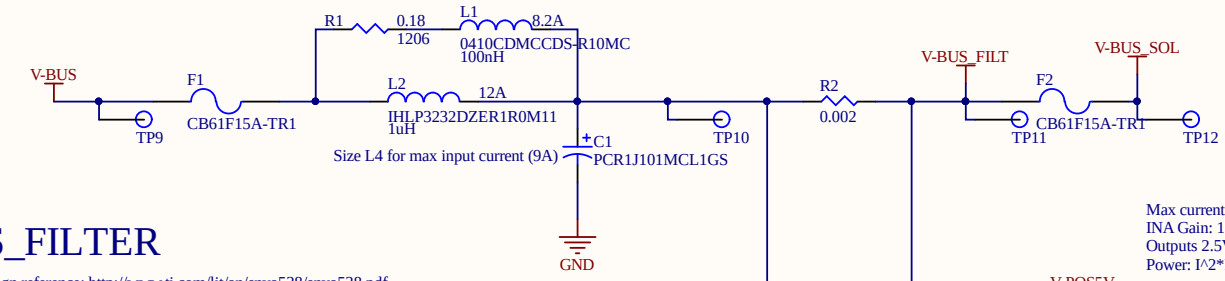
BRAKING IO

POD 5

REV 2

Title	***Braking IO PCB***		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:		Revision:	
Date: 6/27/2020	Time: 10:58:04 AM	Sheet of	
File: braking_io.SchDoc			

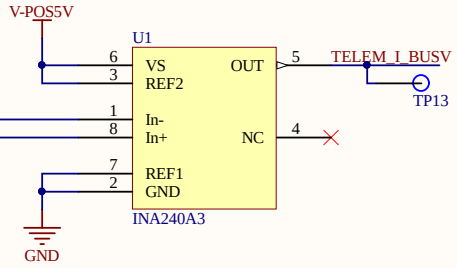
should change upstream fuse to be higher current rating than downstream.



BUS_FILTER

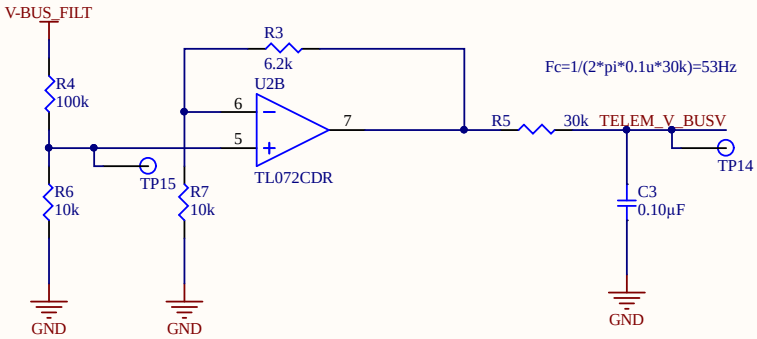
Filter design reference: http://www.ti.com/lit/an/snva538/snva538.pdf
http://ecee.colorado.edu/~rwe/papers/APEC99.pdf

Max current draw: 9A -> 9A*0.002Ohm=0.018V
INA Gain: 100V/V -> 4.3V at Max current
Outputs 2.5V when I = 0
Power: I^2*R=9A*.001=0.162W



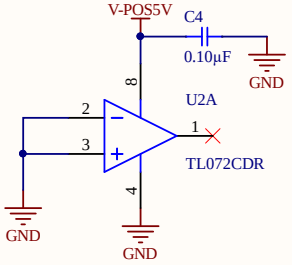
CURRENT TELEM

Max current draw: 9A -> 9A*0.002Ohm=0.018V
INA Gain: 200V/V -> 3.6V at Max current
Power: I^2*R=4A*0.01=0.04W

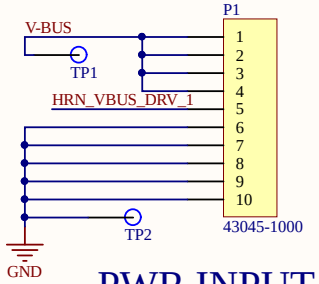


GAIN: 1.62V/V
MIN BUS VOLTAGE: 20V -> 2.945V
MIN BUS VOLTAGE: 28V -> 4.12V

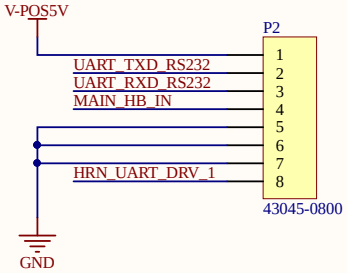
VOLTAGE TELEMETRY



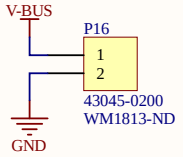
Title	***Bus Filter***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:04 AM	Sheet of	
File: bus_filter.SchDoc		



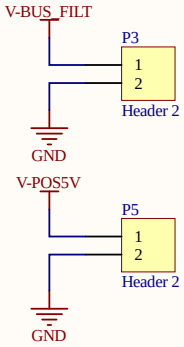
PWR INPUT

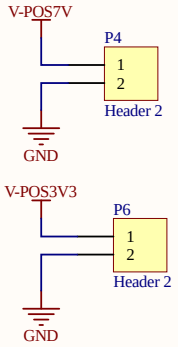


UART

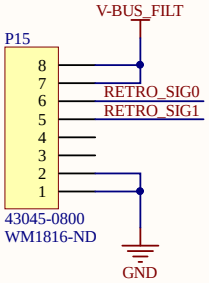


24V POWER LIGHT

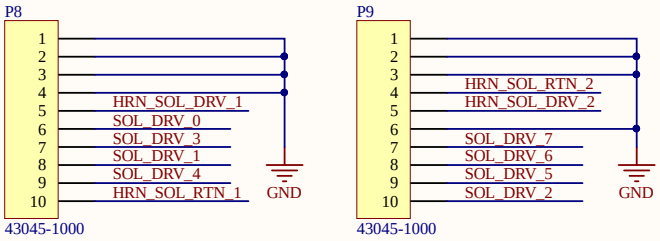




DEBUG

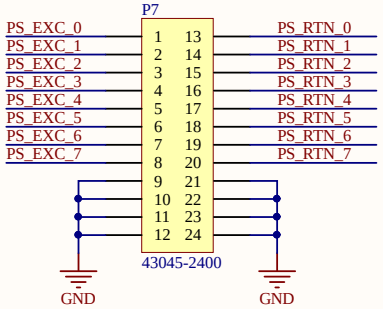


RETRO

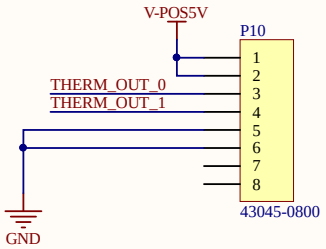


SOLENOIDS

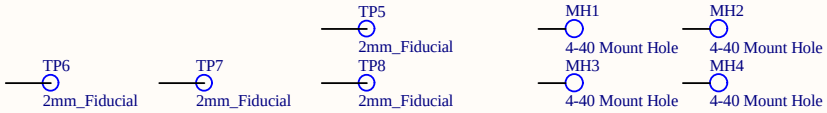
Split into 2 connectors as only 4 solenoids are likely to be used



PRESSURE SENSORS



THERMISTORS



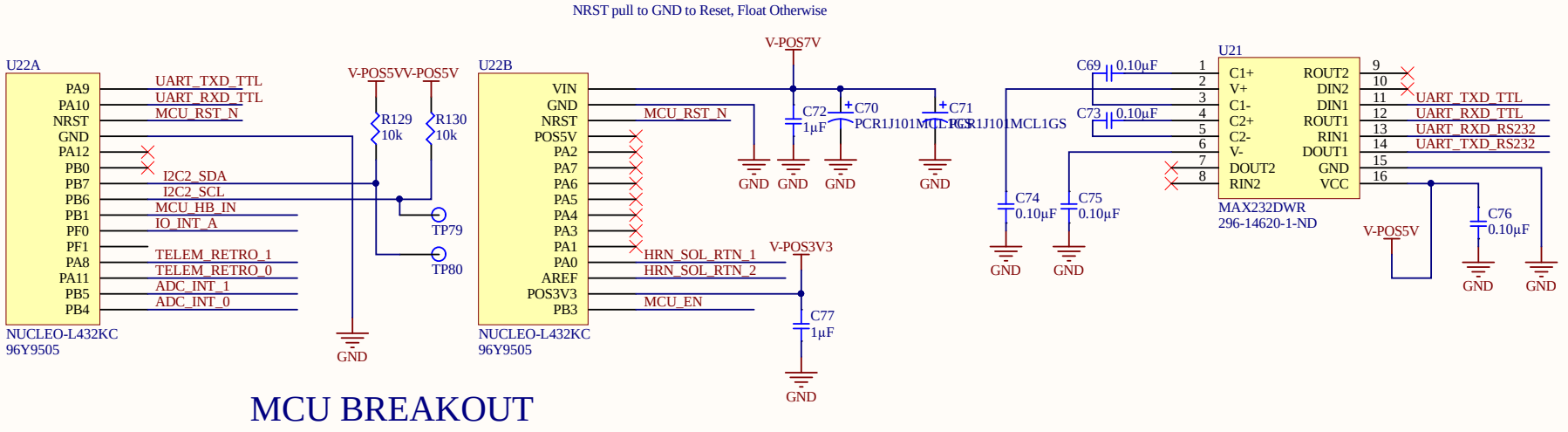
Fiducals

Place on four corners of board

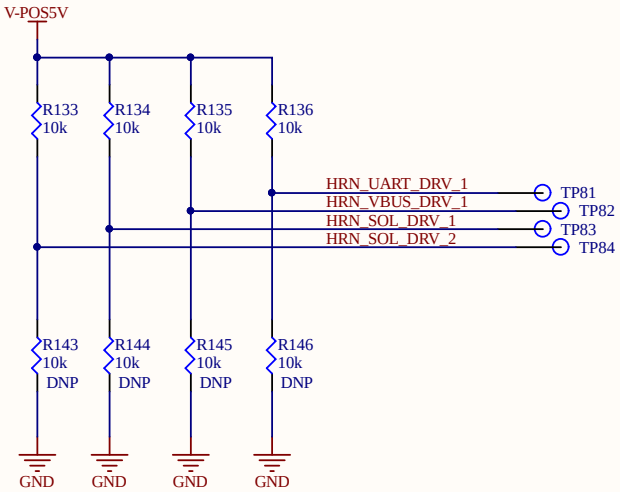
Mount Holes

Avoid routing under screw head

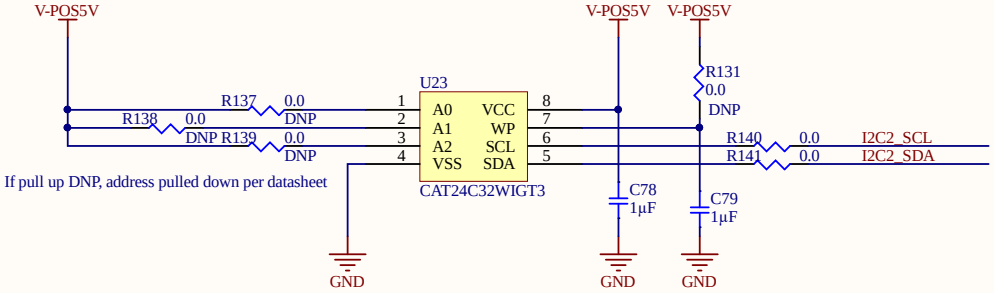
Title	***Connectors***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:04 AM Sheet of		
File: connectors.SchDoc		



MCU BREAKOUT



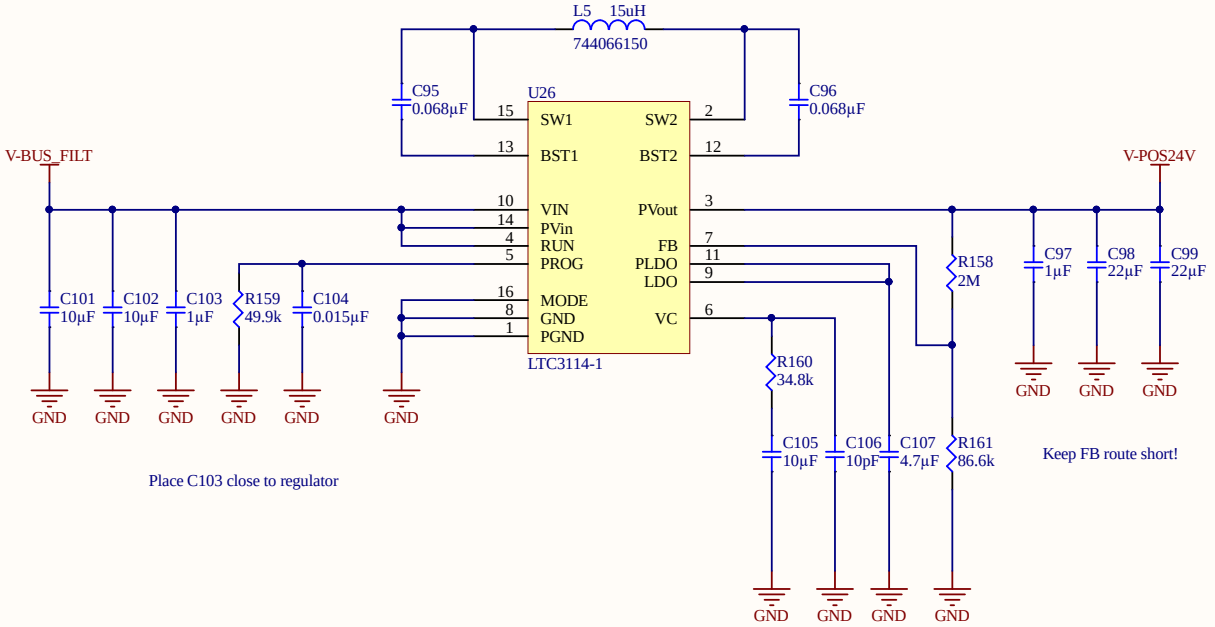
HARNESS ID



Default I2C Address: 0x50h

I2C EEPROM

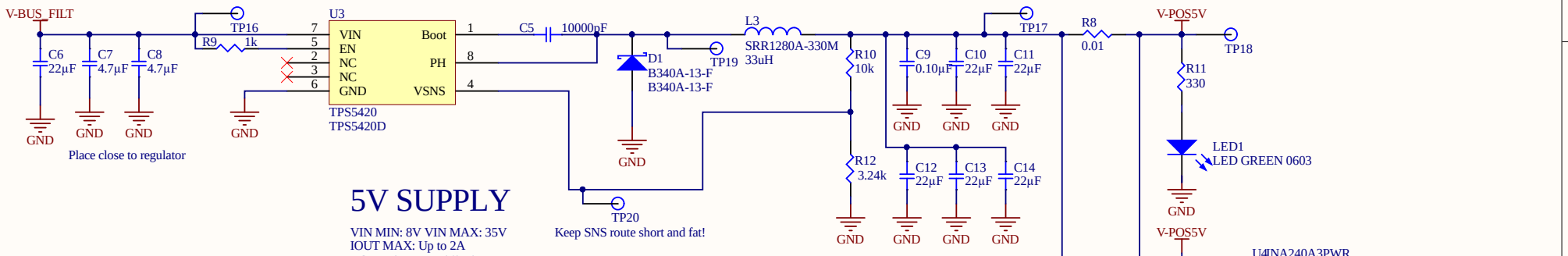
Title **Microcontroller**		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:05 AM	Sheet of	
File: mcu.SchDoc		



Title	***Power 24V***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:05 AM	Sheet of	
File: power_24V.SchDoc		

Notes:
Follow layout reference design
Place bypass caps close to regulator
Keep hot loops as short as possible
Possible to replace ceramic bulk cap with a tantalum.

Replace with Tantalum?
Place close to regulator
See https://github.com/badgerloop-software/hardware/tree/master/braking_io/design



5V SUPPLY

VIN MIN: 8V VIN MAX: 35V
IOUT MAX: Up to 2A
VOUT=(R1*1.221)/(R2)+1.221
VOUT=(10K*1.221)/(3.24K)+1.221=4.989V nominal

CURRENT TELEM

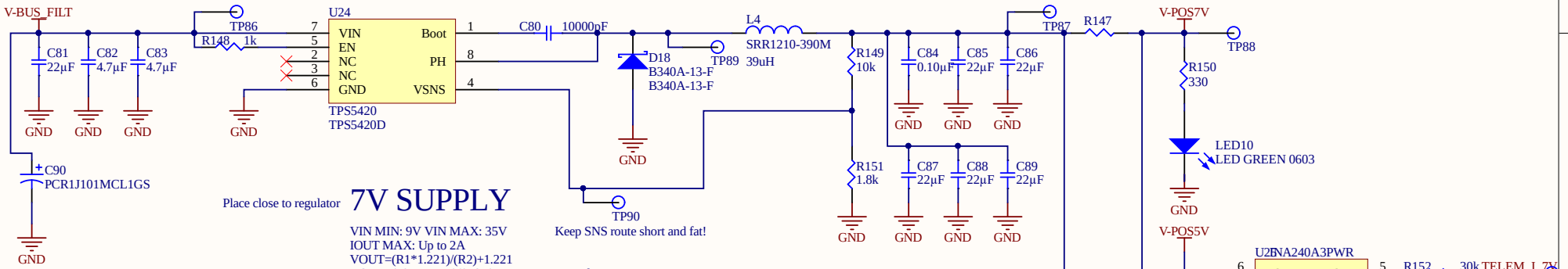
Max current draw: 2A -> 2A*0.002 Ohm=0.004V
INA Gain: 100V/V -> 2.9V at Max current
Outputs 2.5V when I = 0
Power: I^2*R=4A*0.002=0.032W

VOLTAGE TELEMETRY

Title		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:05 AM	Sheet of	
File: power_5V.SchDoc		

Notes:
Follow layout reference design
Place bypass caps close to regulator
Keep hot loops as short as possible
Possible to replace ceramic bulk cap with a tantalum.

Replace with Tantalum?
Place close to regulator
See https://github.com/badgerloop-software/hardware/tree/master/braking_io/design



Place close to regulator

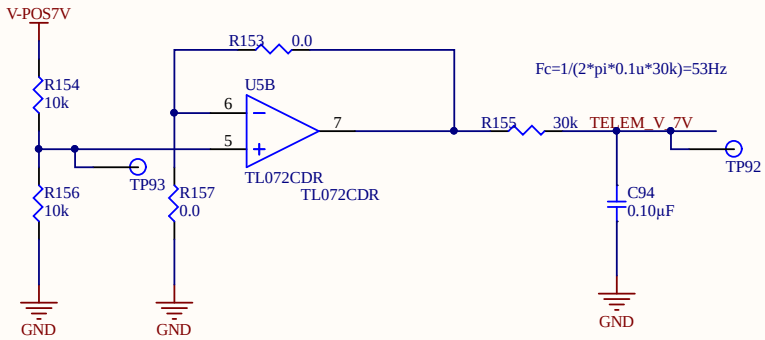
7V SUPPLY

VIN MIN: 9V VIN MAX: 35V
IOUT MAX: Up to 2A
VOUT=(R1*1.221)/(R2)+1.221
VOUT=(10K*1.221)/(1.8K)+1.221=V nominal

Keep SNS route short and fat!

CURRENT TELEM

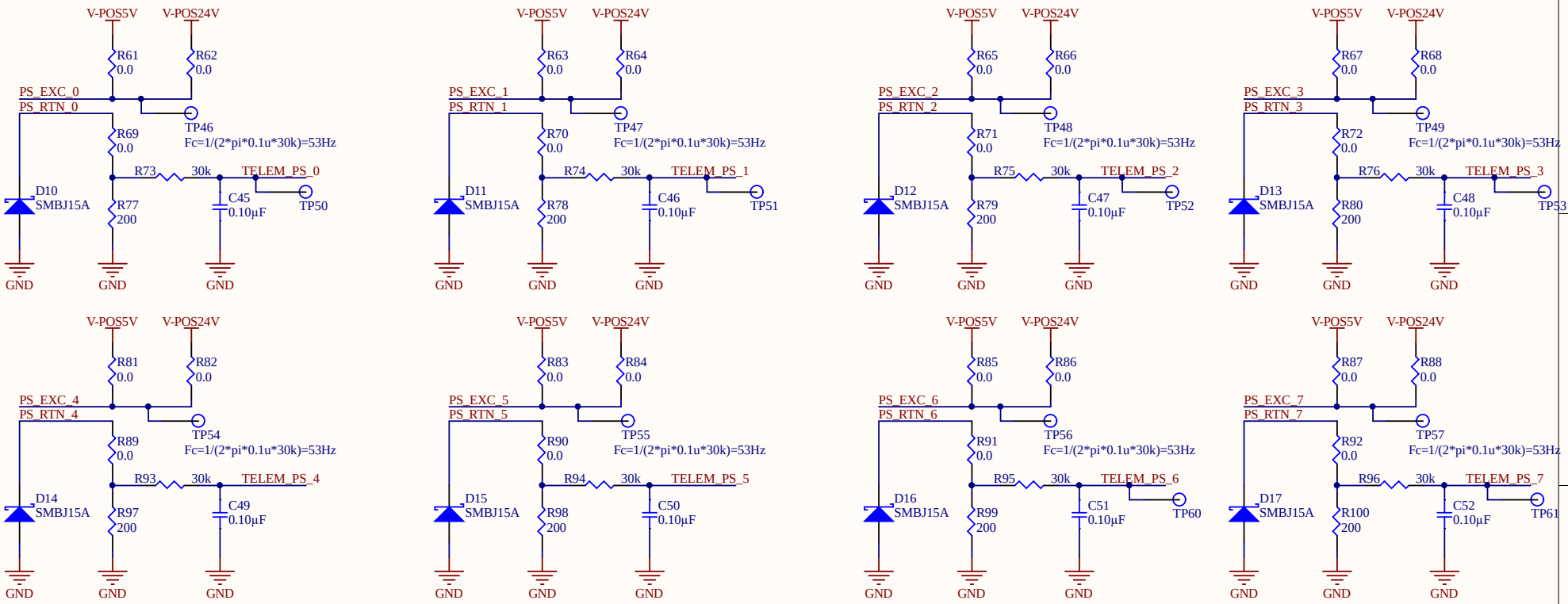
Max current draw: 2A -> 2A*0.002 Ohm=0.004V
INA Gain: 100V/V -> 2.9V at Max current
Outputs 2.5V when I = 0
Power: I^2*R=4A*0.002=0.032W



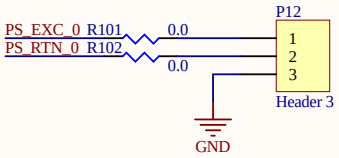
Circuit outputting 9.1V
GAIN: 0.0 -> MAX ADC VOLTAGE 4.55V

VOLTAGE TELEMETRY

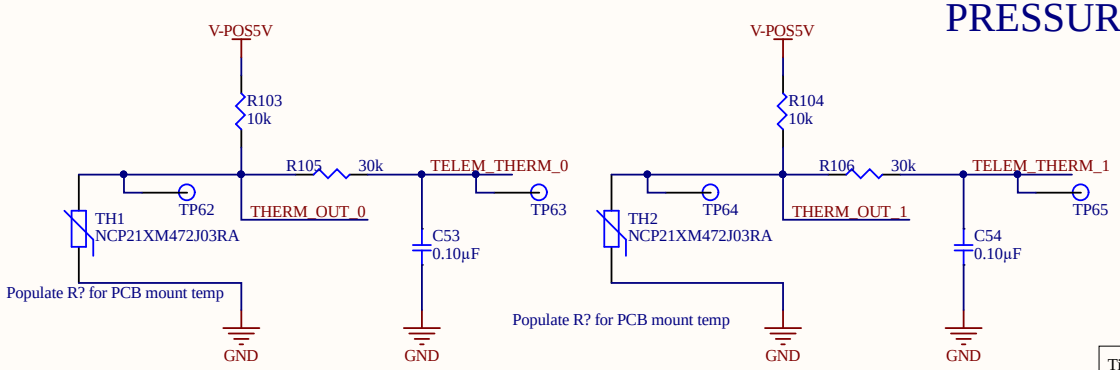
Title	*7V SUPPLY*	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:05 AM	Sheet of	
File: power_7V.SchDoc		



PRESSURE SENSORS

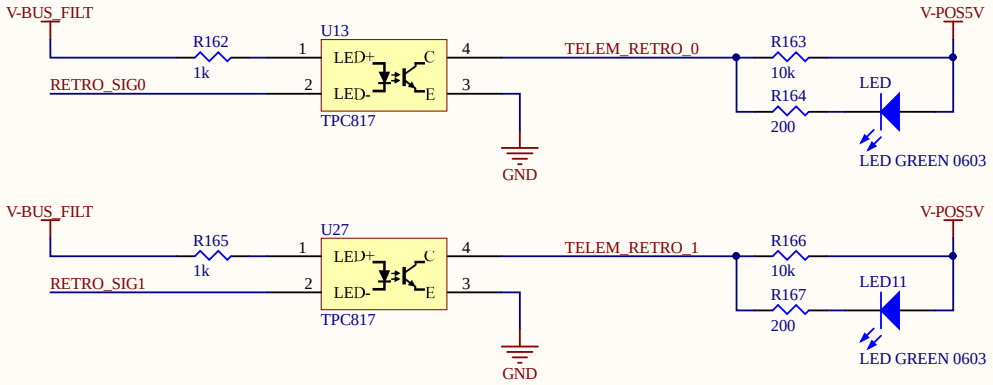


Populate Bottom resistor for current output
Current Min Output: 4mA*200=800mV
Current Max Output: 20mA*200=4.0V
Voltage Min Output: 0.5V
Voltage Max Output: 4.5V

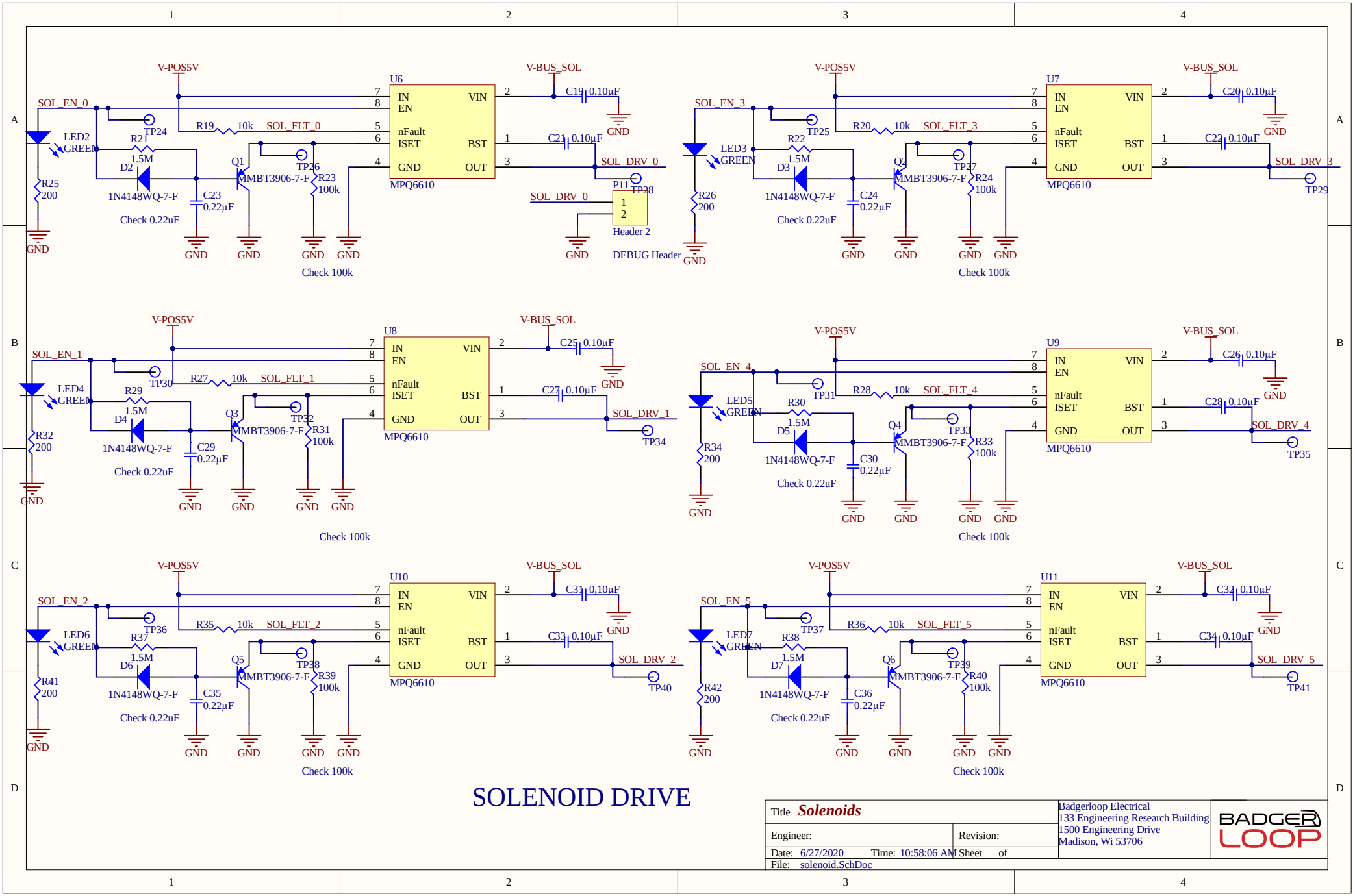


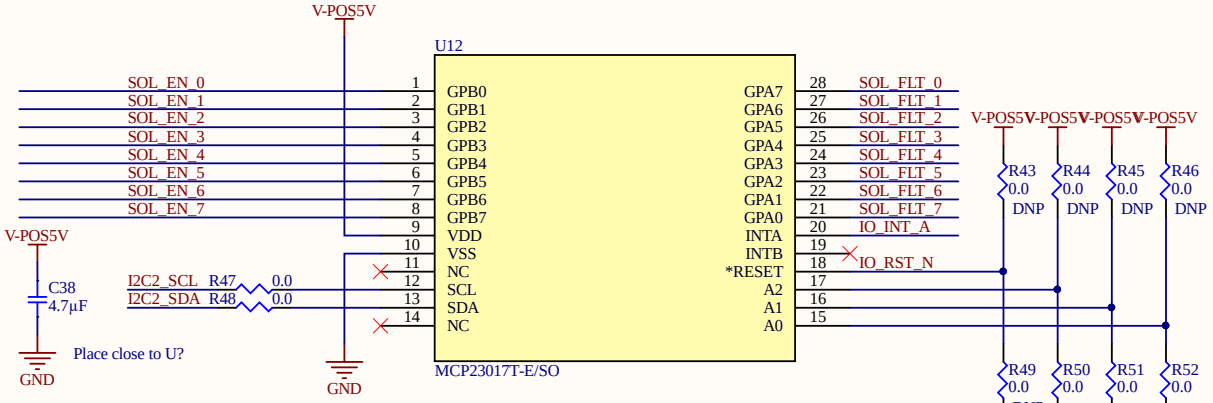
TEMPERATURE

Title	***Pressure Sensors***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020	Time: 10:58:05 AM Sheet of	
File: pressure.SchDoc		

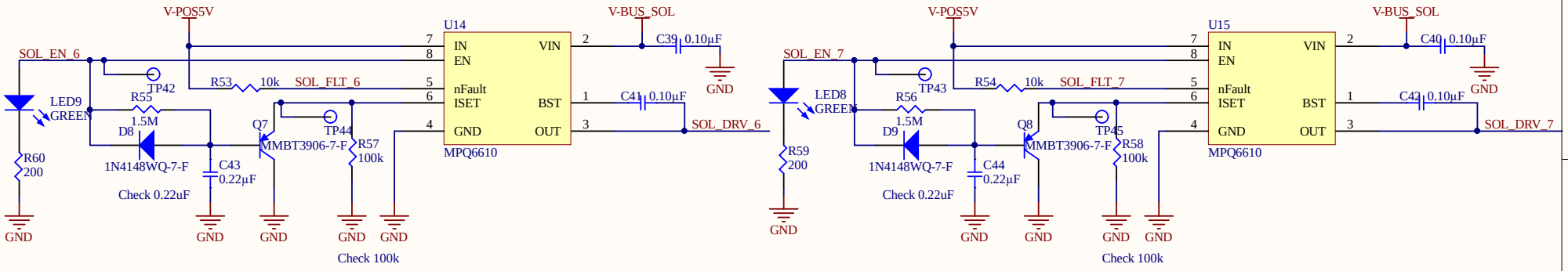


Title **Retro**		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:06 AM	Sheet of	
File: retro.SchDoc		


V-POS5V
V-BUS_SOL
SOL_EN_0
LED2
GREEN
R25
200
TP24
R21
1.5M
D2
1N4148WQ-7-F
C23
0.22µF
Check 0.22uF
R19
10k
SOL_FLT_0
Q1
MMBT3906-7-F
TP26
R23
100k
U6
IN
EN
nFault
ISET
GND
VIN
BST
OUT
MPQ6610
C19 0.10µF
C21 0.10µF
SOL_DRV_0
P11
TP28
SOL_DRV_0
1
2
Header 2
DEBUG Header
Check 100k
SOL_EN_3
LED3
GREEN
R26
200
TP25
R22
1.5M
D3
1N4148WQ-7-F
C24
0.22µF
Check 0.22uF
R20
10k
SOL_FLT_3
Q2
MMBT3906-7-F
TP27
R24
100k
U7
C20 0.10µF
C22 0.10µF
SOL_DRV_3
TP29
Check 100k
SOL_EN_1
LED4
GREEN
R32
200
TP30
R29
1.5M
D4
1N4148WQ-7-F
C29
0.22µF
Check 0.22uF
R27
10k
SOL_FLT_1
Q3
MMBT3906-7-F
TP32
R31
100k
U8
C25 0.10µF
C27 0.10µF
SOL_DRV_1
TP34
Check 100k
SOL_EN_4
LED5
GREEN
R34
200
TP31
R30
1.5M
D5
1N4148WQ-7-F
C30
0.22µF
Check 0.22uF
R28
10k
SOL_FLT_4
Q4
MMBT3906-7-F
TP33
R33
100k
U9
C26 0.10µF
C28 0.10µF
SOL_DRV_4
TP35
Check 100k
SOL_EN_2
LED6
GREEN
R41
200
TP36
R37
1.5M
D6
1N4148WQ-7-F
C35
0.22µF
Check 0.22uF
R35
10k
SOL_FLT_2
Q5
MMBT3906-7-F
TP38
R39
100k
U10
C31 0.10µF
C33 0.10µF
SOL_DRV_2
TP40
Check 100k
SOL_EN_5
LED7
GREEN
R42
200
TP37
R38
1.5M
D7
1N4148WQ-7-F
C36
0.22µF
Check 0.22uF
R36
10k
SOL_FLT_5
Q6
MMBT3906-7-F
TP39
R40
100k
U11
C32 0.10µF
C34 0.10µF
SOL_DRV_5
TP41
Check 100k
GND
SOLENOID DRIVE
Title Solenoids
Engineer:
Revision:
Date: 6/27/2020 Time: 10:58:06 AM Sheet of
File: solenoid.SchDoc
Badgerloop Electrical
133 Engineering Research Building
1500 Engineering Drive
Madison, Wi 53706
BADGER LOOP

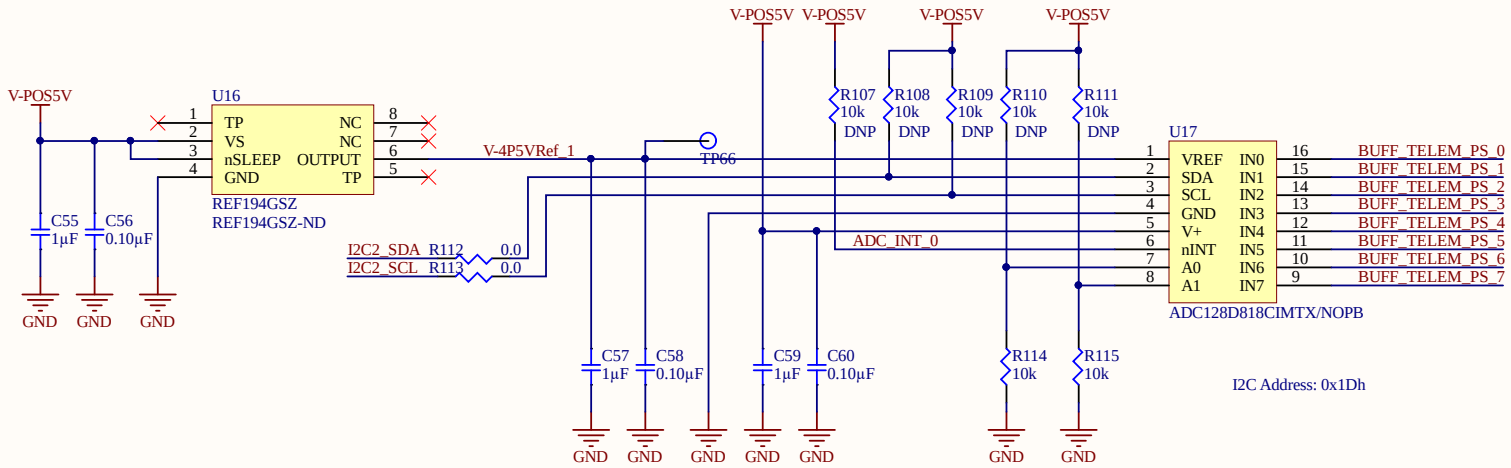


SOLENOID CONTROL

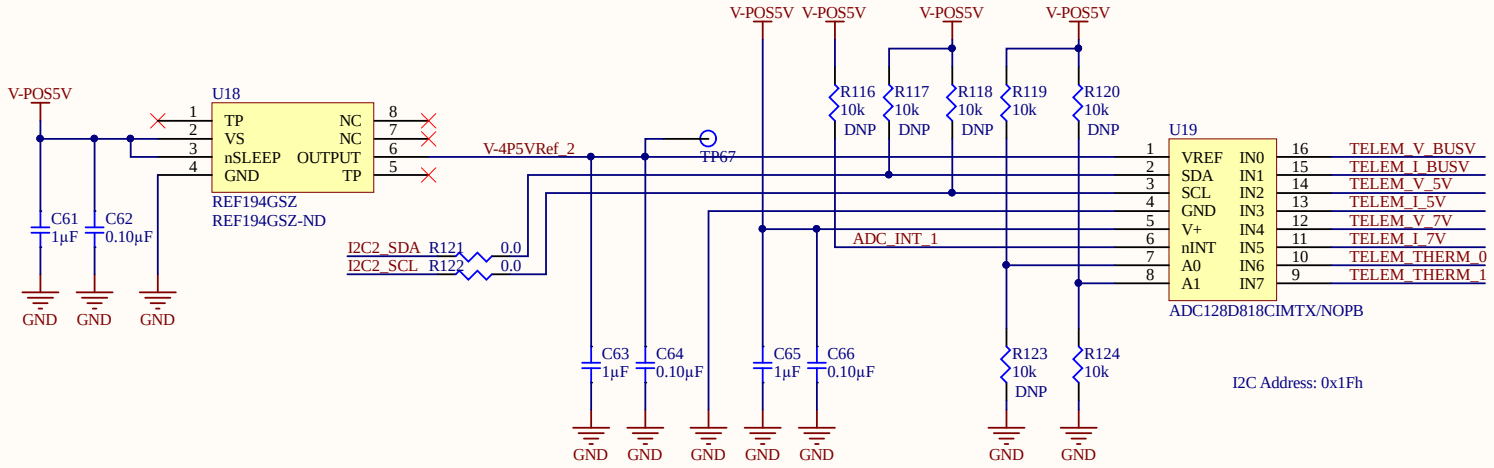


SOLENOID DRIVE

Title	***Solenoid Control***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:06 AM	Sheet of	
File: solenoid_drv.SchDoc		



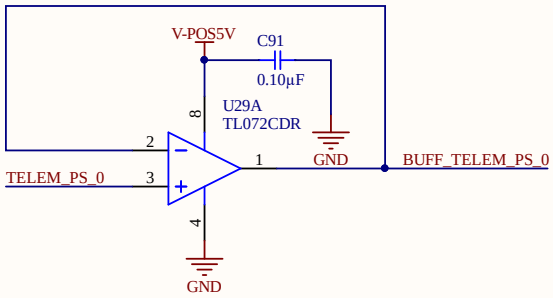
PRESSURE

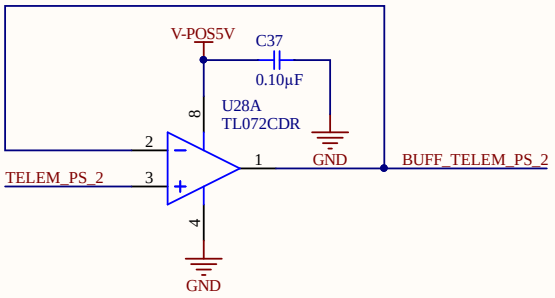


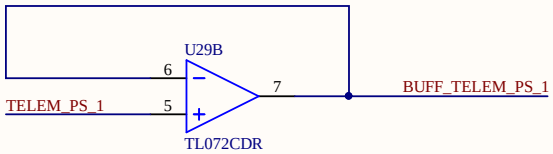
RAIL AND TEMPERATURE

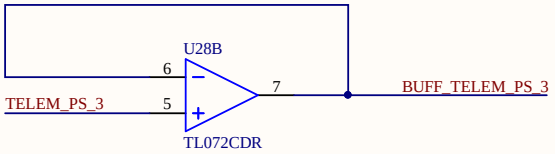
Title **ADC**		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:06 AM	Sheet of	
File: telemetry_adc.SchDoc		

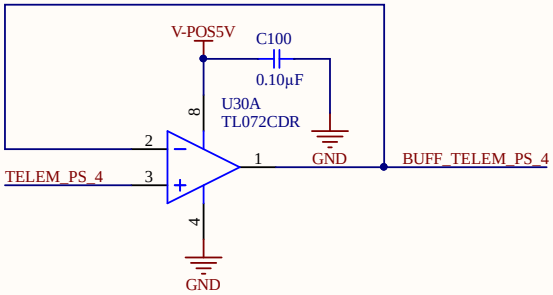
Analog Unity Gain Buffers

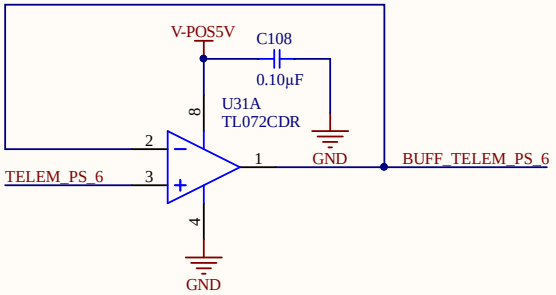


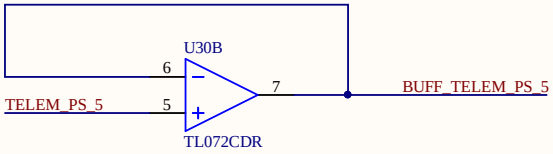


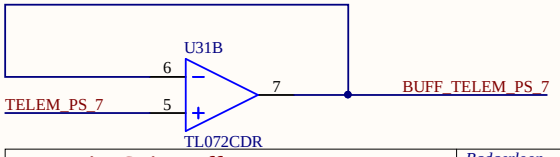




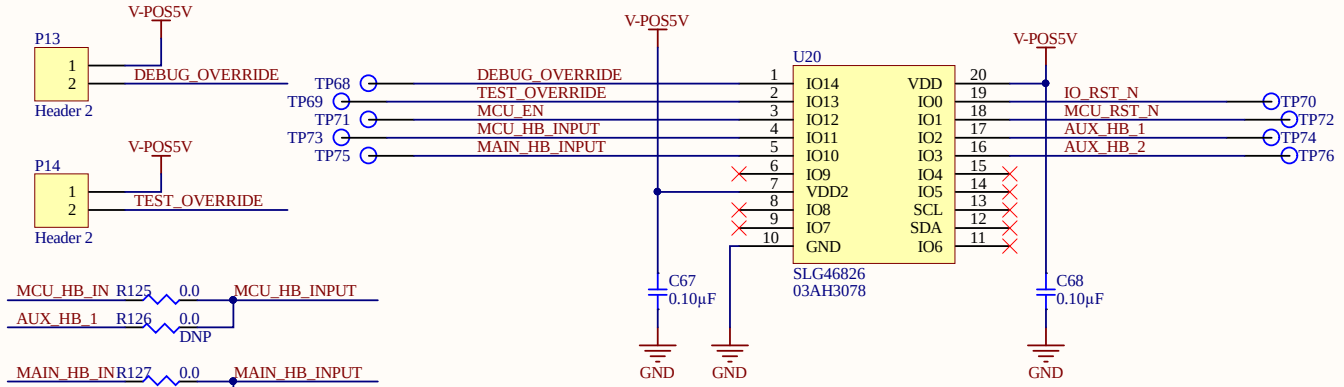








Title	***Unity Gain Buffer***		*Badgerloop* *133 Engineering Research Building* *Madison, WI 53715*
Size: A4	Number:	Revision:	
Date: 6/27/2020	Time: 10:58:07 AM	Sheet of	
File: C:\Users\Windows PC\Desktop\Badgerloop\git_repos\hardware\braking_io\unity_gain_buffer.SchDoc			



WATCHDOG AND RESET CONTROLLER

DEBUG

IO pin selection is arbitrary. Can be adjusted internally for better layout
Currently- Inputs on Left, outputs on right

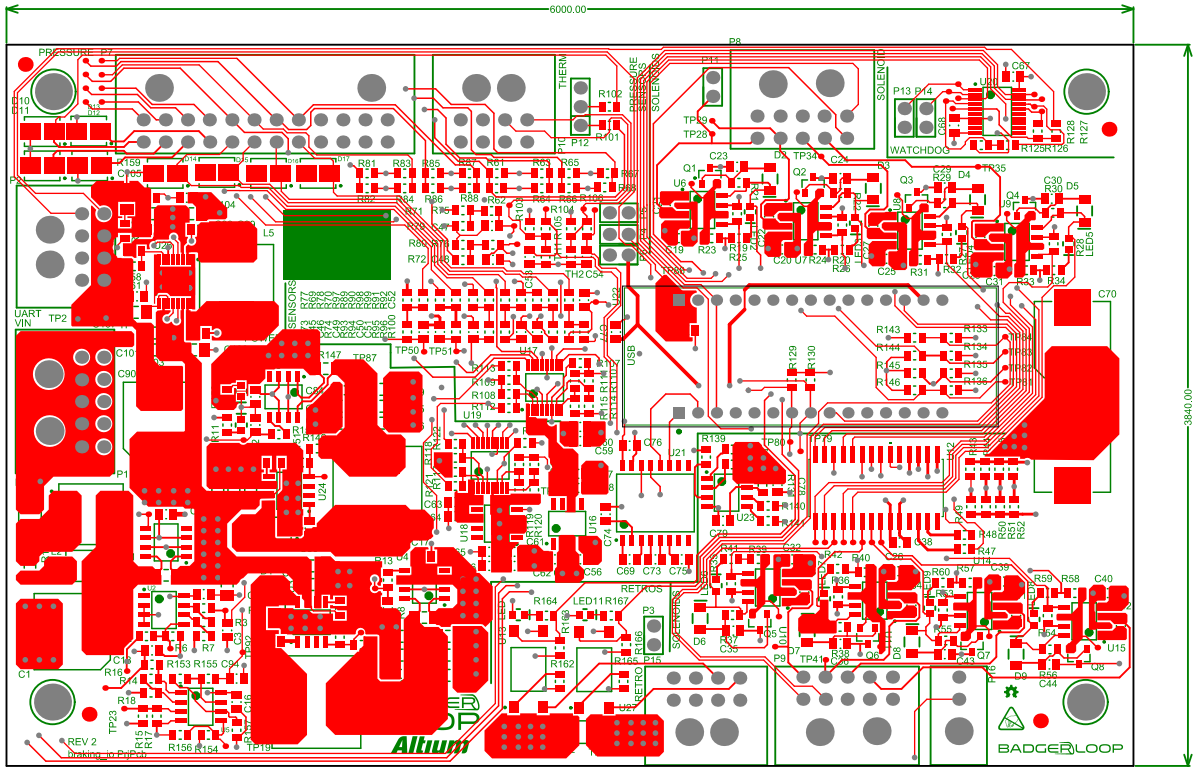
Modes of operation:
Debug: EN signal is always on when SLG has power
Populate Jumper 1
Test: 10Hz signal internal signal is recircuilated to mimic heartbeat
Populate Jumper 2
Operation: U? expects 10Hz heartbeat. If no heartbeat for 1s after 20s Power on reset
MCP RST_N will fall and MCU RST_N will pulse for 200ms

Silego Image here:
https://github.com/badgerloop-software/hardware/blob/master/silego/watchdog.gp6

Silego Image PDF Outputs:

Title *Watchdog*		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/27/2020 Time: 10:58:07 AM	Sheet of	
File: watchdog.SchDoc		

Layer	Name	Material	Thickness	Constant	Board Layer Stack
1	Top Overlay				
2	Top Solder	Solder Resist	0.40mil	3.5	
3	Top Layer	Copper	1.40mil		
4	Dielectric 2	FR-4	18.70mil	4.9	
5	GND	Copper	1.40mil		
6	Dielectric 1	FR-4	18.70mil	4.9	
7	PWR	Copper	1.40mil		
8	Dielectric 3	FR-4	18.70mil	4.9	
9	Bottom Layer	Copper	1.40mil		
10	Bottom Solder	Solder Resist	0.40mil	3.5	
11	Bottom Overlay				



BADGER LOOP

Badgerloop
ERB Room 133
1400 Engineering Drive
Madison, WI 53706

ENGINEER: RCastle, BTobin, JEslinger, SRiggleman	TITLE: braking_io.PcbDoc	
PCB DESIGNER: RCastle, BTobin		
DATE: 6/27/2020	PART NO.: Braking Input Output Controller	REV: A
FILE NAME: braking_io.PcbDoc	DWG NO:	SCALE: 1:1

Layer	Name	Material	Thickness	Constant	Board Layer Stack
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2	Top Solder	Solder Resist	0.40mil	3.5	
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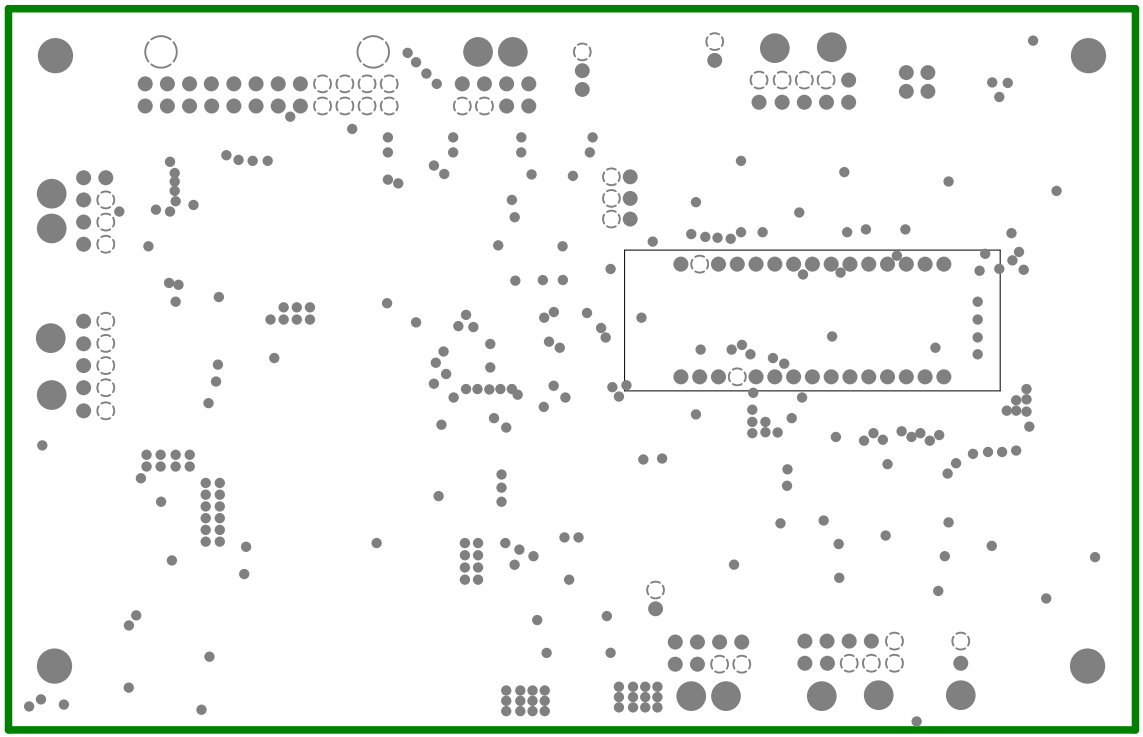
11	Bottom Overlay				



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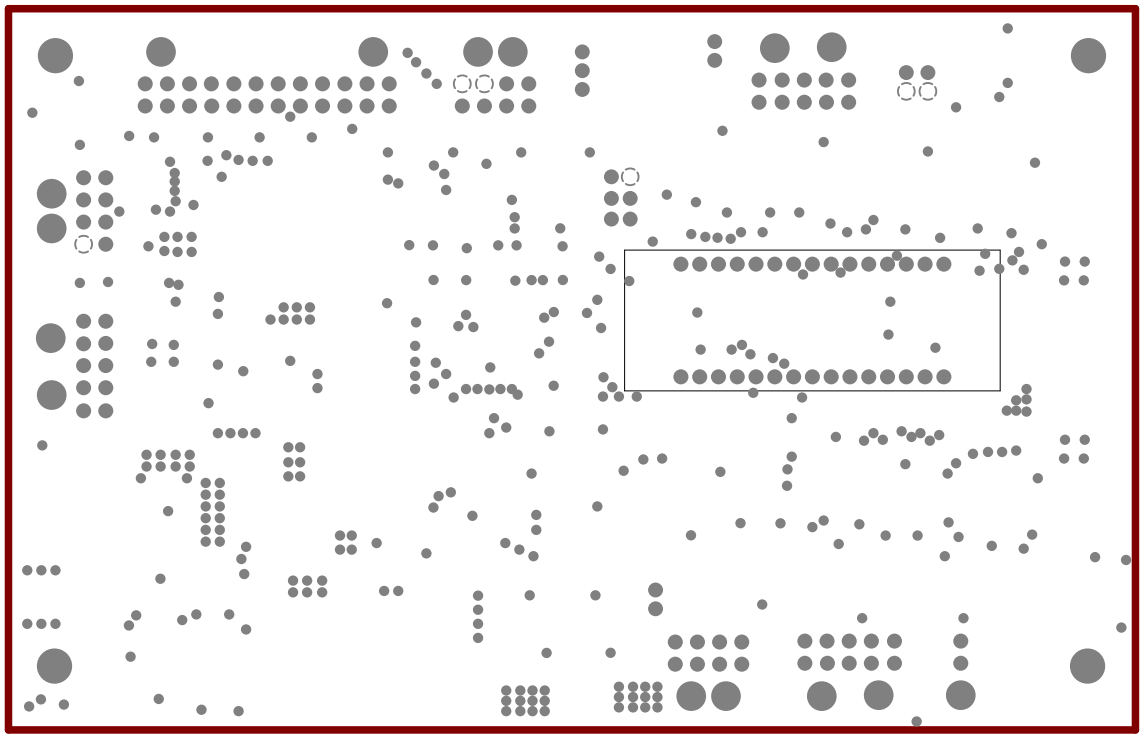

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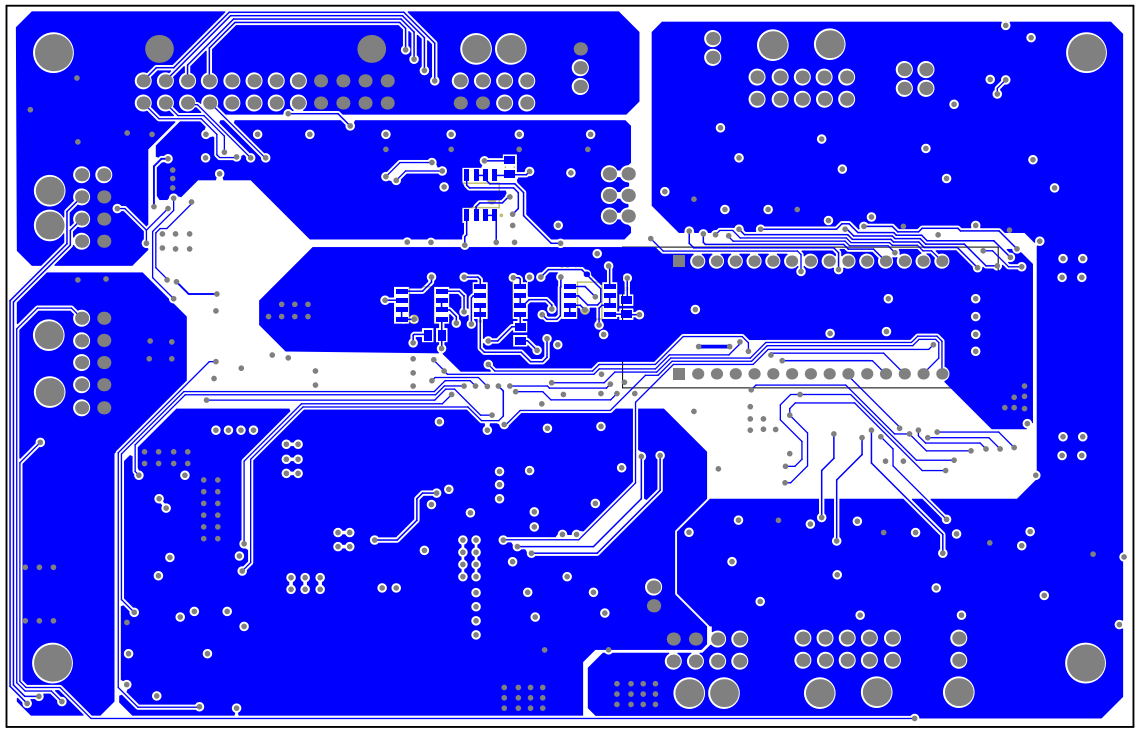

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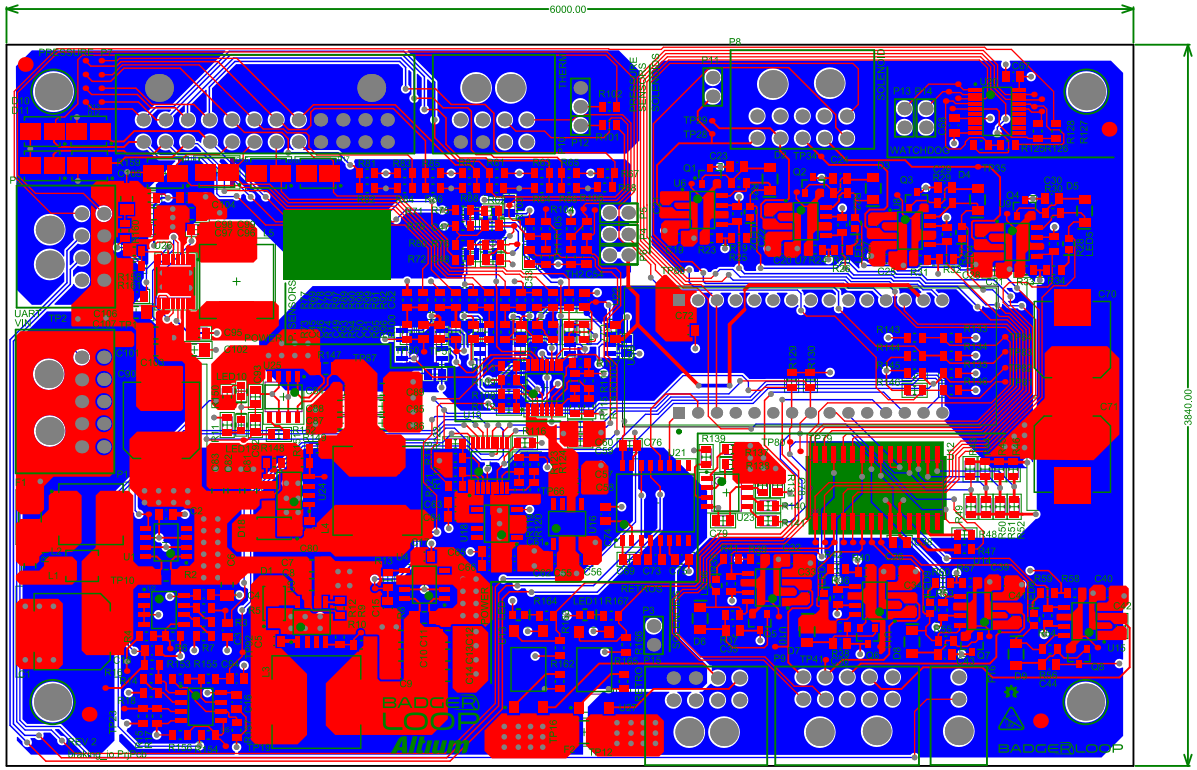

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