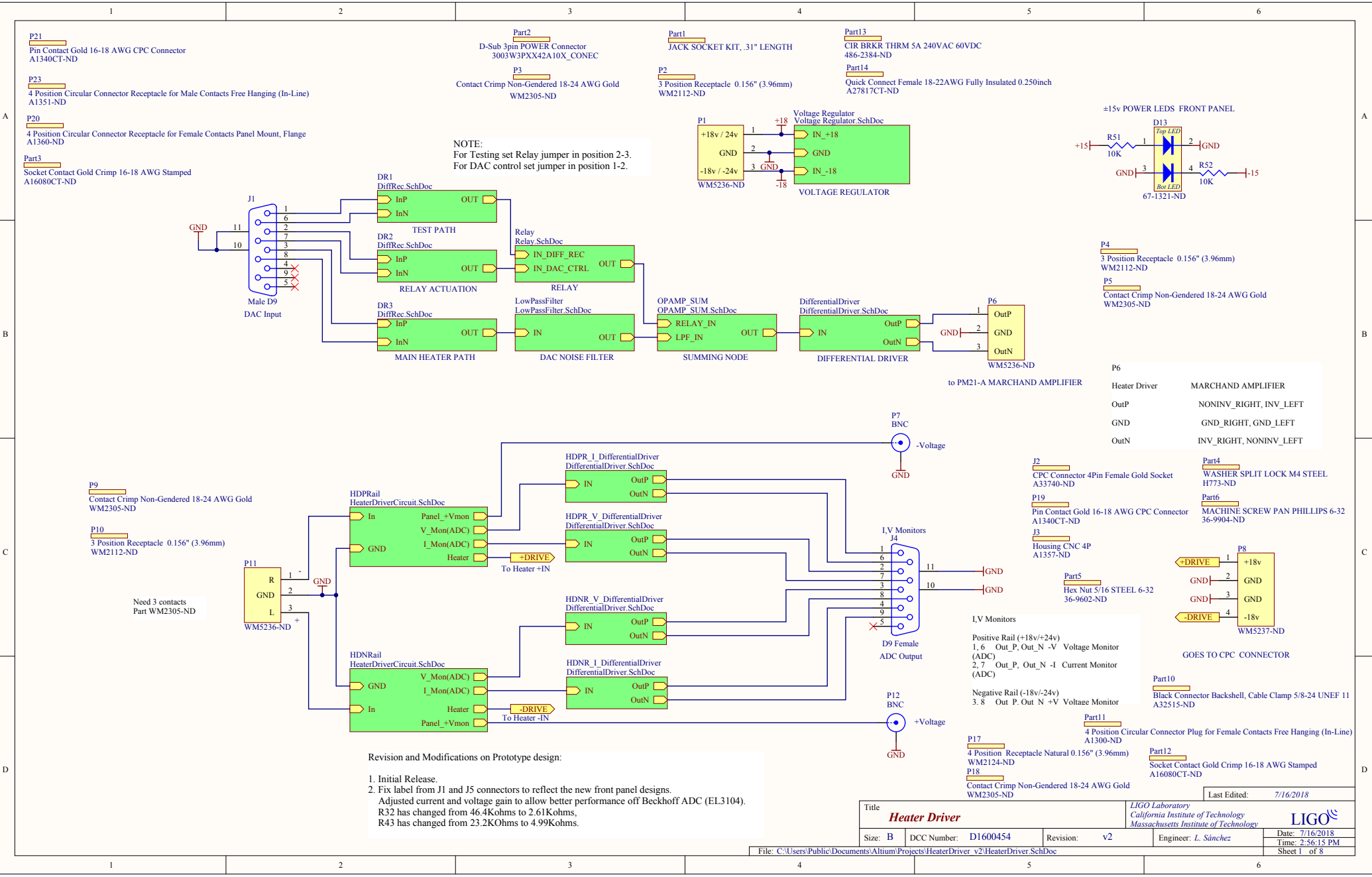




Revision and Modifications on Prototype design:

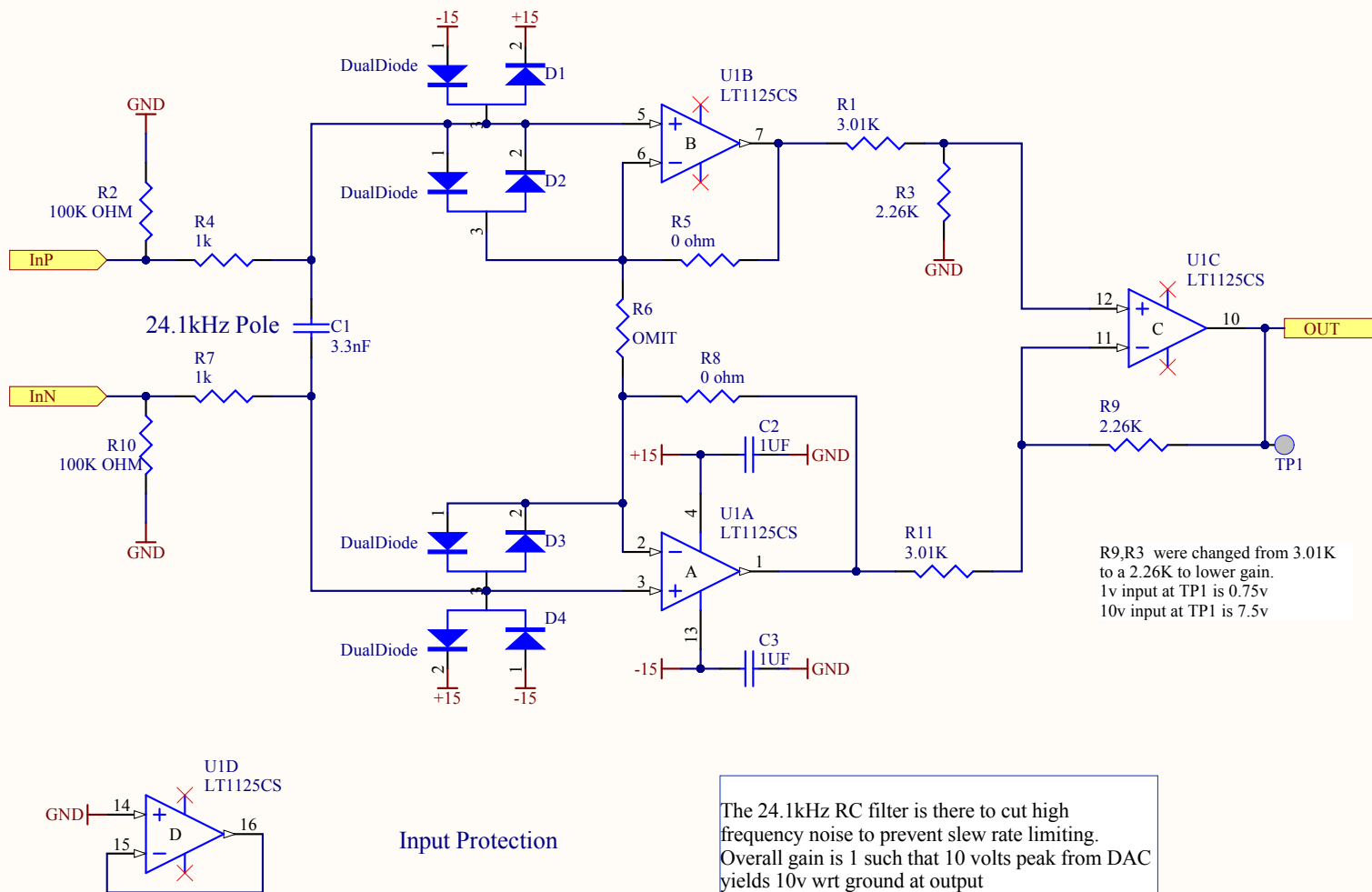
1. Initial Release.
2. Fix label from J1 and J5 connectors to reflect the new front panel designs.
- Adjusted current and voltage gain to allow better performance off Beckhoff ADC (EL3104).
- R32 has changed from 46.4Kohms to 2.61Kohms,
- R43 has changed from 23.2Kohms to 4.99Kohms.

Title Heater Driver		LIGO Laboratory California Institute of Technology Massachusetts Institute of Technology		Last Edited: 7/16/2018	
Size: B	DCC Number: D1600454	Revision: v2	Engineer: L. Sanchez	Date: 7/16/2018	Time: 2:56:15 PM
File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver_v2\HeaterDriver.SchDoc				Sheet 1 of 8	

Overall Gain = 1 from InP-InN to Out

Ex. 10V battery across input = 7.5V from Out to GND

Input Protection



Input Protection

Last Edited: 7/16/2018

Title
Differential Receiver

LIGO Laboratory
California Institute of Technology
Massachusetts Institute of Technology

LIGO

Size: A DCC Number: D1600454

Revision: v2

Engineer: L. Sanchez

Date: 7/16/2018
Time: 2:56:15 PM
Sheet 2 of 8

File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver v2\DiffRec.SchDoc

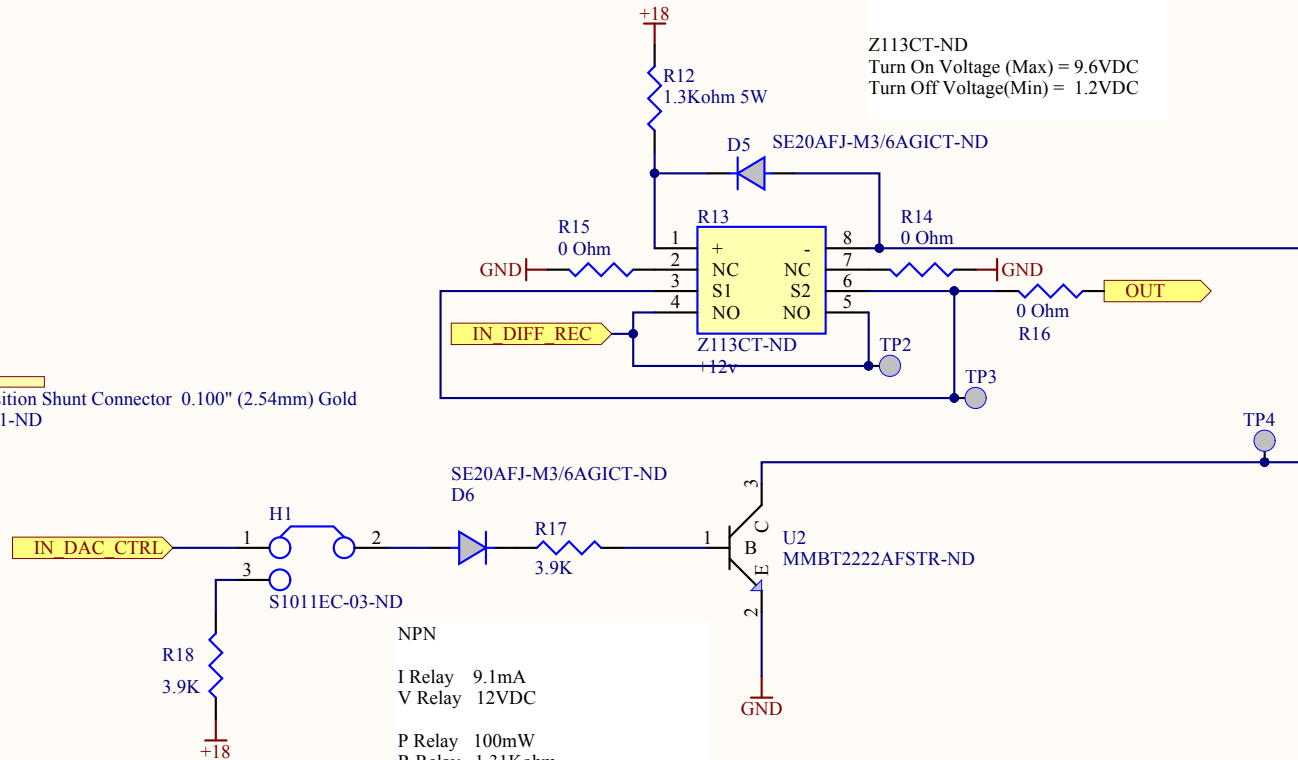
$V_{in} = +18V$
 $R_{Coil} = 1.31K\Omega$

@12V
 $R_{12} = ((R_{Coil} * V_{in}) / 12V) - R_{Coil}$
 $R_{12} = 655\Omega$

@9V
 $R_{12} = ((R_{Coil} * V_{in}) / 9V) - R_{Coil}$
 $R_{12} = 1310\Omega$

Z113CT-ND
 Turn On Voltage (Max) = 9.6VDC
 Turn Off Voltage (Min) = 1.2VDC

Part7
 2 Position Shunt Connector 0.100" (2.54mm) Gold
 S9001-ND



Relay Testing

Place a jumper between pin 1 and 2 at header H1 for DAC Ctrl.
 For testing set a jumper between pin 2 and 3.

NPN
 $I_{Relay} = 9.1mA$
 $V_{Relay} = 12VDC$
 $P_{Relay} = 100mW$
 $R_{Relay} = 1.31K\Omega$
 $10V - V_{diode} - V_{be} = 8.9V$
 $\beta_{transistor} = 100$
 $I_b = I_c / \beta = 0.0091 / 100$
 $R_{17} = 8.9V / 0.000091 = 97.8K\Omega$
 with a 3.9K at R17
 $I_{R17} = 8.9V / 3.9K = 2.28mA$

Last Edited: 7/16/2018

Title

Relay

LIGO Laboratory
 California Institute of Technology
 Massachusetts Institute of Technology

LIGO

Size: A

DCC Number: D1600454

Revision: v2

Engineer: L. Sánchez

Date: 7/16/2018

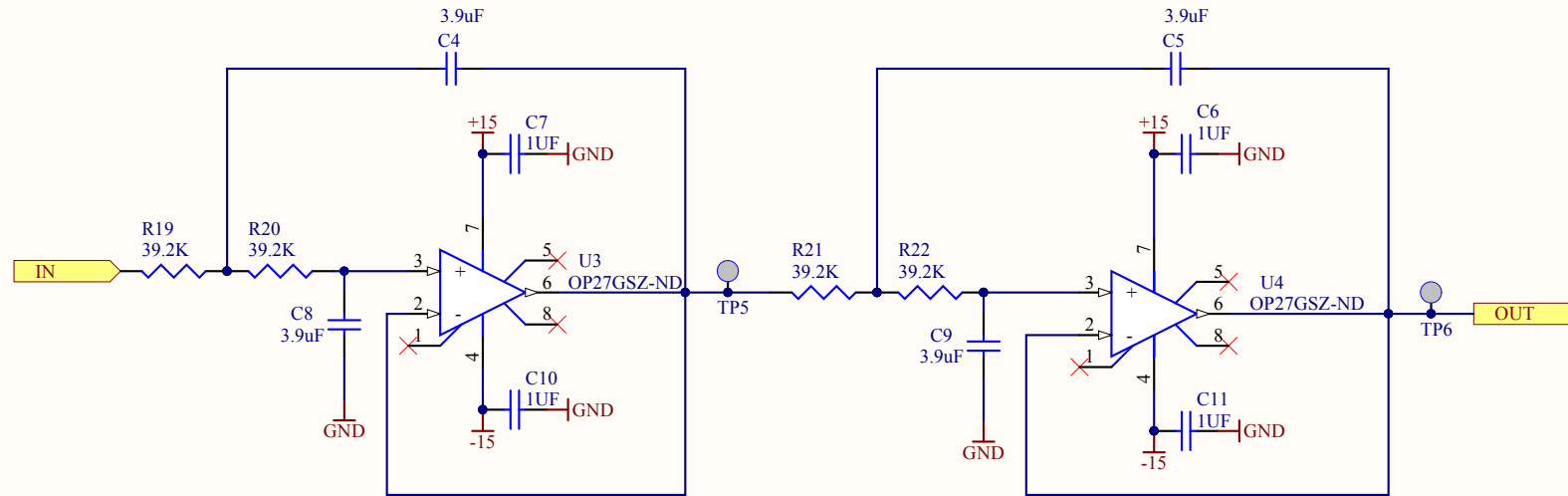
Time: 2:56:15 PM

Sheet 3 of 8

File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver_v2\Relay.SchDoc

1Hz LPF Stage 1

1Hz LPF Stage 2



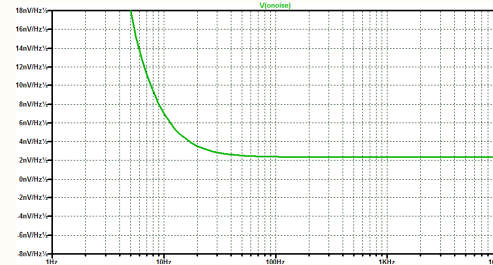
R1=R2, C1=C2

OUTPUT VOLT NOISE			
	SINE(5v,1KHz) @ TP6	DAC NOISE(300nV/√Hz) @ TP6	
@10Hz			
3.9μF 39.2K	7.007nV/√Hz	7.007nV/√Hz	
@30Hz			
3.9μF 39.2K	2.817nV/√Hz	2.817nV/√Hz	
@60Hz			
3.9μF 39.2K	2.42nV/√Hz	2.425nV/√Hz	
@100Hz			
3.9μF 39.2K	2.35nV/√Hz	2.35nV/√Hz	

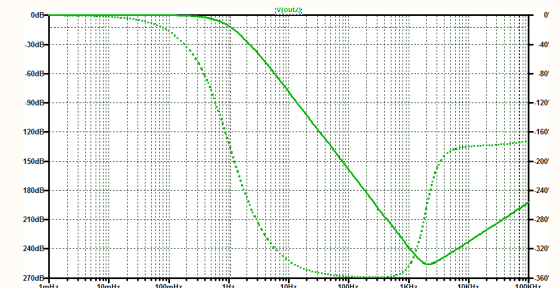
fc= 1.04107Hz

Pole(s)
|p| = 1.04107Hz

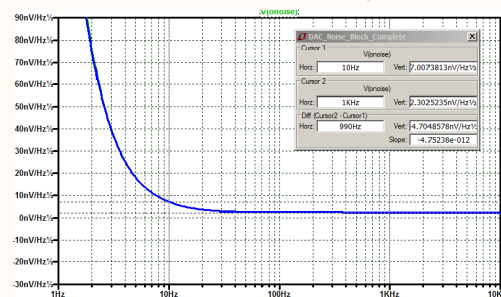
Volt Noise at TP6 from a sin signal



Filter transfer function



Volt Noise at TP6 from a DAC signal



Last Edited: 7/16/2018

Title
Low Pass Filter

LIGO Laboratory
California Institute of Technology
Massachusetts Institute of Technology

LIGO

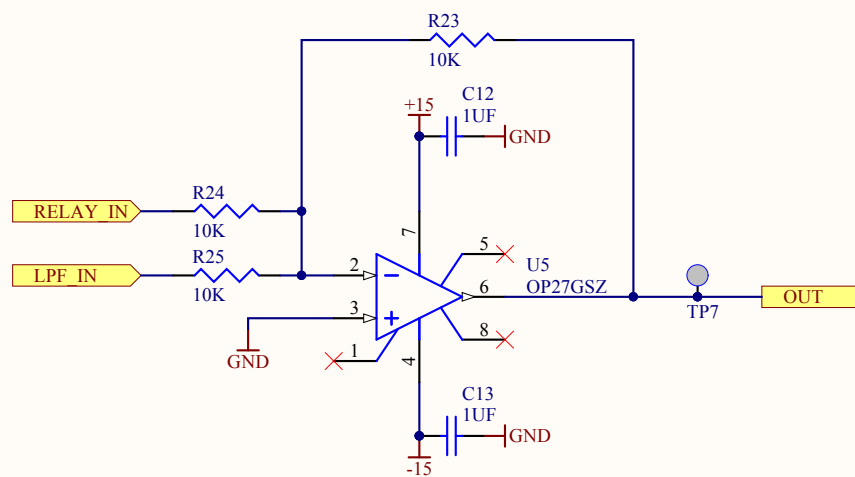
Size: A DCC Number: D1600454

Revision: v2

Engineer: L.Sánchez

Date: 7/16/2018
Time: 2:56:15 PM
Sheet 4 of 8

File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver v2\LowPassFilter.SchDoc



Last Edited: 7/16/2018

Title
OP AMP SUM

LIGO Laboratory
California Institute of Technology
Massachusetts Institute of Technology

LIGO

Size: A

DCC Number: D1600454

Revision: v2

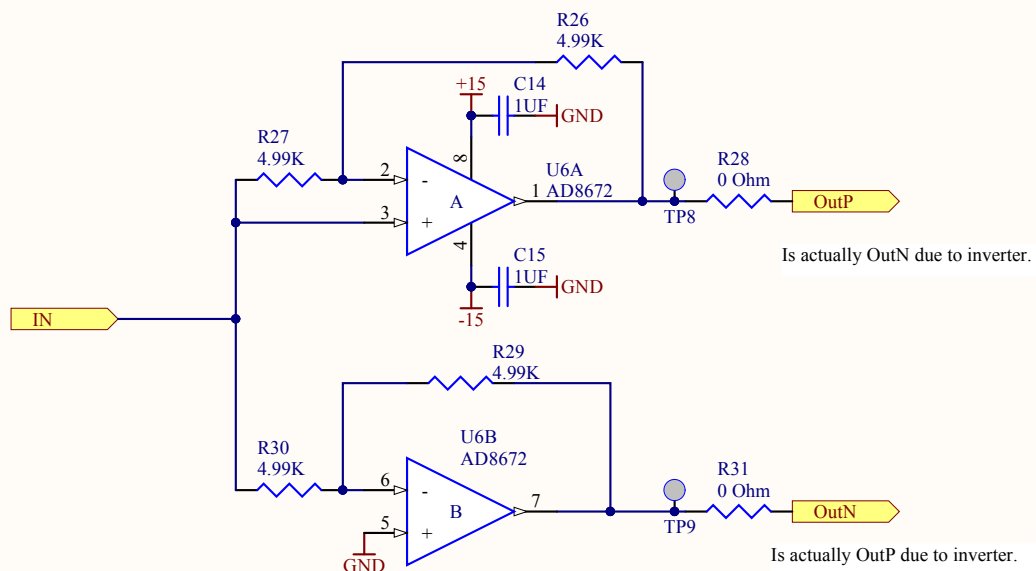
Engineer: L.Sánchez

Date: 7/16/2018

Time: 2:56:15 PM

Sheet 5 of 8

File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver v2\OPAMP_SUM.SchDoc



Typical LIGO differential driver circuit for the monitor signals.

Last Edited: 7/16/2018

Title
Differential Driver

LIGO Laboratory
California Institute of Technology
Massachusetts Institute of Technology

LIGO

Size: A DCC Number: D1600454

Revision: v2

Engineer: L.Sanchez

Date: 7/16/2018
Time: 2:56:15 PM
Sheet 6 of 8

File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver v2\DifferentialDriver.SchDoc

Differential Amplifier

AD620

Gain:

$$G = (49.4K\Omega / R_G) + 1$$

$$R_G = 49.4K\Omega / (G - 1)$$

Gain	RG(Ohms)	Gain	RG(ohms)
20	2.6K	19.92	2.61K
10	5.49K		
5	12.35K		
2	49.4K		

TP11	TP12	TP10	DAC	Load(mA)
±14.5v ±3v	±4.8v ±0.96v	±7.5v ±0.775v	5v 1v	0.40 0.08

F1
F1222CT-ND
1 AMP

F2
F1222CT-ND
1 AMP

F3
F1222CT-ND
1 AMP

OUTPUT VOLT NOISE

@10Hz
1.58K 23.2K 10μF 6.8nF @ TP12
24.98nV/√Hz

@30Hz
1.58K 23.2K 10μF 6.8nF 20.40nV/√Hz

@60Hz
1.58K 23.2K 10μF 6.8nF 19.21nV/√Hz

@100Hz
1.58K 23.2K 10μF 6.8nF 18.715nV/√Hz

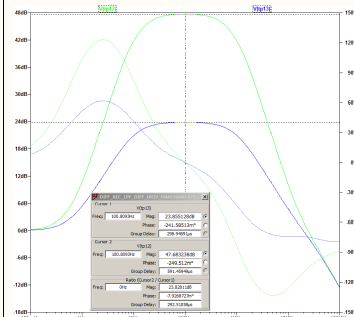
Pole (s) Zero(s)

|p1|=10.05Hz |z1|=0.6Hz

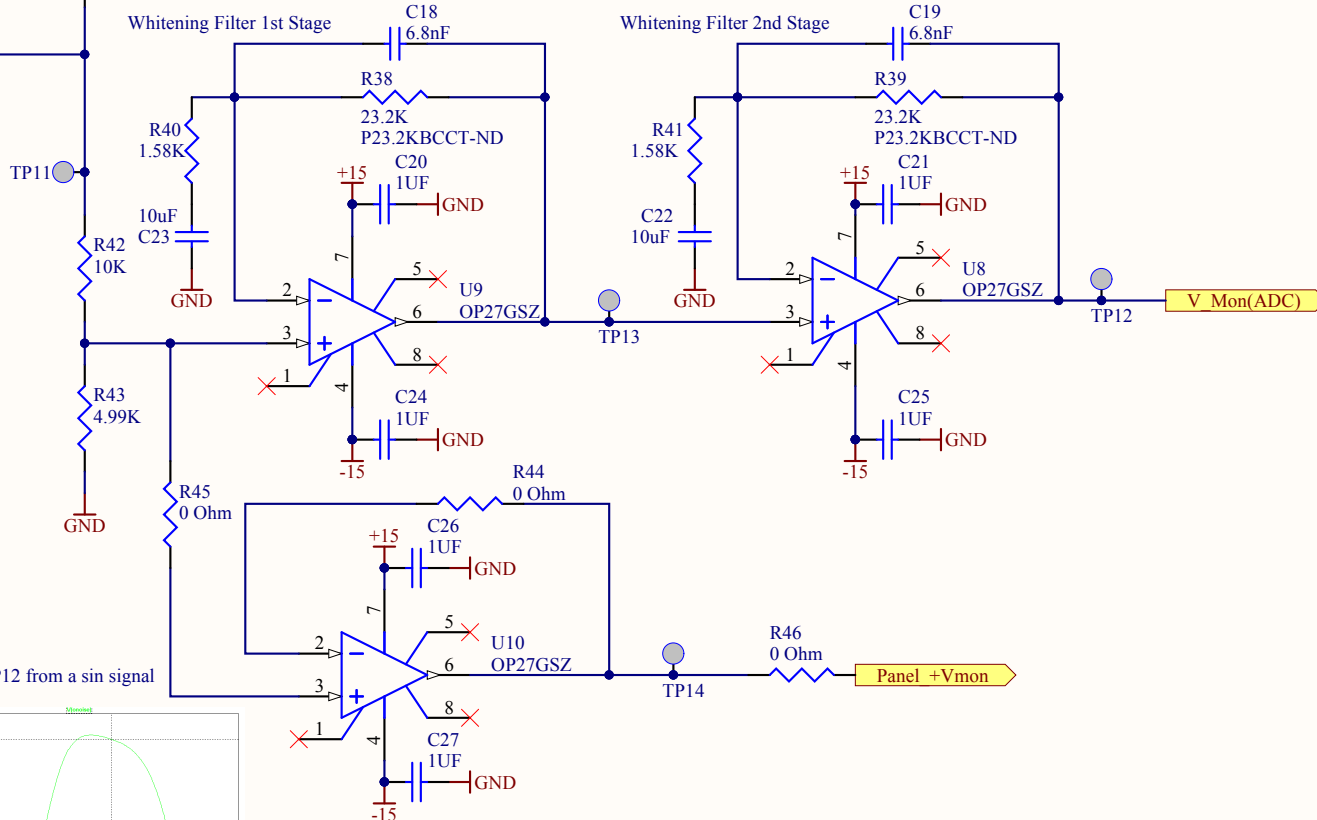
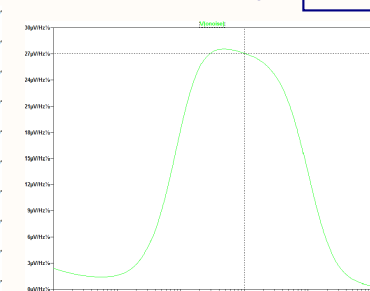
|p2|=1.007KHz |z2|=15.8KHz

R42 = 10K R43 = 4.99K
DC gain = 0.3333 = 1/3

Transfer Function Whitening Filter



Volt Noise at TP12 from a sin signal



Last Edited: 7/16/2018

Title

Heater Driver Circuit

LIGO Laboratory
California Institute of Technology
Massachusetts Institute of Technology

LIGO

Size: A

DCC Number: D1600454

Revision: v2

Engineer: L. Sánchez

Date: 7/16/2018
Time: 2:56:15 PM
Sheet 7 of 8

File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver v2\HeaterDriverCircuit.SchDoc

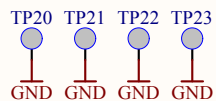
1

2

3

4

P_LED12

LED GREEN 1/4" HOLE PANEL MOUNT
L10005-ND

P_LED13

LED GREEN 1/4" HOLE PANEL MOUNT
L10005-NDD10 protects againsts C44 (input shorts)
D9 protects againsts C43 (output shorts)

$$-V_{out} = 1.25v (1 + R_{56} / R_{57}) + R_{56} * (-I_{adj})$$

$$I_{adj} = 50E-6Amp$$

D7 protects againsts C40 (input shorts)
D8 protects againsts C42 (output shorts)

$$V_{out} = 1.25v (1 + R_{55} / R_{54}) + R_{55} * I_{adj}$$

$$I_{adj} = 50E-6Amp$$

P_PIN11

CONN SOCKET 18-24AWG SL156 GOLD
A24208CT-ND

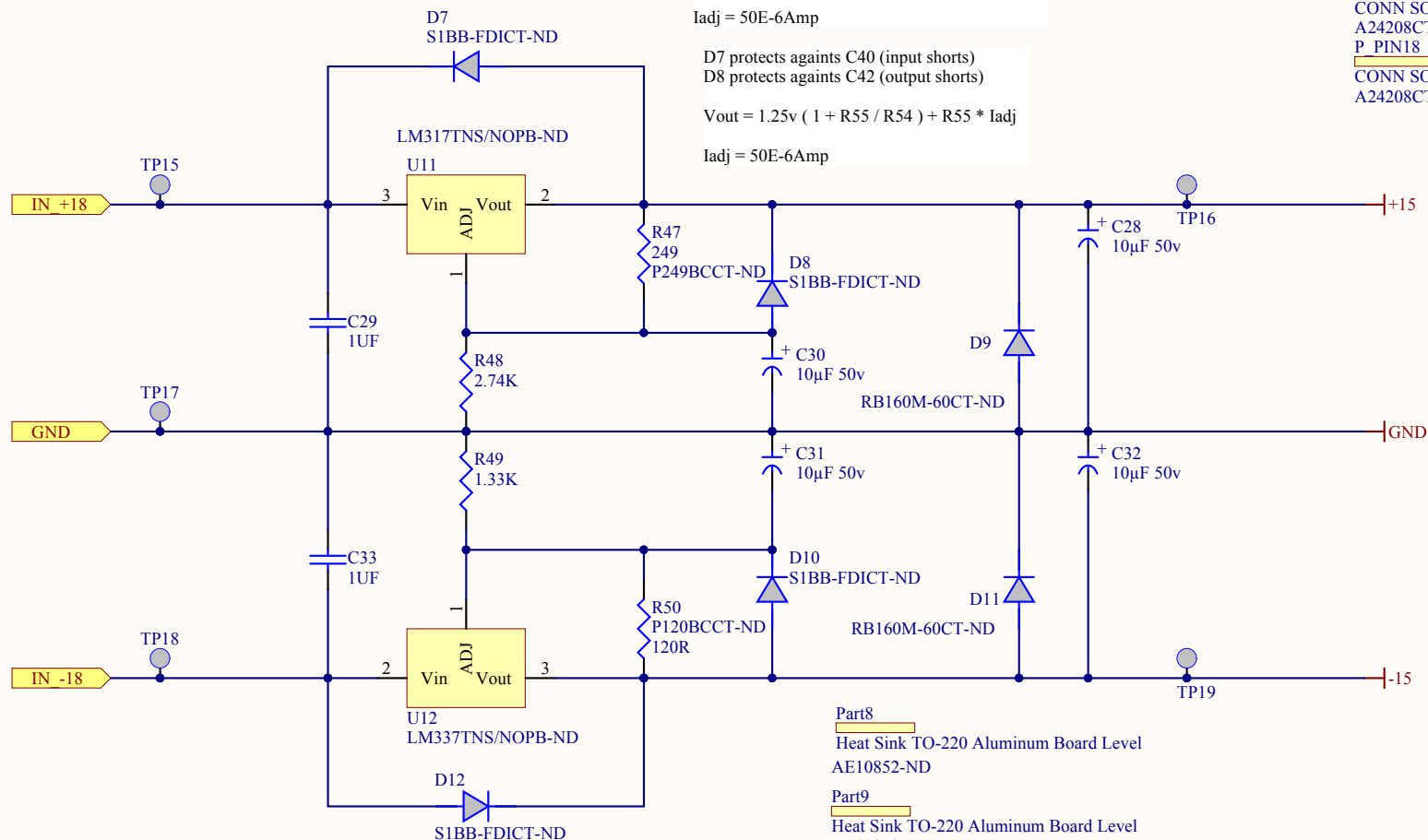
P_PIN14

CONN SOCKET 18-24AWG SL156 GOLD
A24208CT-ND

P_PIN17

CONN SOCKET 18-24AWG SL156 GOLD
A24208CT-ND

P_PIN18

CONN SOCKET 18-24AWG SL156 GOLD
A24208CT-ND

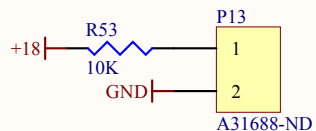
Part8

Heat Sink TO-220 Aluminum Board Level
AE10852-ND

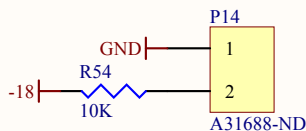
Part9

Heat Sink TO-220 Aluminum Board Level
AE10852-ND

±18v POWER LEDS REAR PANEL



P15

2 Position Receptacle 0.156" (3.96mm)
A24111-ND

P16

2 Position Receptacle 0.156" (3.96mm)
A24111-ND

Last Edited: 7/16/2018

Title

Voltage RegulatorLIGO Laboratory
California Institute of Technology
Massachusetts Institute of Technology

LIGO

Size: A

DCC Number: D1600454

Revision: v2

Engineer: L.Sánchez

Date: 7/16/2018

Time: 2:56:15 PM

Sheet 8 of 8

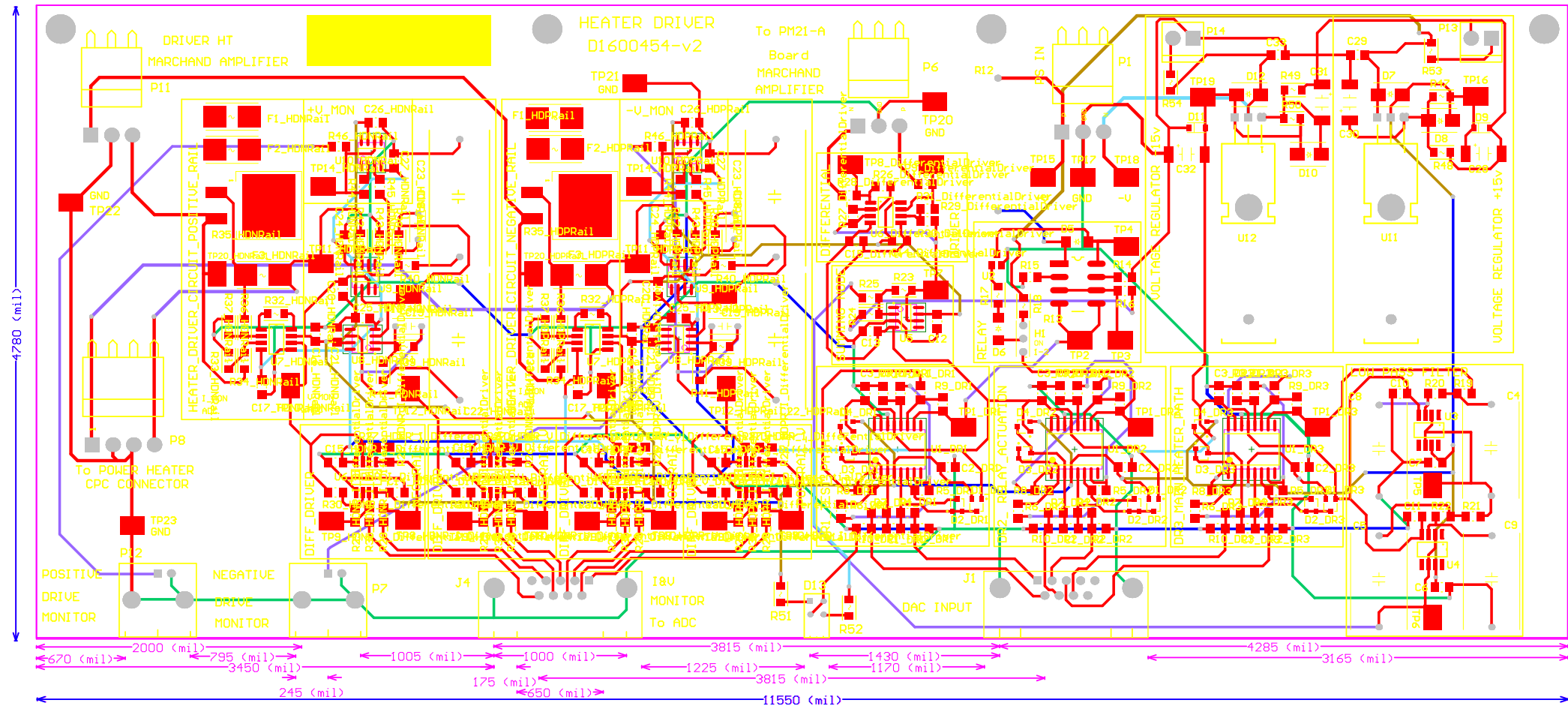
File: C:\Users\Public\Documents\Altium\Projects\HeaterDriver v2\Voltage Regulator.SchDoc

1

2

3

4



100