EGB240 Electronic Design

Assessment 1: PCB Alarm Circuit Design Portfolio

Submitted 31/03/2023

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Executive Summary

Two-tone siren circuit using hex Schmitt inverting trigger and Piezoelectric Buzzer

Salient features of design;

- Costs approximately $12.6 for the 11 unique components, 17 components total
- Produces two alternating tones at 2.65kHz and 3kHz at up to 70dB
- PCB dimensions are width of 46.53mm, height of 34.62mm
- The tones alternate with an approximate rate of 2 two tones a second
- Includes test points on PCB to troubleshoot the device
- The device while draws 14mA at 3V, thus has a power draw of 42mW while active

Contents

1. Circuit schematic

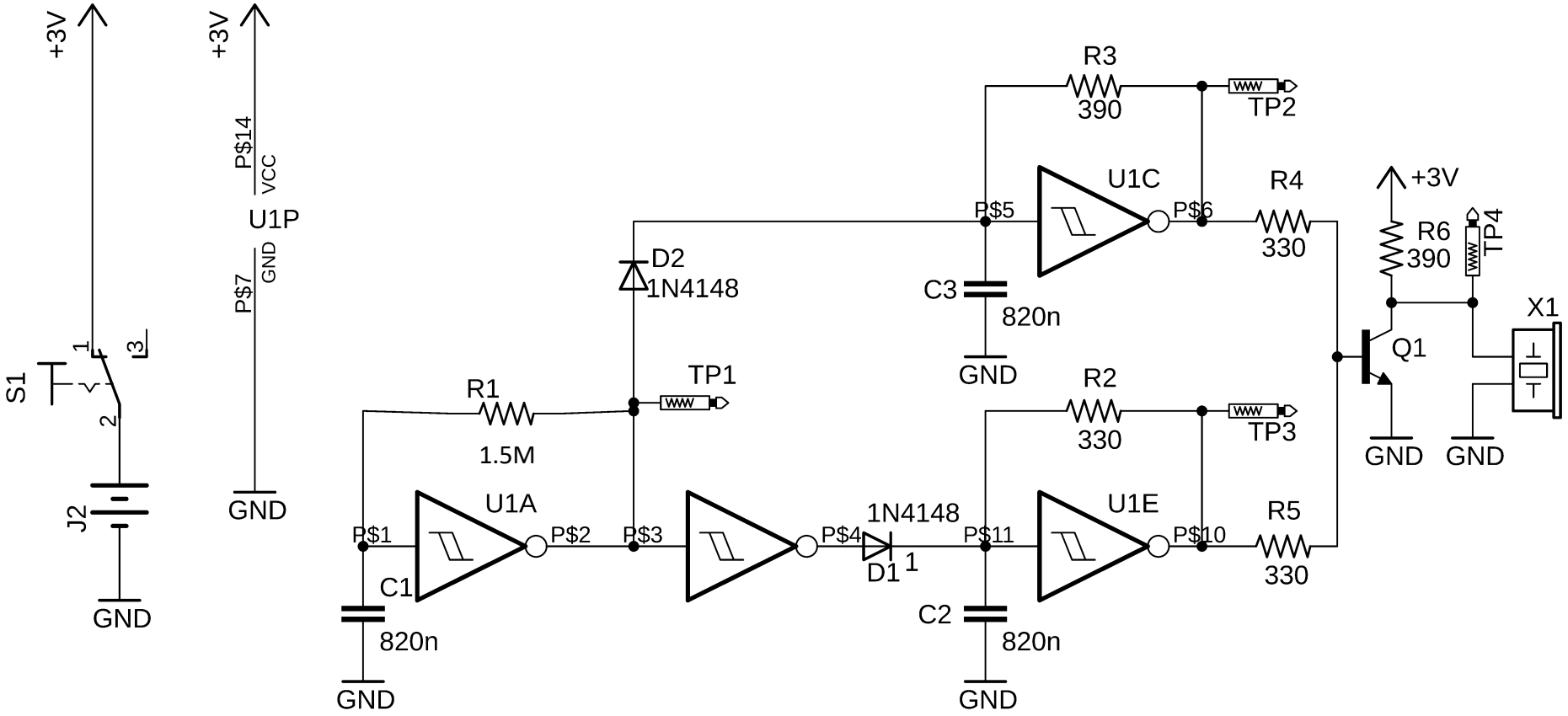


Figure 1: Complete Circuit Schematic to create a two-tone siren.

2. Summary of design and operation

The circuit used consists of an independent low frequency oscillator controlling two high frequency oscillator which output is combined to subsequently result in the output voltage required to drive the Piezoelectric buzzer. The oscillators are a simple circuit using a hex Schmitt inverting trigger which in the case of this design is the 74HC14 which comes with 6 inverting terminals. The oscillator circuit can be in figure 2 below.

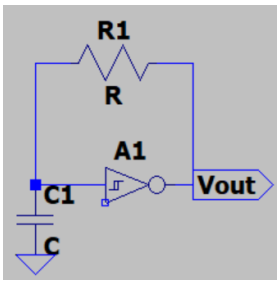


Figure 2: Simple oscillator circuit

This circuit produces a square wave with the frequency approximately given by;

$$f = \frac{1}{1.25 * R_1 * C_1}$$

The first design used the values of 16kΩ and 10μF resulting in a low frequency oscillator of approximately 5Hz. Two high frequency oscillators used the values of; 4.7kΩ, 225nF and 3.9kΩ, 100nF to produce two frequencies of 750Hz and 2051 Hz respectively. These three circuits were added combined using 2 two diodes to control current flow, and another terminal of the Schmitt inverter to invert the signal of the low frequency oscillator.

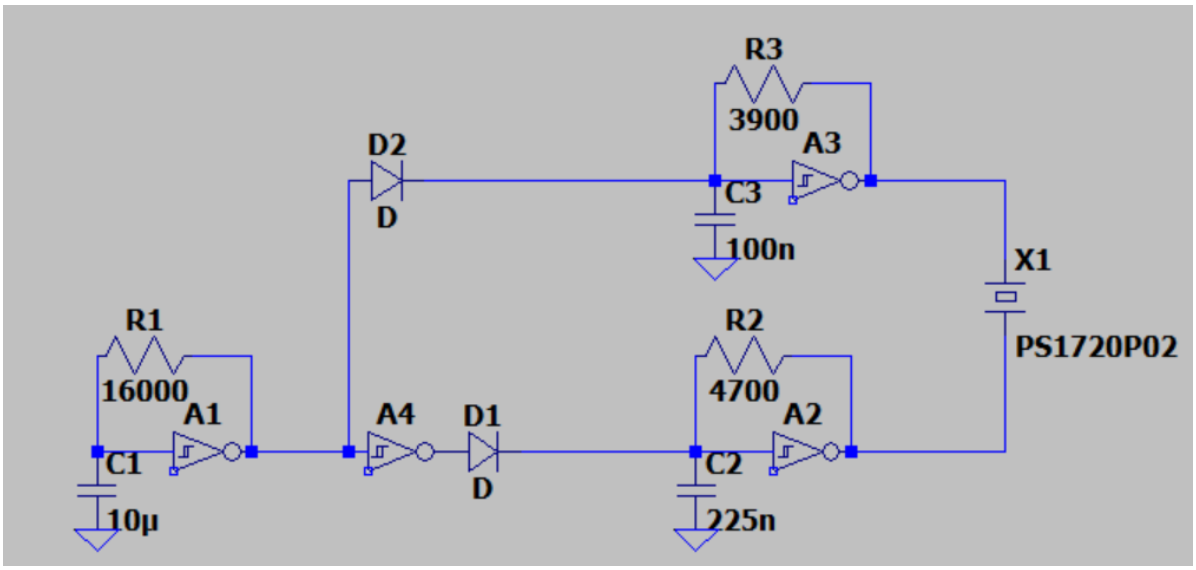


Figure 3: First design (Design 1) of two-tone siren

This circuit produced a two-tone sound however was quiet for an alarm. The PS1720P02, the busser this circuit is driving has peak sound at 2kHz,2.9kHz. New R,C values were calculated and C values were standardized to 825nF. R become 1.5MΩ for the low frequency oscillator resulting in 0.65Hz square wave The two high frequency oscillator were R = 330, R=390 resulting in frequencies 3.0kHz and 2.5kHz. When inputted into design 1 (forming design 2), the busser sounded noisy.

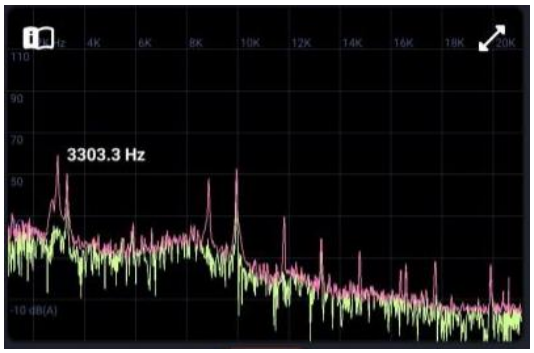


Figure 4: Frequency of sound produced by busser.

Figure 4 shows that the sound produced seems to display equal peaks at 50db at 9kHz and 10kHz to the desired 2.5kHz and 3kHz sound. I assumed this was due to an effect of the busser within the circuit. To fix this I used a NP100 transistor to isolate the busser from the two high frequency oscillators. The best design formed can be seen in figure 1 which includes a switch to control the siren.

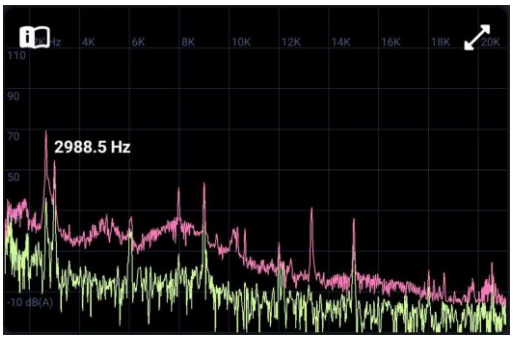


Figure 5: Sound profile of final design.

The final design improves on design 2 as it has noticeably larger peaks at 3kHz and 2.65Hz and the sound of 8kHz and 10kHz is far less audible. This final design was chosen as it sufficiently powered the siren to produce an audible two-tone sound.

It should be noted the common generic 820nF capacitors have a lead pitch of 15mm and cost $1.75 each which was both economically unviable and too large for a compact design. This is despite 820nF capacitors being ideal as they produce 3kHz and 2.5kHz and 0.65Hz using one e-series resistor. Differing 820nF were sourced with a pitch length of 5mm, however I had to build and test the prototype circuit using the generic 15mm 820nF as I did not receive the 5mm pitch capacitors in time. Furthermore, these capacitors have the dimensions of 7.3x6.5mm, which is 0.5mm greater than the silkscreen dimensions for the capacitors on the PCB. Therefore, addition care had to be taken to ensure at least a 0.25mm clearance on the width of these three capacitors.

3. PCB layout

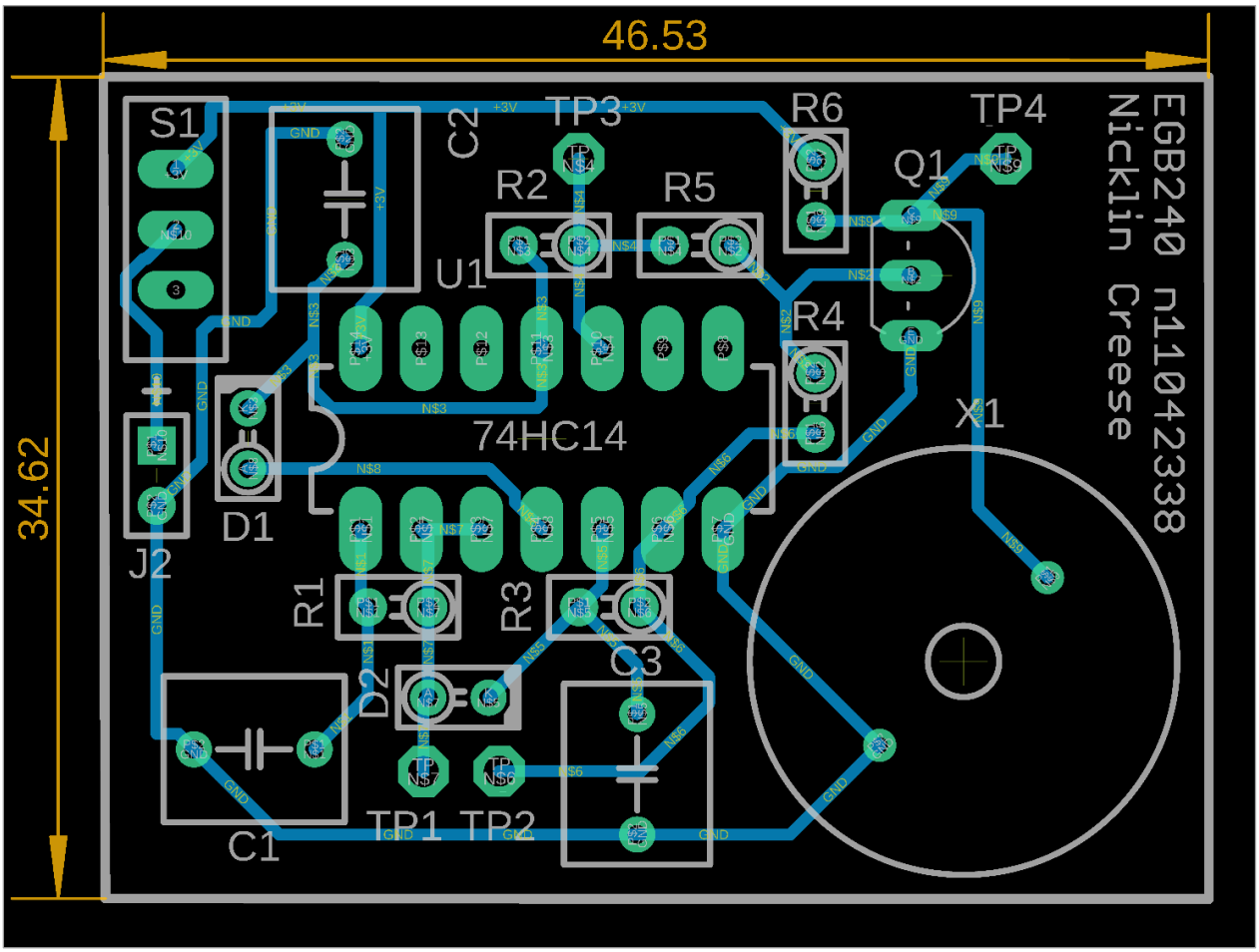


Figure 6: PCB design layout for the circuit (Width of 46.53mm, Height of 34.62mm)

4. Bill of materials

Table 1: Designators with respective values, descriptions, and footprints

Designator	Value	Description	Qty	Footprint
C1,C2,C3	820n	100V, Metallized Polyester Film capacitor, radical 5mm pitch, 5% tol.	3	CAPMKT-7.5X6.0
R1	1.5M	Axial through hole mount, metal film resistor, 0.25W 1% tol.	1	AXIAL-P10.16
R3,R6	390	Axial through hole mount, metal film resistor, 0.5W 1% tol.	2	AXIAL-P10.16
R2,R4,R5	330	Axial through hole mount, metal film resistor, 0.5W 1% tol.	3	AXIAL-P10.16
D1,D2	1N4148	Diode, 100V 200mA	2	DO-204AH, DO-35, Axial
Q1	PN100	BJT NPN type transistor, Ic 500mA, vC 45V	1	TO92-EBC
U1	74HC14	IC, Hex inverting schmitt trigger, DIP-14	1	DIP-14
U1	74HC14	IC Socket	1	DIP-14
X1	PS1720P02	Piezoelectric buzzer	1	PS1720P02
S1	SS12SDP4	Switch, SPDT, Slide, On-On, 0.1" pitch	1	SS-12
J2	N/a	Battery holder, 3V, 2xAA, flying leads	1	BaTT-3V

Table 2: The manufacturers and suppliers for given designators and their total costs

Designator	Manufacturer	MPN	Supplier	SKU	MOQ	Price For MOQ	Total Cost
C1,C2,C3	ARCOTRONICS	R82 Series	Tayda	A-4602	1	$0.13	$0.39
R1	Generic	N/a	Jaycar	RR1652	8	$0.68	$0.085
R2,R6	Generic	N/a	Jaycar	RR0562	8	$0.85	$0.21
R3,R4,R5	Generic	N/a	Jaycar	RR0560	8	$0.85	$0.32
D1,D2	Onsemi	1N4148	Digi-Key	1N4148FS-ND	1	$0.15	$0.30
Q1	Fairchild Semiconductor	PN100	Jaycar	ZT2283	1	$0.65	$0.65
U1	Texas Instruments	SS12SDP4	Jaycar	ZC4821	1	$2.75	$2.75
U1	Generic	SN74HC14N	Jaycar	PI6501	1	$0.50	$0.50
X1	TDK Corporation	PS1720P02	Digi-key	445-2527-ND	1	$1.28	$1.28
S1	NKK Switches	SS12SDP4	Digi-key	360-2922-ND	1	$4.49	$4.49
J1	Generic	N/a	Jaycar	PH9202	1	$1.60	$1.60
Total Costs							$12.58

5. Assembly overlay

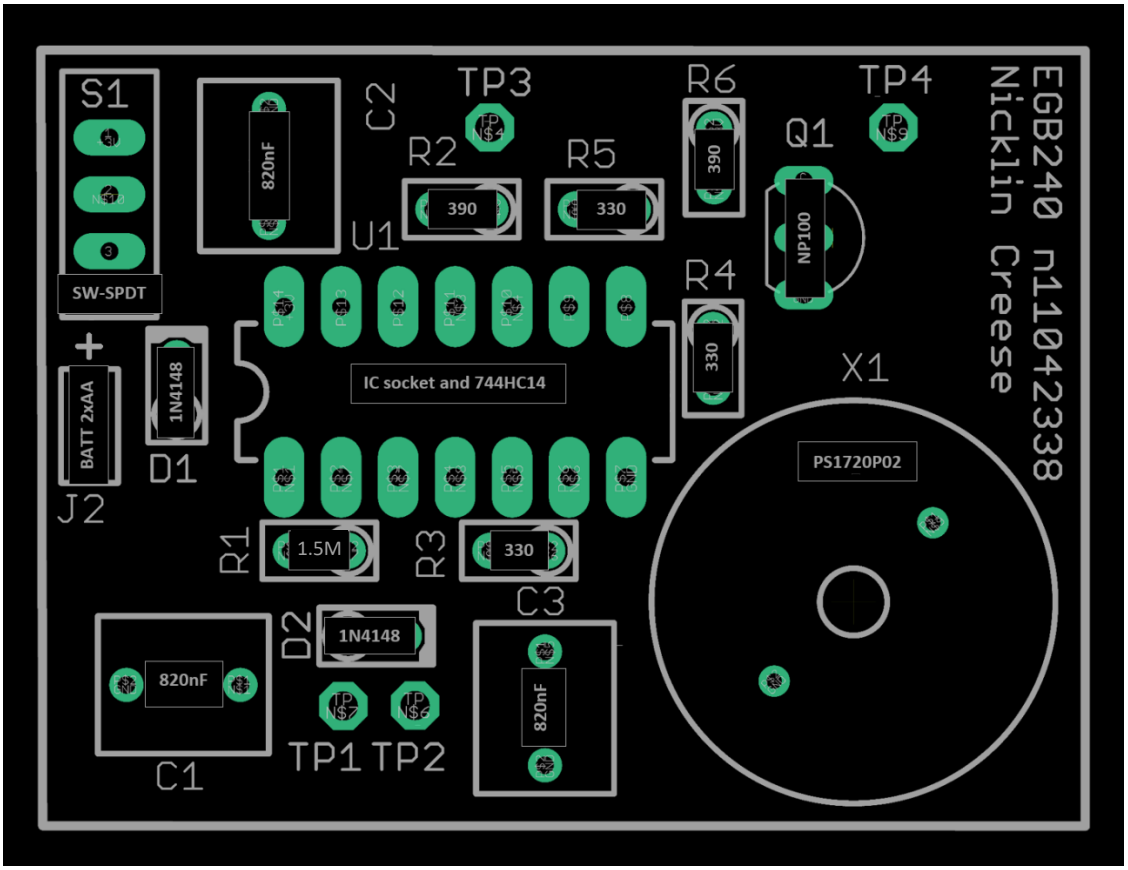


Figure 7: Assembly Overlay for PCB alarm circuit design

6. Photos of assembled prototype

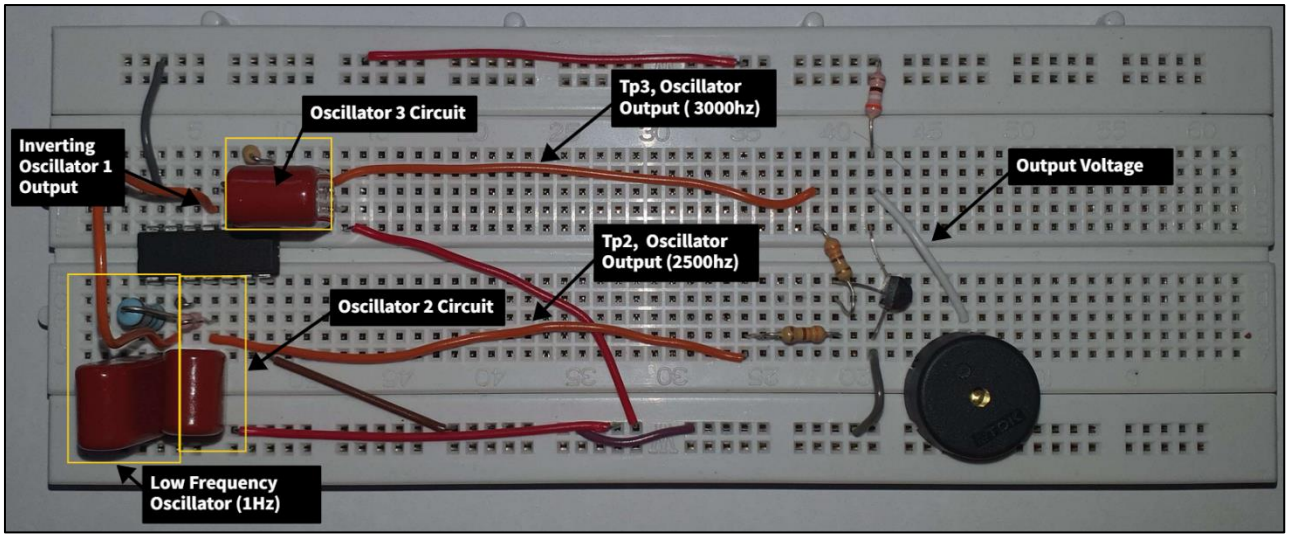


Figure 8: Photo 1, Labelled Prototype design (different 820nF capacitors used)

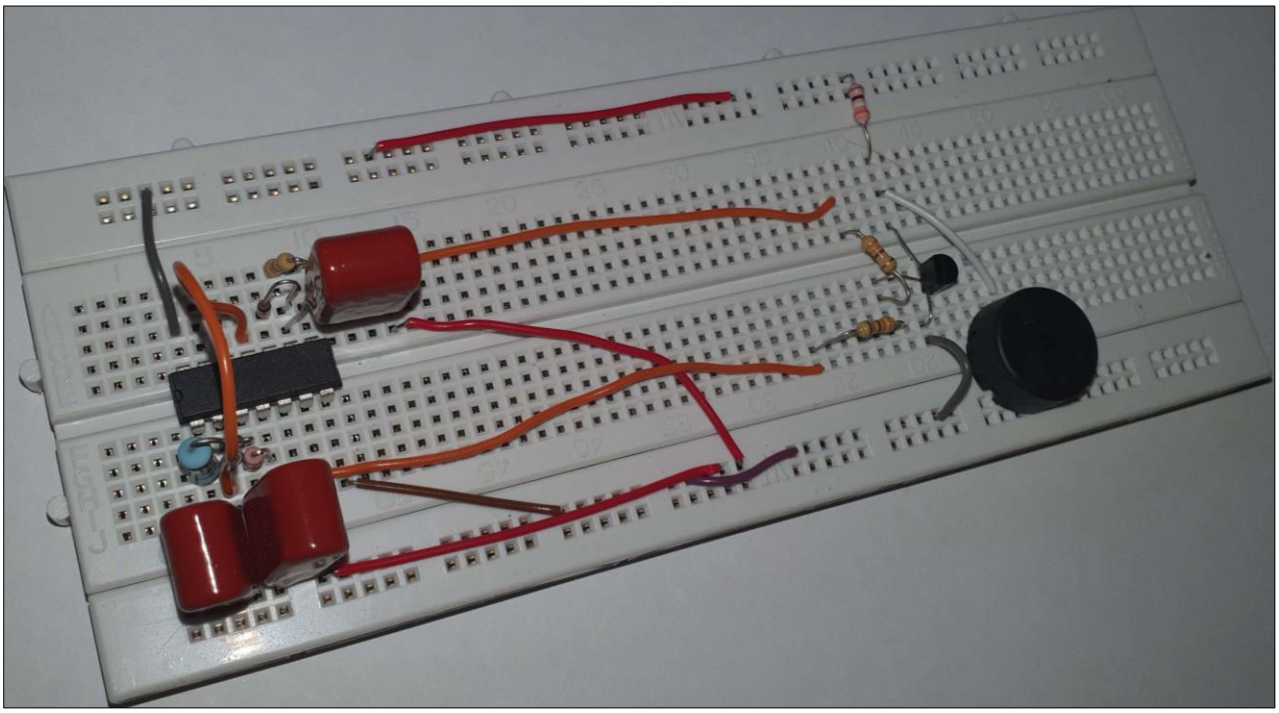


Figure 9: Photo 2 of prototype design

7. Simulation circuit and results

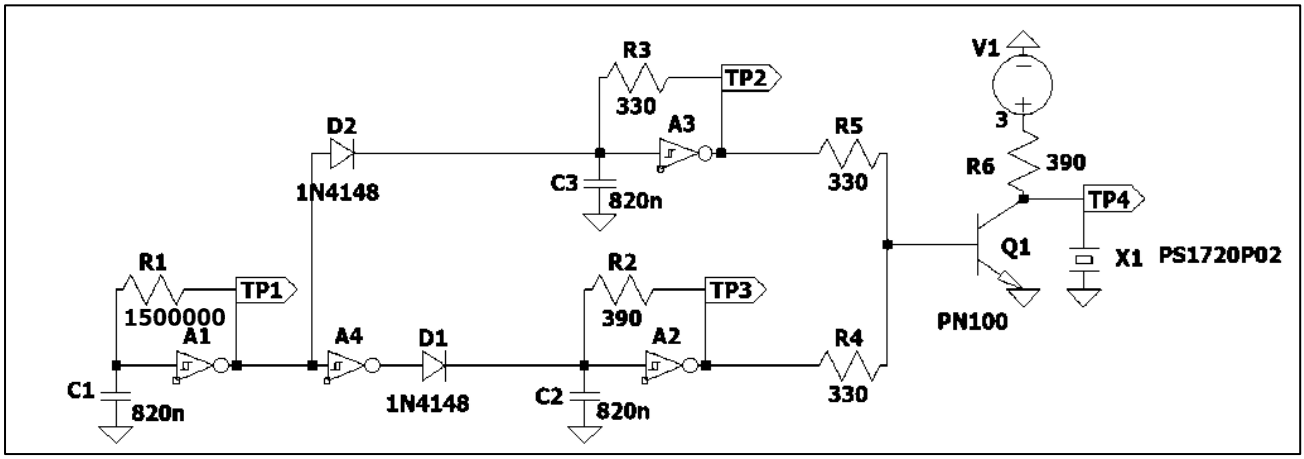
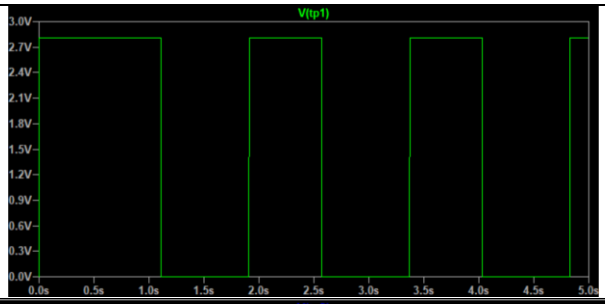
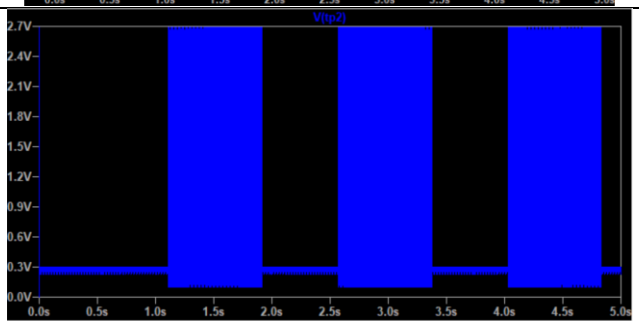
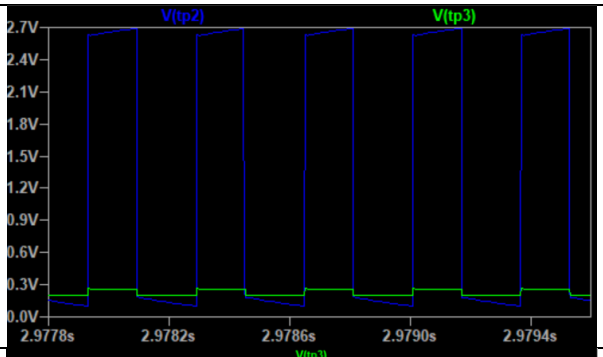
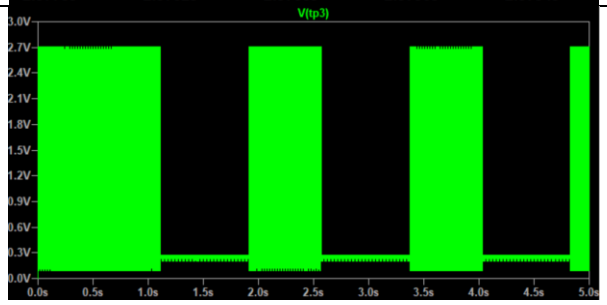
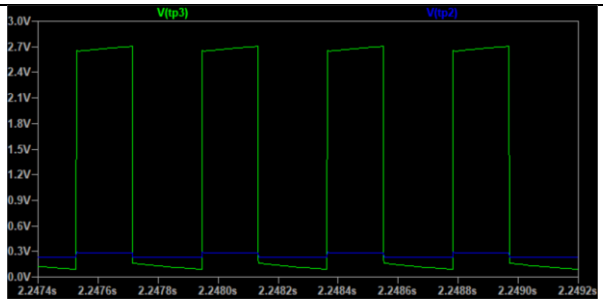


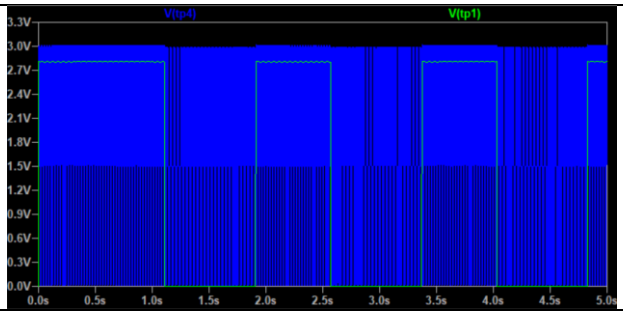
Figure 10: Finalized circuit in Lt spice for simulation.

```
R1 TP1 N003 1500000
A1 N003 0 0 0 0 TP1 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.40 td=31n
C1 N003 0 820n
R2 TP3 N005 390
A2 N005 0 0 0 0 TP3 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.40 td=31n
C2 N005 0 820n
R3 TP2 N001 330
A3 N001 0 0 0 0 TP2 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.40 td=31n
C3 N001 0 820n
A4 TP1 0 0 0 0 N004 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.40 td=31n
D2 TP1 N001 1N4148
V1 P001 0 3
R6 P001 TP4 390
R4 N002 TP3 330
R5 N002 TP2 330
XX1 TP4 0 PS1720P02
Q1 TP4 N002 0 0 PN100
D1 N004 N005 1N4148
.model D D
.lib C:\Users\Nicklin\AppData\Local\LTspice\lib\cmp\standard.dio
.model NPN NPN
.model PNP PNP
.lib C:\Users\Nicklin\AppData\Local\LTspice\lib\cmp\standard.bjt
.tran 0 5 0 100u uic
.include PS1720p02.sub
.model PN100 NPN (IS=50.8F NF=1 BF=292 VAF=156 IKF=0.3 ISE=22.4P NE=2 BR=4 NR=1 VAR=24 IKR=0.45
RE=0.103 RB=0.412 RC=41.2M XTB=1.5 CJE=15.2P VJE=1.1 MJE=0.5 CJC=7.1P VJC=0.3 MJC=0.3 TF=636P
TR=357N Vceo=45 Icrating=500m mfg=Fairchild)
.backanno
.end
```

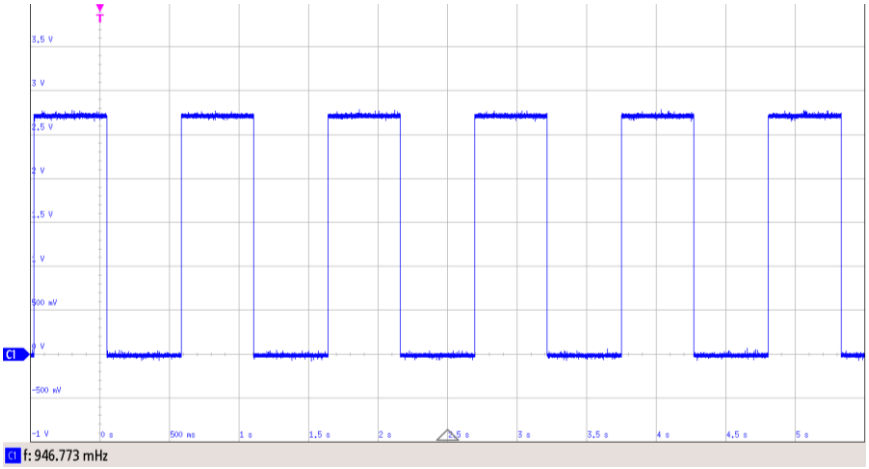
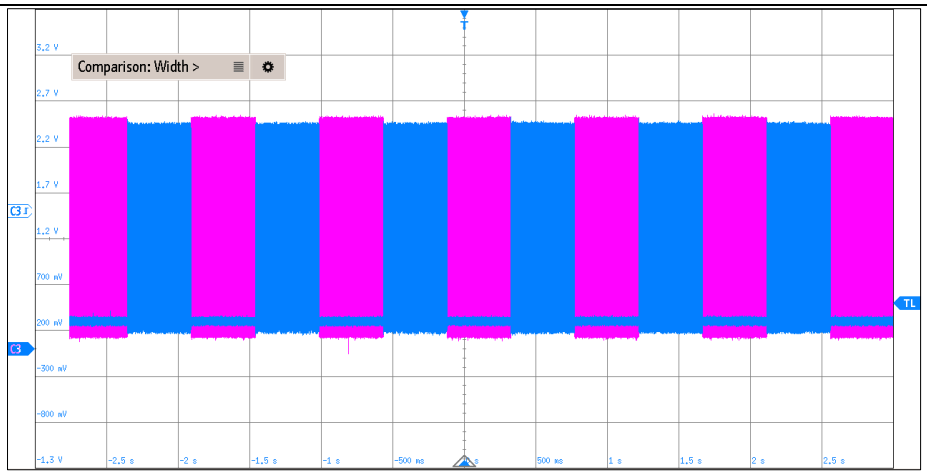
Figure 11: Netcode required for the circuit used.

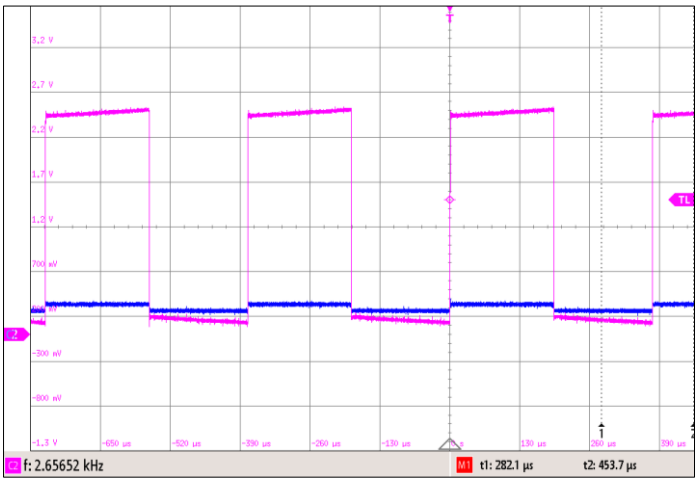
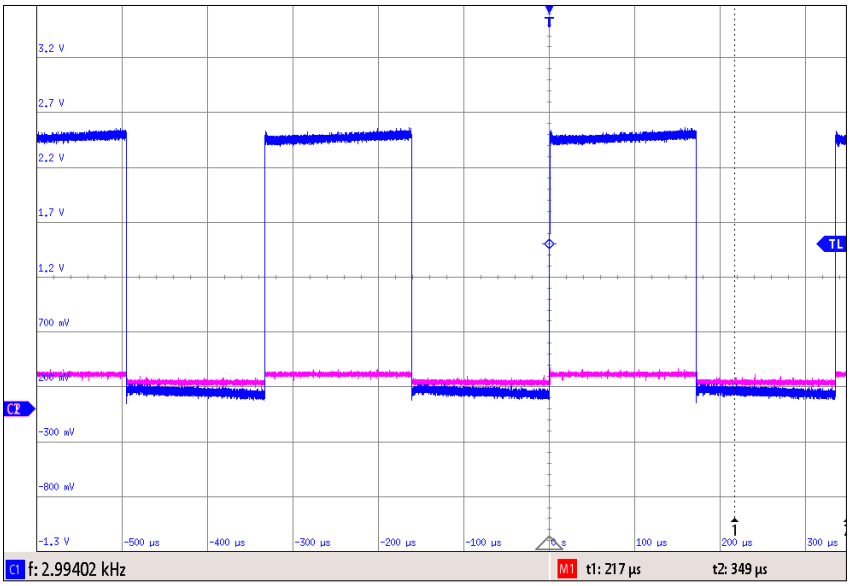
Table 3: Simulation Results and the netcode to reproduce data (.tran and .probe)

TP1	.tran 0 5 0 100u uic .probe V(tp1)		0.7Hz
TP2	.tran 0 5 0 100u uic .probe V(tp2)		2.76kHz
	(This will only produce the blue waveform) .tran 0 2.9794 2.9778 1u uic .probe V(tp2)		
TP3	.tran 0 5 0 100u uic .probe V(tp3)		2.378kHz
	(This will not produce the blue waveform aswell) .tran 0 2.2492 2.2474 1u uic .probe V(tp3)		

TP4 with TP1 Overlay	.tran 0 5 0 100u uic .probe V(tp4)				2.8kHz for 800ms then 2.378kHz for 655ms

8. Experimental results

Test Point used to generate waveform(s)	Image of waveform(s)
TP 1	 *Figure 12: Low Frequency Oscillator Waveform* The low frequencyoscillator realized in the circuit creates a square wave with frequency of approximately 1Hz. This would result in two tones a second. It can also be seen in figure 12, that the waveform is high aproximately the same amount of time that it is low.
TP 2 And TP 3	 *Figure 13: TP2 and TP 3 combined oscilloscope graph*

	This combined waveform shows the expected cycling between TP 2 and TP 3 which oscillate at two different frequencies. This is identical to meshing, the first simulation images of TP2 and TP3.  *Figure 14: TP2 is active, TP3 is off* This shows the frequency is of the 2.5kHz oscillator realized is running at 2.65kHz. It also shows the cycling is working as when TP2 (2.5kHz) oscillator is on and running, TP3(3kHz) oscillator is off.  *Figure 15: TP3 oscillator is active, TP 2 is unactive* Figure 14 shows the frequency of the 3kHz oscillator is 3kHz. Opposite to Figure 13, when TP3 (3kHz) oscillator is on and running, TP2(2.5kHz) oscillator is off.
TP4	These values were acquired at TP4, the output voltage

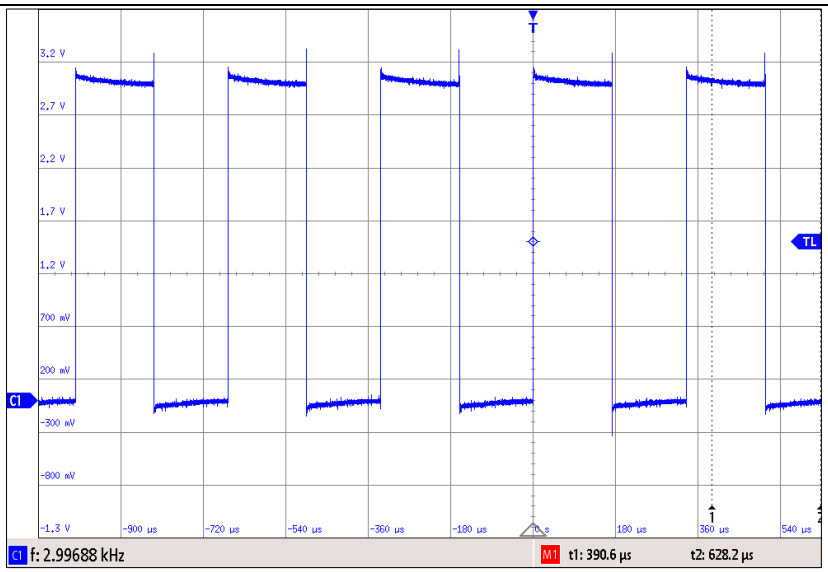


Figure 16: The 3kHz waveform in the output, TP4

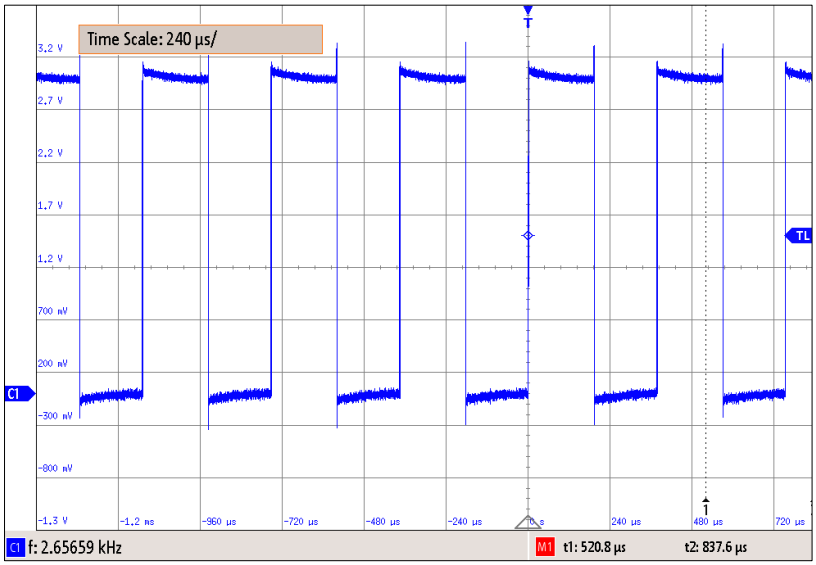


Figure 17: Waveform (2.65kHz) oscillator in the output TP4

The figure 15, and 16 show the output voltage is oscillating between 0-3V with frequency 2.65kHz and 3kHz.