

A

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BRAKING IO

POD 5

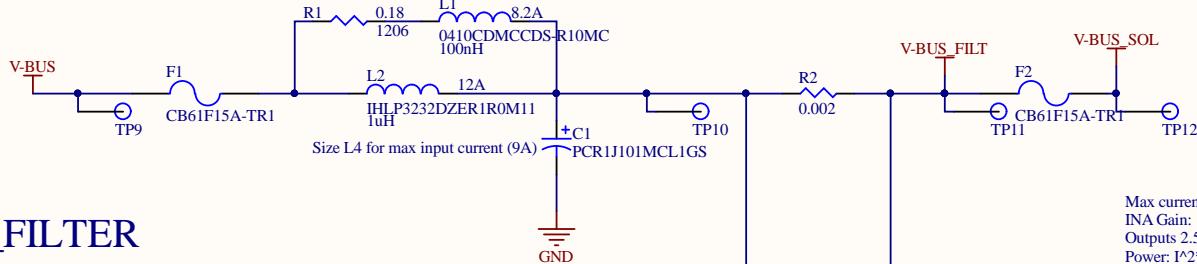
REV 1

Title Braking IO PCB		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706	
Engineer:	Revision:	Date: 6/26/2020 Time: 5:54:27 PM Sheet of	

A

A

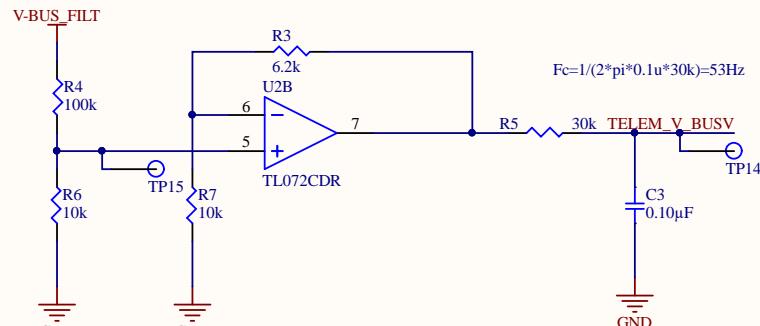
should change upstream fuse to be higher current rating than downstream.



BUS_FILTER

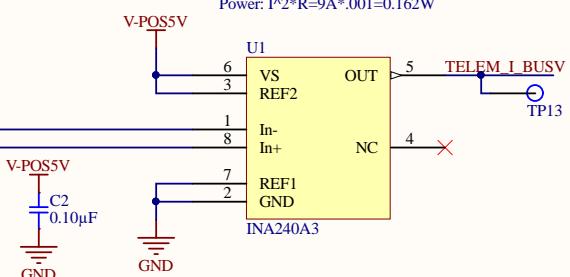
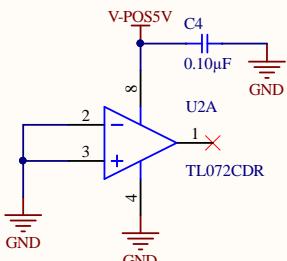
Filter design reference: <http://www.ti.com/lit/an/snva538/snva538.pdf>
<http://ecee.colorado.edu/~rwe/papers/APEC99.pdf>

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: $I^2 \cdot R = 9A \cdot .001 = 0.162W$



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

VOLTAGE TELEMETRY

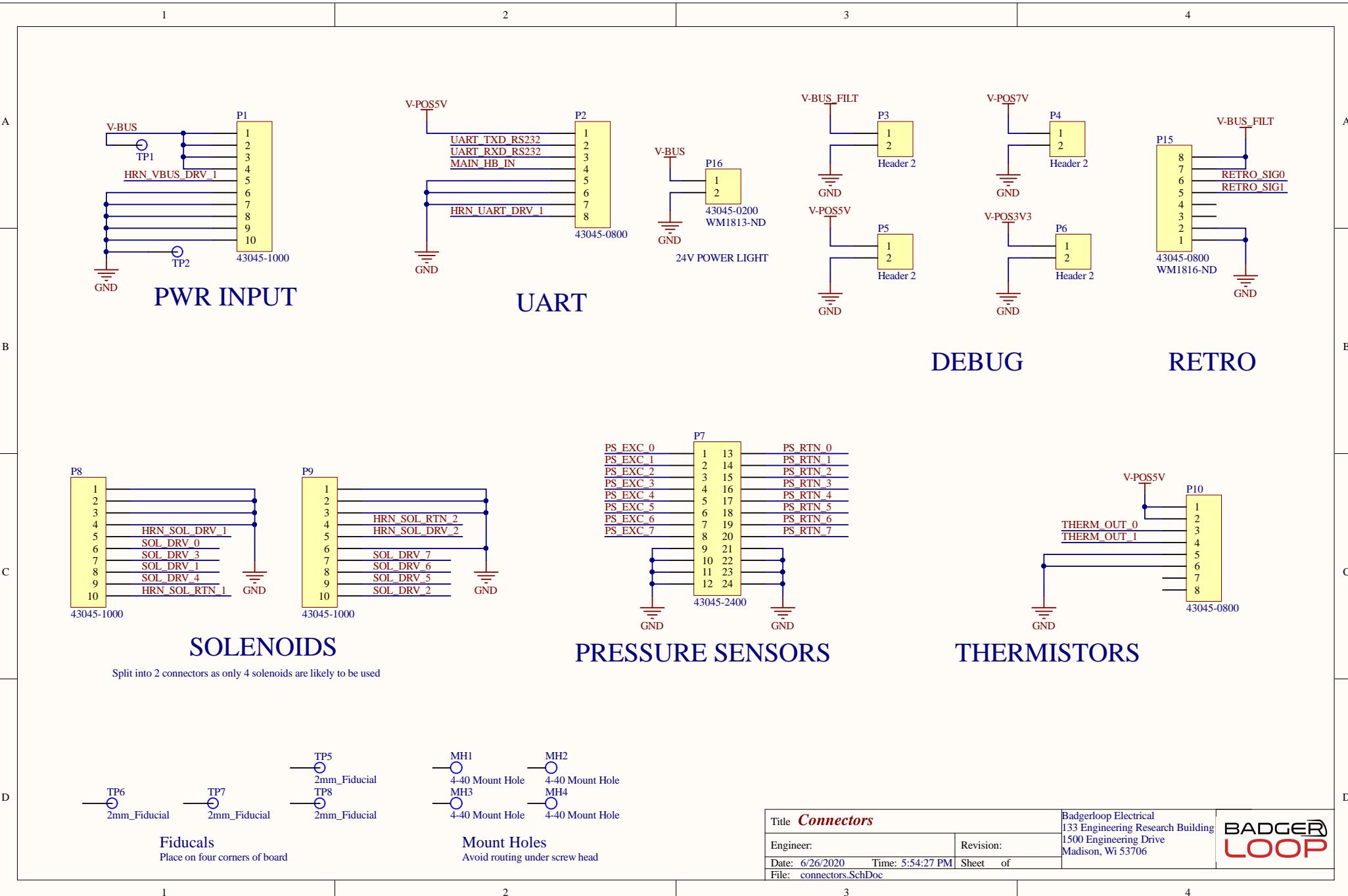


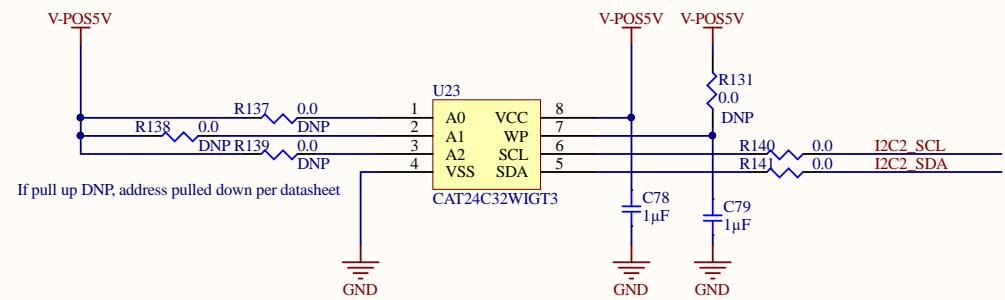
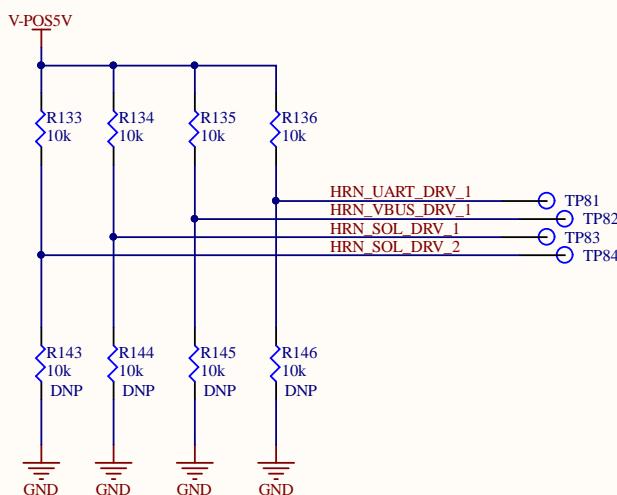
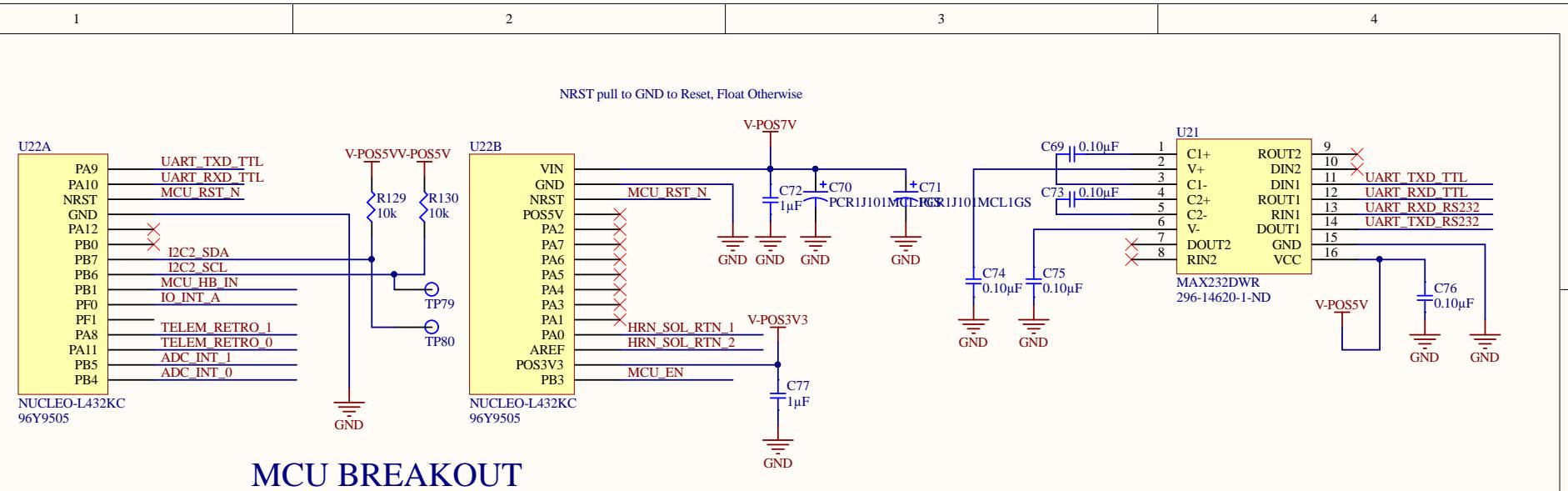
CURRENT TELE

Max current draw: 9A > 9A*0.002Ohm=0.018V
 INA Gain: 200V/V > 3.6V at Max current
 Power: $I^2 \cdot R = 4A \cdot .01 = 0.04W$

Title Bus Filter		Badgerloop Electrical
Engineer:	Revision:	133 Engineering Research Building
Date: 6/26/2020	Time: 5:54:27 PM	1500 Engineering Drive
File: bus_filter.SchDoc		Madison, Wi 53706

BADGER
LOOP

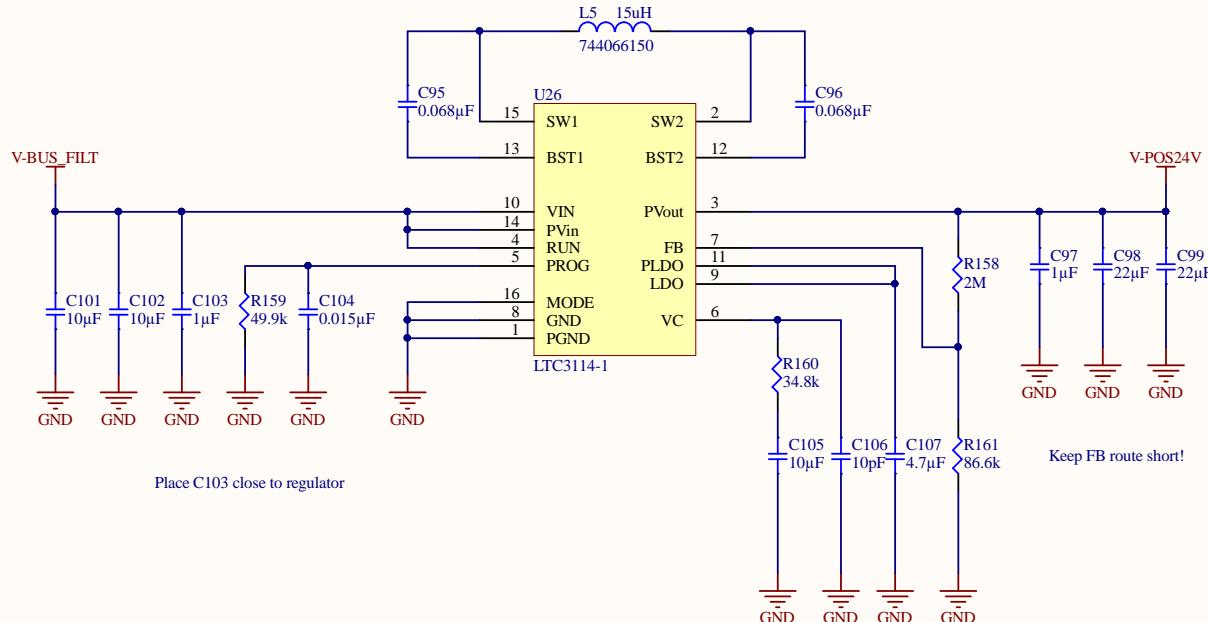




Title Microcontroller		Badgerloop Electrical 133 Engineering Drive 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/26/2020	Time: 5:54:27 PM	Sheet of
File: mcu.SchDoc		BADGER LOOP

A

A



B

B

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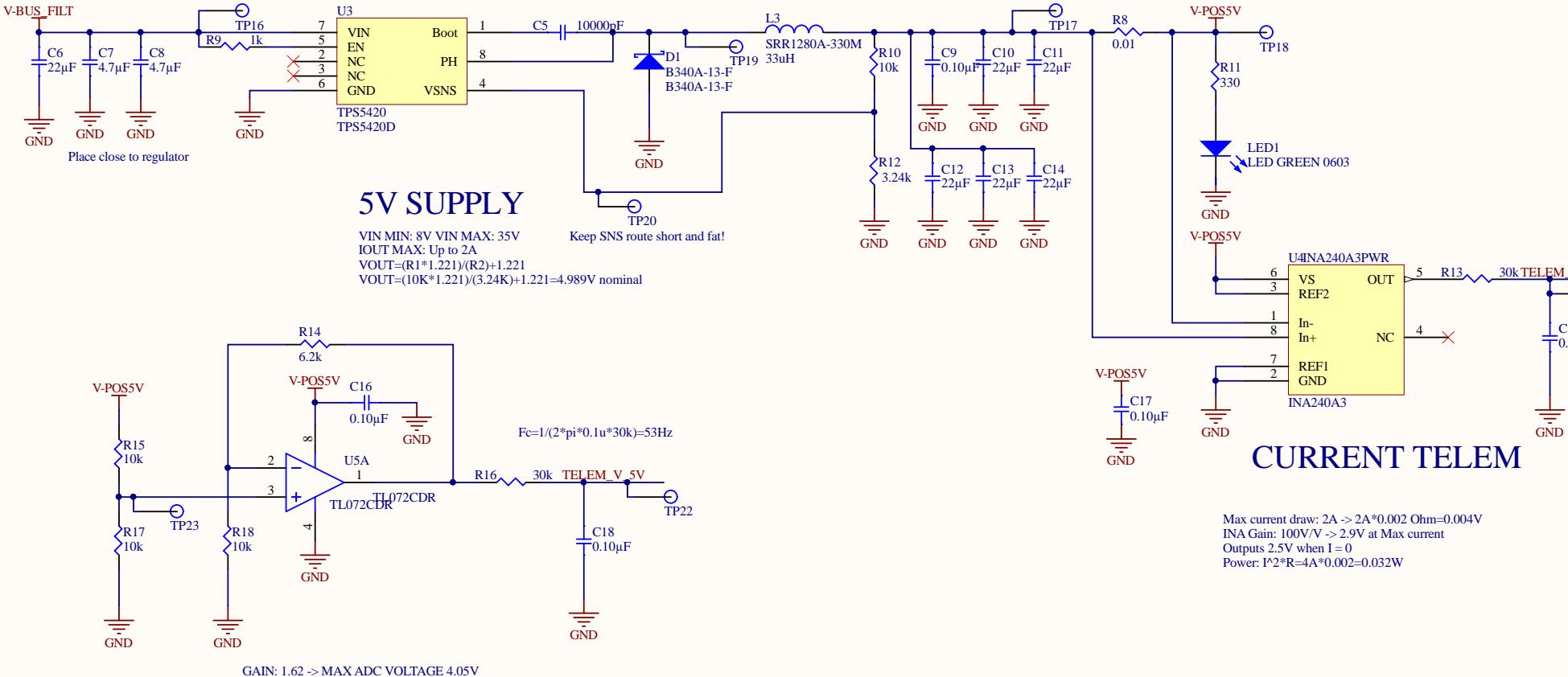
Title Power 24V		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706	BADGER LOOP
Engineer:	Revision:	Date: 6/26/2020 Time: 5:54:27 PM Sheet of	

File: power_24V.SchDoc

A

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](https://github.com/badgerloop-software/hardware/tree/master/braking_io/design)



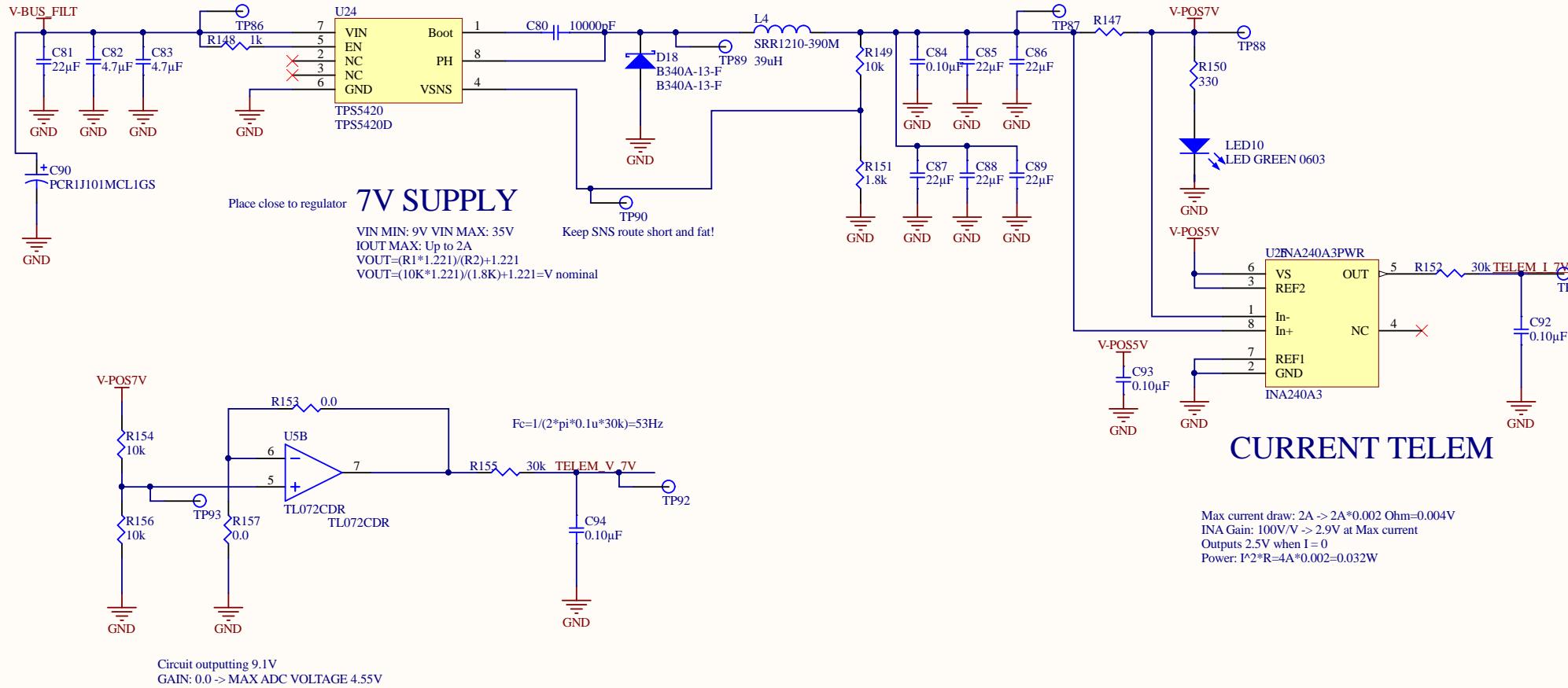
Title		Badgerloop Electrical
Engineer:	Revision:	133 Engineering Research Building
Date: 6/26/2020	Time: 5:54:28 PM	1500 Engineering Drive
File: power_5V.SchDoc		Madison, Wi 53706

BADGER
LOOP

A

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.



Title 7V SUPPLY		Badgerloop Electrical
Engineer:	Revision:	133 Engineering Research Building
Date: 6/26/2020	Time: 5:54:28 PM	1500 Engineering Drive
File: power_7V.SchDoc		Madison, Wi 53706

**BADGER
LOOP**

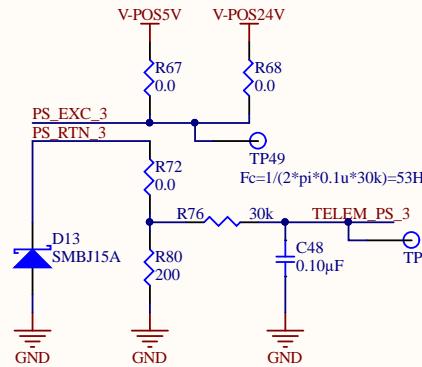
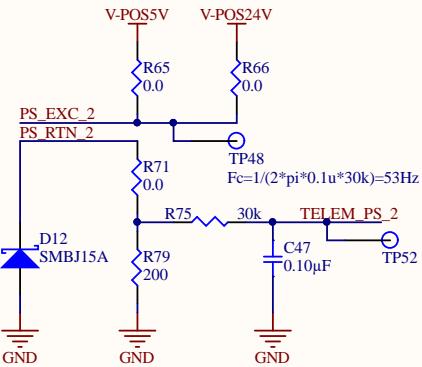
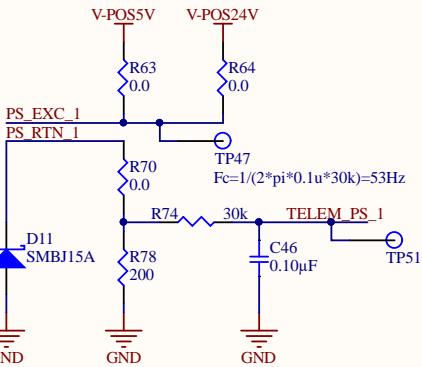
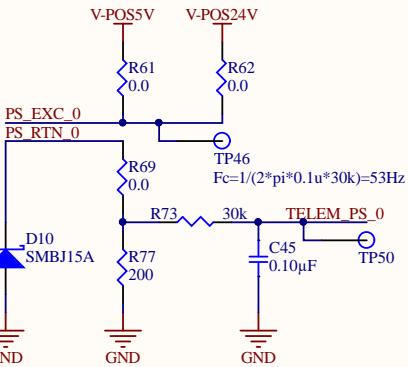
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2

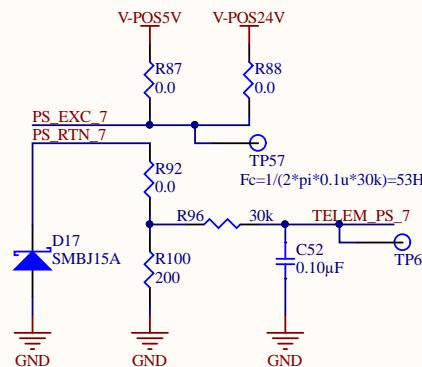
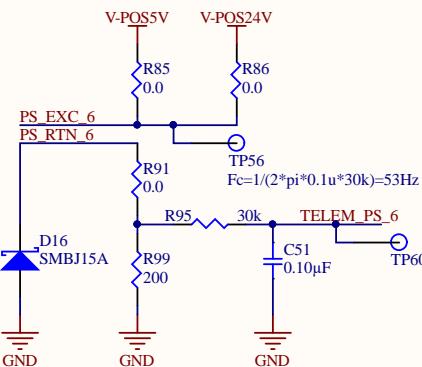
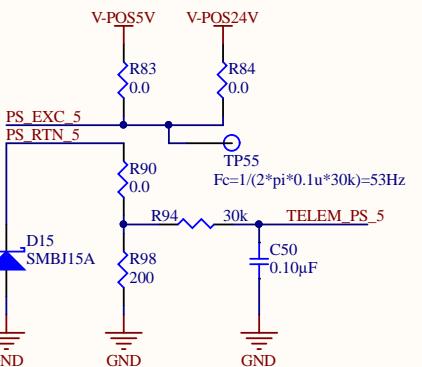
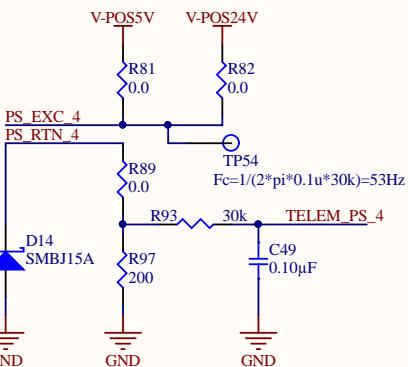
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4

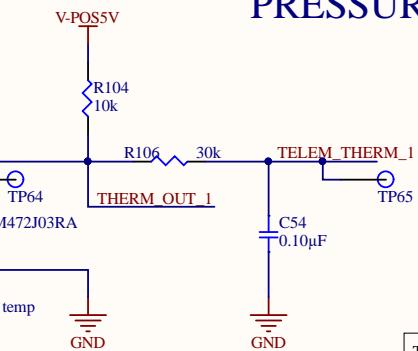
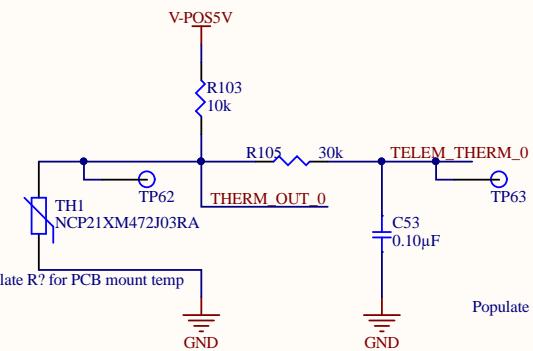
A



B



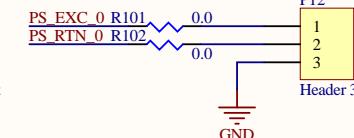
C



TEMPERATURE

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



Title **Pressure Sensors**

Engineer:

Date: 6/26/2020

File: pressure.SchDoc

Badgerloop Electrical
133 Engineering Research Building
1500 Engineering Drive
Madison, Wi 53706

BADGER
LOOP

2

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4

1

2

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4

A

A

B

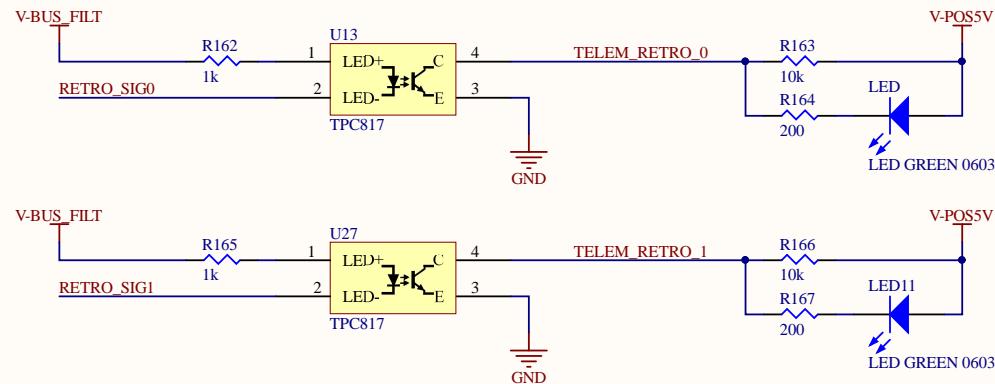
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C

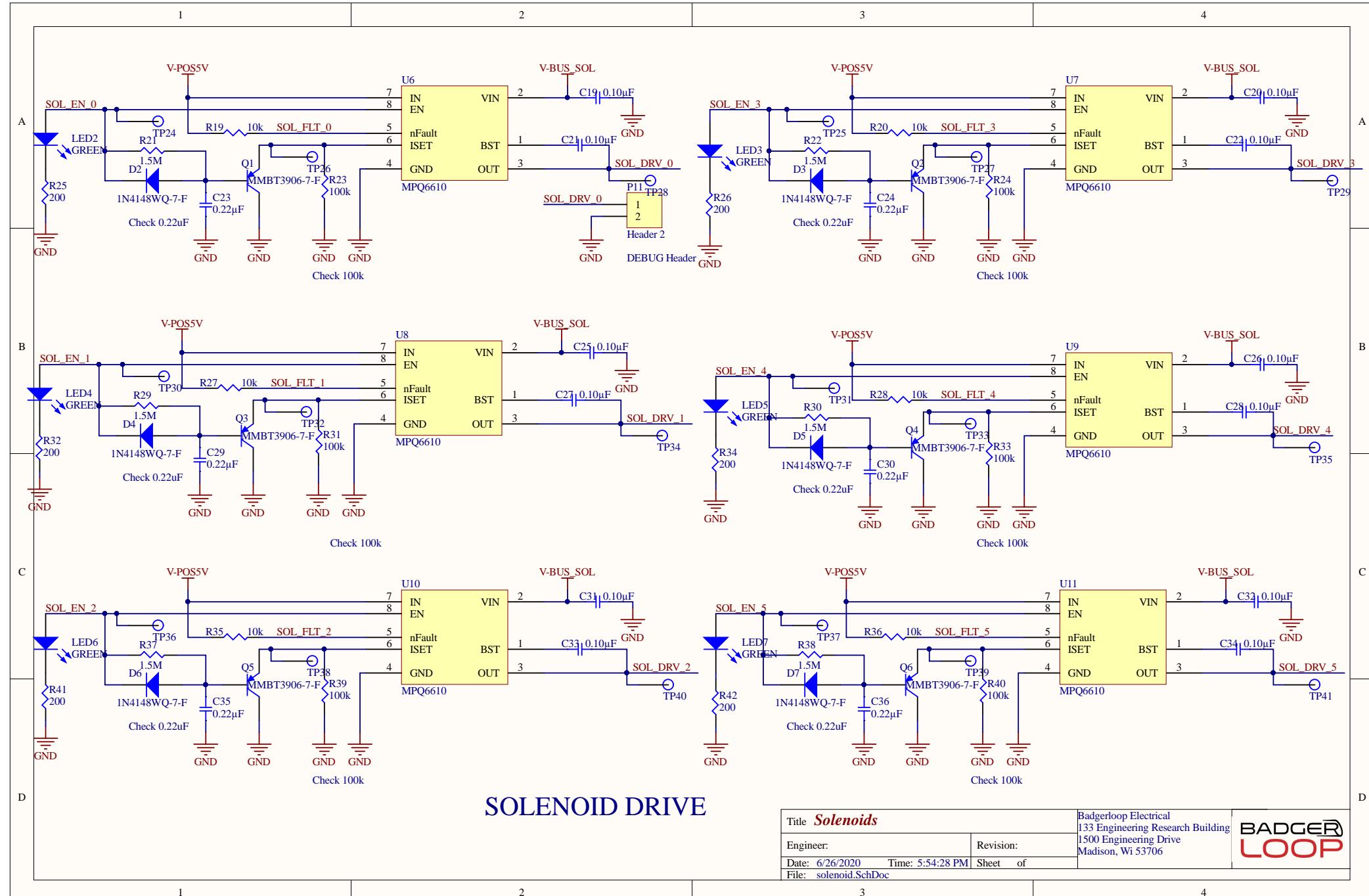
C

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D



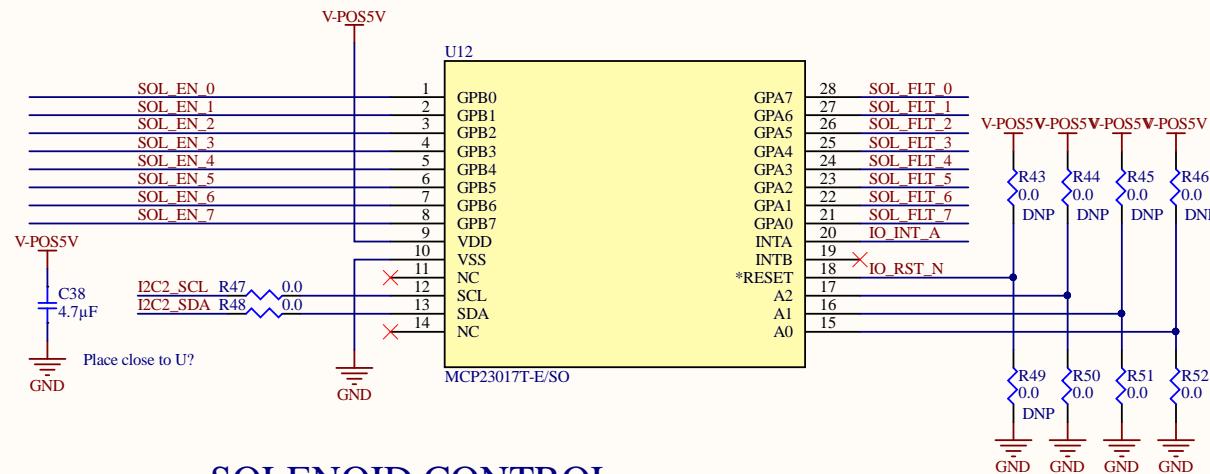
Title <i>Retro</i>		Badgerloop Electrical
Engineer:		133 Engineering Research Building
Date: 6/26/2020	Time: 5:54:28 PM	Revision: Madison, Wi 53706 Sheet of
File: <i>retro.SchDoc</i>		BADGER LOOP



Title Solenoids		Badgerloop Electrical
Engineer:	Revision:	133 Engineering Research Building
Date: 6/26/2020	Time: 5:54:28 PM	1500 Engineering Drive
File: solenoid.SchDoc		Madison, Wi 53706

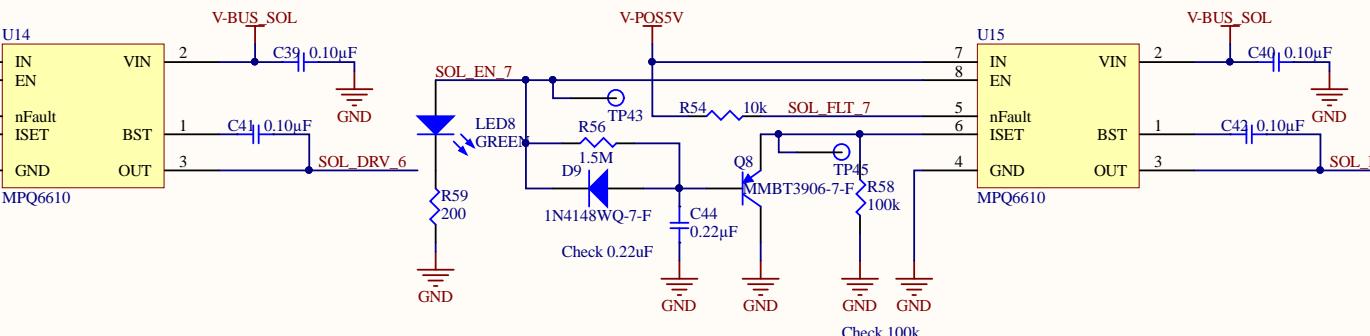
BADGER
LOOP

A



SOLENOID CONTROL

B



SOLENOID DRIVE

Title Solenoid Control		Badgerloop Electrical
Engineer:	Revision:	133 Engineering Research Building
Date: 6/26/2020	Time: 5:54:29 PM	1500 Engineering Drive
File: solenoid_drv.SchDoc		Madison, Wi 53706

BADGER
LOOP

1 2 3 4

A

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C

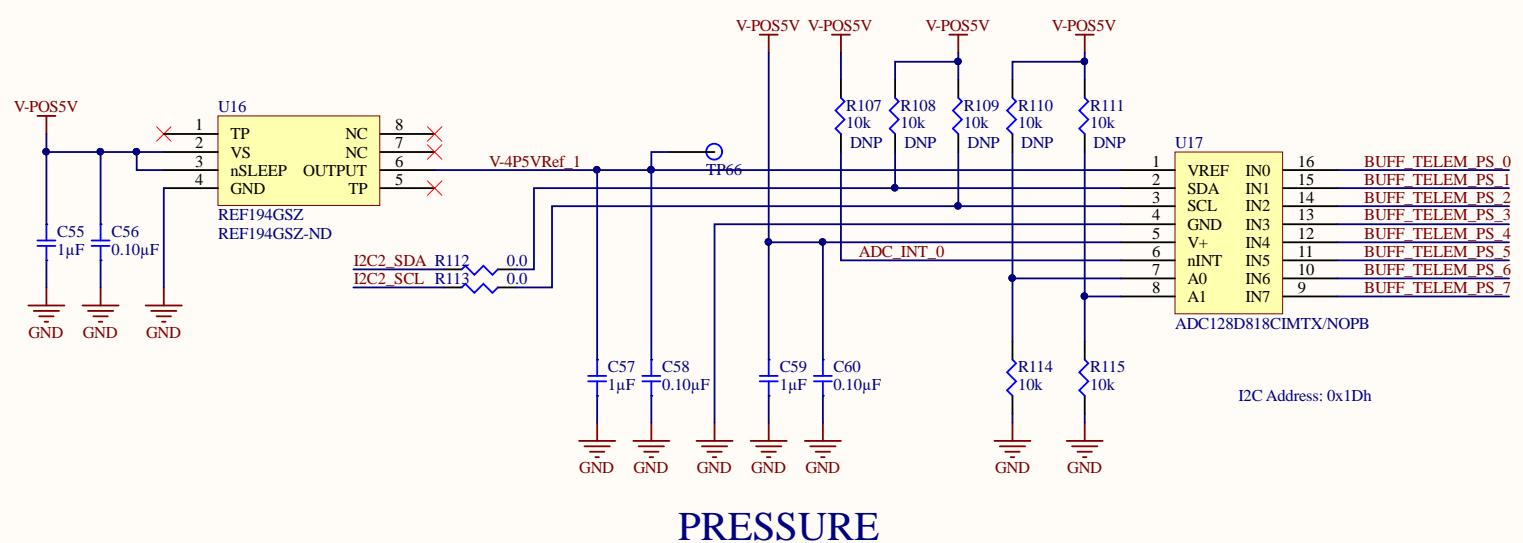
D

A

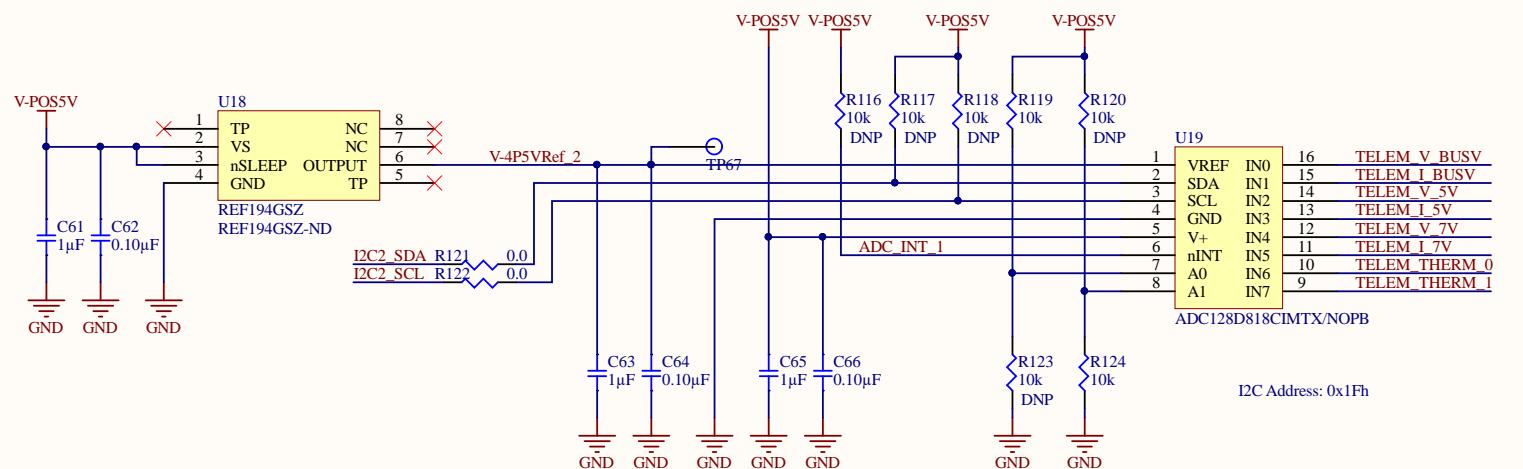
B

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PRESSURE



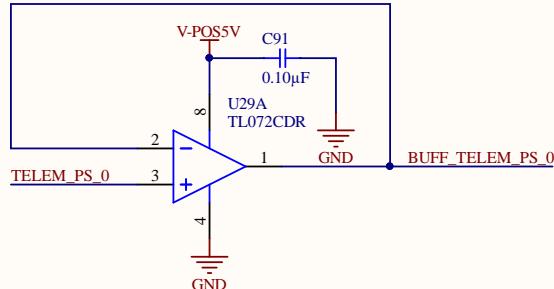
RAIL AND TEMPERATURE

Title ADC		Badgerloop Electrical 133 Engineering Research Building 1500 Engineering Drive Madison, Wi 53706
Engineer:	Revision:	
Date: 6/26/2020	Time: 5:54:29 PM	Sheet of
File: telemetry_adc.SchDoc		BADGER LOOP

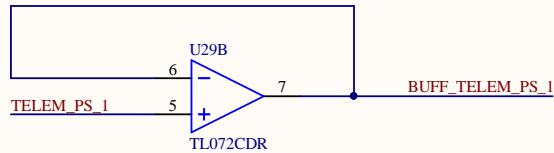
1 2 3 4

Analog Unity Gain Buffers

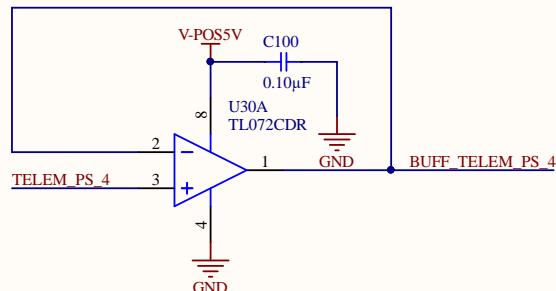
A



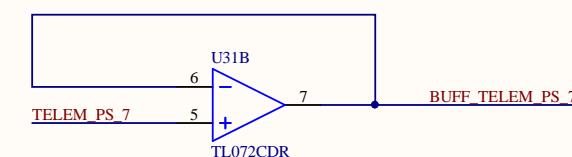
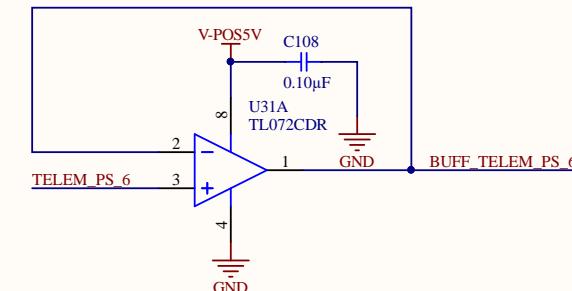
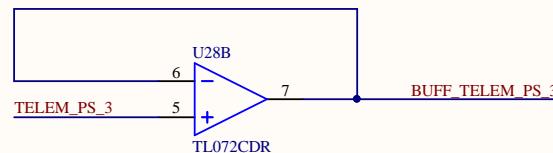
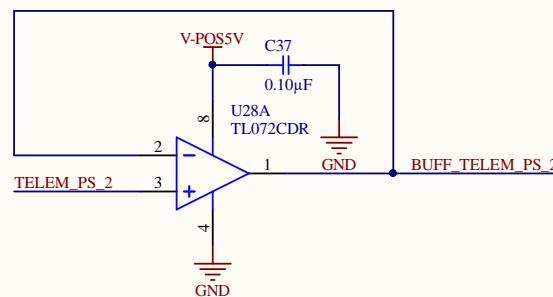
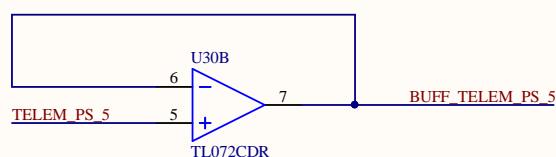
B



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Title Unity Gain Buffer			<i>Badgerloop</i> 133 Engineering Research Building Madison, WI 53715	BADGER LOOP
Size: A4	Number:	Revision:		
Date: 6/26/2020	Time: 5:54:29 PM	Sheet of		
File: C:\Users\Windows PC\Desktop\Badgerloop\git_repos\hardware\braking_io\unity_gain_buffer.SchDoc				

A

A

B

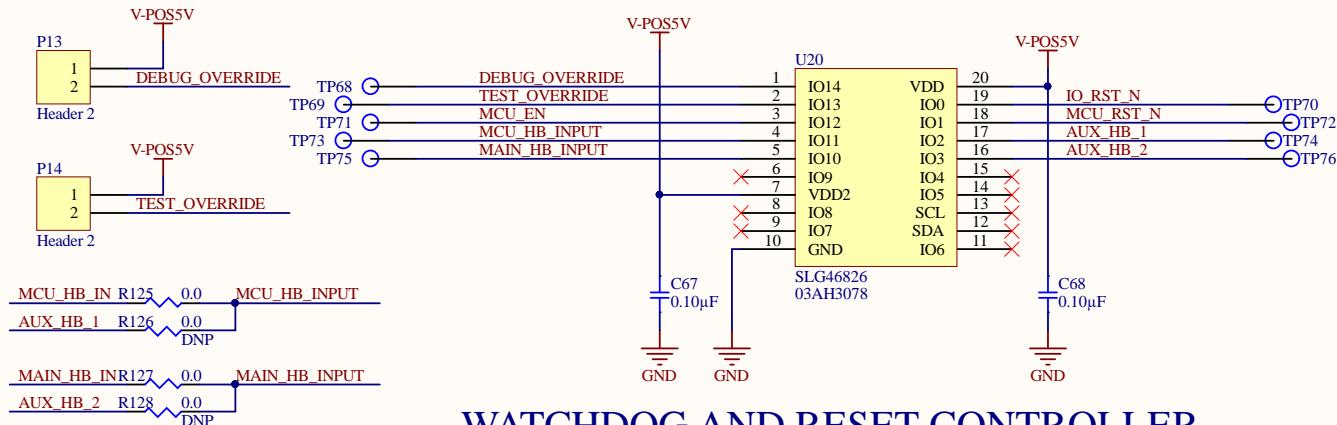
B

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D



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 recirculated to mimic heartbeat

Populate Jumper 2

Operation: U7 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
Engineer:		133 Engineering Research Building
Date: 6/26/2020 Time: 5:54:29 PM		1500 Engineering Drive
File: watchdog.SchDoc		Madison, Wi 53706

BADGER
LOOP

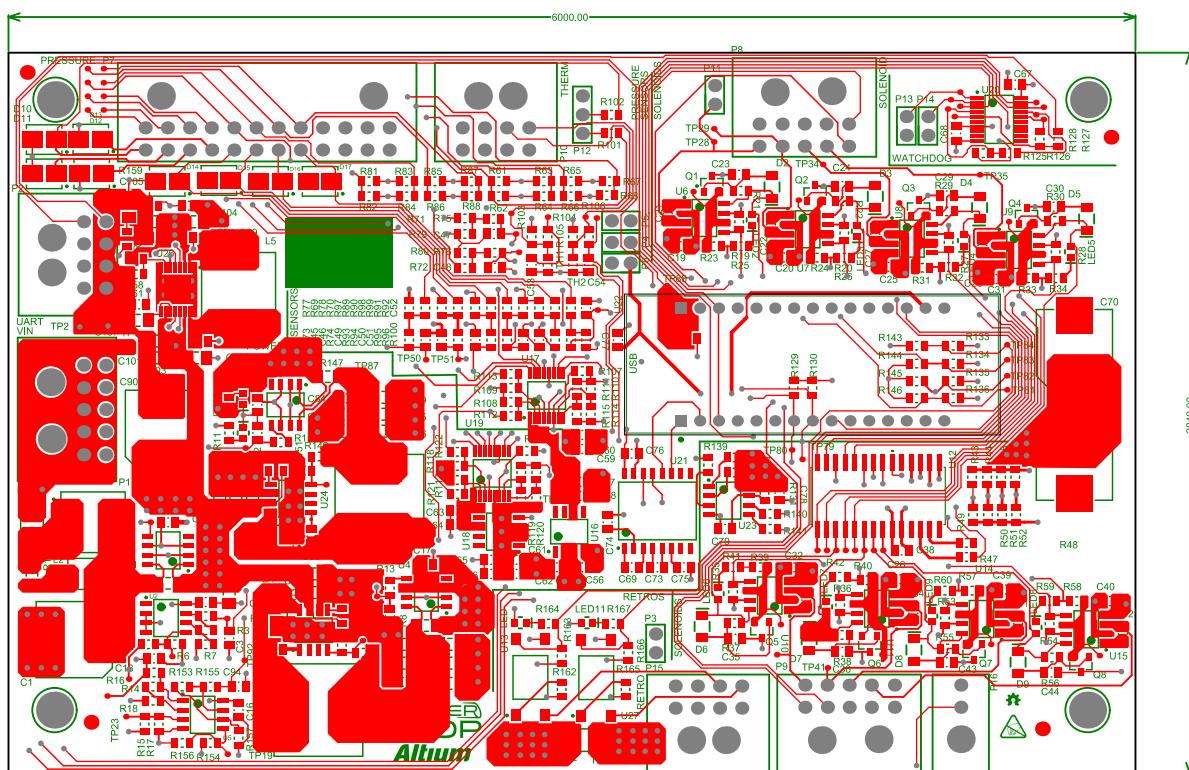
A

A

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				

B

B



C

C

**BADGER
LOOP**

Badgerloop
ERB Room 133
1400 Engineering Drive
Madison, WI 53706

ENGINEER: RCastle, BTobin,
JESlinger,
SRiggleman

PCB DESIGNER:
RCastle, BTobin

DATE:
6/26/2020

FILE NAME:
braking_io.PcbDoc

TITLE:
braking_io.PcbDoc

PART NO:
Braking Input Output Controller

REV:
A

SCALE:
1:1

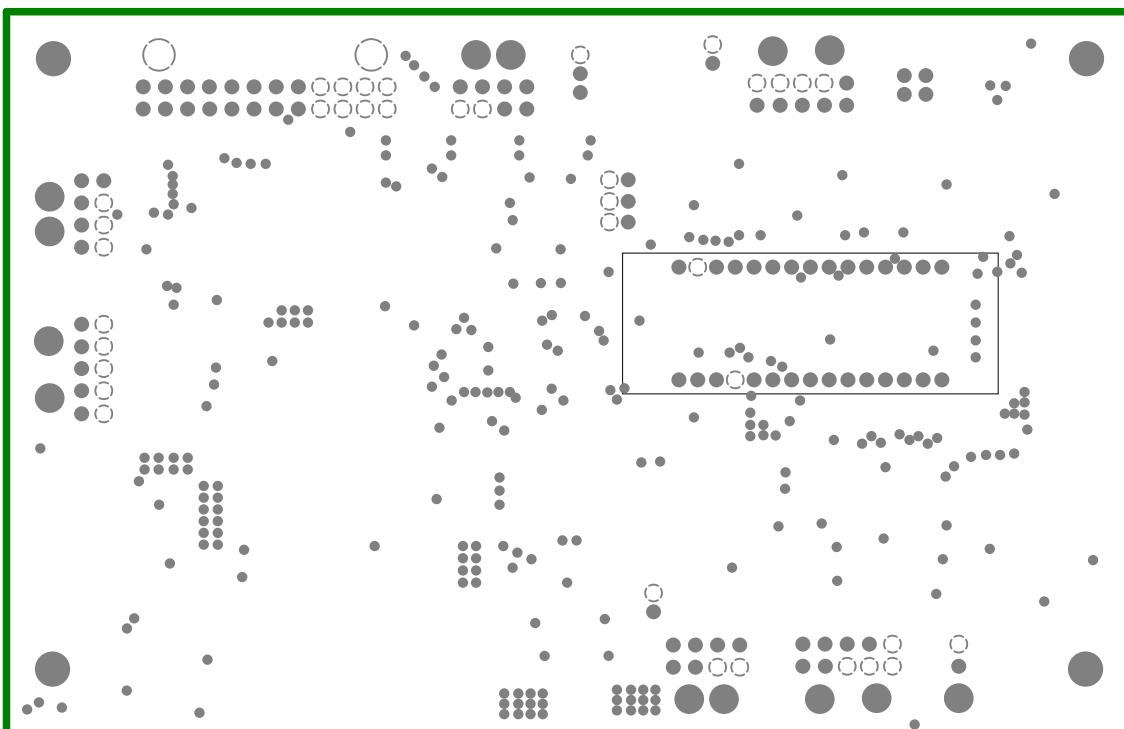
A

A

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	PHR	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				

B

B



C

C

**BADGER
LOOP**
Badgerloop
ERB Room 133
1400 Engineering Drive
Madison, WI 53706

ENGINEER: RCastle, BTobin,
JESlinger,
SRiggleman

PCB DESIGNER:
RCastle, BTobin

DATE:
6/26/2020

FILE NAME:
braking_io.PcbDoc

TITLE:
braking_io.PcbDoc

PART NO:
Braking Input Output Controller

REV:
A

SCALE:
1:1

A

A

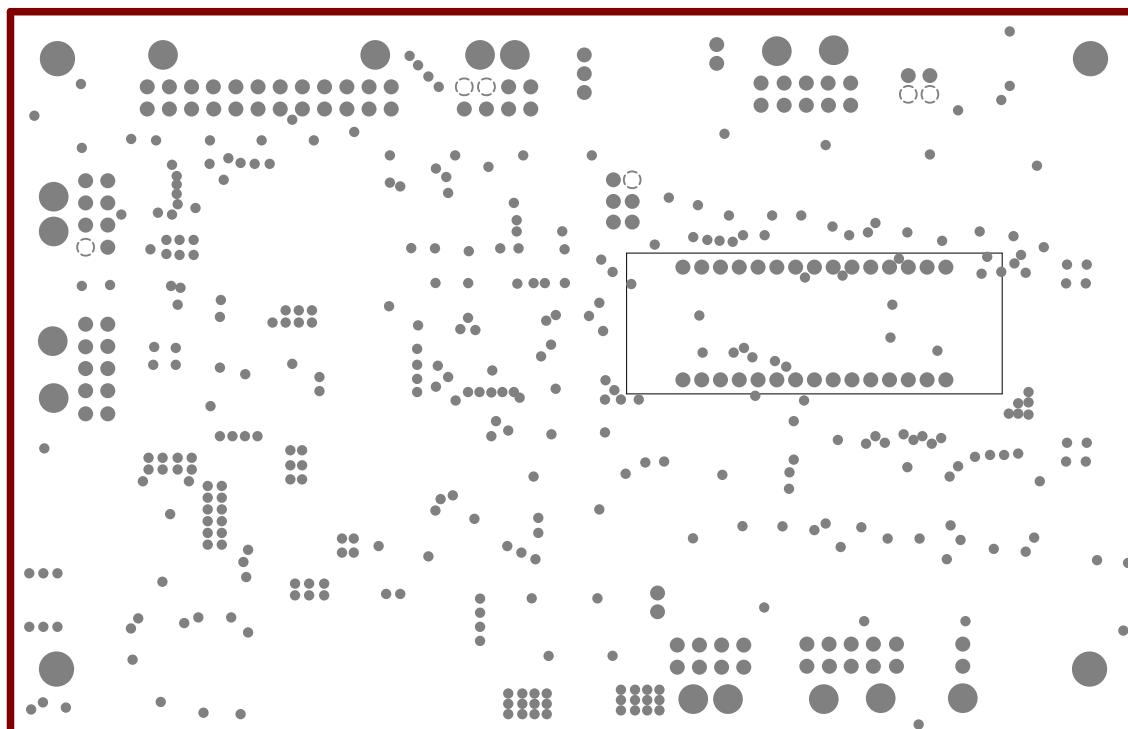
B

B

C

C

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	
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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

PCB DESIGNER:
RCastle, BTobin

DATE:
6/26/2020

FILE NAME:
braking_io.PcbDoc

TITLE:
braking_io.PcbDoc

PART NO:
Braking Input Output Controller

REV:
A

SCALE:
1:1

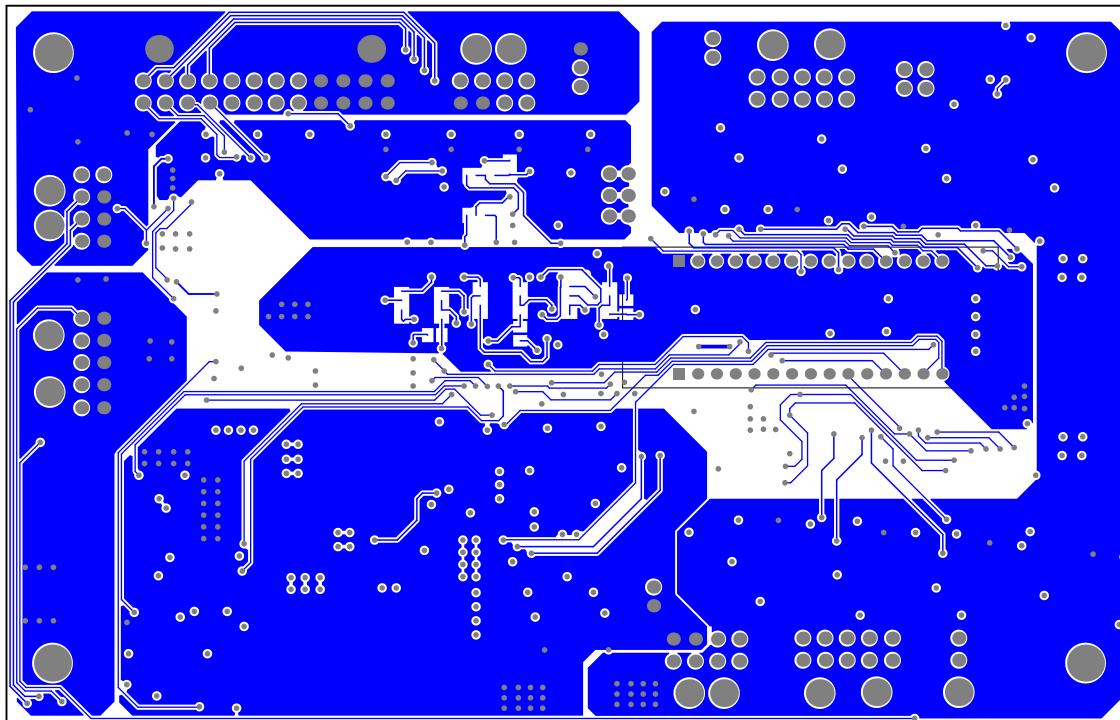
A

A

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				

B

B



C

C

**BADGER
LOOP**

Badgerloop
ERB Room 133
1400 Engineering Drive
Madison, WI 53706

ENGINEER: RCastle, BTobin,
JESlinger,
SRiggleman

PCB DESIGNER:
RCastle, BTobin

DATE:
6/26/2020

FILE NAME:
braking_io.PcbDoc

TITLE:
braking_io.PcbDoc

PART NO:
Braking Input Output Controller

REV:
A

SCALE:
1:1

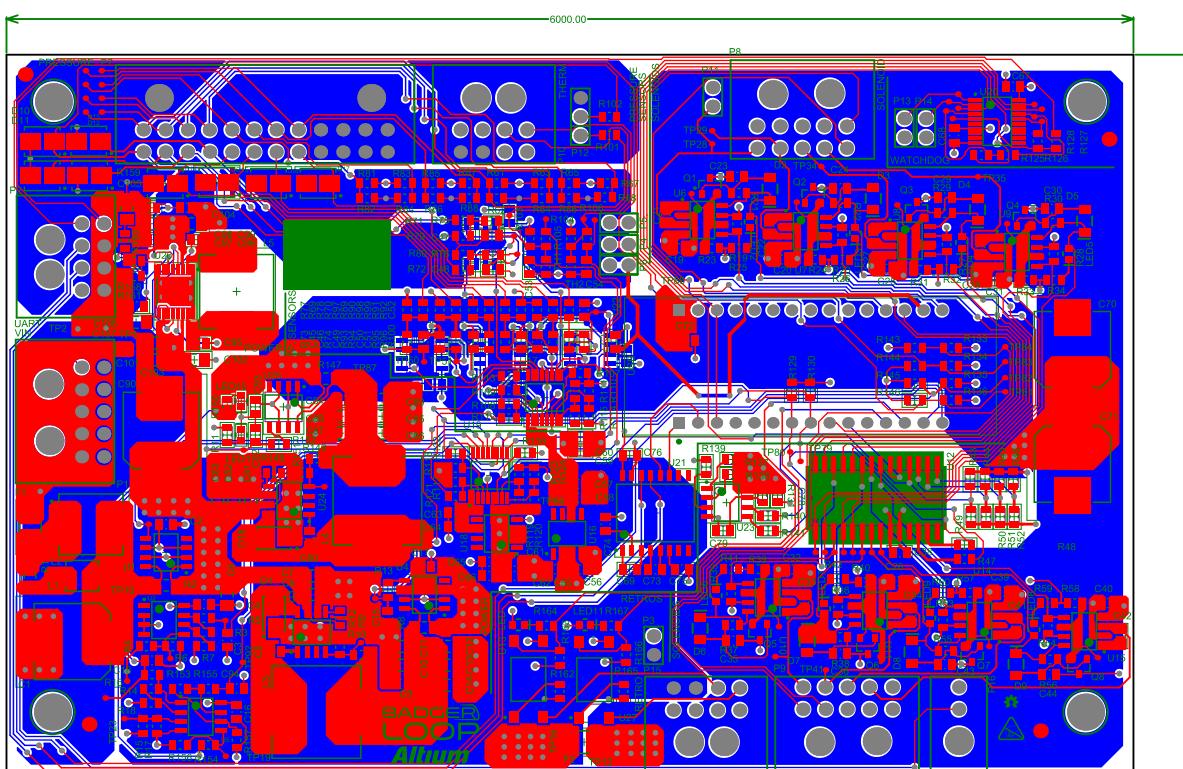
A

A

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				

B

B



C

C

**BADGER
LOOP**

Badgerloop
ERB Room 133
1400 Engineering Drive
Madison, WI 53706

ENGINEER: RCastle, BTobin,
JESlinger,
SRiggleman

PCB DESIGNER:
RCastle, BTobin

DATE:
6/26/2020

FILE NAME:
braking_io.PcbDoc

TITLE:
braking_io.PcbDoc

PART NO:
Braking Input Output Controller

REV:
A

DWG NO:
SCALE:
1:1