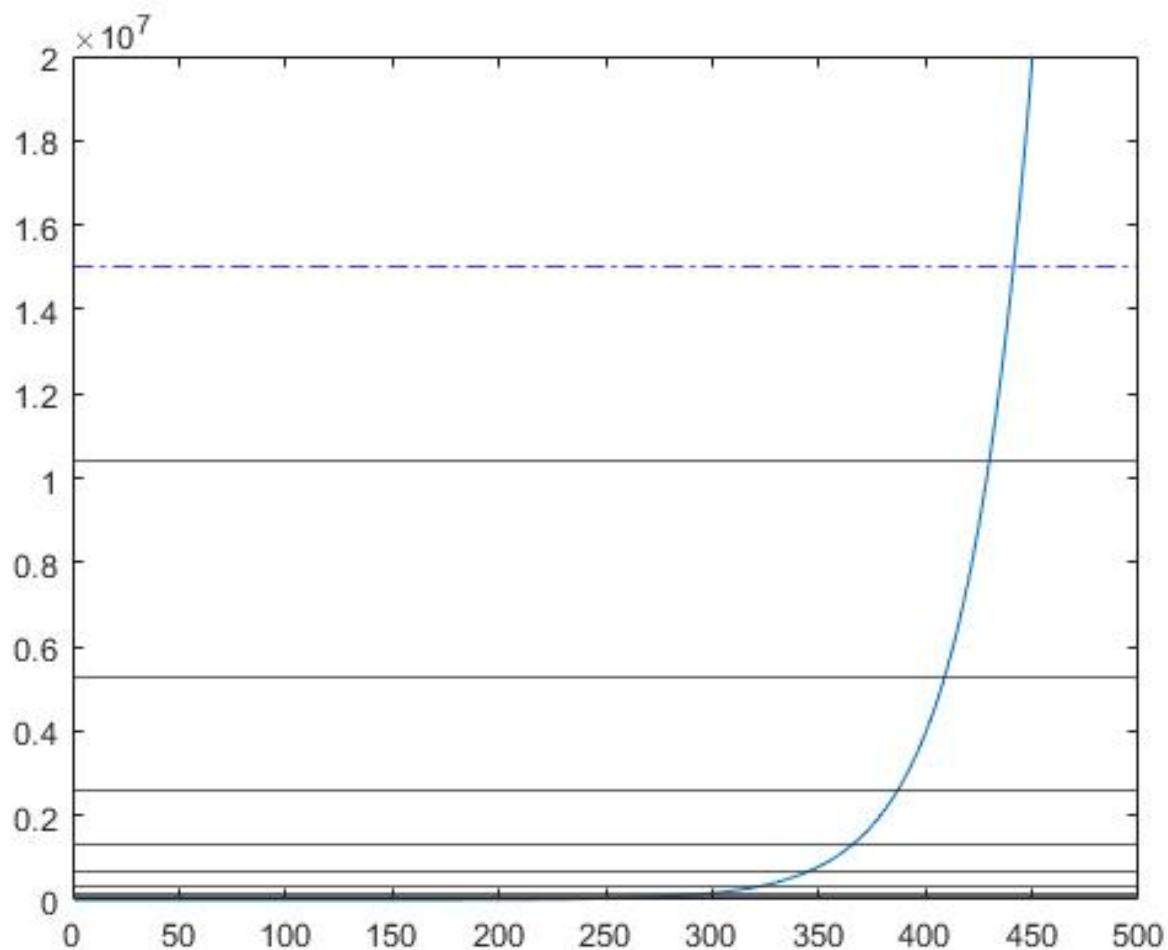


## IMPEDANCE MATCH DOCUMENTATION



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

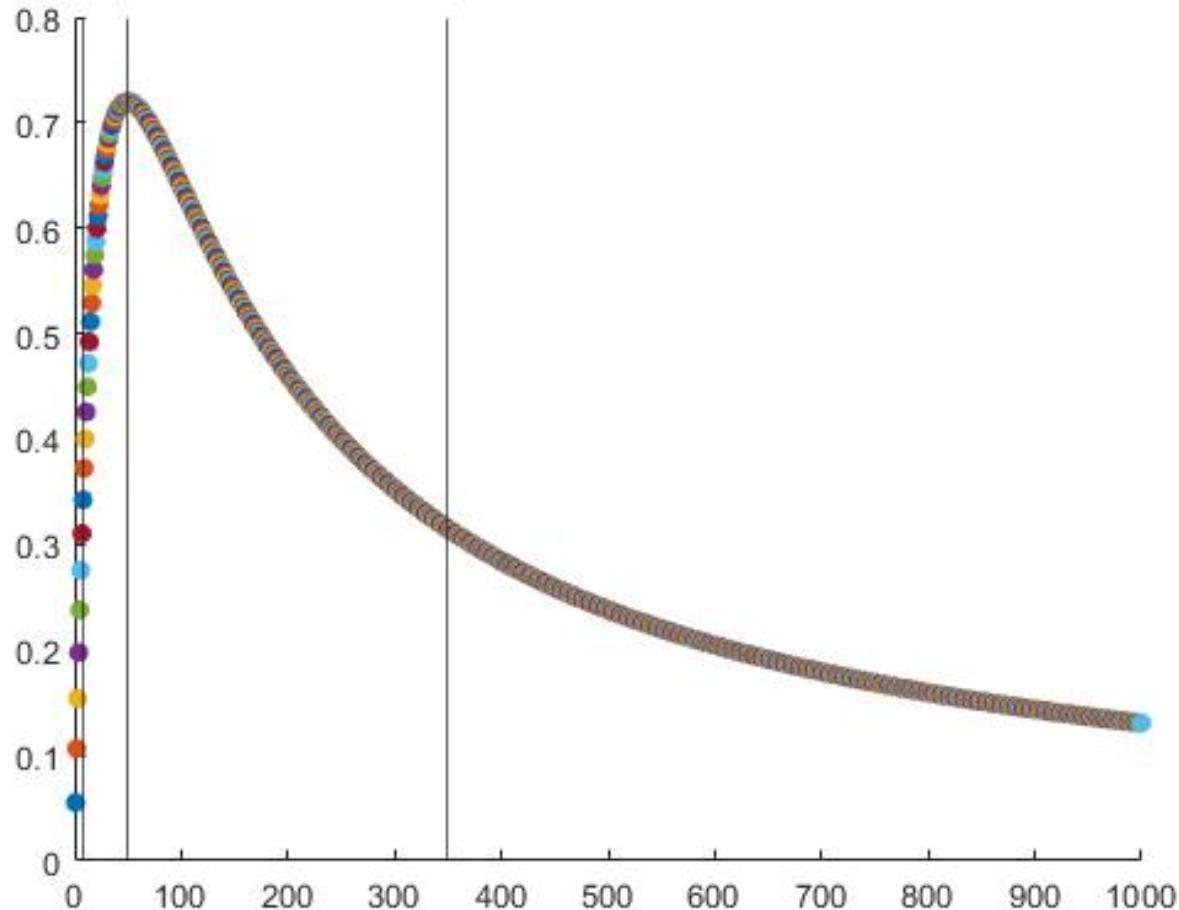
a = a*2;
[val,idx]=min(abs(y-a));
minVal=y(idx);

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

yline(minVal);

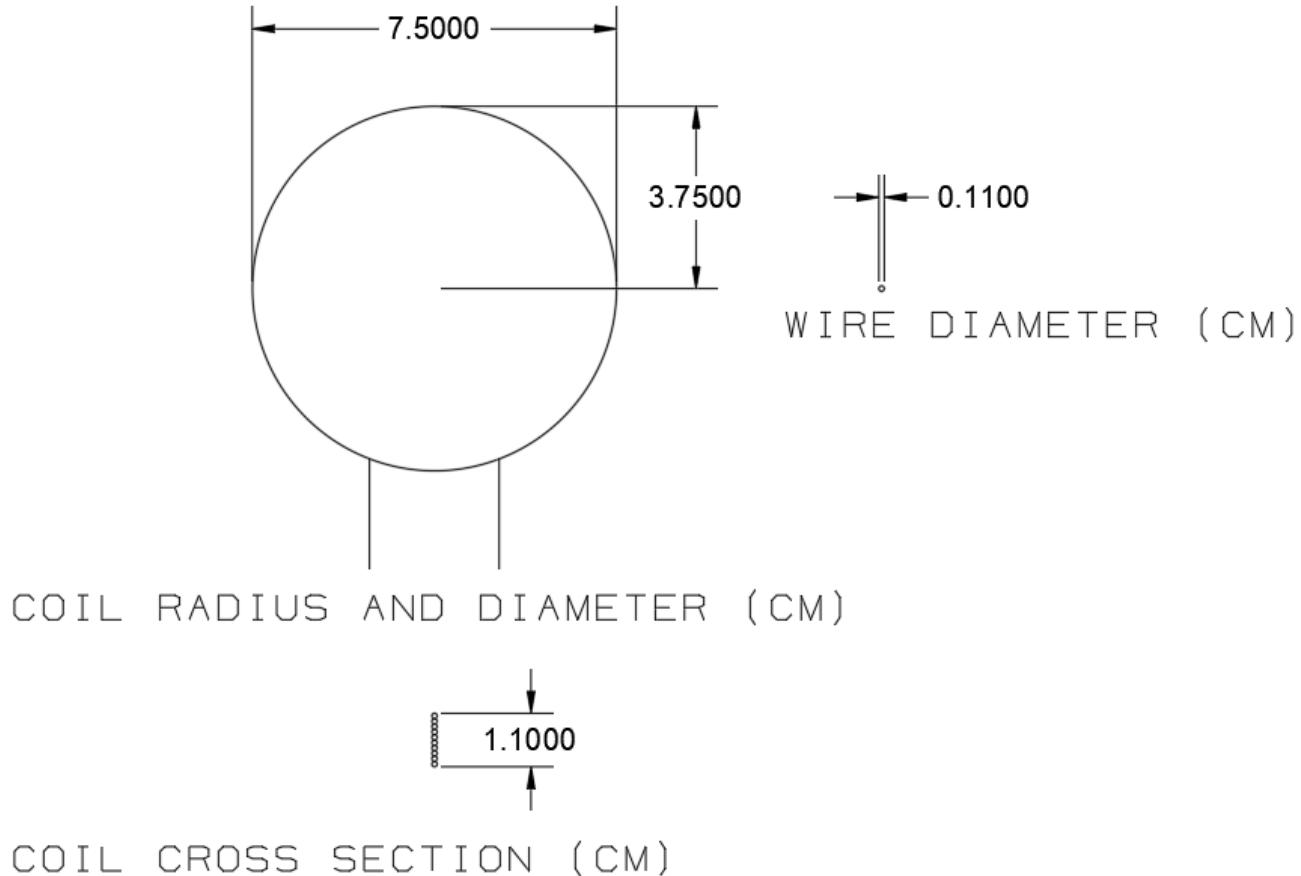
c = c+1;
disp(c);

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:  $X_L = 2\pi f L$

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) =  $\sqrt{(\text{Primary Impedance}/\text{Secondary Impedance})}$

(100/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) =  $\sqrt{\text{Primary Impedance}/\text{Secondary Impedance}}$

(100/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) =  $\sqrt{\text{Primary Impedance}/\text{Secondary Impedance}}$

(100/Secondary Turns) =  $\sqrt{7\Omega / 104.17\Omega}$

Secondary Turns: 48

Final Turn Ratio 10:39

(100/90) =  $\sqrt{50\Omega / \text{Secondary Impedance}}$

Secondary Impedance: 760.5Ω

Coil Frequency at Specific Impedance:  $760.5\Omega = 2\pi f(50.469 \times 10^{-6})$

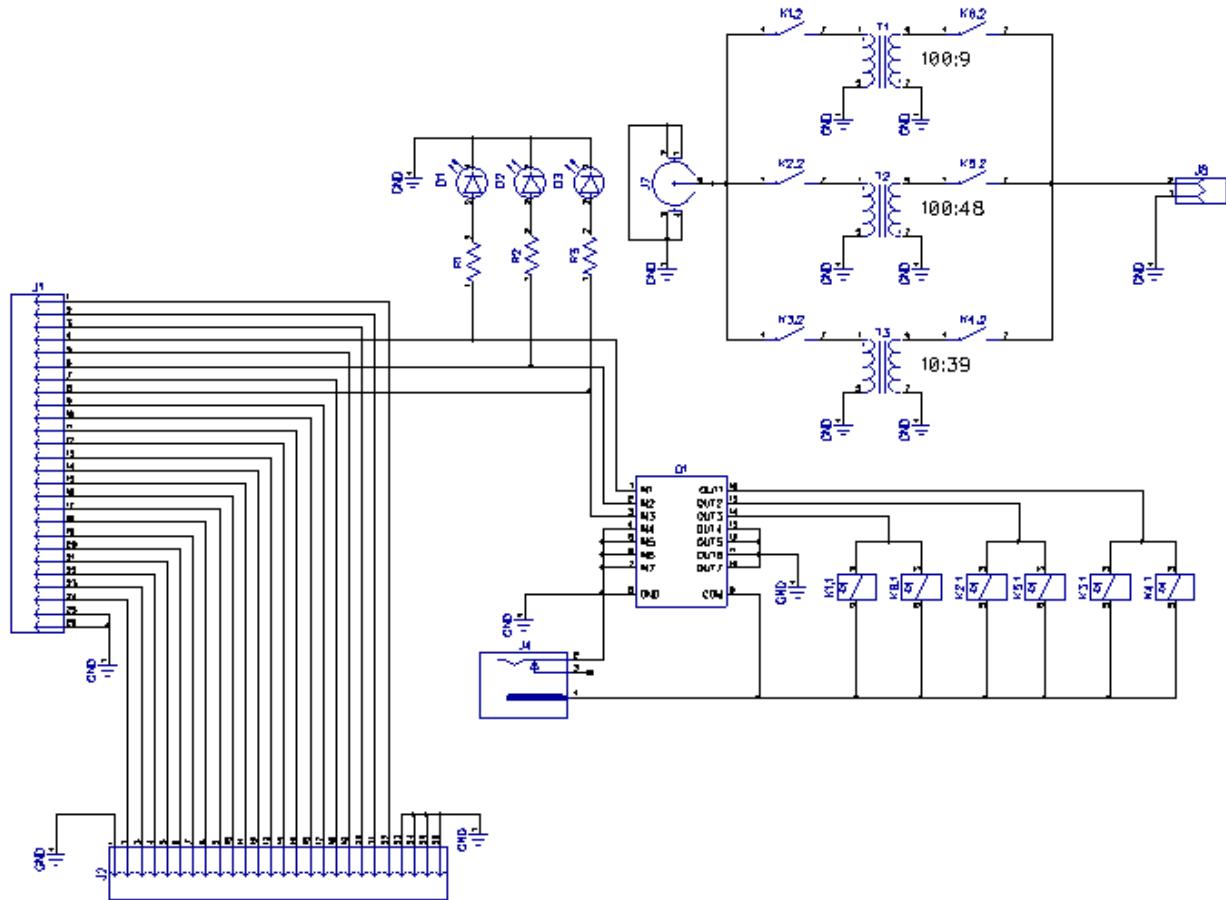
Coil Frequency at Specific Impedance: 2.398 Mhz

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



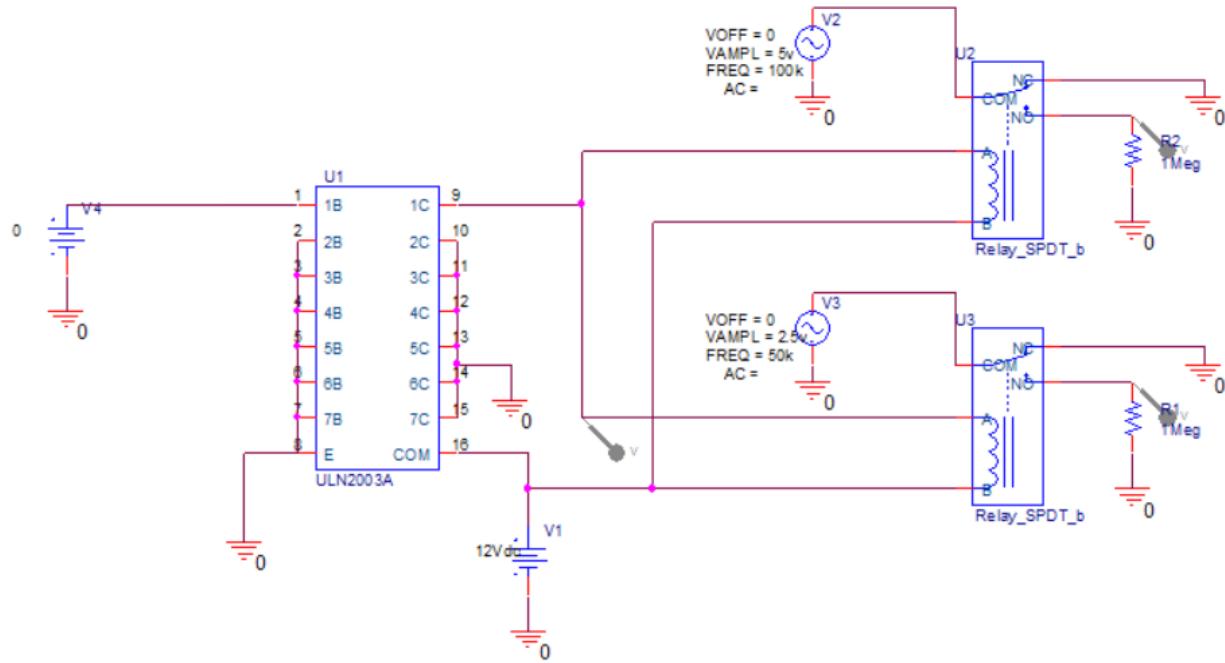
Header J1

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

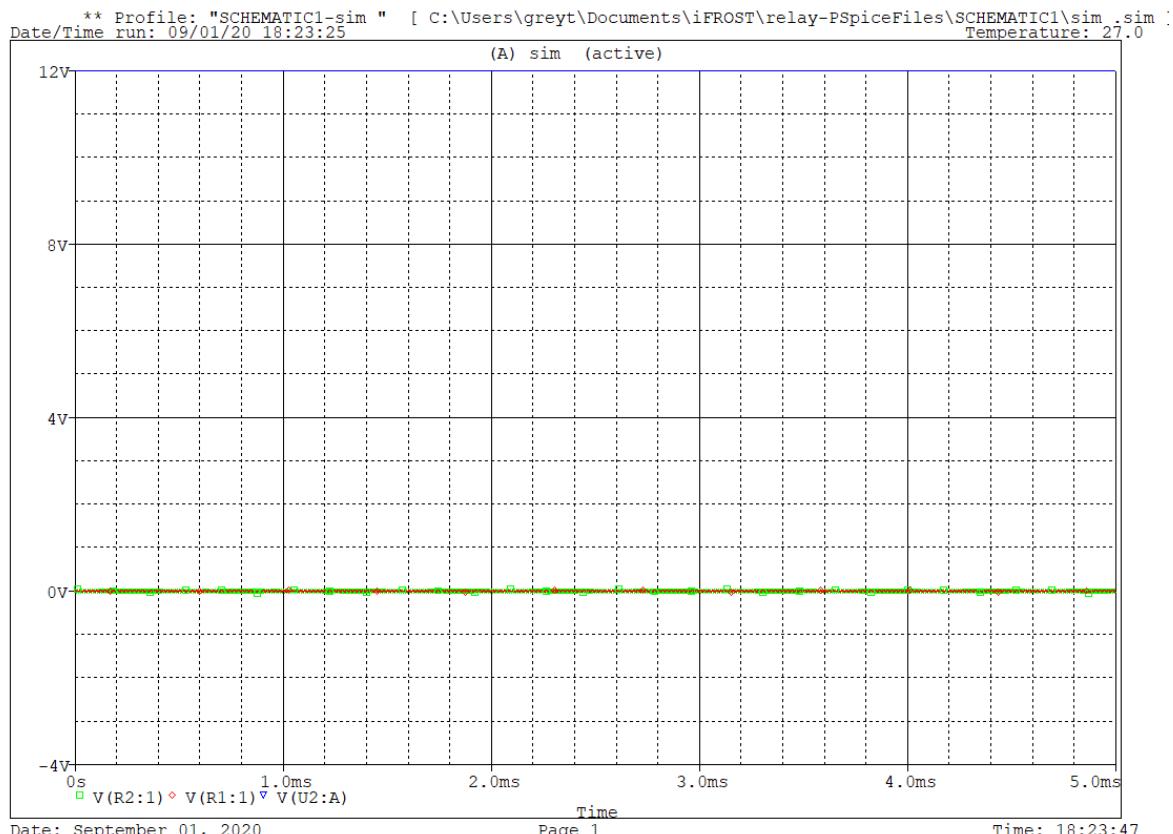
Header J2

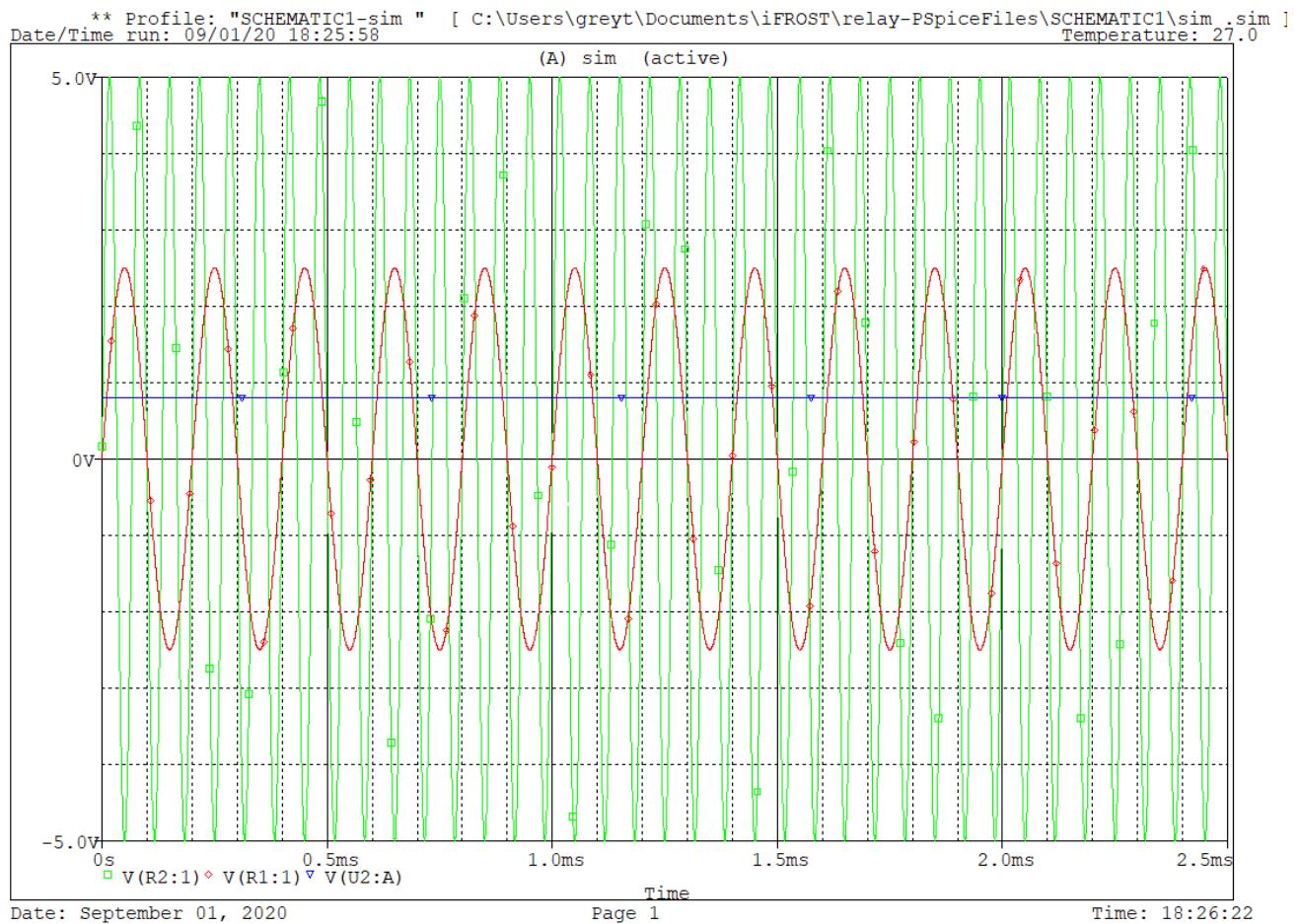
PIN	Description	FPGA Pin	FPGA pin description	Voltage Level
1	GND			
2	NC	N/A	N/A	N/A
3	NC	N/A	N/A	N/A
4	NC	N/A	N/A	N/A
5	NC	N/A	N/A	N/A
6	NC	N/A	N/A	N/A
7	NC	N/A	N/A	N/A
8	DIO7_N	M15	IO_L23N_T3_35	3.3V
9	DIO7_P	M14	IO_L23P_T3_35	3.3V
10	DIO6_N	J16	IO_L24N_T3_AD15N_35	3.3V
11	DIO6_P	K16	IO_L24P_T3_AD15P_35	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.

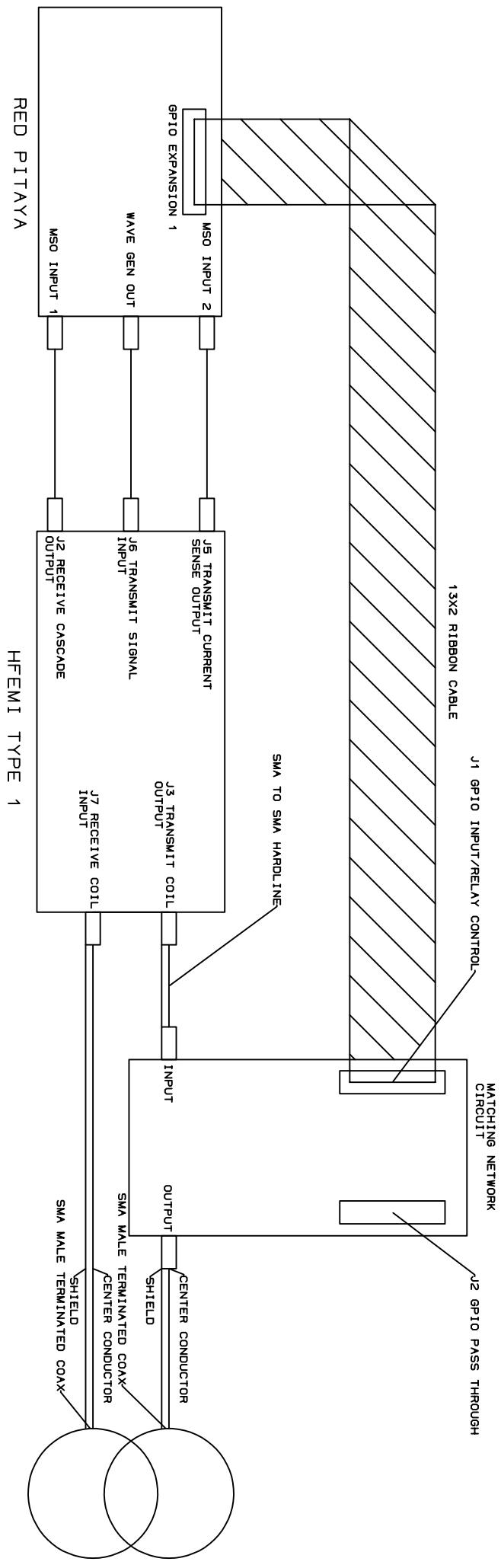




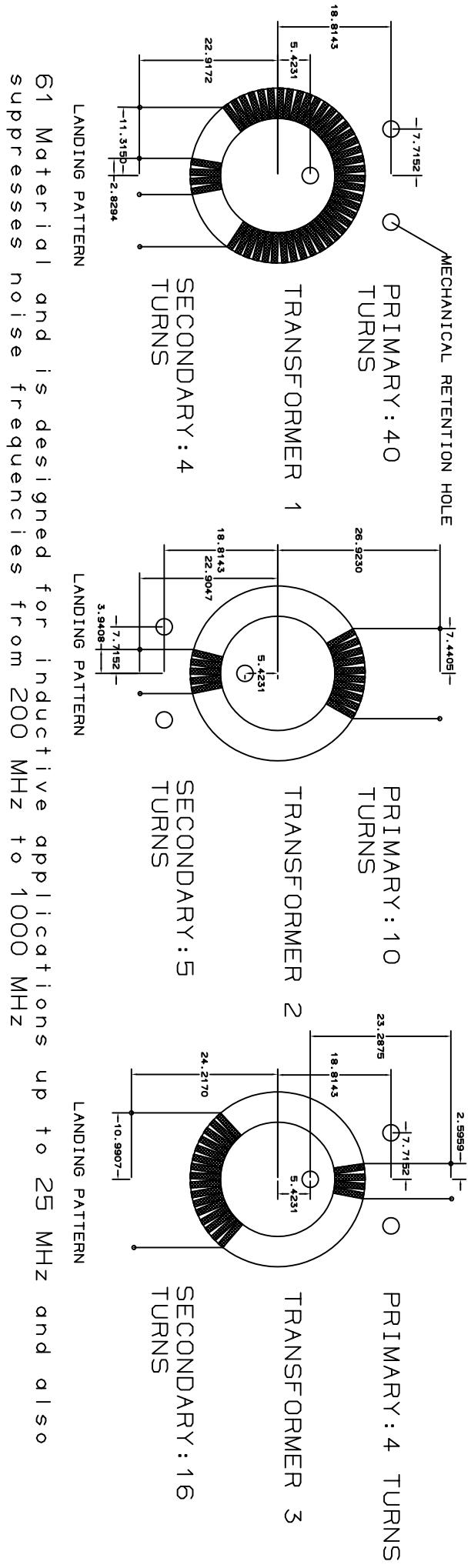
Red Trace: J3 output

Green Trace: J2 output

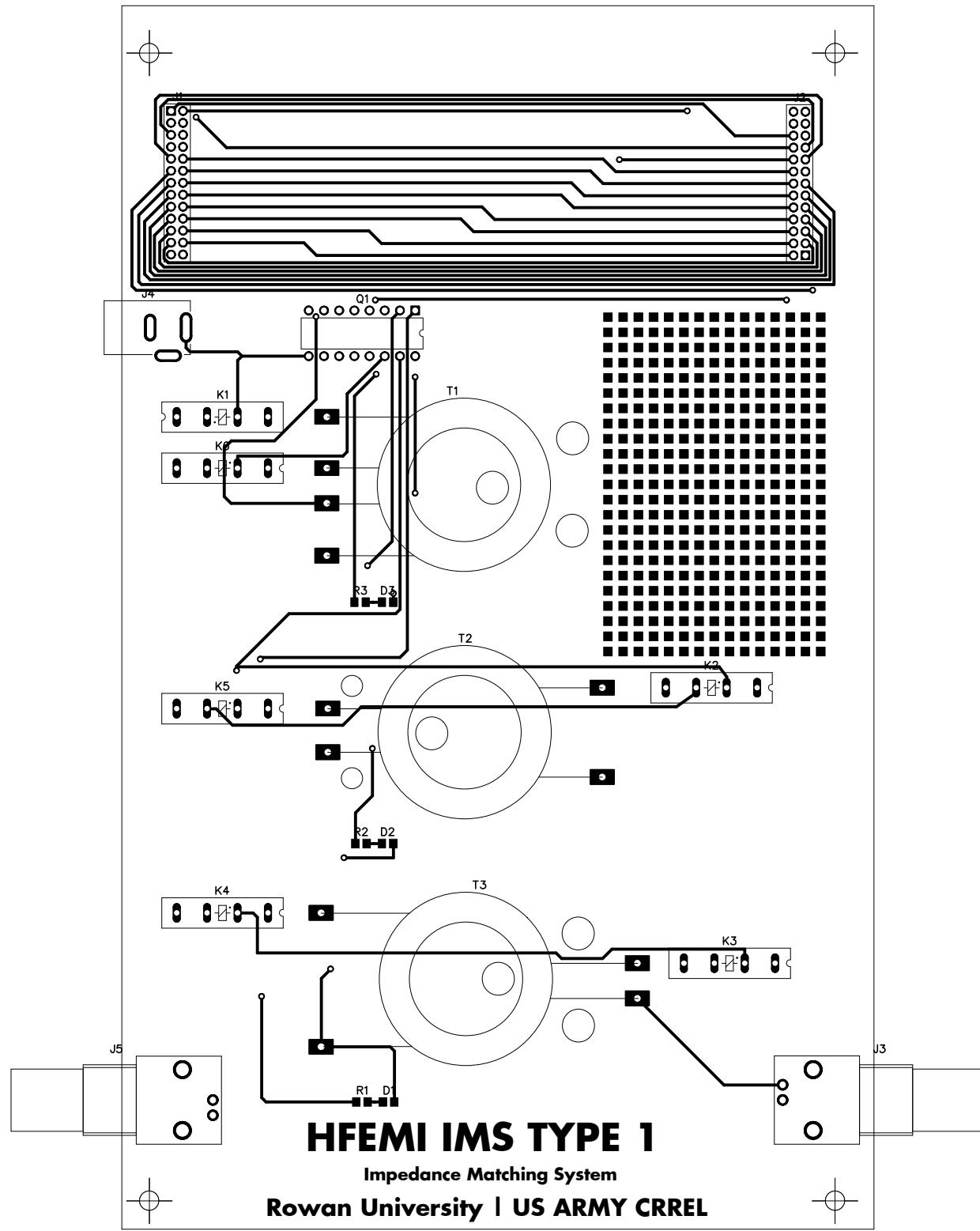
Blue Trace: Relay driver common

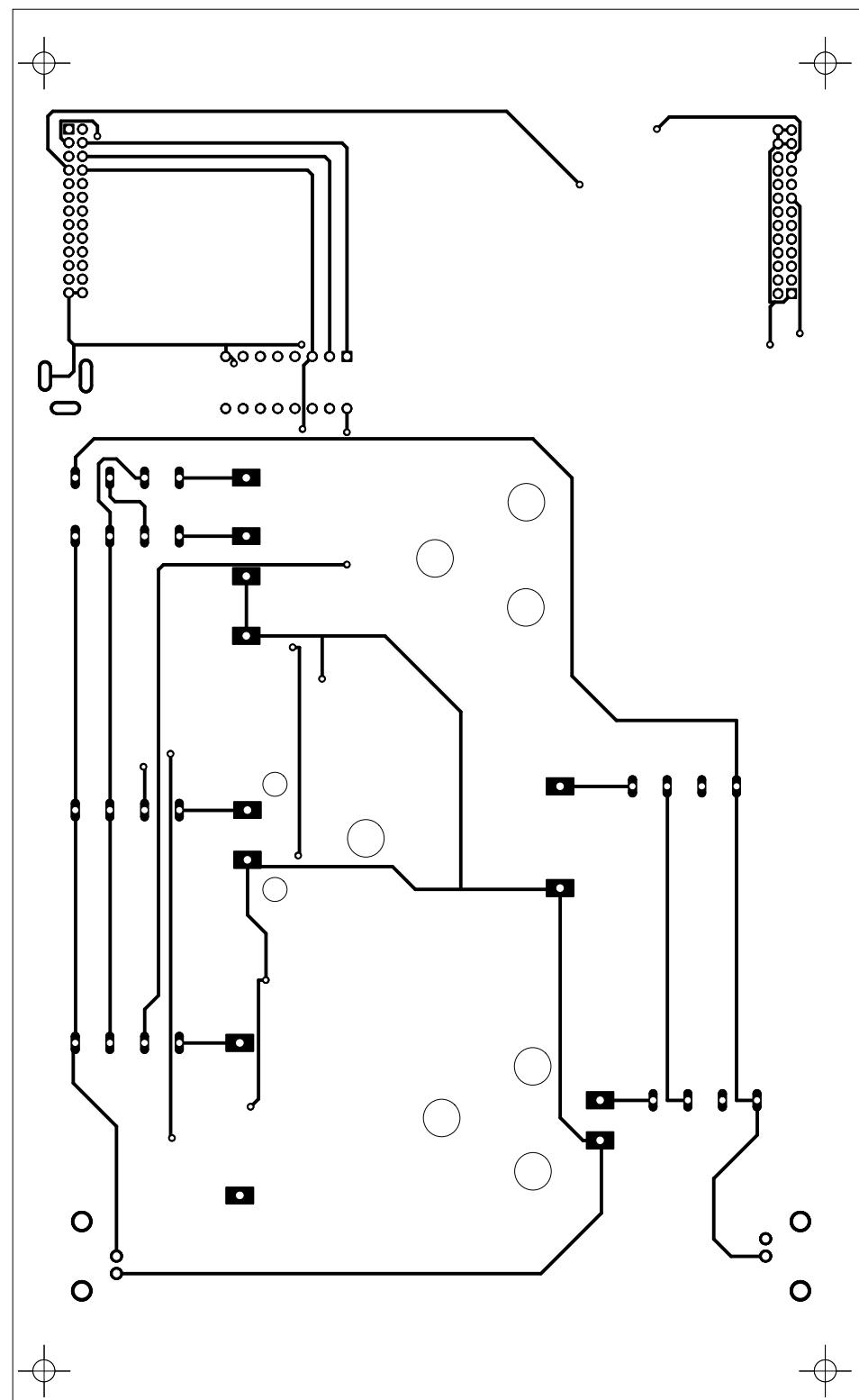


TRANSFORMER CORE MECHANICAL DESIGN (ALL UNITS MM)  
BASED ON AMIDON FT-144-61 / OD:29 / ID:19 / HT 7.5



G1 Material and is designed for inductive applications up to 25 MHz and also suppresses noise frequencies from 200 MHz to 1000 MHz







## SHOPPING CART

This is not an invoice

09-Sep-20 11:58:46

Mouser #	Mfr. #	Manufacturer	Customer #
1 511-ULN2003A	ULN2003A	STMicroelectronics	
2 755-SML-H12U8TT86C	SML-H12U8TT86C	ROHM Semiconductor	
3 934-HE3621A1250	HE3621A1250	Littelfuse	
4 490-PJ-002A	PJ-002A	CUI Devices	
5 517-4816-3000-CP	4816-3000-CP	3M	
6 649-76385-313LF	76385-313LF	FCI / Amphenol	
7 523-31-5637	031-5637	Amphenol	
8 71-CRCW0805-50	CRCW080550R0FKTA	Vishay	
9 534-4946	4946	Keystone Electronics	
10 534-9605	9605	Keystone Electronics	

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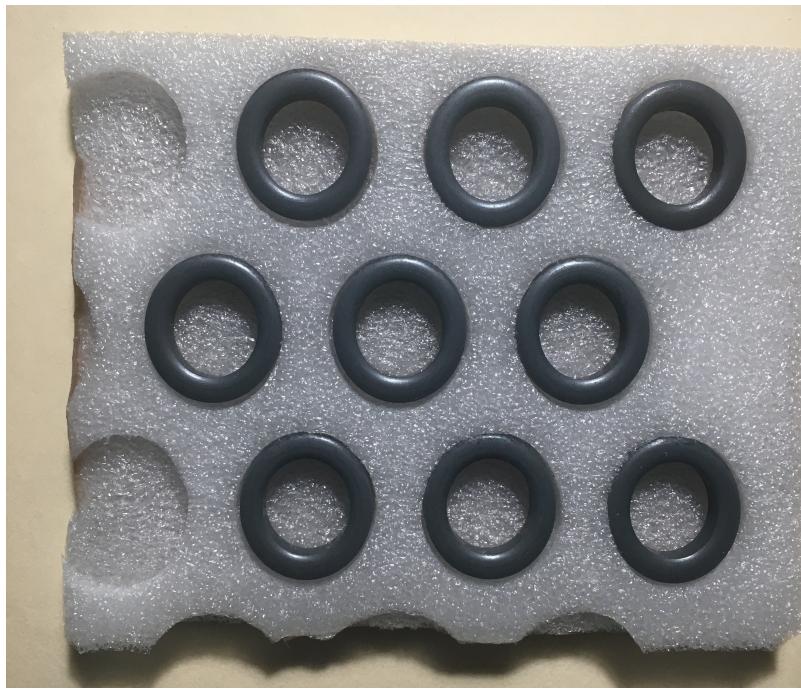
Prices are reflected at the date and time shown.

<b>Description</b>	<b>RoHS</b>
Darlington Transistors Seven NPN Array	RoHS Compliant
Standard LEDs - SMD Red 620nm 40mcd 2.2V; 20mA 0805	RoHS Compliant
Reed Relays REED RELAY	RoHS Compliant
DC Power Connectors Power Jacks	RoHS Compliant
IC & Component Sockets 16P DUAL WIPE DIPSKT	RoHS Compliant
Headers & Wire Housings 26P VERT DR HDR AU	RoHS Compliant
RF Connectors / Coaxial Connectors RIGHT ANGLE PCB JACK	RoHS Compliant By Exemption
Thick Film Resistors - SMD 1/8watt 50ohms 1% Non Std Qt Req'd	No
Standoffs & Spacers M/F NYLON STANDOFF 4-40 1.00 L	RoHS Compliant
Screws & Fasteners 1/4 4-40 Nylon Hex M SCREW NUT	RoHS Compliant

Lifecycle	Order Qty.	Price (USD)	Ext.: (USD)
	5	\$0.51	\$2.55
	20	\$0.283	\$5.66
	10	\$1.79	\$17.90
	5	\$0.59	\$2.95
	2	\$0.53	\$1.06
	3	\$2.34	\$7.02
	4	\$5.18	\$20.72
	50	\$0.279	\$13.95
	10	\$0.566	\$5.66
	11	\$0.124	\$1.36

**Merchandise Total:**

**Shipping Charge:**



Amidon transformer cores

