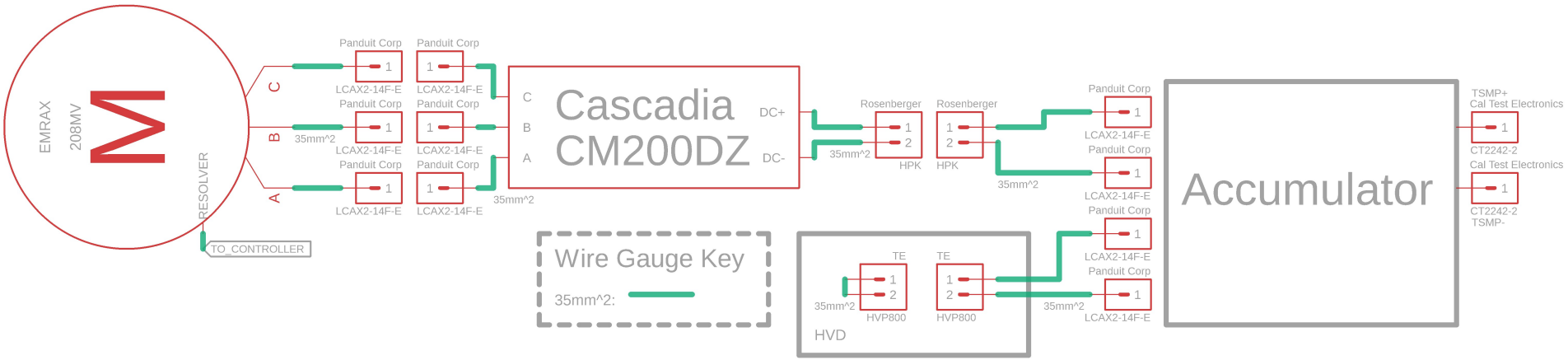
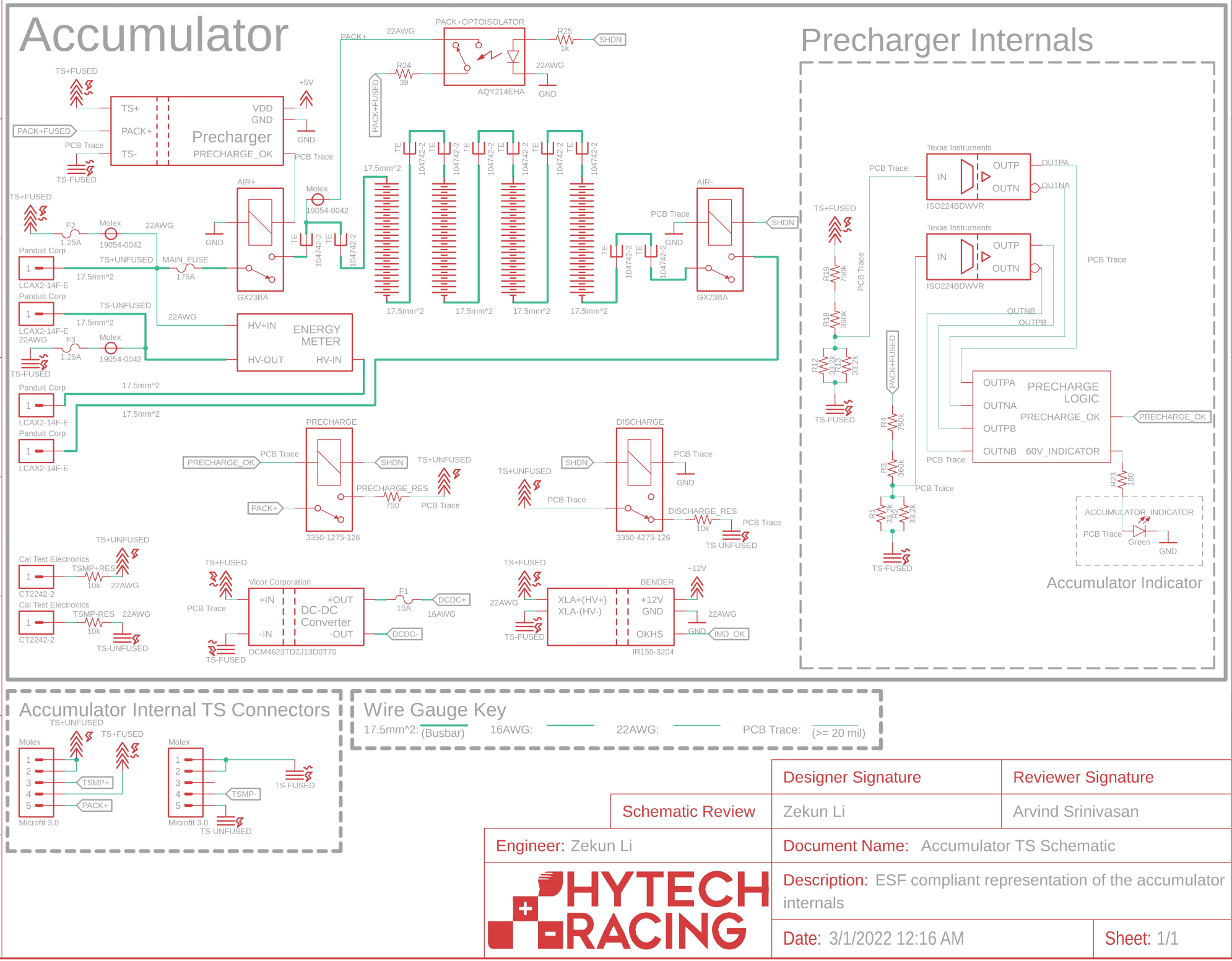
Electrical Design Binder

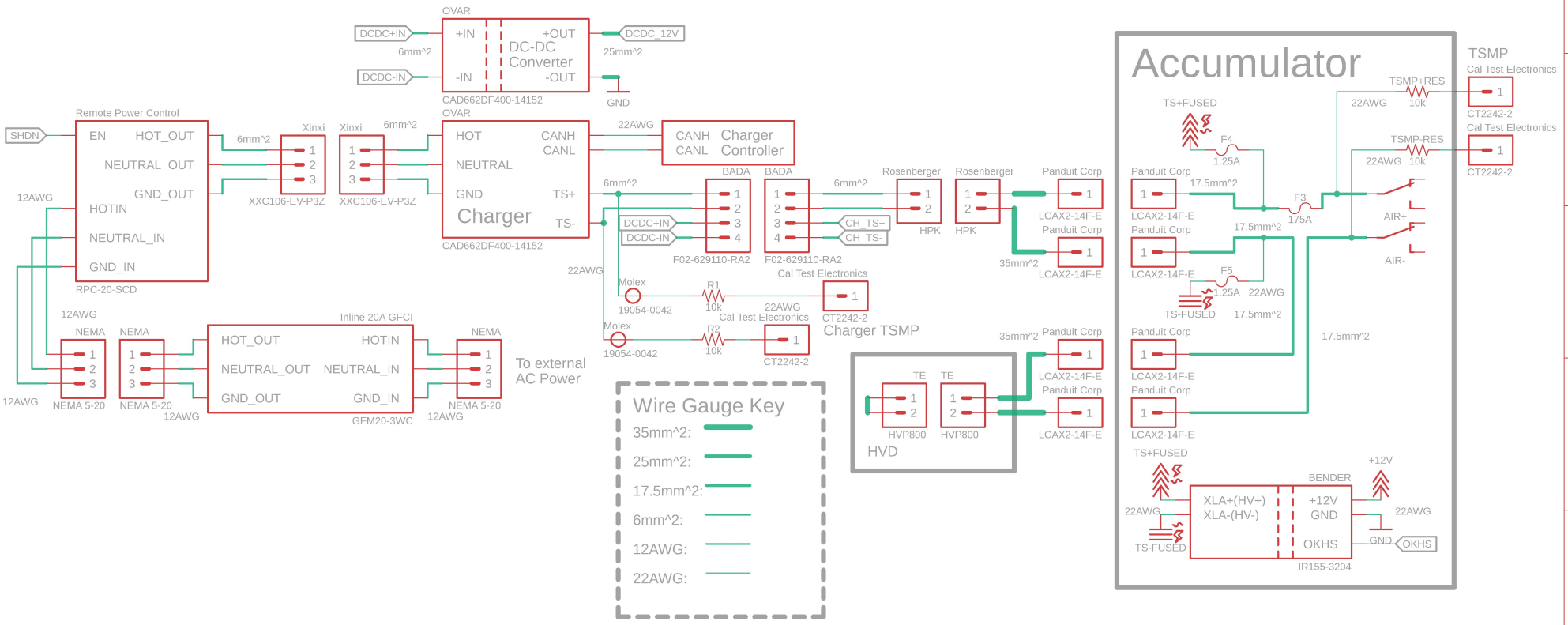
Sections: ESF Schematics, Electronic Circuitry

I. ESF Schematics

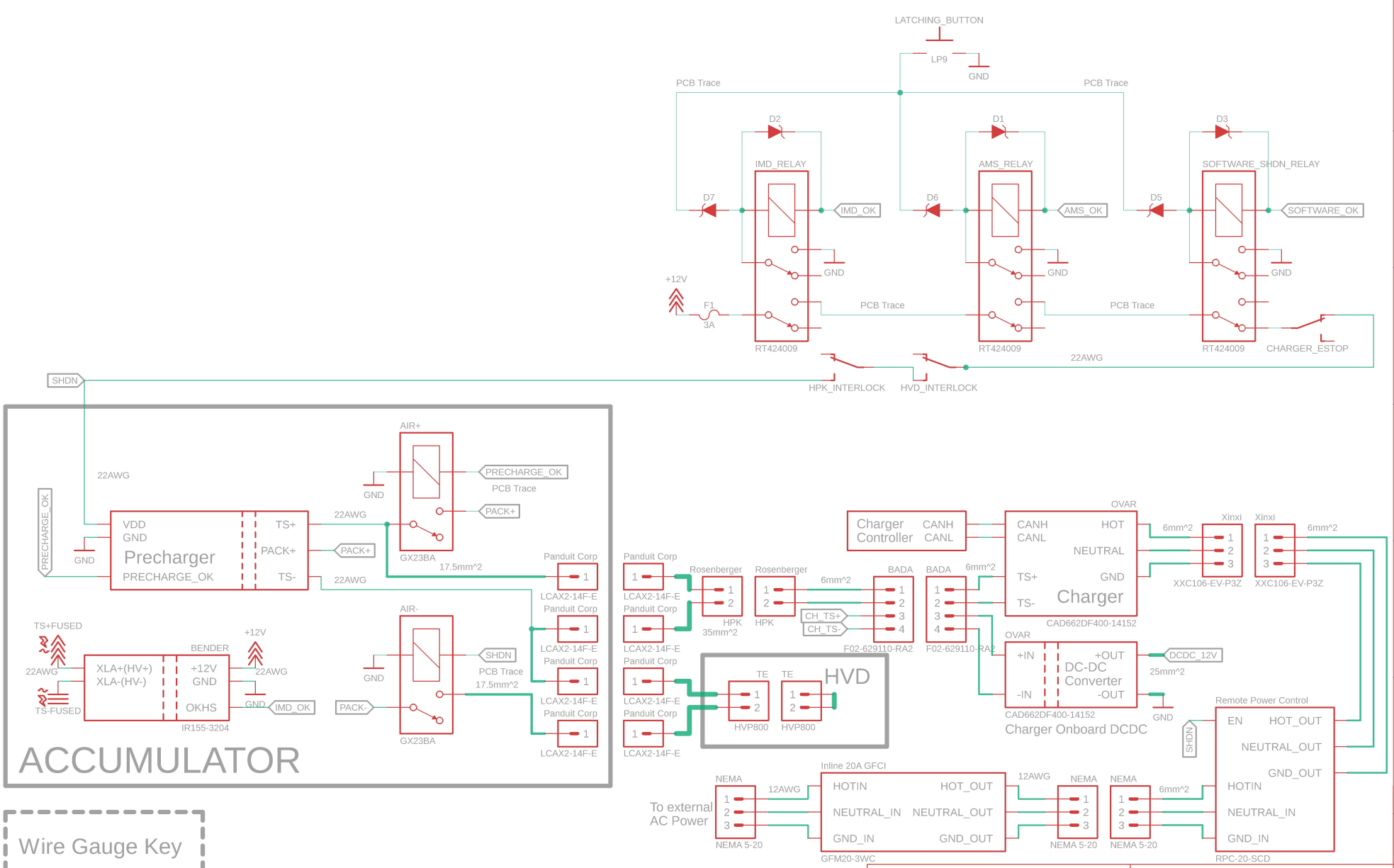


	Designer Signature	Reviewer Signature
Schematic Review	Zekun Li	Arvind Srinivasan
Engineer: Zekun Li	Document Name: Tractive System Schematic	
HYTECH RACING	Description: ESF compliant representation of the HT06 tractive system.	
	Date: 3/1/2022 12:39 AM	Sheet: 1/1


Accumulator
Precharger Internals
Accumulator Internal TS Connectors
Wire Gauge Key
17.5mm^2: (Busbar)
16AWG:
22AWG:
PCB Trace: (>= 20 mil)
Designer Signature
Reviewer Signature
Schematic Review
Zekun Li
Arvind Srinivasan
Engineer: Zekun Li
Document Name: Accumulator TS Schematic
HYTECH RACING
Description: ESF compliant representation of the accumulator internals
Date: 3/1/2022 12:16 AM
Sheet: 1/1
Precharger
PRECHARGE_OK
ENERGY METER
PRECHARGE
DISCHARGE
PACK+OPTOISOLATOR
AQY214EHA
GX23BA
ISO224BDWVR
PRECHARGE LOGIC
ACCUMULATOR_INDICATOR
DC-DC Converter
DCM4623TD2J13D0T70
IR155-3204
Accumulator Indicator



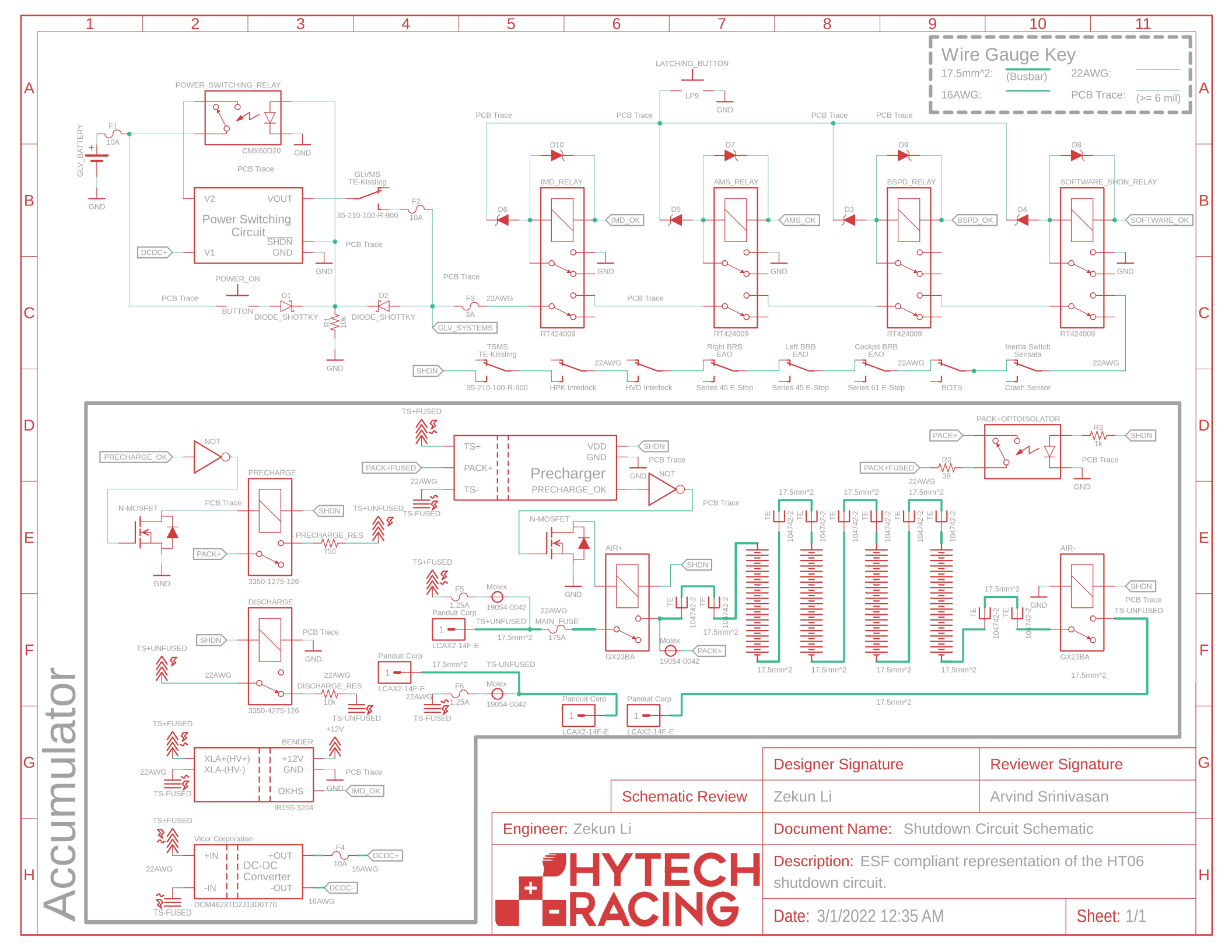
	Designer Signature	Reviewer Signature
Schematic Review	Zekun Li	Arvind Srinivasan
Engineer: Zekun Li	Document Name: Charging Tractive System Schematic	
HYTECH RACING	Description: ESF compliant representation of the charging tractive system.	
	Date: not saved!	Sheet: 1/1

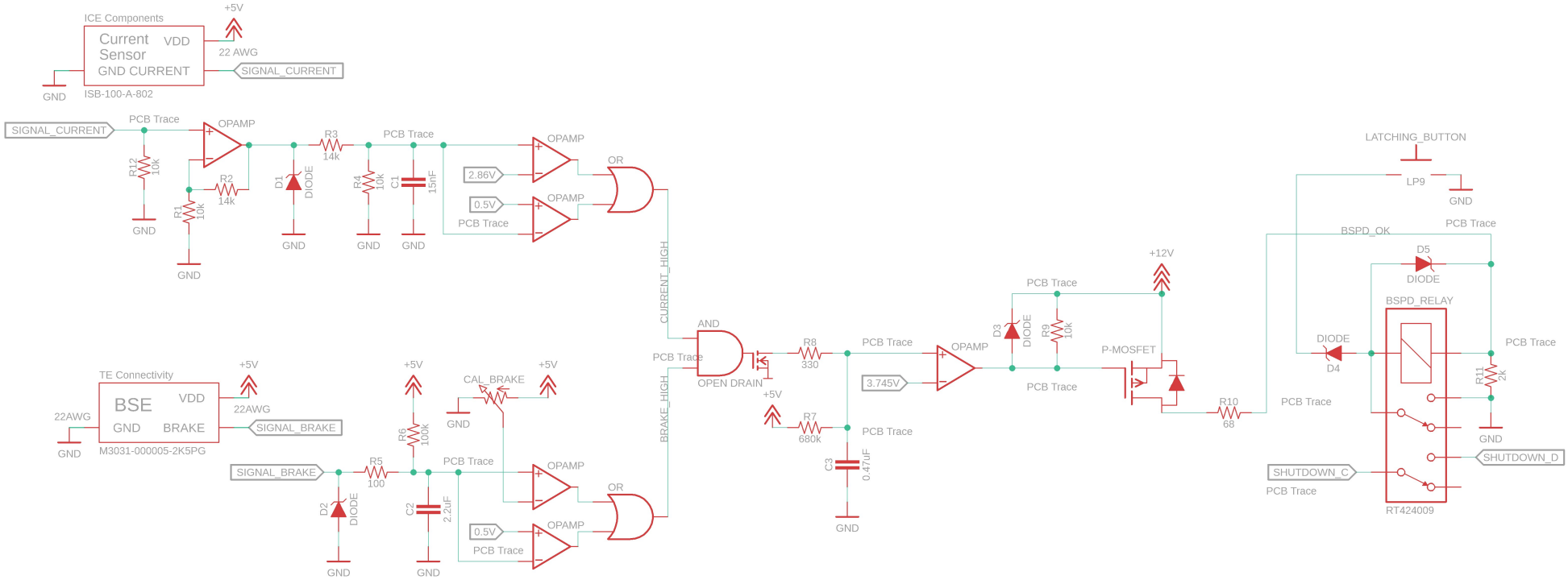


Wire Gauge Key

- 35mm^2:
- 25mm^2:
- 17.5mm^2: (Busbar)
- 6mm^2:
- 12AWG:
- 22AWG:
- PCB Trace: (>= 20 mil)

	Designer Signature	Reviewer Signature
Schematic Review	Zekun Li	Arvind Srinivasan
Engineer: Zekun Li	Document Name: Charging Shutdown Circuit Schematic	
HYTECH RACING	Description: ESF compliant representation of the charging shutdown circuit.	
	Date: 3/2/2022 7:20 PM	Sheet: 1/1


Wire Gauge Key
17.5mm^2: (Busbar)
22AWG:
16AWG:
PCB Trace: (>= 6 mil)
GLV_BATTERY
F1
10A
POWER_SWITCHING_RELAY
CMX60D20
GND
PCB Trace
Power Switching Circuit
V2
VOUT
V1
SHDN
GND
DCDC+
GLVMS
TE-Kissling
35-210-100-R-900
F2
10A
POWER_ON
BUTTON
D1
DIODE_SHOTTKY
D2
DIODE_SHOTTKY
R1
10k
F3
3A
22AWG
GLV_SYSTEMS
LATCHING_BUTTON
LP9
D10
IMD_RELAY
D6
IMD_OK
D7
AMS_RELAY
D5
AMS_OK
D9
BSPD_RELAY
D3
BSPD_OK
D8
SOFTWARE_SHDN_RELAY
D4
SOFTWARE_OK
RT424009
TSMS
TE-Kissling
HPK Interlock
HVD Interlock
Right BRB
EAO
Series 45 E-Stop
Left BRB
EAO
Series 45 E-Stop
Cockpit BRB
EAO
Series 61 E-Stop
BOTS
Inertia Switch
Sensata
Crash Sensor
PRECHARGE_OK
NOT
PRECHARGE
N-MOSFET
PACK+
PRECHARGE_RES
750
3350-1275-126
TS+FUSED
TS+UNFUSED
TS-FUSED
TS+
PACK+
TS-
VDD
GND
Precharger
PRECHARGE_OK
PACK+FUSED
PACK+OPTOISOLATOR
R2
39
R3
1k
AIR+
AIR-
GX23BA
F5
1.25A
Molex
19054-0042
Panduit Corp
LCAX2-14F-E
MAIN_FUSE
175A
17.5mm^2
104742-2
TE
DISCHARGE
DISCHARGE_RES
10k
3350-4275-126
F6
BENDER
XLA+(HV+)
XLA-(HV-)
+12V
GND
OKHS
IR155-3204
+12V
Vicor Corporation
+IN
-IN
+OUT
-OUT
DC-DC Converter
DCM4623TD2J13D0T70
F4
10A
16AWG
DCDC+
DCDC-
Accumulator
Designer Signature
Reviewer Signature
Schematic Review
Zekun Li
Arvind Srinivasan
Engineer: Zekun Li
Document Name: Shutdown Circuit Schematic
HYTECH RACING
Description: ESF compliant representation of the HT06 shutdown circuit.
Date: 3/1/2022 12:35 AM
Sheet: 1/1

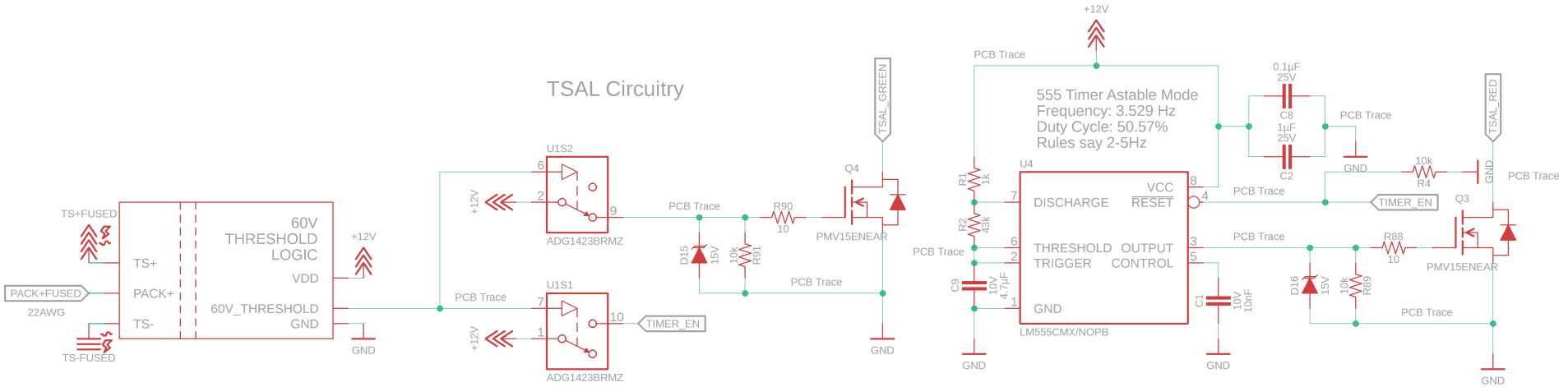


Wire Gauge Key

22AWG:

PCB Trace: (>= 6 mil)

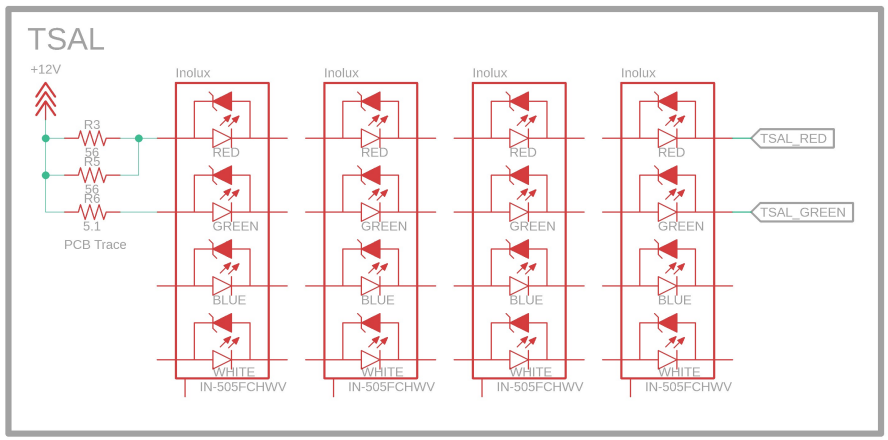
	Designer Signature	Reviewer Signature
Schematic Review	Zekun Li	Arvind Srinivasan
Engineer: Zekun Li	Document Name: BSPD System Schematic	
HYTECH RACING	Description: ESF compliant representation of the BSPD circuit.	
	Date: 3/1/2022 12:18 AM	Sheet: 1/1



Wire Gauge Key

22AWG:

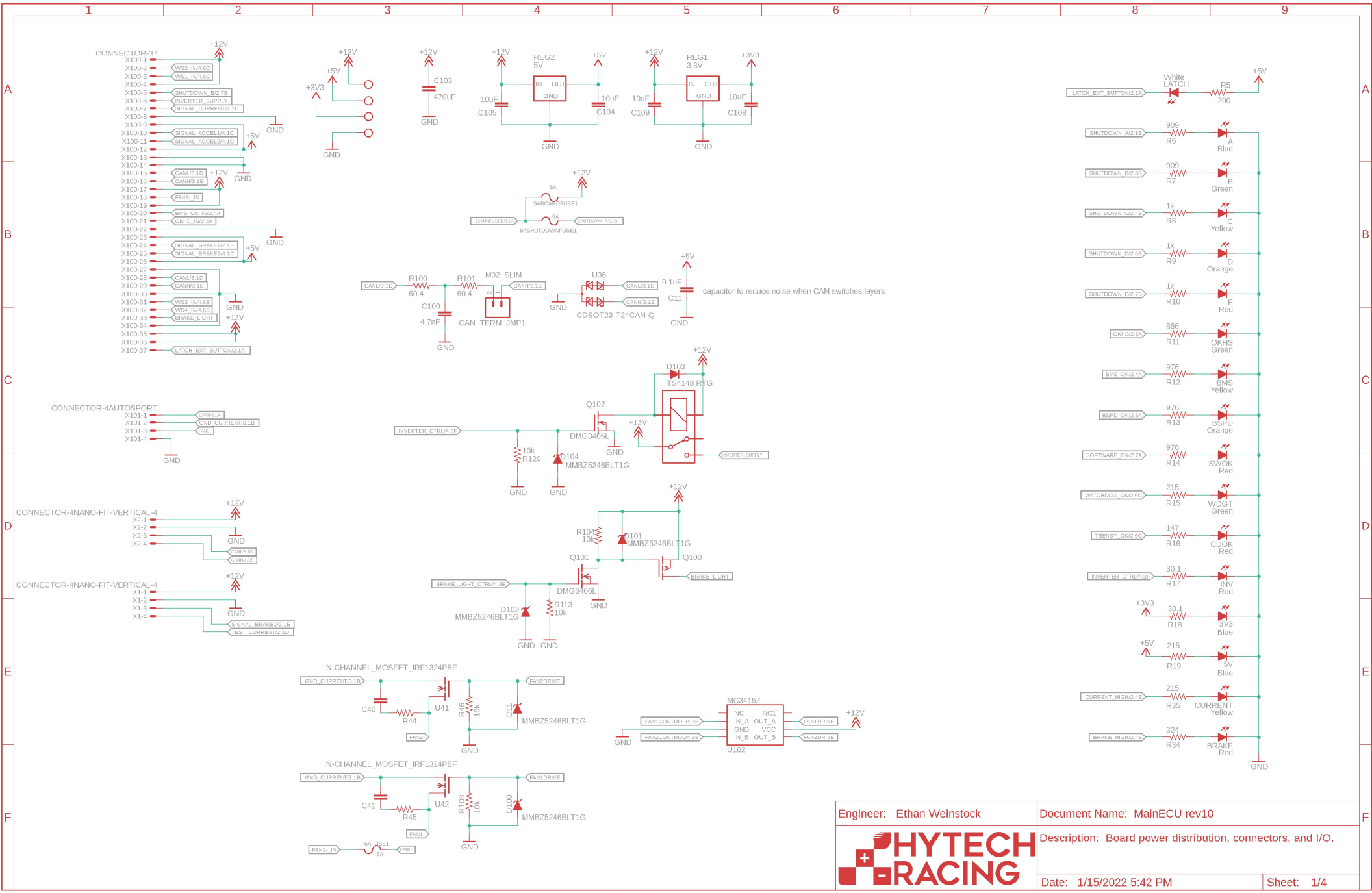
PCB Trace: (>= 6 mil)



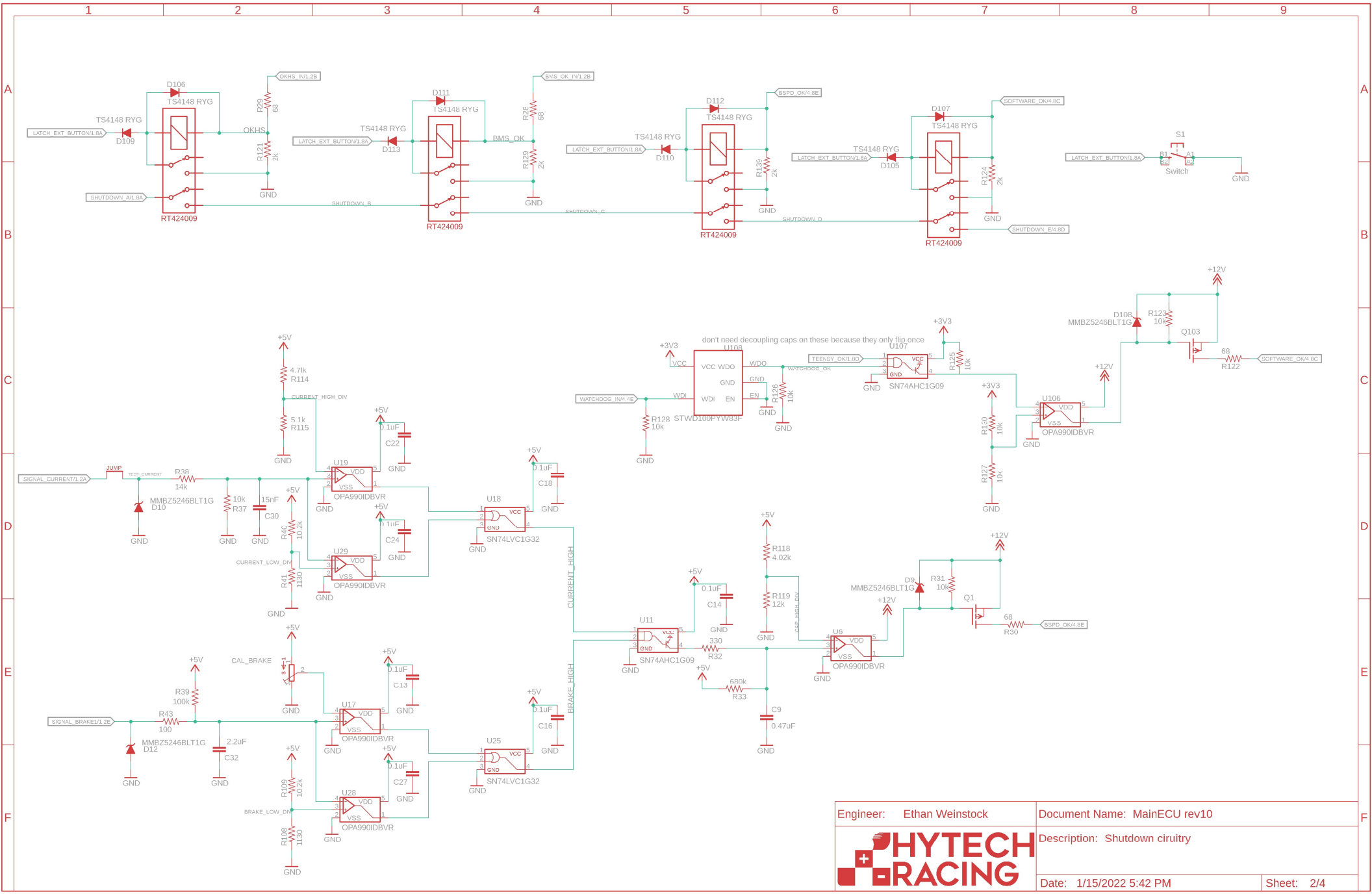
	Designer Signature	Reviewer Signature
Schematic Review	Zekun Li	Arvind Srinivasan
Engineer: Zekun Li	Document Name: TSAL Schematic	
HYTECH RACING	Description: ESF compliant representation of the TSAL circuitry.	
	Date: 3/1/2022 12:36 AM	Sheet: 1/1

II. Electronic Circuitry

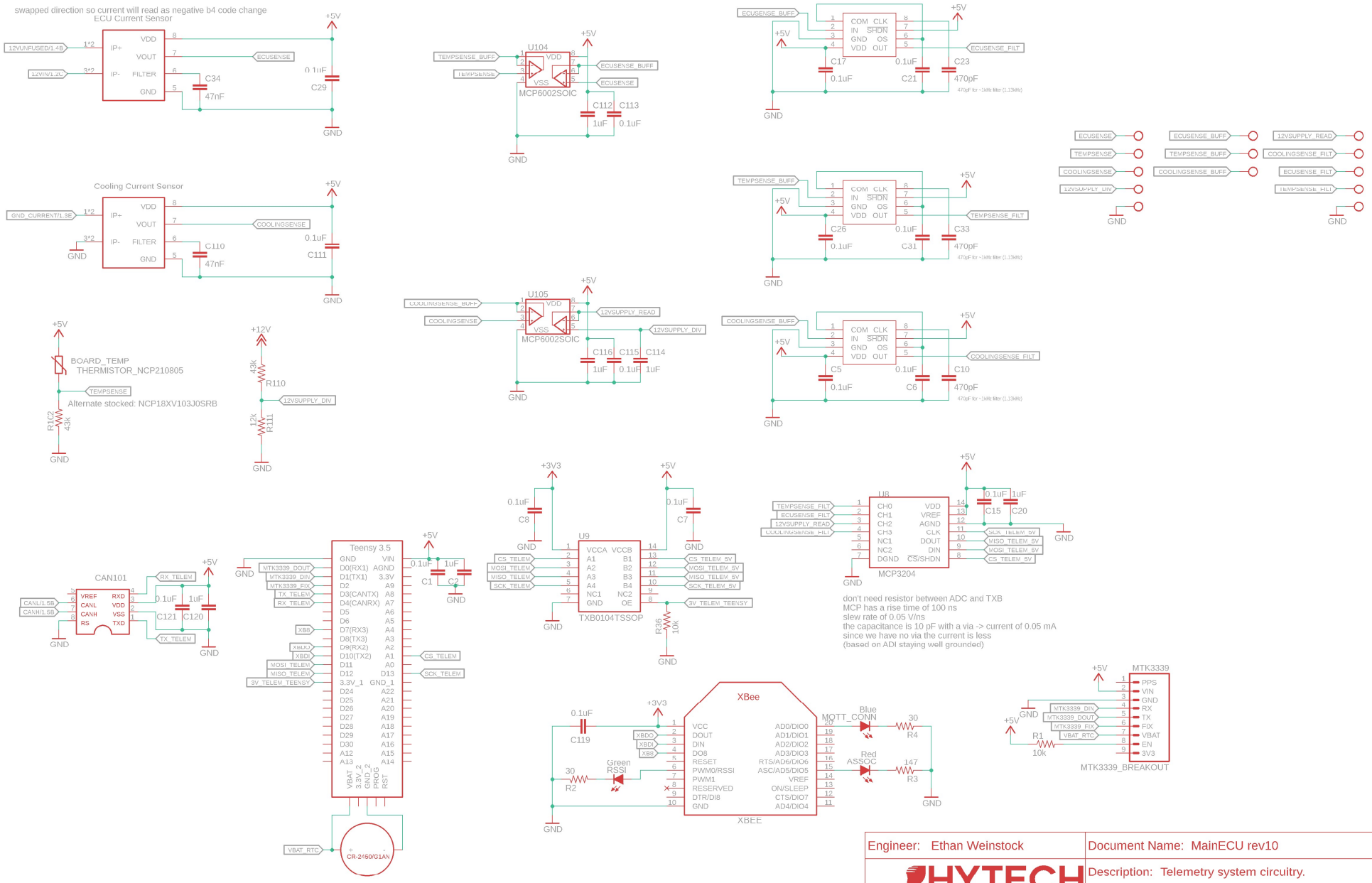
II. A. Main ECU



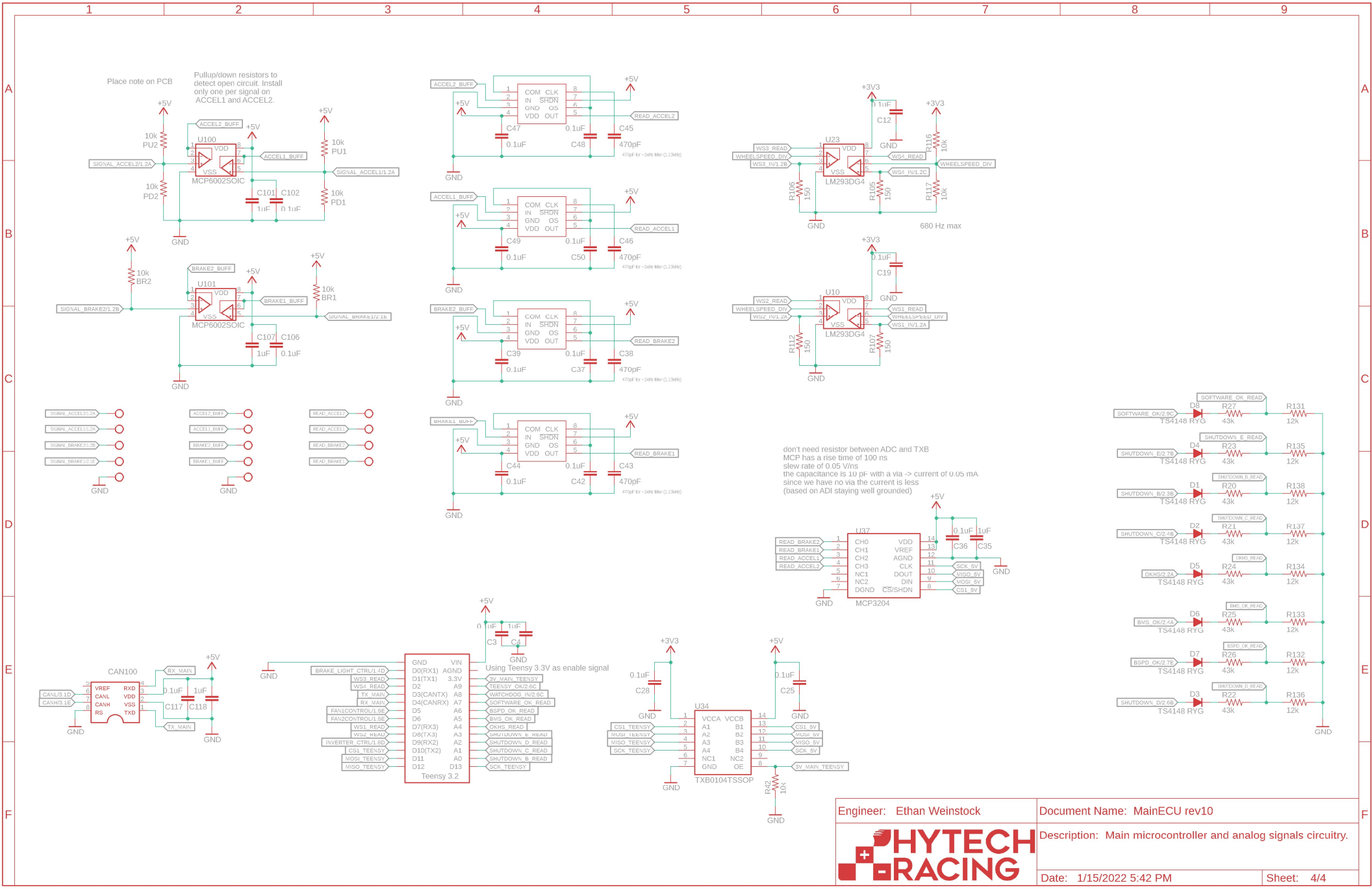
Engineer: Ethan Weinstock	Document Name: MainECU rev10
HYTECH RACING	Description: Board power distribution, connectors, and I/O.
	Date: 1/15/2022 5:42 PM — Sheet: 1/4

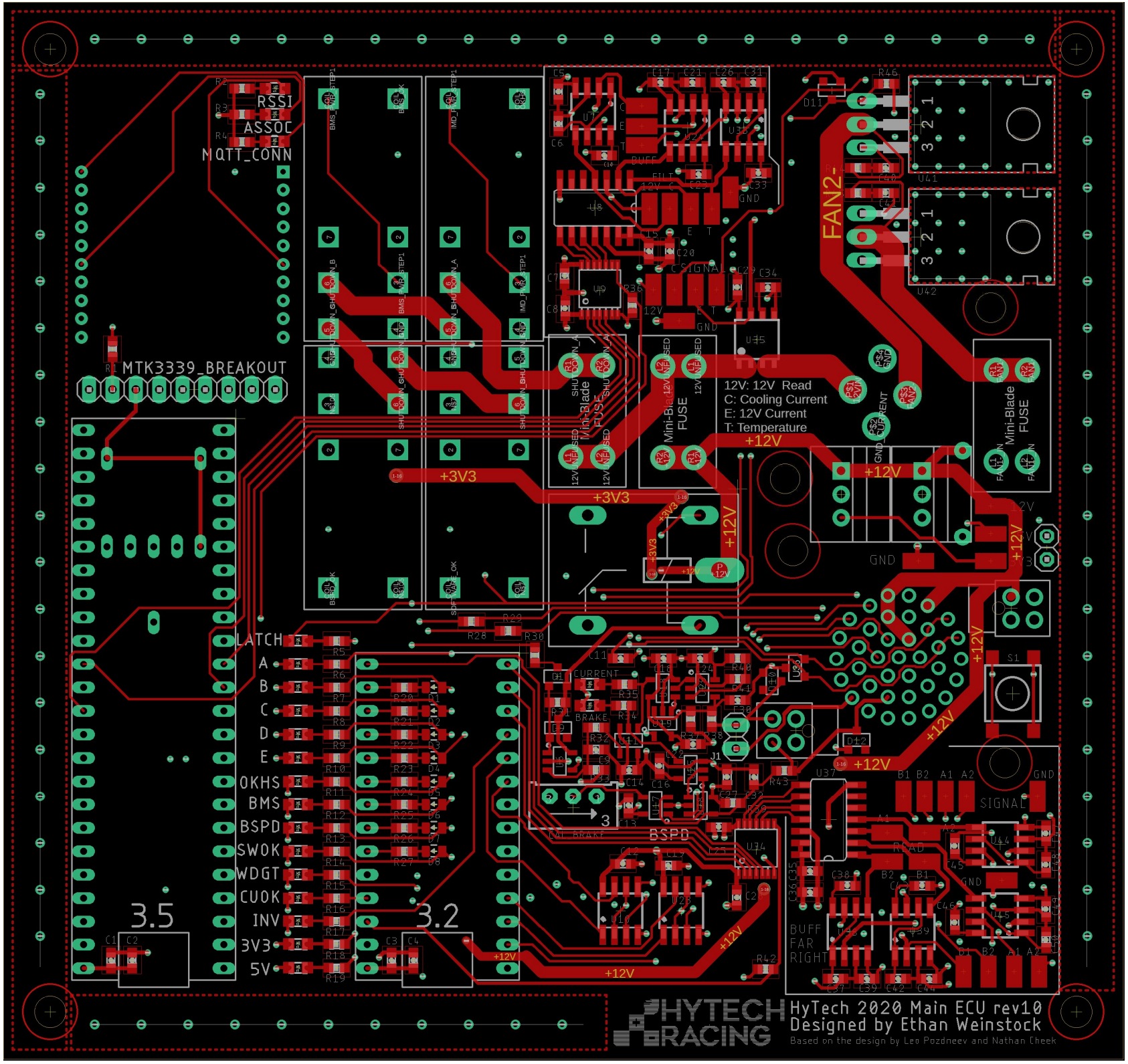


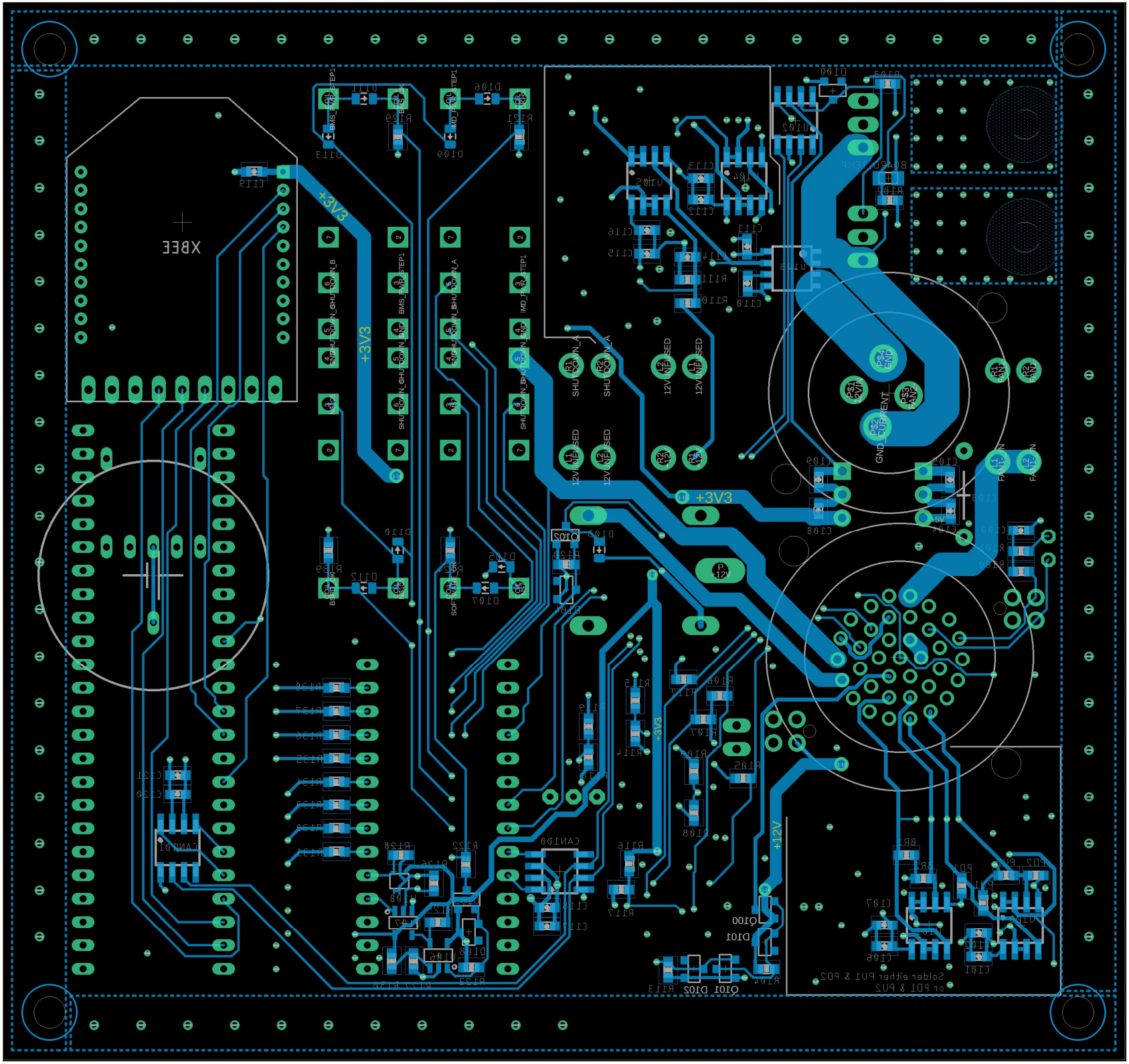
Engineer: Ethan Weinstock	Document Name: MainECU rev10
HYTECH RACING	Description: Shutdown ciruitry
	Date: 1/15/2022 5:42 PM — Sheet: 2/4



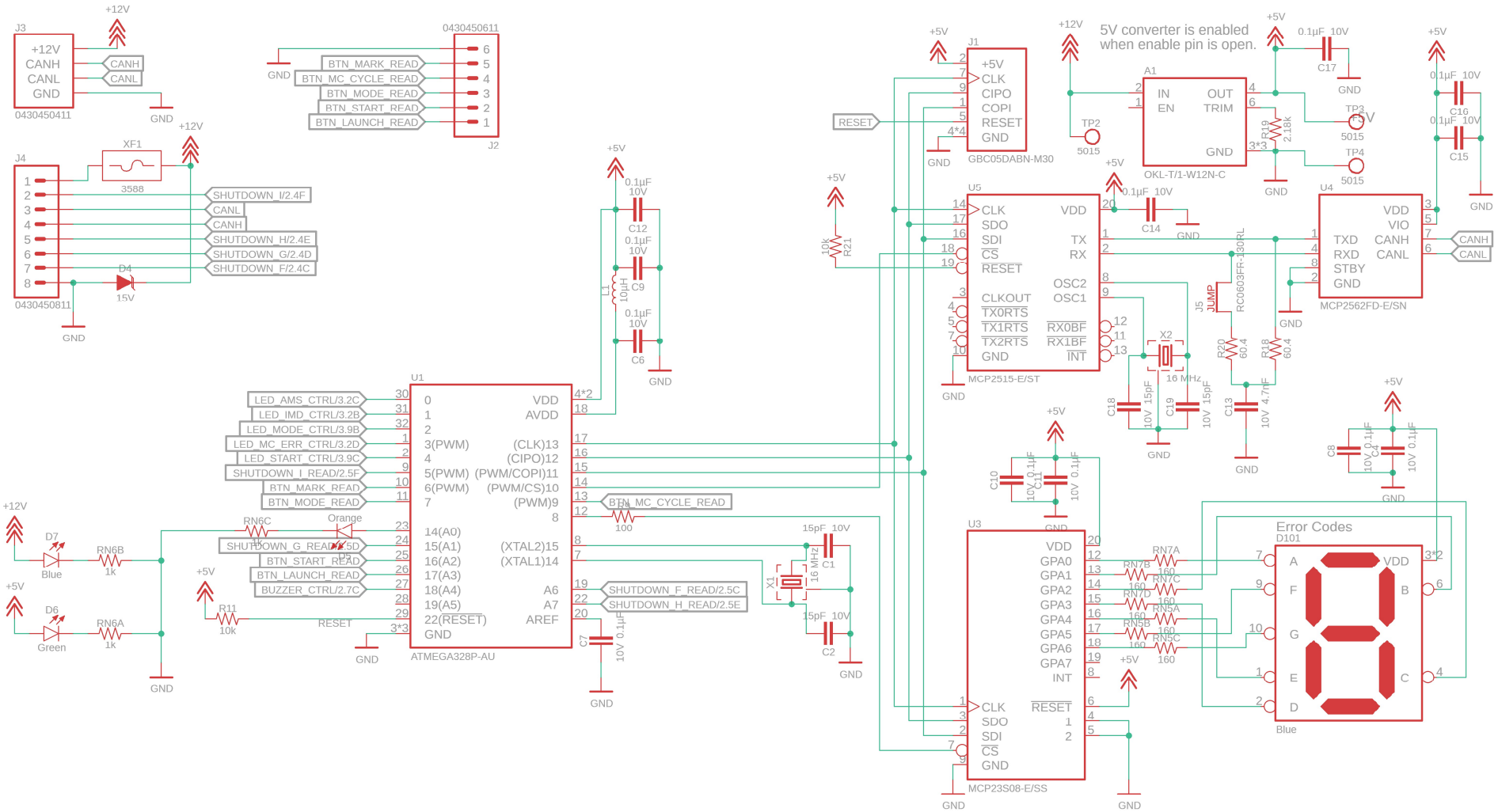
Engineer: Ethan Weinstock	Document Name: MainECU rev10
HYTECH RACING	Description: Telemetry system circuitry.
	Date: 1/15/2022 5:42 PM — Sheet: 3/4


Place note on PCB
Pullup/down resistors to detect open circuit. Install only one per signal on ACCEL1 and ACCEL2.
MCP6002SOIC
LM293DG4
680 Hz max
don't need resistor between ADC and TXB
MCP has a rise time of 100 ns
slew rate of 0.05 V/ns
the capacitance is 10 pF with a via -> current of 0.05 mA
since we have no via the current is less
(based on ADI staying well grounded)
MCP3204
TXB0104TSSOP
Using Teensy 3.3V as enable signal
Teensy 3.2
CAN100
TS4148 RYG
Engineer: Ethan Weinstock
Document Name: MainECU rev10
Description: Main microcontroller and analog signals circuitry.
Date: 1/15/2022 5:42 PM
Sheet: 4/4


RSSI
ASSOC
MQTT_CONN
MTK3339_BREAKOUT
+3V3
+12V
GND
12V: 12V Read
C: Cooling Current
E: 12V Current
T: Temperature
Mini-Blade FUSE
FAN2-
SIGNAL
CURRENT
BRAKE
BSPD
READ
BUFF
FAR
RIGHT
LATCH
A
B
C
D
E
OKHS
BMS
BSPD
SWOK
WDGT
CUOK
INV
3V3
5V
3.5
3.2
HYTECH RACING
HyTech 2020 Main ECU rev10
Designed by Ethan Weinstock
Based on the design by Leo Pozdneev and Nathan Cheek


XBEE
+3V3
+12V
SHUTDOWN_A
SHUTDOWN_B
BMS_STEP1
MD_STEP1
12V_NEUSED
FAN_ON
GND_CURRENT
Solder either PD1 & PD2
or PD1 & PD2

II.B. Dashboard



	Designer Signature	Reviewer Signature
Schematic Review		
Board Review		
Further Reviews		

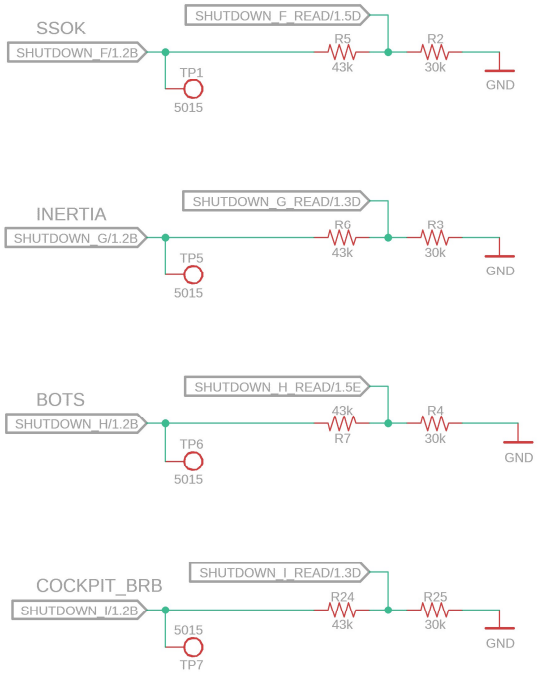
Engineer: Youssef Jaafar

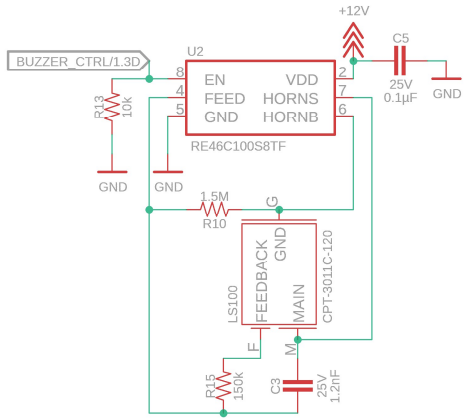
Document Name: Dashboard rev4

Description: Schematic of Dashboard PCB for HT06 : Microcontroller, CAN, 7-Segment Display Connectors

Date: not saved!

Sheet: 1/4

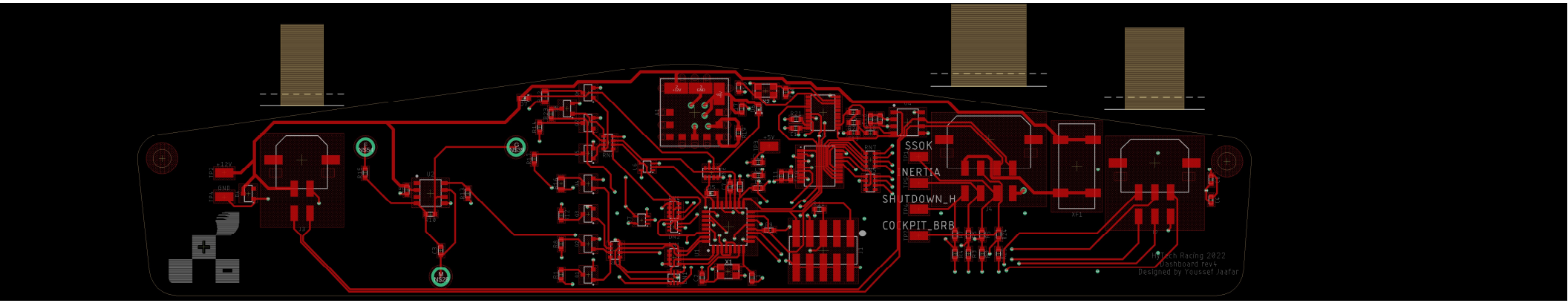




	Designer Signature	Reviewer Signature
Schematic Review		
Board Review		
Further Reviews		

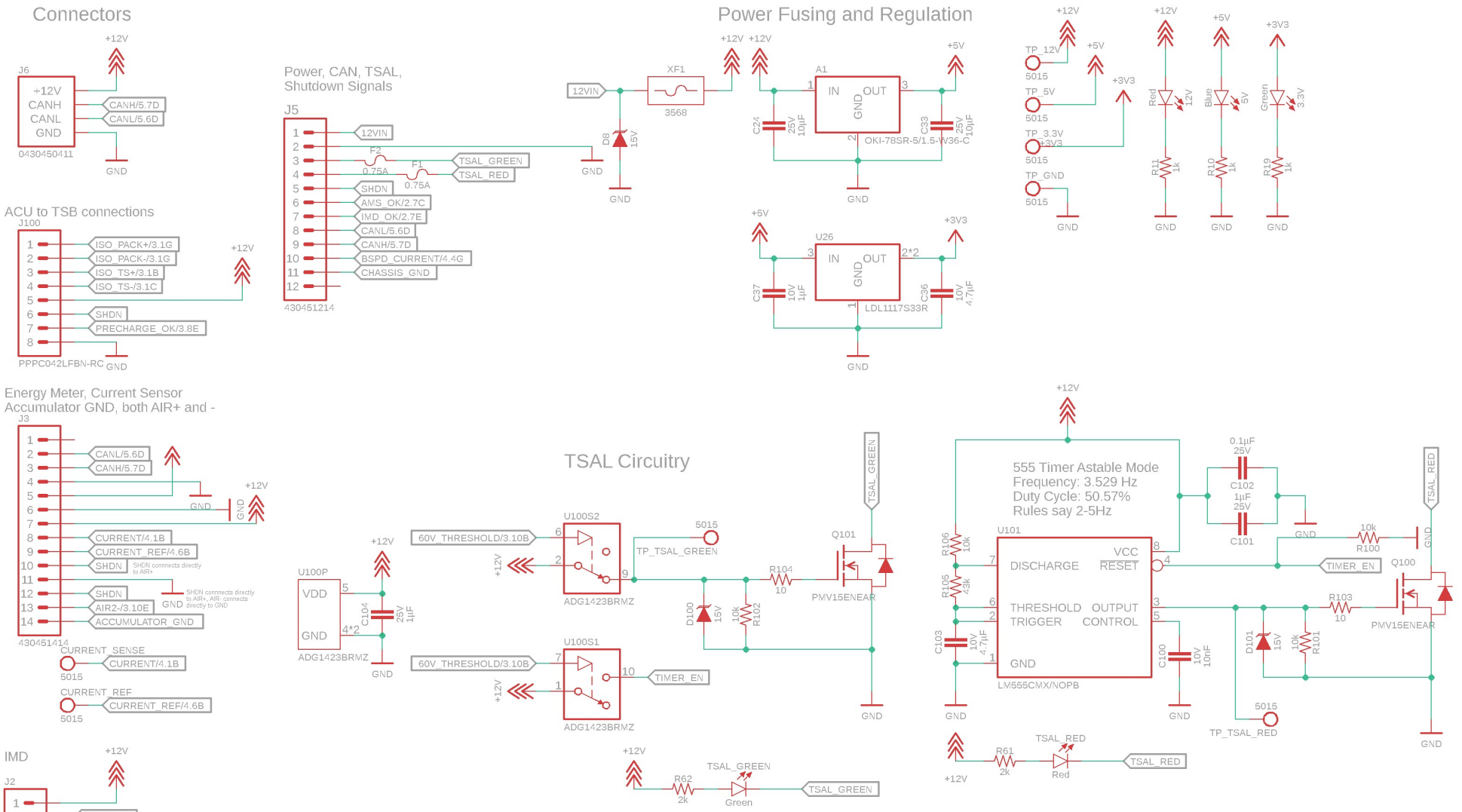
Engineer:	Document Name: Dashboard rev4
HYTECH RACING	Description: Schematic of Dashboard PCB for HT06 : Shutdown and Buzzer Control Circuitry
	Date: not saved! Sheet: 2/4

Dashboard Top



Dashboard Bottom

II.C. Accumulator Control Unit



	Designer Signature	Reviewer Signature
Schematic Review		
Board Review		
Further Reviews		

Engineer: Josh Kirshenbaum

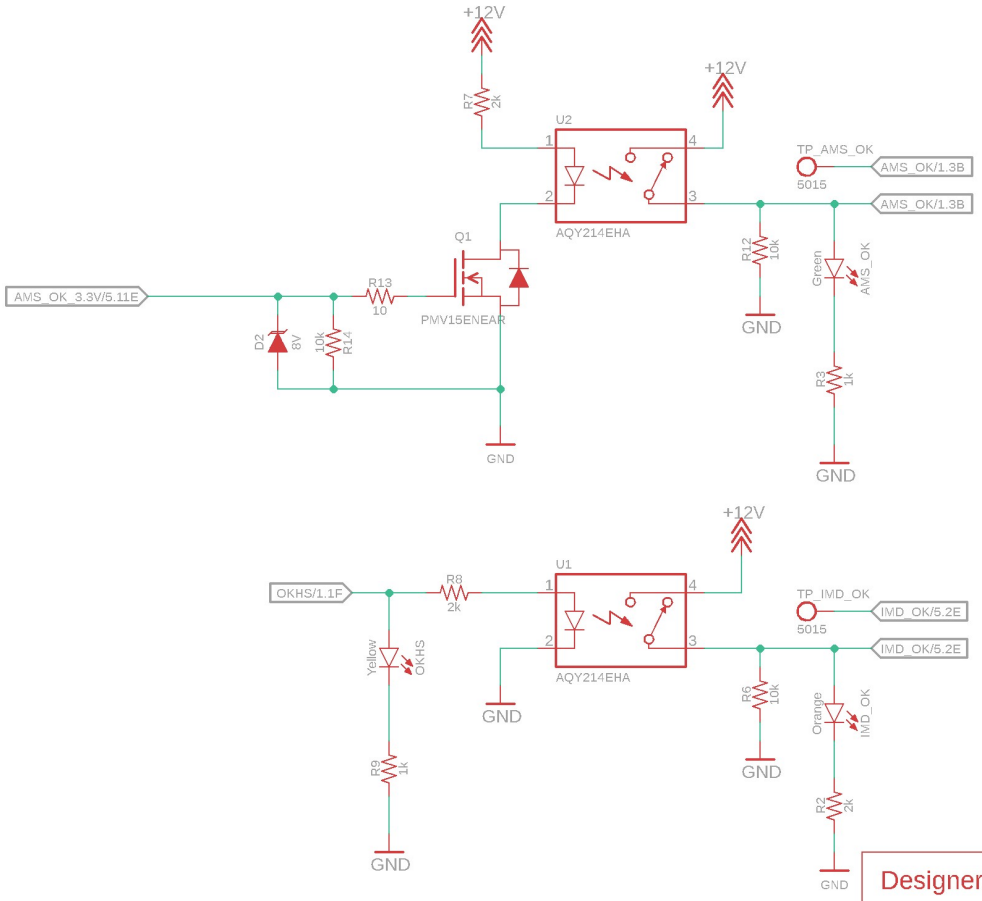
Document Name: Accumulator Control Unit rev3

Description: Connectors, power, fusing, TSAL

Date: 6/11/2022 7:32 PM

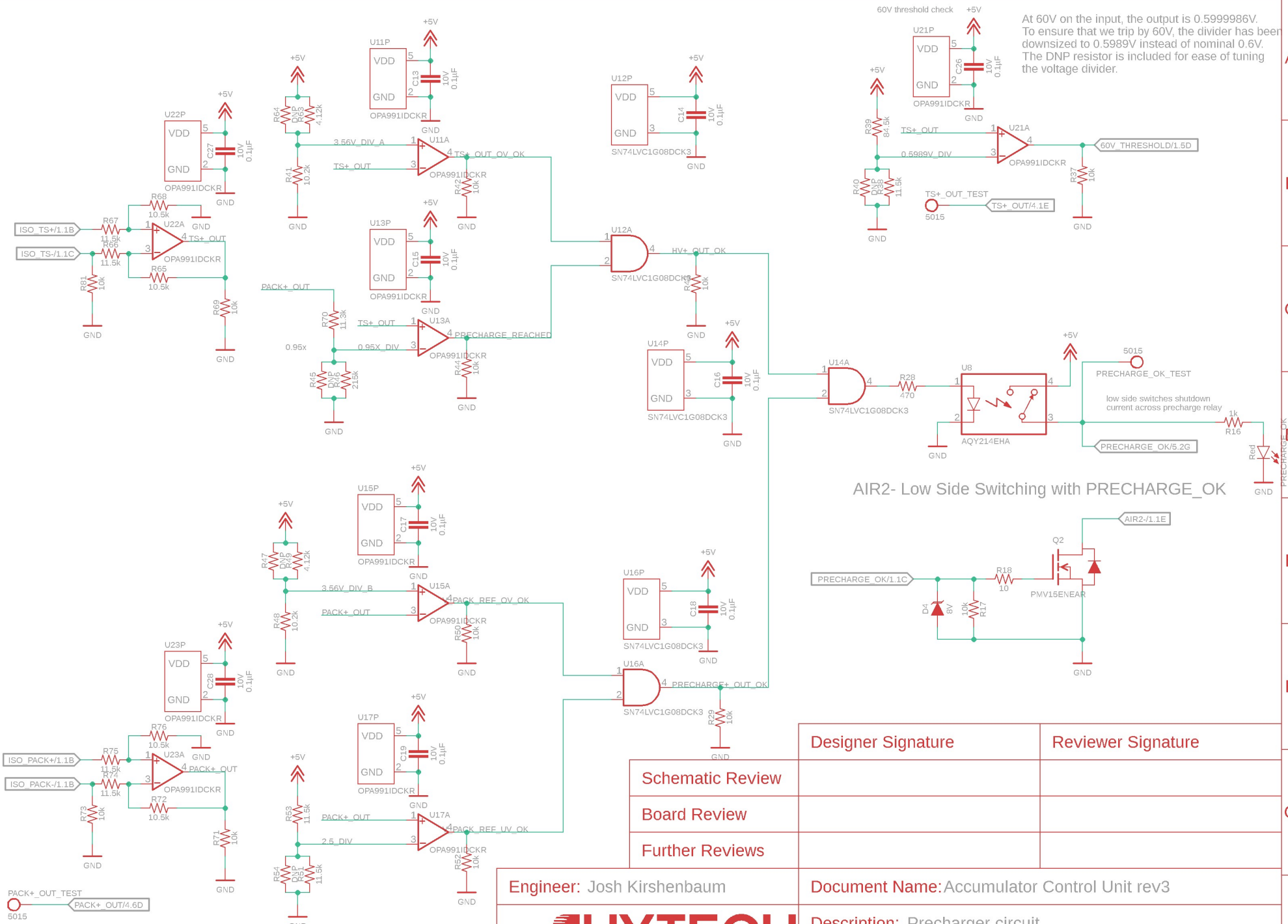
Sheet: 1/6

Shutdown Signal Buffering/Amplification



	Designer Signature	Reviewer Signature
Schematic Review		
Board Review		
Further Reviews		

Engineer: Josh Kirshenbaum	Document Name: Accumulator Control Unit rev3	
HYTECH RACING	Description: Shutdown circuitry	
	Date: 6/11/2022 7:32 PM	Sheet: 2/6



	Designer Signature	Reviewer Signature
Schematic Review		
Board Review		
Further Reviews		

Engineer: Josh Kirshenbaum

Document Name: Accumulator Control Unit rev3

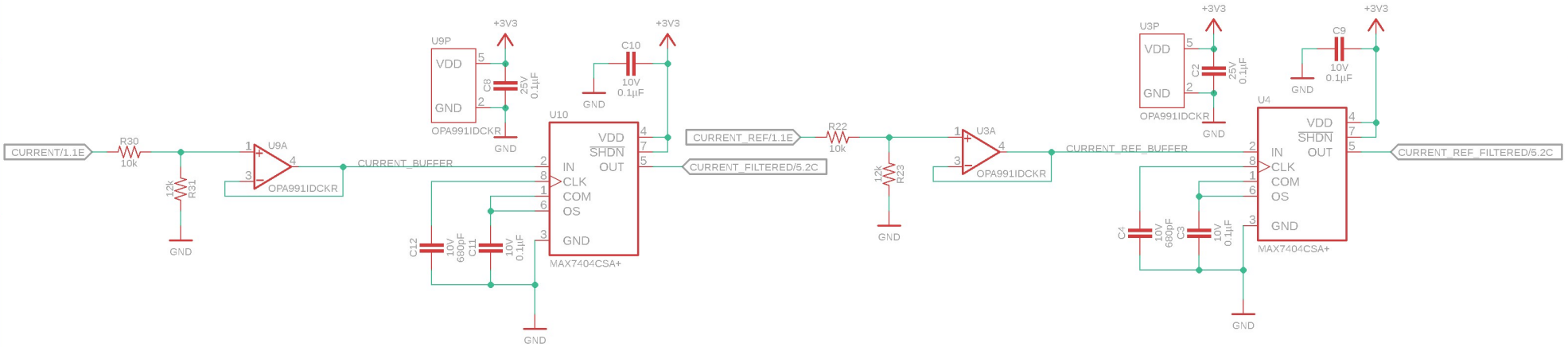
HYTECH RACING

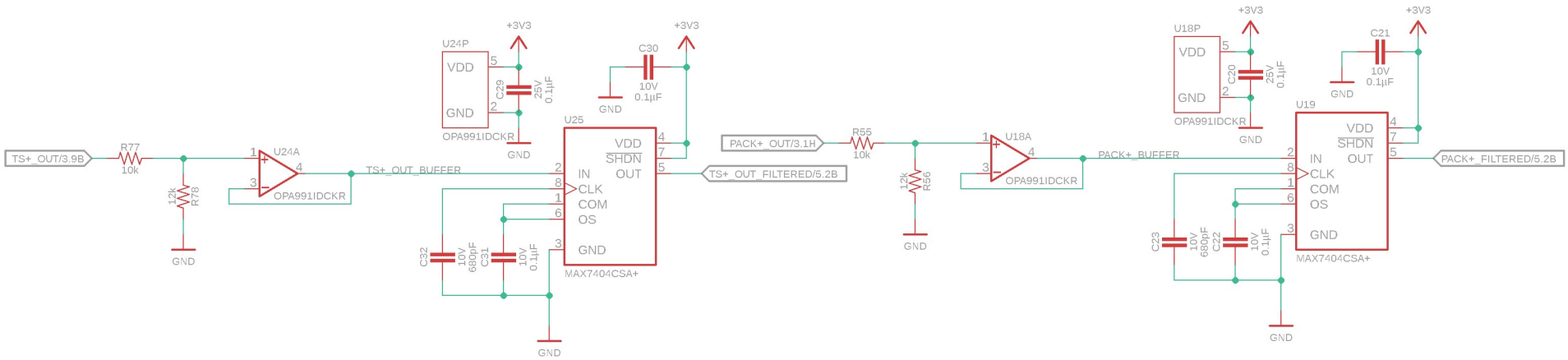
Description: Precharger circuit

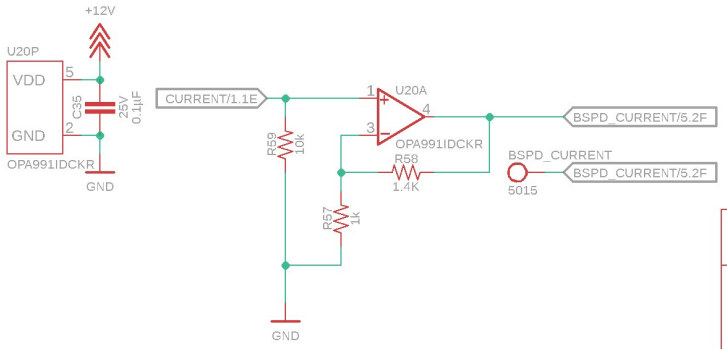
Date: 6/11/2022 7:32 PM

Sheet: 3/6

Analog Filtering







	Designer Signature	Reviewer Signature
Schematic Review		
Board Review		
Further Reviews		

Engineer: Josh Kirshenbaum

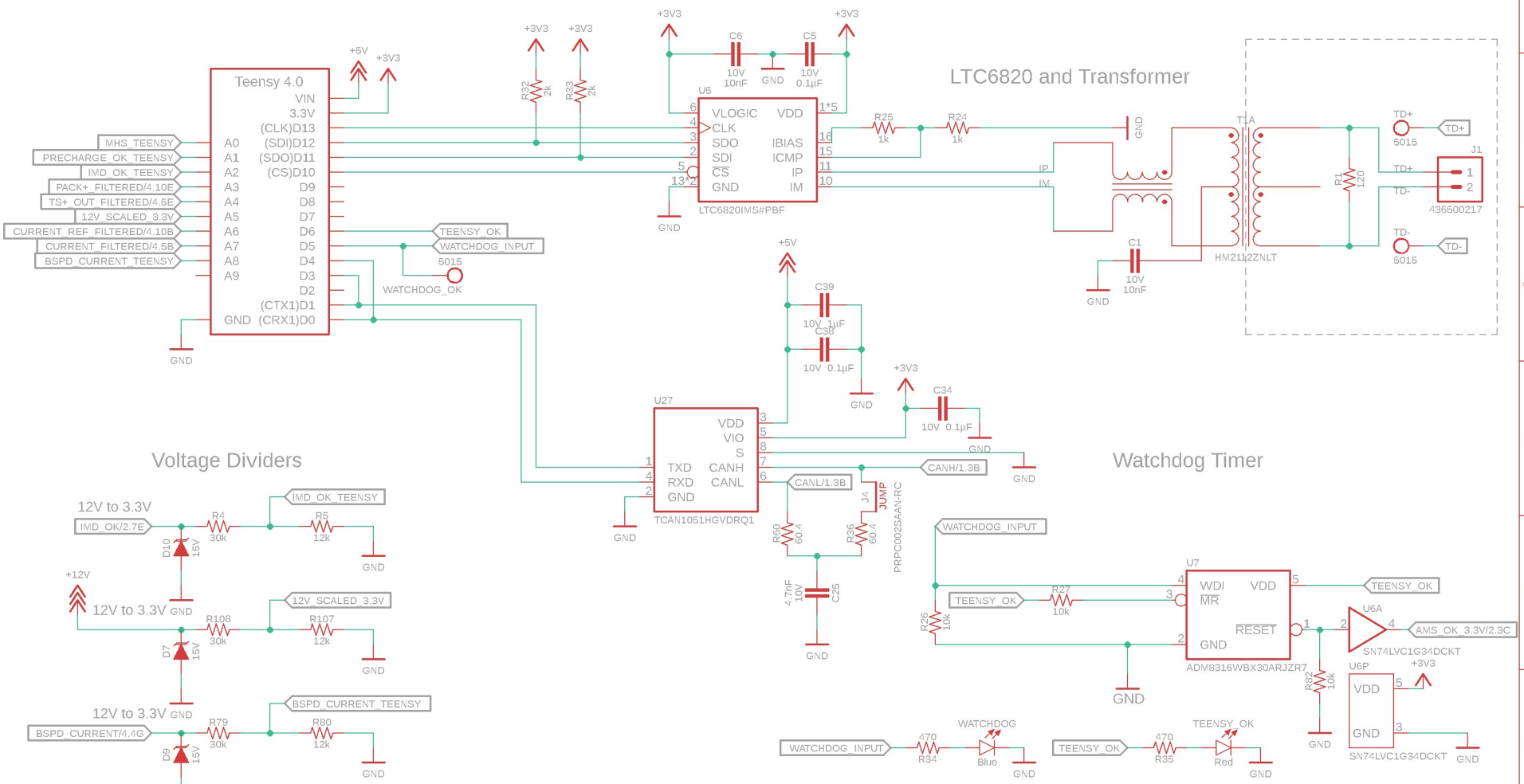
Document Name: Accumulator Control Unit rev3

HYTECH RACING

Description: Analog filtering

Date: 6/11/2022 7:32 PM

Sheet: 4/6



	Designer Signature	Reviewer Signature
Schematic Review	Liwei Sun	Joshua Kirshenbaum
Board Review	Liwei Sun	Zekun Li
Further Reviews		

Engineer: Liwei Sun

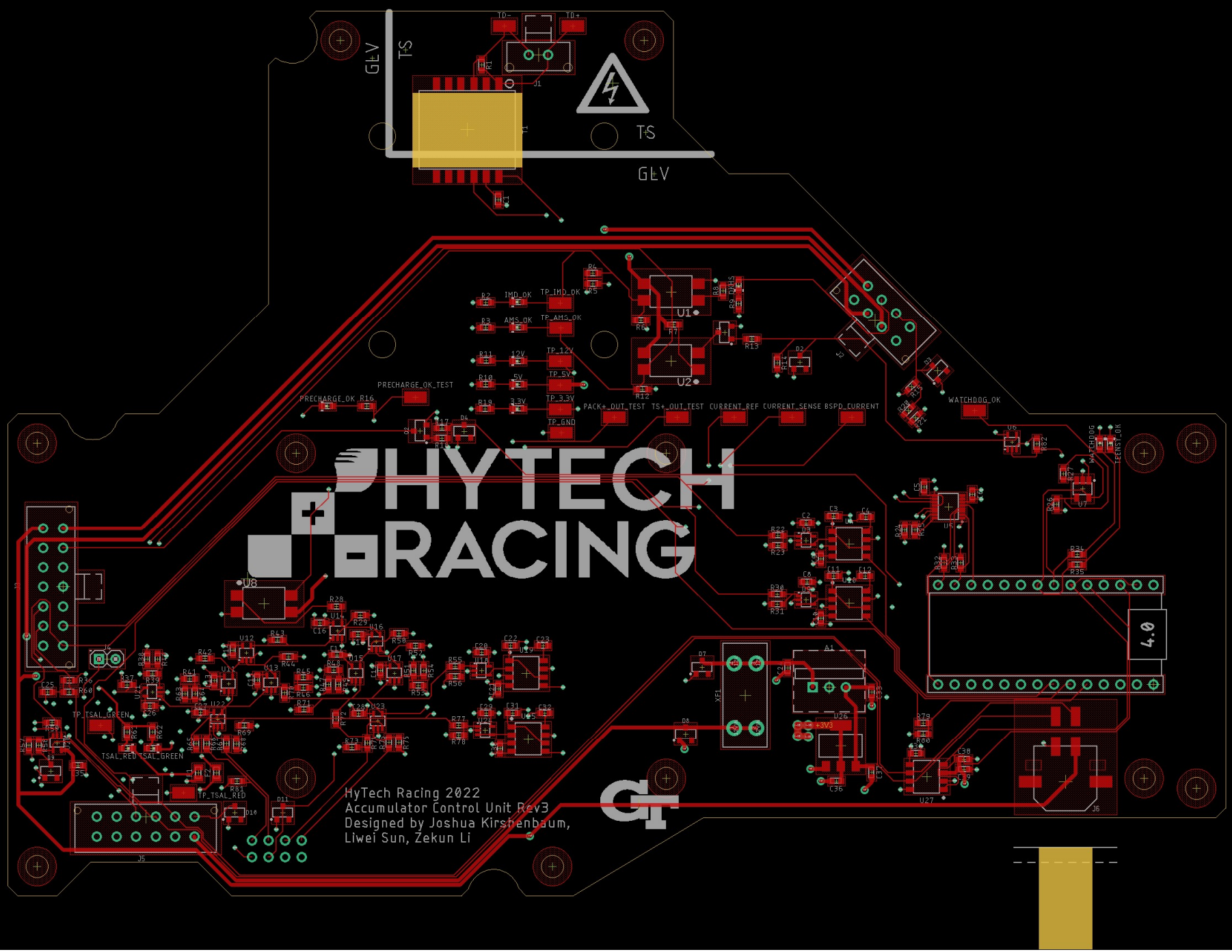
Document Name: Accumulator Control Unit rev3

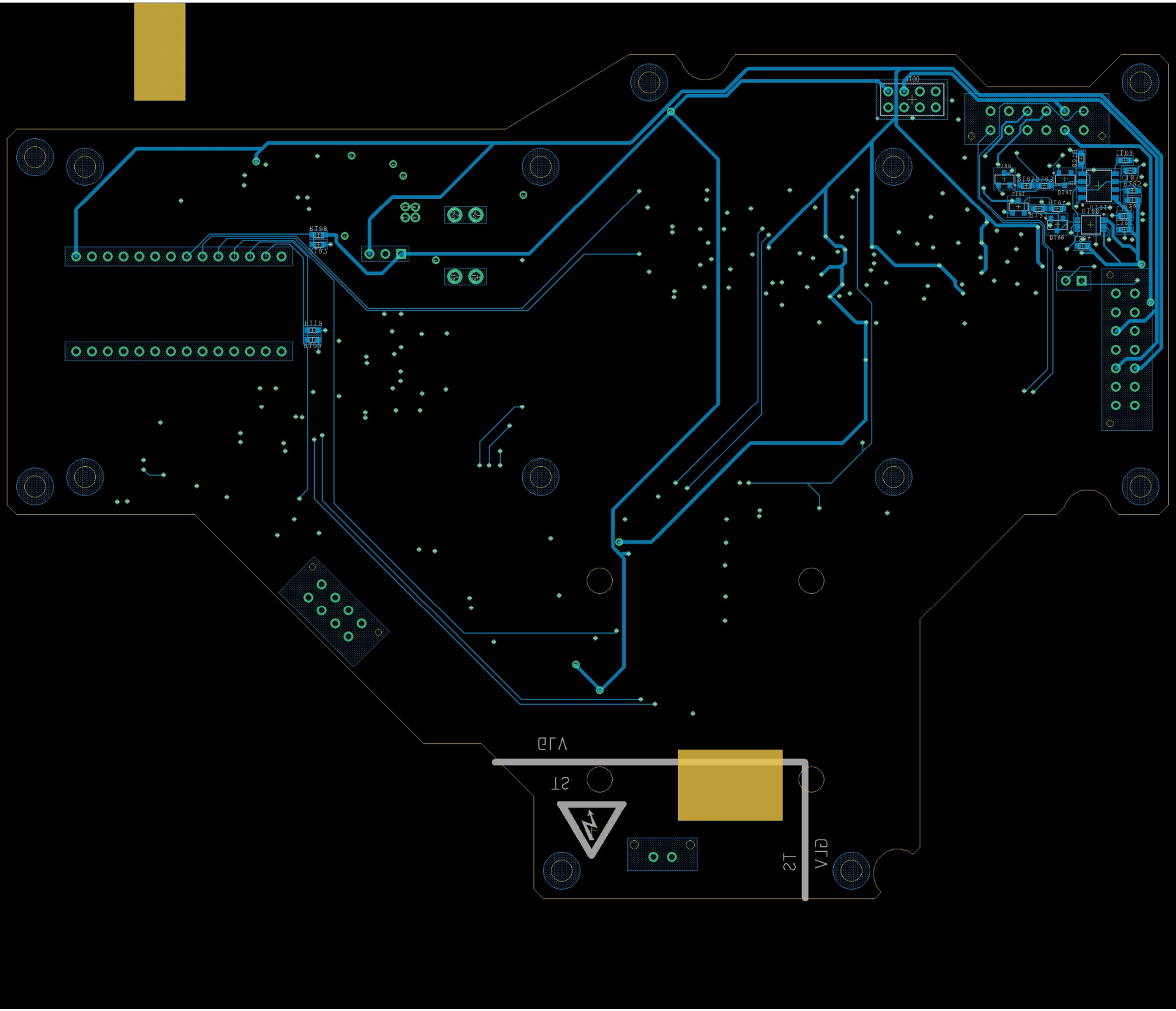
HYTECH RACING

Description: Teensy, LTC6820, CAN, watchdog

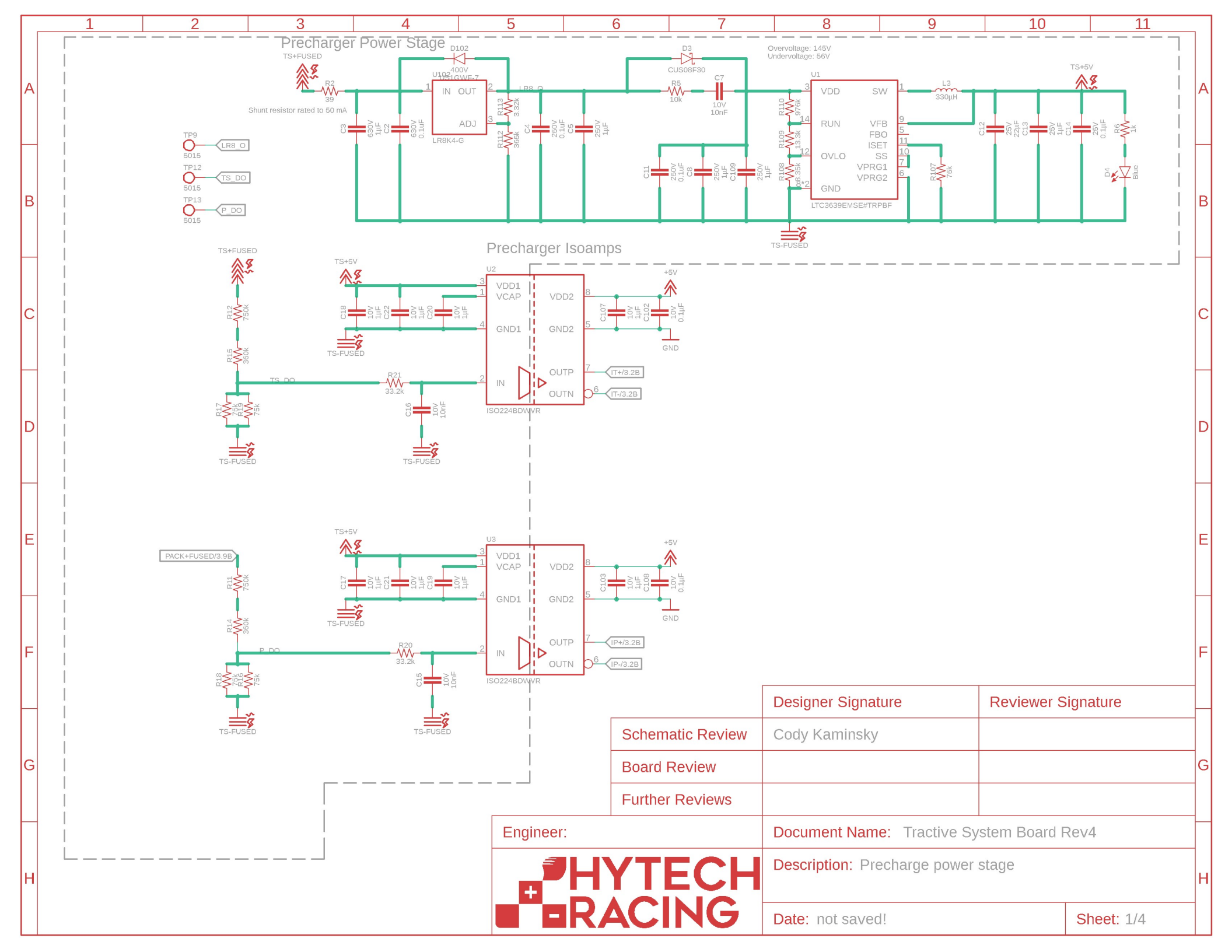
Date: 6/11/2022 7:32 PM

Sheet: 5/6


GLV
TS
TD-
TD+
J1
TS
GLV
U1
U2
IMD_OK
TP_IMD_OK
AMS_OK
TP_AMS_OK
12V
TP_12V
5V
TP_5V
3.3V
TP_3.3V
TP_GND
PRECHARGE_OK_TEST
PRECHARGE_OK
PACK+_OUT_TEST
TS+_OUT_TEST
CURRENT_REF
CURRENT_SENSE
BSPD_CURRENT
WATCHDOG_OK
WATCHDOG
TEENSY_OK
HYTECH
RACING
U8
TP_TSAL_GREEN
TSAL_RED
TSAL_GREEN
TP_TSAL_RED
J5
J6
A1
XF1
+3V3
4.0
HyTech Racing 2022
Accumulator Control Unit Rev3
Designed by Joshua Kirshenbaum,
Liwei Sun, Zekun Li



II.D. Tractive System Board



	Designer Signature	Reviewer Signature
Schematic Review	Cody Kaminsky	
Board Review		
Further Reviews		

Engineer:

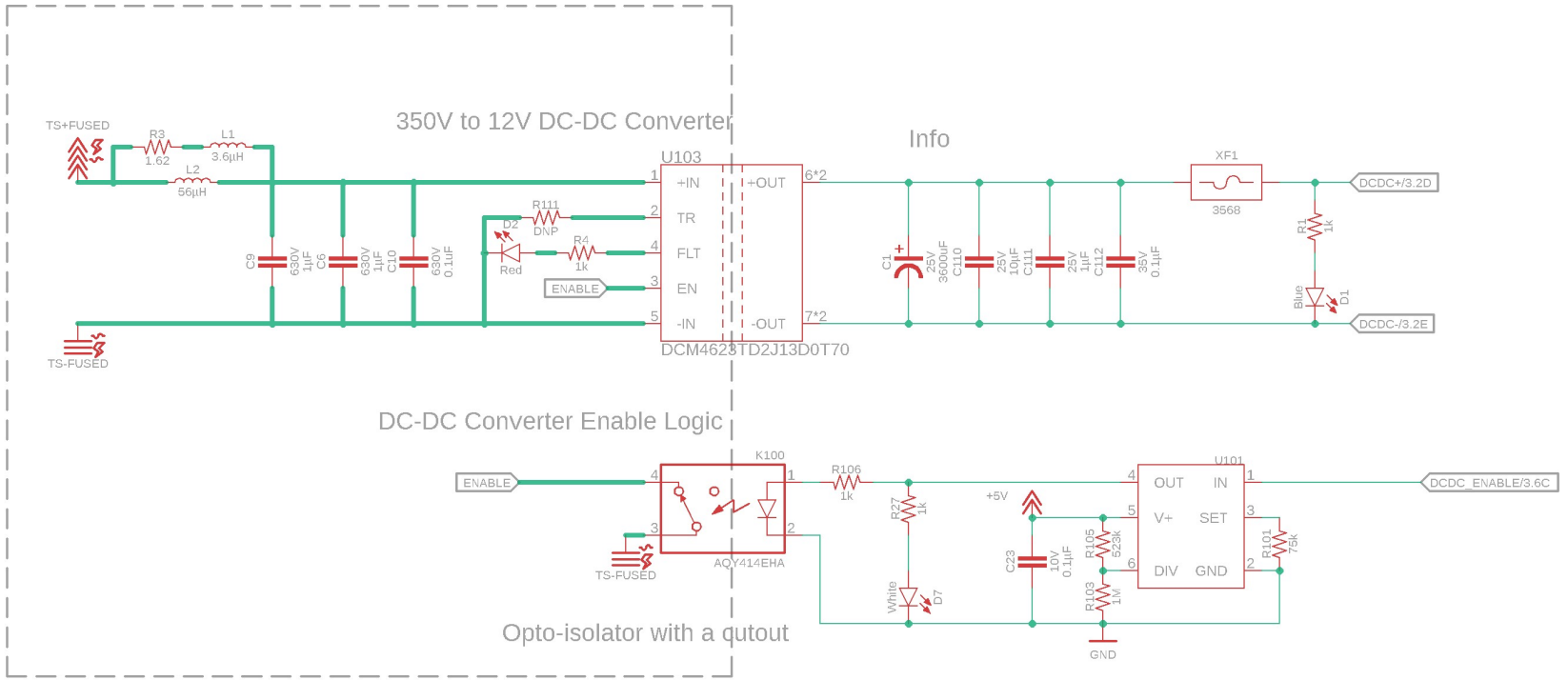
HYTECH RACING

Document Name: Tractive System Board Rev4

Description: Precharge power stage

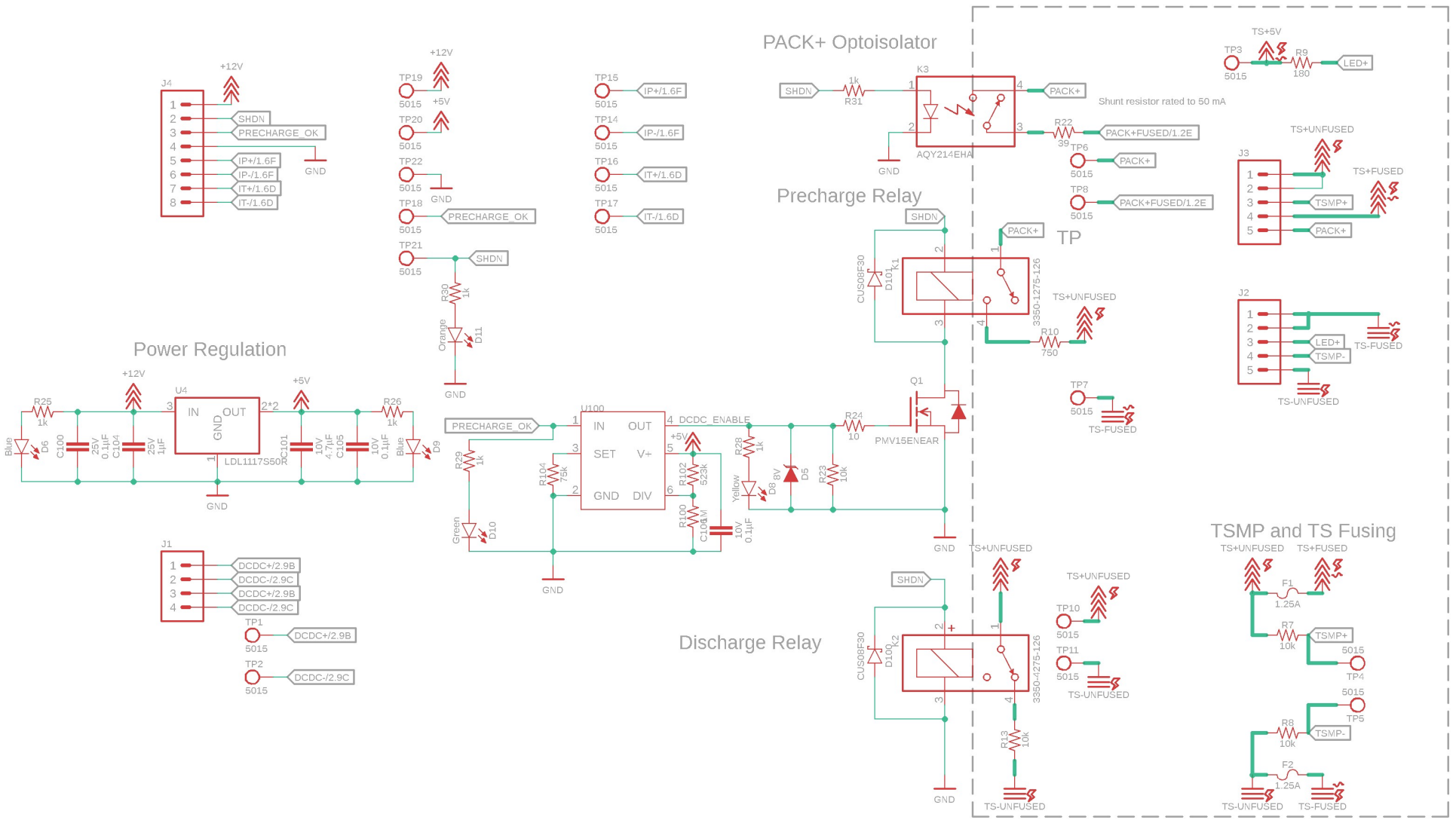
Date: not saved!

Sheet: 1/4



	Designer Signature	Reviewer Signature
Schematic Review	Cody Kaminsky	
Board Review		
Further Reviews		

Engineer:	Document Name: Tractive System Board Rev4
HYTECH RACING	Description: DCDC Converter and DCDC Converter Control Circuitry
	Date: 6/11/2022 10:04 PM — Sheet: 2/4



	Designer Signature	Reviewer Signature
Schematic Review	Cody Kaminsky	
Board Review		
Further Reviews		

Engineer:

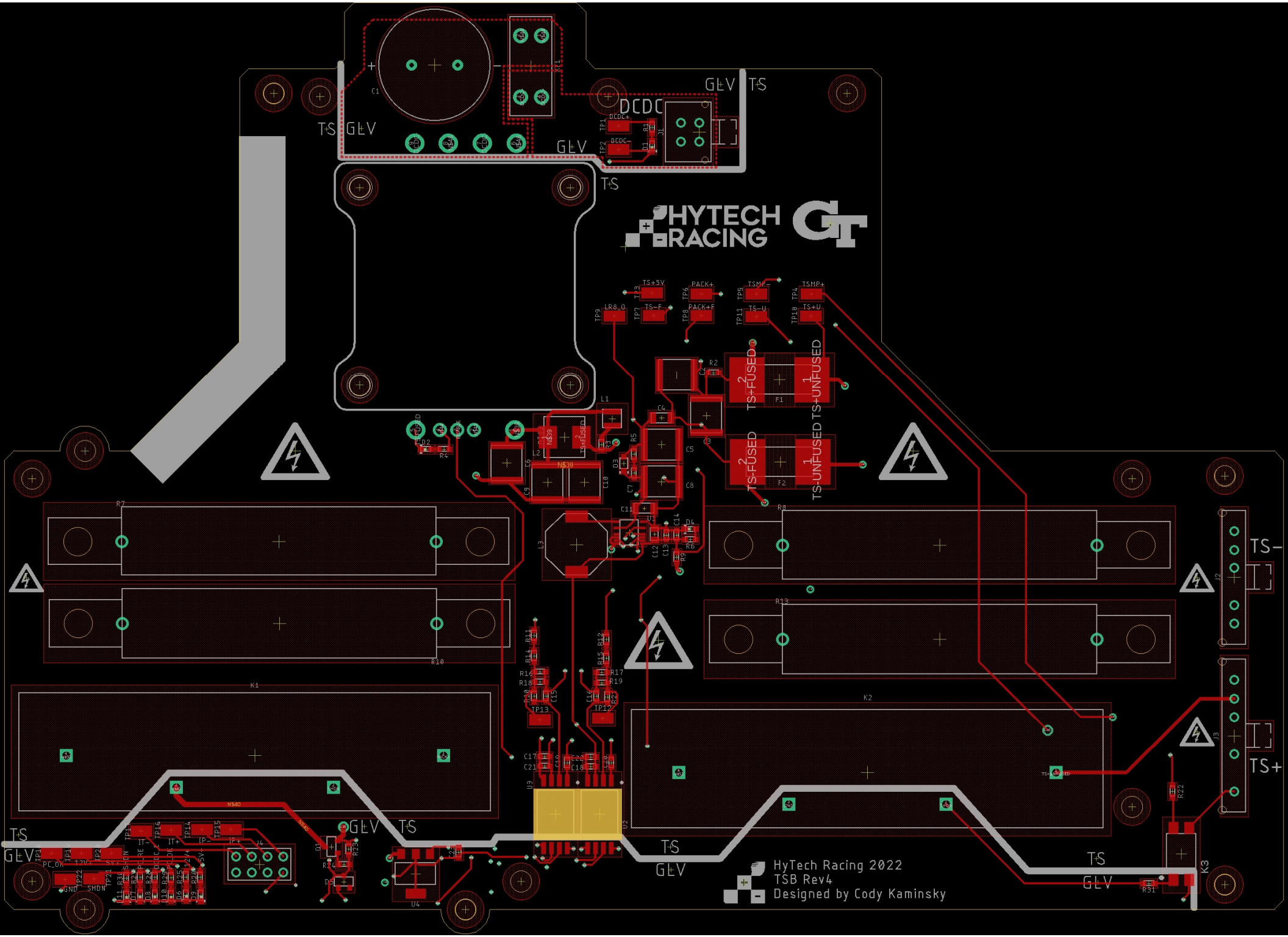
HYTECH RACING

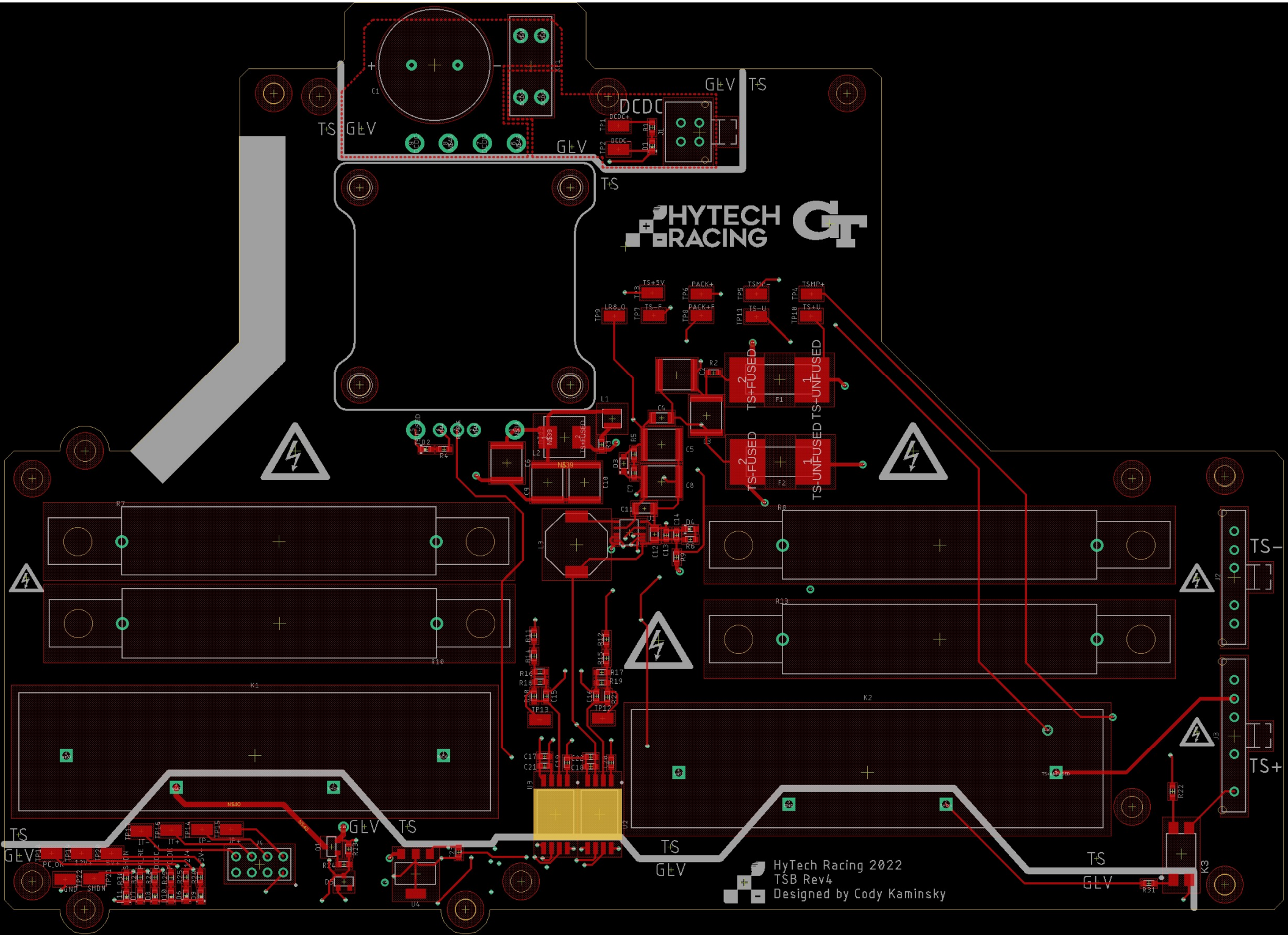
Document Name: Tractive System Board Rev4

Description: Relays and connectors

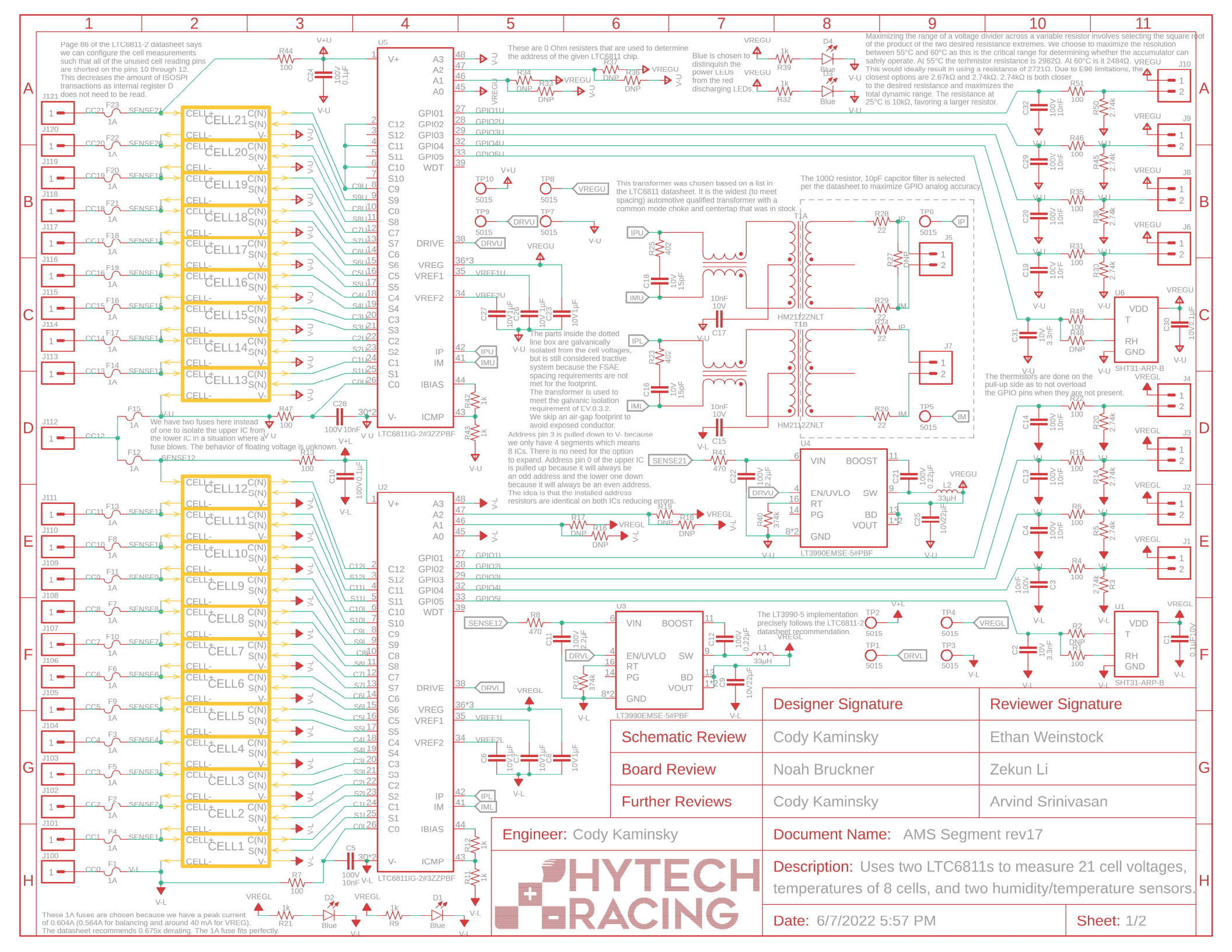
Date: 6/11/2022 10:04 PM

Sheet: 3/4

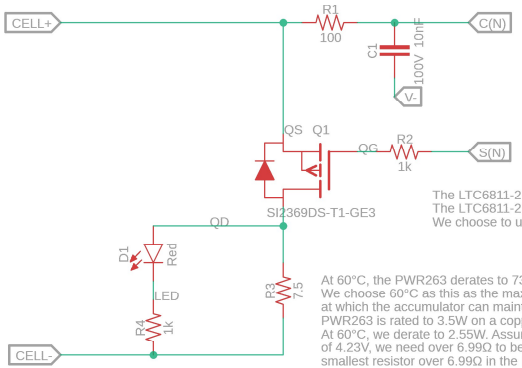

HYTECH RACING
GT
DCDC
GLV
TS
TS+FUSED
TS+UNFUSED
TS-FUSED
TS-UNFUSED
TS-
TS+
HyTech Racing 2022
TSB Rev4
Designed by Cody Kaminsky


HYTECH RACING
GT
DCDC
GLV
TS
TS+FUSED
TS+UNFUSED
TS-FUSED
TS-UNFUSED
TS-
TS+
HyTech Racing 2022
TSB Rev4
Designed by Cody Kaminsky

II.E. Accumulator Management System


Page 86 of the LTC6811-2 datasheet says we can configure the cell measurements such that all of the unused cell reading pins are shorted on the pins 10 through 12. This decreases the amount of ISOSPI transactions an internal register D does not need to be read.
These are 0 Ohm resisters that are used to determine the address of the given LTC6811 chip.
Blue is chosen to distinquish the power LEDs from the red discharging LEDs.
Maximizing the range of a voltage divider across a variable resistor involves selecting the square root of the product of the two desired resistance extremes. We choose to maximize the resolution between 55°C and 60°C as this is the critical range for determining whether the accumulator can safely operate. At 55°C the terhmistor resistance is 2982Ω. At 60°C is it 2484Ω. This would ideally result in using a resistance of 2721Ω. Due to E96 limitations, the closest options are 2.67kΩ and 2.74kΩ. 2.74kΩ is both closer to the desired resistance and maximizes the total dynamic range. The resistance at 25°C is 10kΩ, favoring a larger resistor.
This transformer was chosen based on a list in the LTC6811 datasheet. It is the widest (to meet spacing) automotive qualified transformer with a common mode choke and centertap that was in stock.
The 100Ω resistor, 10pF capcitor filter is selected per the datasheet to maximize GPIO analog accuracy.
The parts inside the dotted line box are galvanically isolated from the cell voltages, but is still considered tractive system because the FSAE spacing requirements are not met for the footprint. The transformer is used to meet the galvanic isolation requirement of EV.0.3.2. We skip an air-gap footprint to avoid exposed conductor.
Address pin 3 is pulled down to V- because we only have 4 segments which means 8 ICs. There is no need for the option to expand. Address pin 0 of the upper IC is pulled up because it will always be an odd address and the lower one down because it will always be an even address. The idea is that the installed address resistors are identical on both ICs reducing errors.
The thermistors are done on the pull-up side as to not overload the GPIO pins when they are not present.
The LT3990-5 implementation precisely follows the LTC6811-2 datasheet recommendation.
We have two fuses here instead of one to isolate the upper IC from the lower IC in a situation where a fuse blows. The behavior of floating voltage is unknown.
These 1A fuses are chosen because we have a peak current of 0.604A (0.564A for balancing and around 40 mA for VREG). The datasheet recommends 0.675x derating. The 1A fuse fits perfectly.
LTC6811IG-2#3ZZPBF
HM2112ZNLT
LT3990EMSE-5#PBF
SHT31-ARP-B
Designer Signature
Reviewer Signature
Schematic Review
Cody Kaminsky
Ethan Weinstock
Board Review
Noah Bruckner
Zekun Li
Further Reviews
Cody Kaminsky
Arvind Srinivasan
Engineer: Cody Kaminsky
Document Name: AMS Segment rev17
HYTECH RACING
Description: Uses two LTC6811s to measure 21 cell voltages, temperatures of 8 cells, and two humidity/temperature sensors.
Date: 6/7/2022 5:57 PM
Sheet: 1/2

RC Filter Determined by one shown on page 70 of the datasheet. This maximizes accuracy of the cell measurement.



The LTC6811-2 datasheet recommends a 3.3kΩ gate resistor.
The LTC6811-2 demo circuit uses a 1kΩ gate resistor.
We choose to use a 1kΩ for part commonality.

At 60°C, the PWR263 derates to 73.077% maximum power. We choose 60°C as this as the maximum allowed temperature at which the accumulator can maintain normal operation. The PWR263 is rated to 3.5W on a copper board without heatsink. At 60°C, we derate to 2.55W. Assuming maximum cell voltage of 4.23V, we need over 6.99Ω to be under 2.55W. 7.5Ω is the smallest resistor over 6.99Ω in the PWR263 series. The smallest resistor value is chosen to speed up balancing as larger currents allow more energy to be discharged.

	Designer Signature	Reviewer Signature
Schematic Review	Cody Kaminsky	Ethan Weinstock
Board Review	Noah Bruckner	Zekun Li
Further Reviews	Cody Kaminsky	Arvind Srinivasan

Engineer: Cody Kaminsky

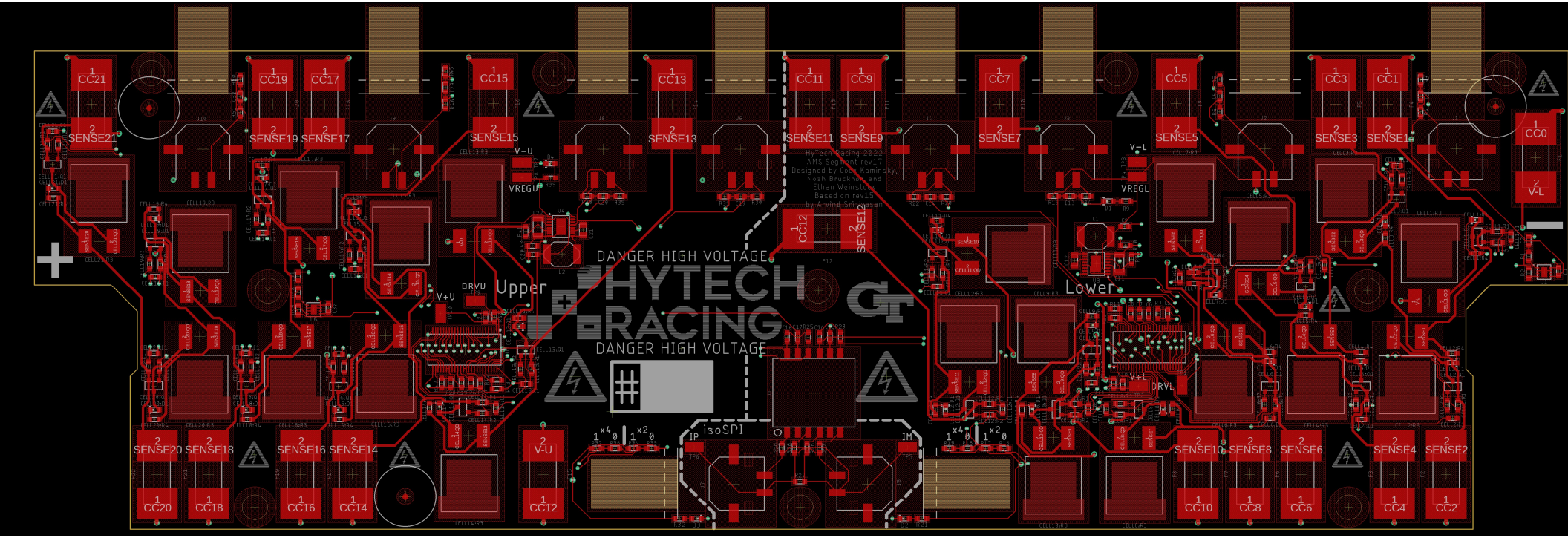
Document Name: AMS Segment rev17

HYTECH RACING

Description: This module is responsible for filtering the cell reading as well as discharging the cell when necessary.

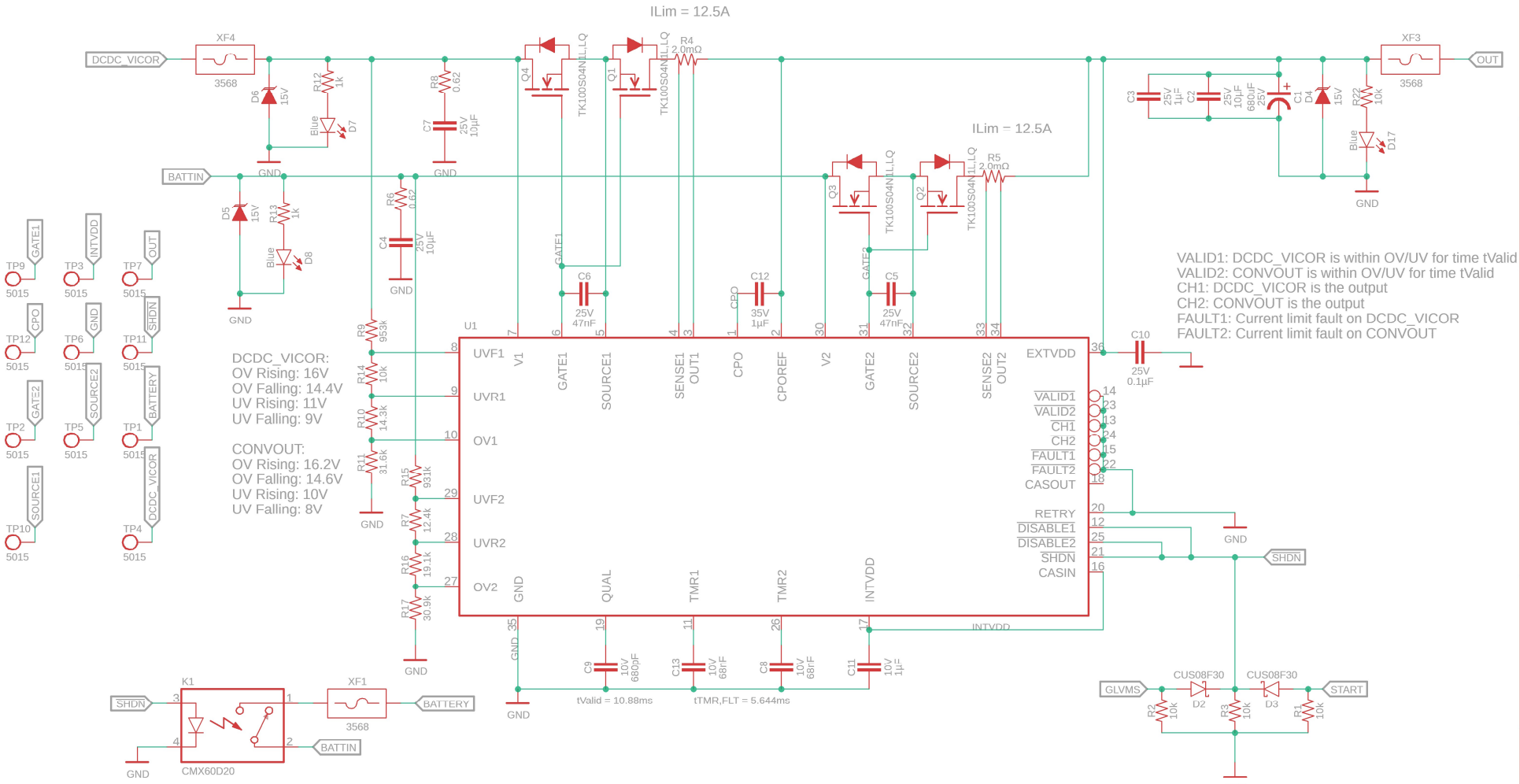
Date: 6/7/2022 5:57 PM

Sheet: 1/1


DANGER HIGH VOLTAGE
HYTECH
RACING
DANGER HIGH VOLTAGE
Upper
Lower
isoSPI
IP
IM
V-U
V-L
VREGU
VREGL
DRVU
DRVL
V+U
HyTech Racing 2022
AMS Segment rev17
Designed by Colin Kaminsky,
Noah Bruckner, and
Ethan Weinstock
Based on rev15
by Arvind Sivakumaran

C21
C19
C17
C15
C13
C11
C9
C7
C5
C3
C1
C0
DANGER HIGH VOLTAGE
Upper
Lower
DANGER HIGH VOLTAGE
C20
C18
C16
C14
C12
C10
C8
C6
C4
C2

II.F. Power Switching Board



	Designer Signature	Reviewer Signature
Schematic Review	Steven Elias	
Board Review	Steven Elias	
Further Reviews		

Engineer: Steven Elias

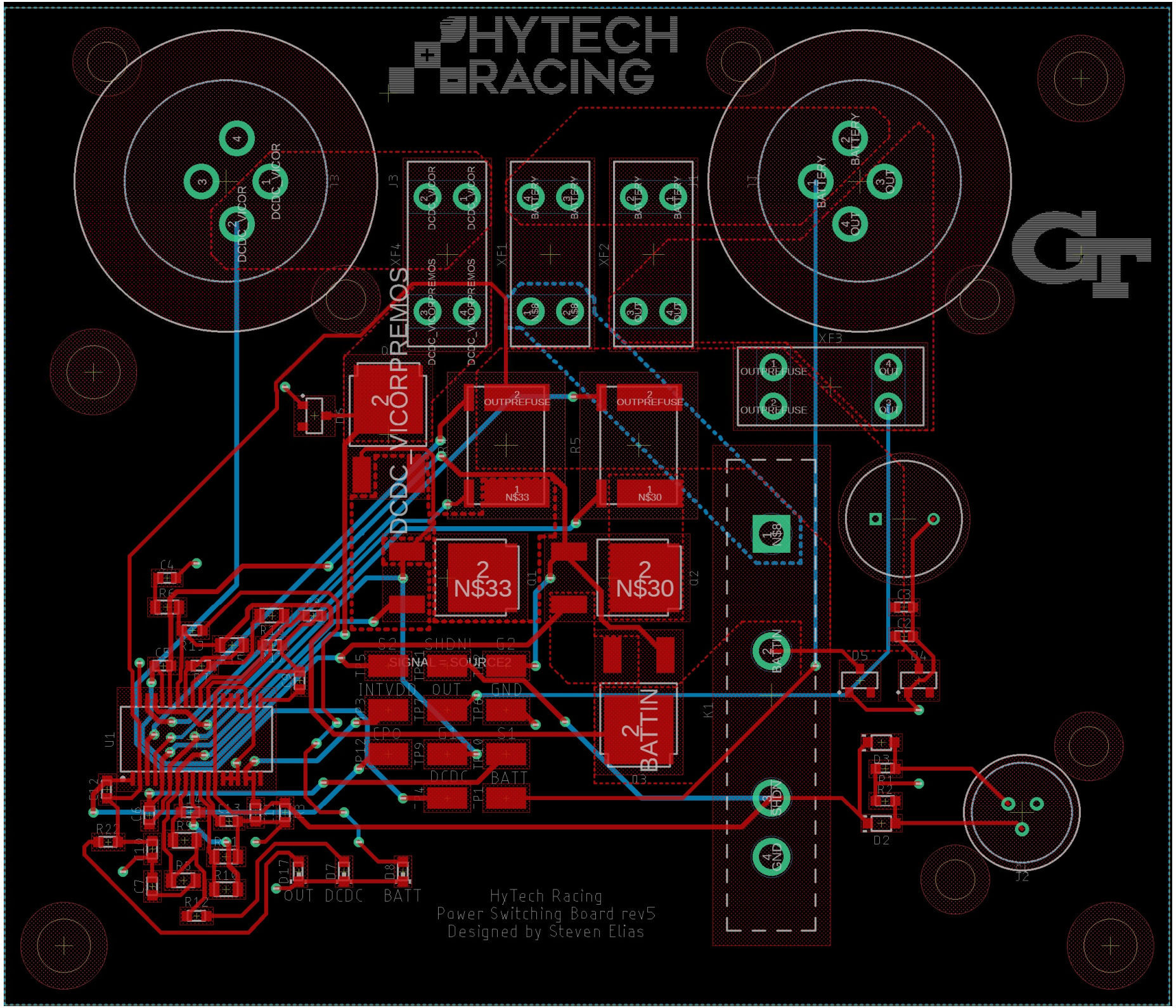
Document Name: Power Switching Circuit rev5

HYTECH RACING

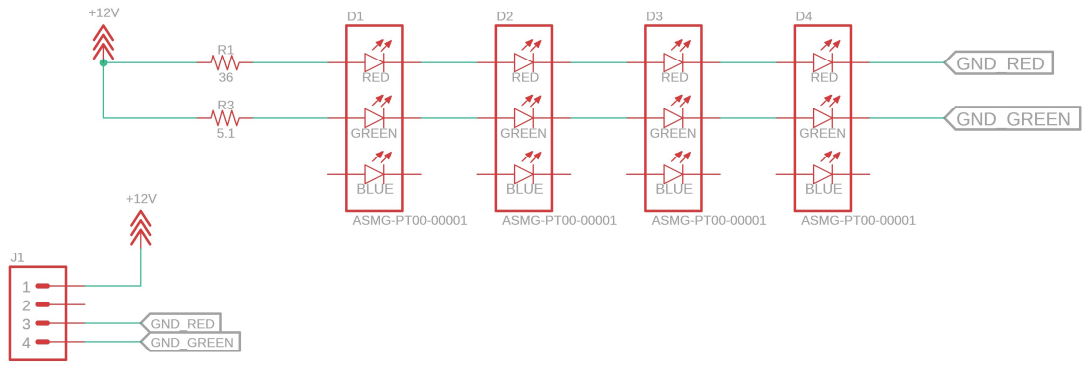
Description: Circuit is used to switch the active power source of the vehicle from the GLV battery to the accumulator

Date: 6/11/2022 7:51 PM

Sheet: 1/2


HYTECH RACING
DCDC_VICOR
DCDC_VICORPREMOS
BATTERY
OUTPREFUSE
N$33
N$30
BATTIN
SHDN
GND
SIGNAL_SOURCE2
INTVDD
OUT
DCDC
BATT
HyTech Racing
Power Switching Board rev5
Designed by Steven Elias

II.G. Tractive System Active Light



	Designer Signature	Reviewer Signature
Schematic Review	Liwei Sun	Zekun Li
Board Review	Liwei Sun	Zekun Li
Further Reviews		

Engineer: Liwei Sun

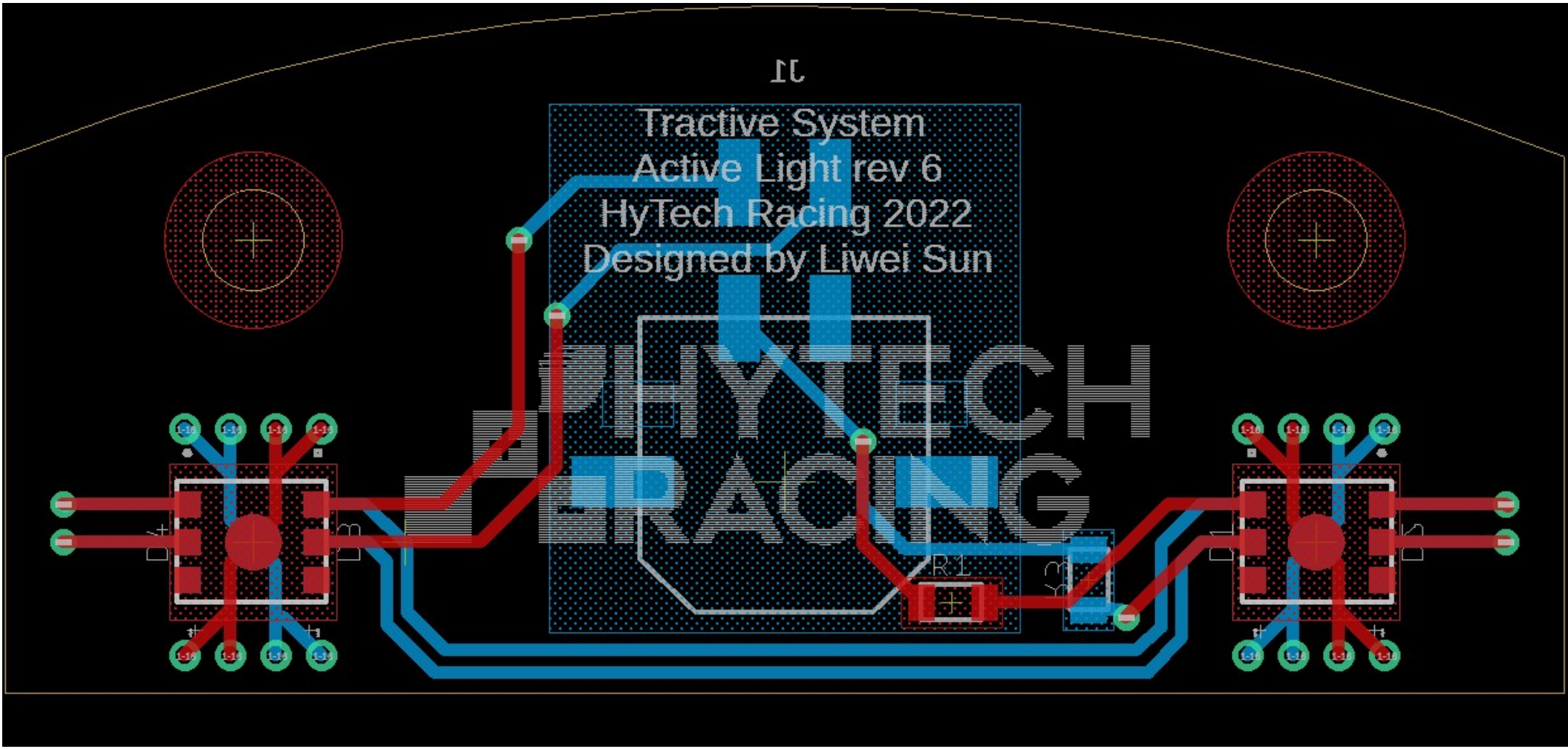
Document Name: Tractive System Active Light rev6

HYTECH RACING

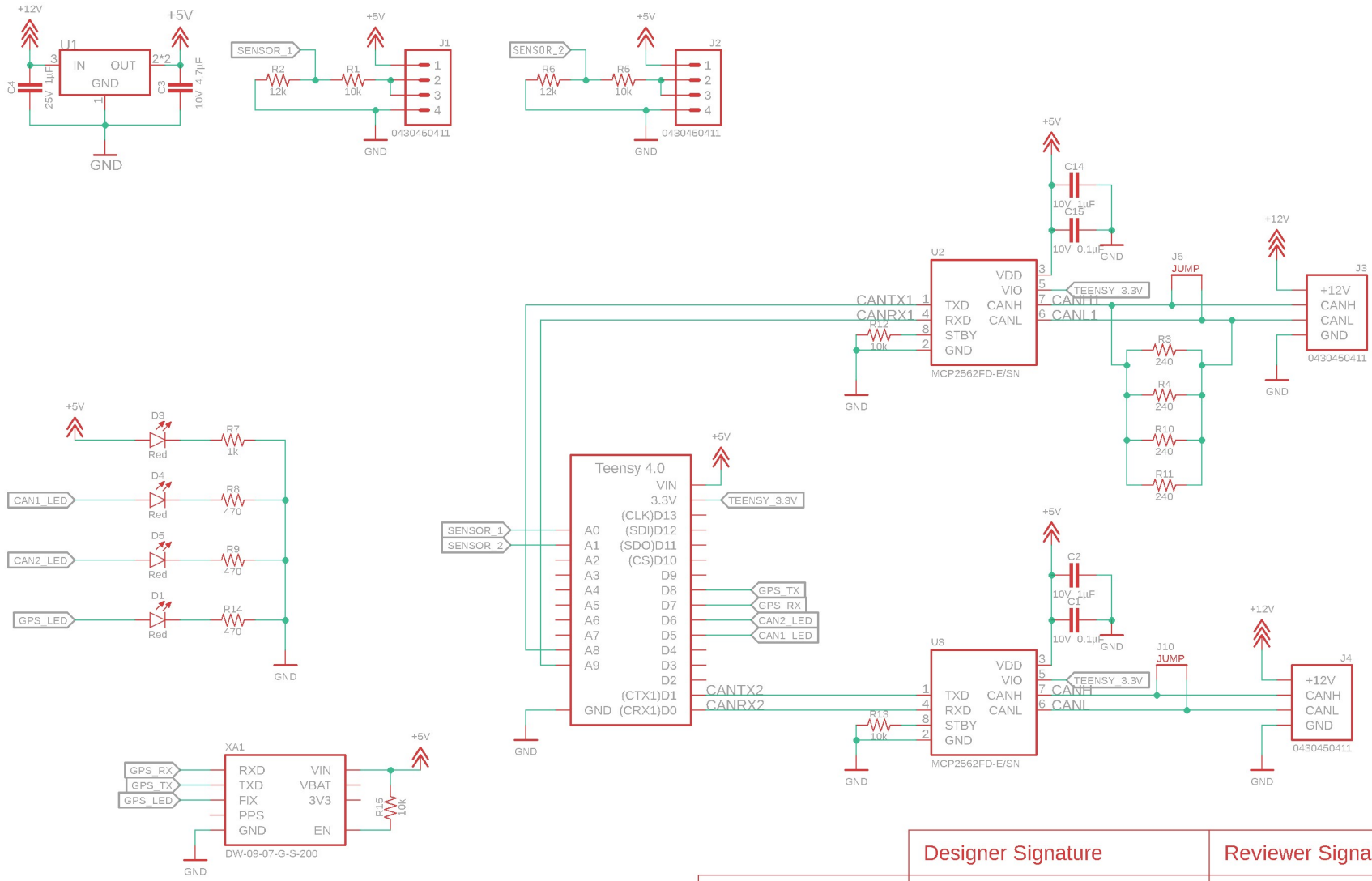
Description: TSAL rev 6 Schematic

Date: 6/11/2022 10:07 PM

Sheet: 1/2


J1
Tractive System
Active Light rev 6
HyTech Racing 2022
Designed by Liwei Sun
HYTECH
RACING
R1
D1
D2
D3
D4

II. H. Front Sensor Acquisition Board



	Designer Signature	Reviewer Signature
Schematic Review	Bo Han Zhu	Zekun Li
Board Review	Bo Han Zhu	Zekun Li
Further Reviews		

Engineer: Bo Han Zhu

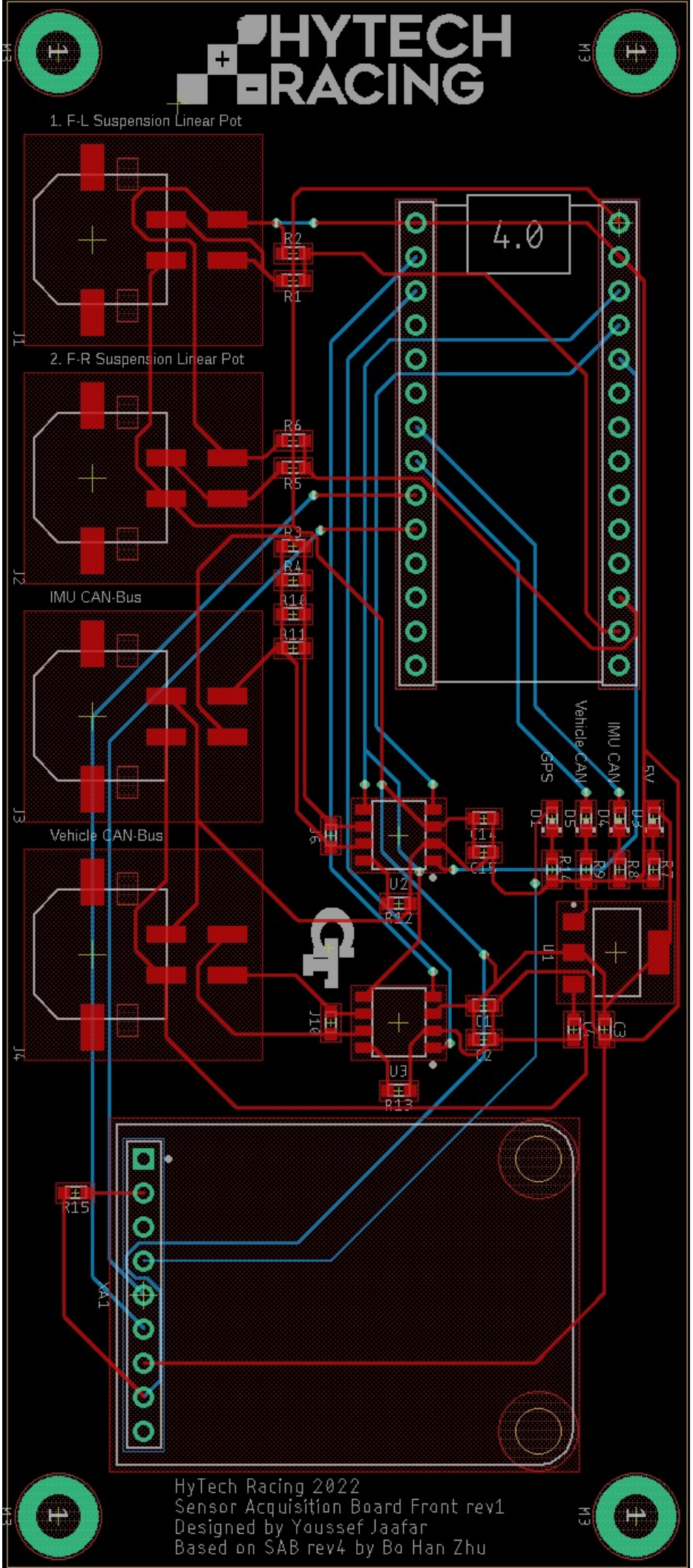
HYTECH RACING

Document Name: Sensor Acquisition Board Front rev1

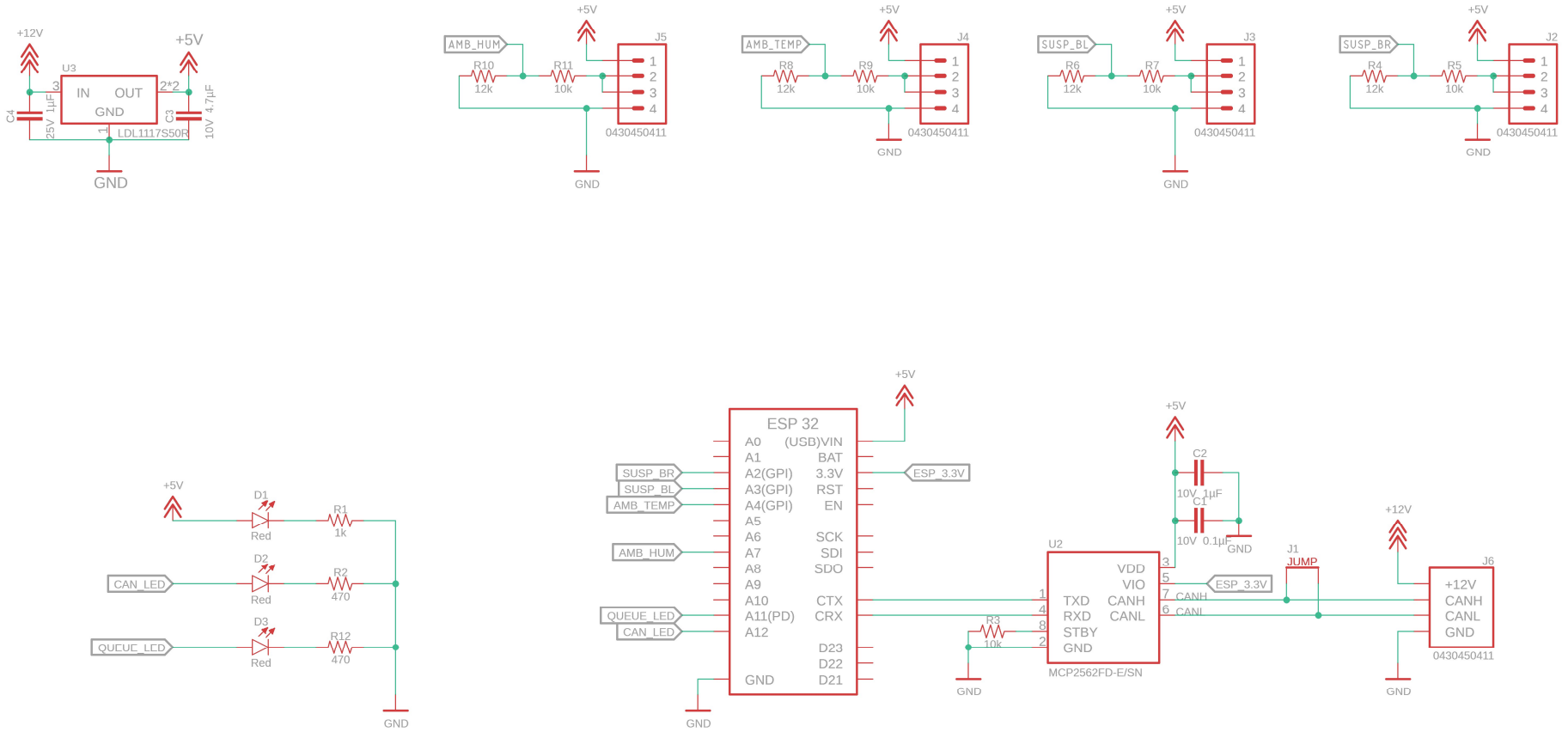
Description: Translates 2 Analog Voltage Sensors to CAN and Supplies GPS Information

Date: 6/11/2022 10:10 PM

Sheet: 1/1


HYTECH RACING
1. F-L Suspension Linear Pot
2. F-R Suspension Linear Pot
IMU CAN-Bus
Vehicle CAN-Bus
4.0
GPS
Vehicle CAN
IMU CAN
5V
HyTech Racing 2022
Sensor Acquisition Board Front rev1
Designed by Youssef Jaafar
Based on SAB rev4 by Bo Han Zhu

II.I. Rear Sensor Acquisition Board



	Designer Signature	Reviewer Signature
Schematic Review	Bo Han Zhu	Zekun Li
Board Review	Bo Han Zhu	Zekun Li
Further Reviews		

Engineer: Bo Han Zhu

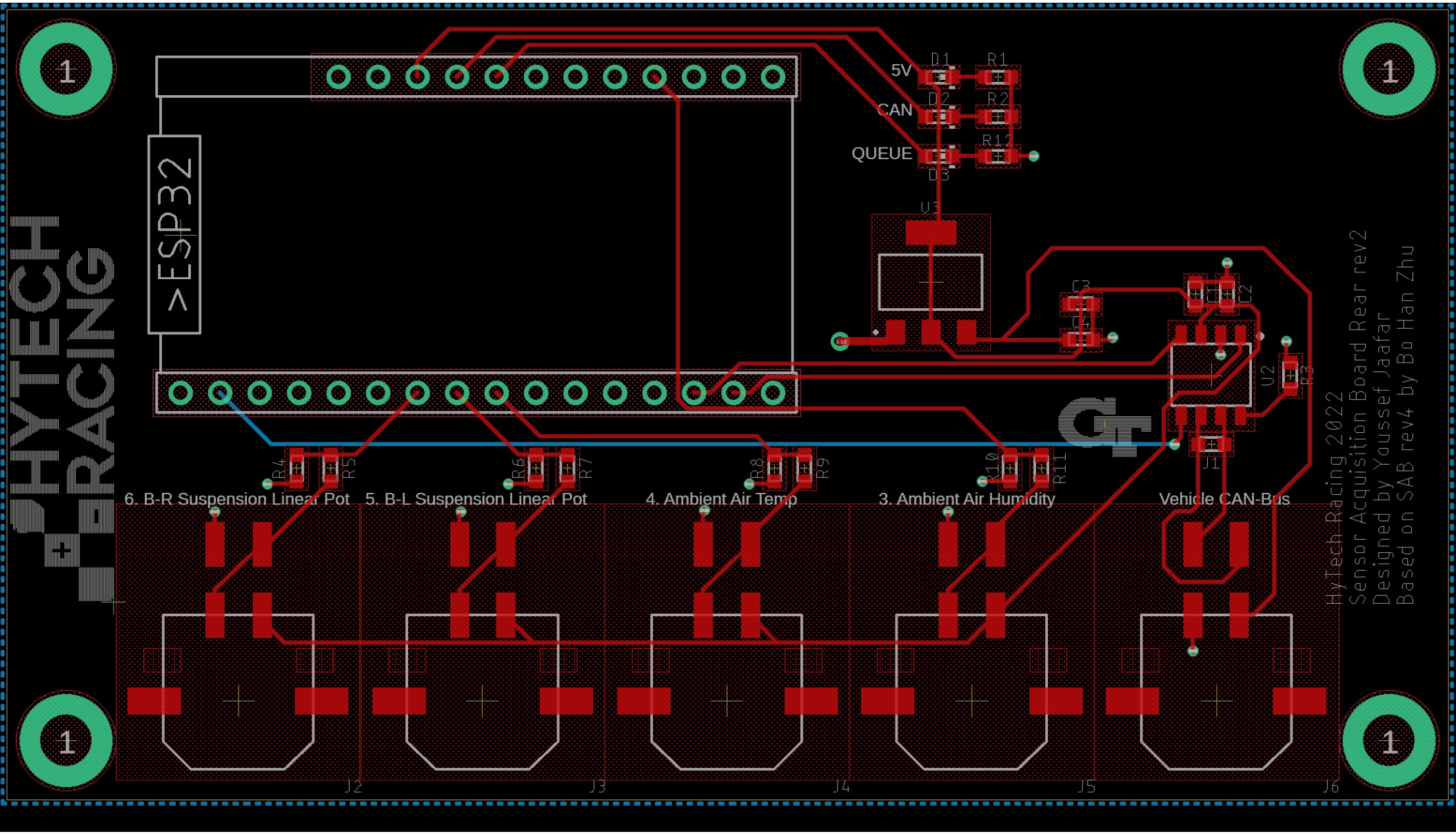
Document Name: Sensor Acquisition Board Rear rev2

HYTECH RACING

Description: Translates 8 Analog Voltage Sensors to CAN

Date: 6/11/2022 10:11 PM

Sheet: 1/2


HYTECH RACING
>ESP32
5V
CAN
QUEUE
D1
D2
D3
R1
R2
R12
U3
C3
C4
C1
C2
U2
R3
J1
R4
R5
R6
R7
R8
R9
R10
R11
6. B-R Suspension Linear Pot
5. B-L Suspension Linear Pot
4. Ambient Air Temp
3. Ambient Air Humidity
Vehicle CAN-Bus
J2
J3
J4
J5
J6
HyTech Racing 2022
Sensor Acquisition Board Rear rev2
Designed by Youssef Jaafar
Based on SAB rev4 by Bo Han Zhu