Talon SRX

Breakout and Adapter Board

Students and Mentors of FRC Teams 5190 and 900

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Introduction

This project is a collaboration between two FIRST Robotics Competition (FRC) teams in North Carolina. The goals were to introduce students to the ideas of printed circuit board design and manufacturing as well as to help create a sense of community between two teams near the Research Triangle region of the state.

Team 5190, the Green Hope Falcons was founded in 2014 and is based out of Green Hope High School in Cary, NC. Team 900, the Zebracorns was founded in 2002 and is based out of the North Carolina School of Science and Mathematics in Durham, NC. The two teams found each other through a desire to improve upon the work that they had each done to develop breakout boards independently in the prior FRC season.

Ultimately the teams wanted to combine forces and jointly develop a custom breakout board to connect quadrature and analog encoders to the Talon SRX motor controllers that could be used during the upcoming FRC season and possibly beyond.

Design

Our design process began with the identification of desirable features not currently offered by other Talon breakout boards. Namely, we wanted a board that mounts directly to the Talon, kept a small footprint, and had breakout connectors to facilitate the connection of bare wires. We also wanted to provide an opportunity to develop the aspiring electrical engineers on our teams and creating these adapter boards, using production grade software (Altium), seemed like the perfect opportunity.

1. Connectors

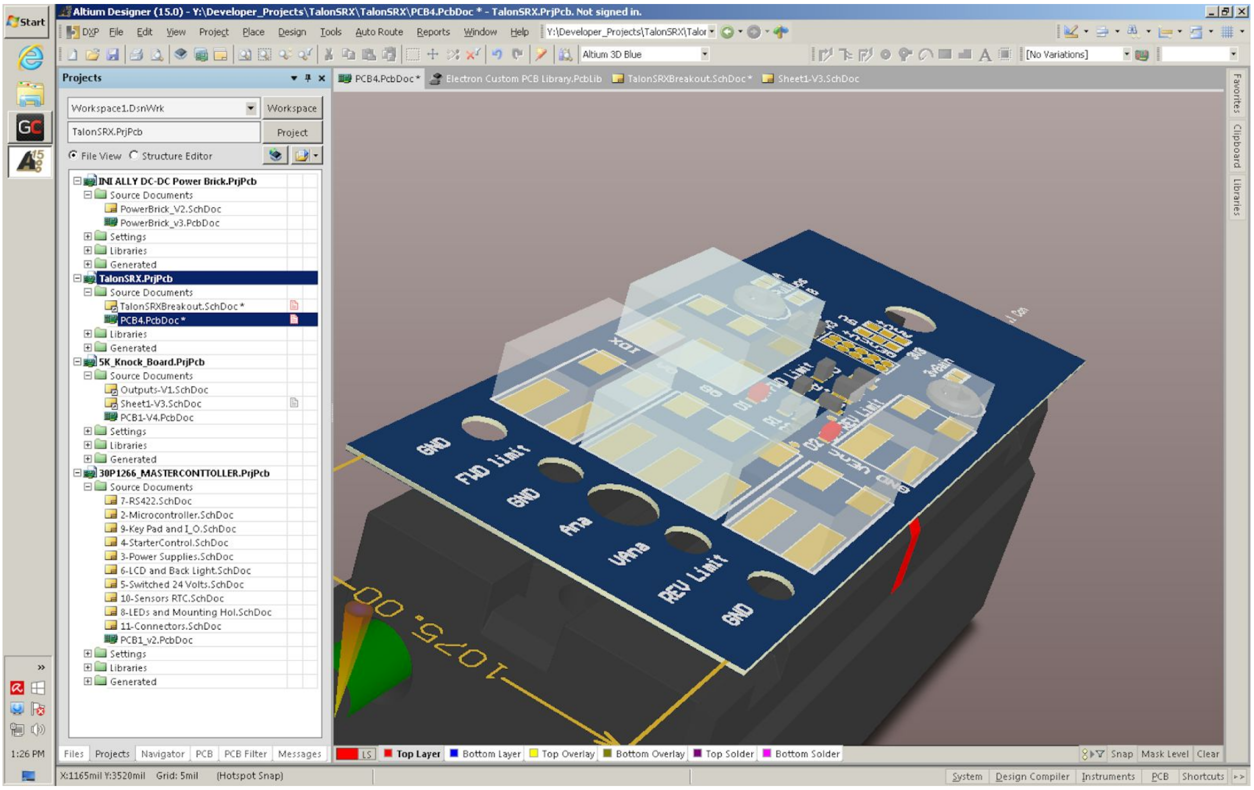
One of the key features of our boards is the choice of connector for attaching the encoder wires to the breakout. The style of connector we wanted is called a “direct wire to board” style connector and enables the attachment of a bare cable to the breakout board without the need for crimping an additional interface or pins to the encoder wires. After much research, we settled on the 2060 Series of connectors from the WAGO company.

Image of WAGO 2060 Series Connector (Hand and Wago Tool not included)

We believe these connectors met our requirements for a sturdy and easy to use connector that would enable us to connect encoders without the need to crimp on additional pins or headers.

2. Printed Circuit Board Layout Software

We chose to use Altium Designer as our PCB layout software. Altium's features, widespread industry adoption, and inclusion in the FRC Virtual Kit of Parts made it a natural choice. Additionally, Altium has the ability to easily render and export boards in a 3D format. This 3D capability aids in the design and layout of the board and can aid in the design of enclosures and checking interfaces between other devices.

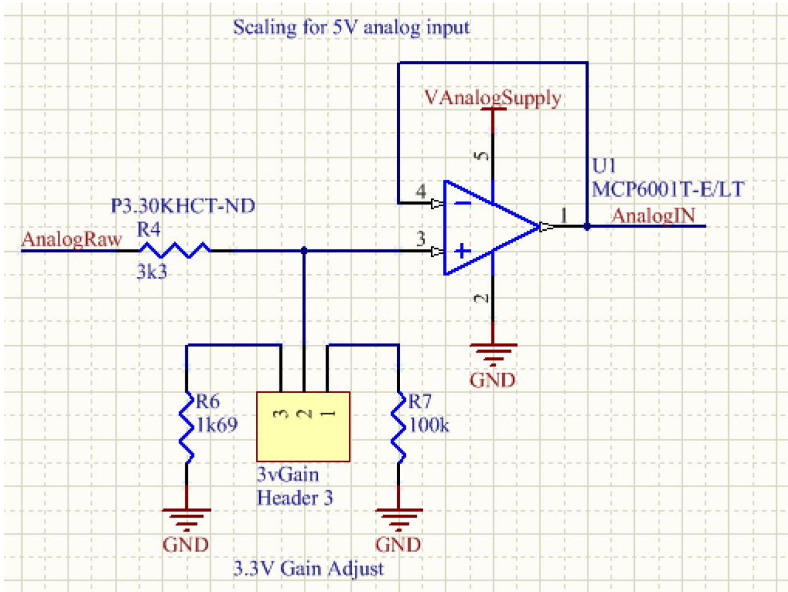


3. Circuits for Features

In addition to easy to use connectors, we also wanted our breakout boards to support several different usage scenarios:

- **5v to 3.3v conversion**

The heart of this circuit lies in the unity gain buffer operational amplifier circuit. This outputs the same signal as the input but draws power from a separate source, which allows a device to pull as much power from the circuit as necessary without affecting the input signal. Following the op-amp circuit is a resistor attenuator, also known as a voltage divider. The complete circuit is shown below where R1 is 66.5k and R2 is 33.2k to produce a voltage of 3.3v.

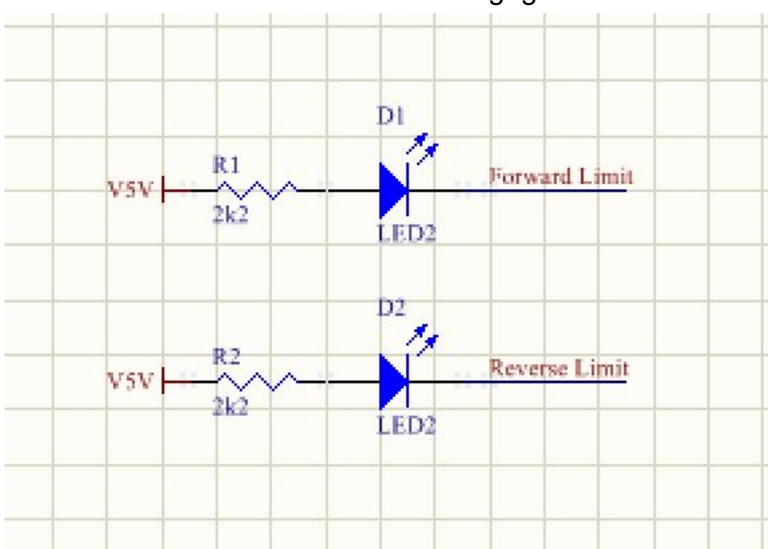


- **Bypass for the op-amp (3.3V Gain Adjust)**

This circuit is used to bypass the op-amp and enables the user to select a 3.3v voltage for the analog encoder via a solder jumper. This is done with an additional 100k resistor and a set of solder pads.

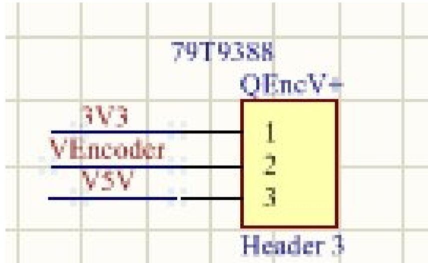
- **LEDs for Limit Switches**

This is a simple circuit with an LED and a resistor in series. These lights are used to help the user know when the forward or reverse limits are engaged.



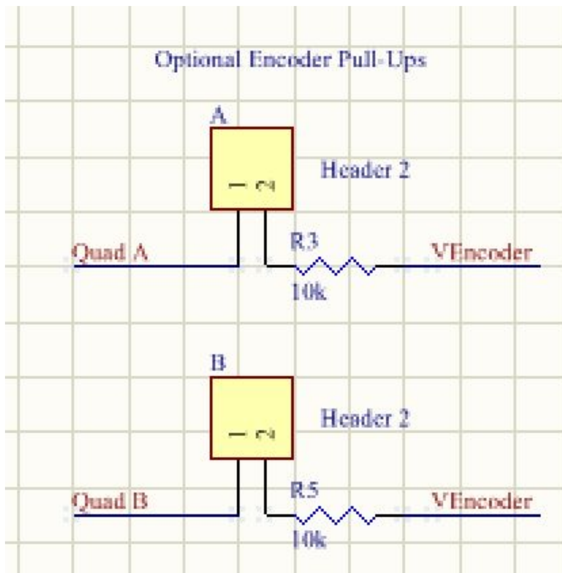
- **5v and 3.3v selection for quadrature**

This circuit is similar to the bypass and enables the user to select the voltage for the quadrature encoder via a solder jumper.



- **Quadrature Encoder Pullup Resistors**

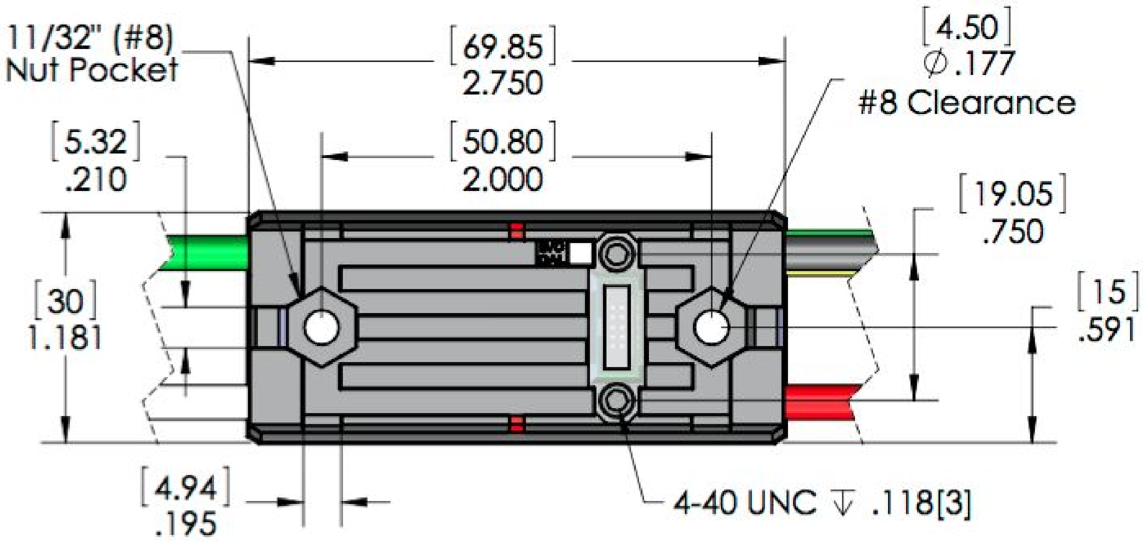
We've also added 10k pullup resistors for the quadrature encoder lines so that they are not floating. They can be activated via solder pads in the same way as the voltage selection:



4. Component placement, vias, and routing

We decided to place the components based on what was the most logical from a wiring and organizational standpoint. When it came down to wiring the components, we focused on using the least amount of vias. This entails keeping the most amount of wiring on the top layer of the board. Doing this helps keeps the board looking clean and avoids any potential hazard of short circuiting the board.

In an attempt to keep the board from short circuiting we created keepouts to indicate the areas that we should not have any connections running through. Using the dimensioned drawings of the Talon SRX, the diagram below, a digital caliper, and lots of patience we mapped out the areas where the board will make contact with the motor controller as seen in dark blue in the picture below.



Talon SRX Dimensions

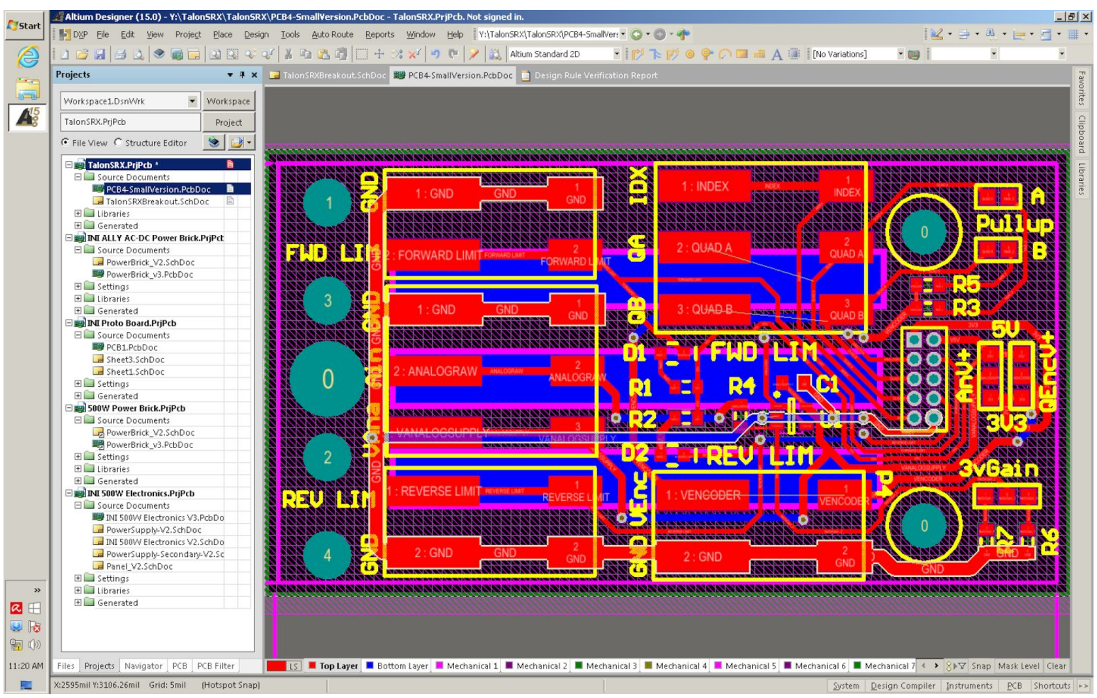


Image of Routing Traces and Vias

5. Final Board Design

Our final board design ended up being compact and we added some additional features for securing the board to the Talon via a zip tie. We also added holes in the board for additional zip ties to be mounted as strain relief for the cables going into the board.

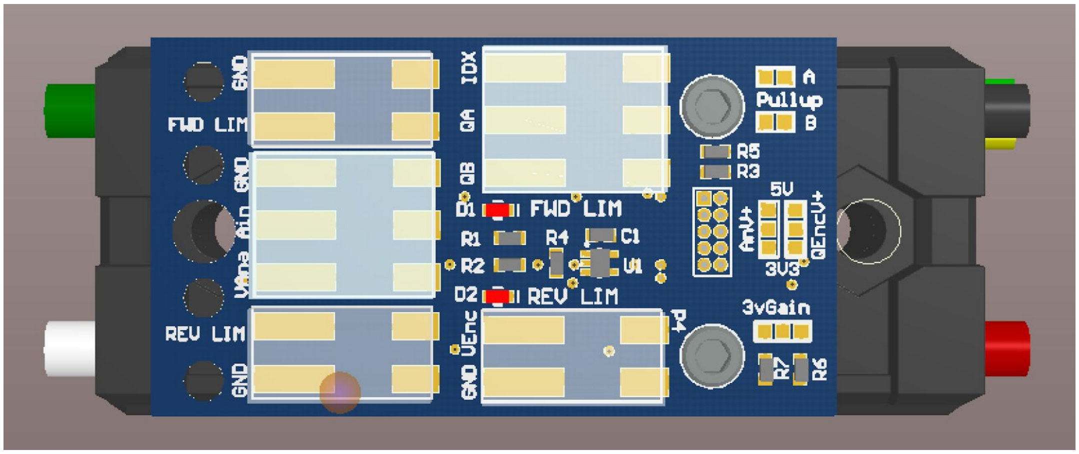
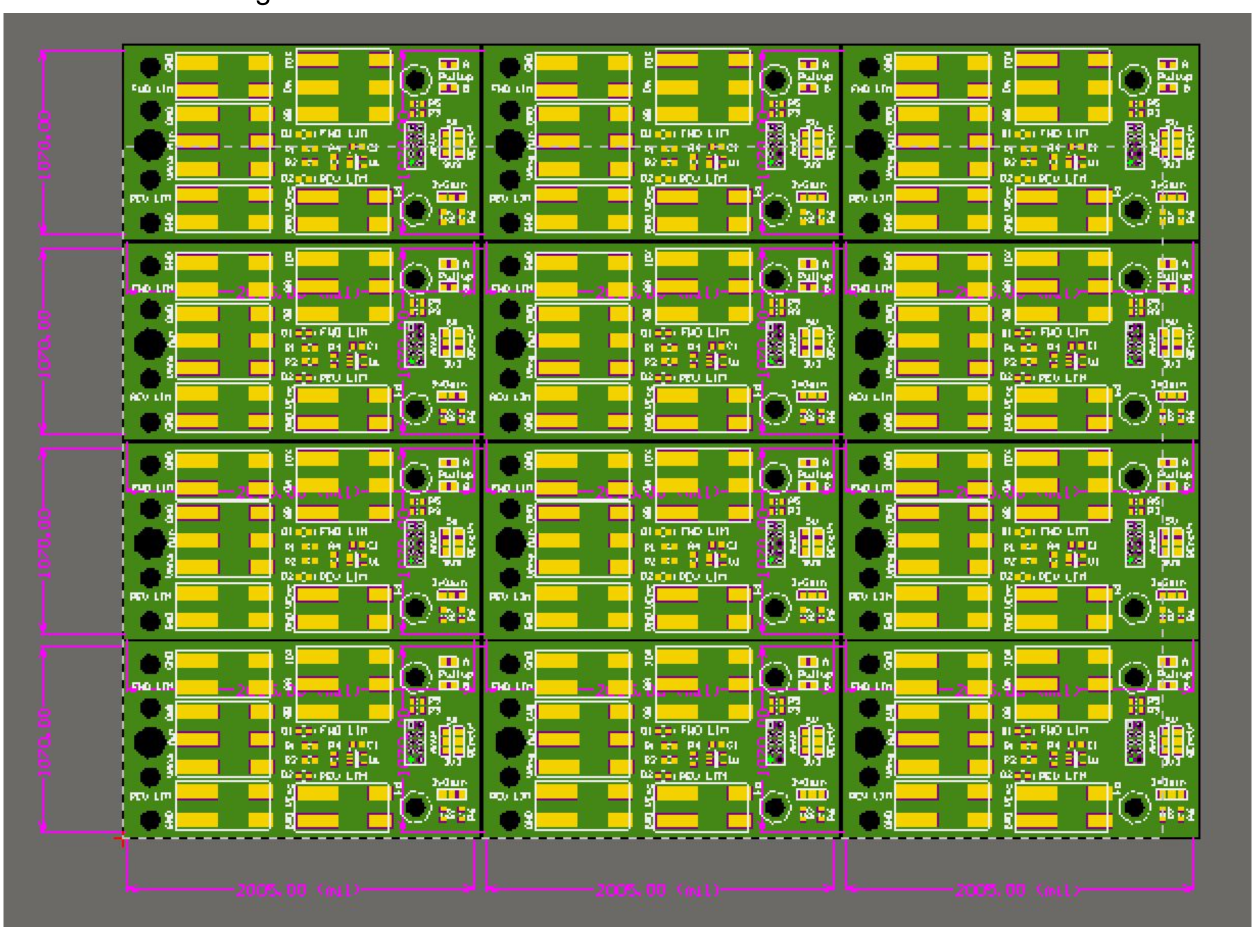


Image of final board design before fabrication

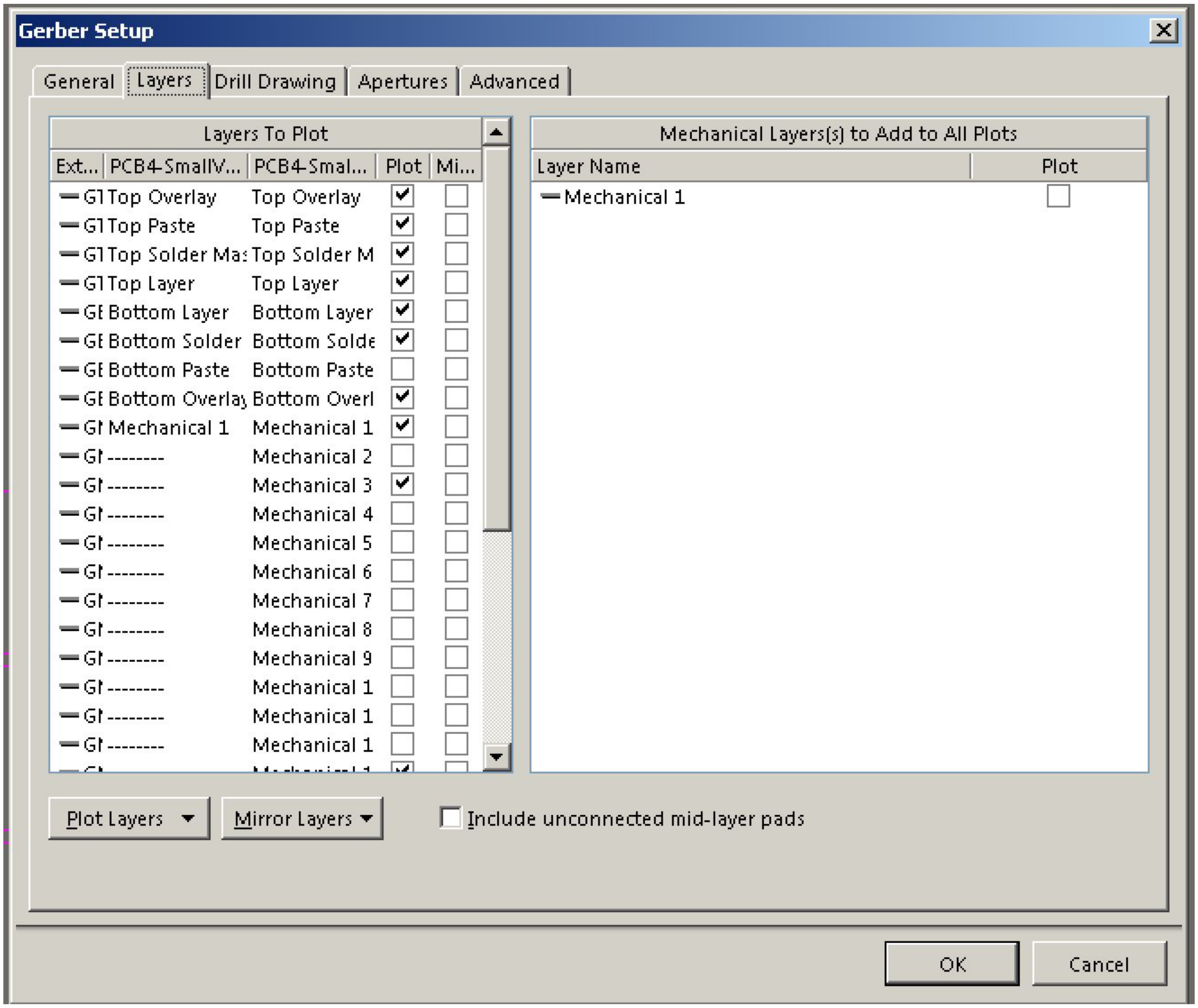
6. Fabrication

Before creating the fabrication outputs, the PCB layout was panelized to create an array of boards. (File > Place > Embedded Board / Panelize) This is done to reduce the piece cost of the individual boards. The panel layout added .010” spacing between the individual boards to give clearance for scoring.



Screenshot showing the PCB Panel

Using Altium's Fabrication Output options, the Gerber and NC Drill files were generated. (File > Fabrication Outputs > Gerber Files AND File > Fabrication Outputs > NC Drill Files) For the Gerber files, the units (inches), format (2:5) , and layers (used layers) were each selected before file generation.

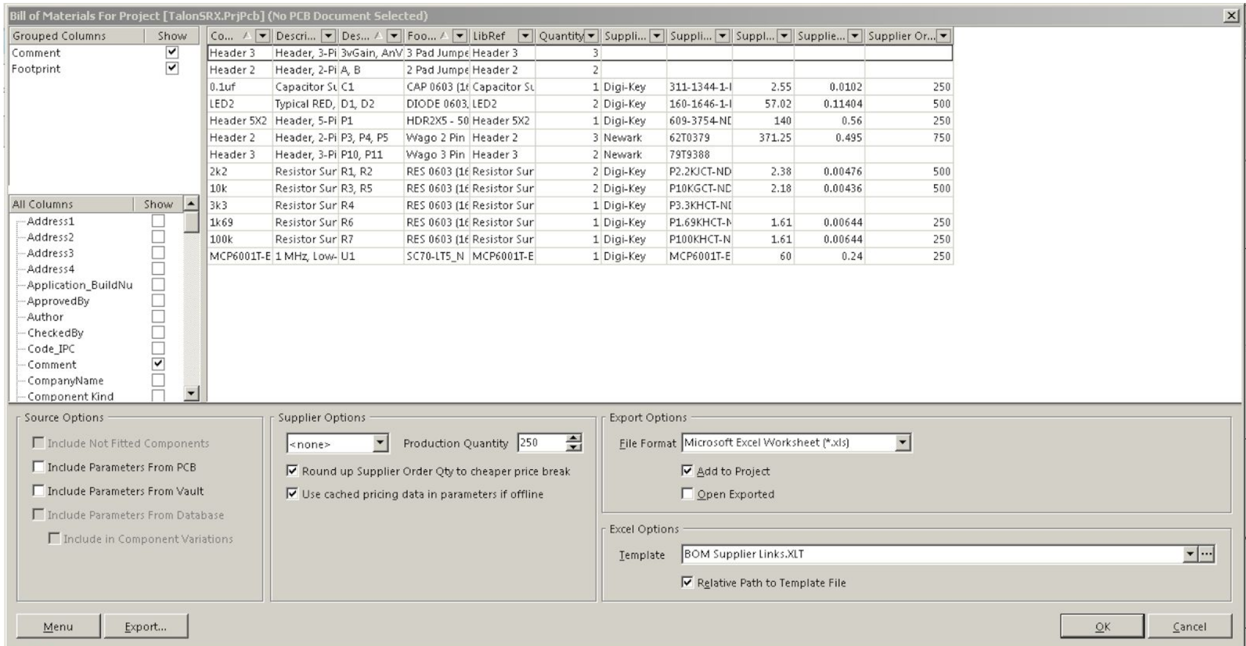


Screenshot showing the output file selection

The output files were double-checked using GC-Preview. This is a great tool for generic footprint and pcb layout checking. It provides an independent view of the board layout and possible errors, such as drill file scaling.

The PCB was sourced through Advanced Circuits (4pcb.com) for several reasons, one is that they are price and quality competitive with other popular quickturn services, such as Sunstone, or PCB Universe. Other reasons include their FreeDFM service (Design for Manufacturability), student discounts, and excellent customer service. Advanced circuits also offers a full turnkey service where they do the PCB and assembly, but for this project we elected to assemble the boards ourselves.

Altium's built-in BOM feature was used to create a parts list in Excel format which was then used to order components from Digikey (digikey.com) and Newark (newark.com).



Screenshot showing the BOM generation

Resource Links

- Link to board source files: https://github.com/5190GreenHopeRobotics/TalonSRXBreakout
- Link to FRC Altium Download Site: http://www.altium.com/first-robotics-competition
- Link to Talon SRX User Manual: http://www.ctr-electronics.com/Talon%20SRX%20User's%20Guide.pdf
- Link to Talon SRX Dimensioned Drawing: http://www.ctr-electronics.com/downloads/cad/217-8080-Drawing-20150120.PDF