

USB-CTR08-OEM

High-Speed Counter/Timer

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-CTR08-OEM data acquisition device and lists device specifications.

Conventions in this user's guide

For more information

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 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

Additional information about USB-CTR08-OEM hardware is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation with specific questions.

- Knowledgebase: kb.mccdaq.com
- Tech support form: www.mccdaq.com/support/support_form.aspx
- Email: techsupport@mccdaq.com
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support

For international customers, contact your local distributor. Refer to the International Distributors section on our website at www.mccdaq.com/International.

Introducing the USB-CTR08-OEM

The USB-CTR08-OEM is a USB 2.0 high-speed data acquisition device that provides the following features:

- Eight counter I/O
 - High-speed pulse counter for general counting applications; multiple counting modes supported
 - 48 MHz, programmable resolution up to 64-bits
 - An aggregate scan rate of 8 MB/s
- Four PWM timers with count, period, delay, and pulse-width registers
- Eight individually-configurable digital I/O channels
- External clock input and internal clock output
- External digital trigger; software-selectable for edge or level sensitive, rising or falling edge, high or low level

The USB-CTR08-OEM is a USB 2.0 high speed device that is compatible with USB 3.0 ports. The device is also compatible with USB 1.1 ports, but use with this older hardware is not recommended due to longer initialization times that can occur when the USB-CTR08-OEM is connected through USB 1.1 ports or hubs.

I/O connections are made to two banks of header connectors. The USB-CTR08-OEM is powered by the 5 volt USB supply from your computer.

Caution! There are no product safety, electromagnetic compatibility (EMC), or CE marking compliance claims made for the USB-CTR08-OEM. The USB-CTR08-OEM is intended for use as a component of a larger system. MCC can help developers meet their compliance requirements. The end product supplier, however, is responsible for conforming to any and all compliance requirements.

Functional block diagram

Device functions are illustrated in the block diagram shown here.

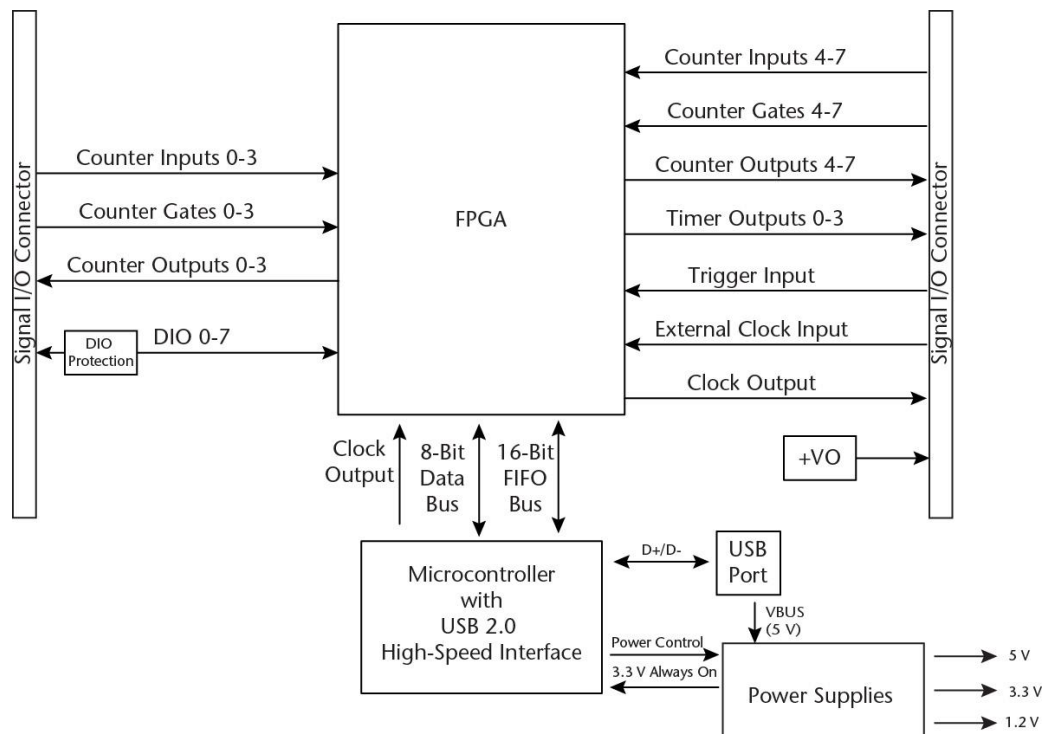


Figure 1. USB-CTR08-OEM functional block diagram

Installing the USB-CTR08-OEM

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.

Downloading the software

Refer to the USB-CTR08-OEM product page on the Measurement Computing website for information about the supported software you can download.

Install the software before you install the hardware

The driver needed to run the USB-CTR08-OEM 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

Connect the USB-CTR08-OEM to a to an available USB port on the computer running Windows, connect the USB cable to an available USB port on the computer or to an external USB hub connected to the computer. Connect the other end of the cable to the USB connector on the device. No external power is required.

When connected for the first time, a **Found New Hardware** dialog box opens when the operating system detects the device. When the dialog box closes, the installation is complete. The **Status LED** turns on after the device is successfully installed (see Figure 2 on page 7).

If the Status LED turns off

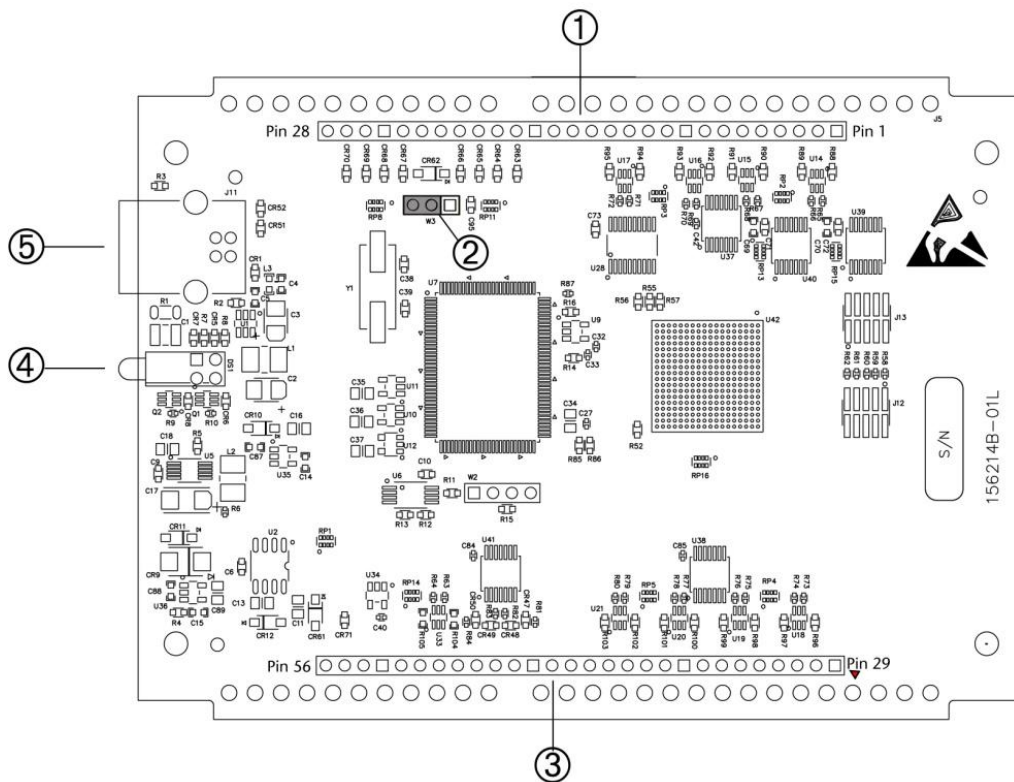
If communication is lost between the device and the computer, the **Status LED** turns off. To restore communication, disconnect the USB cable from the computer and then reconnect it. This should restore communication, and the **Status LED** should turn on.

Functional Details

External components

The USB-CTR08-OEM has the following external components, as shown in Figure 2.

- Two header connector banks
- Device Status and Activity LEDs
- USB connector
- Pull-up/down jumper



- | | |
|------------------------------|---|
| 1 Header connectors 1 to 28 | 4 Status (top) and Activity (bottom) LEDs |
| 2 Pull-up/down jumper | 5 USB connector |
| 3 Header connectors 29 to 56 | |

Figure 2. USB-CTR08-OEM components

Header connectors

The device has two banks of header connectors that provide the following connections:

- Eight counter inputs
- Eight counter outputs
- Eight counter gates
- Eight DIO
- Four timer outputs
- External trigger input
- External clock input
- Internal clock output
- Power output
- Digital grounds

The USB-CTR08-OEM pinout is shown below.

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	C0IN	Counter 0 input	29	C4IN	Counter 4 input
2	C0GT	Counter 0 gate	30	C4GT	Counter 4 gate
3	GND	Digital ground	31	GND	Digital ground
4	C0O	Counter 0 output	32	C4O	Counter 4 output
5	C1IN	Counter 1 input	33	C5IN	Counter 5 input
6	C1GT	Counter 1 gate	34	C5GT	Counter 5 gate
7	GND	Digital ground	35	GND	Digital ground
8	C1O	Counter 1 output	36	C5O	Counter 5 output
9	C2IN	Counter 2 input	37	C6IN	Counter 6 input
10	C2GT	Counter 2 gate	38	C6GT	Counter 6 gate
11	GND	Digital ground	39	GND	Digital ground
12	C2O	Counter 2 output	40	C6O	Counter 6 output
13	C3IN	Counter 3 input	41	C7IN	Counter 7 input
14	C3GT	Counter 3 gate	42	C7GT	Counter 7 gate
15	GND	Digital ground	43	GND	Digital ground
16	C3O	Counter 3 output	44	C7O	Counter 7 output
17	N/C	No connection	45	N/C	No connection
18	DIO0	DIO bit 0	46	TMR0	Timer 0 output
19	DIO1	DIO bit 1	47	TMR1	Timer 1 output
20	DIO2	DIO bit 2	48	GND	Digital ground
21	DIO3	DIO bit 3	49	TMR2	Timer 2 output
22	GND	Digital ground	50	TMR3	Timer 3 output
23	GND	Digital ground	51	TRIG	Trigger input
24	DIO4	DIO bit 4	52	GND	Digital ground
25	DIO5	DIO bit 5	53	CLKI	External clock input
26	DIO6	DIO bit 6	54	GND	Digital ground
27	DIO7	DIO bit 7	55	CLKO	Internal clock output
28	GND	Digital ground	56	+VO	User voltage output

LED indicators

The device has two LED indicators – **Status** and **Activity**.

- The **Status** 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.

Refer to Figure 2 on page 7 for the location of these LEDs.

USB connector

The USB connector provides 5 V power and communication.

Counter I/O and gating

The USB-CTR08-OEM has a counter input (**CxIN**), counter output (**CxO**), counter gate (**CxGT**) pin for each of its eight counter channels.

Counter inputs can be read asynchronously under program control, or synchronously as part of a digital scan group. In both cases, you can configure counters so that they:

- get set to 0 after each read
- count up or down and then roll over at a user-set limit
- count until the user-set limit has been reached.

Counter inputs can concurrently monitor time periods, frequencies, pulses, and other event-driven incremental occurrences directly from pulse-generators, limit switches, proximity switches, and magnetic pick-ups.

Counter outputs can be used to control or transmit signals to external devices, and also to USB-CTR08-OEM counter inputs, counter gates, or digital inputs. Counter outputs are commonly used in [Totalize mode](#).

Counter gates use input signals to clear a counter, change counter direction, or start/stop counting. Gate options are software-selectable and are available when counting in Totalize mode.

Counter input modes

The USB-CTR08-OEM supports the following counter input modes:

- Totalize
- Period measurement
- Pulse-width measurement
- Timing measurement

Counter input modes are programmable with software. Some modes include software-selectable max limit and min limit register values. These values do not directly affect the current count, but set limits in some modes to determine counter behavior.

Each mode supports additional counter operation options. Refer to the discussion of each counter mode in the pages that follow for specific information.

Totalize mode

You can use the USB-CTR08-OEM as a high speed pulse counter for general counting applications.

Each counter can be set to any resolution up to 64-bits based on the software-selectable max limit and min limit register values. The counters can accept frequency inputs up to 48 MHz.

In totalize mode, **CxIN** is used as the primary counter input. **CxGT** can be used to set the count direction, to gate the counter, to clear/reload the counter with the min limit value, or to trigger a particular counter to begin counting.

All totalize measurement mode options are software-selectable. Each option is explained in the table below.

Totalize counter mode options

Counter option	Description
Clear on read	The counter is cleared after each read (synchronous or asynchronous). The value of the counter before it was cleared is latched and returned. It is typically cleared to zero, but depending on counting mode, it may be cleared to the value stored in the min limit register.
Range Limit	When the range limit option is enabled, you can set the max limit and the min limit register values to mimic limit switches in a mechanical counter. <ul style="list-style-type: none"> ▪ When counting up, the counter freezes or rolls over to the min limit count whenever the count reaches the max limit register value. ▪ When counting down, the counter freezes or rolls over to the max limit count whenever the count reaches the min limit register value
Non-recycle	The counter freezes if the max limit or the min limit is reached. <ul style="list-style-type: none"> ▪ When counting up, the counter stops when the max limit is reached. ▪ When counting down, the counter stops when the min limit is reached. Counting resumes if the direction is reversed or if the counter is reloaded with a value between the max limit and the min limit.
CountDown	Enables count down mode. (This is overridden by the state of the gate input if the gate is programmed for direction control.)
Output On	Enables counter output mode. Based on the <i>output initial state</i> of the counter (high or low), the counter output toggles the state of the counter when it reaches the value of output register 0, and toggles back to output initial state of the counter when it reaches the value of output register 1.
Output Initial State	Sets the initial state of the counter output to either high or low (default).

Totalize options that are specific to the counter gate signal (**CxGT**) are explained below.

Counter gate input mode options (Totalize mode)

Gate option	Description
Direction Control	Direction control allows CxIN to act as the pulse source and CxGT as the direction. By default, the counter increments when CxGT =1 (high), and decrements when CxGT =0 (low).
Gating	Gating allows the CxGT input to gate the counter. By default, the counter is enabled when the CxGT signal is high. When the CxGT signal is low the counter is disabled, but holds the count value.
Clear/Reload	Clears the count to zero unless counting in Range Limit mode. If counting in Range Limit mode, the CxGT signal reloads the counter from the min limit register.
Count Trigger	The counter starts counting when the CxGT input goes active. By default, active is on the rising edge.

Period measurement mode

You can use the USB-CTR08-OEM to measure the period of any signal at a counter input (**CxIN**). The device counts the integral number of *ticks* that make up the period, and the data returned is always time measured in ticks.

Data sample errors come from two sources:

- the sampling error caused by not being able to count a partial tick
- the USB-CTR08-OEM internal timebase inaccuracy.

The measurement period is the time from edge-to-edge, either both rising or both falling. Period data is latched as it becomes available, and is acquired at the counter read rate.

Because updates occur only when another full period becomes available:

- If the counter read period is *faster* than the input period, period values repeat in the acquisition. The bigger the difference between the counter read period and the input period, the more period values are repeated.
- If the counter read period is *slower* than the input period, then the acquisition misses some periods. The bigger the difference between the counter read period and the input period, the more period values are missed.

To obtain greater resolution, increase the counter read period, or use a period mode option.

The data returned is interpreted as time measured in ticks. This data represents the number of tick size intervals counted during the period measurement.

Optionally, you can use the counter gate signal (**CxGT**) to gate the counter.

- When **CxGT** is high, the counter is enabled.
- When **CxGT** is low, the counter is disabled, but holds the count value.

The 96 MHz system clock is used as the timing source. Periods from sub-microsecond to many seconds can be measured.

All period measurement mode options are software-selectable. Each period measurement option is explained in the table below.

Period option	Description
Period mode	X1 – The measurement is latched each time one complete period is observed. X10 – The measurement is latched each time 10 complete periods are observed. X100 – The measurement is latched each time 100 complete periods are observed X1000 – The measurement is latched each time 1000 complete periods are observed.
Tick size (period resolution)	The tick size is a fundamental unit of time derived from the period of the 96 MHz system clock. Four counter channel tick sizes are available – 20.83 ns, 208.3 ns, 2083.3 ns, and 20833.3 ns.

The USB-CTR08-OEM internal timebase has an absolute accuracy of 30 ppm. The sampling error varies based on the input frequency, selected tick size, and selected period mode. The absolute error is the root-sum-of-squares of the two independent error sources.

Pulse width measurement mode

You can use the USB-CTR08-OEM to measure the time from the rising edge to the falling edge, or vice versa, on a counter input signal (CxIN). The measurement is either pulse width low or pulse width high, depending upon the edge detection setting.

- If the counter read period is *faster* than the input period, pulse widths repeat in the acquisition. The bigger the difference between the counter read period and the input period, the more pulse widths are repeated.
- If the counter read period is *slower* than the input period, then the acquisition misses some pulse widths. The bigger the difference between the counter read period and the input period, the more pulse width values are missed.

Decrease the counter read period in order to increase the number of different pulse widths received.

Every time the pulse width measurement is latched from the counter, the counter is immediately cleared and enabled to count the time for the next pulse width. The pulse width measurements are latched as they become available.

The data returned is interpreted as time measured in ticks. This data represents the number of tick size intervals counted during the pulse width measurement.

Optionally, you can use the counter gate signal (**CxGT**) to gate the counter.

- When **CxGT** is high, the counter is enabled.
- When **CxGT** is low, the counter is disabled, but holds the count value.

The 96 MHz system clock is used as the timing source. Pulse widths from sub-microsecond to many seconds can be measured.

Pulse width measurement mode tick size options are software-selectable. The tick size is a fundamental unit of time derived from the period of the 96 MHz system clock.

Four counter channel tick sizes (pulse width resolutions) are available – 20.83 ns, 208.3 ns, 2083.3 ns, and 20833.3 ns.

Timing mode

You can use the USB-CTR08-OEM to measure the time between an event on **CxIN** and a subsequent event on **CxGT**, such as the rising or falling edge of one event with respect to the rising or falling edge of another event (based on the edge detection setting).

Whenever the time measurement is latched from the counter, the counter is immediately cleared and enabled for accepting the subsequent time period, which starts with the next edge on the main channel.

The following example measures the time between the rising edge on a counter input (**CxIN**) and the falling edge on the counter gate (**CxGT**). The counter read operation returns zeroes until one complete time measurement has been taken. Then, the value (time in ticks) is latched by the device until the next time measurement is completed. At that time, rising edges on the counter input channel clear the counter and falling edges on the gate input latch the output of the counter.

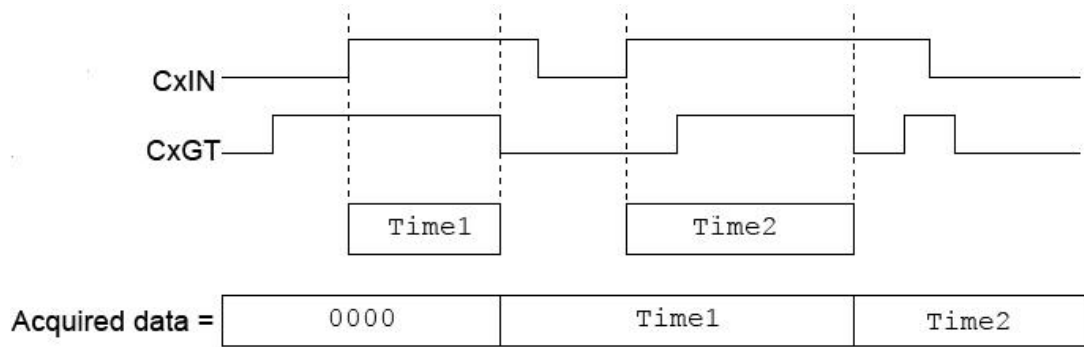


Figure 3. Counter input channel in timing mode

- If the counter read period is *faster* than the than the occurrence of the next time-frame rate (available on the two channels), then some time frames repeat in the acquisition. The bigger the difference between the counter read period and the time frame occurrence, the more time frames are repeated.
- If the counter read period is *slower* than the time-frame occurrence, then the acquisition misses some time frames. The bigger the difference between the counter read period and the time frame occurrence, the more time frames are missed.

Decrease the counter read period in order to capture more time frames.

The data returned is interpreted as time measured in ticks. This data represents the number of tick size intervals counted during the timing measurement.

Timing mode tick size options are software-selectable. The tick size is a fundamental unit of time derived from the period of the 96 MHz system clock.

Four counter channel tick sizes are available – 20.83 ns, 208.3 ns, 2083.3 ns, and 20833.3 ns.

Debounce filters

The USB-CTR08-OEM has debounce circuitry which eliminates switch-induced transients that are typically associated with electro-mechanical devices including relays, proximity switches, and encoders.

All debounce filter options are software-selectable. You can select a debounce time, debounce mode, and rising-edge or falling-edge sensitivity. Each channel can be debounced with 16 programmable debounce times in the range of 500 ns to 25.5 ms.

Two debounce filter modes (*trigger after stable* and *trigger before stable*) and a debounce bypass are shown in Figure 4. The signal from the buffer can be inverted before it enters the debounce circuitry. The inverter is used to make the input rising-edge or falling-edge sensitive.

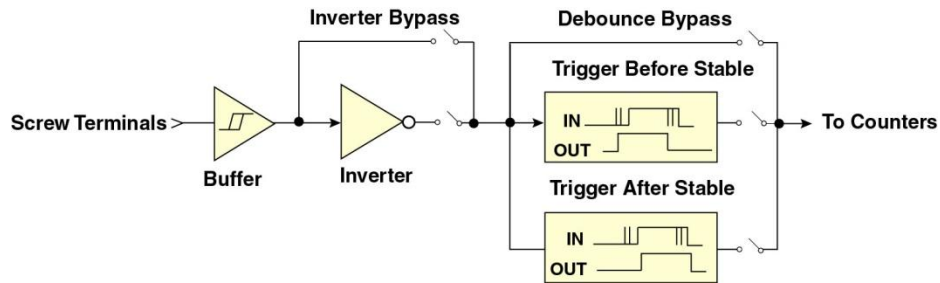


Figure 4. Debounce block diagram

Edge selection is available with or without debounce. In this case, the debounce time setting is ignored and the input signal goes straight from the inverter or inverter bypass to the counter module.

The two debounce filter modes are *trigger after stable* and *trigger before stable*. In either mode, the selected debounce time determines how fast the signal can change and still be recognized.

Trigger after stable mode

In the *trigger after stable* mode, the output of the debounce module does not change state until a period of stability has been achieved. This means that the input has an edge, and then must be stable for a period of time equal to the debounce time. Refer to Figure 5.

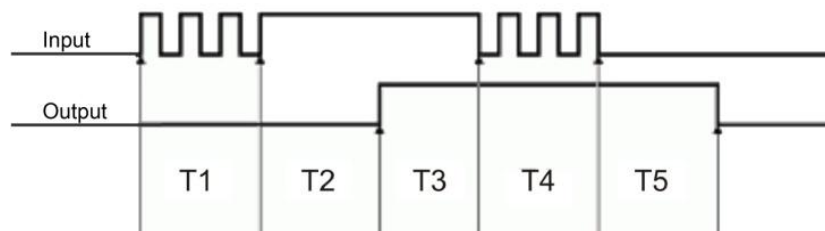


Figure 5. Trigger after stable mode

T1 through T5 indicate time periods. In trigger after stable mode, the input signal to the debounce module is required to have a period of stability after an incoming edge, in order for that edge to be accepted (passed through to the counter module). For this example, the debounce time is equal to T2 and T5.

- T1 – In Figure 5, the input signal goes high at the beginning of time period T1, but never stays high for a period of time equal to the debounce time setting (equal to T2 for this example.)
- T2 – At the end of time period T2, the input signal has transitioned high and stayed there for the required amount of time—therefore the output transitions high. If the input signal does not stabilize in the high state long enough, no transition would have appeared on the output and the entire disturbance on the input would have been rejected.
- T3 – During time period T3, the input signal remained steady. No change in output is seen.
- T4 – During time period T4, the input signal has more disturbances and does not stabilize in any state long enough. No change in the output is seen.
- T5 – At the end of time period T5, the input signal has transitioned low and stayed there for the required amount of time—therefore the output goes low.

Trigger before stable mode

In the *trigger before stable* mode, the output of the debounce module immediately changes state, but will not change state again until a period of stability has passed. For this reason the mode can be used to detect glitches. Refer to Figure 6.

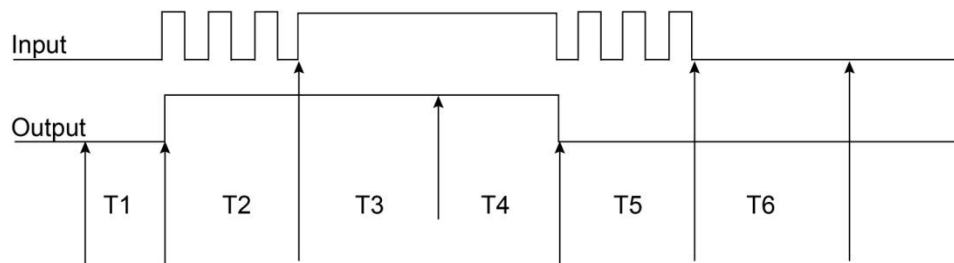


Figure 6. Trigger before stable mode

T1 through T5 in Figure 6 indicate time periods:

- T1 – The input signal is low for the debounce time (equal to T1); therefore when the input edge arrives at the end of time period T1, it is accepted and the output (of the debounce module) goes high. Note that a period of stability must precede the edge in order for the edge to be accepted.
- T2 – During time period T2, the input signal is not stable for a length of time equal to T1 (the debounce time setting for this example.) Therefore, the output stays "high" and does not change state during time period T2.
- T3 – During time period T3, the input signal is stable for a time period equal to T1, meeting the debounce requirement. The output is held at the high state. This is the same state as the input.
- T4 – At anytime during time period T4, the input can change state. When this happens, the output will also change state. At the end of time period T4, the input changes state, going low, and the output follows this action by going low.
- T5 – During time period T5, the input signal again has disturbances that cause the input to not meet the debounce time requirement. The output does not change state.
- T6 – After time period T6, the input signal has been stable for the debounce time, and therefore any edge on the input after time period T6 is immediately reflected in the output of the debounce module.

Debounce filter mode comparisons

Figure 7 shows how the two modes interpret an input signal, which exhibits glitches. Notice that the *trigger before stable* mode recognizes more glitches than the *trigger after stable* mode. Enable the **bypass** option in software to achieve maximum glitch recognition.

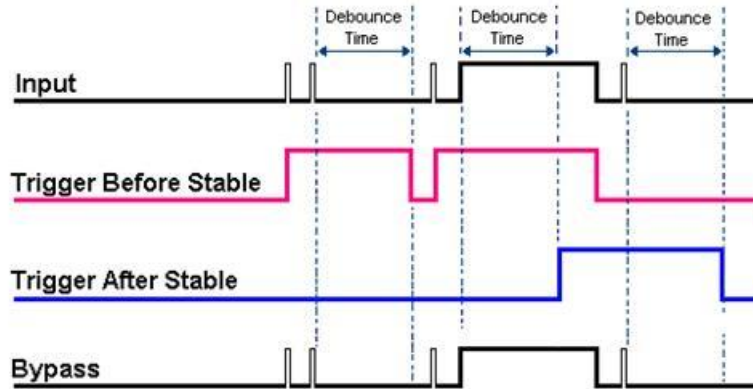


Figure 7. Example of two debounce modes interpreting the same signal

Set the debounce time according to the amount of instability expected in the input signal. Setting a debounce time that is too short may result in unwanted glitches clocking the counter. Setting a debounce time that is too long may result in an input signal being rejected entirely. Some experimentation may be required to find the appropriate debounce time for a particular application.

To see the effects of different debounce time settings, view the analog waveform along with the counter output. This can be done by connecting the source to an analog input.

Use *trigger before stable* mode when the input signal has groups of glitches and each group is to be counted as one. The trigger before stable mode recognizes and counts the first glitch within a group but rejects the subsequent glitches within the group if the debounce time is set accordingly. Set the debounce time to encompass one entire group of glitches, as shown in Figure 8.

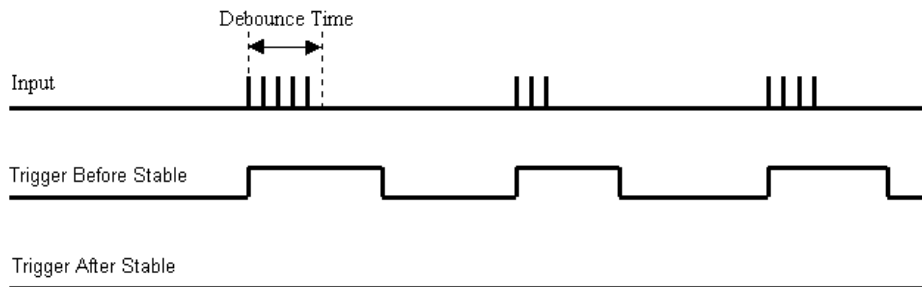


Figure 8. Optimal debounce time for trigger before stable mode

Trigger after stable mode behaves more like a traditional debounce function: rejecting glitches and only passing state transitions after a required period of stability. *Trigger after stable* mode is used with electro-mechanical devices like encoders and mechanical switches to reject switch bounce and disturbances due to a vibrating encoder that is not otherwise moving.

The debounce time should be set short enough to accept the desired input pulse but longer than the period of the undesired disturbance, as shown in Figure 9.

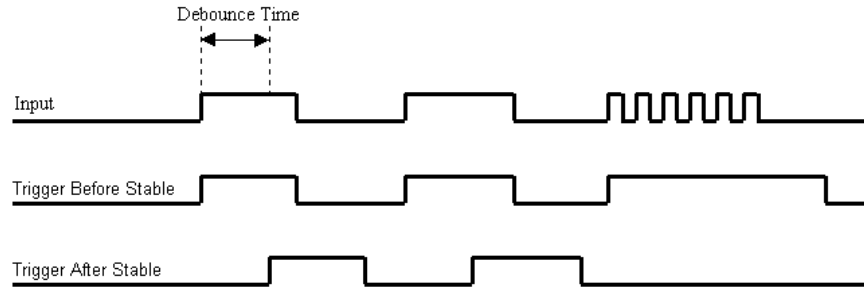


Figure 9. Optimal debounce time for trigger after stable mode

Digital I/O

You can connect up to eight digital I/O lines to **DIO0** through **DIO7**. The digital I/O connectors can detect the state of any TTL-level input. Refer to the schematic shown in Figure 10.

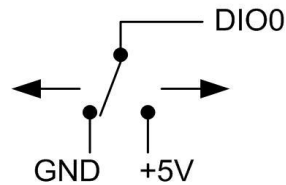


Figure 10. Schematic showing switch detection by digital channel DIO0

If you set the switch to the +5 V input, DIO0 reads *TRUE* (1). If you move the switch to GND, DIO0 reads *FALSE* (0).

Pull-up/down jumper

The digital port has 47 k Ω resistors that you can configure as pull-up or pull-down with the jumper labeled W3.

Unconnected inputs are pulled low by default to 0 V through 47 k Ω resistors. The pull-up/pull-down voltage is common to all 47 k Ω resistors.

Caution! The discharge of static electricity can damage some electronic components. Before changing the jumper, either ground yourself using a wrist strap or touch the computer chassis or other grounded object to eliminate any stored static charge.

Configure the jumper for either pull-up or pull-down. Figure 11 shows the location of the pull-up/down jumper on the USB-CTR08-OEM.

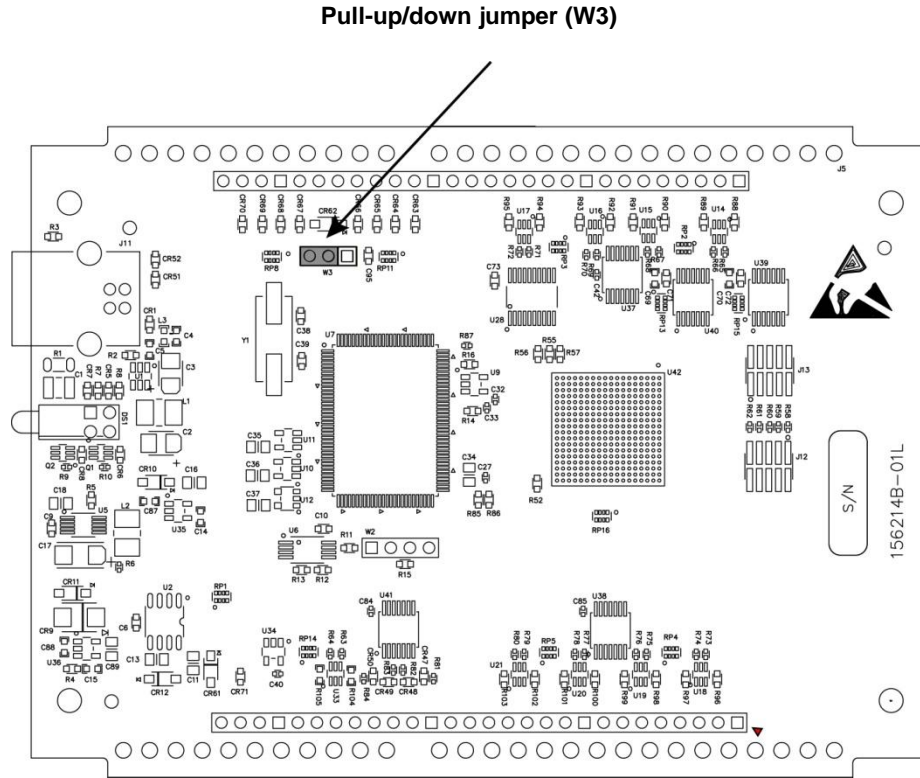


Figure 11. Pull-up/down jumper location

The pull-up/down jumper is configured by default for pull-down (see Figure 12).

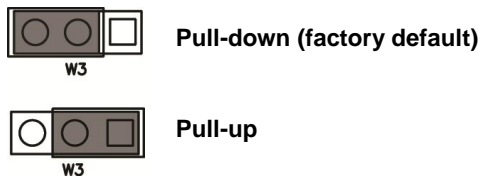


Figure 12. Pull-up/down jumper configurations

To pull the digital inputs high (5 V), configure the jumper for pull-up.

Timer output

You can use **TMR0** through **TMR3** as 32-bit timer outputs. Each timer can generate a programmable width pulse with a software-selectable frequency in the range of 0.022 Hz to 48 MHz. At higher frequencies, the timer output frequency and duty cycle depend on the load impedance and the supply.

The timer output rate and pulse width can be updated asynchronously at any time, however, doing so results in a pulse stream that is not seamless.

The following timer output options are software-selectable:

- pulse frequency
- duty cycle (pulse width divided by the pulse period)
- number of pulses to generate
- time delay before starting the timer output after it's enabled
- resting state of the output (*idle high* or *idle low*)

Both the period and time delay ranges are 20.83 ns to 44.739 seconds.

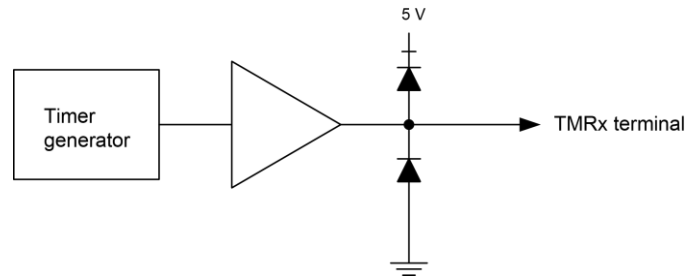


Figure 13. USB-CTR08-OEM PWM timer channel

Trigger input

You can trigger synchronous acquisitions of counter data internally with software or externally using the **TRIG** digital trigger pin.

The **TRIG** input allows TTL-level triggering with latencies guaranteed to be less than 20.83 ns. The acquisition can be triggered on a rising or falling edge, or on a high or low level. The trigger input is TTL logic. Latency is one sample period, maximum. The input signal range is -0.5 V to 5.5 V maximum. The logic level (1 or 0) and the rising or falling edge for the discrete trigger input are software-selectable. You can set up a repetitive trigger mode with software; the trigger is automatically rearmed after it is activated.

When using the external trigger, the counter begins counting when the scan starts, even though acquisition of the count is held off by the trigger. To coordinate the start of acquisition with the start of the count, you could use the trigger signal to also trigger the gate of the counter in use. Clearing the counter before starting the scan will re-arm the gate trigger.

External clock pacing

You can pace synchronous acquisition of counter data by the onboard clock or by an external clock connected to the **CLKI** external clock input pin.

Power

Use the **+VO** power output pin to supply power to external devices or circuitry.

Caution! The **+VO** pin is an output. Do not connect to an external power supply or you may damage the USB-CTR08-OEM and possibly the computer.

The maximum total output current that can be drawn from all USB-CTR08-OEM connections (counter outputs, timer outputs, digital outputs, pacer clock output, and **+VO**) is 240 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.

If the current requirement of the device exceeds the current available from the computer, connect to a self-powered hub or power the computer with an external power adapter.

Ground

The digital ground (**GND**) connections provide a common ground for the digital, counter, and power connections.

Caution! Make sure that the signals are connected such that there is no potential between PC ground and signal ground.

Mechanical Drawings

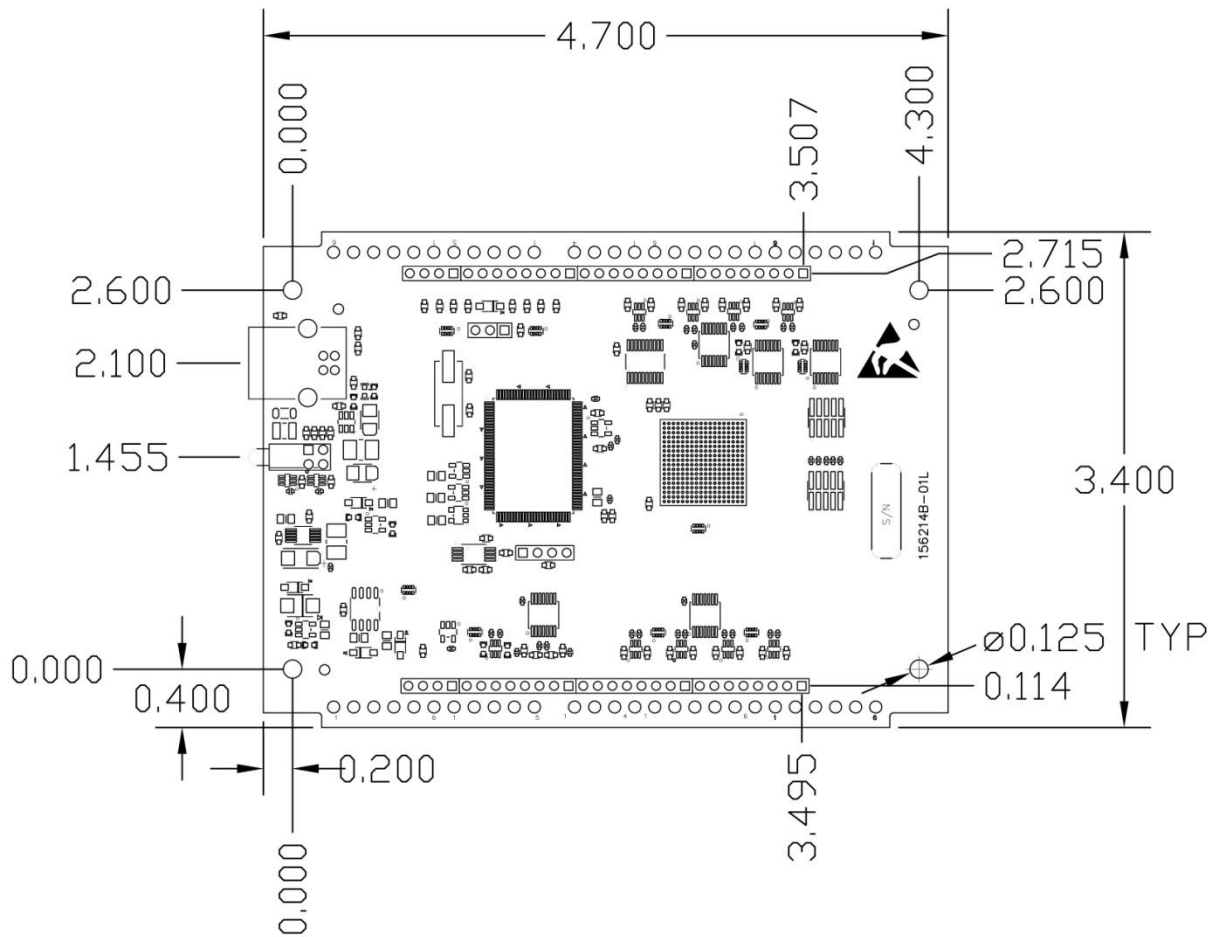


Figure 14. USB-CTR08-OEM dimensions

Specifications

All specifications are subject to change without notice.

Typical for 25°C unless otherwise specified.

Specifications in *italic text* are guaranteed by design.

Counter

Table 1. Counter specifications

Parameter	Specification
Counter type	FPGA
Counters	8 (each with a corresponding Input, Gate, and Output)
Counter input modes	Totalize, Pulse width, Period, Timing
Mode options	Non-Recycle, Range Limit, Clear on Read, Up/Down
Gate options	Clear/Reload, Direction Control, Gate, Count trigger; mode dependent
Resolution	Up to 64-bits (software-selectable)
Maximum input frequency	48 MHz
Debounce times	16 steps from 500 ns to 25.5 ms; positive or negative edge sensitive; glitch detect mode or debounce mode; software-selectable.
Timebase and accuracy	96 MHz (24 MHz – 30 ppm with a 4x DLL (delay-locked loop))
Counter read pacer	Internal or external scan pacer up to 4 MHz
Period/pulse width resolution	20.83 ns; 208.3 ns; 2.083 μ s; or 20.83 μ s
Input type (C0IN to C7IN and C0GT to C7GT)	Schmitt trigger, 47 k Ω pull-down to ground with 33 Ω in series
Schmitt trigger hysteresis (C0IN to C7IN and C0GT to C7GT)	0.76 V typ 0.4 V min 1.2 V max
Input high voltage threshold (C0IN to C7IN and C0GT to C7GT)	1.74 V typ 1.3 V min 2.2 V max
Input high voltage limit (C0IN to C7IN and C0GT to C7GT)	5.5 V absolute max
Input low voltage threshold (C0IN to C7IN and C0GT to C7GT)	0.98 V typ 0.6 V min 1.5 V max
Input low voltage limit (C0IN to C7IN and C0GT to C7GT)	-0.5 V absolute min 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	24 mA max per pin, constrained to 240 mA across all output pins (counter outputs, timer outputs, digital outputs, pacer clock output, and +VO)

Timers

Table 2. Timer specifications

Parameter	Specification
Terminal names	TMR0, TMR1, TMR2, TMR3
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
Internal clock frequency	96 MHz
Effective frequency range	0.022 Hz to 48 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 = -24 mA)
Output low voltage	0.1 V max (IOL = 50 μ A) 0.44 V max (IOL = 24 mA)
Output current	24 mA max per pin, constrained to 240 mA across all output pins (counter outputs, timer outputs, digital outputs, pacer clock output, and +VO)

Digital input/output

Table 3. Digital input/output specifications

Parameter	Specification
Digital type	TTL
Number of I/O	8
Configuration	Bit-configurable as input (power on default) or output
Pull-up configuration	The port has a 47 k Ω resistor configurable as a pull-up or pull-down (default) with an internal jumper.
Digital I/O transfer rate (system-paced, asynchronous)	33 to 8000 port reads/writes or single bit reads/writes per second typical, system dependent.
Digital input pacing	Onboard clock, external input scan clock (CLKI)
Digital input trigger source	External single channel digital trigger (TRIG)
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	24 mA max per pin, constrained to 240 mA across all output pins (counter outputs, timer outputs, digital outputs, pacer clock output, and +VO)

External trigger

Table 4. Digital trigger specifications

Parameter	Specification
Trigger source	External digital; TRIG terminal
Trigger mode	Software-selectable for edge or level sensitive, rising or falling edge, high or low level.
Retrigger mode	Trigger is rearmed after each trigger event
Trigger latency	100 ns max
Trigger pulse width	100 ns min
Input type	Schmitt trigger, 47 k Ω pull-down to ground with 33 Ω in series
Schmitt trigger hysteresis	0.76 V typ 0.4 V min 1.2 V max
Input high voltage threshold	1.74 V typ 1.3 V min 2.2 V max
Input high voltage limit	5.5 V absolute max
Input low voltage threshold	0.98 V typ 0.6 V min 1.5 V max
Input low voltage limit	-0.5 V absolute min 0 V recommended min

External clock input/output

Table 5. External clock input/output specifications

Parameter	Specification
Terminal names	CLKI, CLKO
Terminal type	CLKI: Input, active on rising edge CLKO: Output, power on default is 0V, active on rising edge
Input clock frequency	4 MHz, max
Input clock pulse width	10.417 ns min
Input type	Schmitt trigger, 47 k Ω pull-down to ground with 33 Ω in series
Input Schmitt trigger hysteresis	0.76 V typ 0.4 V min 1.2 V max
Input high voltage threshold	1.74 V typ 1.3 V min 2.2 V max
Input high voltage limit	5.5 V absolute max
Input low voltage threshold	0.98 V typ 0.6 V min 1.5 V max
Input low voltage limit	-0.5 V absolute min 0 V recommended min
Output clock frequency	4 MHz, max
Output clock pulse width	10.417 ns
Output high voltage	4.4 V min (IOH = -50 μ A) 3.78V min (IOH = -24 mA)
Output low voltage	0.1 V max (IOL = 50 μ A) 0.44 V max (IOL = 24 mA)

Parameter	Specification
Output current	24 mA max per pin, constrained to 240 mA across all output pins (counter outputs, timer outputs, digital outputs, pacer clock output, and +VO)

Memory

Table 6. Memory specifications

Parameter	Specification
FIFO	8 KS
Non-volatile EEPROM	32 KB (10 KB firmware storage, 22 KB user data)

Power

Table 7. Power specifications

Parameter	Condition	Specification
Supply current, USB source	During enumeration	< 100 mA
	After USB enumeration	< 500 mA
+VO power available	After USB enumeration	5 V, $\pm 5\%$
+VO output current	After USB enumeration	24 mA max per pin, constrained to 240 mA across all output pins (counter outputs, timer outputs, digital outputs, pacer clock output, and +VO)

USB

Table 8. USB specifications

Parameter	Specification
USB device type	USB 2.0 (high-speed)
Device compatibility	USB 1.1, USB 2.0, USB 3.0
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 9. Environmental specifications

Parameter	Specification
Operating temperature range	0 °C to 50 °C
Storage temperature range	-40 °C to 70 °C
Humidity	0% to 90% non-condensing

Mechanical

Table 10. Mechanical specifications

Parameter	Specification
Dimensions (L × W × H)	119.38 × 86.36 × 15.24 mm (4.7 × 3.4 × 0.60 in.)
User connection length	3 m (9.84 ft) max

Header connector

Table 11. Header connector specifications

Parameter	Specification
Connector type	Two 1 × 28 pin 0.1 in. pitch headers

Header pinout

Table 12. Header pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	C0IN	Counter 0 input	29	C4IN	Counter 4 input
2	C0GT	Counter 0 gate	30	C4GT	Counter 4 gate
3	GND	Digital ground	31	GND	Digital ground
4	C0O	Counter 0 output	32	C4O	Counter 4 output
5	C1IN	Counter 1 input	33	C5IN	Counter 5 input
6	C1GT	Counter 1 gate	34	C5GT	Counter 5 gate
7	GND	Digital ground	35	GND	Digital ground
8	C1O	Counter 1 output	36	C5O	Counter 5 output
9	C2IN	Counter 2 input	37	C6IN	Counter 6 input
10	C2GT	Counter 2 gate	38	C6GT	Counter 6 gate
11	GND	Digital ground	39	GND	Digital ground
12	C2O	Counter 2 output	40	C6O	Counter 6 output
13	C3IN	Counter 3 input	41	C7IN	Counter 7 input
14	C3GT	Counter 3 gate	42	C7GT	Counter 7 gate
15	GND	Digital ground	43	GND	Digital ground
16	C3O	Counter 3 output	44	C7O	Counter 7 output
17	N/C	No connection	45	N/C	No connection
18	DIO0	DIO bit 0	46	TMR0	Timer 0 output
19	DIO1	DIO bit 1	47	TMR1	Timer 1 output
20	DIO2	DIO bit 2	48	GND	Digital ground
21	DIO3	DIO bit 3	49	TMR2	Timer 2 output
22	GND	Digital ground	50	TMR3	Timer 3 output
23	GND	Digital ground	51	TRIG	Trigger input
24	DIO4	DIO bit 4	52	GND	Digital ground
25	DIO5	DIO bit 5	53	CLKI	External clock input
26	DIO6	DIO bit 6	54	GND	Digital ground
27	DIO7	DIO bit 7	55	CLKO	Internal clock output
28	GND	Digital ground	56	+VO	User voltage output

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