EGB240 Electronic Design

Assessment 1: PCB Alarm Circuit Design Portfolio

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Executive Summary

This portfolio documents the design for a Two Tone Siren, which will be fabricated on a printed circuit board (PCB). The design will be constructed with the following specifications:

- Supplied with two AA batteries (3v supply)
- IC socket
- Activated from a slide switch (on-off)
- 2.67Khz and 3.28Khz tones switching at 2Khz (56.46, 41.67 duty cycle respectively)
- supply current 5mA, peak current 19mA.
- Physical size is 55.7 x 27.90 mm (excluding battery holder)

The two-tone siren will be constructed on the top side of the PCB, While the copper wires will be placed on the bottom, to minimise the layers reducing the cost.

Contents

1. Circuit schematic

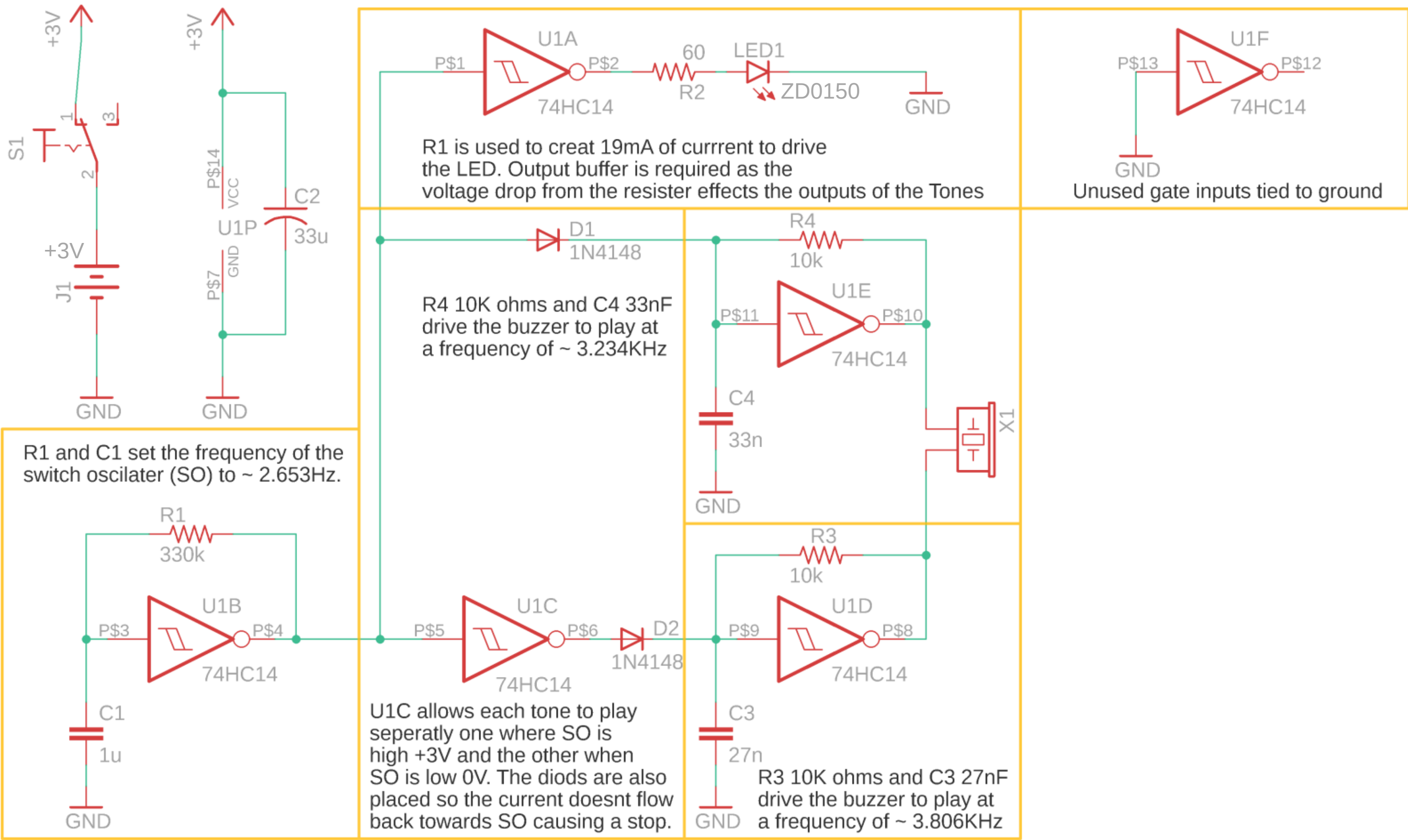


Figure 1: PCB Two-tone siren schematic, used to produce the PCB in figure 2.

2. Summary of design and operation

Items used in this project was the piezoelectric buzzer (PS1720P02) and The Hex Inverting Schmitt trigger IC (74HC14). The Schmitt trigger is operated by supplying 3V to the supply pin and 0V to the ground trigger which enables the ability to add Schmitt triggers to the circuit, enabling the ability to add oscillators within the circuit to create a two-tone siren circuit.

The piezoelectric buzzer can be used to create a tone supplying a 3V voltage at a specific frequency allowing the ability to create an audible frequency or even a low frequency to drive the switching between the two tones to create a two-tone siren.

The circuit I have created is a two-tone siren circuit with an added LED to emphasize the alarm behaviour. These behaviours were created using the piezoelectric buzzer and The Hex Inverting Schmitt trigger IC. In designing this circuit there is a Switching Oscillator circuit (SO) a low frequency at ~2Hz, to drive the transition between the frequencies (Tone 1, Tone 2). For these Tones to not be played at the same time another Schmitt trigger is placed in between one of the Tones and the Oscillating switch, which causes the two Tones to be out of phase of each other.

A bypass capacitor was added after noticing a distortion when turning on the Two-tone siren, caused by long lengths of wire creating parasitic inductance. this was fixed by implementing a bypass capacitor from the positive and negative pins of the Schmitt trigger IC. However, now when turning off the capacitor a discharge like sound was created by the large capacitance of the 33uF capacitor therefore It has since been changed to 10uF to minimise these effects.

For visual feedback I added a red LED I first added this without another Schmitt trigger however it was causing a voltage drop on the tone generators due to the resistance I needed to power the LED. To fix this issue I put a Schmitt trigger before the resister and the LED to avoid a voltage drop across the tone generators, I used a 60ohm resister at 3 volts to create 19-amp current which was more than enough to power the bulb.

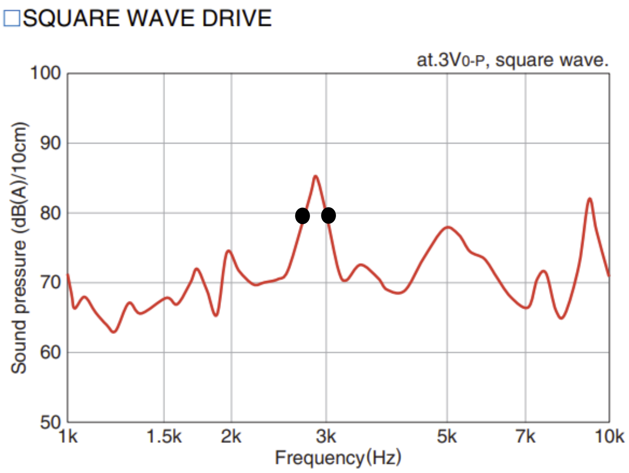
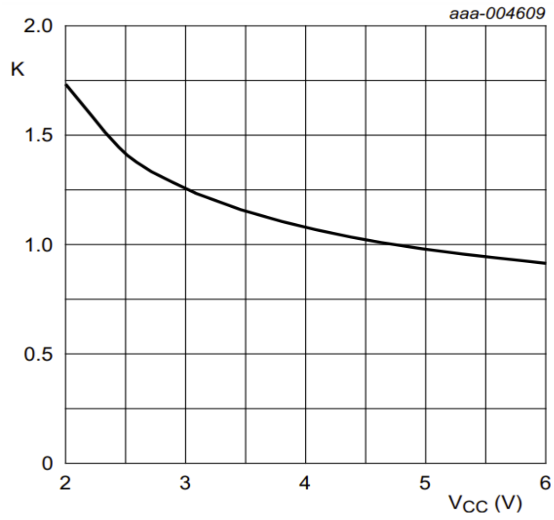


Diagram 1: decibels produced from different frequency from the buzzer.

When designing the two-tone siren, the frequencies used to create a tone is important. From diagram 1 I chose to use a frequency that had a high decibel range, considering the fact that the frequencies can be close enough in values to still be distinguished by the user. Tone 1 was chosen to be 3.28KHz and tone 2 2.67KHz. As indicated by the black dots.



To calculate the frequencies a K value must be determined from a diagram from the Schmitt trigger diagram. In diagram 2 it shows a value of K respect to the supplied voltage. In this case the system is powered by 2 AA batteries creating 3V therefore the diagram shows the K value being 1.25. To then calculate the frequency the following formular can be used to select an appropriate resister then working backwards to find the desired frequencies.

Diagram 2: constant value K dictated by the amount of voltage supply used to produce frequency calculations.

$$f = \frac{1}{T} \approx \frac{1}{K \times RC}$$

Equation 1: used to calculate frequencies from a specific supply voltage, resister, and capacitor.

Using the following formular I can determine a value closes to 3.28KHz and 2.67KHz provided the components within QUT S9 resources:

$$2.05Hz = \frac{1}{1.25 \times (390 \times 10^{3}) \times (1 \times 10^{-6})}$$

$$2.424KHz = \frac{1}{1.25 \times (10 \times 10^{3}) \times (33 \times 10^{-9})}$$

$$2.962KHz = \frac{1}{1.25 \times (10 \times 10^{3}) \times (27 \times 10^{-9})}$$

Using the resister and capacitor values to plug into the schematic will create an output frequency that will be used to create a two-tone siren. For any modifications for the two-tone siren the following diagrams and calculation can be used to create a desired frequency.

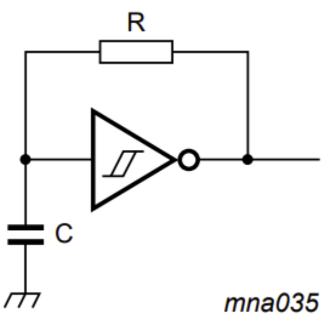


Diagram 3: Layout used to produce an output frequency.

3. PCB layout

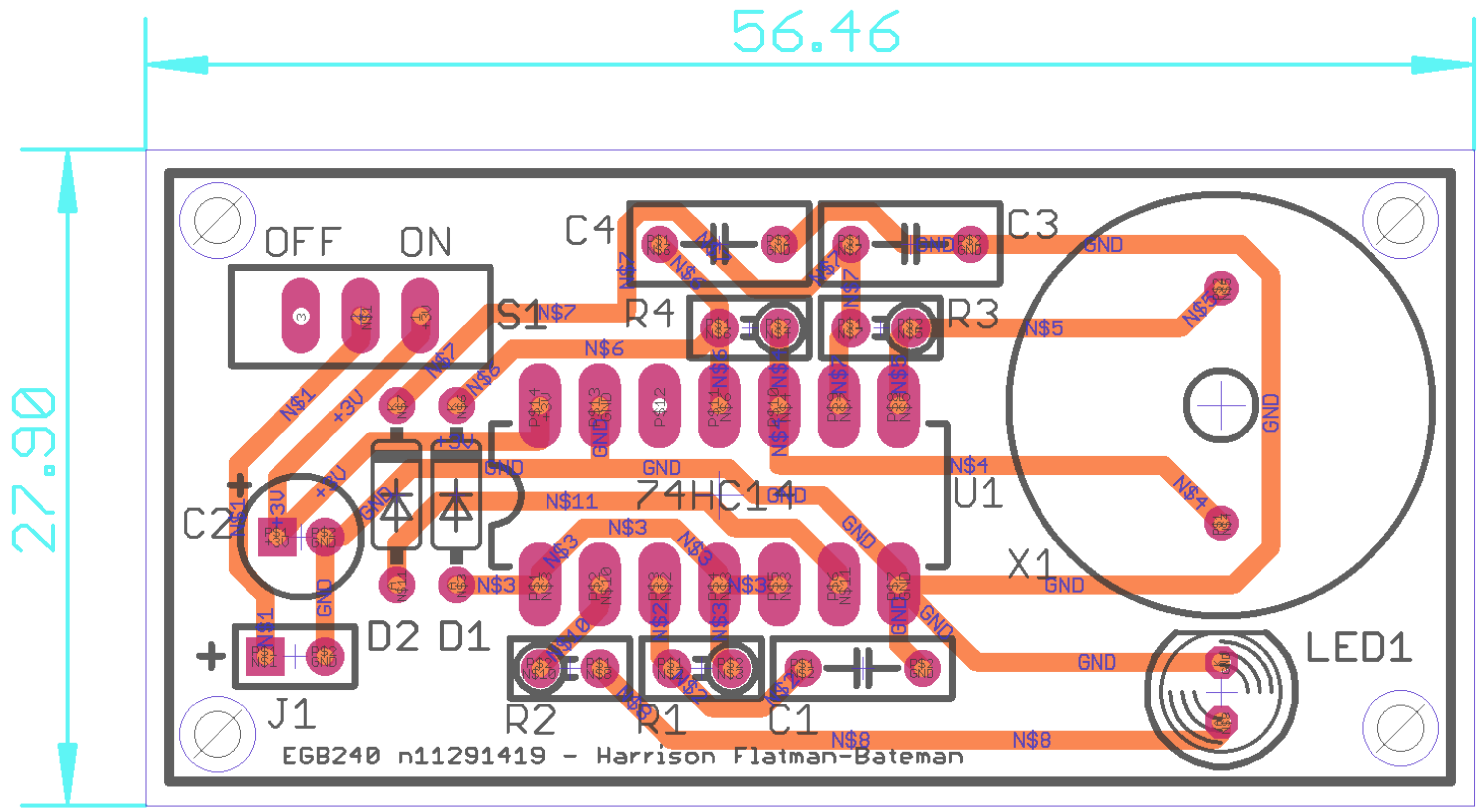


Figure 2: PCB circuit of the two-tone siren showing the size of the board in mm.

4. Bill of materials

Designator	Value	Description	Qty	Footprint
C1	1u	Capacitor, Radial, Non-polarised, 1uF 35V 12%, 5mm pitch	1	CAP-DISC-P5.08
C2	33u	Capacitor, Radial, Polarised, 33u 50V, 3.5mm pitch	1	CAP-RB-P2.0-D5.0
C3	27n	Capacitor, Radial, Non-polarised, MKT, 27nF 100V 10%, 5mm pitch	1	CAP-DISC-P5.08
C4	33n	Capacitor, Radial, Non-polarised, MKT, 33nF 100V 10%, 5mm pitch	1	CAP-DISC-P5.08
D1	1N4148	Diode, 100V 150mA, DO-35	1	DO35-P7.62
D2	1N4148	Diode, 100V 150mA, DO-35	1	DO35-P7.62
LED1	LED	LED, RED 8mcd Round diffused, 20mA fc, 1.8v fv, 5mm diameter	1	ZD0150
J1	3V	Battery holder, 3V, 2xAA, flying leads	1	BATT-3V
R1	330k	Resistor, Axial, Carbon Film, 330K 5% 0.25W	1	AXIAL-P2.54
R2	60	Resistor, Axial, Metal Film, 62 1% 0.25W	1	AXIAL-P2.54
R3	10K	Resistor, Axial, Carbon Film, 10K 1% 0.25W	1	AXIAL-P2.54
R4	10K	Resistor, Axial, Carbon Film, 10K 1% 0.25W	1	AXIAL-P2.54
S1		Switch, SPDT, Slide, On-On, 0.1" pitch	1	SS-12
U1	74HC14	Hex Schmitt trigger INVERTER, DIP-14	1	DIP-14
U1	IC socket	IC socket, DIP-14	1	DIP-14
X1	PS1720P02	Piezoelectonic buzzer	1	PS1720P02

Designator	Manufacturer	MPN	Supplier	SKU	MOQ	Price
C1	Generic	Capacitor, Radial, Non-polarised, 1uF 35V 12%, 5mm pitch	Jaycar	RZ6628	1	0.75
C2	Generic	Capacitor, Radial, Polarised, 33u 50V, 3.5mm pitch	Jaycar	RY6818	1	1.15
C3	Generic	Capacitor, Radial, Non-polarised, MKT, 27nF 100V 10%, 5mm pitch	Jaycar	RG5090	1	0.3
C4	Generic	Capacitor, Radial, Non-polarised, MKT, 33nF 100V 10%, 5mm pitch	Jaycar	RM7095	1	0.35
D1	NXP	1N4148	Jaycar	ZR-1100	1	0.95
D2	NXP	1N4148	Jaycar	ZR-1100	1	0.95
LED1	Generic	LED, RED 8mcd Round diffused, 20mA fc, 1.8v fv, 5mm diameter	Jaycar	ZD0150	1	0.4
J1	Generic	Battery holder, 3V, 2xAA, flying leads	Jaycar	PH-9202	1	1.6
R1	Generic	Resistor, Axial, Carbon Film, 330K 5% 0.25W	Jaycar	RR2834	1	0.68
R2	Generic	Resistor, Axial, Metal Film, 62 1% 0.25W	Jaycar	RR0543	1	0.85
R3	Generic	Resistor, Axial, Carbon Film, 10K 1% 0.25W	Jaycar	RR2798	1	0.68
R4	Generic	Resistor, Axial, Carbon Film, 10K 1% 0.25W	Jaycar	RR2798	1	0.68
S1	NKK Switches	SS12SDP4	Digi Key	360-2922-ND	1	4.94
U1	Texas Instruments	SN74HC14N	Jaycar	ZC-4821	1	2.75
U1	Texas Instruments	IC socket, DIP-14	Jaycar	PI-6501	1	0.5
X1	TDK	PS1720P02	Element14	1669968	1	1.35

5. Assembly overlay

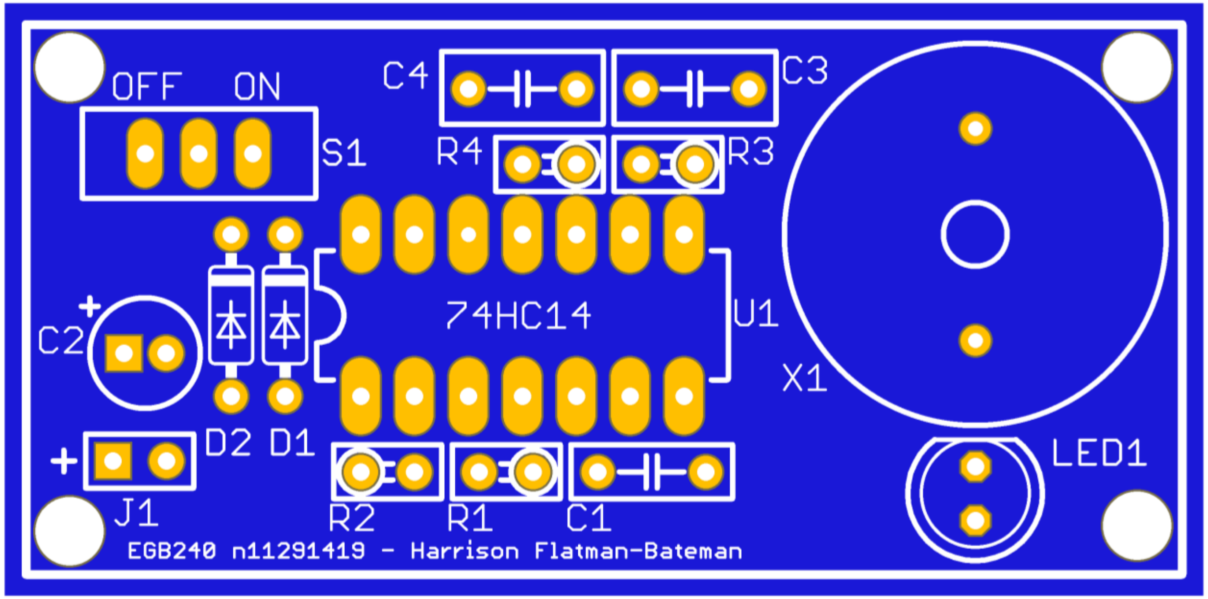


Figure 3: Assembly overlay and instructions for two-tone siren.

When constructing the board, it is important that the respected diode and other polarised components face their respected positions. This can be dictated by the thick line for a diode and a positive icon for a polarised capacitor. It is also important to Solder in the IC socket before implementing the Schmitt trigger IC, this allows the IC to be easily replaced or removed when required.

M3 bolt size holes have been produced for an industry standard mounting option. with a 3.2mm diameter hole to account for any clearance issues.

6. Photos of assembled prototype

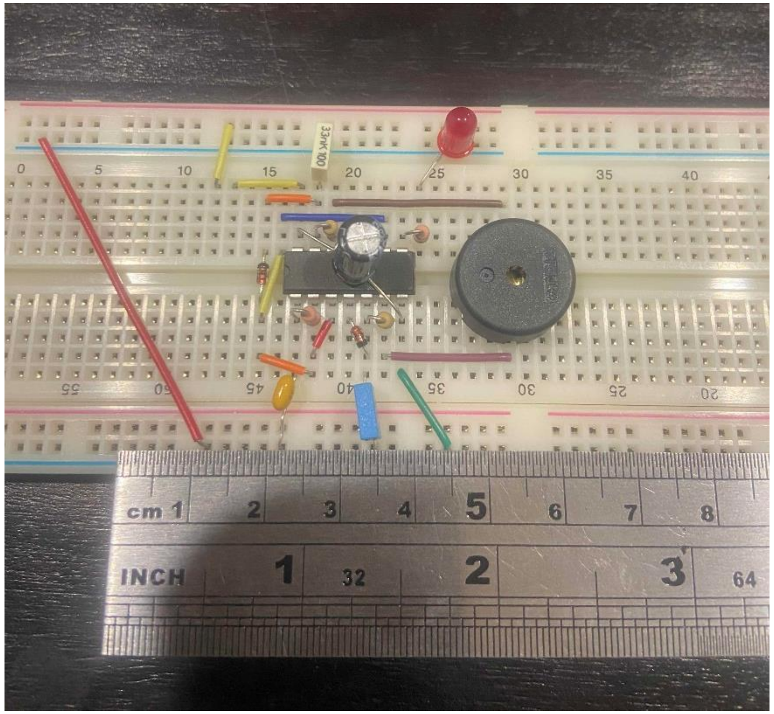


Figure 4: Horizontal view of prototype two-tone siren constructed on a bread board Scale in mm.

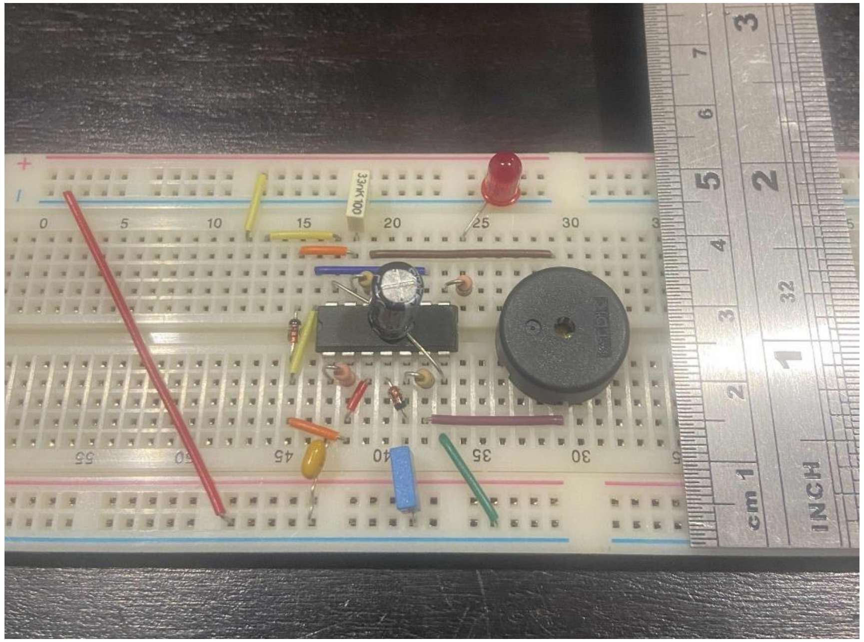


Figure 5: Vertical scale of two-tone siren prototype showing the supply connections (yellow 3V, green 0V) scale in mm.

7. Simulation circuit and results

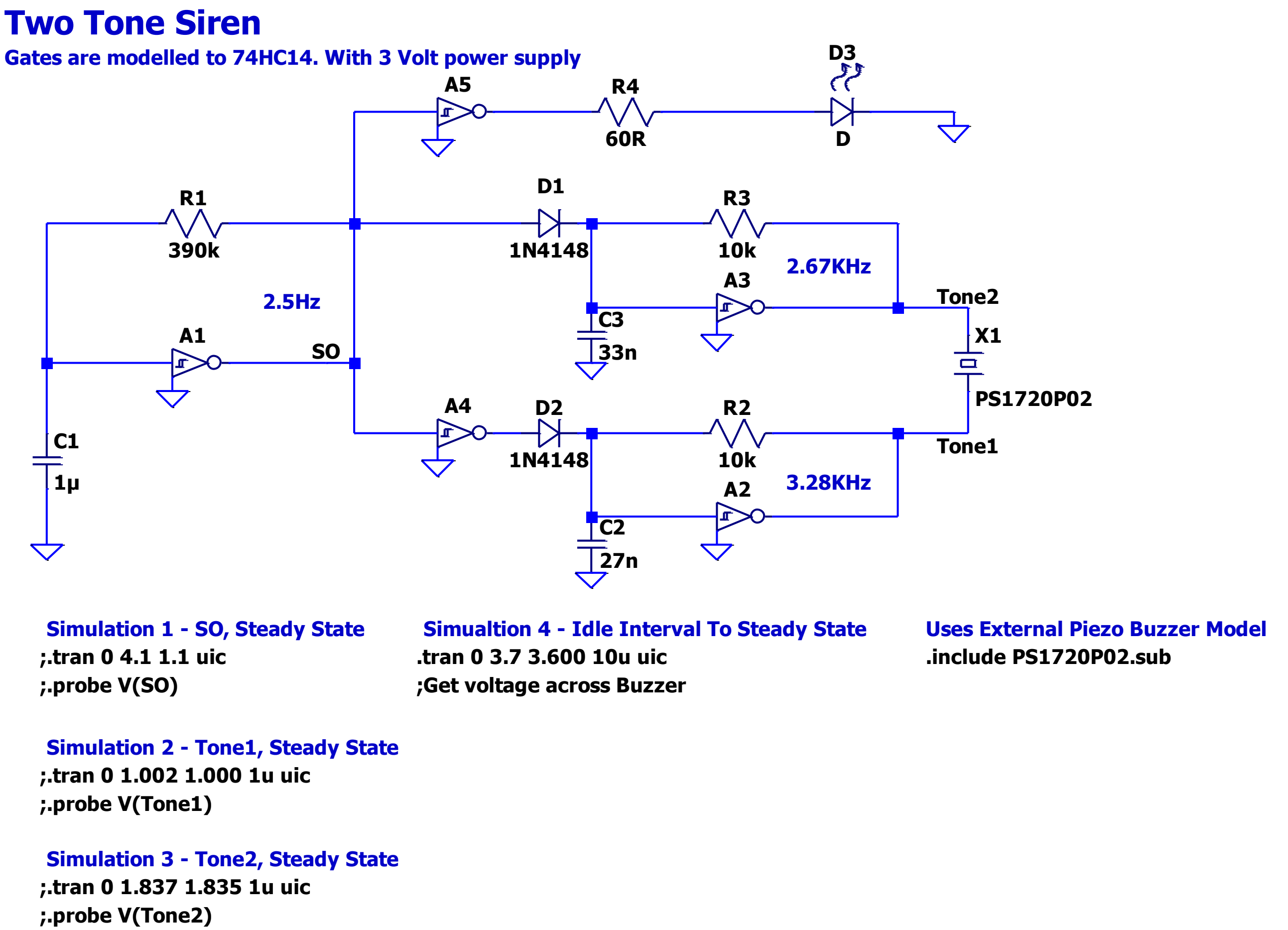


Figure 6: Ltspice circuit used to aid in construction and run simulations on the oscillators. Testing parameters included and component values to reproduce.

```
* Two Tone Siren

* Simulation 1 - SO, Steady State
.tran 0 4.1 1.1 uic
.probe V(SO)
* 2Hz

* Simulation 2 - Tone1, Steady State
;.tran 0 1.002 1.000 1u uic
;.probe V(Tone1)
* 3.28KHz

* Simulation 3 - Tone2, Steady State
;.tran 0 1.837 1.835 1u uic
;.probe V(Tone2)
* 2.67KHz

* Gates are modelled to 74HC14. With 3 Volt power supply
R1 SO N003 390k
A1 N003 0 0 0 0 SO 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.4 td=31n
C1 N003 0 1Âµ
R2 Tone1 N006 10k
A2 N006 0 0 0 0 Tone1 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.4 td=31n
C2 N006 0 27n
R3 Tone2 N004 10k
A3 N004 0 0 0 0 Tone2 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.4 td=31n
C3 N004 0 33n
A4 SO 0 0 0 0 N005 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.4 td=31n
D1 SO N004 1N4148
D2 N005 N006 1N4148
XX1 Tone2 Tone1 PS1720P02
R4 N001 N002 60R
D3 N002 0 D
A5 SO 0 0 0 0 N001 0 0 SCHMITT Vhigh=3 Rhigh=34 Rlow=41 Cout=200p Vt=1.27 Vh=0.4 td=31n
.model D D

.lib C:\Users\Harrison\AppData\Local\LTspice\lib\cmp\standard.dio

* Uses External Piezo Buzzer Model
.include PS1720P02.sub

.backanno
.end
```

Figure 7: Ltspice netlist for circuit in figure 6.

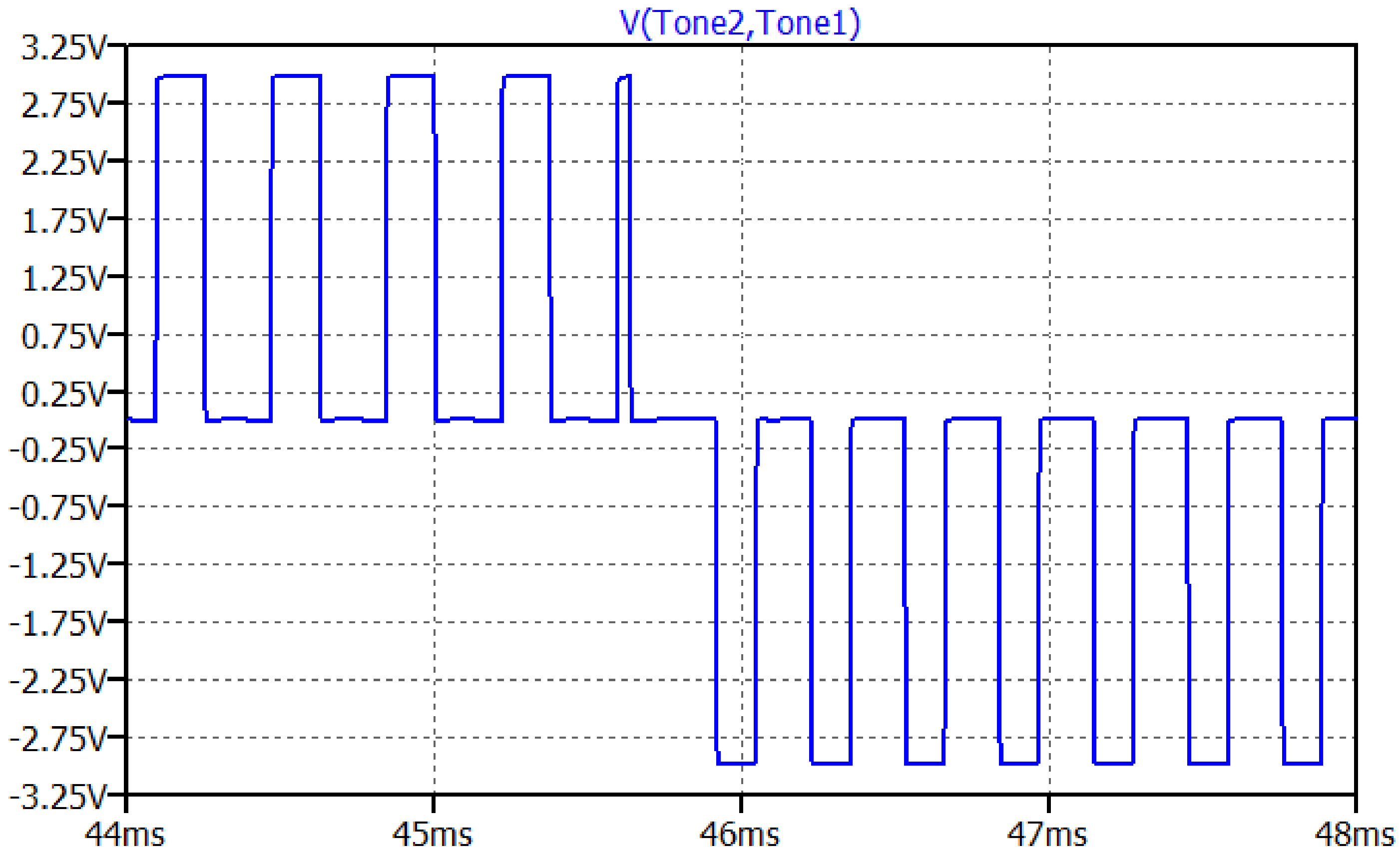


Figure 8: Plot of the voltage across the buzzer showing the correlation between the oscillating switch and the two tones.

Figure 8 shows the switch changing, causing the tone from the buzzer changing from 2.67KHz to 3.28KHz causing Tone 1 from figure 6 to flow in the opposite direction showing the buzzers peak at -3V after 46ms.

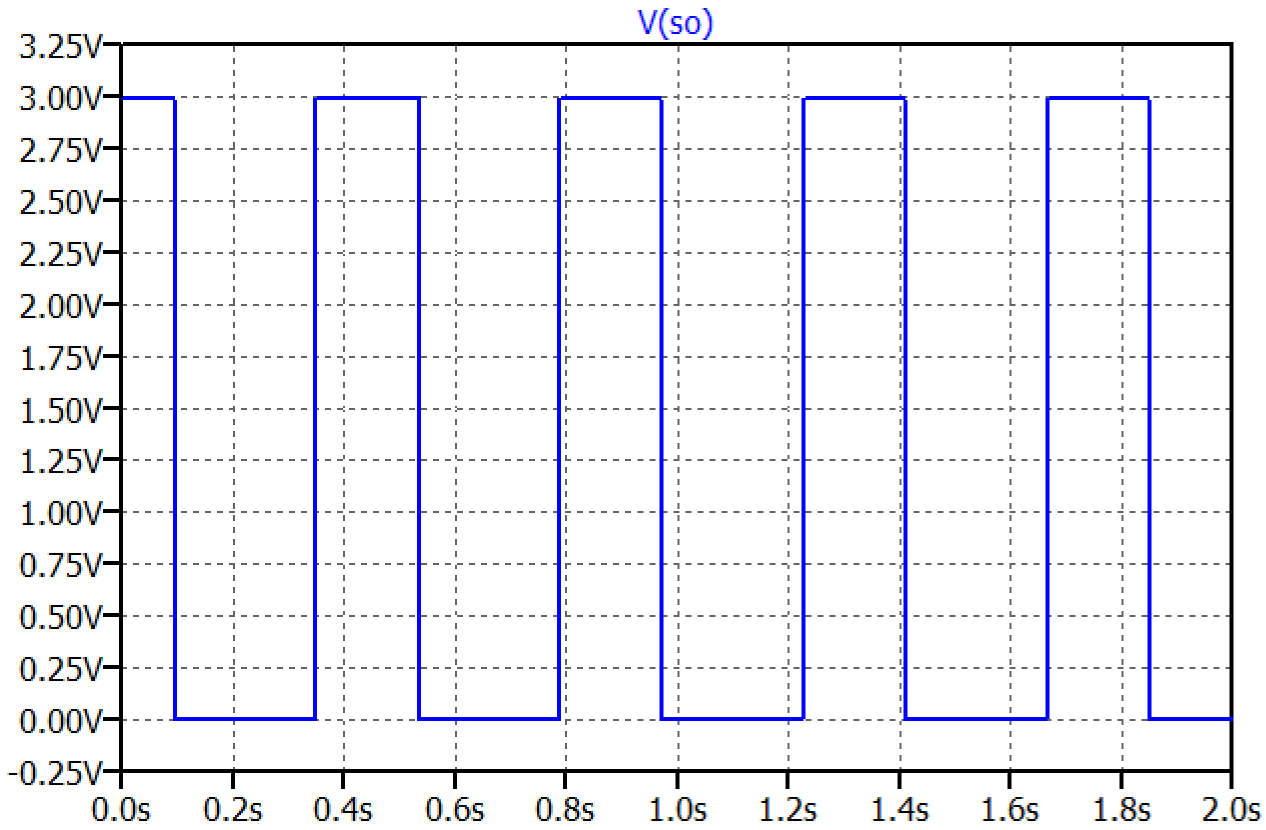


Figure 9: Plot of the oscillating switch that controls when the tones switch driving the two tones to play separately.

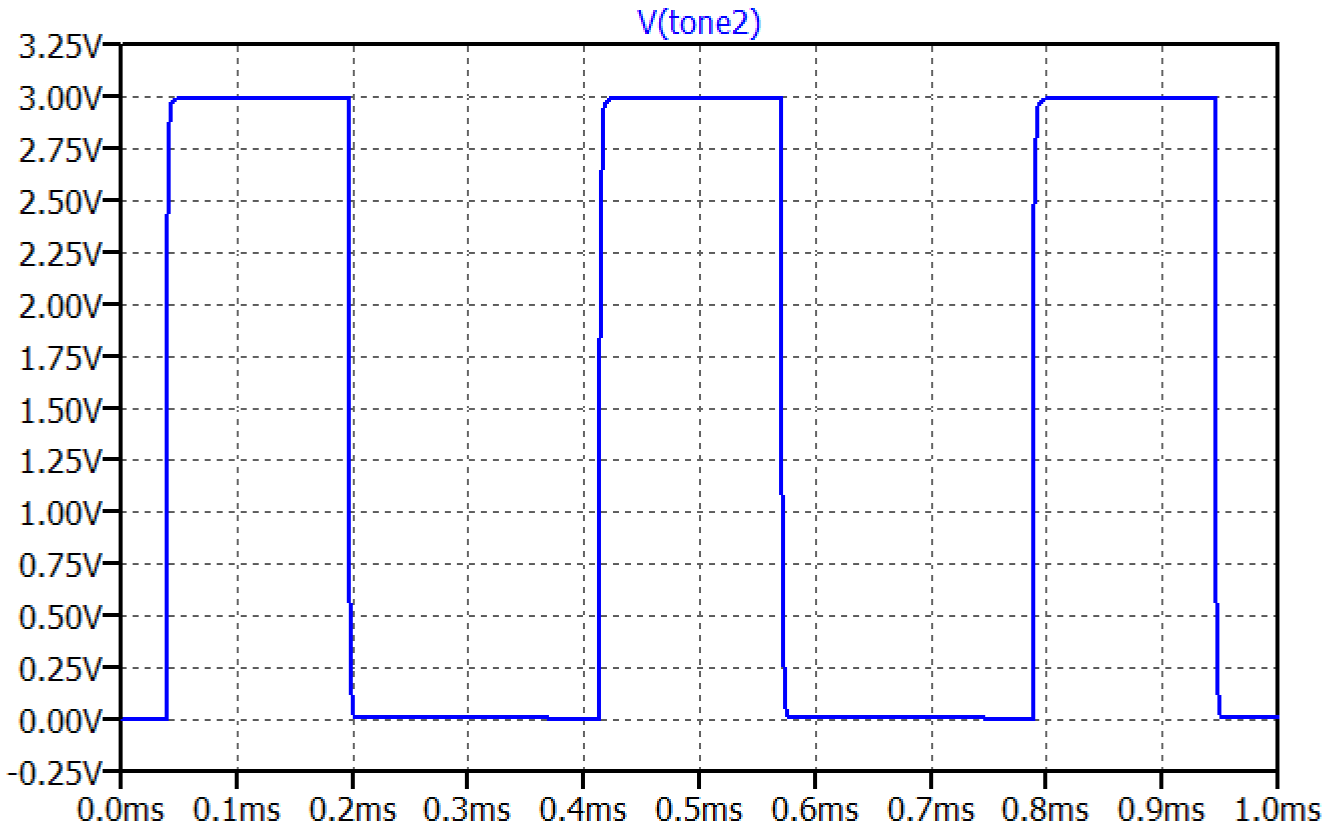


Figure 20: Shows tone 2 with a frequency of 2.67KHz and a duty cycle of 46.67%

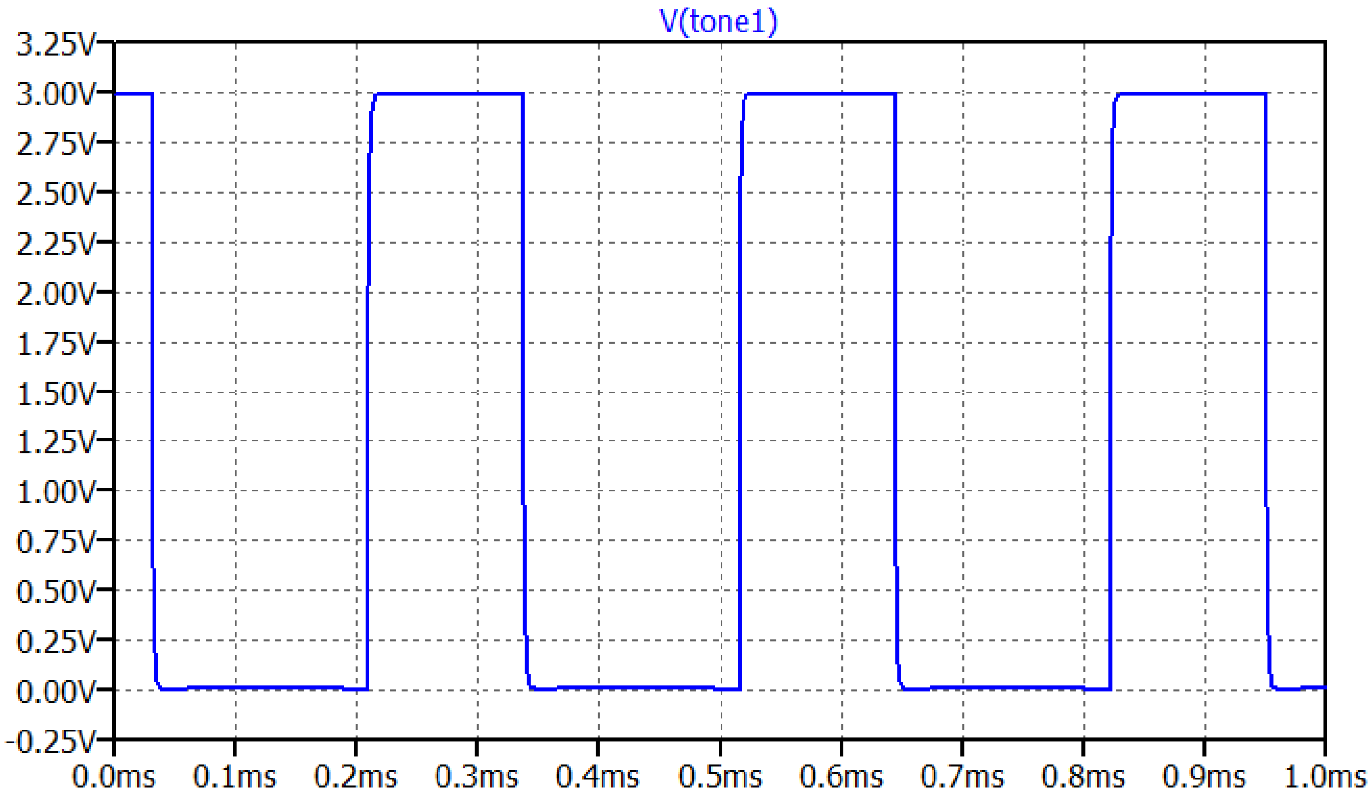


Figure 11: Shows tone 1 with a frequency of 3.28KHz and a duty cycle of 41.67%

8. Experimental results

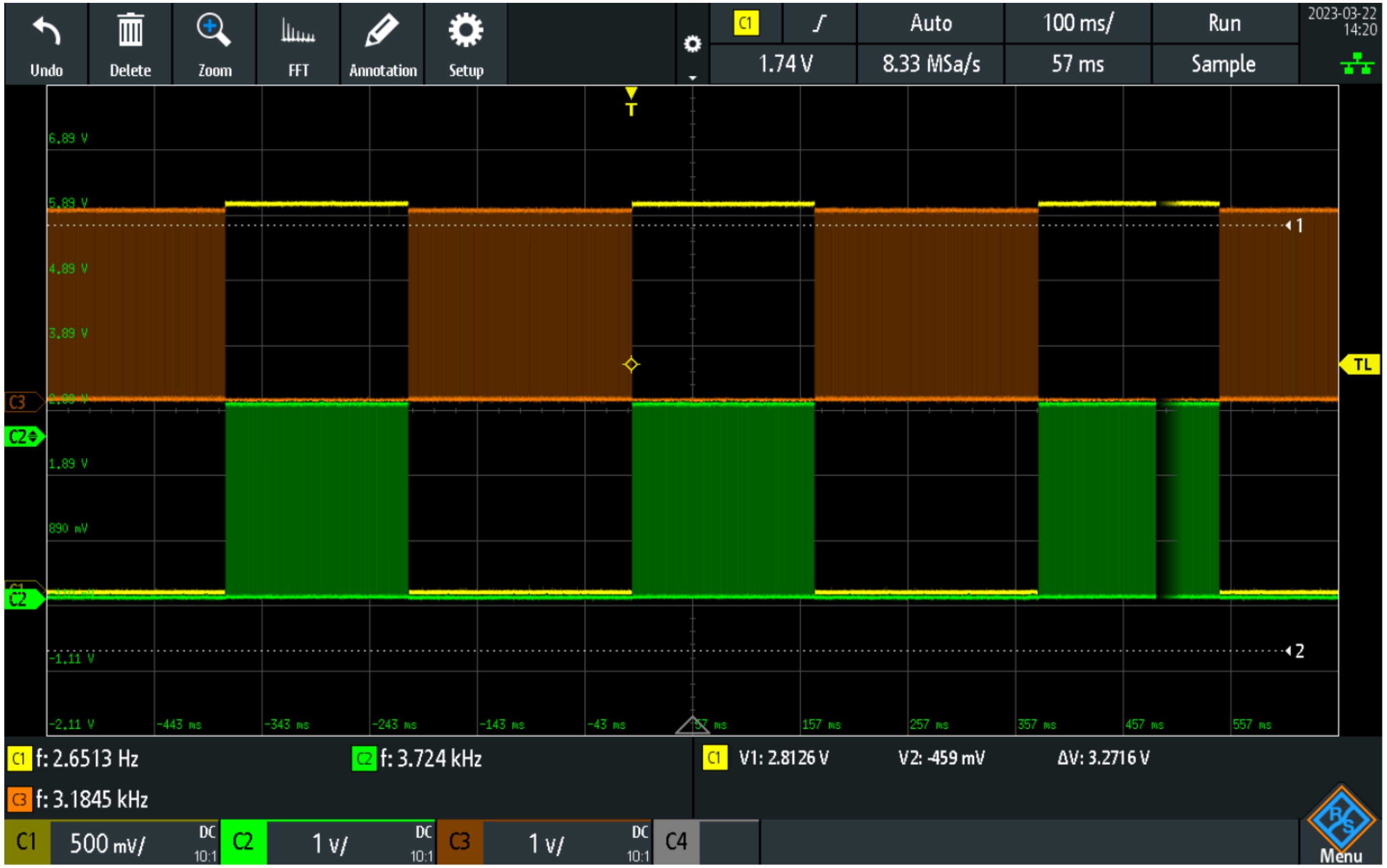


Figure 13:The oscilloscope captures the relations between the switching oscillator and two tones generated by the IC.

As the switching oscillator is driven low (0V) Tone 2 from figure 6 is switched on and generates a frequency of 3.184Khz for the buzzer. When the switch is driven high to 3V, Tone 1 is then turned off and Tone 1 starts playing with a frequency of 3.724KHz.

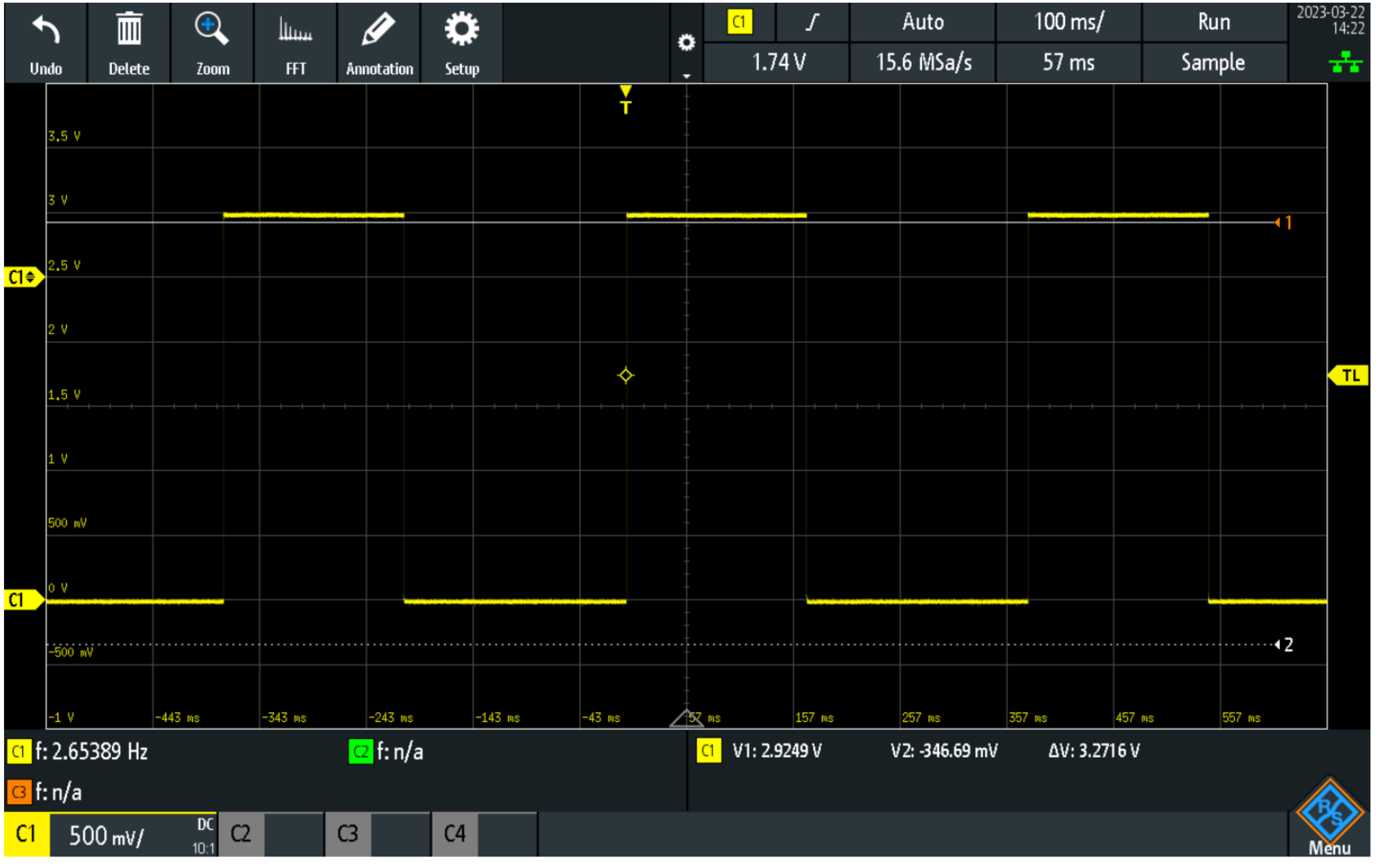


Figure 14: Captured on the oscilloscope shows the oscillating switch, at a frequency of 2.653Hz and a duty cycle of 44.82%

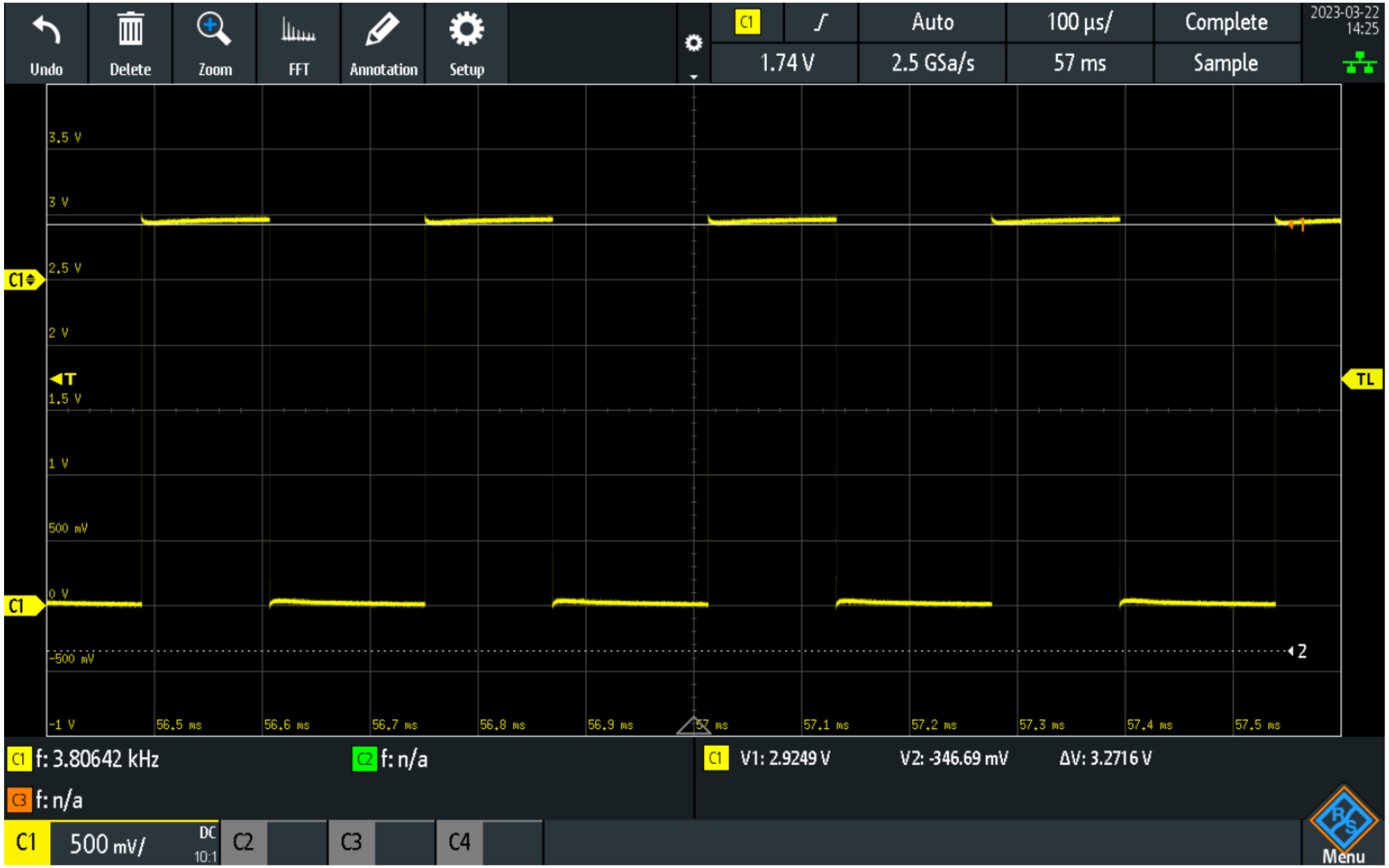


Figure 15: captures tone 1 from figure 6 with a frequency of 3.806KHz and a duty cycle of 41.67%

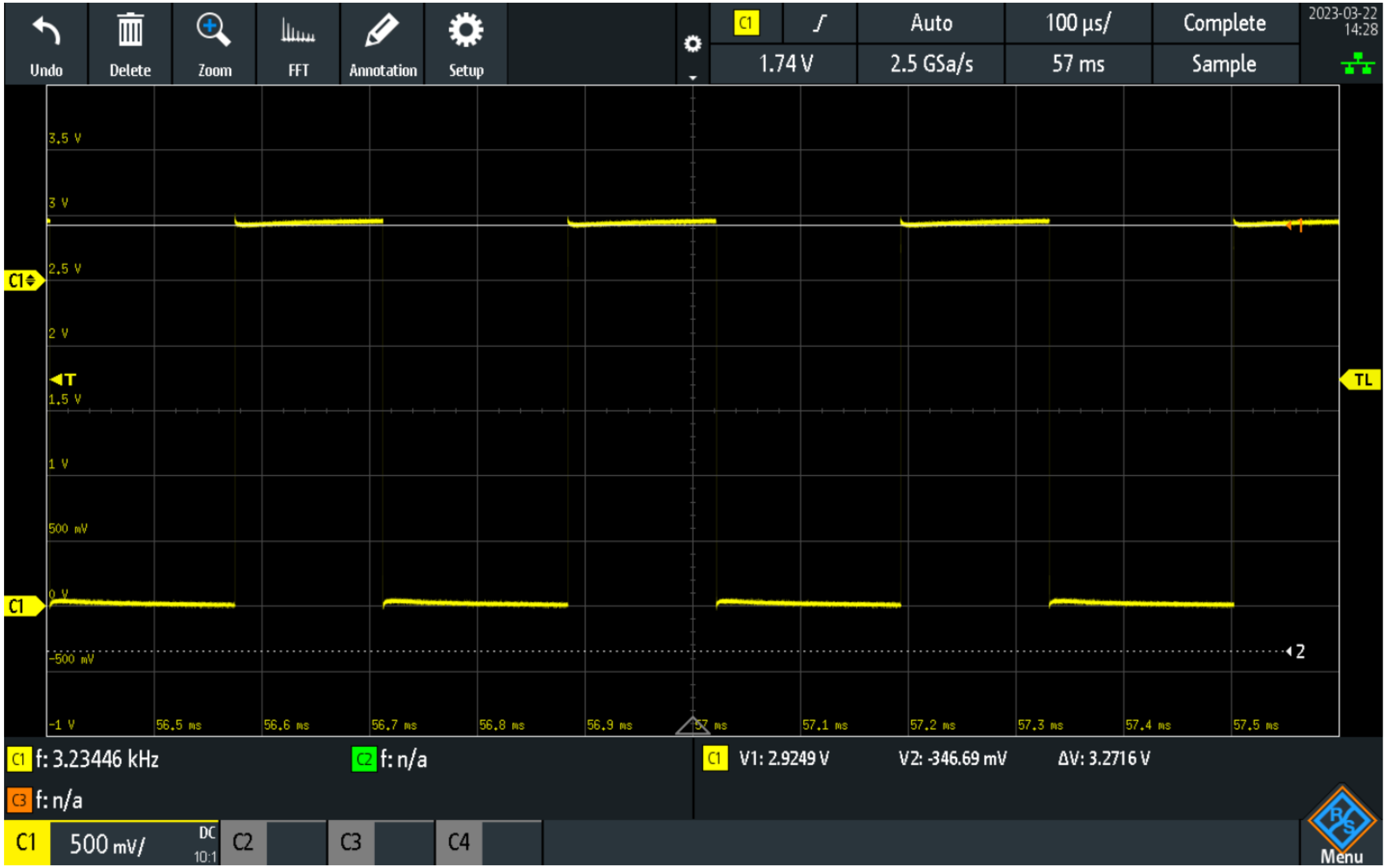


Figure 16:Ccaptures tone 2 from figure 6 with a frequency of 3.234KHz and a duty cycle of 46.67%