Talon Tach User's Guide

Revision 1.2

Cross The Road Electronics

www.ctr-electronics.com

Table of Contents

TO OUR VALUED CUSTOMERS

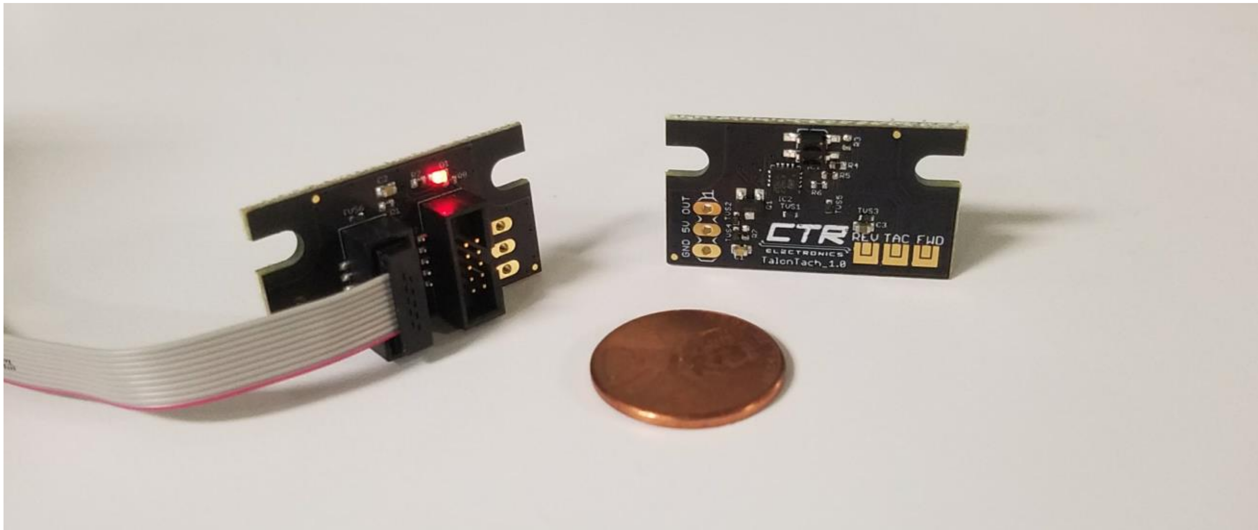
It is our intention to provide our valued customers with the best documentation possible to ensure successful use of your CTRE products. To this end, we will continue to improve our publications, examples, and support to better suit your needs.

If you have any questions or comments regarding this document, or any CTRE product, please contact support@crosstheroadelectronics.com

To obtain the most recent version of this document, please visit www.ctr-electronics.com.

1. Device description

The CTRE Talon Tach is a multipurpose reflective sensor with limit switch and tachometer capabilities. The device powers an infrared emitter and senses how much of the light is reflected to a detector. Small solder pad selectors allow for easy selection of the forward limit, reverse limit, and tachometer features. Dual 10-pin Talon headers permit daisy chaining of Talon Tachs with other devices.



1.1. Features

- Senses reflective surfaces 1-5mm away
- Single LED for showing sensor state
- Square-wave output with low jitter
- Solder pad selectors to enable tachometer, forward limit, or reverse limit feedback
- Conformal coating helps protect against shorts from foreign body debris (FBD)
- Built-in ESD protection diodes
- Connects directly to Talon SRX without the need for custom cables
- 3-pin header holes for non-Talon use
- Supported by Talon SRX firmware

1.2. Pin Descriptions

The Talon Tach has two 10-pin Gadgeteer connectors that mate with the Talon SRX through a ribbon cable (sold separately). The table below contains the pin descriptions and numbering for users who wish to connect the Talon Tach to other devices. Section 1.2.3 shows an operating schematic of the Talon Tach. See Section 4 for information about the external pullup on the OUT pin.

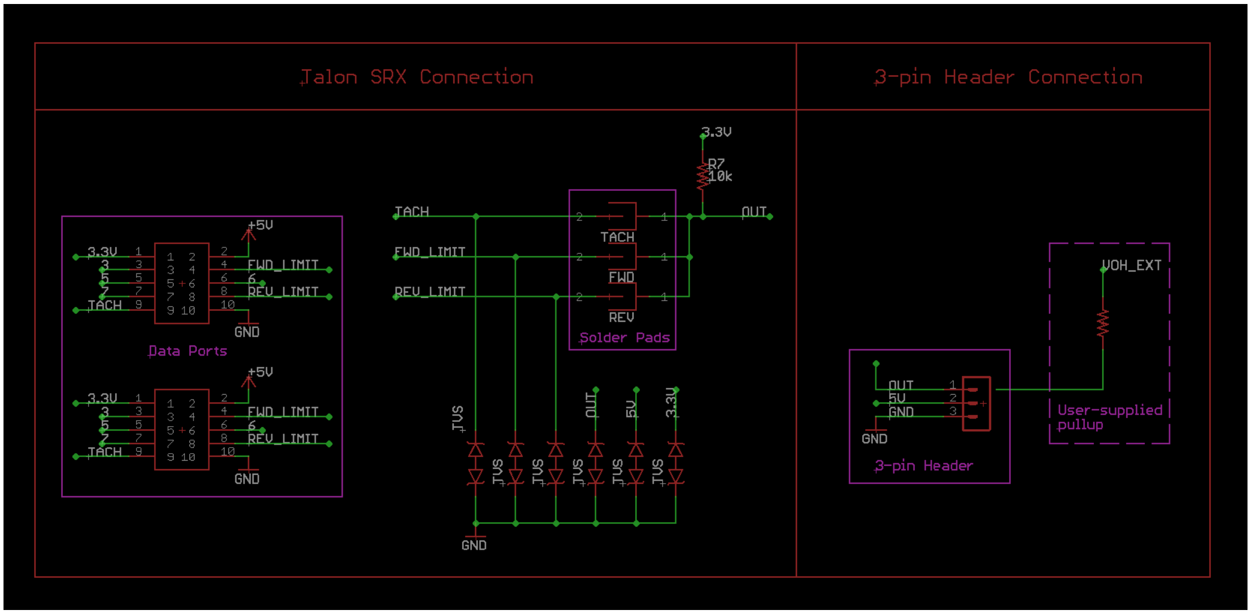
1.2.1. Gadgeteer Connector (Talon SRX ribbon cable) Breakout

Pin number	Name	Function
1	3.3V	3.3 volt supply (for pullup only)
2	5V	5 volt supply (externally sourced)
3	NC	Not connected, pass-through only
4	FLMT	Forward limit switch output (selectable)
5	NC	Not connected, pass-through only
6	NC	Not connected, pass-through only
7	NC	Not connected, pass-through only
8	RLMT	Reverse limit switch output (selectable)
9	TACH	Tachometer output (selectable)
10	GND	Device power ground

1.2.2. Three pin header Breakout (Not Using Talon SRX)

Pin number	Name	Function
1	OUT	Open-collector output
2	5V	5 volt supply (externally sourced)
3	GND	Device power ground

1.2.3. Schematic



Note: The user supplied pullup resistor is only necessary when not using the Talon SRX via ribbon cable. See Section 4 for more information.

1.3. Specifications

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Tamb	Ambient temperature		-40		+85	°C
Isupp	Supply Current	DC supply voltage 5.0V	12	15	17	mA
Vdd	Supply voltage	On 5V supply rail	4.5	5.0	5.5	V
Dsense	Sensing Distance		1	3	5	mm
S	Sense speed	Edges per minute	100 (1)		20,000 (2)	EPM (3)
VoL	Low level output voltage				0.2	V
VoH	High level output voltage at OUT	With Talon SRX and ribbon cable.	2.8	3.2	3.3	V
VoH_ext	High level output voltage at OUT	No Talon SRX and external pullup			30 (4)	V
Isink	Sink current (open collector output)				20	mA
ESD Rating						
	ESD Protection Contact Discharge				±8	kV
	ESD Protection Air-Gap Discharge				±8	kV

See Section 5.1 for information about the testing conditions.

Note 1: The Talon SRX Firmware may have limitations on the *minimum* tachometer speed. See Section 8 for more details.
Note 2: There is no theoretical max EPM for the Talon Tach. Speeds >20,000 EPM can be measured if conditions are ideal however are not guaranteed.
Note 3: Edges Per Minute (EPM) = RPM when a single white mark is present on the sensing surface. See Section 6.5 for more details.
Note 4: See Section 4 for information about the external pullup on the OUT pin

1.4. LED States

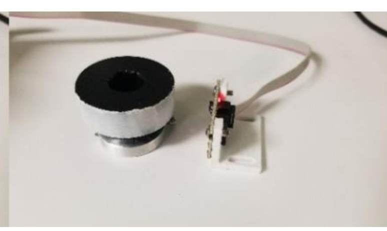
The Talon Tach features a red LED that indicates the state of the sensor. The LED is **on** when the sensor points at open air for a long distance (if not situated in a high-IR environment / no reflection). If a reflective object is placed in front of the sensor, such as white paper, the LED will turn **off**.

Note that when the LED is **on**, the signal on the OUT pin will be **logic-low**, and when the LED is **off**, the signal on the OUT pin will be **logic-high**.

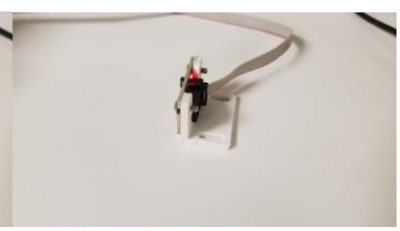
Color	Condition	Reflection	OUT Pin	Description
Off	Talon Tach is unpowered.	--	Logic-low	Check cabling to the Talon Tach and ensure that it is powered. Rotate/move mechanism slowly to ensure there is no reflection, thereby confirming LED is off due to loss of power.
Off	Target is in range.	Light is reflected if Tach is powered. **Sensor "sees" light.**	Logic-high	There is a reflective target in range. If mechanism is rotated/moved out of the reflection range, the LED will then transition to **on** (next row below).
On	Target is out of range.	No Light is reflected. **Sensor "sees" dark.**	Logic-low	Talon Tach is pointing at air or non-reflective surface. Rotate/move mechanism into the reflective range and the LED will transition to **off** (previous row above).
Flickering between on and off	Target is continuously switching between **off** and **on**.	Light is reflected intermittently.	Pulse train will appear. An oscilloscope can be used to measure the output. When using a Talon SRX, this is typically not necessary.	Mechanism is likely in continuous motion, particularly for tachometer applications. Otherwise, confirm the Talon Tach is within range and mounted securely.

Target in range

Target out of range



No target



Target is non-reflective

2. Installation

Proper configuration of the Talon Tach and the sensing surface is critical to correct operation.
The sensing surface typically contains…

- A reflective region, such as polished metal or white paper.

  If Tach is being used as a critical sensor (mission critical, competition, etc.) avoid using tape solutions that are meant for temporary use: Gaffer tape, electrical tape, reflective tape, etc. These may to wear-off/fall-off over time. Otherwise take precautions to ensure such tape solutions cannot fall off.

  White paint markers have proven to be an excellent solution for the reflective range.

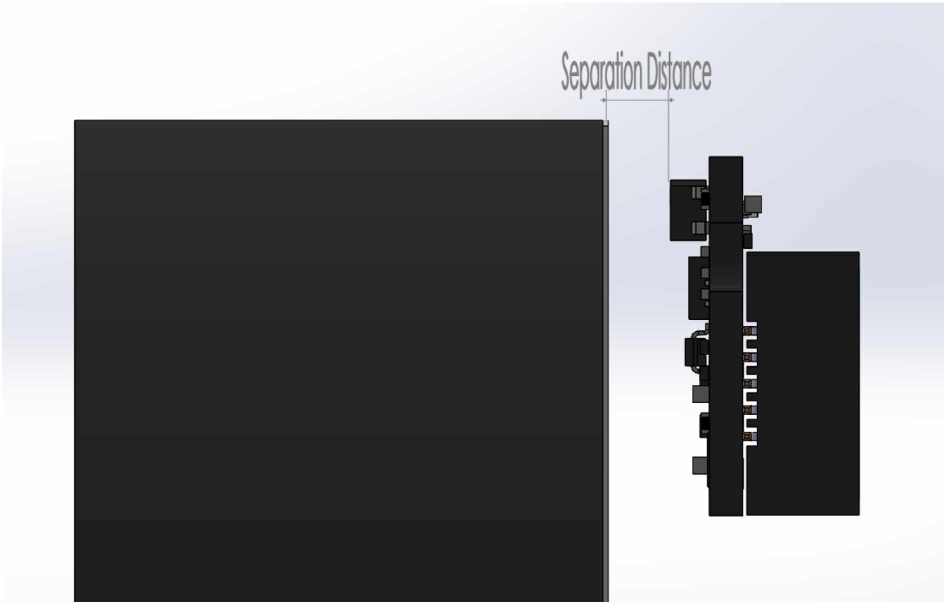
- A non-reflective region such as black plastic or air. Note that some "dark" surfaces (like polished black plastic) may be slightly reflective, and may not reliably transition the Talon Tach. See Section 6.9 for more details on material selection.

  Black paint markers/Sharpies have proven to be an excellent solution for the non-reflective range.

2.1. Sensor Placement Considerations

The typical Separation Distance between the sensor and the surface, as illustrated in Figure 2.1, is 1mm (.039") to 5mm (.197"). A 2-3mm (.079-.118") Separation Distance typically gives the best results for common sensing surfaces. Note that Separation Distance is measured from the face of the sensor to the face of the reflective medium.
The sensor should be in a low-IR environment; any devices that emit IR (such as photogates or IR rangefinders) may interfere with the function of the Talon Tach.

Figure 2.1.



2.2. Sensor Mounting

The sensor should be mounted to a surface that is rigid and in a fixed position relative to the sensing surface. The sensor should be as close to parallel to the sensing surface as possible. Ensure that tape or different nonconductive cover is placed over exposed solder pads to prevent shorts from foreign body debris (Section 3.1). 3D STEP and STL files for adjustable 3D-printable mounts (See Section 6.4) are available on the Talon Tach product page, but many mounting options are possible. Take care to ensure the mounting solution electrically insulates Talon Tach from conducting surfaces (from a metal chassis for example).

2.3. Confirming Proper Installation Using a Talon SRX

Depending on the operating mode of the Talon Tach, there are multiple ways to check the health of the installation.

2.3.1. Limit Switch Use

For limit switch usage, moving the sensing surface into and out of view of the sensor should be sufficient to check the function of the Talon Tach. The onboard LED should turn off as the reflective surface comes into view and turn on when it leaves view. See Section 6.8 for information about configuring the Talon Tach as a limit switch.

2.3.2. Tachometer Use

Checking the health of the Talon Tach output involves finding the pulse width and period of the mechanism at its maximum RPM. Drive the mechanism to its maximum speed, then use the `TalonSRX.getPulseWidthRiseToFall()` and `TalonSRX.getPulseWidthRiseToRiseUs()` methods to find the Rise-To-Fall time (the pulse width) and the Rise-To-Rise time (the period of the pulses). Ensure that the pulse width is at least 1ms (1000us) in length, and that the period is at least 1ms (1000us) longer than the pulse width.

Future release of the Talon SRX software (Phoenix framework) will also include additional feedback modes, settings, and status signals better suited for the Tachometer use.

If this test reports that the sensor is in poor condition, the following improvements can be done…
- Increase the reflectivity of the reflective surface
- Decrease the reflectivity of the non-reflective surface.
- Vary the distance to the surface and retest signal quality.

2.4. Confirming Proper Installation without a Talon SRX

If the Talon Tach is being used through the 3-pin header interface, the process for checking the health of the installation is slightly different.

2.4.1. Limit Switch Use

For limit switch usage, the process is the same as with a Talon SRX. Moving the sensing surface into and out of view of the sensor should be sufficient to check the function of the Talon Tach. The onboard LED should turn off as the reflective surface comes into view and turn on when it leaves view.

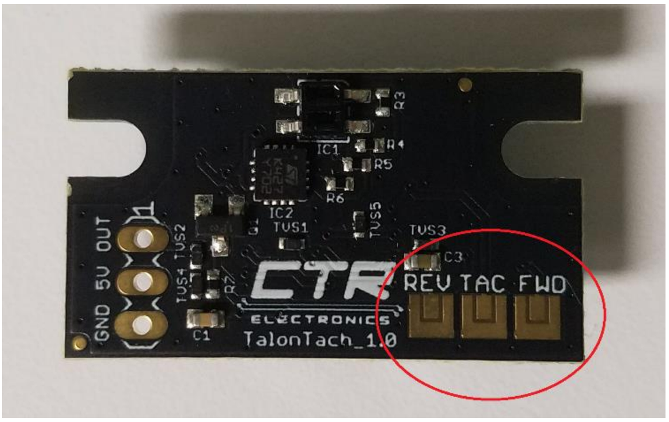
2.4.2. Tachometer Use

For tachometer usage, power the drive motor for the mechanism to its maximum speed. Measure the pulse width of the waveform on the OUT pin. A signal that is a minimum of 1ms wide for both the high and low states is a good indicator of sensor health. If your signal is less than 1ms wide for either high or low, increasing the reflectivity of the reflective surface, decreasing the reflectivity of the non-reflective surface, and/or varying the distance to the surface can improve the health of the signal. Use the results in Section 5.2 for help.

3. Using the Talon Tach with a Talon SRX

Located on the back of the Talon Tach are three solder pad selector bridges (Figure 3.1). These pads allow the user to select one or multiple outputs for the Talon Tach if it is plugged into the Talon SRX. Bridging one or more solder pad selectors selects Limit Forward (FWD), Limit Reverse (REV), or Tachometer (TACH) operation. Note that selecting the output mode does **not** affect the function of the OUT pin (3 pin header), only the signals being sent to the Talon SRX when one is connected via the data port. See the schematic in Section 1.2 for details about how this feature is implemented.

Figure 3.1.



3.1. Bridging the Solder Pad Selectors

To enable a Talon signal (Forward, reverse, and/or Tach) use a soldering iron to bridge the small gap between the outer U-shaped pad and the inner square-shaped pad. Cover exposed pads with a nonconductive material to protect against foreign body debris. Figure 3.2 shows Reverse Limit Switch (REV) operation mode selected, and Figures 3.3 and 3.4 show electrical tape covering the exposed pads (REV, TAC, FWD, the 3-pin header holes, and any unused data ports).

Figure 3.2.

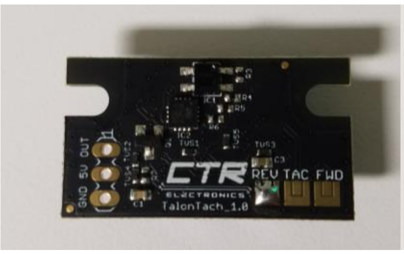


Figure 3.3.

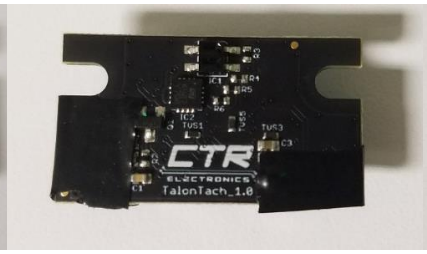
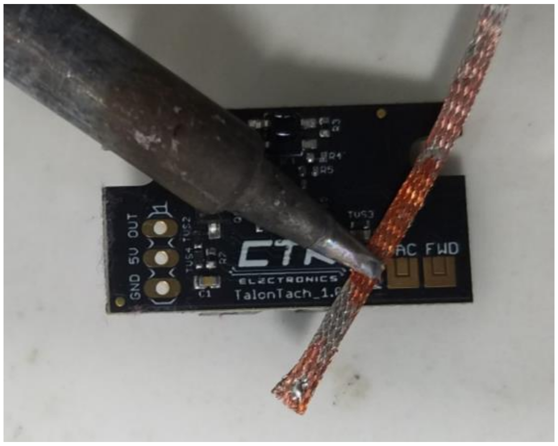


Figure 3.4.

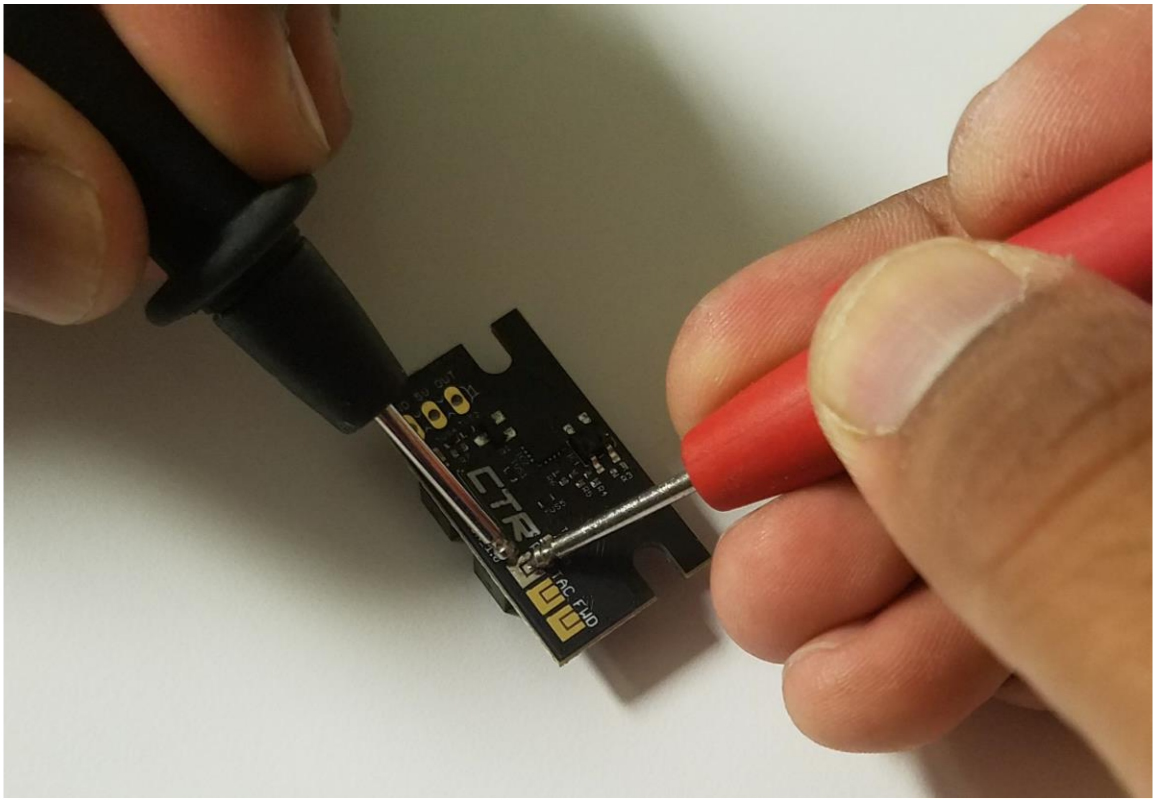
To undo a bridge, use solder wick or a solder sucker to remove solder from the solder pad selectors. Gently clean the pads with alcohol or acetone afterwards to remove any residue left by solder or flux. Figure 3.5 shows how to undo a solder joint using solder wick.

Figure 3.5.



To check for any residual shorts left by soldering after unsoldering, use a multimeter in continuity mode. Place one lead of the multimeter on the small square pad, and the other lead on the large U-shaped pad. There should be no continuity between the two pads when unsoldered. Figure 3.6 shows how to check for shorts on the Talon Tach.

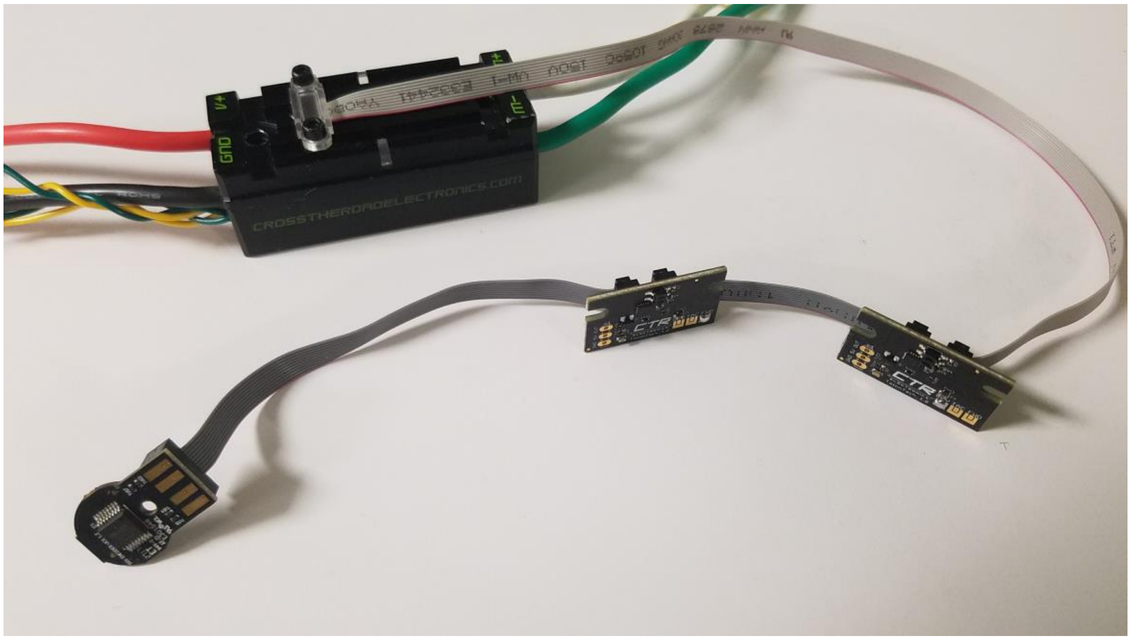
Figure 3.6.



3.2. Using the Talon Tach with an SRX Mag Encoder

To use one or more Talon Tach(s) with a Mag Encoder, use the two headers on the Talon Tach to "daisy chain" the Talon Tach(s) and put the Mag Encoder at the end of the chain. Because the Mag Encoder uses Pin 9 of the data port for absolute position data, the Talon Tach **must not** have the TAC solder pad selector bridged. Doing so will cause incorrect operation of the absolute position interface of the Mag Encoder. FWD and REV can be selected without contention to provide limit switch functionality for the Talon SRX. Figure 3.6 shows how the wiring is arranged with two Talon Tachs and a Mag Encoder.

Figure 3.6.



3.3. Using the Talon Tach as a Tachometer with the Talon SRX

Previous firmware releases of the Talon SRX do not have firmware support tailored to the next generation of peripherals. However, Talon SRXs do support general decoding of the pulse width and period of a pulse train within a given range.

Currently the Talon SRX, CANifier, Pigeon-IMU, etc. software support is being redesigned and packaged into a new software frame called "Phoenix Framework", which will include Talon SRX and CANifier features specifically tailored to the Talon Tach. In the meantime, the Talon Tach can still be used with documented limitations.

3.3.1. Previous generation TALON SRX firmware

If using a previous release of Talon SRX firmware/software, the logic inside the robot controller can decode the current speed by taking the measured period (rise to rise measurement) and scaling to a unit of speed, typically RPM.

For example, in java the `TalonSRX.getPulseWidthRiseToRiseUs(),` routine would return the period measurement in us, which can be scaled into RPM knowing how many marks per rotation there are.

```
RPM = 60,000,000 / (TalonSRX.getPulseWidthRiseToRiseUs() * NUM_MARKS)
```

This RPM can then be used for software closed-loop control at the robot-controller level (HERO/roboRIO/etc.).

Note that if there is no pulse train present for the Talon to measure, the `getPulseWidthRiseToRiseUs()`routine will return zero, and therefore should be checked before executing the division above.

Additionally, the Talon SRX's previous firmware cannot measure a pulse width that is **wider** than ~16ms. Thus, speeds less than **4,000 RPM** (when using one mark per rotation), are not measurable. However, the next release of Talon SRX firmware will not have this limitation, and will allow for decoding the full period range of the Talon Tach (and other sensors as well)!

3.3.2. Next generation TALON SRX firmware

The Talon SRX newest features will be added to "Alpha Phoenix Installer", link below…

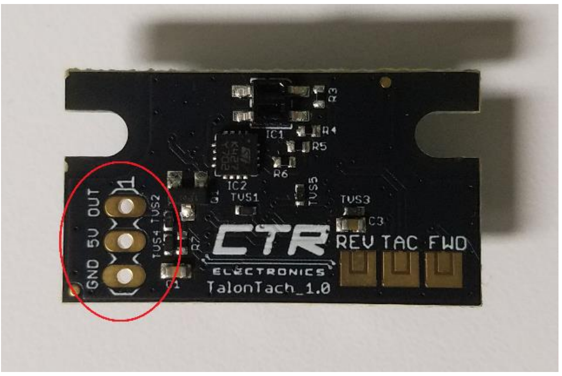
https://www.ctr-electronics.com/hro.html#product_tabs_technical_resources

As features are added, this document will be updated accordingly.

4. Using the Talon Tach without a Talon SRX

The Talon Tach provides a general-purpose interface via a 0.100" (2.54mm) pitch 3-pin header (Figure 4.1).

Figure 4.1.



5V and GND powers the sensing circuitry, and OUT is the open-collector signal returned by sensor. You will need to provide a pullup resistor from the OUT pin to your target high-level voltage (30V max). A 10k ohm resistor works well for most purposes. See the schematic in Section 1.2 for more details about implementation.
The OUT pin will provide an open-collector logic-high signal when the Talon Tach senses a reflective surface and a low signal when it senses a non-reflective surface. Bridging or un-bridging the solder pad selectors (REV, TAC, and FWD) has no effect on the signal at the OUT pin.

Avoid connecting the Talon Tach to a Talon SRX while using the 3-pin header interface, and vice-versa. If access to the signals generated by the Talon Tach is necessary while the Talon SRX is connected, connect only the OUT and GND pins (do not connect 5V) and **do not** use an external pullup resistor on OUT.

Remember to cover all exposed pads with electrical tape, as shown in Figures 4.2 and 4.3.

Figure 4.2.

Figure 4.3.

5. Typical Performance

The Talon Tach's performance is based on several factors…

- Reflectivity of the reflective surface.
- Non-reflectivity of the non-reflective surface.
- The distance from the target.
- Operating speed.

Output captures are provided in this section to aid in setup and debugging of the Talon Tach. Note that due to minor differences in the sensor die (Section 6.6) or the testing conditions, the output of your Talon Tach may not precisely match the captures shown here.

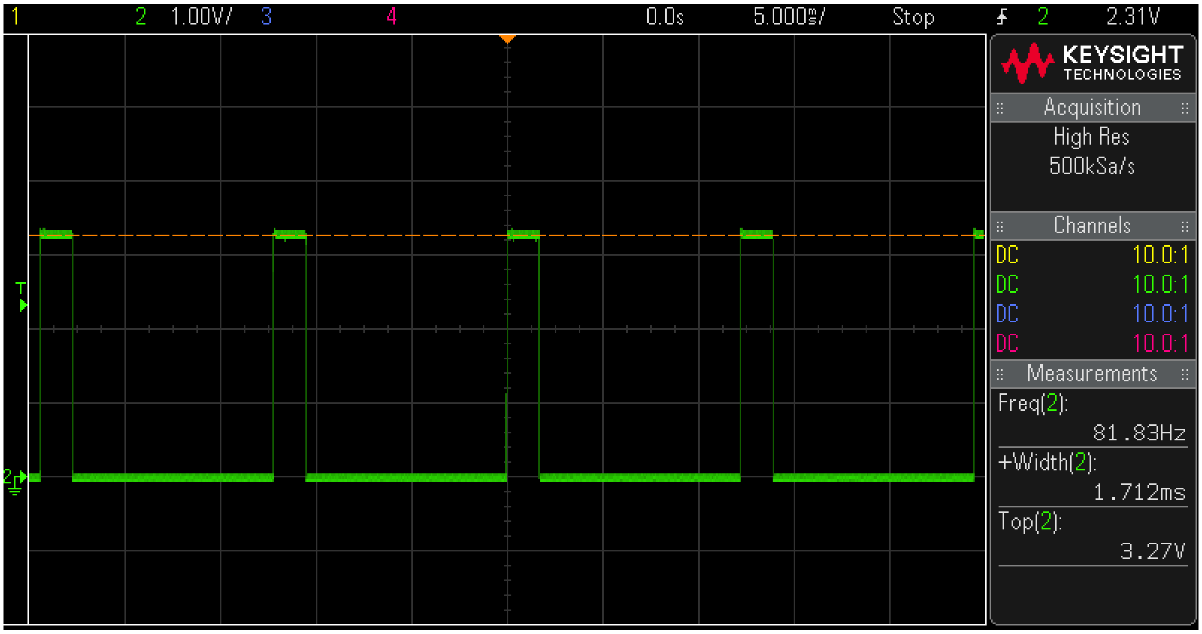
5.1. Test Conditions

Testing Parameter	Condition
Sensor face to sensing surface	1mm, 3mm, 5mm
Ambient lighting	Indoors, neutral white fluorescent bulbs
Non-reflective area material	Black Delrin (acetal)
Reflective area material	White paint (marker)
Reflective portion of sensing surface	5% and 50%
Test frequency	5,000 EPM (5,000 RPM with one white mark)
Power source	Talon SRX cable (3.3v and 5v supply)
Measurement location	OUT pin of Talon Tach
External Pullup resistor	None

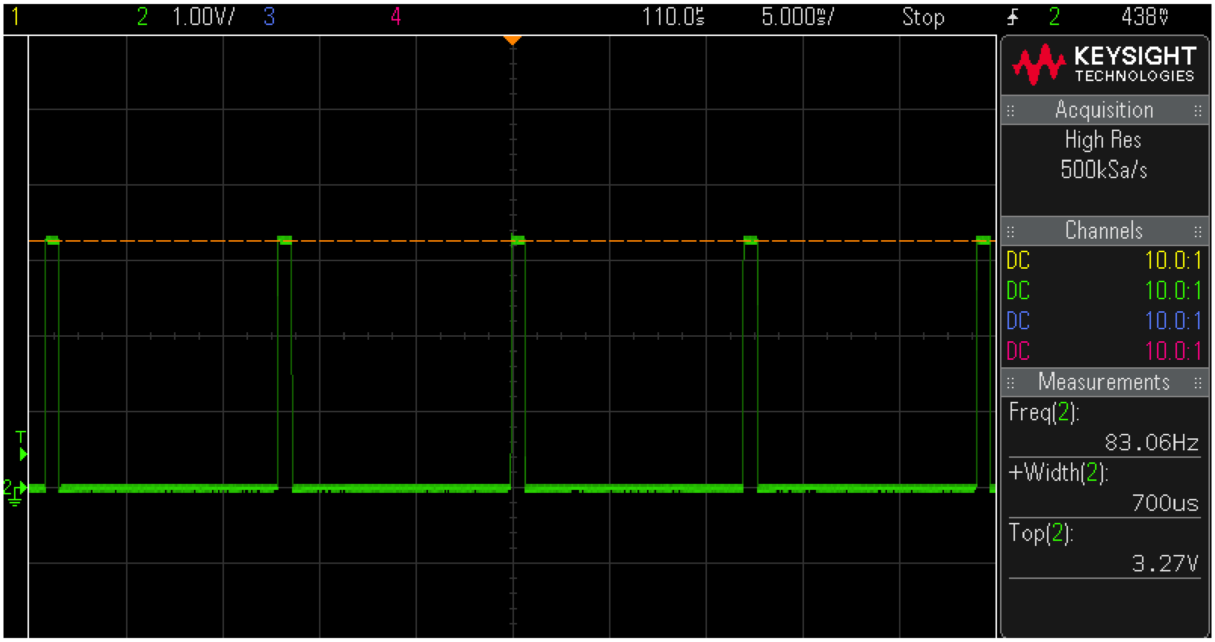
5.2. Test Results

5.2.1. Test Results With 5% Reflective Area and 95% Non-Reflective Area

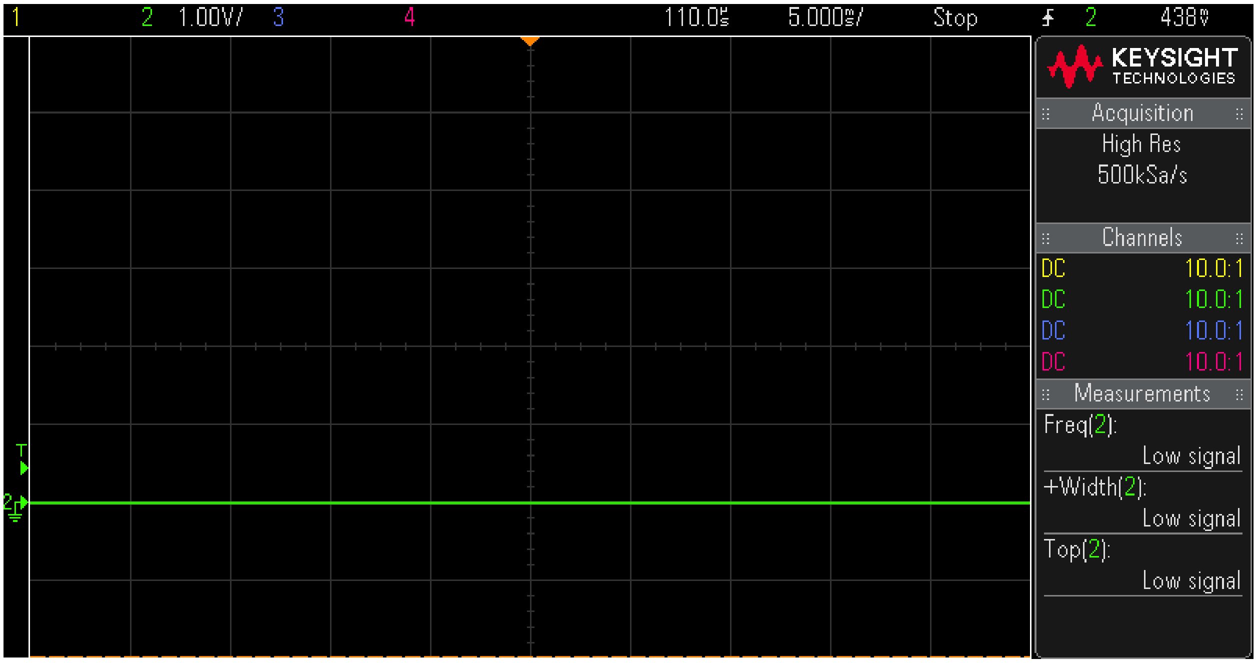
Sensor-Surface Distance: 1mm



Sensor-Surface Distance: 3mm



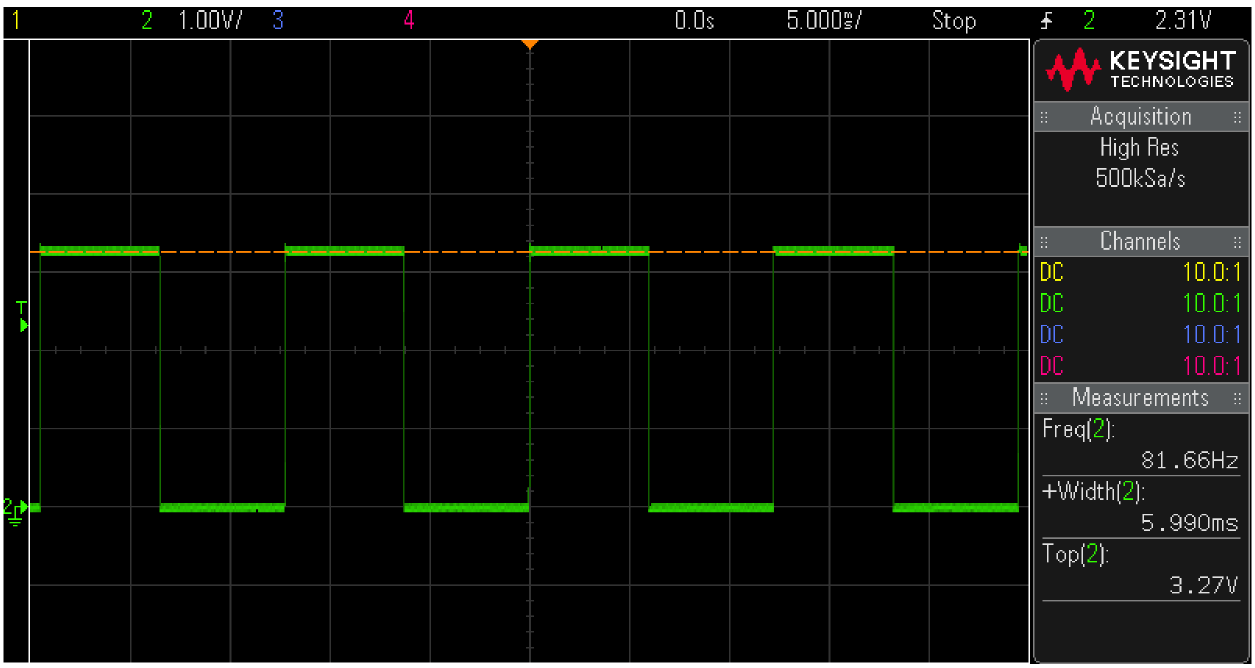
Sensor-Surface Distance: 5mm



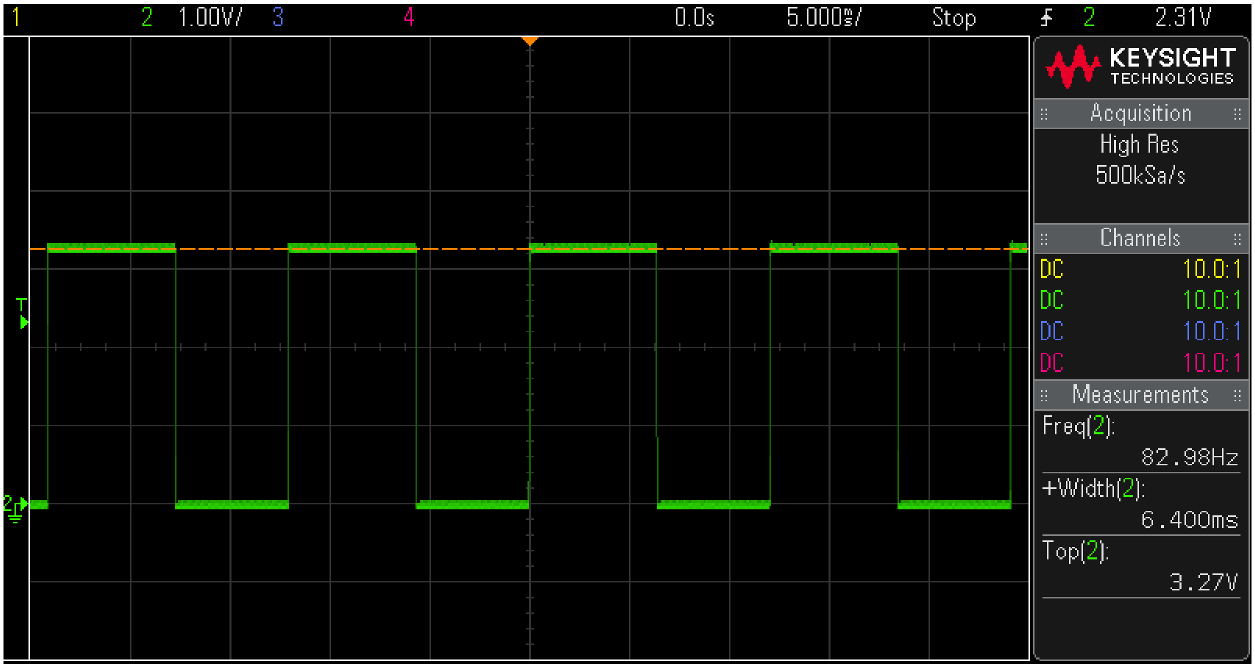
(No output)

5.2.2. Test Results With 50% Reflective Area and 50% Non-Reflective Area

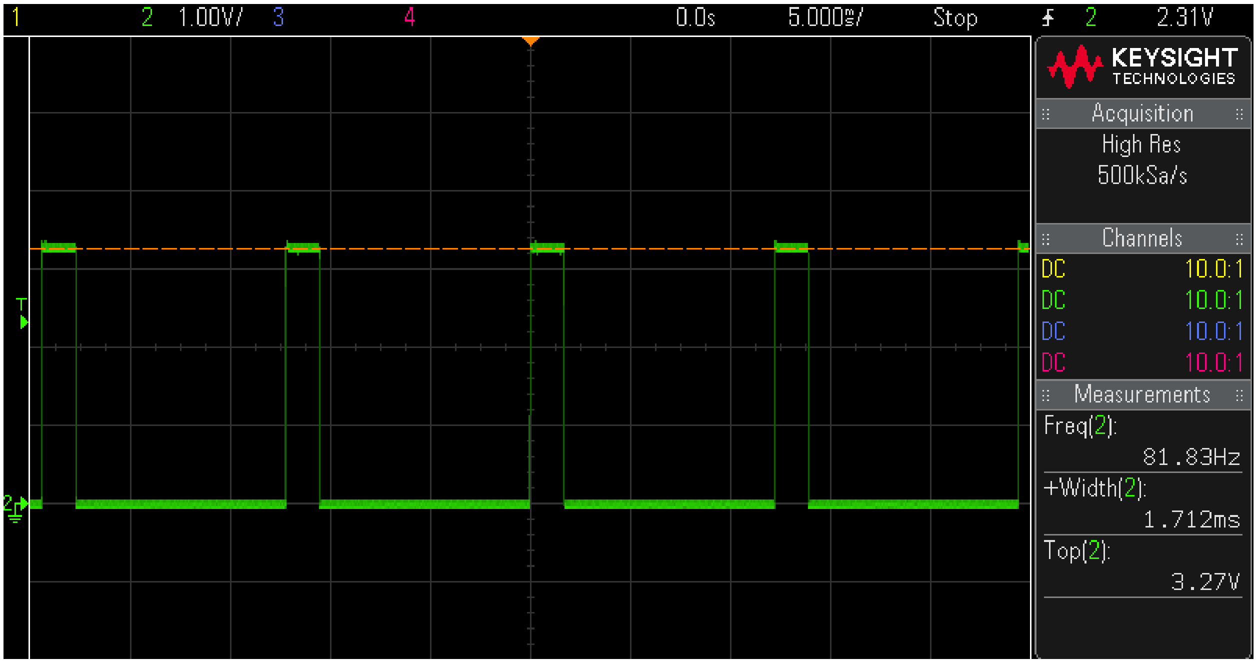
Sensor-Surface Distance: 1mm



Sensor-Surface Distance: 3mm



Sensor-Surface Distance: 5mm



6. Frequently Asked Questions (FAQ)

6.1. Is there a way to tell if the sensor is present/powered?

To determine visually if the sensor is powered and functioning, check the built-in LED using the table in Section 1.4.

6.2. Where can we get more data cables? Lengths?

Cabling options will be available at ctr-electronics.com.

6.3. Is the sensor Quadrature or not? I am not sure what is best for my application.

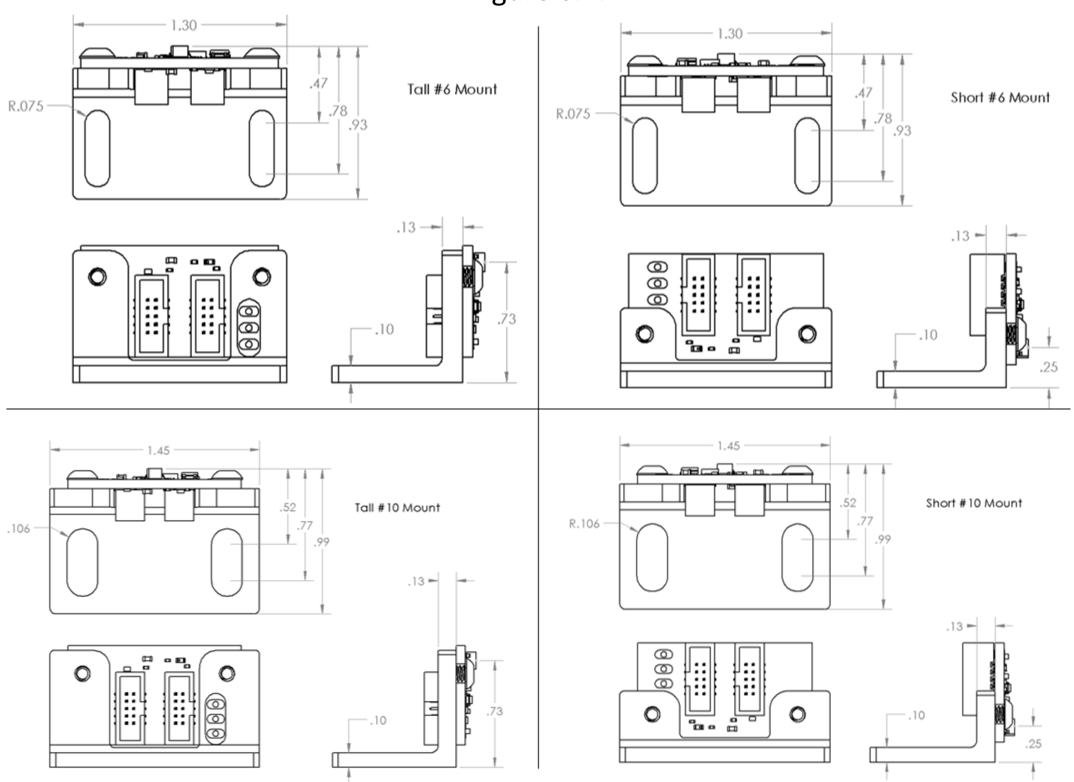
The Talon Tach is **not** a Quadrature sensor. In general, the Talon Tach should only be used as a unidirectional tachometer or limit switch. If one is using the Talon Tach to sense speed, it is the responsibility of the user to ensure that the target is spinning in the correct direction. Therefore, using the Talon Tach as a direct quadrature encoder replacement is not recommended.

6.4. How do I use the 3D printable mounts on the website?

The website has four printable mounts available: Short #6, Tall #6, Short #10, and Tall #10.

The "#6" mounts mount to the chassis via #4 or #6 screws, e.g. 4-40 or 6-32. The "#10" mounts mount to the chassis with #8 or #10 screws, e.g. 8-32 or 10-32. See Figure 6.1 for mechanical drawings of the mounts. Use a short 4-40 button head screw to attach the Talon Tach to the mounts. No nut is required; the screw threads can bite into the plastic.

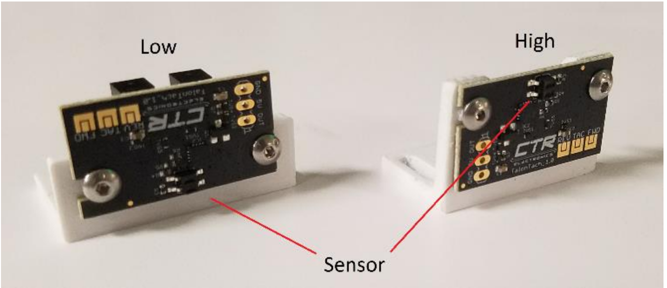
Figure 6.1.



Note that due to plastic shrinkage and 3D printing tolerances, you may need to tune your printer to print the mounts correctly or drill out holes manually (especially the Talon Tach mounting holes, which may need to be drilled out with a 3/32" drill bit). However, the mounts were designed with very loose tolerances in mind, so most printers should be able to handle them without issues. A MakerBot printer configuration file can be downloaded with the mounts.

Figure 6.2 shows how the sensor is mounted on the "Low" and "High" mounts.

Figure 6.2.



6.5. Can I use more than one reflective mark on my flywheel to improve resolution?

It is possible to have more than a single mark on a flywheel when using the Talon Tach in tachometer mode to measure RPM. Note that the rated typical maximum speed is 20,000 EPM. This means that with a single mark the rated RPM range is 0-20,000, with two marks the RPM range is 0-10,000 (albeit twice as accurate), etc.

Furthermore, using the average RPM calculated from the last *n* Talon Tach output pulses, where *n* is the number of marks on the wheel, will always report the correct RPM regardless of the spacing or position of the marks. Note that the Talon SRX may not support the full EPM range depending on the firmware version. See Section 8 for more details.

6.6. I swapped out one Talon Tach for another and it stopped working!

There are some slight manufacturing inconsistencies in the sensor die itself between each board. One Talon Tach may work at a 5.5mm distance (outside of 5mm range limit) and 8000EPM, while another may only be able to get 8000EPM and 5.0mm in the same conditions. Thus, if your mechanism is right at the edge of workability for one Talon Tach, it may not work correctly with another Talon Tach.

The best way to prevent this is to place the Talon Tach at a 2-3mm distance from its target, and to use a reflective-as-possible reflective medium and a dark-as-possible non-reflective medium. This will guarantee reliable functionality of the sensor.

Use the methods described in Section 2.3 and 2.4 to confirm the health of your setup.

6.7. How do I use the Talon Tach with other Gadgeteer devices?

When using the Talon Tach with other Gadgeteer port devices, read the datasheets and schematics carefully for both devices to ensure there is no I/O contention between data lines, especially from bridged solder pad selectors. I/O contention will cause incorrect behavior of devices on the Gadgeteer data lines and may cause damage to devices.

6.8. Are the Limit Switch Outputs Normally Open (NO) or Normally Closed (NC)?

The Talon Tach will provide a logic-high signal to Talon SRX when it senses a reflective surface and a logic-low signal when it senses a non-reflective surface.

For applications where the Talon Tach is pointing to a **non-reflective surface** or open air (LED is **on**) when **motor movement is allowed**, the Talon Tach should be treated as **a NC limit switch**.

For applications where the Talon Tach is pointing to **a reflective surface** when **motor movement is allowed** (LED is **off**), it should be treated as a **NO limit switch.**

6.9. What materials work best with the Talon Tach?

The Talon Tach will work well with a variety of reflective materials. For the reflective surface, aluminum, steel, white tape, white paper, and white paint all function well. The reflective surface should be as evenly reflective as possible.

For the non-reflective surface, black Delrin, long distances of air, black paper, black tape, and black paint all work well. Note that some plastics and tapes are slightly reflective, such as electrical tape, so the Talon Tach may need to be placed farther away from the sensing surface than normal.

A 50/50 ratio of reflective to non-reflective surface on the sensed object provides the best results with the Talon Tach.

If using tape, ensure tape is adequately adhesive and will not fall off the surface with time. Otherwise avoid using tape solutions if this cannot be guaranteed.

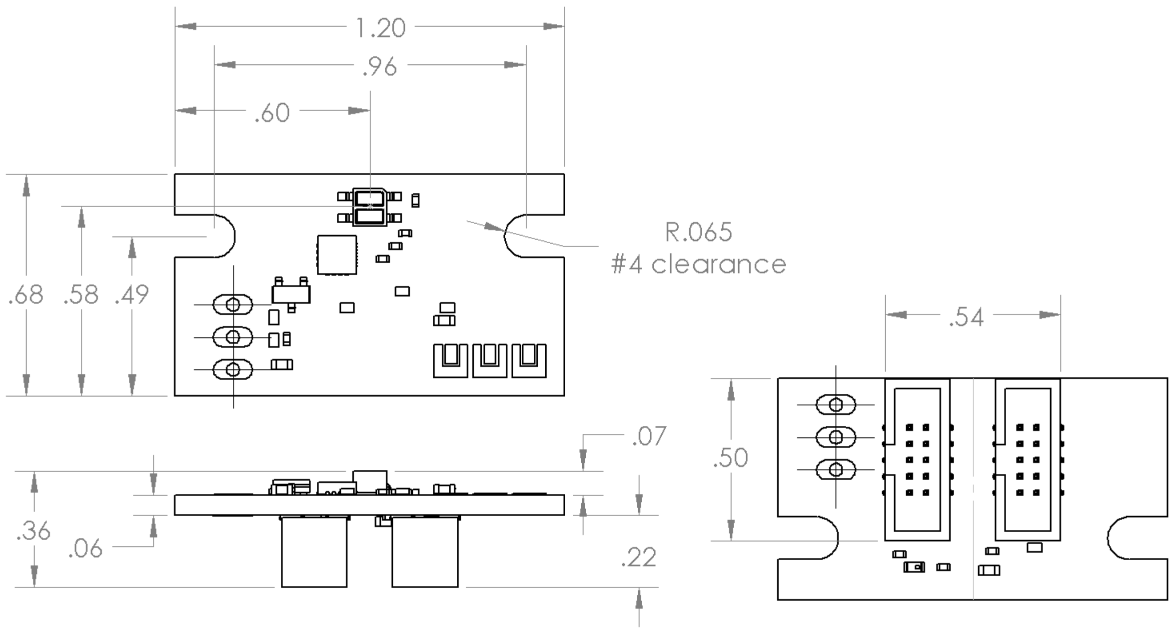
6.10. How do I make my Talon Tach work consistently up to 20,000 EPM?

If you are not able to make your Talon Tach wok consistently up to 20,000 EPM, follow these steps:

1. Verify that the Tach is within a 2-3mm distance to the target for best results
2. Check that your reflective surface is very reflective and your non-reflective surface is very non-reflective
3. Make your reflective/non-reflective surface ratio as close to 50/50 as possible

Following these steps will provide the most optimal working environment for the Talon Tach.

7. Mechanical Drawings



8. Talon SRX Firmware Limitations

The Talon SRX Firmware may not support low-RPM operation of the Talon Tach due to limitations of the pulse width reading functionality. This table describes the limitations of various firmware versions. These limitations do **not** affect the functionality of the Talon Tach itself, only the way the Talon interprets the data.

Firmware Version	Limitations
FRC 2.34 and below	4,000 EPM minimum tachometer speed, limit switch operation unchanged. Use getPulseWidth* methods to find speed.
Non-FRC 10.23 and below	4,000 EPM minimum tachometer speed, limit switch operation unchanged Use getPulseWidth* methods to find speed.

9. Revision History

1.2	3-Oct-2017	Additional updates before public release.
1.1	22-Sept-2017	Various updates and first release candidate.
1.0	23-Aug-2017	Initial Creation.