 3	8	ACH11	Analog input 11
9	ACH2	Analog input 2	10	ACH10	Analog input 10
11	ACH17	Analog input 17	12	ACH25	Analog input 25
13	ACH16	Analog input 16	14	ACH24	Analog input 24
15	ACH1	Analog input 1	16	ACH9	Analog input 9
17	ACH0	Analog input 0	18	ACH8	Analog input 8
19	AGND	Analog ground	20	AGND	Analog ground
21	ACH23	Analog input 23	22	ACH31	Analog input 31
23	ACH22	Analog input 22	24	ACH30	Analog input 30
25	ACH7	Analog input 7	26	ACH15	Analog input 15
27	ACH6	Analog input 6	28	ACH14	Analog input 14
29	AGND	Analog ground	30	ACH21	Analog input 21
31	ACH29	Analog input 29	32	ACH20	Analog input 20
33	ACH28	Analog input 28	34	ACH5	Analog input 5
35	ACH13	Analog input 13	36	ACH4	Analog input 4
37	ACH12	Analog input 12	38	AGND	Analog ground
39	AGND	Analog ground	40	AGND	Analog ground

Table 23. J3 connector pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	ACH43	Analog input 43	2	ACH59	Analog input 59
3	ACH35	Analog input 35	4	ACH51	Analog input 51
5	AGND	Analog ground	6	ACH58	Analog input 58
7	ACH42	Analog input 42	8	ACH50	Analog input 50
9	ACH34	Analog input 34	10	ACH57	Analog input 57
11	AGND	Analog ground	12	ACH49	Analog input 49
13	ACH41	Analog input 41	14	ACH56	Analog input 56
15	ACH33	Analog input 33	16	ACH48	Analog input 48
17	ACH40	Analog input 40	18	AGND	Analog ground
19	ACH32	Analog input 32	20	ACH63	Analog input 63
21	ACH47	Analog input 47	22	ACH55	Analog input 55
23	ACH39	Analog input 39	24	AGND	Analog ground
25	ACH46	Analog input 46	26	ACH62	Analog input 62
27	ACH38	Analog input 38	28	ACH54	Analog input 54
29	AGND	Analog ground	30	ACH61	Analog input 61
31	ACH45	Analog input 45	32	ACH53	Analog input 53
33	ACH37	Analog input 37	34	ACH60	Analog input 60
35	ACH44	Analog input 44	36	ACH52	Analog input 52
37	ACH36	Analog input 36	38	AGND	Analog ground
39	AGND	Analog ground	40	AGND	Analog ground

Table 24. J4 connector pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	GND	Digital ground	2	XAPCR	External analog input scan clock
3	A0	Port A bit 0	4	A4	Port A bit 4
5	A1	Port A bit 1	6	A5	Port A bit 5
7	A2	Port A bit 2	8	A6	Port A bit 6
9	A3	Port A bit 3	10	A7	Port A bit 7
11	GND	Digital ground	12	TTLTRG	External digital trigger input
13	B0	Port B bit 0	14	B4	Port B bit 4
15	B1	Port B bit 1	16	B5	Port B bit 5
17	B2	Port B bit 2	18	B6	Port B bit 6
19	B3	Port B bit 3	20	B7	Port B bit 7
21	GND	Digital ground	22	+VO	Power output
23	C0	Port C bit 0	24	C4	Port C bit 4
25	C1	Port C bit 1	26	C5	Port C bit 5
27	C2	Port C bit 2	28	C6	Port C bit 6
29	C3	Port C bit 3	30	C7	Port C bit 7
31	GND	Digital ground	32	TMR1	Timer output 1
33	TMR0	Timer output 0	34	CNT1	Counter input 1
35	CNT0	Counter input 0	36	CNT3	Counter input 3
37	CNT2	Counter input 2	38	GND	Digital ground
39	GND	Digital ground	40	GND	Digital ground

Table 25. J5 connector pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	NC	No connection	2	NC	No connection
3	NC	No connection	4	NC	No connection
5	AGND	Analog ground	6	AGND	Analog ground
7	XDAC0	Analog output 0	8	XDAC2	Analog output 2
9	XDAC1	Analog output 1	10	XDAC3	Analog output 3
11	AGND	Analog ground	12	AGND	Analog ground
13	NC	No connection	14	AGND	Analog ground
15	AGND	Analog ground	16	AGND	Analog ground
17	TTLTRG	External digital trigger input	18	XDPCR	External analog output scan clock
19	XAPCR	External analog input scan clock	20	GND	Digital ground
21	GND	Digital ground	22	GND	Digital ground
23	NC	No connection	24	NC	No connection
25	+VO	Power output	26	NC	No connection
27	NC	No connection	28	NC	No connection
29	GND	Digital ground	30	NC	No connection
31	TMR2	Timer output 2	32	NC	No connection
33	GND	Digital ground	34	NC	No connection
35	TMR3	Timer output 3	36	NC	No connection
37	GND	Digital ground	38	NC	No connection
39	NC	No connection	40	NC	No connection

Standoff locations

The board is designed with standoff holes labeled TL1 to TL8.

- **TL1:** Standoff hole TL1 is connected directly to the J1 USB connector shield.
- **TL2:** Standoff hole TL2 is connected directly to the P1 SCSI connector shield (pin 69, pin 70). The SCSI connector shield and TL2 can also be connected to the board chassis ground guard trace using the R21 (OPEN by default) resistor location.
- **TL4-8:** Standoff holes TL4-TL8 are electrically isolated from the PCB.

Refer to the mechanical drawing in the hardware user guide for the location of these standoff holes.

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