Motor Control Progress Report #7

Skittle Sorter Project

Jaidon Lybbert, Motor Control Design Lead, EWU IEEE Student Chapter

Week of 08/16/20

Problem:

- The motor driver circuit using the l293b has been prototyped on a breadboard, which is a temporary solution, and has poor cooling, causing the chip to melt the breadboard when run for extended periods of time
- Motor control development has been done on a separate branch on GitHub for several weeks, and merge conflicts have shown up between the motor control branch and the master branch
- Motor control progress reports have been in scattered formats and memos without a defined format

Research:

- Resolving merge conflicts on GitHub
    - https://docs.github.com/en/github/collaborating-with-issues-and-pull-requests/resolving-a-merge-conflict-using-the-command-line
- Using KiCad to design PCBs
    - See “Getting Started with KiCad” at the end of this report

Action:

- Researched PCB design and manufacturing
- Learned KiCad
- Designed and redesigned PCB for the driver circuit
    - See “Stepper Driver PCB Design” and “Stepper Driver PCB Iterations” at the end of this report
- Merged the motor control branch to the master branch on GitHub
- Consolidated weeks of notes into polished progress reports

Value:

- Merging multiple weeks of changes onto the master branch finalizes the changes and brings our main development branch up to date
- A PCB for the driver circuit will allow us to clean up our hardware to make it more presentable, easier to use, and allows for better cooling of the ICs
- Knowledge of designing PCBs will aid in future projects that require them
- A clear history of progress with the motor control will help new team members get up to date, as well as communicate new changes with other teams

Stepper Driver PCB Design

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08/23/20

This document describes the current stepper motor driver PCB design.

3D View:

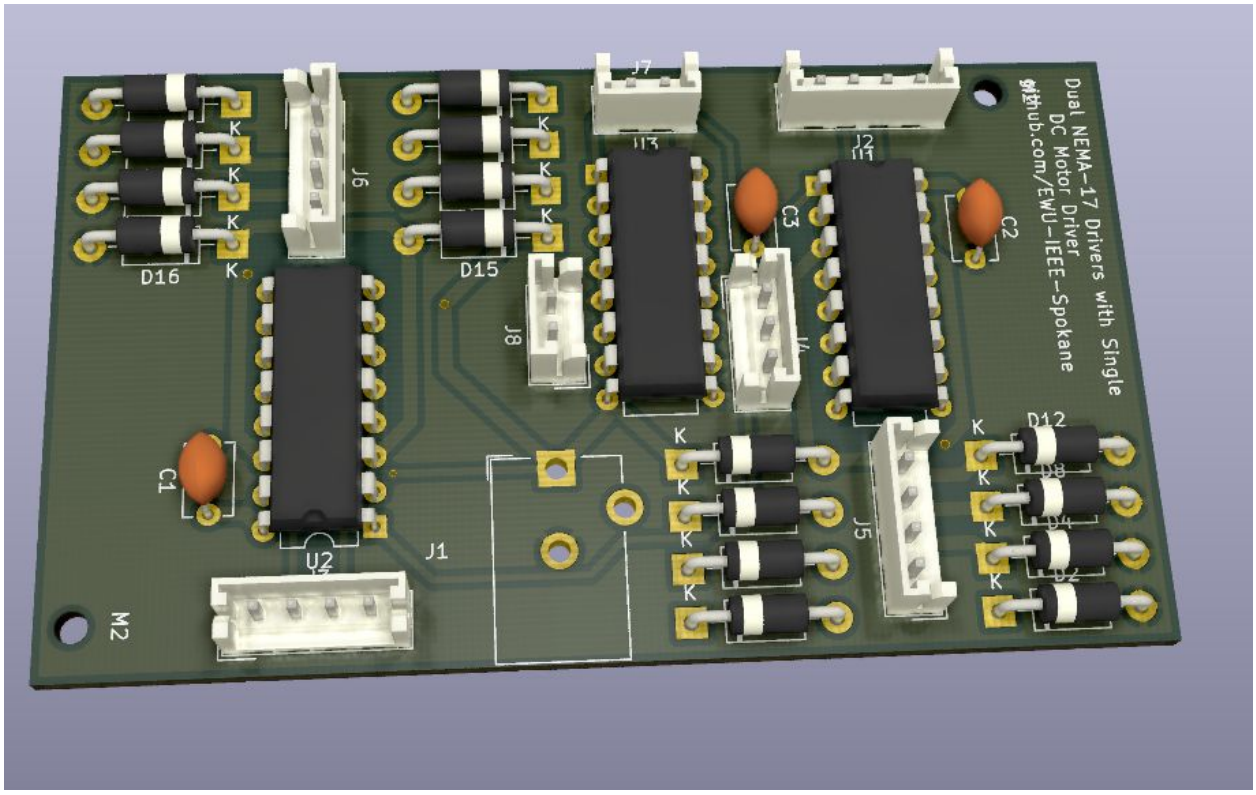

Fig. 1: Current version of the driver PCB. The outer ICs are l293B chips, and the center IC is an l293D chip. The l293Bs have 2 external 1N4001 flyback diodes for each of their 4 output pins (J5, J6). The connectors at the top end of each IC are the logical inputs (J2, J7, J3) and connector J4 has one active high enable pin for each IC. Each IC has one 0.22uF bypass capacitor for its logic power supply input.

PCB Specifications:

- Layers: 2
- Dimensions: 44.45 x 76.20mm
- Thickness: 1.6mm
- Copper weight: 2 Oz.

Components List:

"Source:" "C:\Users\Jaidon Lybbert\Documents\Classwork\EENG250\Lab0\MotorDriver\Motor_Driver\Motor_Driver.sch"
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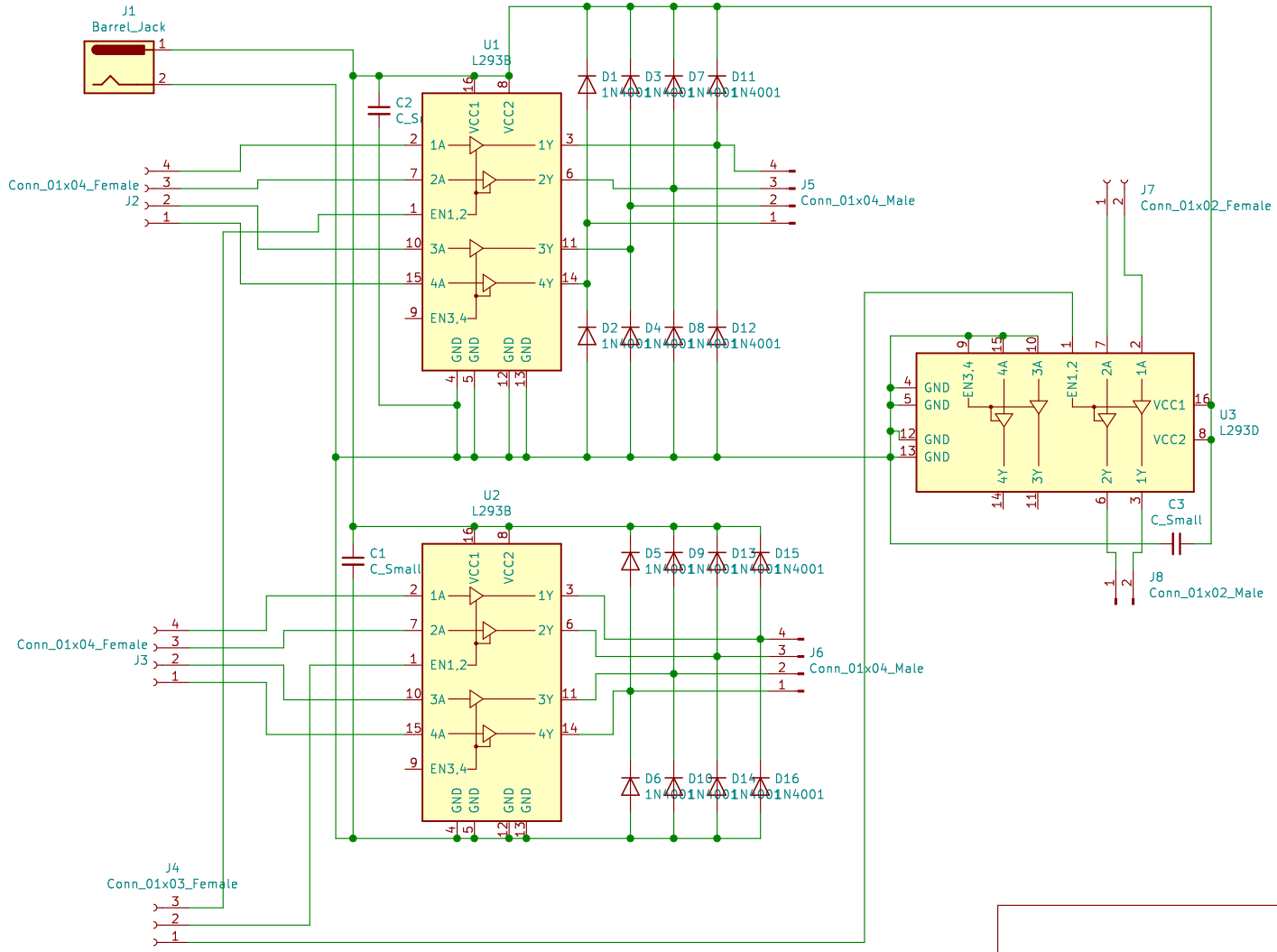
"C1"	"0.22uF"	"Device:C_Small"	"Capacitor_THT:C_Disc_D5.1mm_W3.2mm_P5.00mm"	"Unpolarized capacitor, small symbol"	""
"C2"	"0.22uF"	"Device:C_Small"	"Capacitor_THT:C_Disc_D5.1mm_W3.2mm_P5.00mm"	"Unpolarized capacitor, small symbol"	""
"C3"	"0.22uF"	"Device:C_Small"	"Capacitor_THT:C_Disc_D5.1mm_W3.2mm_P5.00mm"	"Unpolarized capacitor, small symbol"	""
"D1"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D2"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D3"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D4"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D5"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D6"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D7"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D8"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D9"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D10"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D11"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D12"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D13"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D14"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D15"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"D16"	"1N4001"	"Diode:1N4001"	"Diode_THT:D_DO-41_SOD81_P10.16mm_Horizontal"	"50V 1A General Purpose Rectifier Diode, DO-41"	
"J1"	"Barrel_Jack"	"Connector:Barrel_Jack"	"Connector_BarrelJack:BarrelJack_Horizontal"	"DC Barrel Jack"	""
"J2"	"Conn_01x04_Female"	"Connector:Conn_01x04_Female"	"Connector_JST:JST_EH_B4B-EH-A_1x04_P2.50mm_Vertical"		
"J3"	"Conn_01x04_Female"	"Connector:Conn_01x04_Female"	"Connector_JST:JST_EH_B4B-EH-A_1x04_P2.50mm_Vertical"		
"J4"	"Conn_01x03_Female"	"Connector:Conn_01x03_Female"	"Connector_JST:JST_EH_B3B-EH-A_1x03_P2.50mm_Vertical"		
"J5"	"Conn_01x04_Male"	"Connector:Conn_01x04_Male"	"Connector_JST:JST_EH_B4B-EH-A_1x04_P2.50mm_Vertical"		
"J6"	"Conn_01x04_Male"	"Connector:Conn_01x04_Male"	"Connector_JST:JST_EH_B4B-EH-A_1x04_P2.50mm_Vertical"		
"J7"	"Conn_01x02_Female"	"Connector:Conn_01x02_Female"	"Connector_JST:JST_EH_B2B-EH-A_1x02_P2.50mm_Vertical"		
"J8"	"Conn_01x02_Male"	"Connector:Conn_01x02_Male"	"Connector_JST:JST_EH_B2B-EH-A_1x02_P2.50mm_Vertical"		
"U1"	"L293B"	"Driver_Motor:L293"	"Package_DIP:DIP-16_W7.62mm"	"Quadruple Half-H Drivers"	""
"U2"	"L293B"	"Driver_Motor:L293"	"Package_DIP:DIP-16_W7.62mm"	"Quadruple Half-H Drivers"	""
"U3"	"L293D"	"Driver_Motor:L293D"	"Package_DIP:DIP-16_W7.62mm"	"Quadruple Half-H Drivers"	""

Additional notes:

- The l293B chips require heatsinks



EWU IEEE Student Chapter		
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Stepper Driver PCB Iterations

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08/23/20

This document serves as a history for the various changes that have been made to the motor driver PCB design over its many iterations, and why those changes were necessary.

Iteration 1

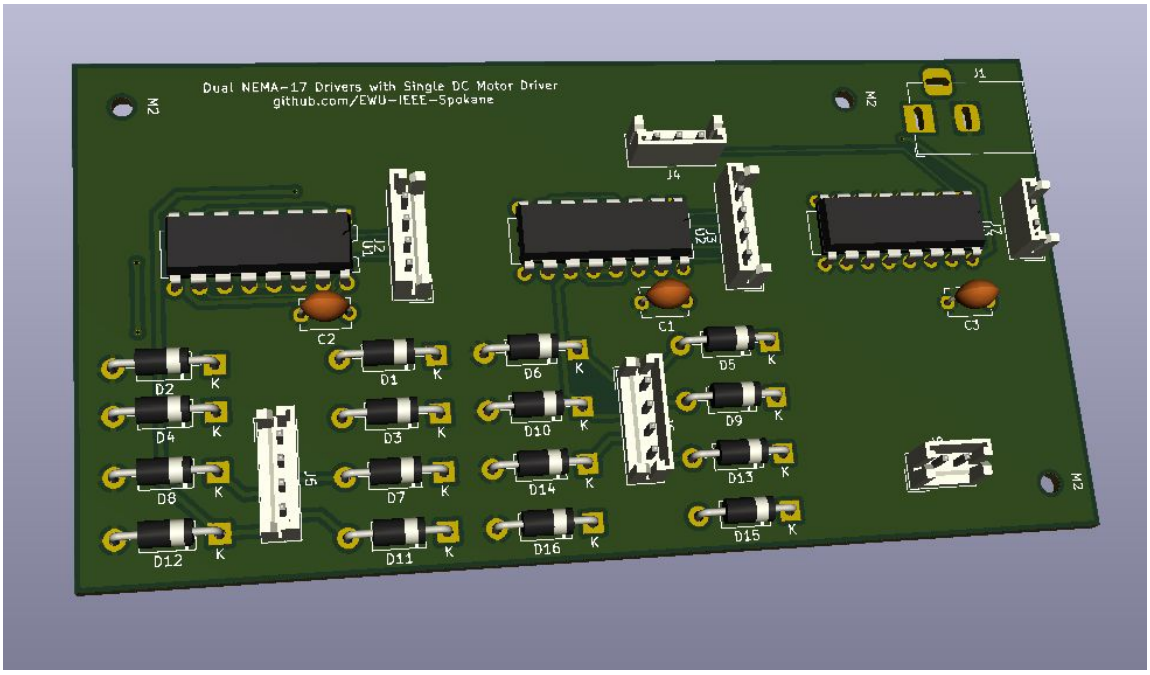

Fig. 1: 3D view of the first design of the motor driver PCB.

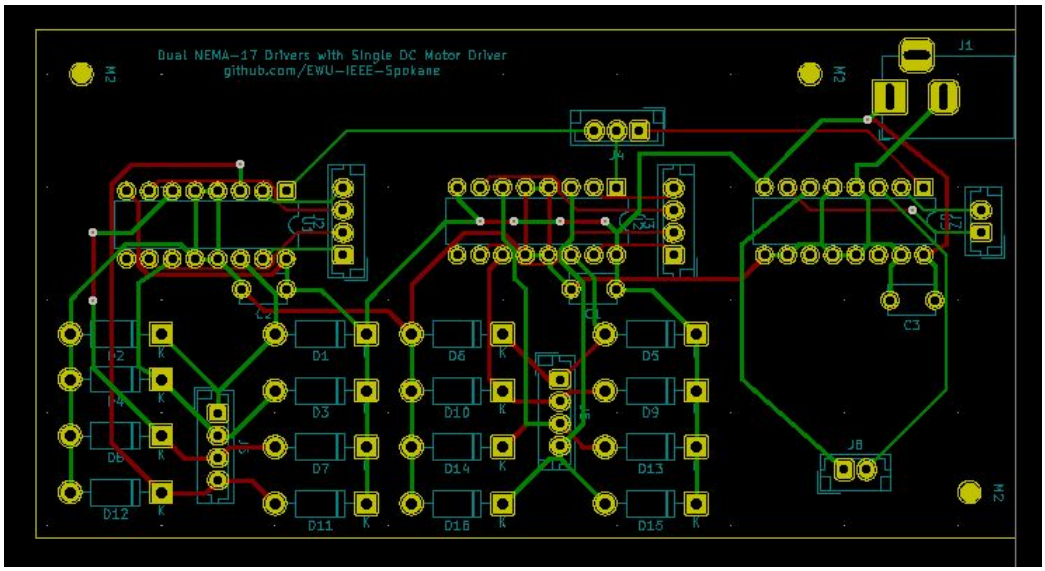

Fig. 2: Trace view of the first PCB design. Notice the poor layout of components, long traces, excessive vias necessary, and ridiculous daisy-chained power supply with slim traces.

Issues with iteration 1:

- The power supply is located at one end of the board, and the ICs are daisy-chained together. When one IC draws a lot of current, the ICs up the chain will likely experience a lot of noise at both their logic supply, and power supply inputs.
- The trace widths for the power supply pins are not wide enough. They would burn and short with less than 1 amp of current. Since the chips are daisy-chained, a lot more than 1 amp (closer to 4) could be drawn through these traces.
- There is a lot of unused space on the board. Traces are long, which will increase noise and thermal losses.
- The outputs are far from the ICs and placed in an awkward position, making running traces to them difficult (there are two output pins on either side of each IC) and long.

Iteration 2

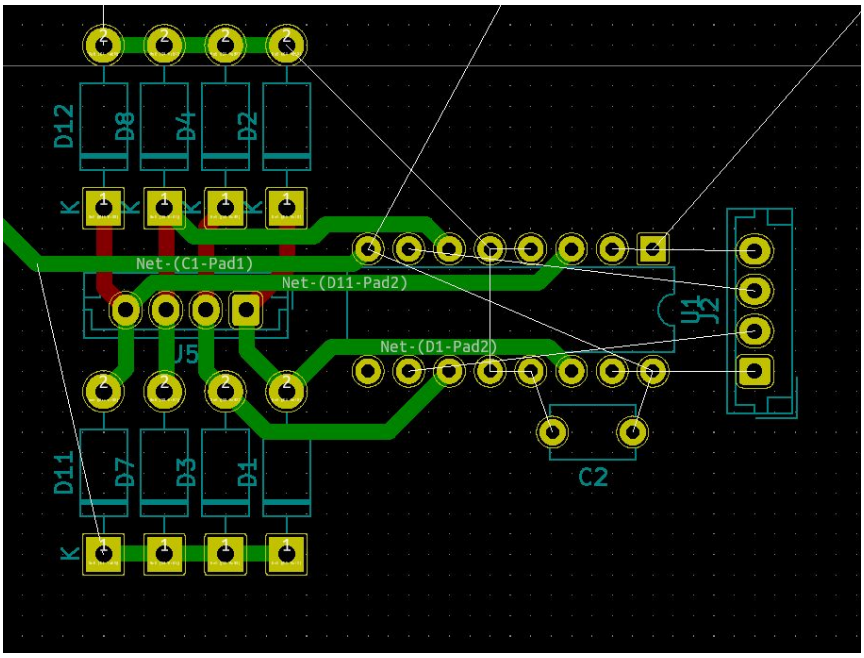

Figure 3: The second iteration of the PCB design. At this stage I focused only on the layout of one L293B, since it would be duplicated for the other. When I noticed issues, I stopped and restarted instead of carrying through and finishing the board.

Improvements in iteration 2:

- The trace widths are now wide enough to carry the desired current, so long as ICs are not daisy-chained, and a copper weight of 2 oz is used.
- The placement of the output pins at the bottom of the IC, instead of the side, allows for shorter, more direct connections between the IC and connector.
- Traces around the heatsink/ground pins are eliminated, allowing better thermal dissipation across the ground planes.
- Due to the better layout, no vias are necessary, and the footprint is reduced in size.

Issues with iteration 2:

- The flyback diodes from output to VCC are on the opposite side of the IC from the VCC input pin. This means a high current trace would have to be run around the board or underneath it. Rotating the flyback diode/output connector section 180° would allow a shorter direct connection.

Iteration 3

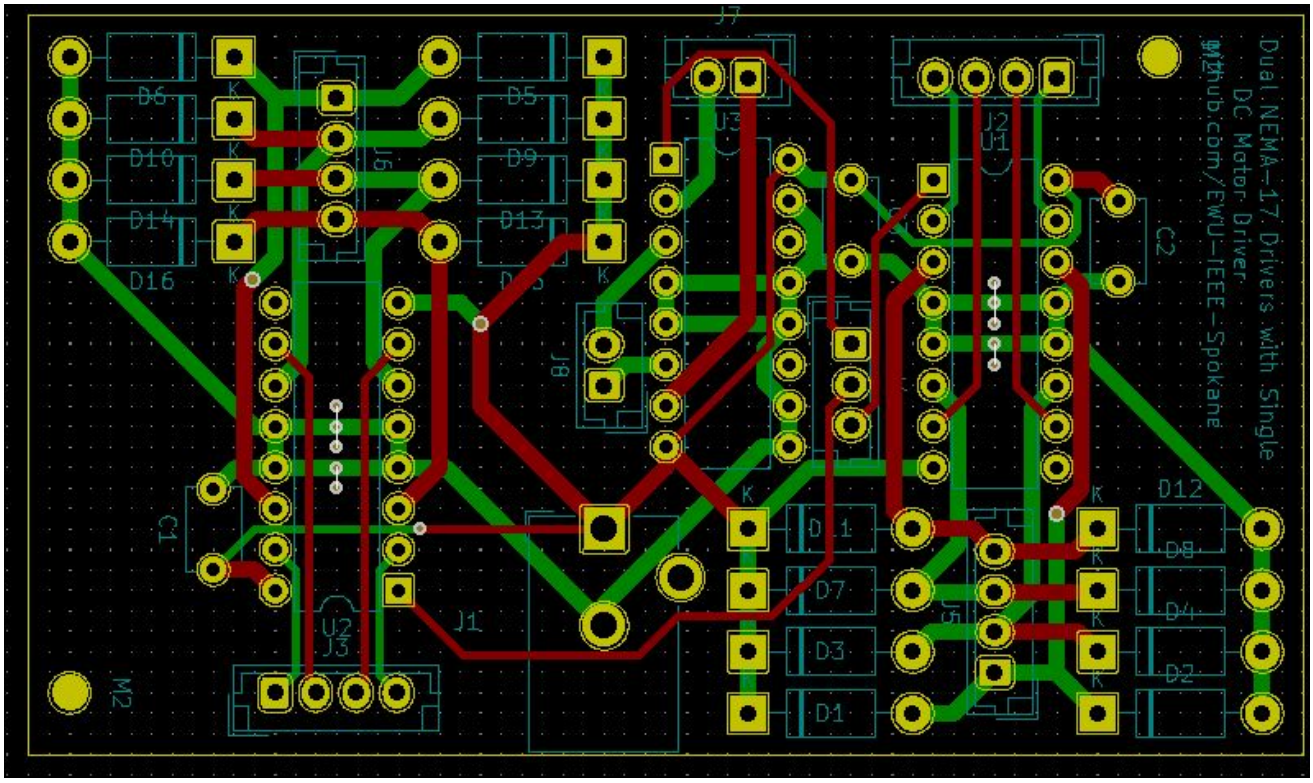

Figure 4: Iteration 3 of the driver PCB. A small layout means high current traces are kept minimized and direct, and noise is reduced.

Iteration 3 improvements:

- Total area is reduced from 64 cm^2 to 34 cm^2 when compared to iteration 1.
- Power connections are direct (the daisy-chaining seen between U1 and U3 does not occur in the design, that is the one modification not shown here).
- Thermal vias are included to conduct heat from the center of each l293B to the ground plane on the backside of the board.
- Total number of vias (excluding thermal vias) is reduced from 9 to 4.

Iteration 3 issues:

- This design will require external heatsinks for the l293B chips as there is simply not enough copper on the ground planes to dissipate the heat