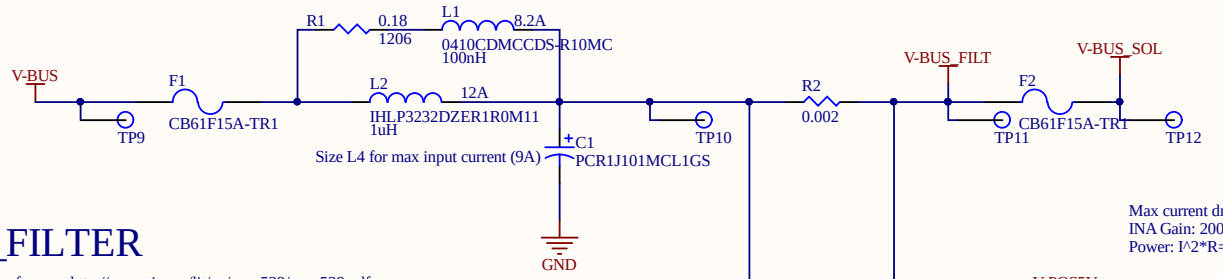
BRAKING IO

POD 5

REV 1

Title *Braking IO PCB*		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:47 PM	Sheet of	
File: braking_io.SchDoc		

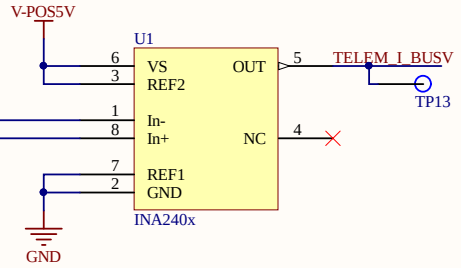
should change upstream fuse to be higher current rating than downstream.



BUS_FILTER

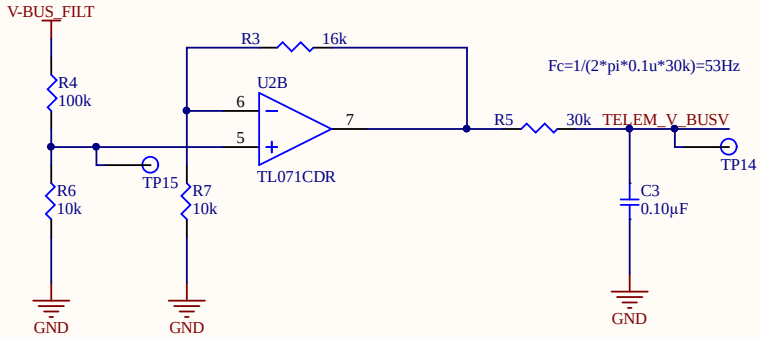
Filter design reference: http://www.ti.com/lit/an/snva538/snva538.pdf
http://ecee.colorado.edu/~rwe/papers/APEC99.pdf

Max current draw: 9A -> 9A*0.01Ohm=0.09V
INA Gain: 200V/V -> 4.0V at Max current
Power: I^2*R=4A*0.01=0.04W



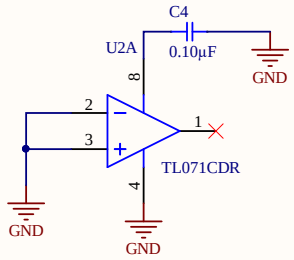
CURRENT TELEM

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

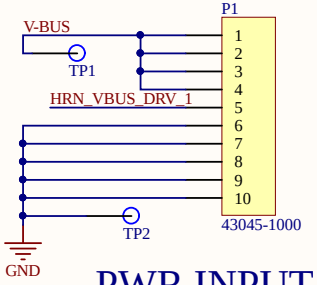


GAIN: 1.6V/V
MIN BUS VOLTAGE: 20V -> 1.82V
MIN BUS VOLTAGE: 28V -> 2.54V

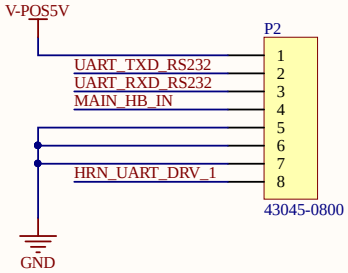
VOLTAGE TELEMETRY



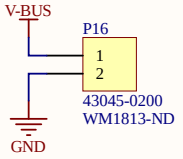
Title **Bus Filter**		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:47 PM	Sheet of	
File: bus_filter.SchDoc		



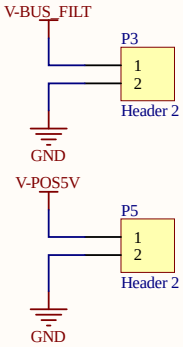
PWR INPUT

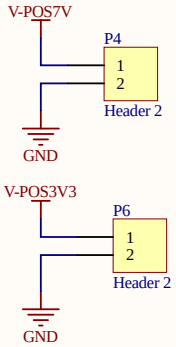


UART

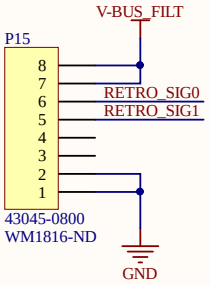


24V POWER LIGHT

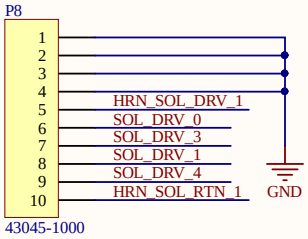


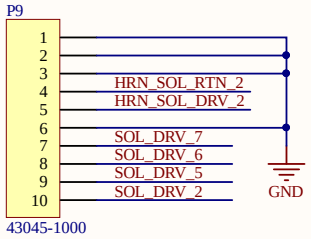


DEBUG



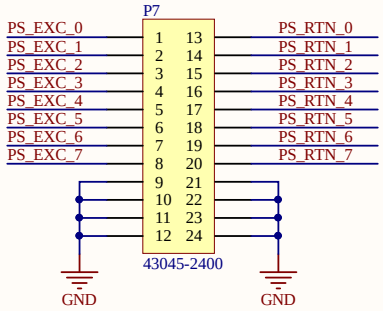
RETRO



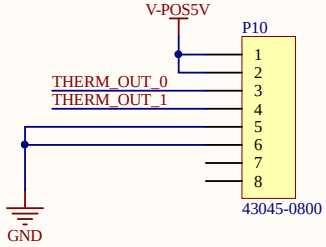


SOLENOIDS

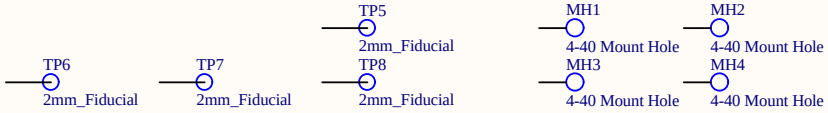
Split into 2 connectors as only 4 solenoids are likely to be used



PRESSURE SENSORS



THERMISTORS



Fiducals

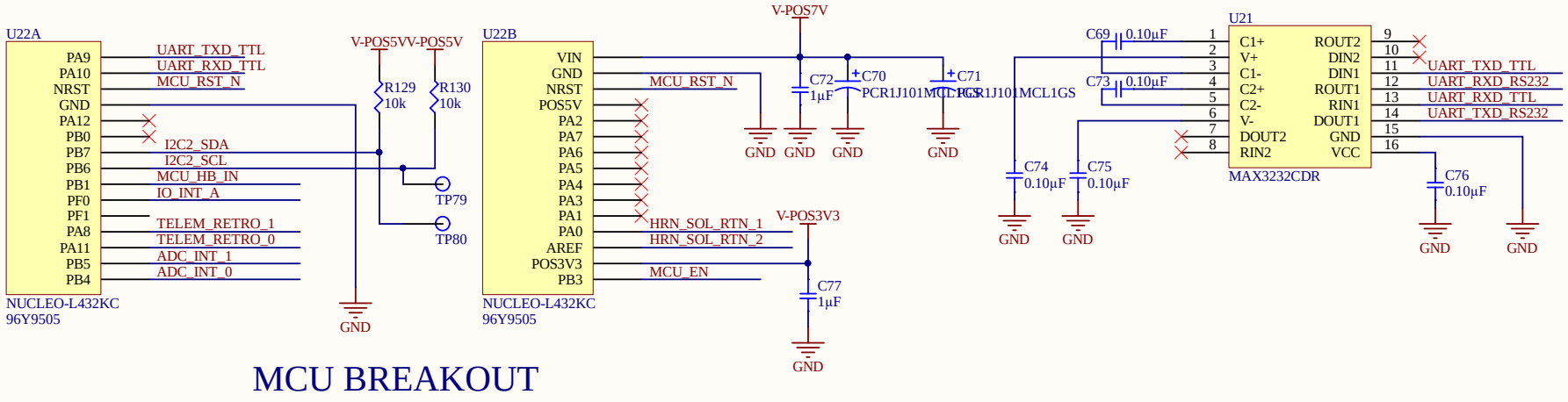
Place on four corners of board

Mount Holes

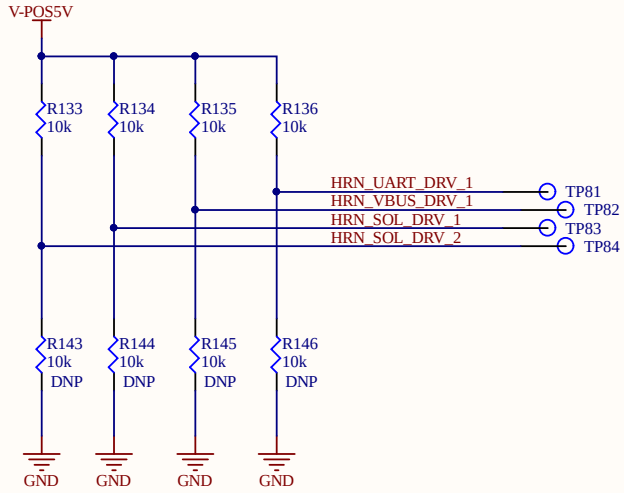
Avoid routing under screw head

Title	***Connectors***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:47 PM	Sheet of	
File: connectors.SchDoc		

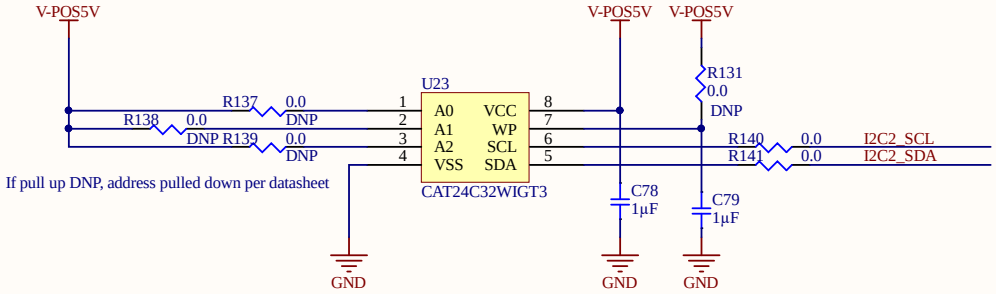
NRST pull to GND to Reset, Float Otherwise



MCU BREAKOUT



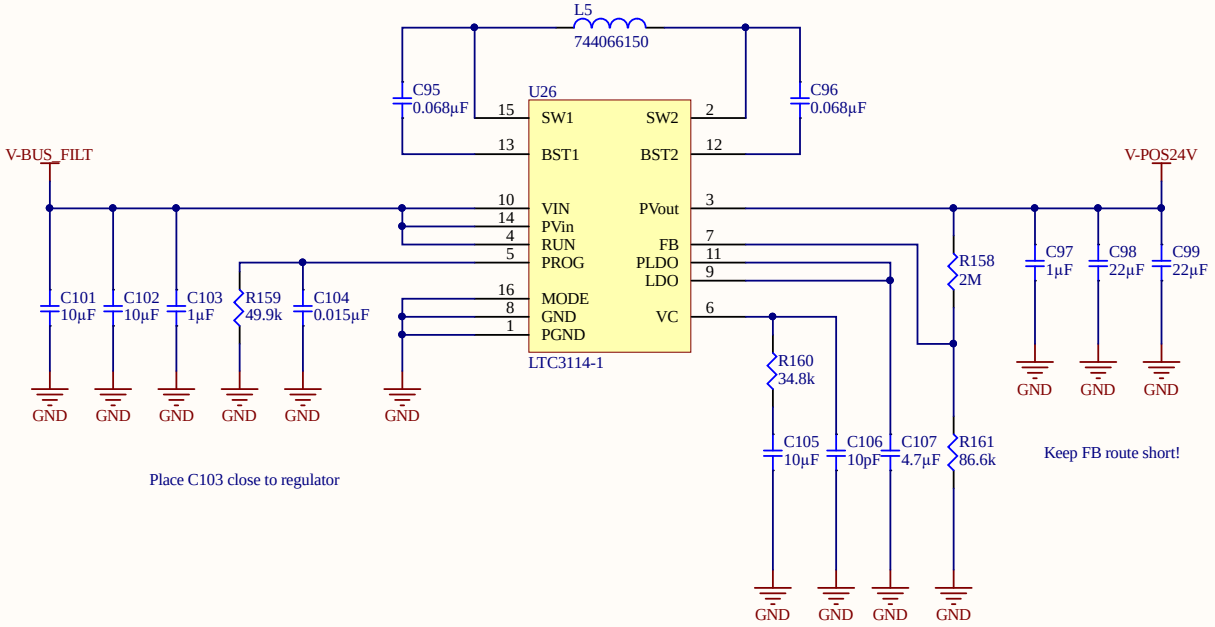
HARNESS ID



Default I2C Address: 0x50h

I2C EEPROM

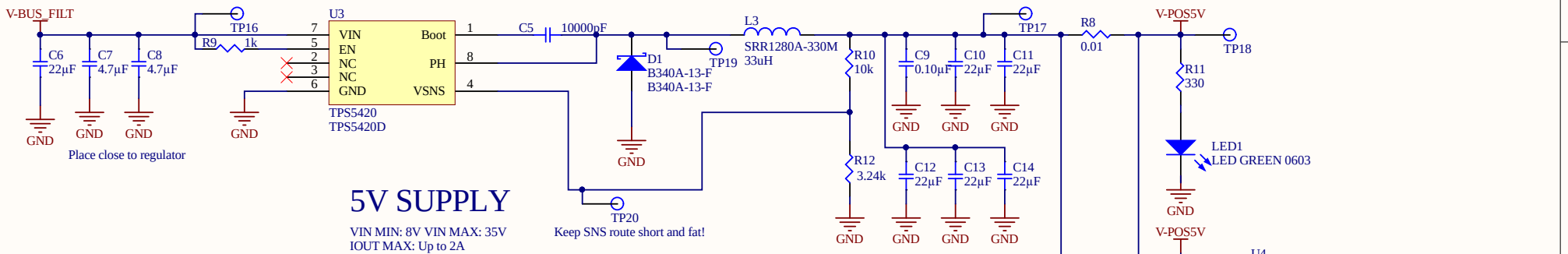
Title **Microcontroller**		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:47 PM	Sheet of	
File: mcu.SchDoc		



Title	***Power 24V***		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:		Revision:	
Date: 10/29/2019	Time: 7:05:47 PM	Sheet of	
File: power_24V.SchDoc			

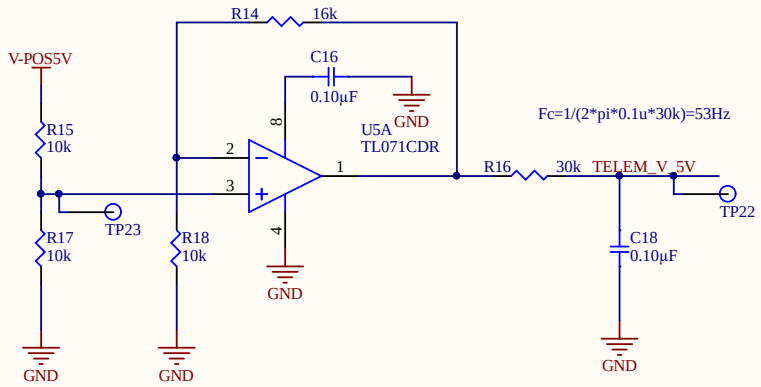
Notes:
Follow layout reference design
Place bypass caps close to regulator
Keep hot loops as short as possible
Possible to replace ceramic bulk cap with a tantalum.

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



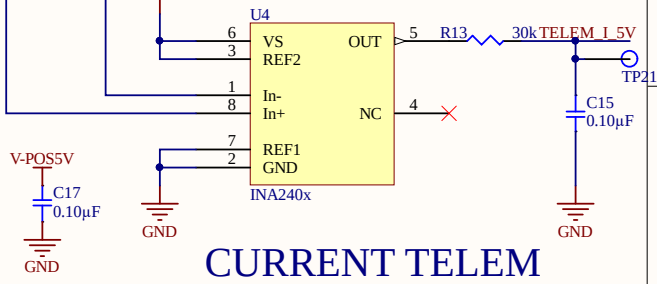
5V SUPPLY

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



GAIN: 1.6 -> MAX ADC VOLTAGE 4.0V

VOLTAGE TELEMETRY



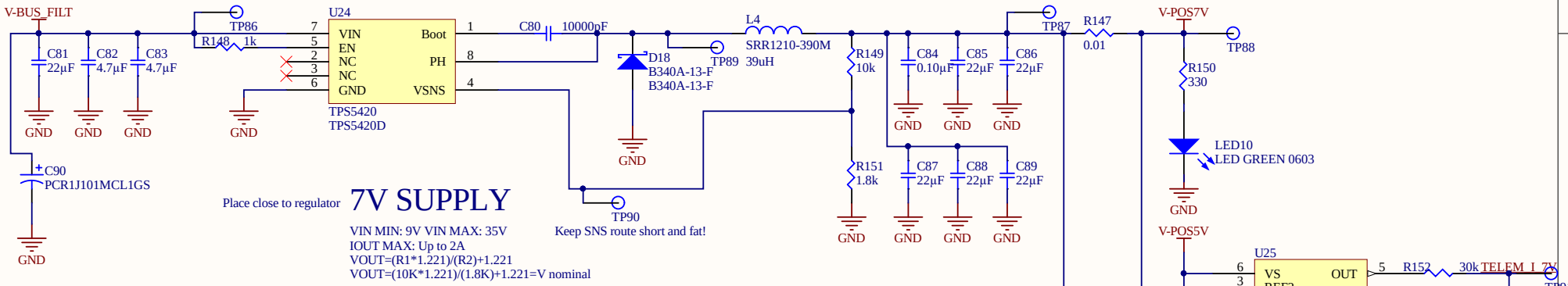
CURRENT TELEM

Max current draw: 2A -> 2A*0.01Ohm=0.02V
INA Gain: 200V/V -> 4.0V at Max current
Power: I^2*R=4A*0.01=0.04W

Title		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:47 PM	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

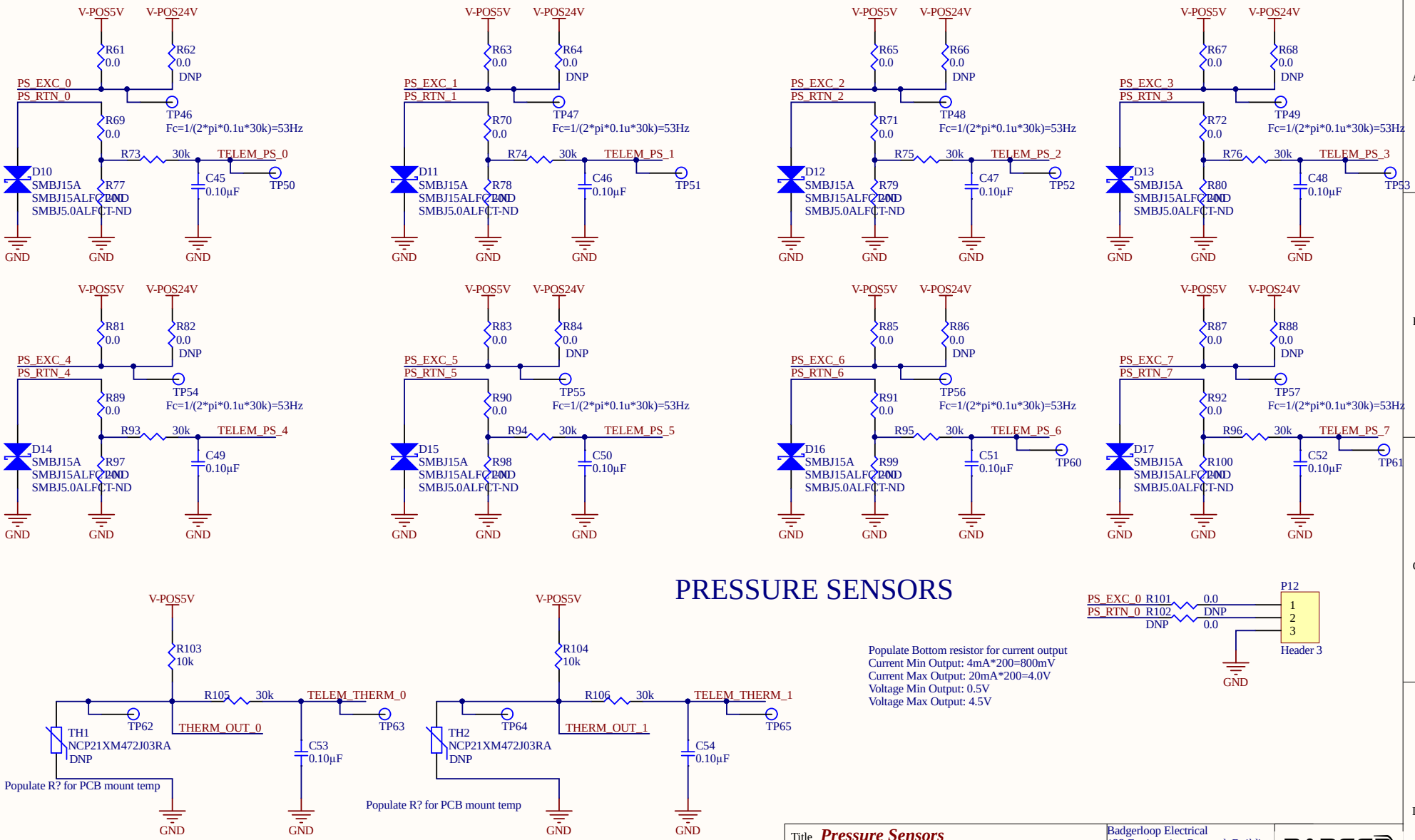
CURRENT TELEM

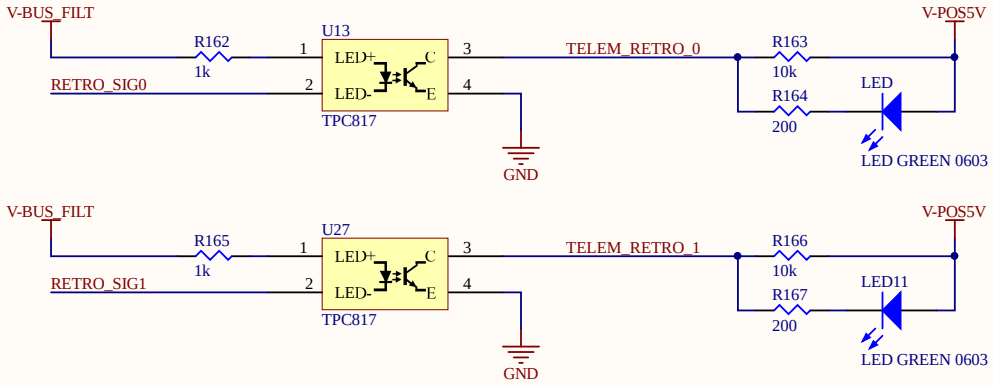
Max current draw: 2A -> 2A*0.01Ohm=0.02V
INA Gain: 200V/V -> 4.0V at Max current
Power: I^2*R=4A*0.01=0.04W

GAIN: 1.2 -> MAX ADC VOLTAGE 4.20V

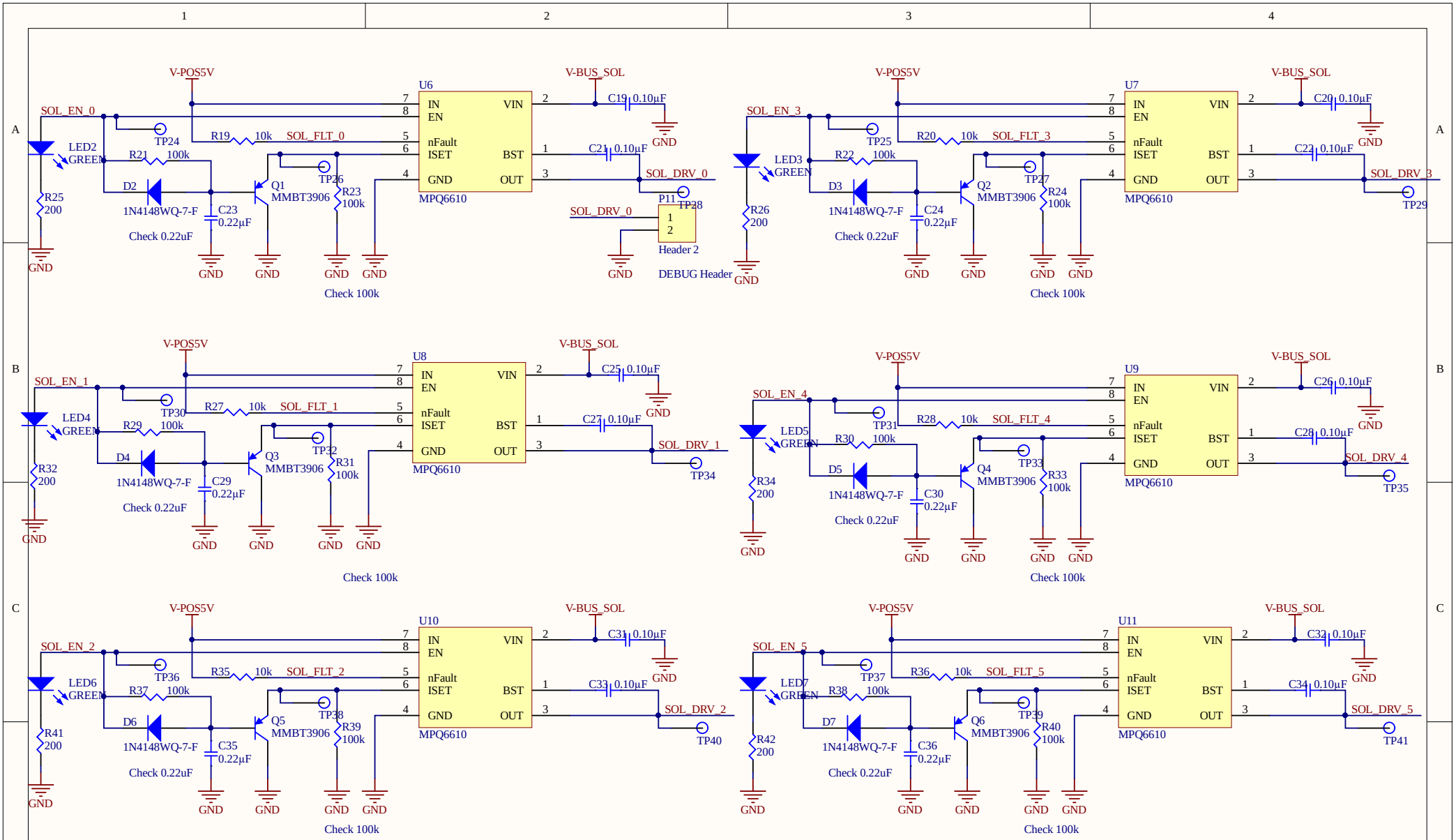
VOLTAGE TELEMETRY

Title *7V SUPPLY*		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:48 PM	Sheet of	
File: power_7V.SchDoc		


V-POS5V
V-POS24V
R61 0.0
R62 0.0 DNP
PS_EXC_0
PS_RTN_0
TP46
Fc=1/(2*pi*0.1u*30k)=53Hz
R69 0.0
R73 30k
TELEM_PS_0
D10 SMBJ15A SMBJ15ALFCT-ND
R77 200
SMBJ5.0ALFCT-ND
C45 0.10µF
TP50
GND
R63 0.0
R64 0.0 DNP
PS_EXC_1
PS_RTN_1
TP47
R70 0.0
R74 30k
TELEM_PS_1
D11 SMBJ15A SMBJ15ALFCT-ND
R78 200
SMBJ5.0ALFCT-ND
C46 0.10µF
TP51
R65 0.0
R66 0.0 DNP
PS_EXC_2
PS_RTN_2
TP48
R71 0.0
R75 30k
TELEM_PS_2
D12 SMBJ15A SMBJ15ALFCT-ND
R79 200
SMBJ5.0ALFCT-ND
C47 0.10µF
TP52
R67 0.0
R68 0.0 DNP
PS_EXC_3
PS_RTN_3
TP49
R72 0.0
R76 30k
TELEM_PS_3
D13 SMBJ15A SMBJ15ALFCT-ND
R80 200
SMBJ5.0ALFCT-ND
C48 0.10µF
TP53
R81 0.0
R82 0.0 DNP
PS_EXC_4
PS_RTN_4
TP54
R89 0.0
R93 30k
TELEM_PS_4
D14 SMBJ15A SMBJ15ALFCT-ND
R97 200
SMBJ5.0ALFCT-ND
C49 0.10µF
R83 0.0
R84 0.0 DNP
PS_EXC_5
PS_RTN_5
TP55
R90 0.0
R94 30k
TELEM_PS_5
D15 SMBJ15A SMBJ15ALFCT-ND
R98 200
SMBJ5.0ALFCT-ND
C50 0.10µF
R85 0.0
R86 0.0 DNP
PS_EXC_6
PS_RTN_6
TP56
R91 0.0
R95 30k
TELEM_PS_6
D16 SMBJ15A SMBJ15ALFCT-ND
R99 200
SMBJ5.0ALFCT-ND
C51 0.10µF
TP60
R87 0.0
R88 0.0 DNP
PS_EXC_7
PS_RTN_7
TP57
R92 0.0
R96 30k
TELEM_PS_7
D17 SMBJ15A SMBJ15ALFCT-ND
R100 200
SMBJ5.0ALFCT-ND
C52 0.10µF
TP61
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
PS_EXC_0 R101 0.0
PS_RTN_0 R102 DNP
DNP 0.0
P12
1
2
3
Header 3
R103 10k
R105 30k
TELEM_THERM_0
TP62
THERM_OUT_0
TP63
TH1 NCP21XM472J03RA DNP
C53 0.10µF
Populate R? for PCB mount temp
R104 10k
R106 30k
TELEM_THERM_1
TP64
THERM_OUT_1
TP65
TH2 NCP21XM472J03RA DNP
C54 0.10µF
Populate R? for PCB mount temp
TEMPERATURE
Title Pressure Sensors
Engineer:
Revision:
Date: 10/29/2019 Time: 7:05:48 PM
Sheet of
File: pressure.SchDoc
Badgerloop Electrical
133 Engineering Research Building
1500 Engineering Drive
Madison, Wi 53706
BADGER LOOP



Title *Retro*		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:48 PM	Sheet of	
File: retro.SchDoc		



SOLENOID DRIVE

Title	***Solenoids***	
Engineer:		Revision:
Date: 10/29/2019	Time: 7:05:48 PM	Sheet of
File: solenoid.SchDoc		

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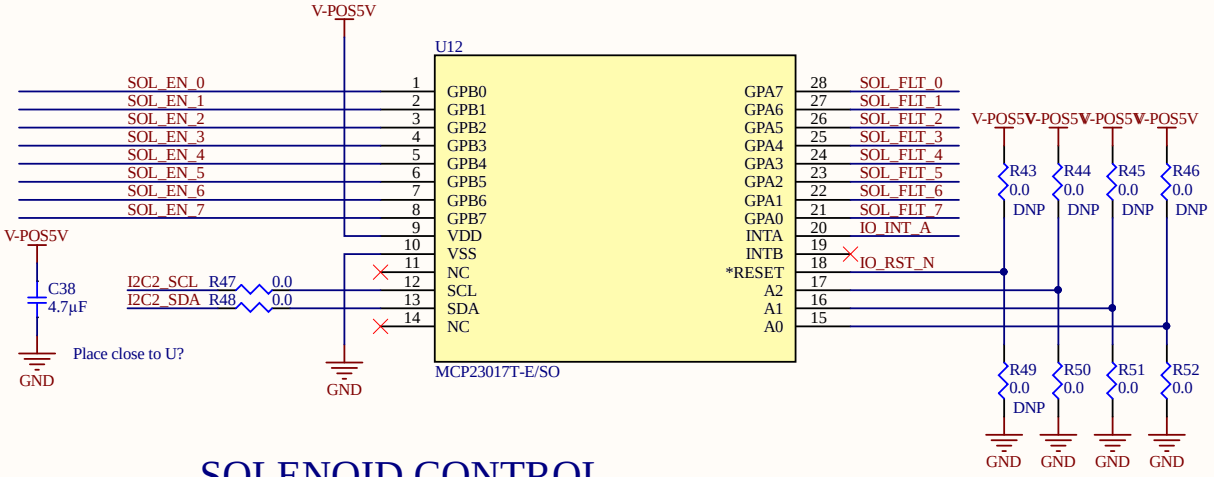
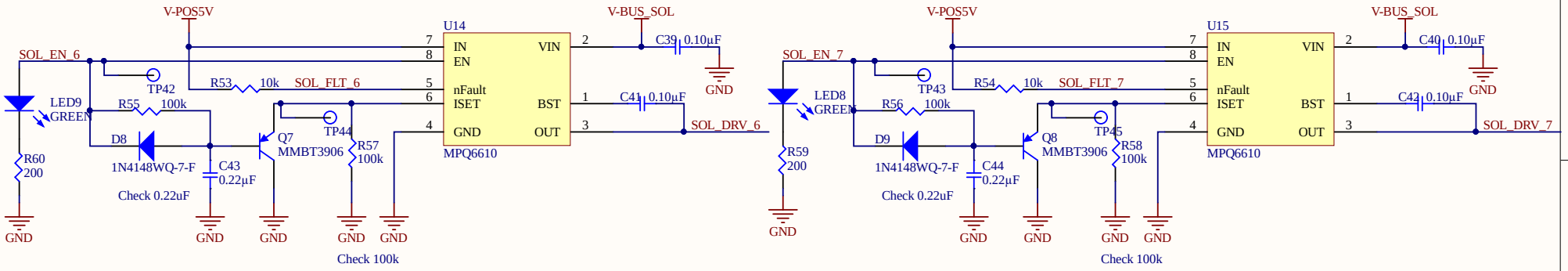
133 Engineering Research Building
1500 Engineering Drive
Madison, Wi 53706

BADGER LOOP

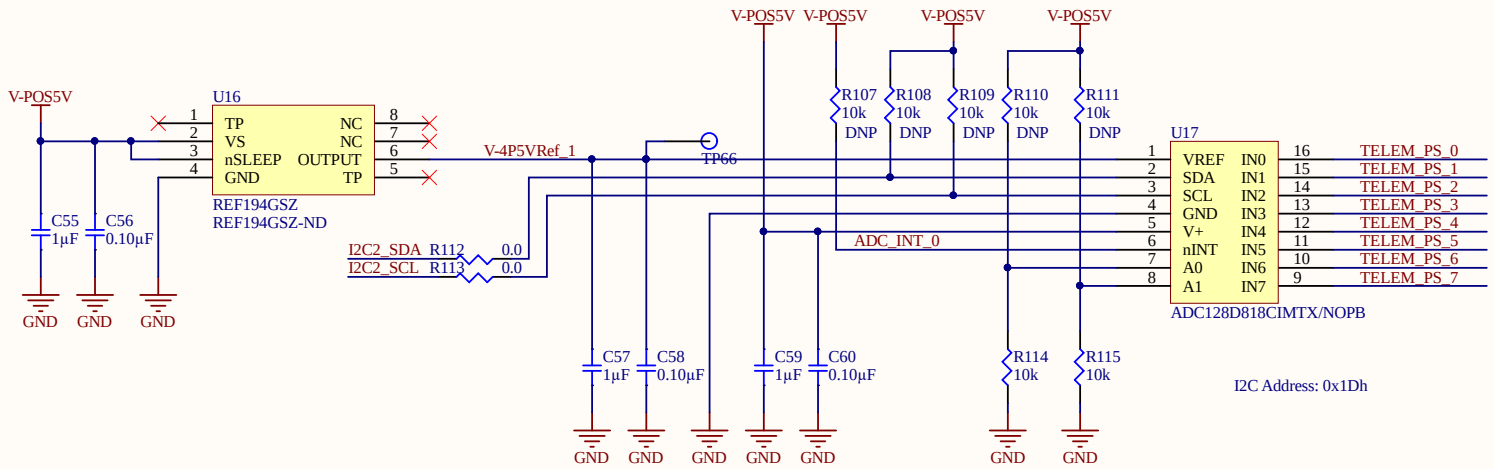


SOLENOID CONTROL

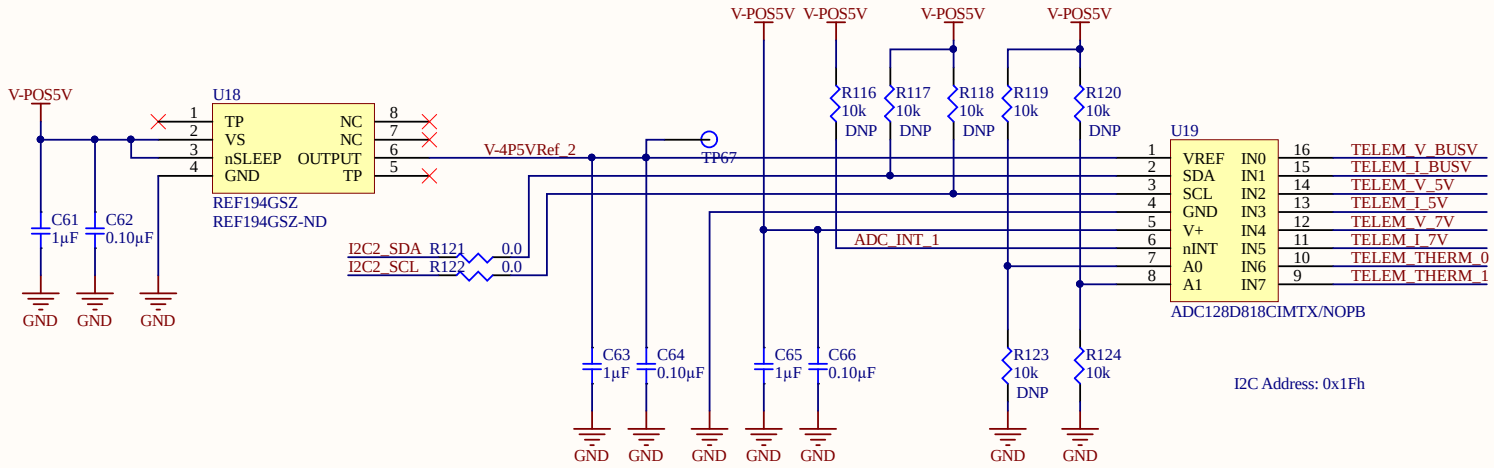


SOLENOID DRIVE

Title	***Solenoid Control***	Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:48 PM	Sheet of	
File: solenoid_drv.SchDoc		

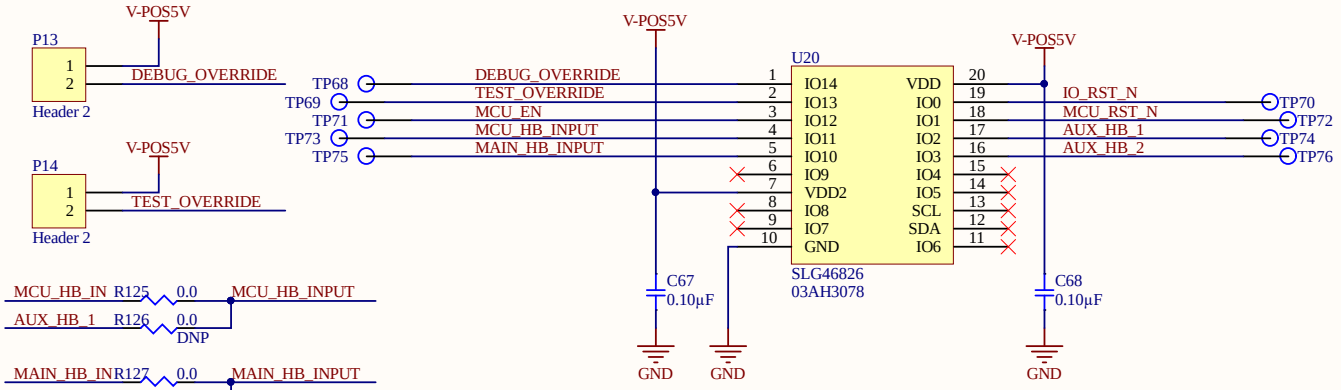


PRESSURE



RAIL AND TEMPERATURE

Title **ADC**		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 10/29/2019 Time: 7:05:48 PM	Sheet of	
File: telemetry_adc.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

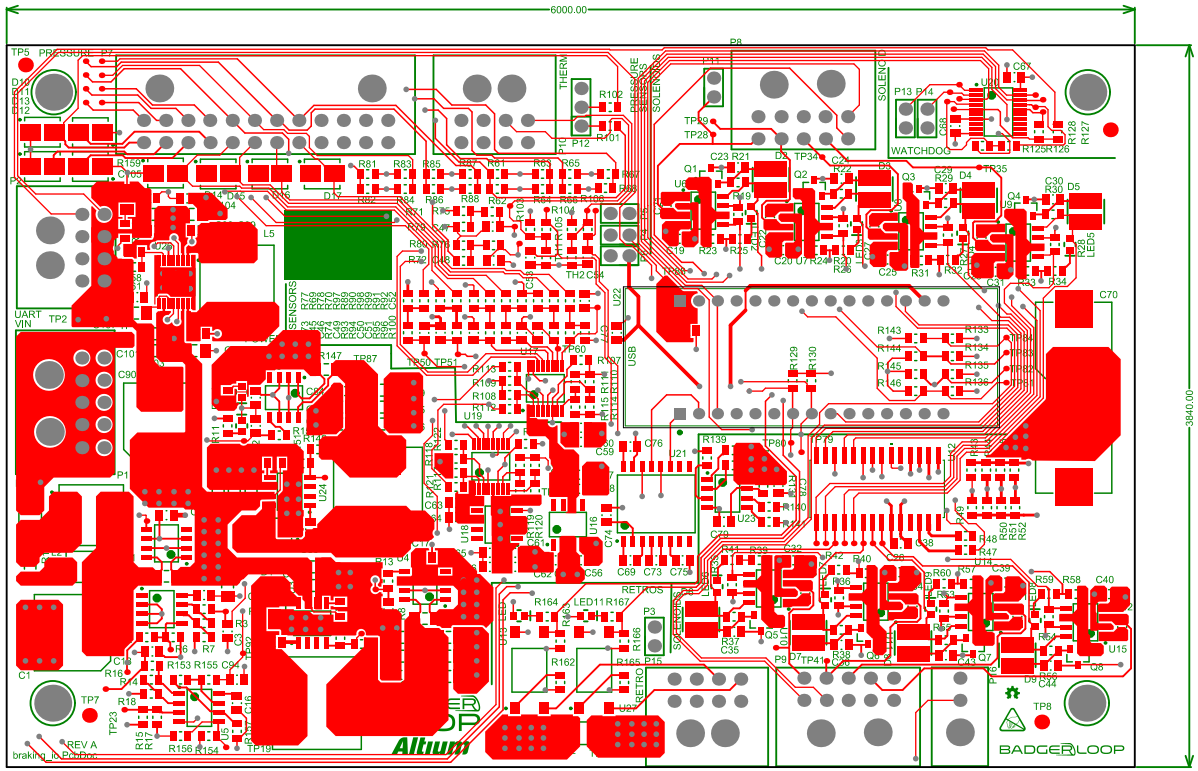
Modes of operation:
Debug: EN signal is always on when SLG has power
Populate Jumper 1
Test: 10Hz signal internal signal is recircuilated to mimic heartbeat
Populate Jumper 2
Operation: U? expects 10Hz heartbeat. If no heartbeat for 1s after 20s Power on reset
MCP RST_N will fall and MCU RST_N will pulse 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: 10/29/2019 Time: 7:05:49 PM	Sheet of	
File: watchdog.SchDoc		

Layer	Name	Material	Thickness	Constant	Board Layer Stack
	Top Overlay				
	Top Solder	Solder Resist	0.40mil	3.5	
1	Top Layer	Copper	1.40mil		
	Dielectric 2	FR-4	18.70mil	4.9	
2	GND	Copper	1.40mil		
	Dielectric 1	FR-4	18.70mil	4.9	
3	PWR	Copper	1.40mil		
	Dielectric 3	FR-4	18.70mil	4.9	
4	Bottom Layer	Copper	1.40mil		
	Bottom Solder	Solder Resist	0.40mil	3.5	
	Bottom Overlay				
Total board thickness:			62.50mil		



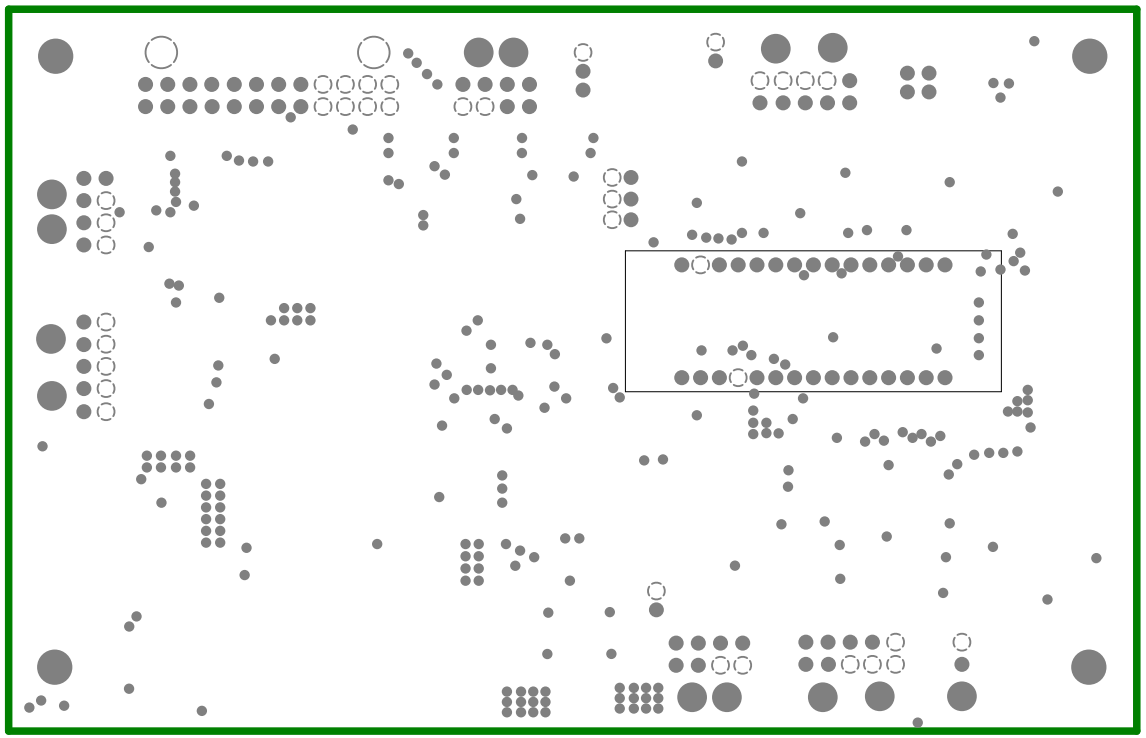
Top Layer

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: 10/29/2019	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
	Top Overlay				
	Top Solder	Solder Resist	0.40mil	3.5	
1	Top Layer	Copper	1.40mil		
	Dielectric 2	FR-4	18.70mil	4.9	
2	GND	Copper	1.40mil		
	Dielectric 1	FR-4	18.70mil	4.9	
3	PWR	Copper	1.40mil		
	Dielectric 3	FR-4	18.70mil	4.9	
4	Bottom Layer	Copper	1.40mil		
	Bottom Solder	Solder Resist	0.40mil	3.5	
	Bottom Overlay				
Total board thickness:			62.50mil		



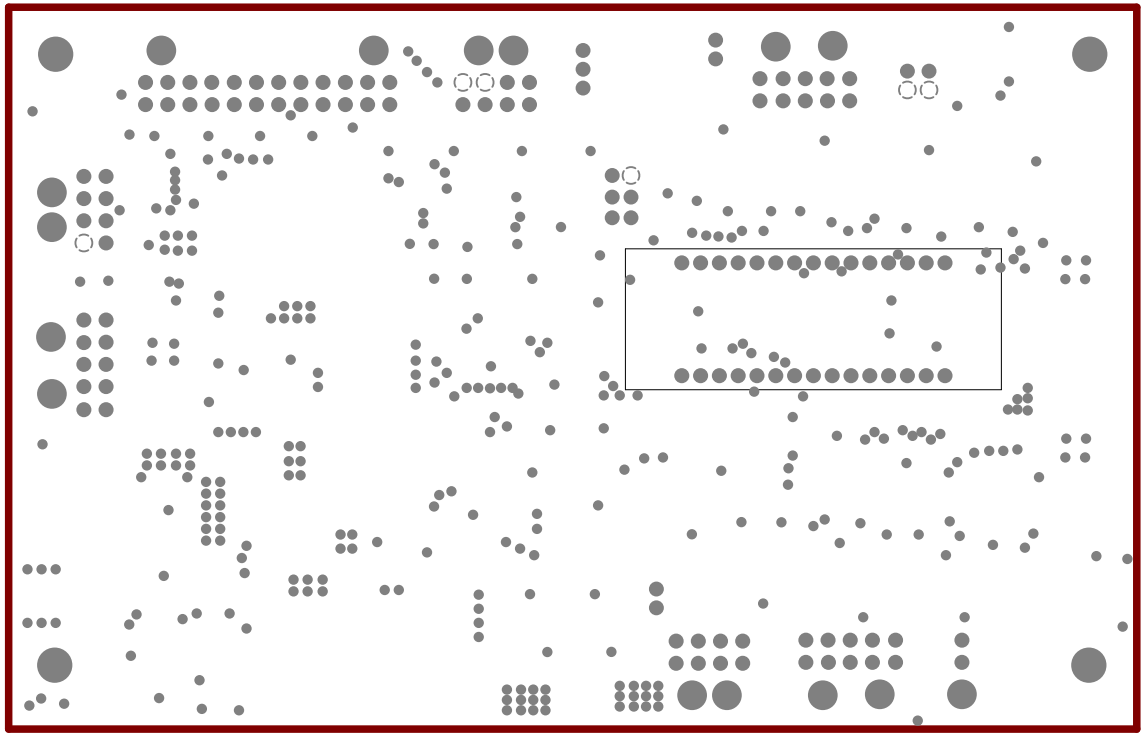
GND

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: 10/29/2019	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
	Top Overlay				
	Top Solder	Solder Resist	0.40mil	3.5	
1	Top Layer	Copper	1.40mil		
	Dielectric 2	FR-4	18.70mil	4.9	
2	GND	Copper	1.40mil		
	Dielectric 1	FR-4	18.70mil	4.9	
3	PWR	Copper	1.40mil		
	Dielectric 3	FR-4	18.70mil	4.9	
4	Bottom Layer	Copper	1.40mil		
	Bottom Solder	Solder Resist	0.40mil	3.5	
	Bottom Overlay				
Total board thickness:			62.50mil		



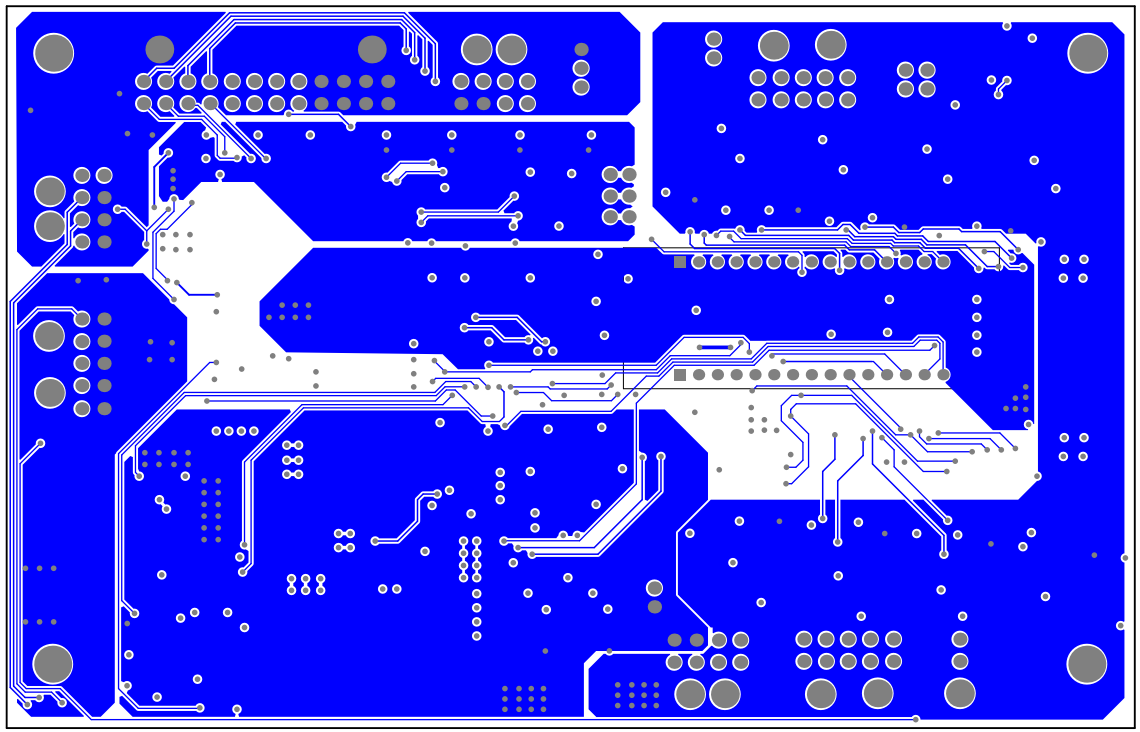
PWR

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: 10/29/2019	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
	Top Overlay				
	Top Solder	Solder Resist	0.40mil	3.5	
1	Top Layer	Copper	1.40mil		
	Dielectric 2	FR-4	18.70mil	4.9	
2	GND	Copper	1.40mil		
	Dielectric 1	FR-4	18.70mil	4.9	
3	PWR	Copper	1.40mil		
	Dielectric 3	FR-4	18.70mil	4.9	
4	Bottom Layer	Copper	1.40mil		
	Bottom Solder	Solder Resist	0.40mil	3.5	
	Bottom Overlay				
Total board thickness:			62.50mil		



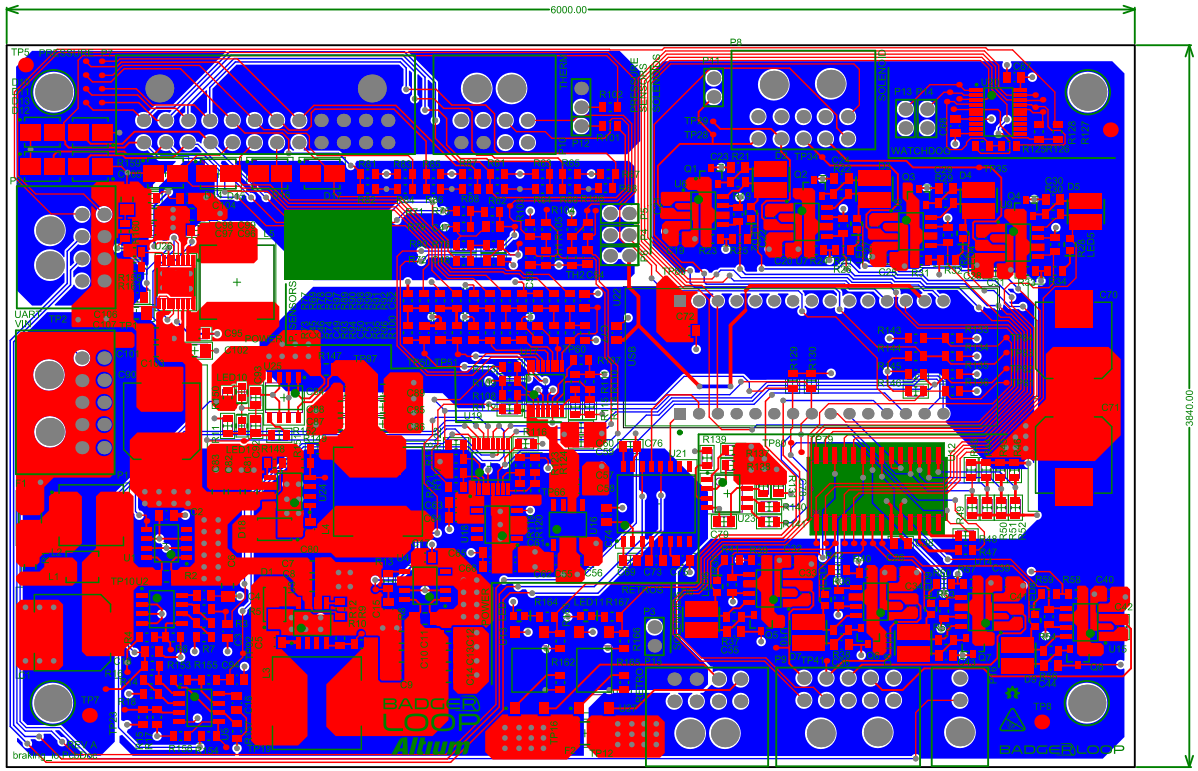
Bottom Layer

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: 10/29/2019	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
	Top Overlay				
	Top Solder	Solder Resist	0.40mil	3.5	
1	Top Layer	Copper	1.40mil		
	Dielectric 2	FR-4	18.70mil	4.9	
2	GND	Copper	1.40mil		
	Dielectric 1	FR-4	18.70mil	4.9	
3	PWR	Copper	1.40mil		
	Dielectric 3	FR-4	18.70mil	4.9	
4	Bottom Layer	Copper	1.40mil		
	Bottom Solder	Solder Resist	0.40mil	3.5	
	Bottom Overlay				
Total board thickness:			62.50mil		



Bottom Layer

BADGER LOOP

Badgerloop
ERB Room 133
1400 Engineering Drive
Madison, WI 53706

ENGINEER: RCastle, BTobin, JEslinger, SRiggleman	TITLE: braking_io.PcbDoc	
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DATE: 10/29/2019	PART NO.: Braking Input Output Controller	REV: A
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