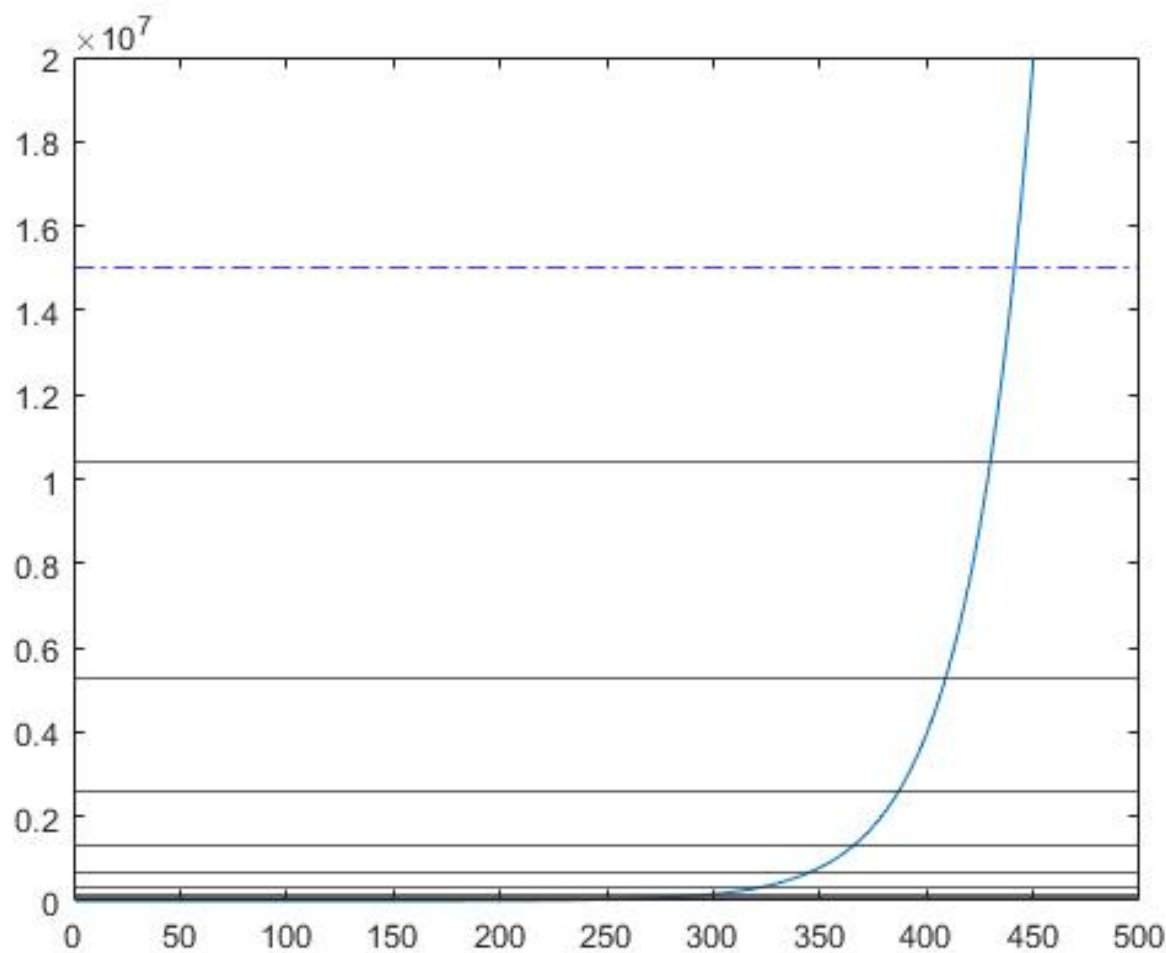


IMPEDANCE MATCH DOCUMENTATION



octave		
19.7055780	161590.8753896	328877.4285826
2	15	16
40.1057288	2587.1740786	648071.9826312
3	9	17
79.0306568	5098.1760644	1318986.8961987
4	10	18
160.8469483	10376.0501977	2599139.9183829
5	11	19
316.9582089	20446.6066658	5289893.0760982
6	12	20
645.0884089	41613.9055332	10424040.0702156
7	13	21
1271.1839969	82002.6061993	21215501.7136245
8	14	22

```
numfreq = 500;
y = logspace(1,8,numfreq);
stopFreq = y(numfreq);
startFreq = y(1);
a = double(startFreq);
c = 1;
figure(4);
plot(y);
xlim([0 numfreq]);
ylim([0 20000000]);
yline(15*10^6, '-.b');

while a <= 15000000

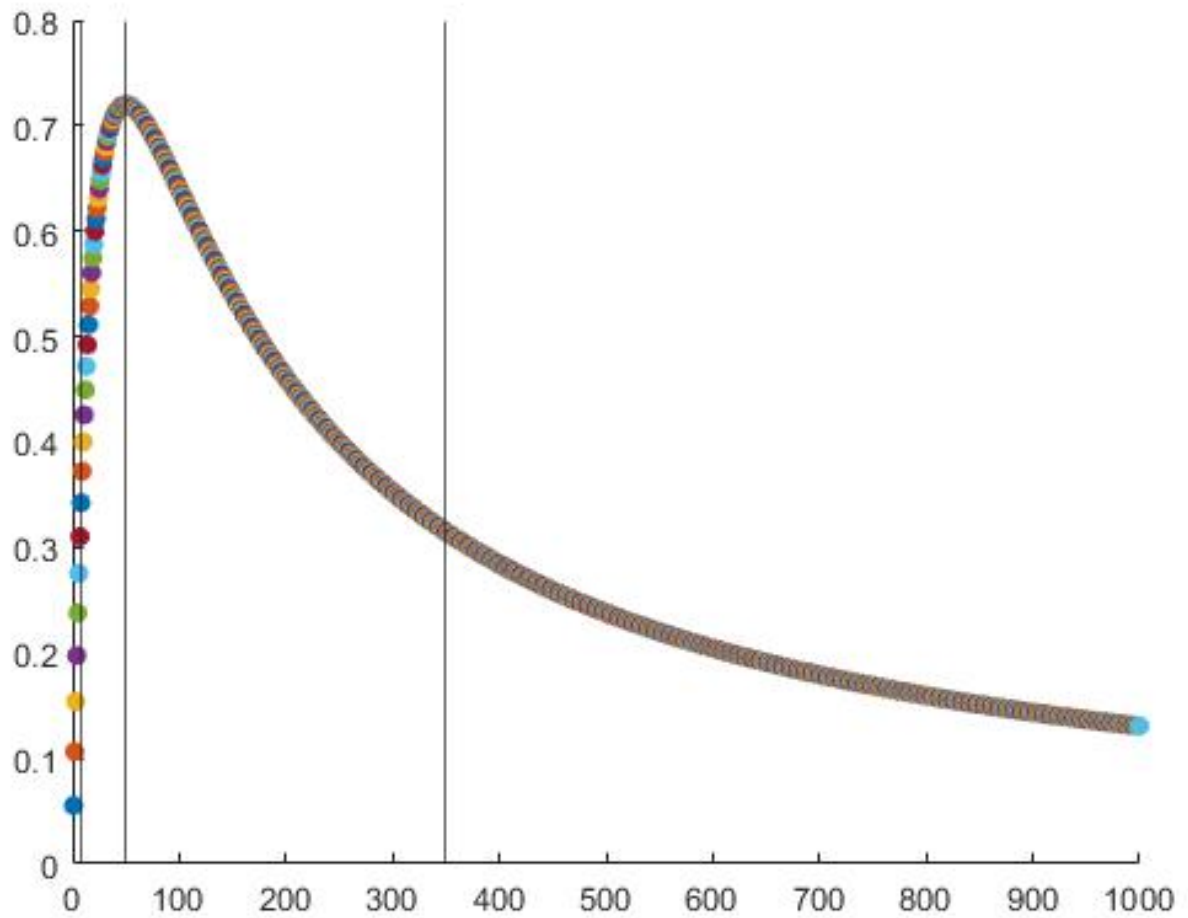
a = a*2;
[val,idx]=min(abs(y-a));
minVal=y(idx);

fprintf('%.7f\n',minVal)

yline(minVal);

c = c+1;
disp(c);

end
```

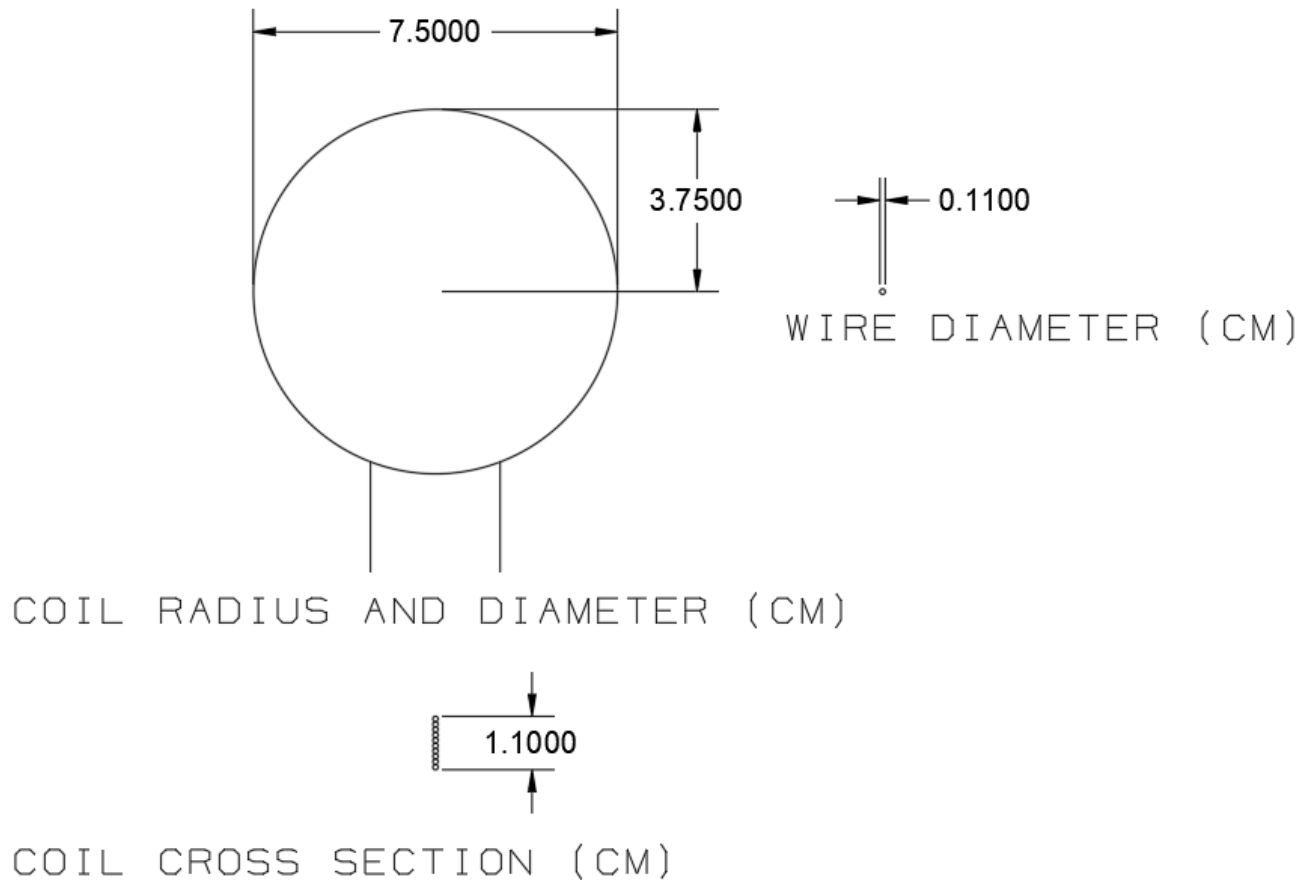


```

Vs = 12;
Zs = 50;
Zl = 0;
PL = 0;
figure(2);
scatter(Zl,PL,'filled');
x = [];
for c = 1:1000
    Zl = Zl+1;
    PL = (((Vs)/(Zs+Zl))^2)*Zl;
    disp(PL);
    scatter(Zl,PL,'filled');
    hold on
    x = [x, PL];
end
xline(50);
xline(7);
xline(350);
[M,I] = max(x)

```

Calculations



Final Coil Inductance: 50.469 uH

Transformer 1

Boundaries:	~%43.75	----	%100	----	~%43.75
Primary Impedance:	7Ω		50Ω		350Ω
Transformer 1 Frequency Range:	160.84Hz		1277.17Hz		5.098Khz

Inductor Impedance Formula: $X_L = 2\pi fL$

f = frequency

L = Coil Inductance

Coil Impedance at 160.84 Hz: $2\pi(160.84)(50.469 \times 10^{-6}) = .05097748\Omega$

Impedance Matching Formula: (Primary Turns/Secondary Turns) = $\sqrt{\text{Primary Impedance/Secondary Impedance}}$

$(100/\text{Secondary Turns}) = \sqrt{7\Omega / .05097748\Omega}$

Secondary Turns: 9

Final Turn Ratio 100:9

$(100/90) = \sqrt{50\Omega / \text{Secondary Impedance}}$
 Secondary Impedance: 2.853
 Coil Frequency at Specific Impedance: $0.405 = 2\pi f(50.469 \times 10^{-6})$
 Coil Frequency at Specific Impedance: 1277.17Hz

$(100/90) = \sqrt{350\Omega / \text{Secondary Impedance}}$
 Secondary Impedance: 2.835
 Coil Frequency at Specific Impedance: $2.835 = 2\pi f(50.469 \times 10^{-6})$
 Coil Frequency at Specific Impedance: 8.94 Khz

Normalized based on octave allocations: 5.098 Khz
 Secondary Impedance at 5.098 Khz: 1.61578Ω
 Primary Impedance at 5.098Khz: 199.469
 Power Transfer at Primary Impedance: 64%

Transformer 2

Boundaries:	~%43.75	----	%100	----	~%43.75
Primary Impedance:	7Ω		50Ω		350Ω
Transformer 1 Frequency Range:	5.098Khz		36.32Khz		328.7Khz

Inductor Impedance Formula: $X_L = 2\pi fL$
 f = frequency
 L = Coil Inductance

Coil Impedance at 5.098Khz Hz: $2\pi(5098)(50.469 \times 10^{-6}) = 1.61578\Omega$
 Impedance Matching Formula: (Primary Turns/Secondary Turns) =
 $\sqrt{\text{Primary Impedance/Secondary Impedance}}$

$(100/\text{Secondary Turns}) = \sqrt{7\Omega / 1.61578\Omega}$
 Secondary Turns: 48
 Final Turn Ratio 100:48

$(100/90) = \sqrt{50\Omega / \text{Secondary Impedance}}$
 Secondary Impedance: 11.52Ω
 Coil Frequency at Specific Impedance: $11.52\Omega = 2\pi f(50.469 \times 10^{-6})$
 Coil Frequency at Specific Impedance: 36.3215 Khz

$(100/90) = \sqrt{350\Omega / \text{Secondary Impedance}}$
 Secondary Impedance: 80.64Ω
 Coil Frequency at Specific Impedance: $80.64\Omega = 2\pi f(50.469 \times 10^{-6})$
 Coil Frequency at Specific Impedance: 254.299824 Khz

Normalized based on octave allocations: 328.7Khz
 Secondary Impedance at 328.7 Khz: 104.17Ω
 Primary Impedance at 5.098Khz: 452.126Ω
 Power Transfer at Primary Impedance: 35.27%

Transformer 3

Boundaries: ~%43.75 ---- %100 ---- ~%43.75
Primary Impedance: 7Ω 50Ω 350Ω
Transformer 1 Frequency Range: 328.7Khz 2.397Mhz 21.215Mhz

Inductor Impedance Formula: $X_L = 2\pi fL$
f = frequency
L = Coil Inductance

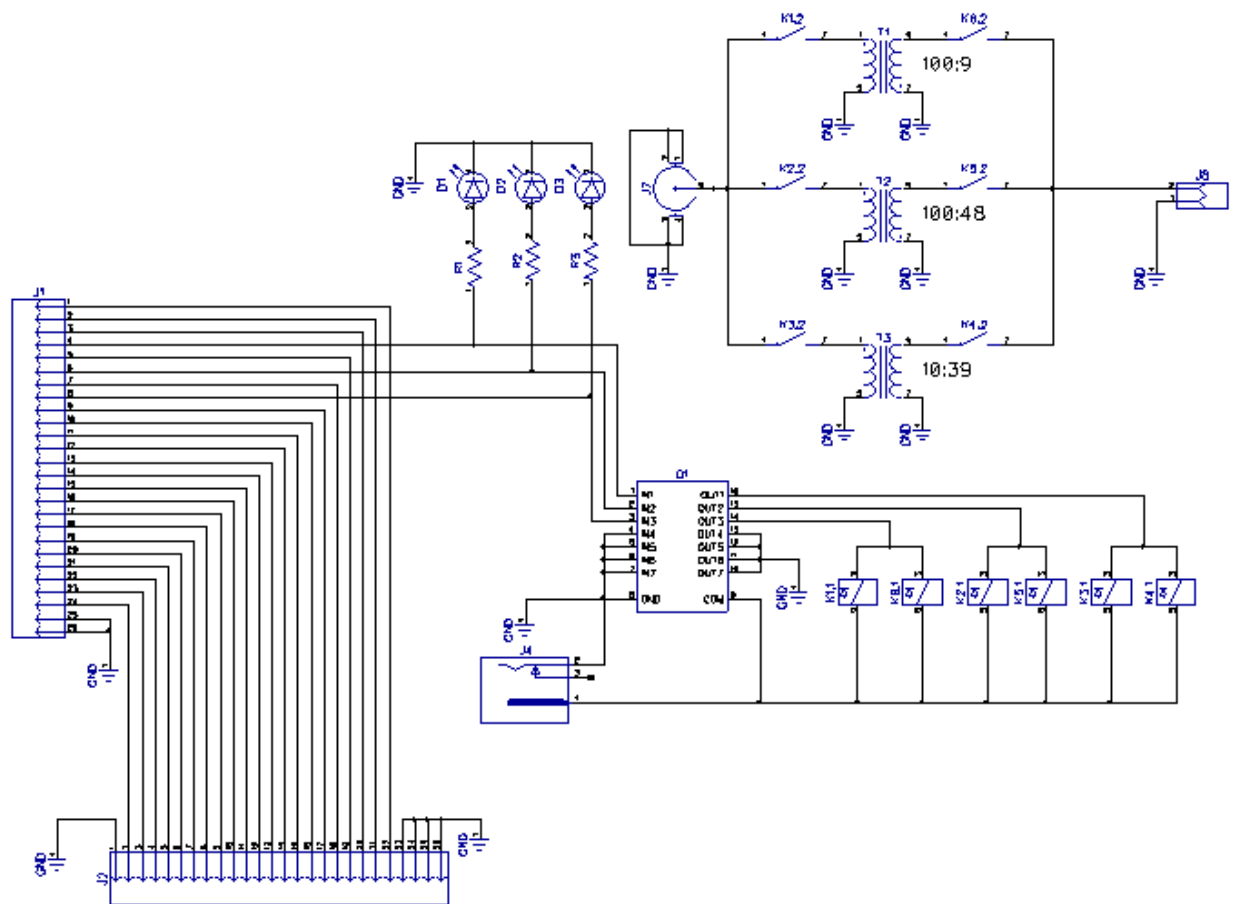
Coil Impedance at 328.7 Khz: $2\pi(328.7\text{Khz})(50.469 \times 10^{-6}) = 104.17\Omega$
Impedance Matching Formula: (Primary Turns/Secondary Turns) =
 $\text{sqrt}(\text{Primary Impedance}/\text{Secondary Impedance})$

$(100/\text{Secondary Turns}) = \text{sqrt}(7\Omega / 104.17\Omega)$
Secondary Turns: 48
Final Turn Ratio 10:39

$(100/90) = \text{sqrt}(50\Omega / \text{Secondary Impedance})$
Secondary Impedance: 760.5Ω
Coil Frequency at Specific Impedance: $760.5\Omega = 2\pi f(50.469 \times 10^{-6})$
Coil Frequency at Specific Impedance: 2.398 Mhz

Coil Impedance for a Frequency of 21.215Mhz: $6723.9\Omega = 2\pi(2398251)(50.469 \times 10^{-6})$
Primary Impedance: 442.07
Power Delivery at this Impedance: %36.51

Lower Bound	Upper Bound	Span		Turn Ratio	~43.75% Max Power	100% Max Power	~43.75% Max Power
160.84Hz	316.95Hz	156.110Hz	Transformer 1	100:9	160.84 Hz	1277.17 Hz	5.098 Khz (64%)
316.95Hz	645.08Hz	328.130Hz					
645.08Hz	1.271KHz	615.920Hz					
1.271KHz	2.587KHz	1.3160KHz					
2.587KHz	5.098KHz	2.511KHz					
5.098KHz	10.376KHz	5.278KHz	Transformer 2	100:48	5.098 Khz	36.3285 Khz	328.877 Khz (35.27%)
10.376KHz	20.446KHz	10.070KHz					
20.446KHz	41.613KHz	21.1670KHz					
41.613KHz	82.002KHz	40.389KHz					
82.002KHz	161.590KHz	79.588KHz					
161.590KHz	328.877KHz	167.287KHz	Transformer 3	10:39	328.877 Khz	2.39721 Mhz	21.215MHz (36.51%)
328.877KHz	648.071KHz	319.194KHz					
648.071KHz	1.328MHz	680.0KHz					
1.328MHz	2.599MHz	1.271MHz					
2.599MHz	5.289MHz	2.690MHz					
5.289MHz	10.424MHz	5.135MHz					
10.424MHz	21.215MHz	10.791MHz					



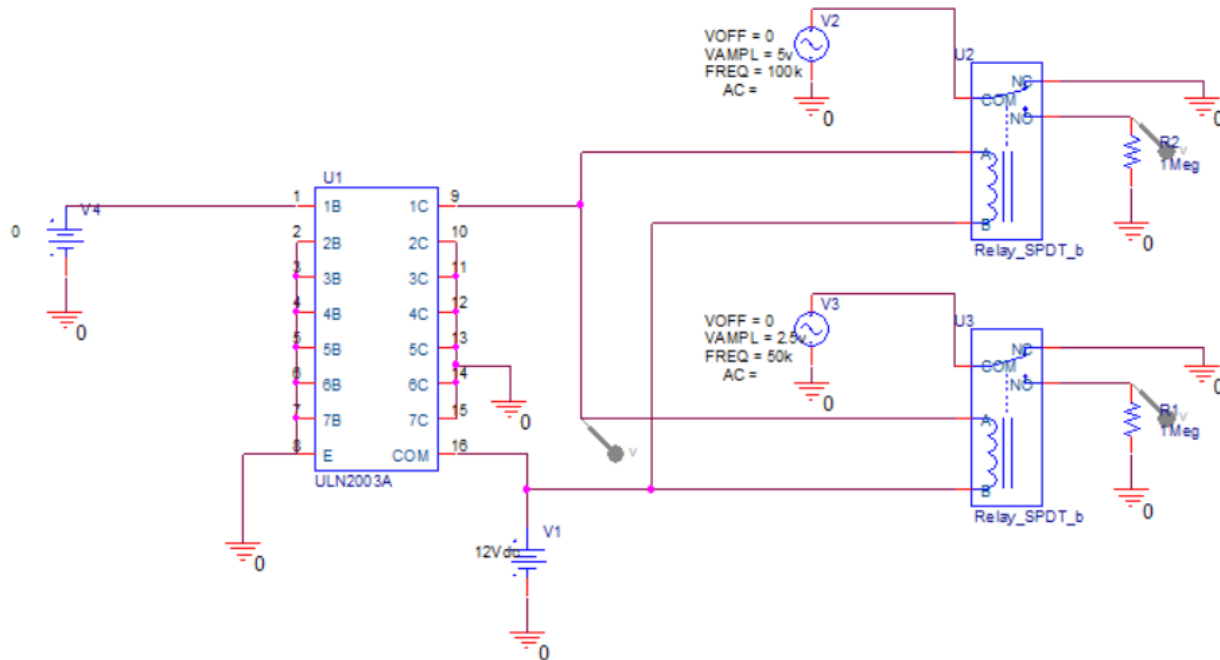
Header J1

PIN	Description	Assignment	FPGA Pin	FPGA pin description	Voltage Level
1	3V3	Pass Through	N/A	N/A	3.3V
2	3V3	Pass Through	N/A	N/A	3.3V
3	DIO0_P	Pass Through	G17	IO_L16P_T2_35 (EXT TRIG)	3.3V
4	DIO0_N	Relays transformer 3	G18	IO_L16N_T2_35	3.3V
5	DIO1_P	Pass Through	H16	IO_L13P_T2_MRCC_35	3.3V
6	DIO1_N	Relays transformer 2	H17	IO_L13N_T2_MRCC_35	3.3V
7	DIO2_P	Pass Through	J18	IO_L14P_T2_AD4P_SRCC_35	3.3V
8	DIO2_N	Relays transformer 1	H18	IO_L14N_T2_AD4N_SRCC_35	3.3V
9	DIO3_P	Pass Through	K17	IO_L12P_T1_MRCC_35	3.3V
10	DIO3_N	Pass Through	K18	IO_L12N_T1_MRCC_35	3.3V
11	DIO4_P	Pass Through	L14	IO_L22P_T3_AD7P_35	3.3V
12	DIO4_N	Pass Through	L15	IO_L22N_T3_AD7N_35	3.3V
13	DIO5_P	Pass Through	L16	IO_L11P_T1_SRCC_35	3.3V
14	DIO5_N	Pass Through	L17	IO_L11N_T1_SRCC_35	3.3V
15	DIO6_P	Pass Through	K16	IO_L24P_T3_AD15P_35	3.3V
16	DIO6_N	Pass Through	J16	IO_L24N_T3_AD15N_35	3.3V
17	DIO7_P	Pass Through	M14	IO_L23P_T3_35	3.3V
18	DIO7_N	Pass Through	M15	IO_L23N_T3_35	3.3V
19	NC	Pass Through	N/A	N/A	3.3V
20	NC	Pass Through	N/A	N/A	3.3V
21	NC	Pass Through	N/A	N/A	3.3V
22	NC	Pass Through	N/A	N/A	3.3V
23	NC	Pass Through	N/A	N/A	3.3V
24	NC	Pass Through	N/A	N/A	3.3V
25	GND	Pass Through	N/A	N/A	3.3V
26	GND	Pass Through	N/A	N/A	3.3V

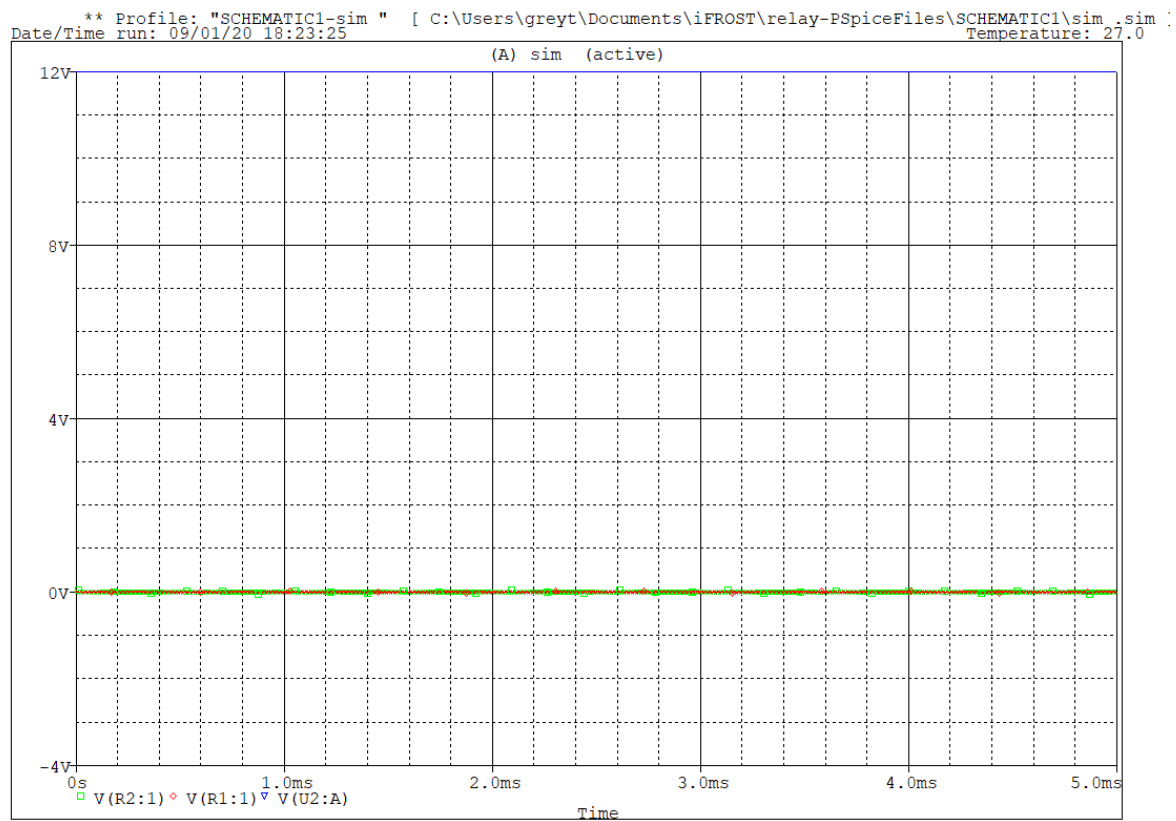
Header J2

PIN	Description	FPGA Pin	FPGA pin description	Voltage Level
	1 GND			
	2 NC	N/A	N/A	N/A
	3 NC	N/A	N/A	N/A
	4 NC	N/A	N/A	N/A
	5 NC	N/A	N/A	N/A
	6 NC	N/A	N/A	N/A
	7 NC	N/A	N/A	N/A
	8 DIO7_N	M15	IO_L23N_T3_35	3.3V
	9 DIO7_P	M14	IO_L23P_T3_35	3.3V
	10 DIO6_N	J16	IO_L24N_T3_AD15N_35	3.3V
	11 DIO6_P	K16	IO_L24P_T3_AD15P_35	3.3V
	12 DIO5_N	L17	IO_L11N_T1_SRCC_35	3.3V
	13 DIO5_P	L16	IO_L11P_T1_SRCC_35	3.3V
	14 DIO4_N	L15	IO_L22N_T3_AD7N_35	3.3V
	15 DIO4_P	L14	IO_L22P_T3_AD7P_35	3.3V
	16 DIO3_N	K18	IO_L12N_T1_MRCC_35	3.3V
	17 DIO3_P	K17	IO_L12P_T1_MRCC_35	3.3V
	18 DIO2_P	J18	IO_L14P_T2_AD4P_SRCC_35	3.3V
	19 DIO1_P	H16	IO_L13P_T2_MRCC_35	3.3V
	20 DIO0_P	G17	IO_L16P_T2_35 (EXT TRIG)	3.3V
	21 3V3	N/A	N/A	3.3V
	22 3V3	N/A	N/A	3.3V
	23 GND			
	24 GND			
	25 GND			
	26 GND			

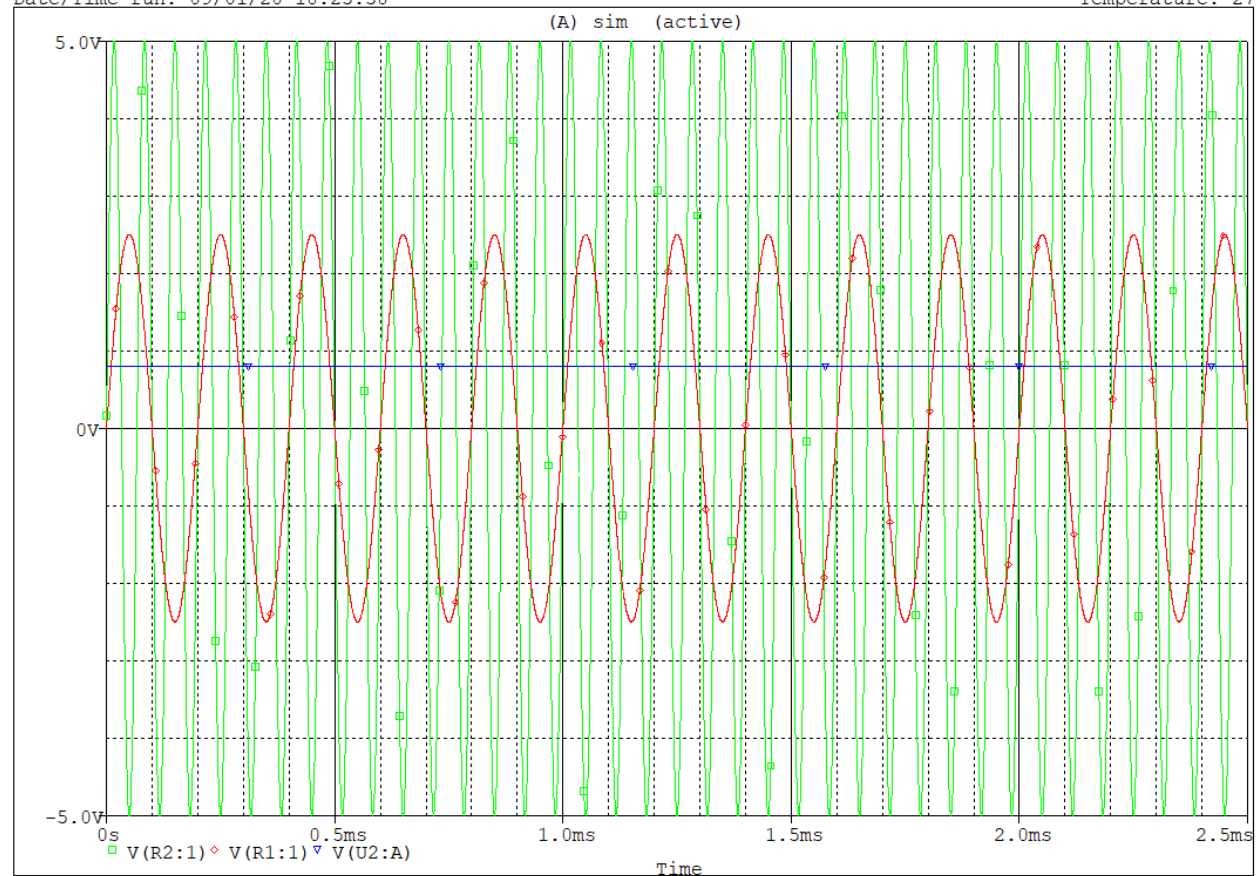
Relay Driver Sim



The relay circuit was simulated to ensure that driver IC could drive 2 relays per channel. Relay J2 was fed by a 100KHz sin source, relay J3 was fed by a 50KHz sin source. When the voltage to pin 1B is 0 the output should be 0, when voltage to pin 1B is 3.3v the output of each relay should be a sin waves with an amplitude of 5v and 2.5v respectively and a frequency of 100Khz and 50KHz respectively.



** Profile: "SCHEMATIC1-sim " [C:\Users\greyt\Documents\iFROST\relay-PSpiceFiles\SCHEMATIC1\sim.sim]
Date/Time run: 09/01/20 18:25:58 Temperature: 27.0



Date: September 01, 2020

Page 1

Time: 18:26:22

Red Trace: J3 output
Green Trace: J2 output
Blue Trace: Relay driver common