CRFC Tackle Sensor V4
User Manual

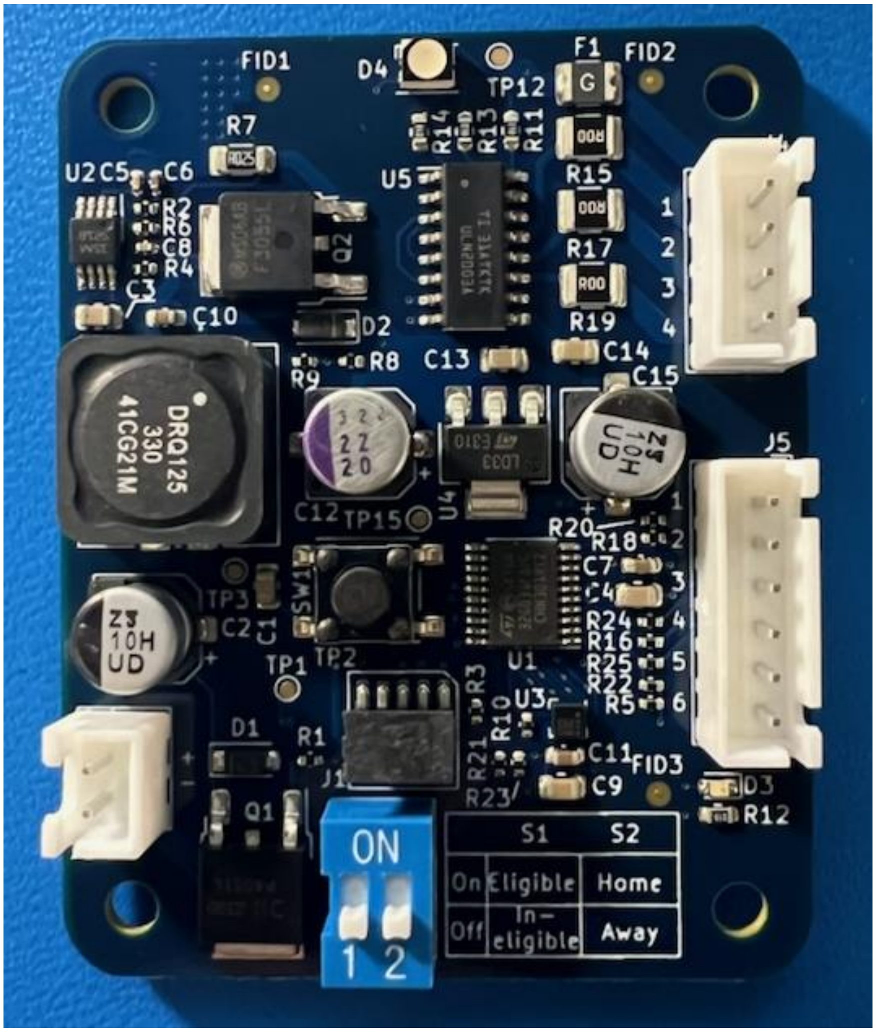

Figure 1 - Tackle Sensor V4

Revision History

Revision	Date	Author	Description
1	09/29/2024	Eddie Hunckler	Initial draft.

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Introduction

The tackle sensor module is a subsystem designed to detect if an upsetting event or tackle has occurred during gameplay in the Collegiate Robotic Football Conference. This sensor is required to be rigidly mounted to the HDPE baseplate in a robot. For the latest rules regarding the tackle sensor, please see the Collegiate Robotic Football Conference website: https://collegeroboticfootball.org/.

This document will focus on the functional behavior of the tackle sensor subsystem as well as provide technical details for interfacing with the module.

The tackle sensor has four primary connectors labeled J1, J2, J4, and J5. (There is no J3!) J1 is used to program the device and should not be used by any team unless directed to by the Conference for the purposes of updating the firmware on the device. J2 must be used by every team as it provides power to the tackle sensor module. J4 can be connected to a 12V common anode LED strip or equivalent. J5 provides an advanced configuration interface for monitoring or controlling eligible or ineligible status, for monitoring or controlling home or away, for monitoring tackle state, or for configuring the home LED color via UART.

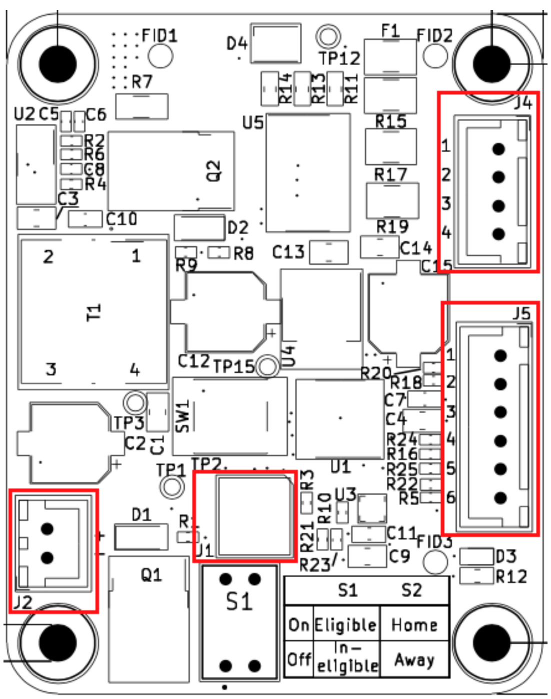


Figure 2- Connector Locations

The major features of the module are the following:

- Drives RGB LEDs indicating the robot system states which are as follows:
  - Tackled or not tackled
  - Eligible receiver or ineligible receiver
  - Home or away.

- Allows configuration of the system states via on-board configuration switches or via remote IO.
- Continuously monitor acceleration of the system at 100 Hz. If the filtered acceleration exceeds 2.5g in either the X or Y axis, the system triggers a tackle.
- A tackle lasts 1 second and the LEDs display red.
- During a tackle the Tackle status remote IO monitor pin changes state.
- Ineligible receivers are unable to be tackled.

IO Electrical Characteristics

Power Connector J2

Pin	Description	Requirements
1	GND	Power input ground. System ground.
2	V_SUPPLY	Power input - 10V to 30V DC

J2 has reverse polarity protection up to 30V DC. This will protect the system against damage if the submodule power connector is incorrectly wired.

LED Connector J4

Pin	Description	Requirements
1	12V+	Power Output to LED Strips, 1A Maximum Current Source
2	RED	Open Collector, 500mA Maximum Current Sink
3	GREEN	Open Collector, 500mA Maximum Current Sink
4	BLUE	Open Collector, 500mA Maximum Current Sink

J4 pin 1 has a PTC fuse with a trip current of 1.5A and hold current of 750mA with a time to trip of 100ms. This will help protect the system against too large of LED loads placed on the 12V output.

Status Connector J5

Pin	Description	Requirements
1	UART TX	Serial UART command interface TX line.
2	UART RX	Serial UART command interface RX line.
3	TACKLE STATUS	Tackle status output. 3.3V Logic Output
4	HOME/AWAY	Home/away input or high impedance output. 3.3V Logic Input or Output.
5	ELIGIBLE/ INELIGIBLE	Eligible/ineligible input or high impedance output. 3.3V Logic Input or Output.
6	GND	System ground.

The serial UART requires the following configuration: 115200 baud, 1 start bit, 8 data bits, no parity bit, 1 stop bit. (115200bps, 8N1).

The tackle sensor logic levels are as follows:

Condition	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5
TACKLED	X	X	L	X	X
NOT TACKLED (OK)	X	X	H	X	X
HOME	X	X	X	L	X
AWAY	X	X	X	H	X
ELIGIBLE	X	X	X	X	L

INELIGIBLE	X	X	H	X	H

H: High Level – 3.3V
L: Low Level – 0V
X: Does not matter, is not affected.

Getting Started

Powering The Module

The system is powered through connector J2. The connectors on this module are all JST XHP style connectors with differing numbers of pins. For the power connector, the mating part will be a XHP-2 connector with mating connector pins SXH-001T-P0.6N. This is an extremely common form factor, and many equivalent substitutes exist if these are unavailable. High quality premade cables can also be purchased from standard suppliers and places like Amazon.

This device is designed to be compatible with a variety of different power systems with minimal additional circuitry requirements. The recommended supply voltage range is from 10V to 30V. Voltages less than 10V are possible to use with the system, but not recommended due to the higher current requirements.

The plot below shows the power requirements of the tackle sensor given various input supply voltages and LED loads. The LED loads will vary based on the style and the number of LEDs that will be driven. This chart is an actual performance measurement of the device and include inefficiencies that might exist within the device.

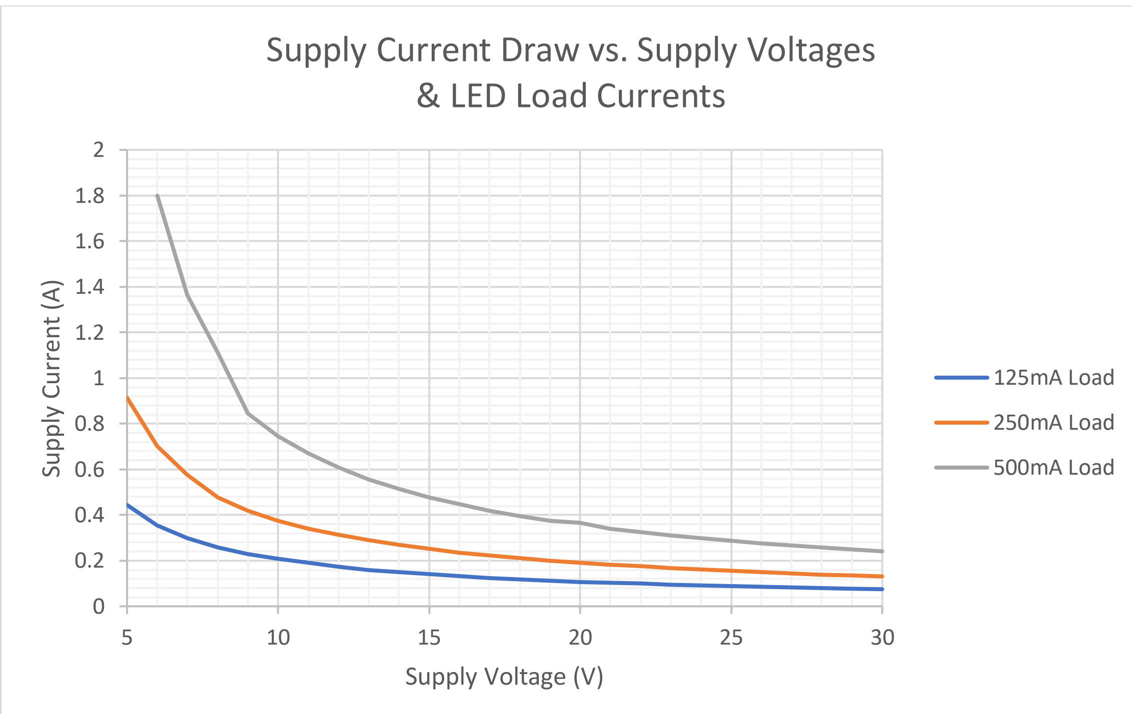


Figure 3 - Supply Current Draw vs. Supply Voltages & Load Currents

Example:
Let's assume I'm building a robot with a 24V battery, and I have chosen LED strips that require a maximum of 500mA. How much current will the tackle sensor draw?
I can look on the chart and see that the 500mA LEDs will require about 300mA at 24V. I can then include this in my power budget for the system that I'm creating.

Interfacing with LEDs

For the power connector, the mating part will be a XHP-4 connector with mating connector pins [SXH-001T-P0.6N](). This is an extremely common form factor, and many equivalent substitutes exist if these are unavailable. A standard common anode RGB LED strip will be compatible with this output as they are typically 12V compatible and they have integrated current limiting resistors.

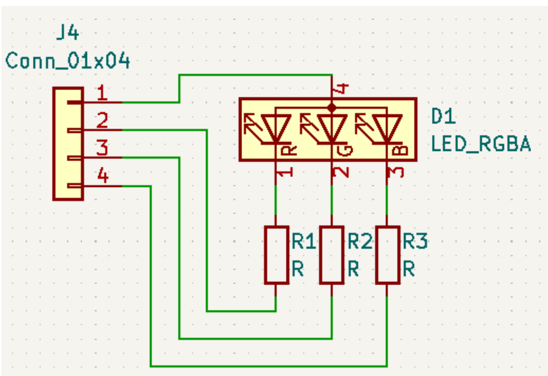
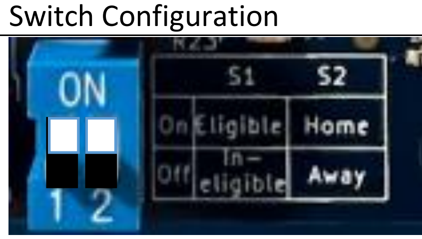
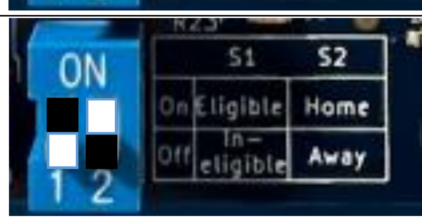
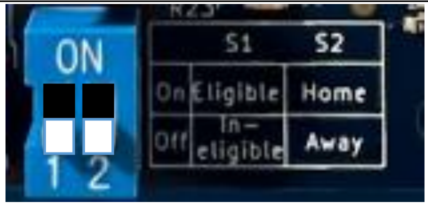


Figure 4- Example LED Connection

Configuring the On-board Switches

The system state can be configured using the on-board DIP switches. The table below indicates the switch position and the system state. The system state is also printed on the tackle sensor itself for ease of use.

Description	Switch Configuration
Tackle sensor is eligible. Tackle sensor is home.	
Tackle sensor is ineligible. Tackle sensor is home.	

<table>
<tr>
<td>Tackle sensor is ineligible.
Tackle sensor is away.</td>
<td>
</td>
</tr>
<tr>
<td>Tackle sensor is eligible.
Tackle sensor is away.</td>
<td>
</td>
</tr>
</table>

Configuring with Remote IO

The tackle sensor system is also configurable using remote IO lines that can be connected to custom circuitry to set the tackle sensor operating state. The tackle sensor subsystem is compatible with 3.3V logic levels. When using 3.3V compatible system logic, the inputs and outputs can be directly monitored with a microcontroller or controlled with a microcontroller output.

The tackle output pin can be monitored with a digital input on a microcontroller. The inputs need to be set to high impedance input mode. Then the state of the TACKLE STATUS can be monitored. Additionally, the HOME/AWAY and the ELIGIBLE/INELIGIBLE status pins can be monitored via microcontroller inputs. When monitored via high impedance inputs, the switches on the tackle sensor PCBs control the configuration mode of the tackle sensor.

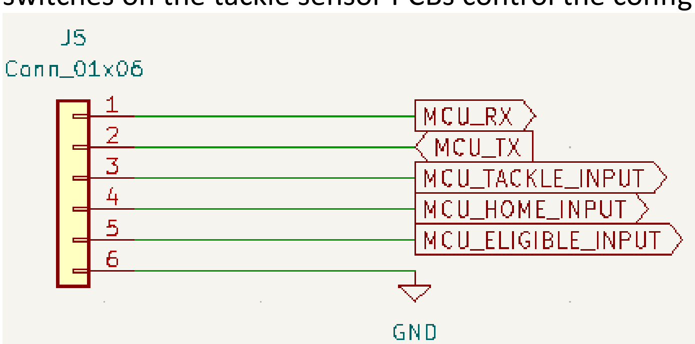


Figure 5- Monitor Remote IO with MCU Inputs

Alternatively, the HOME/AWAY and the ELIGIBLE/INELIGIBLE status pins can be driven by 3.3V logic levels externally. When doing this, the states of the switches on-board the tackle sensor are ignored, and the logic level driven to each pin is what determines the state of the tackle sensor. This provides a way to interface the custom microcontroller system to the tackle sensor. The system designer could then be able to remotely toggle between home and away or eligible and ineligible.

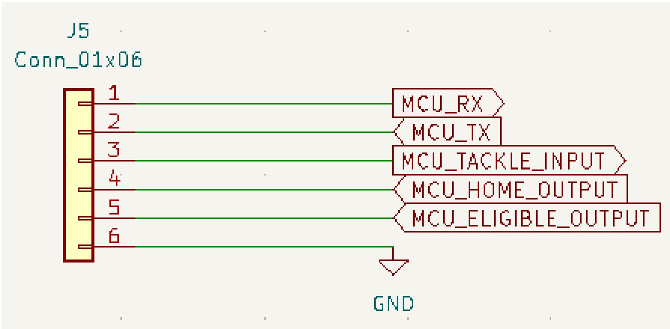


Figure 6- Control Remote IO with MCU Outputs

Configuring with the Serial UART

The simplest way to configure a tackle sensor is to build up a small cable that includes a USB to UART and the J5 connector. This adapter gives the designer the ability to easily send commands to the tackle sensor for configuration purposes. When configuring the tackle sensor, the changes are stored in non-volatile on-board memory.

Below is a diagram of the wiring between a USB to UART adapter and the XHP-6 connector that will interface with the Status Connector on the tackle sensor. Please note that the TX line from the USB to UART adapter goes to the RX line on the tackle sensor and the RX line from the USB to UART goes to the TX line on the J5 connector.

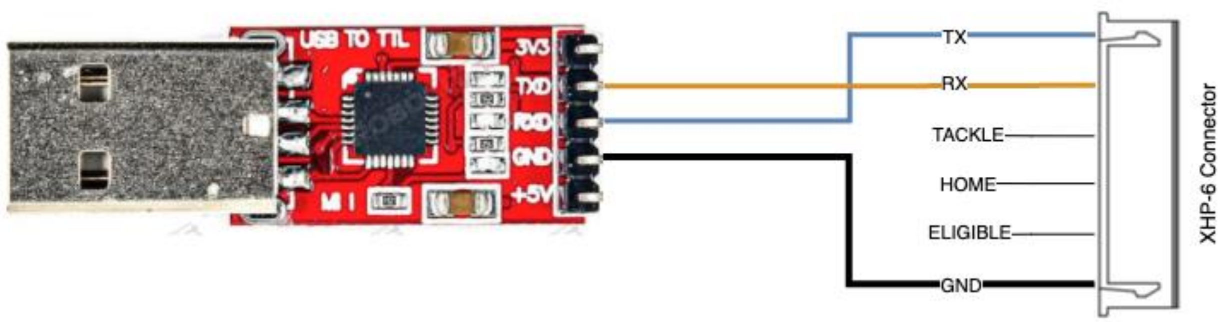


Figure 7 - Serial UART Wiring Diagram

Configure the USB to UART at a baudrate of 115200 with the configuration of 8 data bits, no parity bit, and 1 stop bit. The configuration is 115200-8-N-1. A serial terminal can be used to directly send and receive the messages.

The following commands and responses are available.

Function	**Character (Hex)**	**Example Command**	**Example Response**	**Description**
Set RGB Value	l (0x6C)	l:255,255,0\n	l:255,255,0\n	Set the RGB value of the home LED. Saved to settings with each send. Limit to less than 10,000 lifetime sends.

Get Acceleration	a (0x61)	a\n	a:0,0,1000\n	Reports the latest acceleration X, Y, and Z in milli-g.
Get Acceleration Magnitude Range	r (0x72)	r\n	r:0,100,0,100\n	Reports the minimum and maximum acceleration observed since the last call to this function. Min X, Max X, Min Y, and Max Y in milli-g.
Get Home Away Status	h (0x68)	h\n	h:1\n	Home = 1. Away = 0.
Get Eligible Status	e (0x65)	e\n	e:1\n	Eligible = 1. Ineligible = 0.
Get Tackled Status	t (0x74)	t\n	t:0\n	Tackled = 1. Not tackled = 0.
Get Firmware Version	v (0x76)	v\n	v:0.0.0\n	Reports the firmware version.

This protocol has been fully implemented in a webapp that can be found hosted on GitHub: https://collegiate-robotic-football-conference.github.io/tackle-sensor-utility/. This requires a Chrome browser to work properly. Once connected, the information will be pulled from the device periodically. The minimum and maximum acceleration in the X and Y directions will be plotted in real-time. The Home Jersey color can be selected with the color picker.

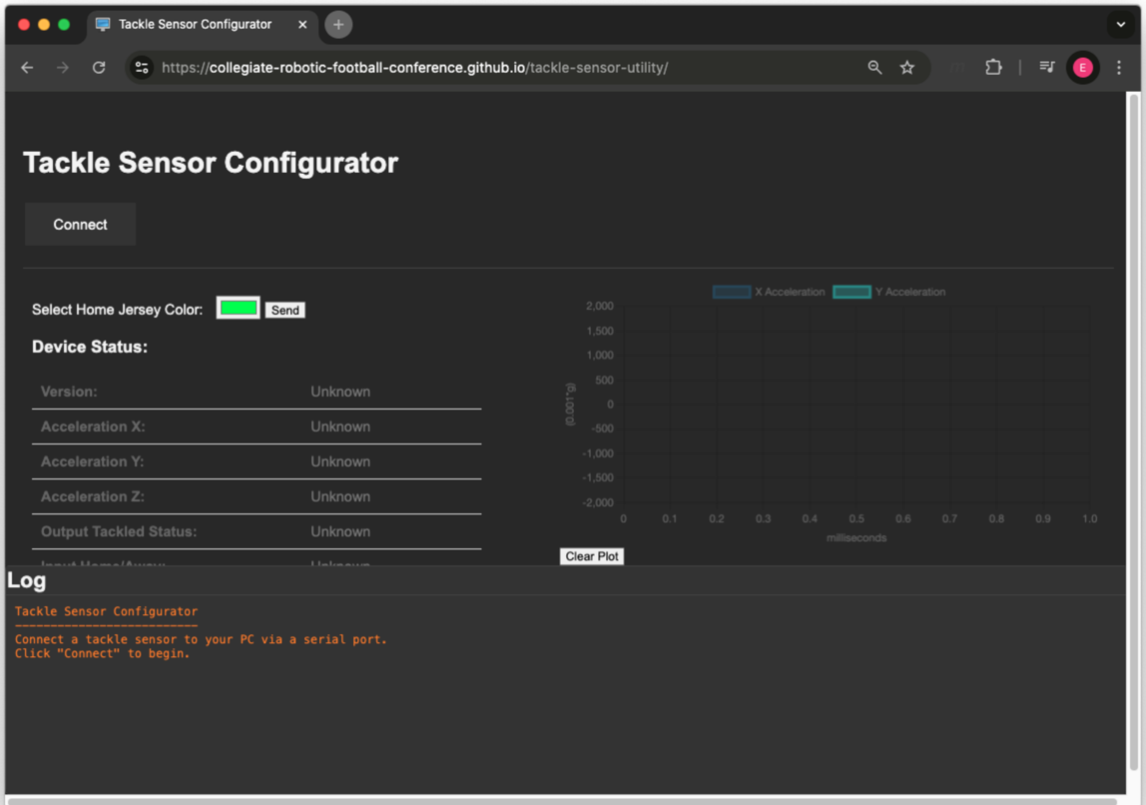


Figure 8- Tackle Sensor Configurator Web App

Resources

The latest design files and firmware can be found on the Collegiate Robotic Football Conference GitHub page.

- Firmware - https://github.com/Collegiate-Robotic-Football-Conference/tackle-sensor-firmware
- Hardware - https://github.com/Collegiate-Robotic-Football-Conference/tackle-sensor-hardware
    - Reference Sheet PDF - https://github.com/Collegiate-Robotic-Football-Conference/tackle-sensor-hardware/blob/main/Releases/REV2_02_04_2024/reference_sheet_rev2.pdf
    - Schematic PDF - https://github.com/Collegiate-Robotic-Football-Conference/tackle-sensor-hardware/blob/main/Releases/REV2_02_04_2024/schematic_sheet_rev2.pdf
    - 3D Model STEP File - https://github.com/Collegiate-Robotic-Football-Conference/tackle-sensor-hardware/blob/main/Releases/REV2_02_04_2024/tackle_sensor_hardware.STEP

- Configuration Utility - https://github.com/Collegiate-Robotic-Football-Conference/tackle-sensor-utility

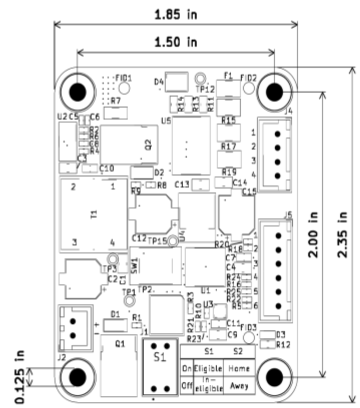
Electrical Connector Details

Power Connector – J2
Mating Connector Housing: XHP–2
Mating Connector Pins: (see below)
– Pin 1 – GND
– Pin 2 – V+ (10V to 30V)

Status Connector – J5 (Optional)
Mating Connector Housing: XHP–6
Mating Connector Pins: (see below)
– Pin 1 – UART TX (115200 bps, 8N1, 3.3V Logic Output)
– Pin 2 – UART RX (115200 bps, 8N1, 3.3V Logic Input)
– Pin 3 – TACKLE Status Output (3.3V Logic Output)
– Pin 4 – HOME Input (3.3V Logic Input)
– Pin 5 – ELIGIBLE Receiver Input (3.3V Logic Input)
– Pin 6 – GND

LED Connector – J4
(Common Anode RGB LED)
Mating Connector Housing: XHP–4
Mating Connector Pins: (see below)
– Pin 1 – +12V
– Pin 2 – RED
– Pin 3 – GREEN
– Pin 4 – BLUE

All connector housings in this design
use the same style of crimp terminals.
An exammple part number for 22–26 AWG wire is below.
Mating crimp terminals: SXH–001T–P0.6N (example)
The recommended path is to used precrimped jumpers
for high–quality connections suchs as ASXHSXH22K305.
Alternatively, complete cables can be purchased as assemblies
from places like Amazon. <https://a.co/d/Il46hP2>



Sheet:
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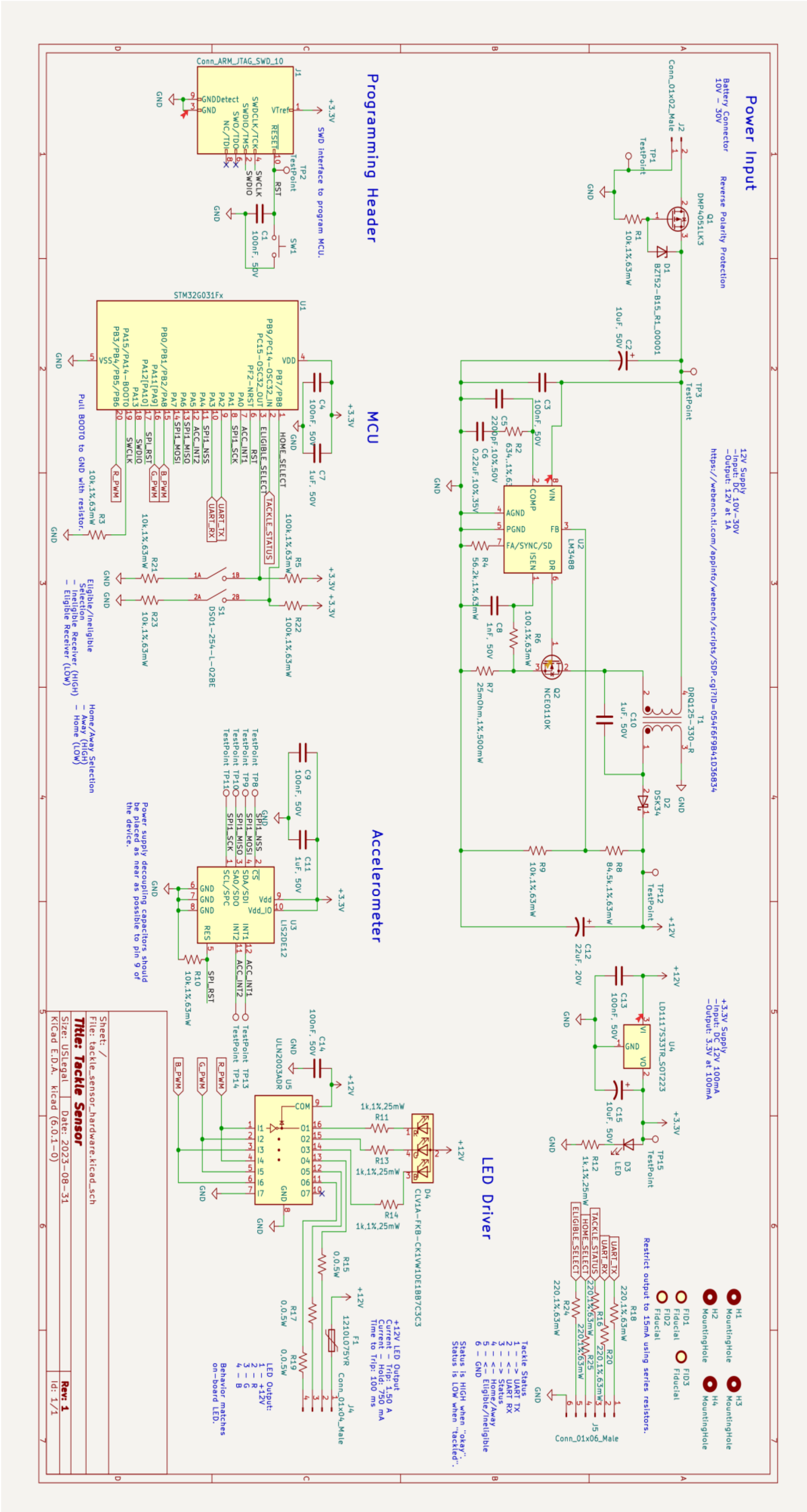
Title: Tackle Sensor
Size: USLegal Date: 2023–08–31 **Rev: REV1**
KiCad E.D.A. kicad (6.0.1–0) Id: 1/1


Power Input
Battery Connector
10V - 30V
Reverse Polarity Protection
12V Supply
-Input: DC 10V-30V
-Output: 12V at 1A
https://webench.ti.com/appinfo/webench/scripts/SDP.cgi?ID=054F6F9B41D36834
+3.3V Supply
-Input: DC 12V 100mA
-Output: 3.3V at 100mA
Restrict output to 15mA using series resistors.
Tackle Status
1 - -> UART TX
2 - <- UART RX
3 - -> Status
4 - <- Home/Away
5 - <- Eligible/Ineligible
6 - GND
Status is HIGH when "okay".
Status is LOW when "tackled".
LED Driver
+12V LED Output
Current - Trip: 1.50 A
Current - Hold: 750 mA
Time to Trip: 100 ms
LED Output:
1 - +12V
2 - R
3 - G
4 - B
Behavior matches
on-board LED.
Programming Header
SWD interface to program MCU.
MCU
Pull BOOT0 to GND with resistor.
Eligible/Ineligible
Selection
- Ineligible Receiver (HIGH)
- Eligible Receiver (LOW)
Home/Away Selection
- Away (HIGH)
- Home (LOW)
Accelerometer
Power supply decoupling capacitors should be placed as near as possible to pin 9 of the device.
Sheet: /
File: tackle_sensor_hardware.kicad_sch
Title: Tackle Sensor
Size: USLegal Date: 2023-08-31 Rev: 1
KiCad E.D.A. kicad (6.0.1-0) Id: 1/1