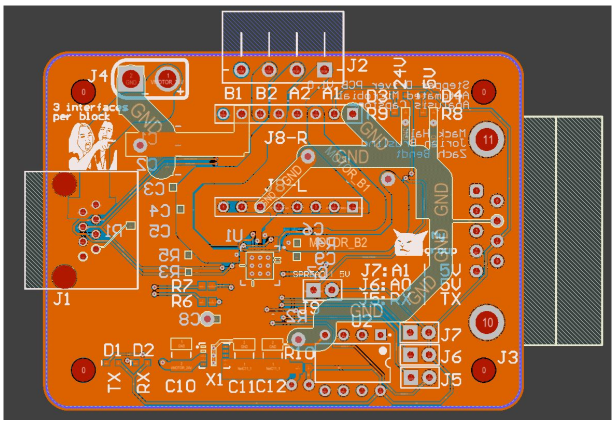
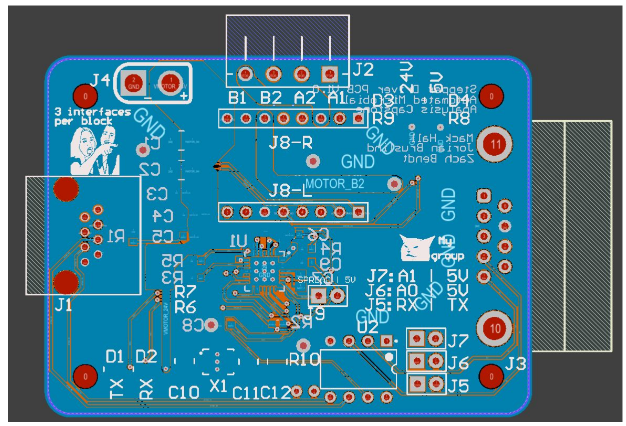
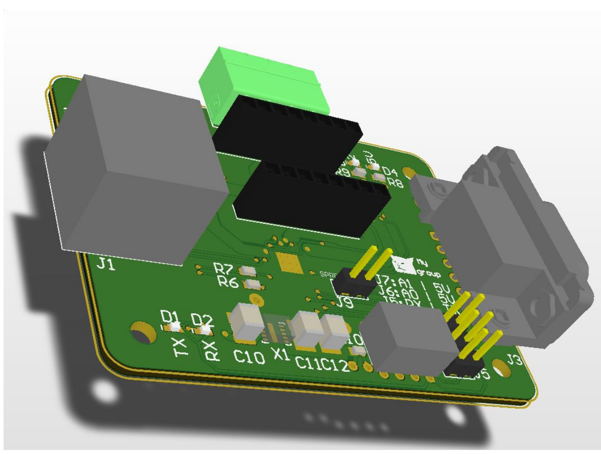
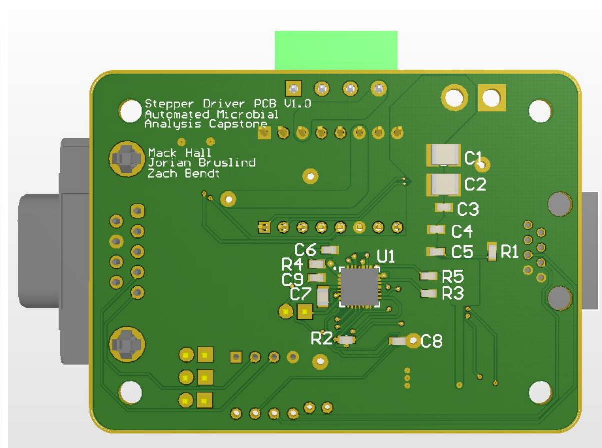
Auxiliary Driver PCB

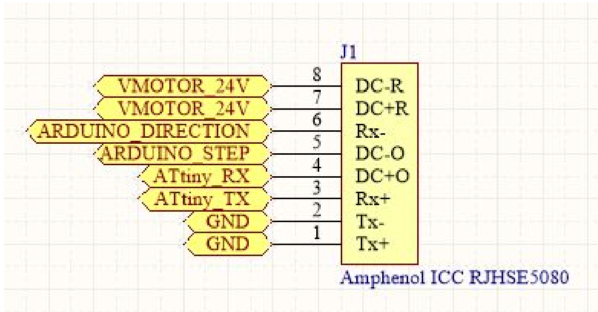
Block Owner: Mack Hall
Date: Mar-17-2020

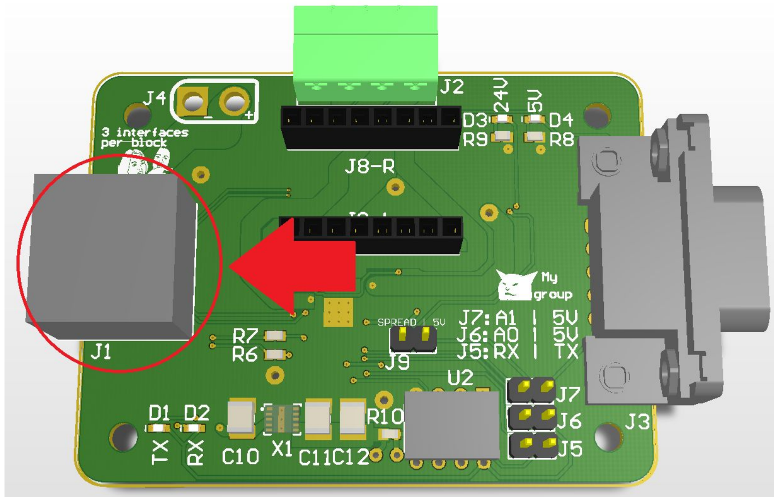
Design Overview

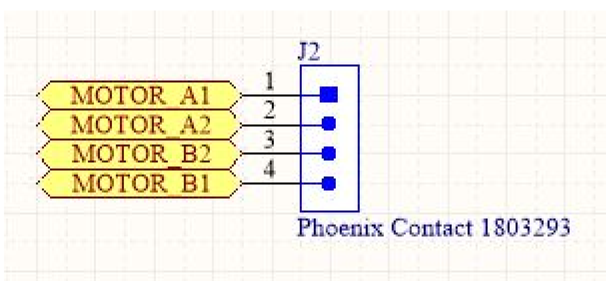
Design Validation Overview

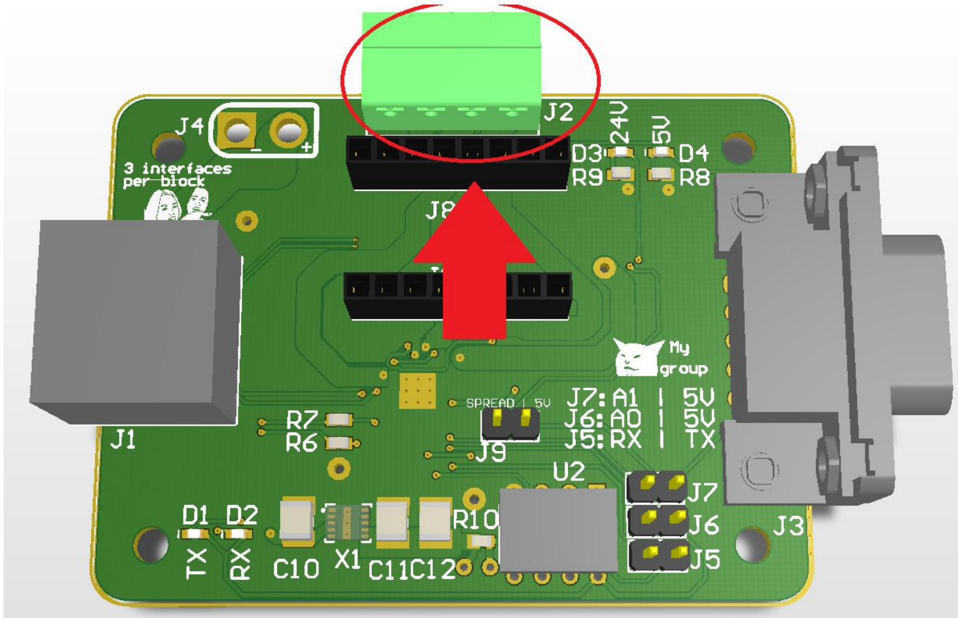
This PCB acts as a link between the Primary Control PCB and the stepper motors themselves. Since there are three stepper motors, there will be three separate instances of this PCB in the final system. This PCB takes in a signal from one of the ATMEGA328s on the Primary Control PCB, and outputs another electrical signal which will turn the stepper motors. In order to verify that this PCB is working correctly, there are status LEDs for 24V and 5V power, as well as status LEDs for RX and TX packets.



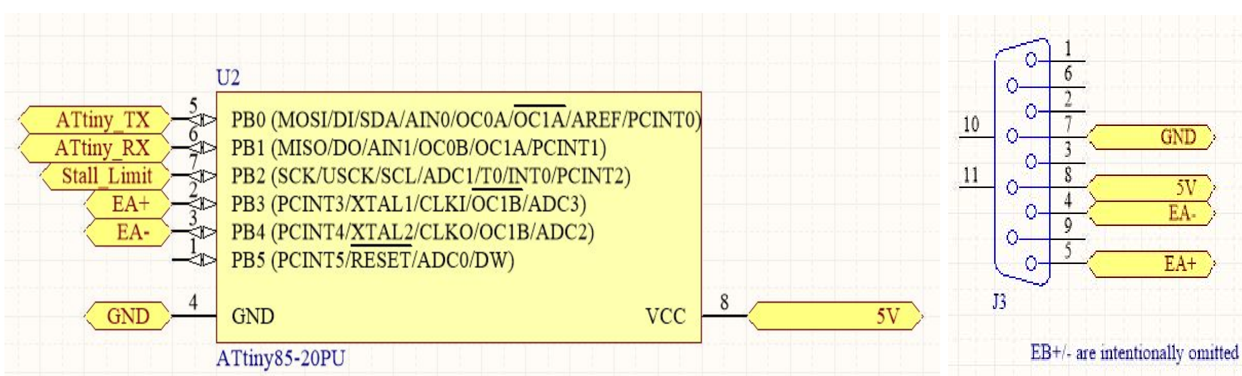


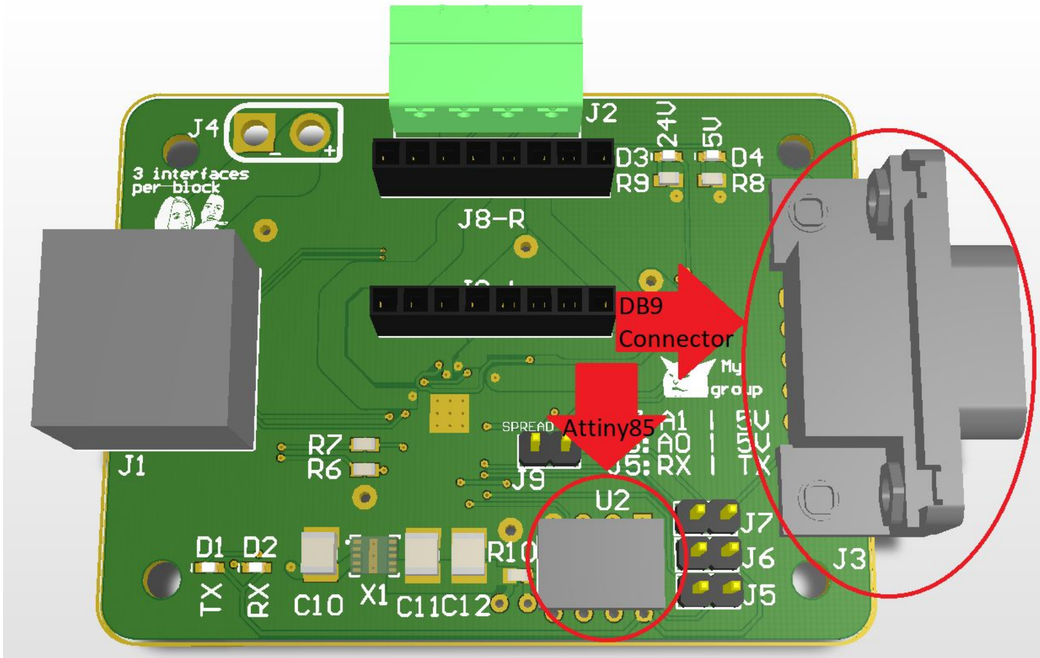
J2, a Phoenix Contact 1803293, is the connector for the stepper motor itself. The connector is compatible with the stepper motors we already had as a group, and were chosen as a result. This connector is capable of handling up to 8A. Since the motors themselves only use up to 2A maximum at a time, this has a safety factor of 400%.



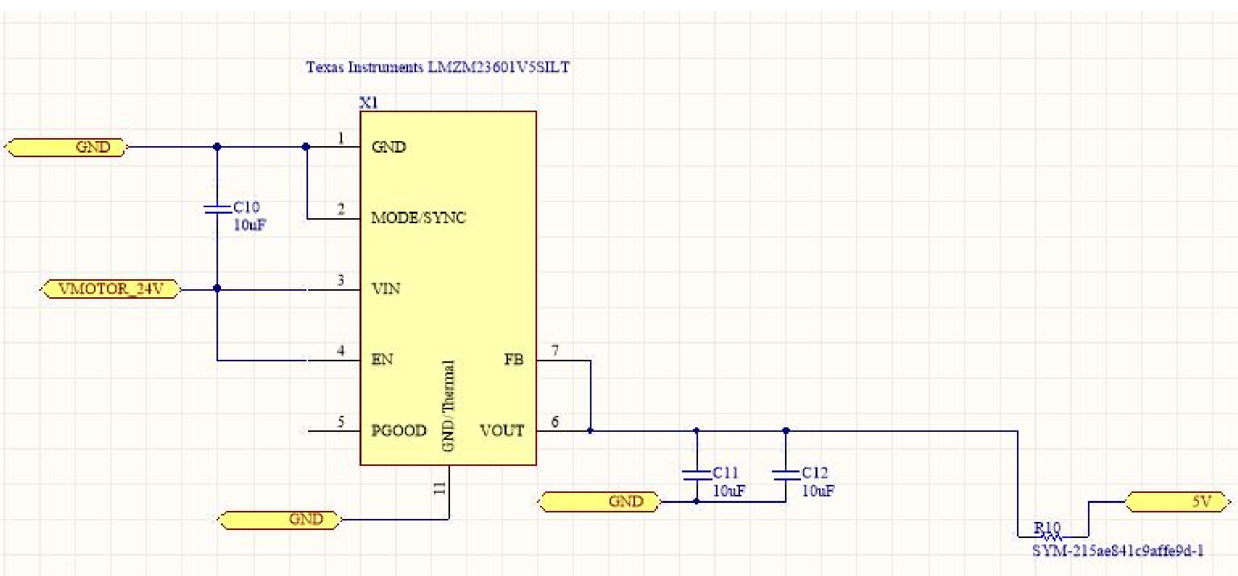


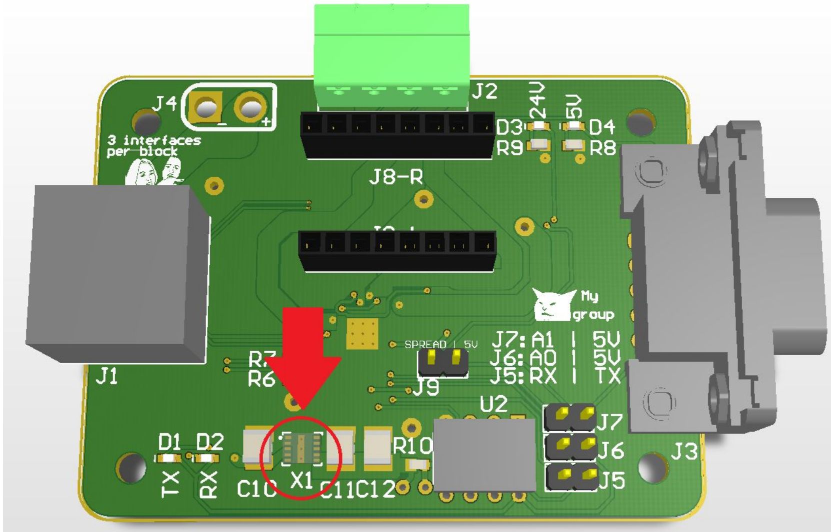
J3, a TE Connectivity / AMP 5747844-4, is the DB9 connector used to interface with the encoder integrated on the stepper motor itself. The DB9 connector allows the encoder signal to be read in by the ATtiny85 (U2 on the PCB), where the signal is interpreted. Finally, the motor position is sent back to the Central Processing PCB along the ethernet cable via serial communication. This allows the software to know where the motors are physically at all times. This allows a greater degree of control, because the motors may occasionally “miss” a step and become misaligned with their intended position. The encoder signal allows us to detect this and either compensate for this error on the software side of things or completely re-home the system altogether. Missing a step typically only occurs at higher speeds, and our motors are run at relatively low speeds, so it should not come up too often, but it is always good to prepare for the worst.



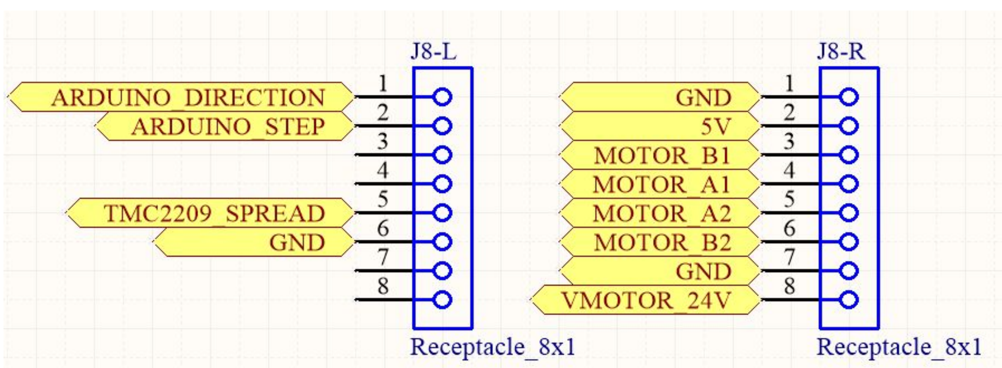


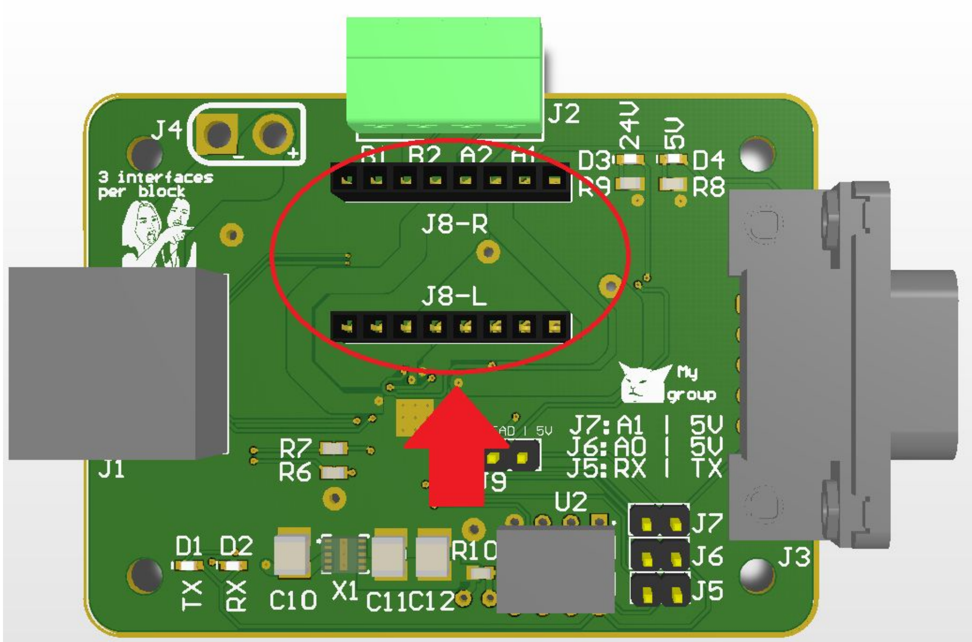
X1 is a Texas Instruments LMZM23601V5SILT buck converter which converts the 24VDC line to a 5VDC line for use on the Auxiliary Driver PCB. The 5V line is used to power the stepper driver, the encoder, the Attiny85, and the RX, TX, and 5V status LEDs. The LMZM23601V5SILT is rated for up to 1A of use, but the auxiliary current the Auxiliary Driver PCB draws is much less than that in reality.

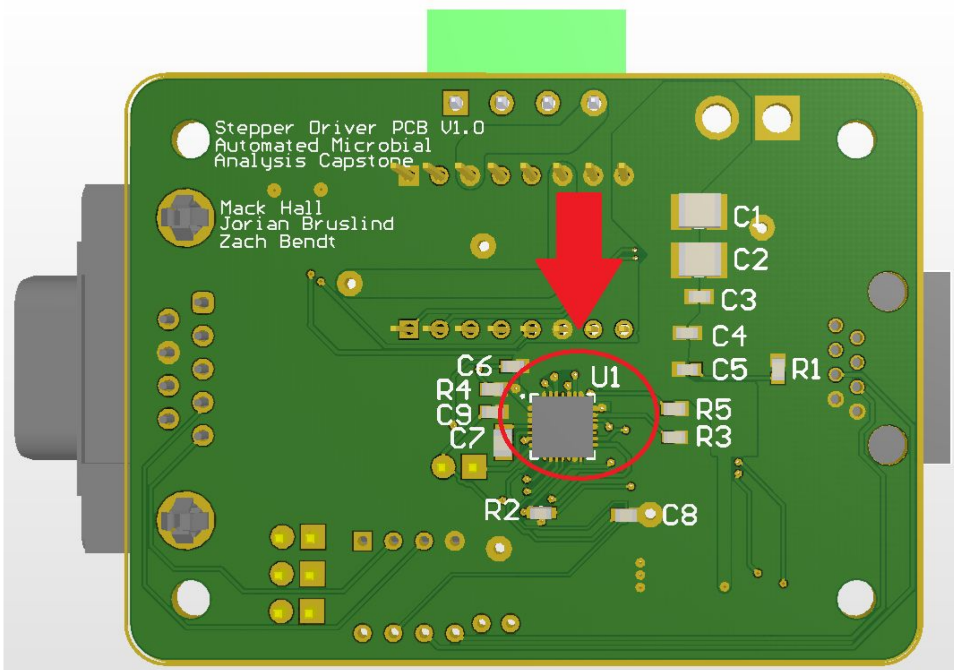




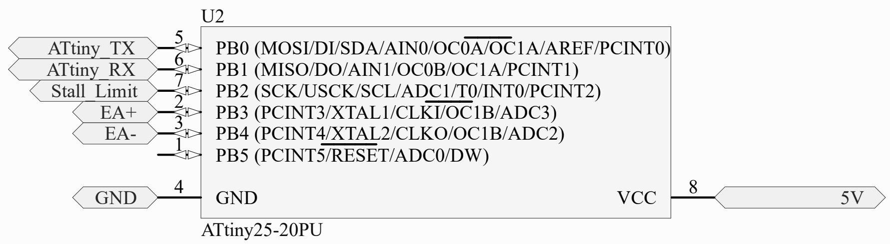
J8-L and J8-R are sockets for where a stepper driver daughterboard (a.k.a. stepstick) could connect. Although it can be used for testing and debugging purposes, this socket is not to be used in the final system, as all microcontrollers under 64 pins must be soldered directly on the PCB. On the opposite side of the PCB, there is a place to solder an SMD stepper driver chip (U1 on the PCB). We chose to go with the Trinamic TMC2209 due to its low cost and high reliability. The TMC2209 is capable of handling up to 2.2 A per stepper motor, which is below our peak of 2 A. The stepper driver will have a heatsink in addition in order to help dissipate heat and ensure high performance over extended operational periods.







A detailed list, and link to all of the datasheets for the components on the Auxiliary Driver PCB are found here: [Stepper PCB Materials]



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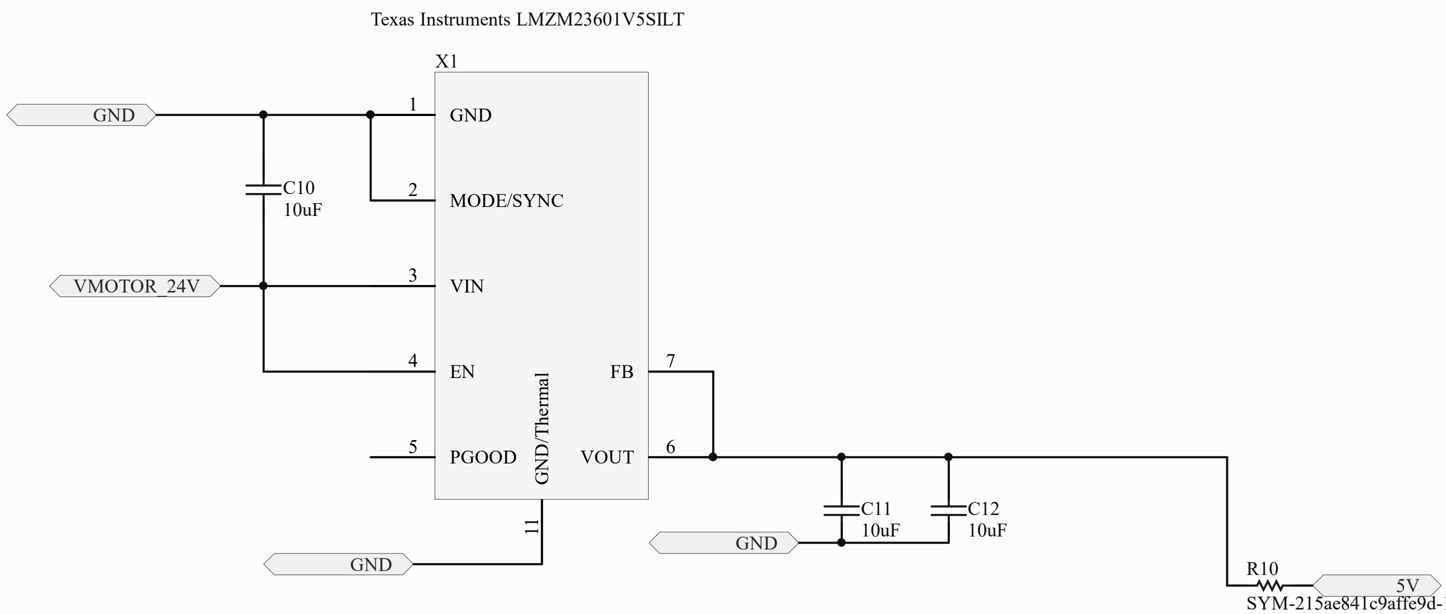

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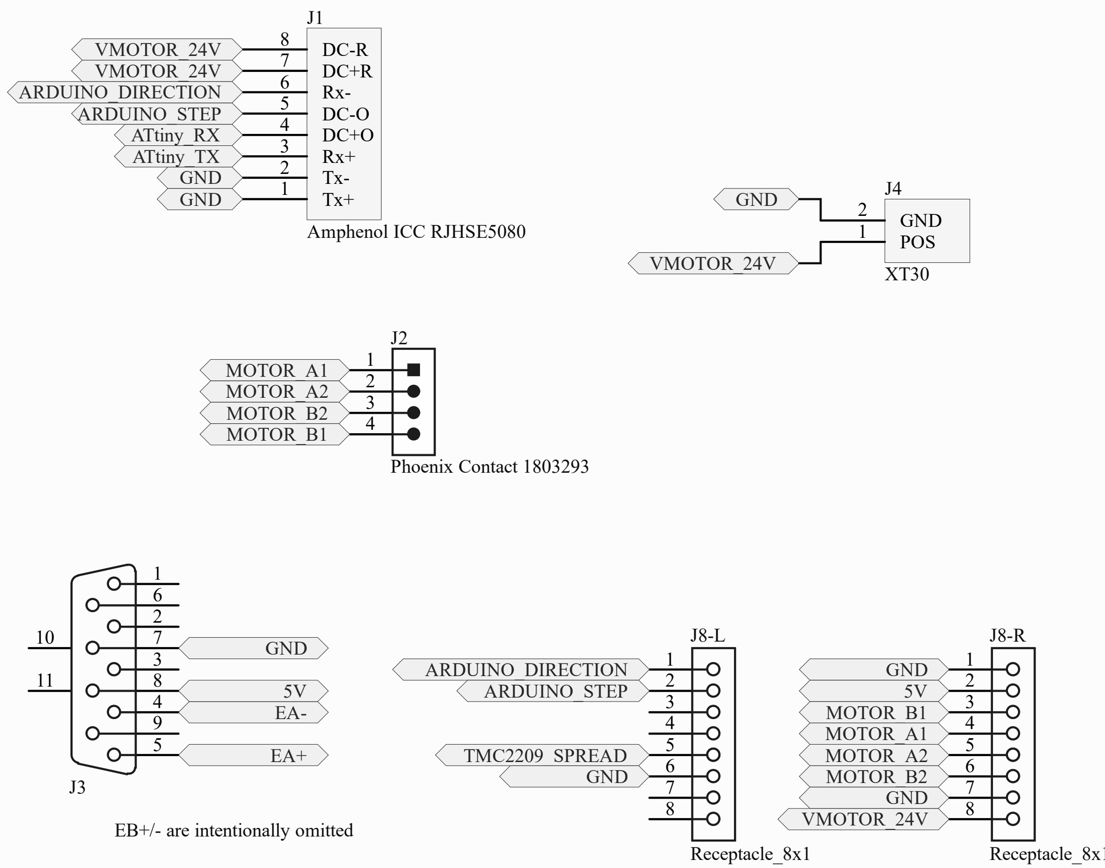

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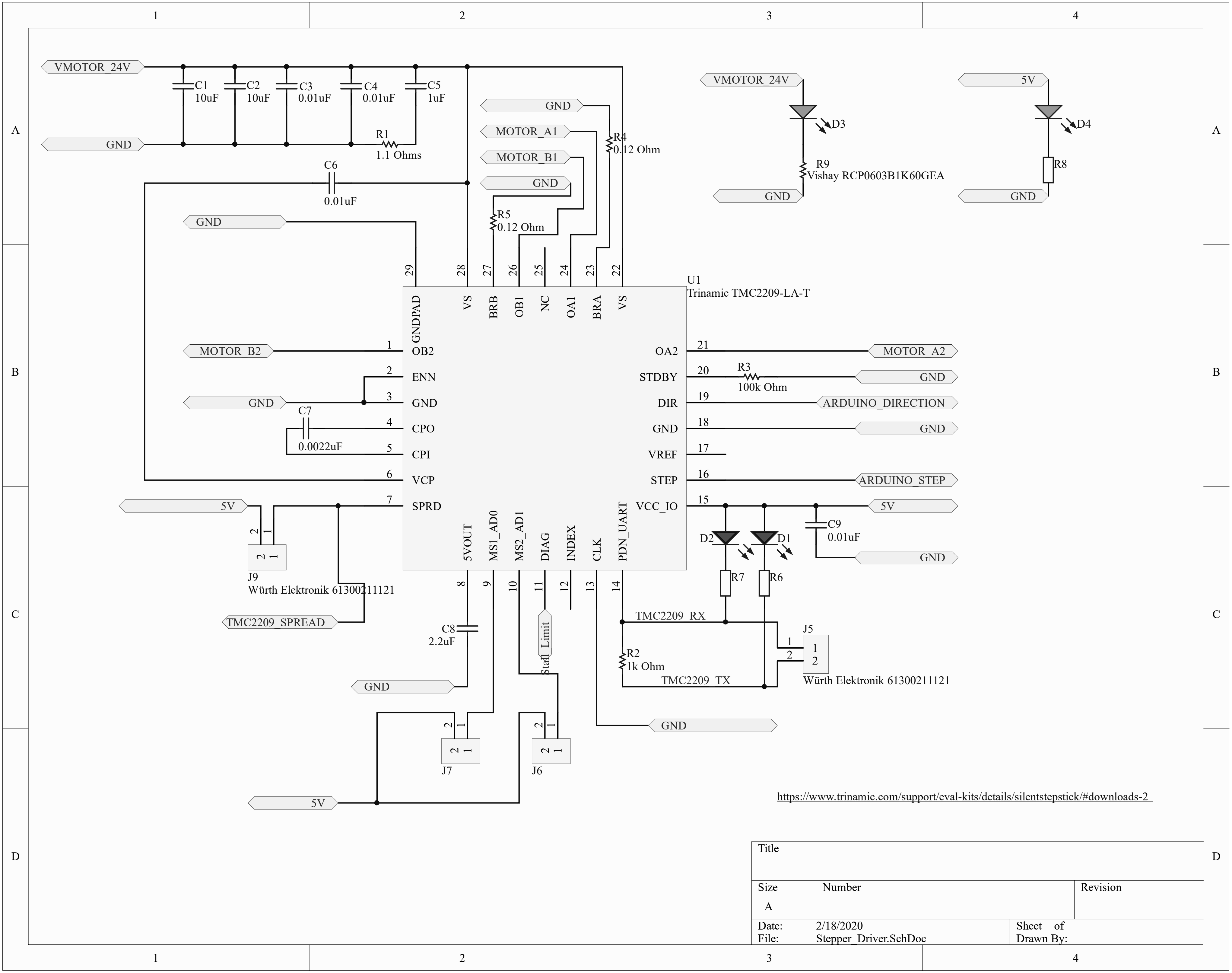
VMOTOR_24V
GND
C1 10uF
C2 10uF
C3 0.01uF
C4 0.01uF
C5 1uF
R1 1.1 Ohms
C6 0.01uF
GND
MOTOR_A1
MOTOR_B1
GND
R4 0.12 Ohm
R5 0.12 Ohm
U1
Trinamic TMC2209-LA-T
GNDPAD
VS
BRB
OB1
NC
OA1
BRA
VS
OB2
ENN
GND
CPO
CPI
VCP
SPRD
OA2
STDBY
DIR
GND
VREF
STEP
VCC_IO
5VOUT
MS1_AD0
MS2_AD1
DIAG
INDEX
CLK
PDN_UART
MOTOR_B2
GND
C7 0.0022uF
5V
J9
Würth Elektronik 61300211121
TMC2209_SPREAD
C8 2.2uF
GND
Stall_Limit
J7
J6
5V
GND
MOTOR_A2
R3 100k Ohm
GND
ARDUINO_DIRECTION
GND
ARDUINO_STEP
5V
C9 0.01uF
GND
D2
D1
R7
R6
TMC2209_RX
R2 1k Ohm
TMC2209_TX
J5
Würth Elektronik 61300211121
VMOTOR_24V
D3
R9 Vishay RCP0603B1K60GEA
GND
5V
D4
R8
GND
https://www.trinamic.com/support/eval-kits/details/silentstepstick/#downloads-2
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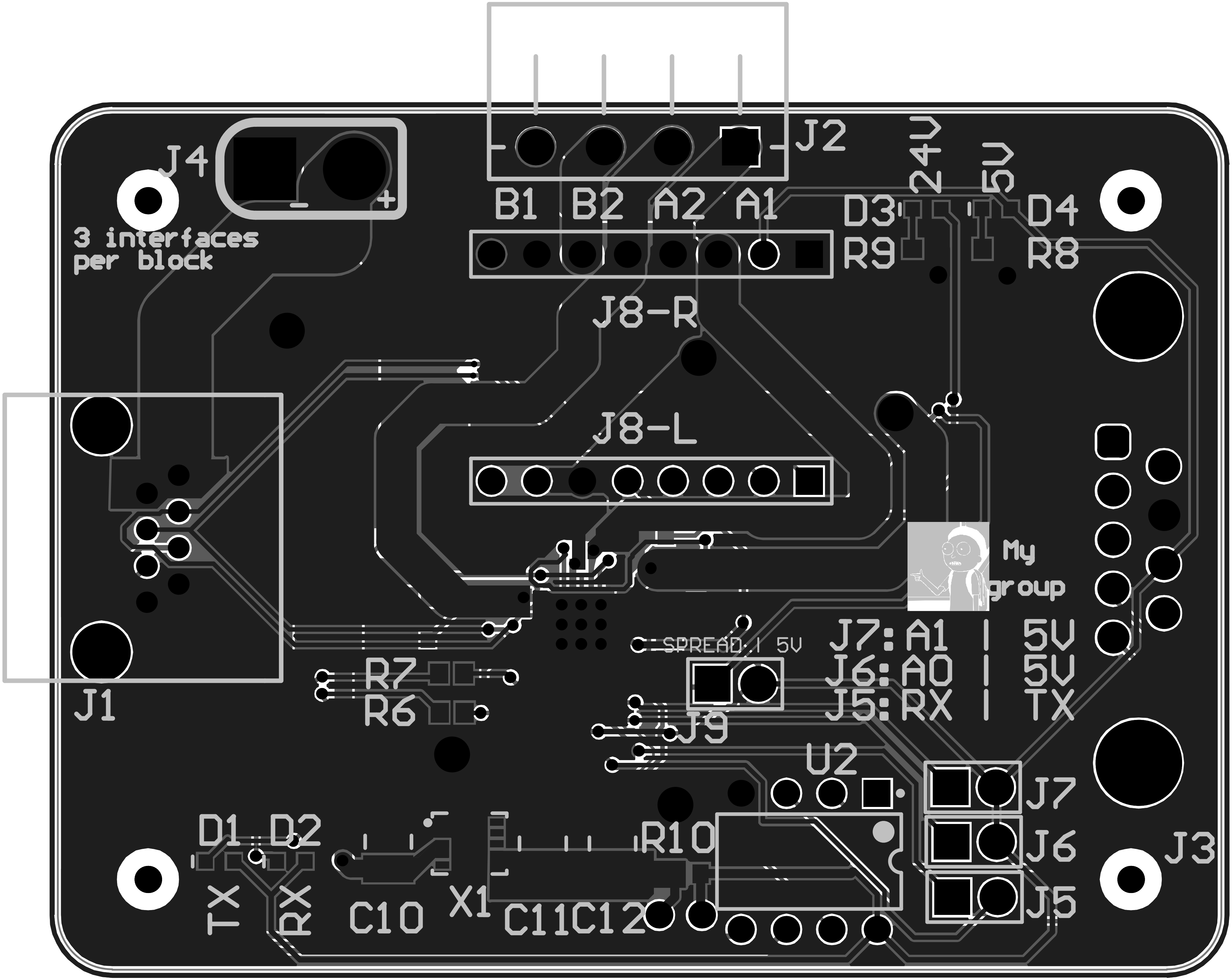
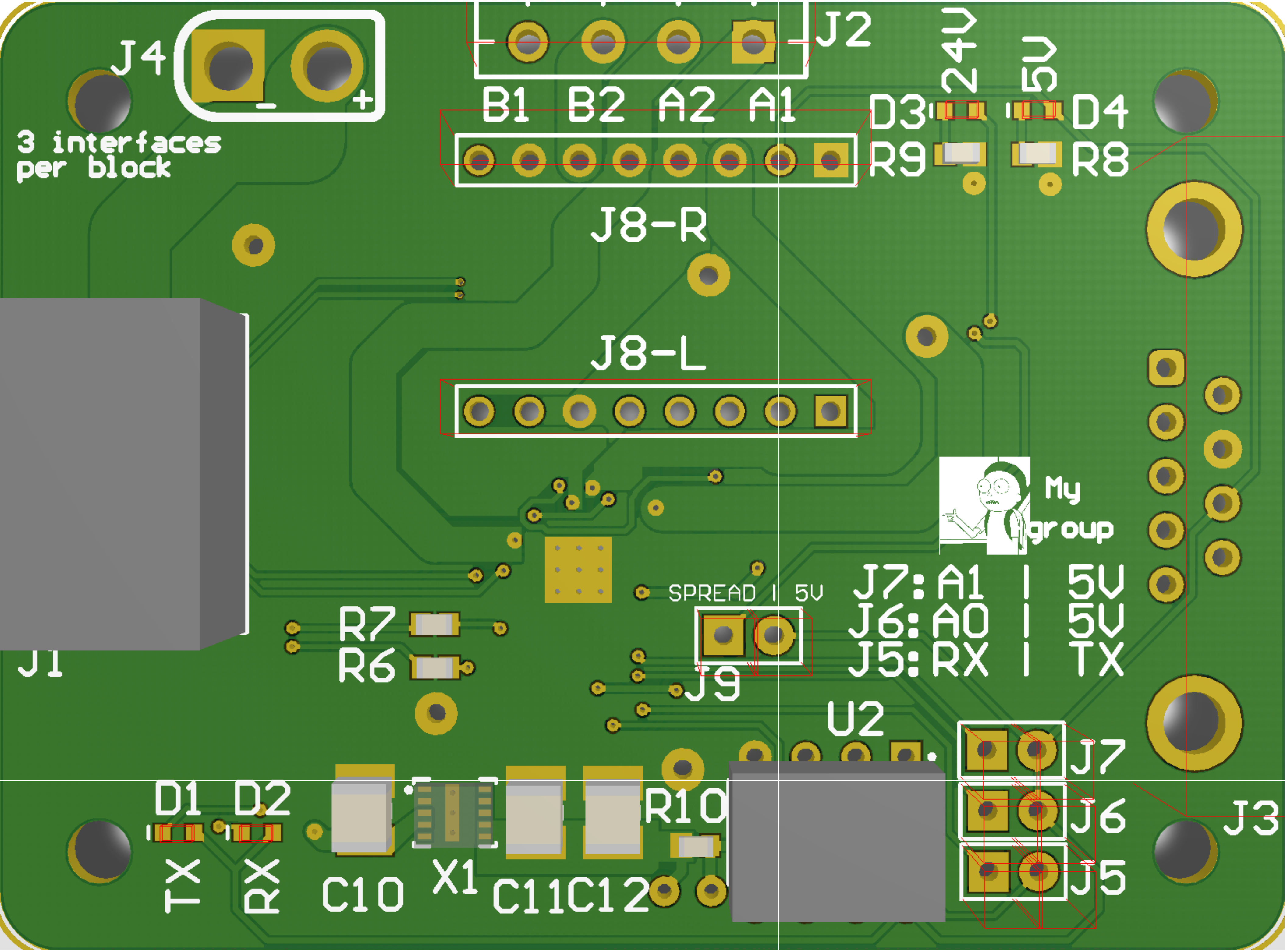

J4
J2
B1 B2 A2 A1
24V
5V
D3
D4
R9
R8
3 interfaces
per block
J8-R
J8-L
J1
My
group
J7: A1 | 5V
J6: A0 | 5V
J5: RX | TX
SPREAD | 5V
J9
R7
R6
U2
J7
J6
J5
J3
D1 D2
R10
TX
RX
C10
X1
C11C12



J4
3 interfaces
per block
J2
B1 B2 A2 A1
24V
5V
D3
D4
R9
R8
J8-R
J8-L
J1
My
group
SPREAD | 5V
J7: A1 | 5V
J6: A0 | 5V
J5: RX | TX
R7
R6
J9
U2
J7
J6
J5
J3
D1 D2
TX
RX
C10
X1
C11C12
R10

Design Validation Interface Table

mtr_axlry_drvr_pcb_dsig

Logic-Level: 5V	The voltage level for the encoders on the motors is specified as 5V in the datasheet provided by the manufacturer
Other: DB9 Connector	The motors encoders were observed to have DB9 connectors on arrival
Other: Pulled high when not rotating	During testing the motor encoders were observed to be logic level “high” (5V) while not spinning the motor
Other: Quadrature encoder signal	The encoders are specified to use the quadrature signal method as specified in the datasheet and during live testing

prmry_cntrl_pcb_axlry_drvr_pcb_dsig

Logic-Level: 5V	The source of this signal is the Arduino Nano, which according to the official user manual, utilizes an Atmega328p, which is capable of a 5VDC digital signal. https://bit.ly/2uyfkgN
Other: Sends a step pulse signal	The source of this signal is an Arduino Nano running grbl, which translates G-Code from the Raspberry Pi to stepper motor signals. According to the official website for grbl, the Nano will output a step signal for every step it wants the stepper motor to step. This design is universal across all stepper motors, and is inherent by design. https://github.com/grbl/grbl
Other: Sends a direction signal	The source of this signal is an Arduino Nano running grbl, which translates G-Code from the Raspberry Pi to stepper motor signals. According to the official website for grbl, the Nano will output a direction signal, high for clockwise, and low for counter-clockwise. https://github.com/grbl/grbl

prmry_cntrl_pcb_axlry_drvr_pcb_dcpwr

Inominal: 1.8-2.1A	According to the datasheet for the TMC2209, the stepper driver we are using, there is a current limiting function. We will utilize this function to ensure that our stepper motors never exceed 2A for reduced heat output and increased component longevity. https://bit.ly/37sqxN0
Ipeak: 2.2A	According to the datasheet for the TMC2209, the stepper driver we are using, there is a current limiting function. We will utilize this function to ensure that our stepper motors never exceed 2A for reduced heat output and increased component longevity. https://bit.ly/37sqxN0
Vmax: 25VDC	According to the datasheet for the TMC2209, the stepper driver we are using, the IC is capable of handling up to a 29VDC input. We will be feeding this chip from a 24VDC power supply, so this will be a non-issue. https://bit.ly/37sqxN0
Vmin: 22VDC	According to the datasheet for the TMC2209, the stepper driver we are using, the IC is capable of handling as low as a 4.75VDC input. We will be feeding this chip from a 24VDC power supply with 0.5% load regulation, so this will be a non-issue. https://bit.ly/3bFQ1Ku https://bit.ly/37sqxN0

axlry_drvr_pcb_mtr_dcpwr

Inominal: 1.4A-1.6A	The motors are specified to draw 1.4 - 1.6A nominally during mid range torque operation (as according to the torque curve for NEMA17 motors)
Ipeak: 3A	The motors are rated for a max of 2.3A draw as specified in the datasheet provided by the manufacturer
Vmax: 24VDC	The max rated voltage of the chosen stepper drivers is stated as 29V on the manufacturer website

Vmin: 3VDC	The min rated voltage of the chosen stepper drivers is stated to be 4.75V on the manufacturer website

axlry_drvr_pcb_prmry_cntrl_pcb_dsig

Logic-Level: 5VDC	The source of this signal is an ATtiny85, which according to the official datasheet, has a 5VDC digital signal. https://bit.ly/2SLR82e
Other: USI Protocol	The source of this signal is an ATtiny85, which according to the official datasheet, utilizes the Universal Serial Interface. https://bit.ly/2SLR82e
Other: 9600 Baud	The source of this signal is an ATtiny85, which according to the official datasheet, is capable of up to 10 MHz, which is well over 9600 baud or 9.6 kHz. https://bit.ly/2SLR82e