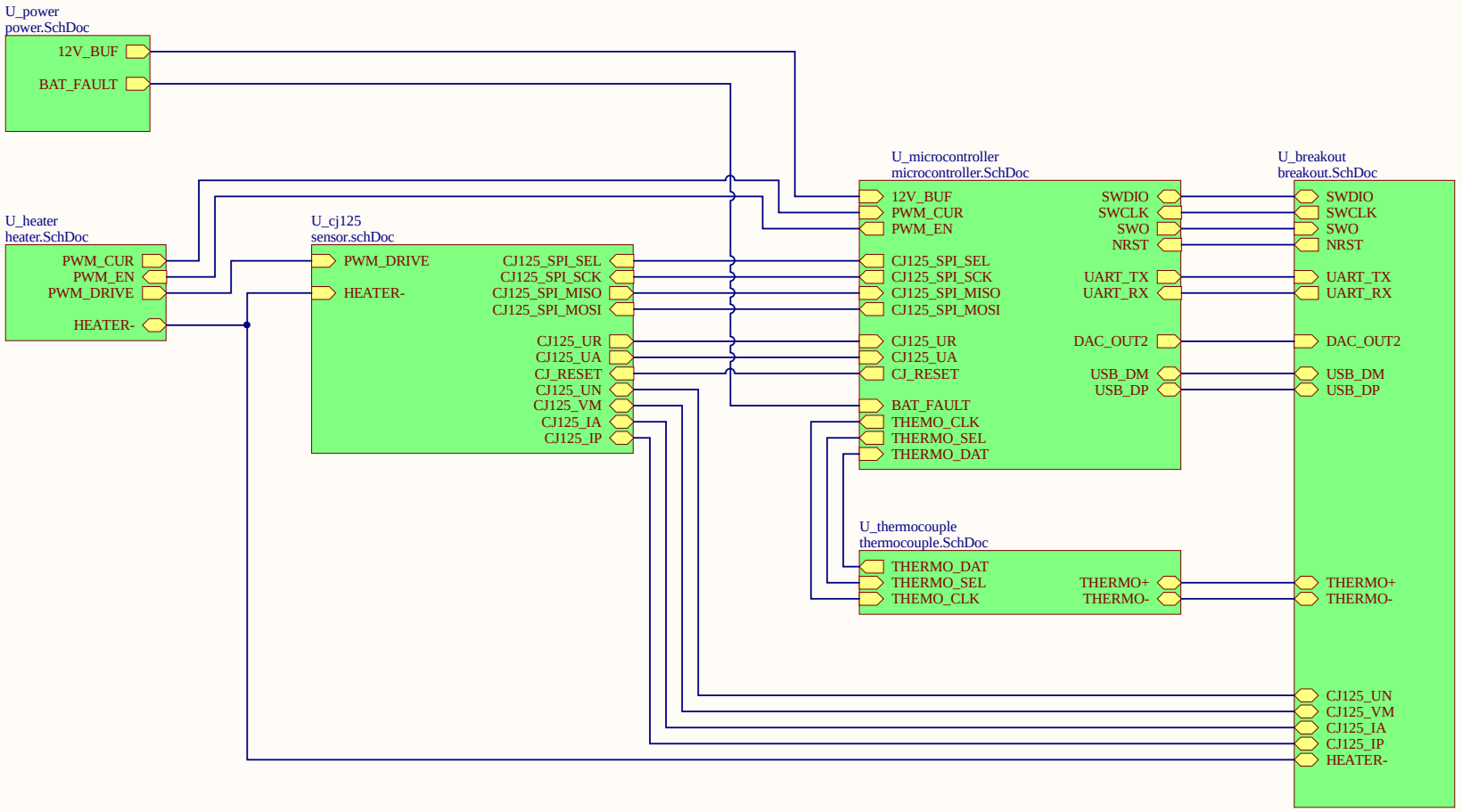
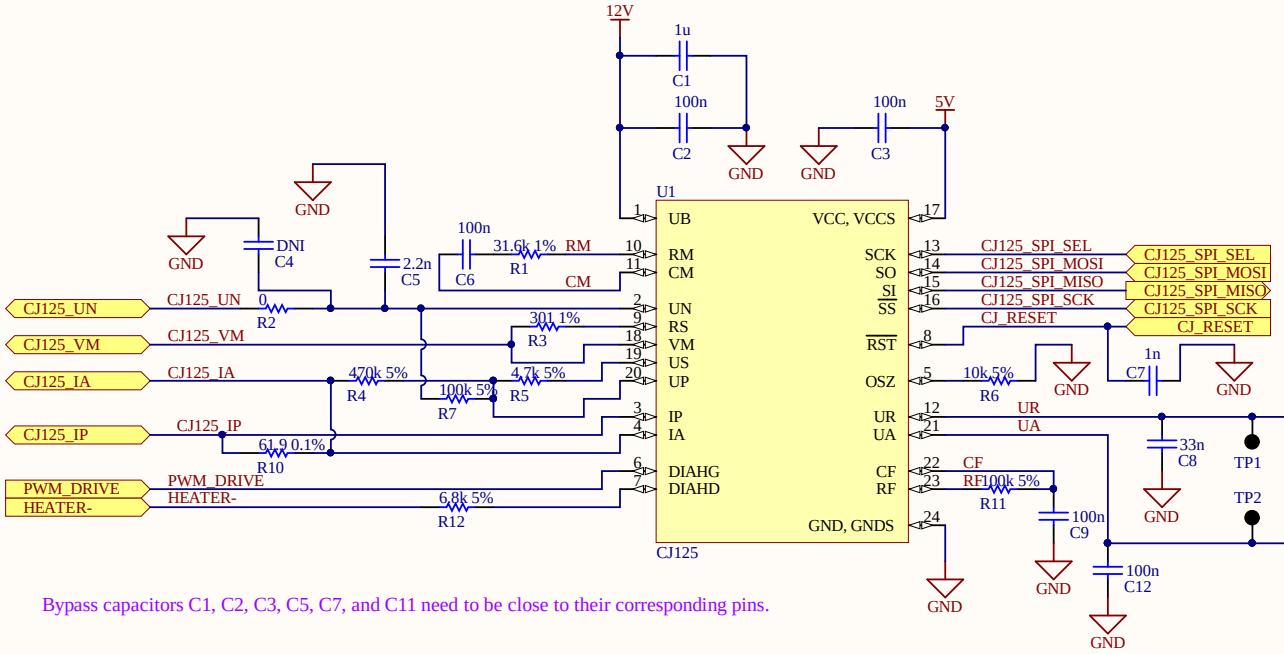


Note:
All capacitors are rated for 50V unless otherwise noted.
All resistors are rated for 1/10W unless otherwise noted.

Title: Top			
Project: Lambda Oxygen Sensor Interface			
Date: 12/18/2018	Time: 12:17:48 PM	Sheet 1 of 7	File: cjb.SchDoc

CJ125



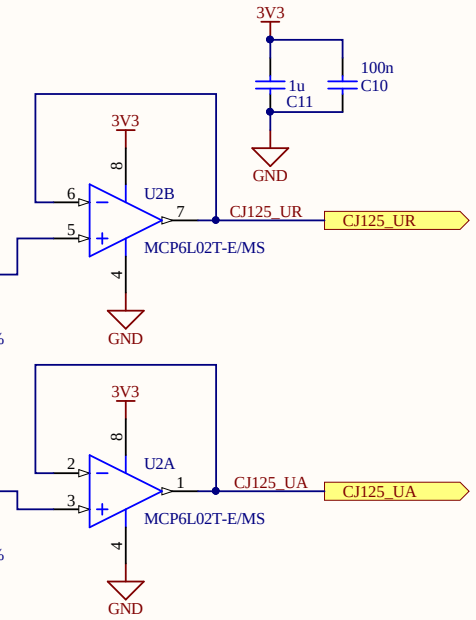
Bypass capacitors C1, C2, C3, C5, C7, and C11 need to be close to their corresponding pins.

Guard ring connected to the UA pin and enclosing the CF pin and C9 is recommended to prevent interference with the the RC filter connected to CF and RF. A guard ring is traditionally used to protect high impedance nodes in a circuit from surface leakage currents. The guard ring is a ring of copper driven by a low-impedance source to the same voltage as the high impedance node. The guard ring prevents current from the GND,GNDS pin from flowing to the filter pins. The guard ring won't drive current to the filter because they are at a very similar voltage potential.

The 10k Ohm R6 sets the internal oscillator to 192kHz.
The 31.6k Ohm R1 sets the current for Ri measurement to +-79uA.
The 100nF C6 acts as a DC filter for the Ri measurement current.
The 301 Ohm R3 is the calibration value for the optimal nernst resistance.
The 61.9 Ohm R10 is a current sense resistor for measuring lambda.
The 6.8k Ohm R12 sets the current input to DIAHD.
The 470k Ohm R4 compensates parasitic effects of the lambda sensor.
The 100k Ohm R7 is used for leakage detection. When the sensor is cold, the R7 makes the voltages at pins UN and UP equal.
The 4.7k Ohm R5 is used to feed the nernst cell reference voltage into the pump current control circuit.

The 100k Ohm R11 and 100nF C9 create a RC lowpass filter with a cutoff frequency of 15.915Hz to filter out the switching currents in the lambda measurement.
The 100nF C12 adds aditional filtering fo the lambda measurement. The UA pin has an output resistance of 100 Ohms creating a RC filter with a cutoff of 15.915kHz.
The 33nF C8 filters the resistance measurement. UR has an output resistance of 15k Ohm creating a RC filter with a cutoff of 321.5Hz.

Analog Buffer



100nF capacitor need to be within 2mm the VDD pin
1uF capacitor need to be within 100mm the VDD pin

The 187k Ohm and 365k Ohm create a resistor divider that scales by 365/(187+365) = 0.66123.

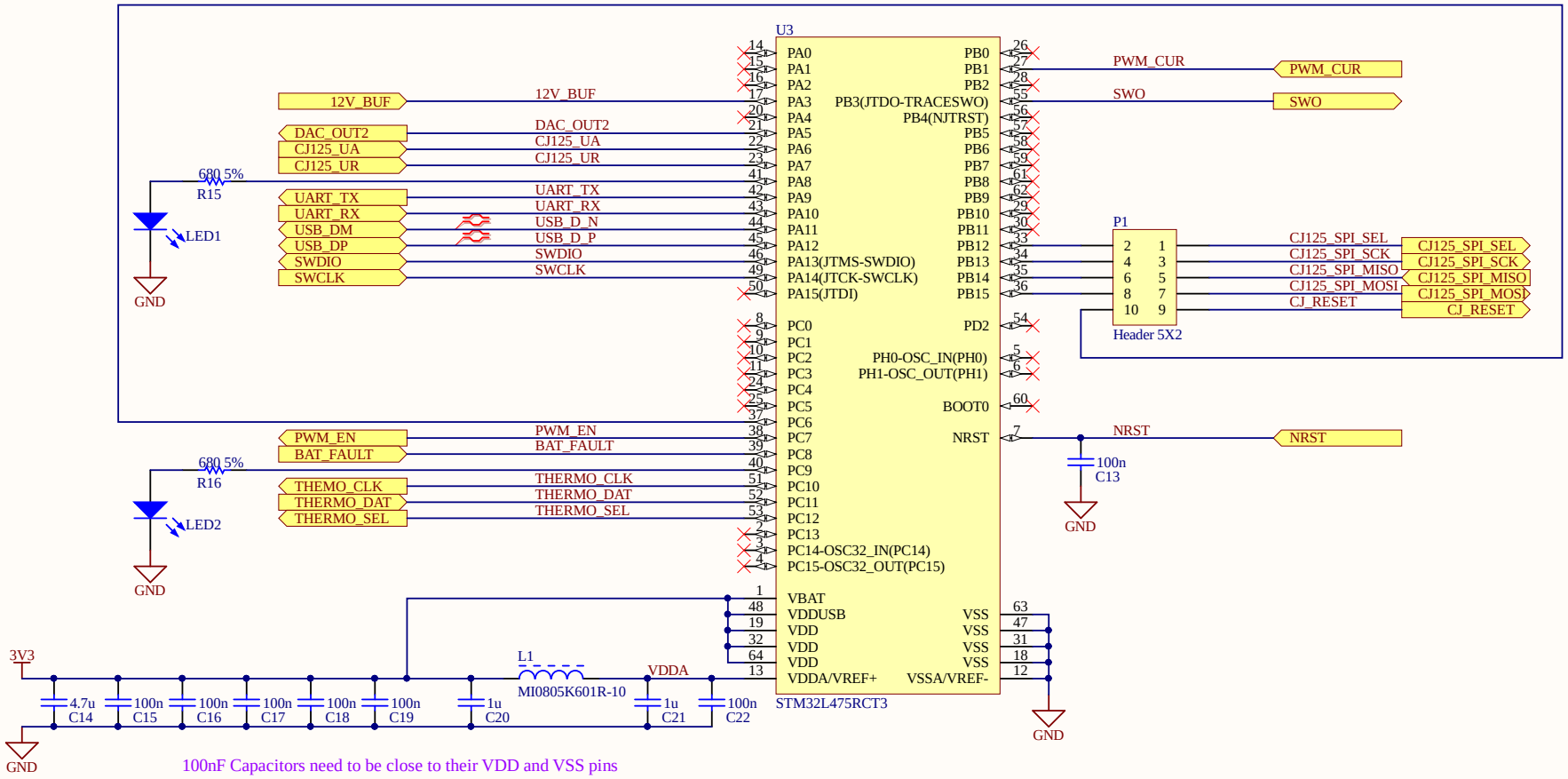
The maximum expected input of 5V scales down to 3.306V to be read by the microcontroller ADC.

The MCP6L02 acts as a unity gain buffer to provide the ADCs with low impedance inputs.

The MCP6L02 has 1MHz bandwidth, rail-to-rail input and output swing, 1.8V to 6.0V supply operation, and consuming 85uA per amplifyer.

Title: Sensor Controller	
Project: Lambda Oxygen Sensor Interface	
Date: 12/18/2018 Time: 12:17:49 PM Sheet 2 of 7	File: sensor.schDoc

Microcontroller



LED has 2V forward voltage and 30mA continuous forward current. 680 Ohm resistor limits LED current to 2mA. LED resistor calculated with (3.3V - 2V) / 2mA = 680Ohm.

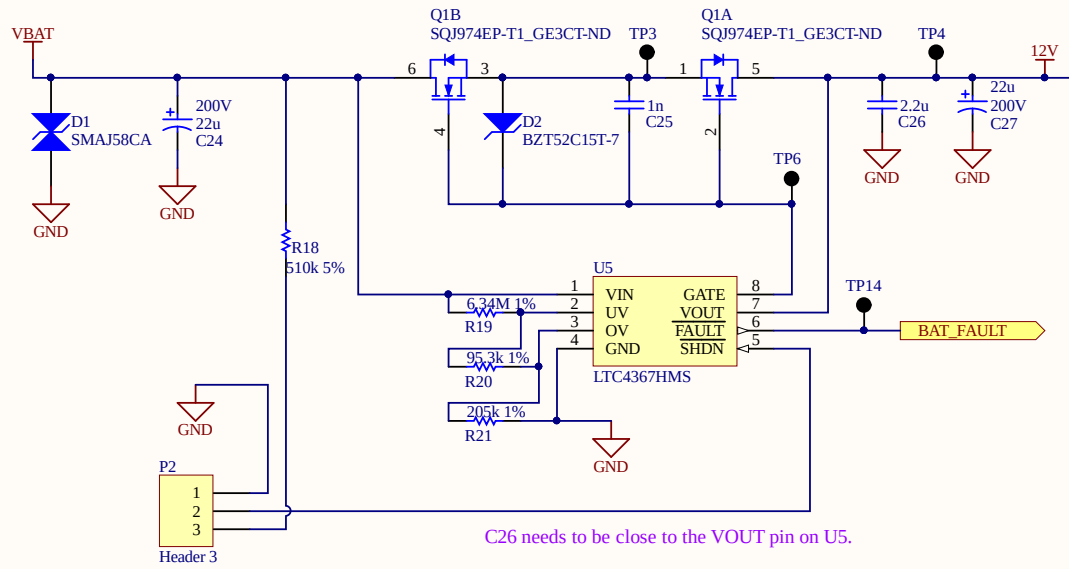
The L1 ferrite bead allows for AC filtering for the analog supply with a minimum DC voltage drop for peak current draw. At low frequencies the ferrite bead is seen as an inductor resisting current change. The 1uF capacitor C21 provides peak currents for the analof circuitry. Near 100mHz the ferrite bead is seen as a resistor and filters out the high frequencies. At higher frequencies the ferrite bead is seen as a capacitor. The frequency expected to be seen is 80MHz from the microcontroller. The ferrite bead has a impedance around 600 Ohms at 100MHz filtering the high frequency.

STM32L475RC has DAC output impedance 9.6kOhm to 13.8kOhm, max ADC external input impedance is 50kOhm,

USART is internally pulled up, SPI is internally pulled down, BAT_FAULT is internally pulled up, CJ_RESET is internally pulled up, and PWM_EN is push-pull.

Title: Microcontroller			
Project: Lambda Oxygen Sensor Interface			
Date: 12/18/2018	Time: 12:17:49 PM	Sheet 3 of 7	File: microcontroller.SchDoc

Protection



The LTC4367 has an operating range of 2.5V to 60V with protection for up to 100V, consumes 70uA, fault recovery of 500us, UV and OV thresholds of 500mV, shutdown threshold of 1.2V, and open-drain fault output. Gate pin output is 7.2V to 13.1V greater than the input voltage.

R19, R20, and R21 set the undervoltage threshold to 11.067V and overvoltage threshold to 16.195V.

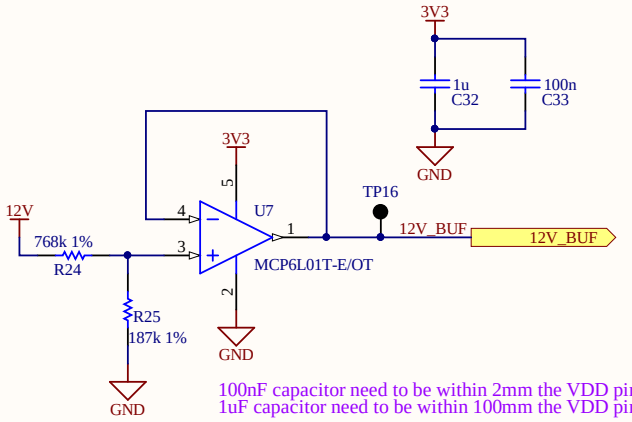
The SQJ974EP has dual n-channel MOSFET with drain source voltage of 100V, drain current of 30A, gate-source voltage of +-20V, on-resistance of 25.5m Ohm, and gate threshold of 2.5V.

SMAJ58CA clips battery voltages to -58V and +58V and operates up to 93V.

BZT52C15T clips gate-source voltages to 15V preventing damage of the SQJ974EP.

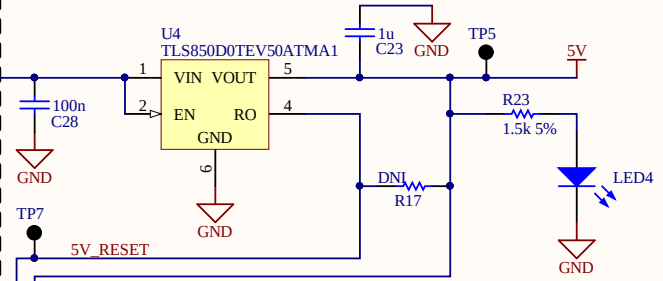
The 1nF C25 prevents the gate from switching on or off too quickly.

Battery Voltage



The 187k Ohm and 365k Ohm create a resistor divider that scales by 187/(187+768) = 0.19581.
The maximum expected input of 16.2V scales down to 3.172V to be read by the ADC.
The MCP6L01 acts as a unity gain buffer to provide the ADCs with low impedance inputs.

5V LDO

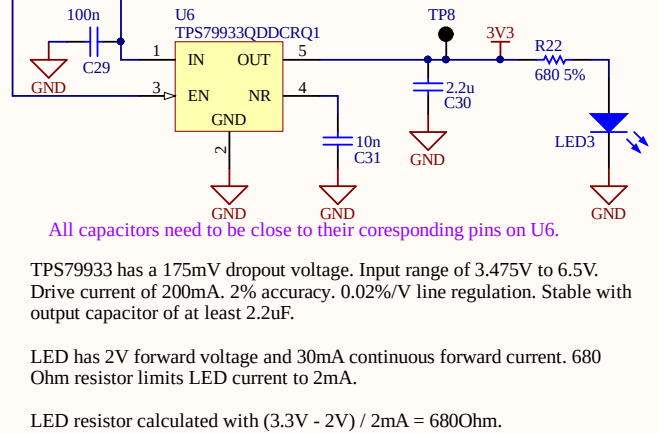


TLS850D0TEV50 has a 425mV dropout voltage. Input range of 5.425V to 40V. Drive current of 500mA. 2% accuracy. +-20mV line regulation. Stable with output capacitor of at least 1uF. Internal RO 20kOhm pull-up resistor.

LED has 2V forward voltage and 30mA continuous forward current. 1.5k Ohm resistor limits LED current to 2mA.

LED resistor calculated with (5V - 2V) / 2mA = 1.5kOhm.

3V3 LDO



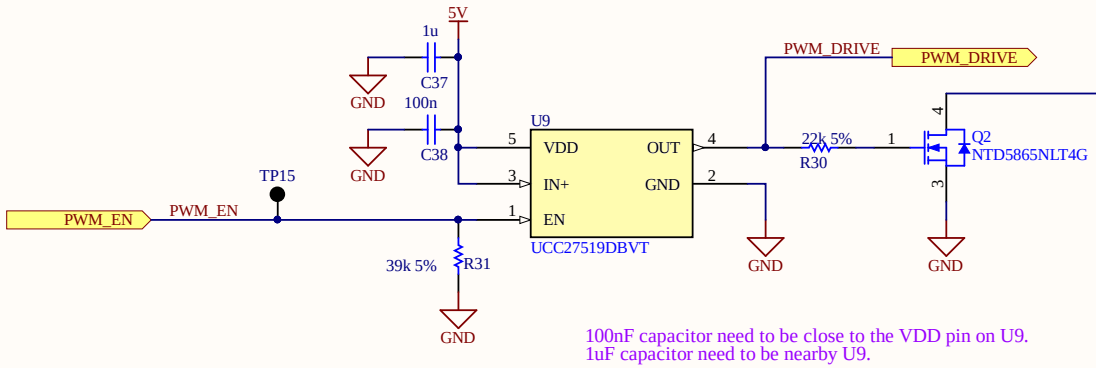
TPS79933 has a 175mV dropout voltage. Input range of 3.475V to 6.5V. Drive current of 200mA. 2% accuracy. 0.02%/V line regulation. Stable with output capacitor of at least 2.2uF.

LED has 2V forward voltage and 30mA continuous forward current. 680 Ohm resistor limits LED current to 2mA.

LED resistor calculated with (3.3V - 2V) / 2mA = 680Ohm.

Title: Power				
Project: Lambda Oxygen Sensor Interface				
Date: 12/18/2018	Time: 12:17:49 PM	Sheet 4 of 7	File: power.SchDoc	

MOSFET Drive



100nF capacitor need to be close to the VDD pin on U9.
1uF capacitor need to be nearby U9.

UCC27519DBVT has an internal 200kOhm pull-up.

If PWM_EN input is floating the EN voltage will be VDD * 39kOhm / (39kOhm + 200kOhm).

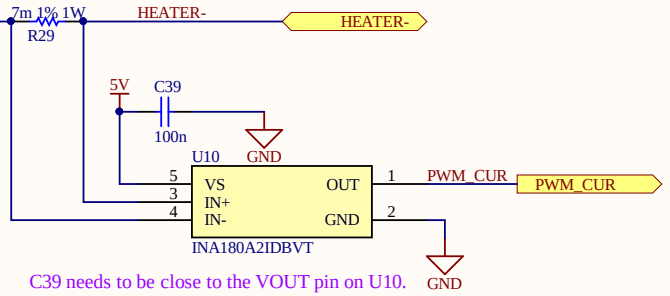
If VDD is 5V, EN will see 815.9mV. The enable is high when EN is at least 1V.

R30 limits the current driving the MOSFET to prevent spikes when switching.

UCC27519 has a propagation delay of 17ns and requires a VDD of at least 4.5V.

NTD5865NLT4G has a 60V drain-source voltage, 20V gate-source voltage, drain current of 46A, gate threshold of 2V, and on resistance of 16mOhms.

Current Sense



C39 needs to be close to the VOUT pin on U10.

Curren Sense Output = Battery Voltage / (Heater Resistance + 7mOhm + 16mOhm) * 7mOhm * 50V/V

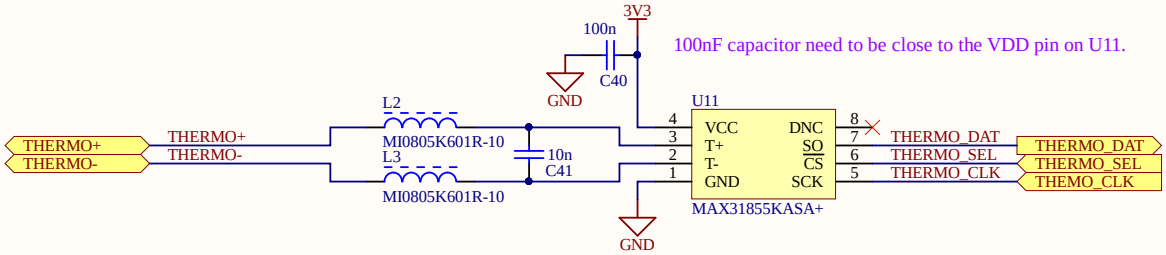
For the maximum battery voltage of 16.2V and minimum heater resistance of 1.8Ohms, the current sense output is 3.110V

The 5V supply is used for VS because it is easier to route then the 3V3. The microcontroller ADC is 5V tolerant.

INA180A2 has common-mode range of –0.2 V to +26 V. Operates with VDD of 2.7V to 5.5V. 210kHz bandwidth.

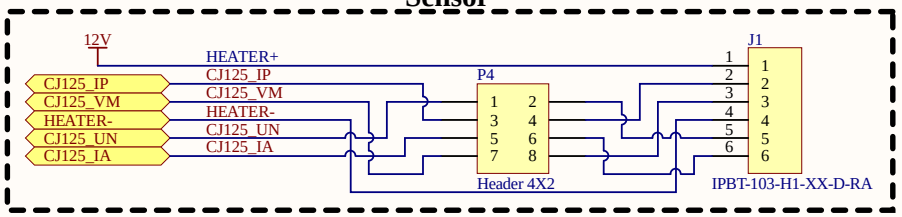
Title: Sensor Heater Control			
Project: Lambda Oxygen Sensor Interface			
Date: 12/18/2018	Time: 12:17:49 PM	Sheet 5 of 7	File: heater.SchDoc

Thermocouple

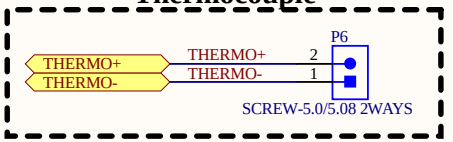


Title: Thermocouple Interface			
Project: Lambda Oxygen Sensor Interface			
Date: 12/18/2018	Time: 12:17:49 PM	Sheet 6 of 7	File: thermocouple.SchDoc

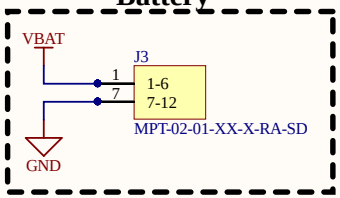
Sensor



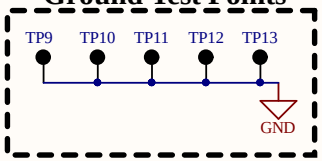
Thermocouple



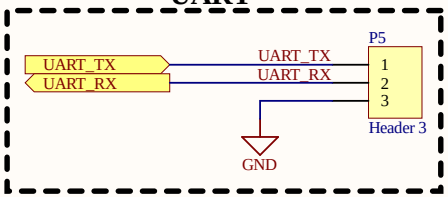
Battery



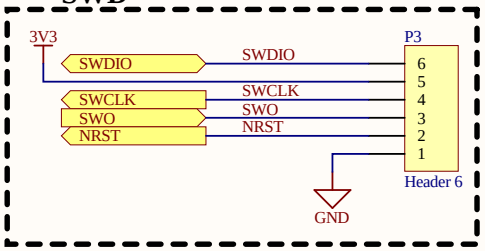
Ground Test Points



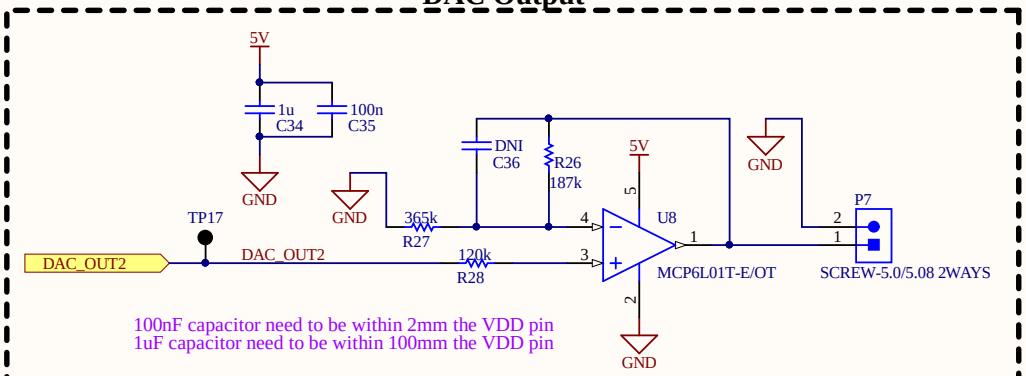
UART



SWD



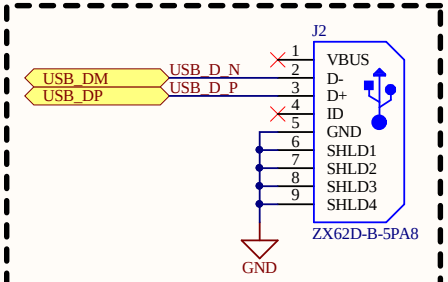
DAC Output



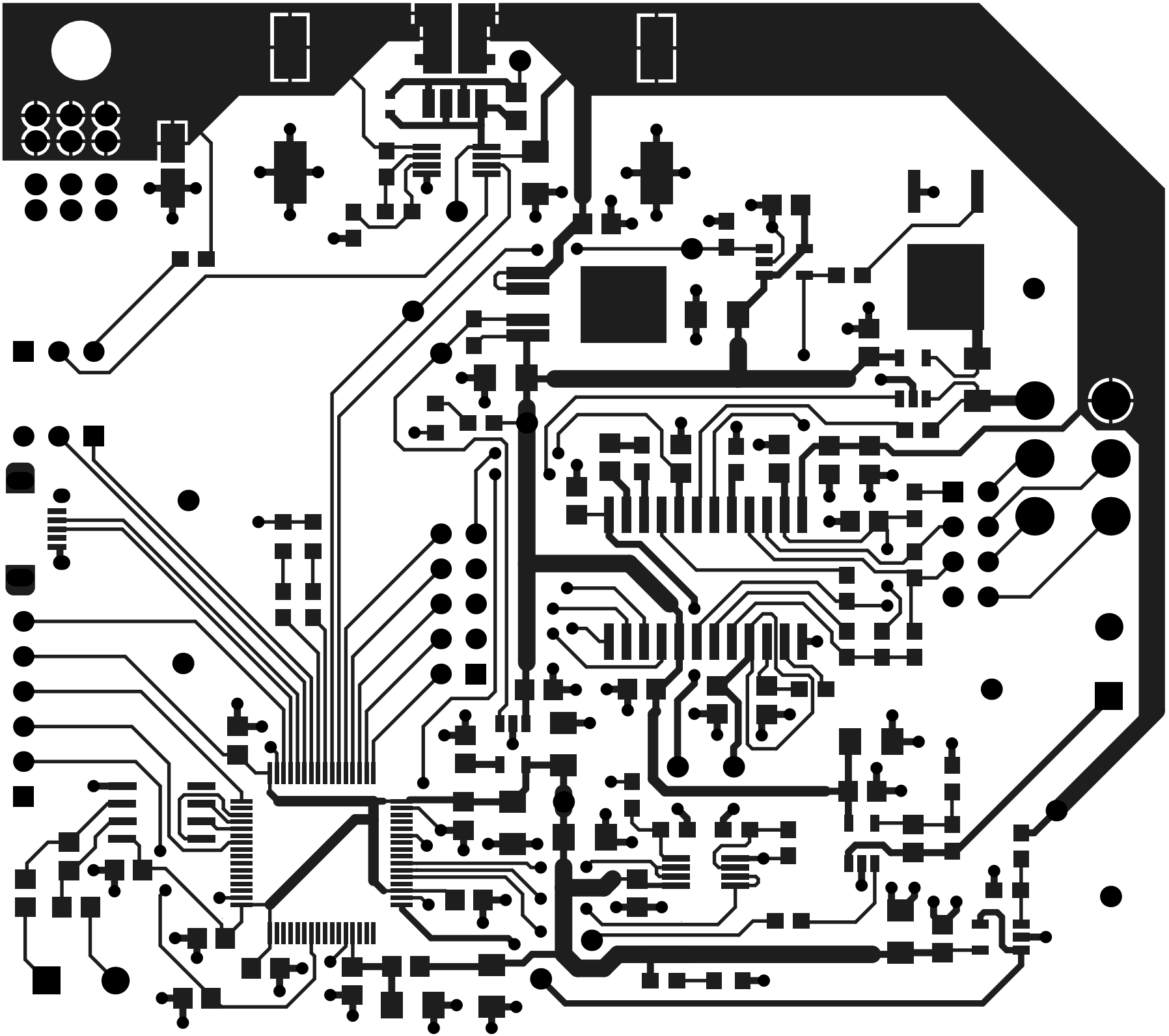
The MCP6L01 boosts 3.3V input to 5V with R26 and R27 ceating a gain of 1 + (187 / 365) = 1.512V/V
An input of 3.3V has an output of 4.991V.

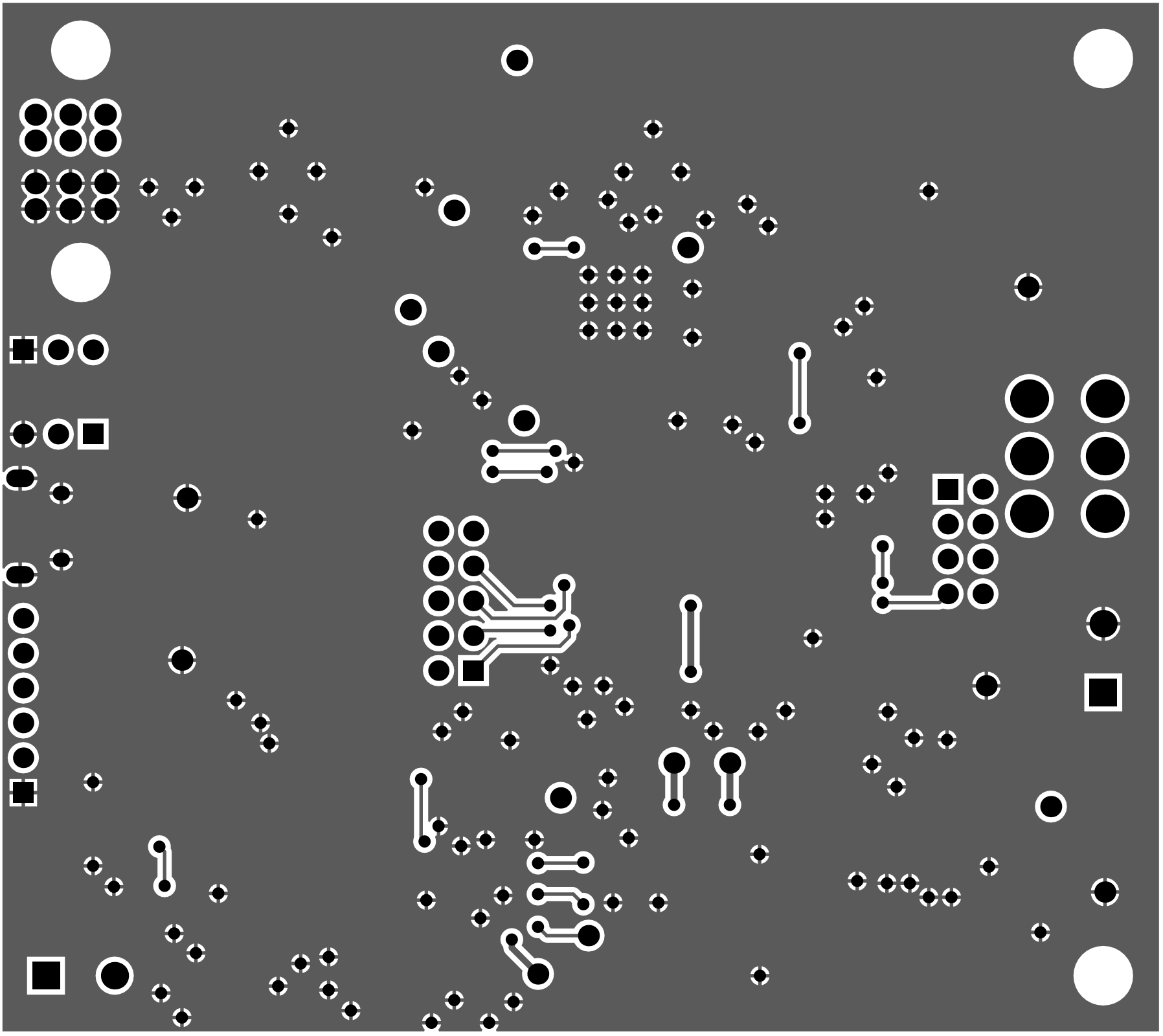
The 120k Ohm R28 is used to compensate for current through the negative terminal of the MCP6L01 and preventing the voltage from changing. The compensation resistor required is equal to (365k * 187k) / (365k + 187k) = 123.65k Ohm. 120k Ohm is the closest 5% resistor value.

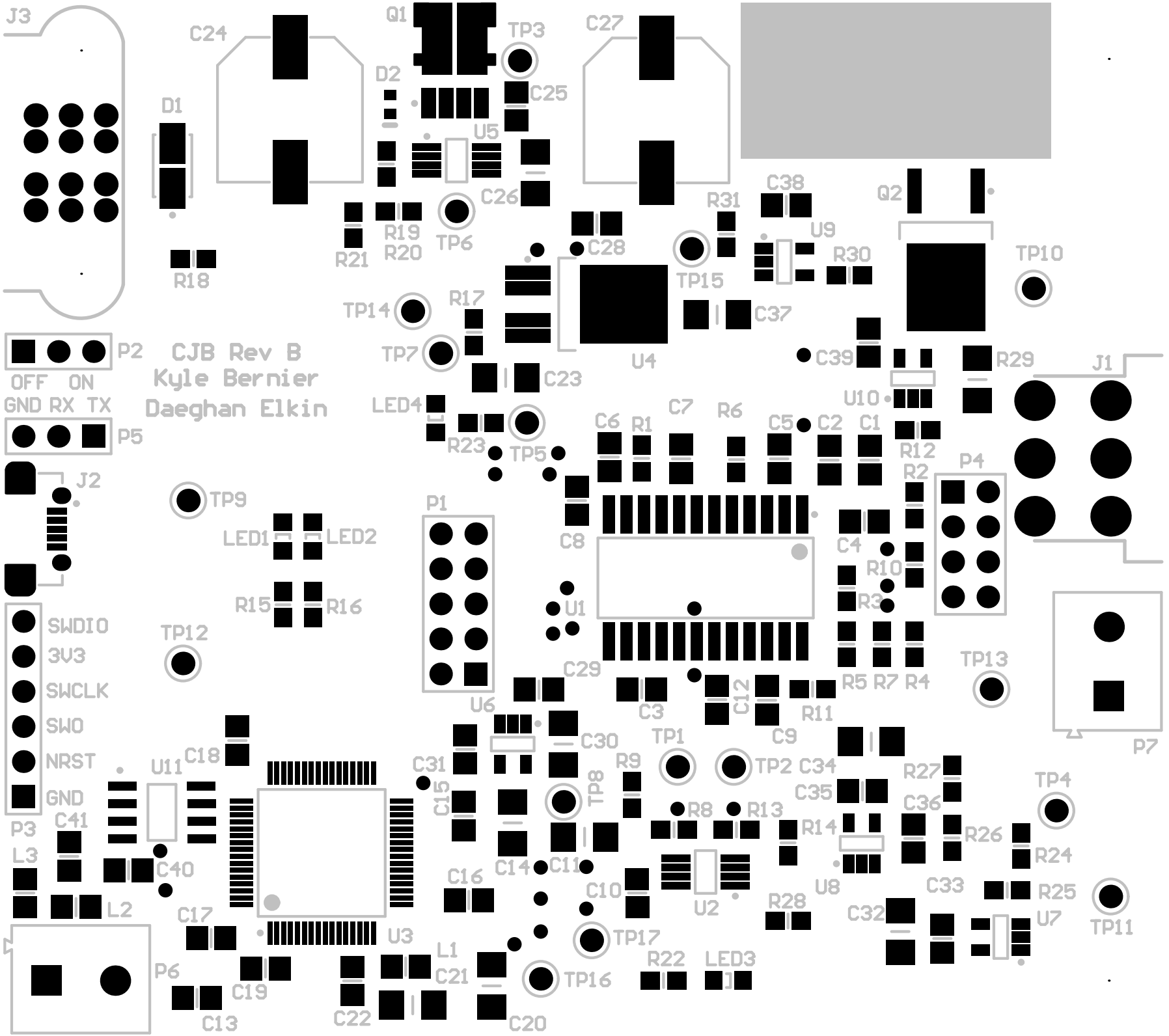
USB



Title: Pin Breakout	
Project: Lambda Oxygen Sensor Interface	
Date: 12/18/2018 Time: 12:17:49 PM Sheet 7 of 7	File: breakout.SchDoc






J3
C24
Q1
TP3
C27
D2
C25
D1
U5
C26
C38
R31
Q2
R19
R20
TP6
C28
U9
R30
TP10
R21
R18
TP15
C37
TP14
R17
U4
P2
CJB Rev B
Kyle Bernier
Daeghan Elkin
OFF ON
GND RX TX
P5
TP7
C23
C39
R29
J1
LED4
U10
C6
R1
C7
R6
C5
C2
C1
R12
R23
TP5
P4
J2
TP9
P1
R2
LED1
LED2
C8
C4
R10
R15
R16
U1
R3
SWDIO
3V3
SWCLK
SWO
NRST
GND
TP12
C29
C3
C12
R5
R7
R4
TP13
U6
C30
C9
R11
P7
TP1
TP2
C34
R27
U11
C18
C31
C15
TP8
R9
C35
TP4
P3
C41
R8
R13
R14
C36
R26
L3
C40
C14
C11
R24
C16
U2
U8
C33
R25
L2
C10
R28
C32
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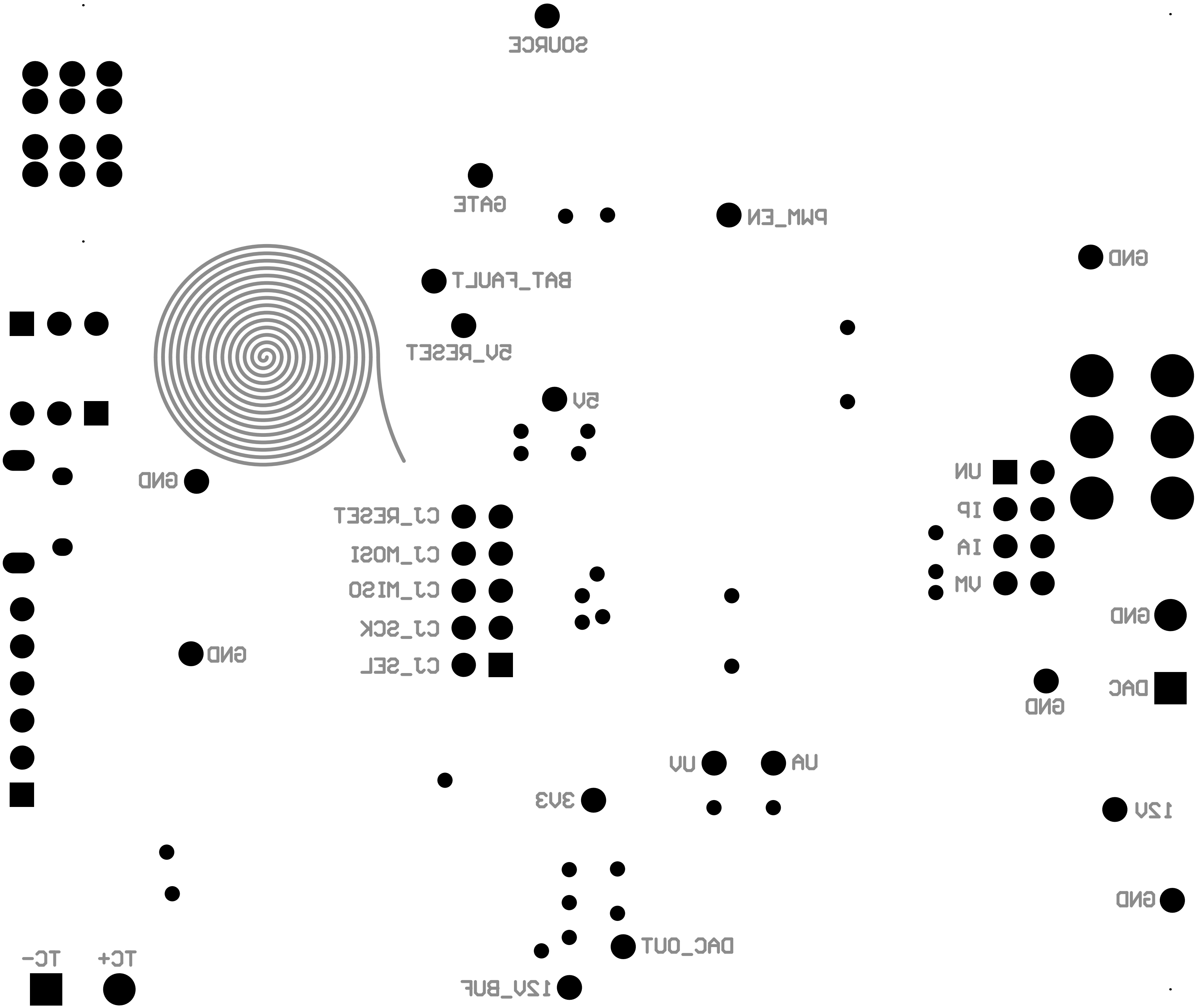
LED3
P6
C19
C21
TP16
C13
C22
C20



SOURCE
GATE
PWM_EN
GND
BAT_FAULT
5V_RESET
5V
GND
CJ_RESET
CJ_MOSI
CJ_MISO
CJ_SCK
CJ_SEL
GND
VN
IP
IA
VM
GND
DAC
GND
VV
VA
3V3
12V
GND
DAC_OUT
12V_BUF
TC-
TC+