# LAB NOTE

**Subject: Electronic Design Principles**

**Topic: Astable Multivibrator**

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# 1. Objectives

To create a working Astable Multivibrator using 2 BJTs, LEDs and capacitors.

Step 1: Design and calculate the equipment in the circuit.

Step 2: Simulate the result in Multisim to test the theory.

Step 3: Build the circuit based on theory and Multisim design.

# 2. Theory and Design

## 2.1 Theory

Astable-Multivibrator basically is used to generate the square waves at a desired frequency without any external intervention.

## 2.2 Design and Calculation

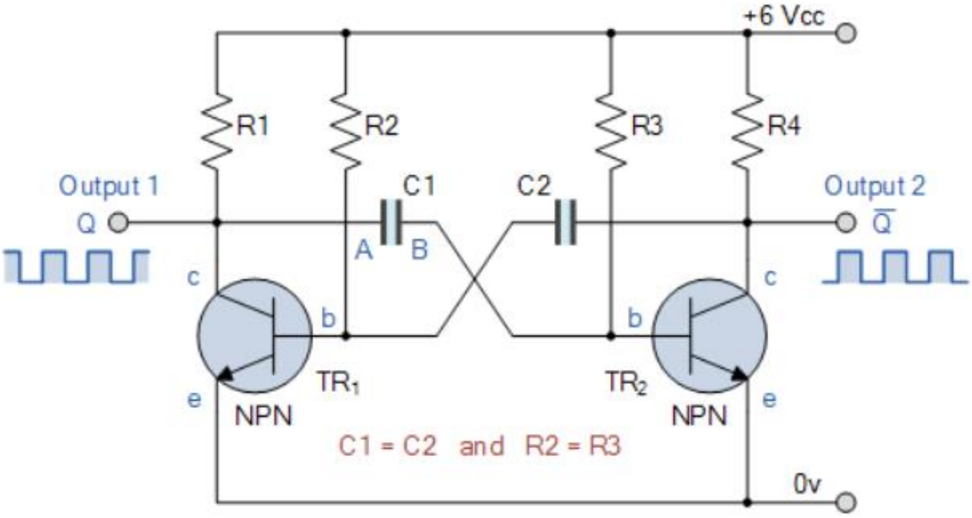


Figure 2-1: Astable Multivibrator Circuit

For this design the following equipment are use:

- 4 Resistor
- 2 Capacitor
- 2 BJT Transistors
- Power Supply

Astable Multivibrator’s Periodic time (for Output 1):

$$\begin{cases} T = t_1 + t_2 \\ t_1 = ln(2) \times R_2 \times C_2 \\ t_2 = ln(2) \times R_3 \times C_1 \end{cases} \tag{2.1}$$

*Equation 2-1: Astable Multivibrator's Periodic time formula*

For this assignment, 5 sample frequencies will be tested.

# 3. Result

## 3.1 16 Hz

### 3.1.1 Calculation for equipment

Because $R_2 = R_3$ and $C_1 = C_2$ so,

$$t_1 = t_2 = ln(2) \times R_2 \times C_2$$

To design an Astable Multivibrator with frequency of 16Hz, the periodic time will be:

$$T = \frac{1}{f} = \frac{1}{16\ Hz} = 62.5\ (ms)$$

So $t_1$ and $t_2$ will be.

$$T = t_1 + t_2 = 2 \times t_1$$

$$t_1 = \frac{T}{2} = 31.25\ (ms)$$

From the result, choosing $R_2 = 47k\Omega$ and $C_2 = 1\mu F$ will give the closest time:

$$t_1 = ln(2) \times R_2 \times C_2 = 32.5\ (ms)$$

$$f = \frac{1}{T} = \frac{1}{2 \times t_1} = 15.38\ (Hz)$$

### 3.1.2 Multisim Design

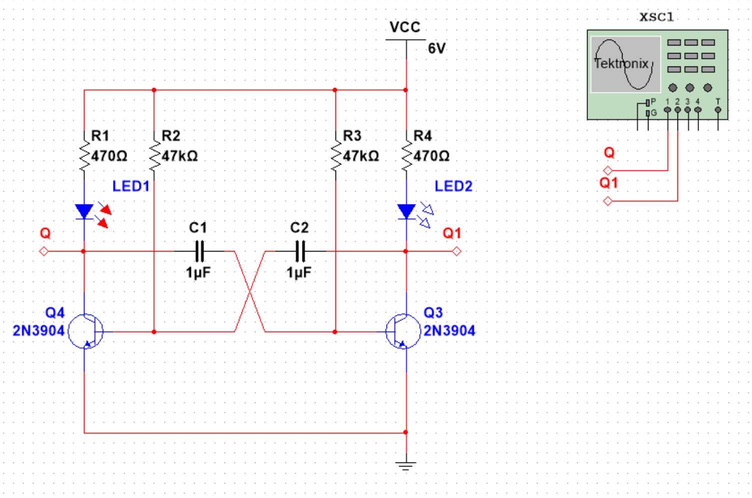


Figure 3-1: Circuit design with R = $47k\Omega$ and C = $1\mu F$

## 3. Result

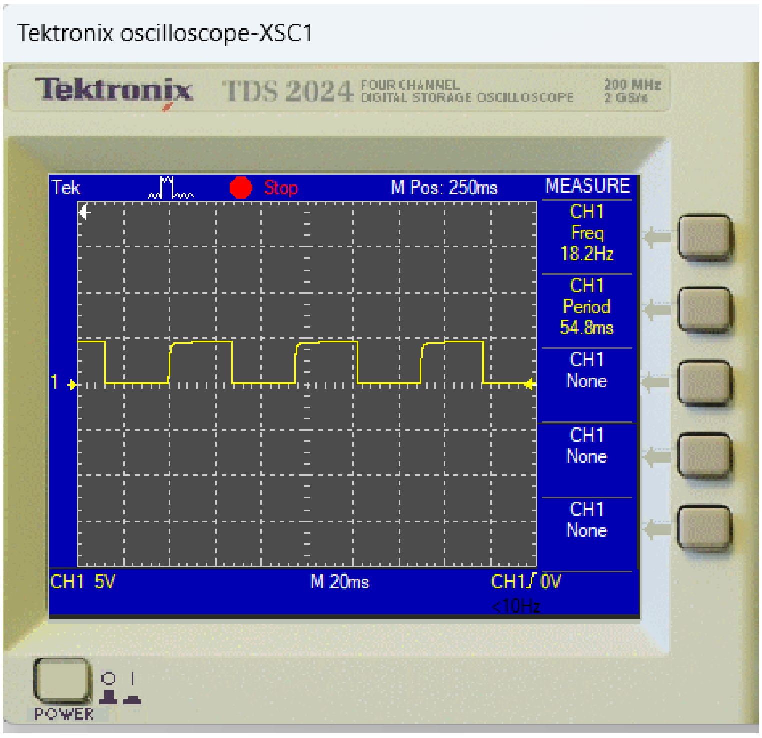


Figure 3-2: Circuit's output for 16 Hz

### 3.1.3 Breadboard Design

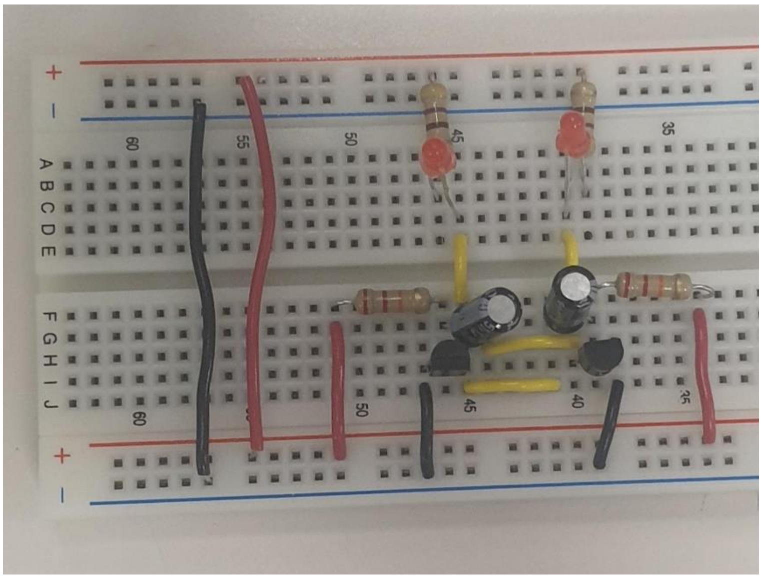

Figure 3-3: Breadboard's design for 16 Hz

## 3. Result

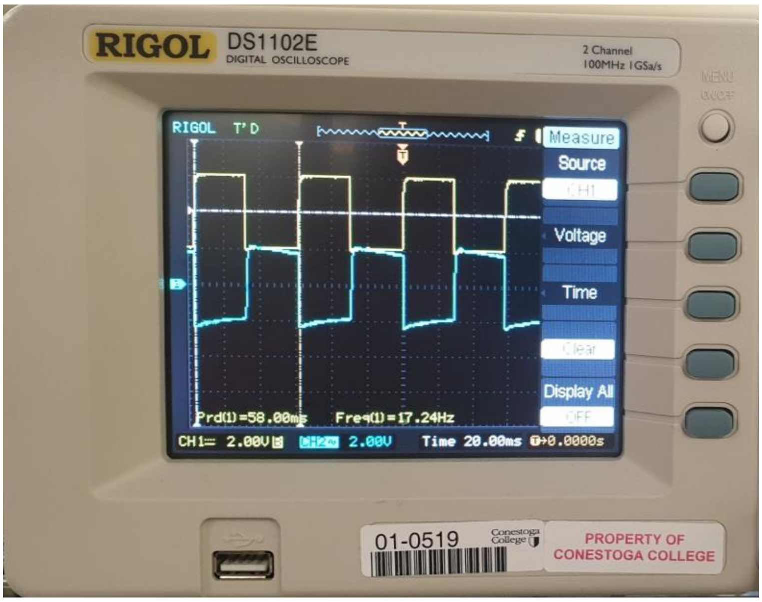


Figure 3-4: Breadboard's output for 16 Hz

### 3.1.4 Result

| Theory expected frequency (Hz) | Multisim’s frequency (Hz) | Breadboard’s frequency (Hz) |
|---|---|---|
| 15.38Hz | 18.2Hz | 17.24Hz |

Table 3-1: Result for 16 Hz

## 3.2 33 Hz

### 3.2.1 Calculation for equipment

Because $R_2 = R_3$ and $C_1 = C_2$ so,

$$t_1 = t_2 = ln(2) \times R_2 \times C_2$$

To design an Astable Multivibrator with 33 Hz, the periodic time will be:

$$T = \frac{1}{f} = \frac{1}{33\ Hz} = 30.3(ms)$$

So $t_1$ and $t_2$ will be.

$$T = t_1 + t_2 = 2 \times t_1$$

$$t_1 = \frac{T}{2} = 15.15\ (ms)$$

From the result, choosing $R_2 = 22k\Omega$ and $C_2 = 1\mu F$ will be best:

$$t_1 = ln(2) \times R_2 \times C_2 = 15.246(ms)$$

$$f = \frac{1}{T} = \frac{1}{2 \times t_1} = 32.79\ (Hz)$$

### 3.2.2 Multisim Design

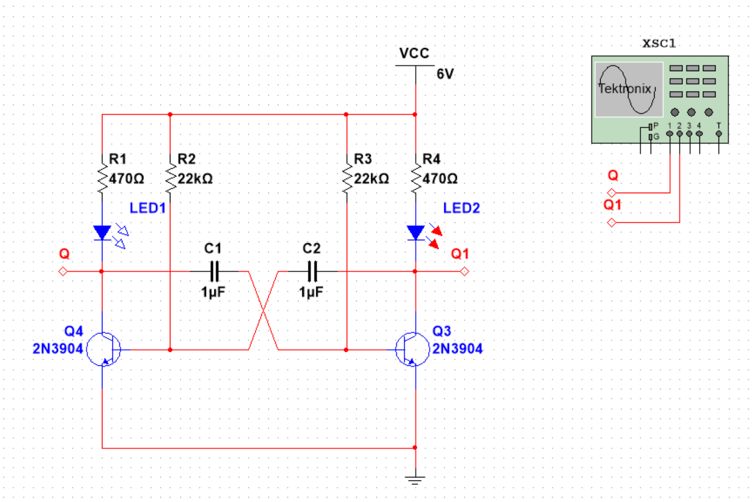


Figure 3-5: Circuit design with R = $22k\Omega$ and C = $1\mu F$

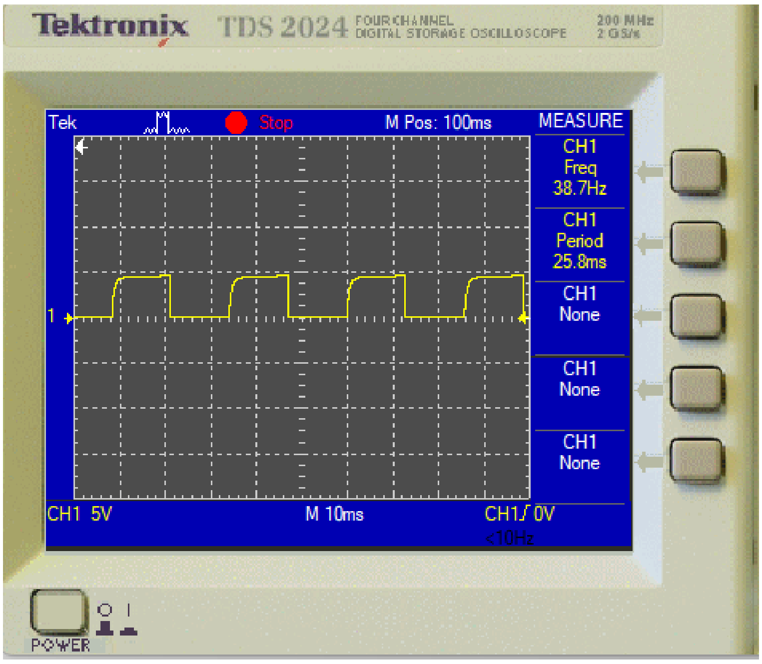


Figure 3-6: Circuit's output for 33 Hz

### 3.2.3 Breadboard Design

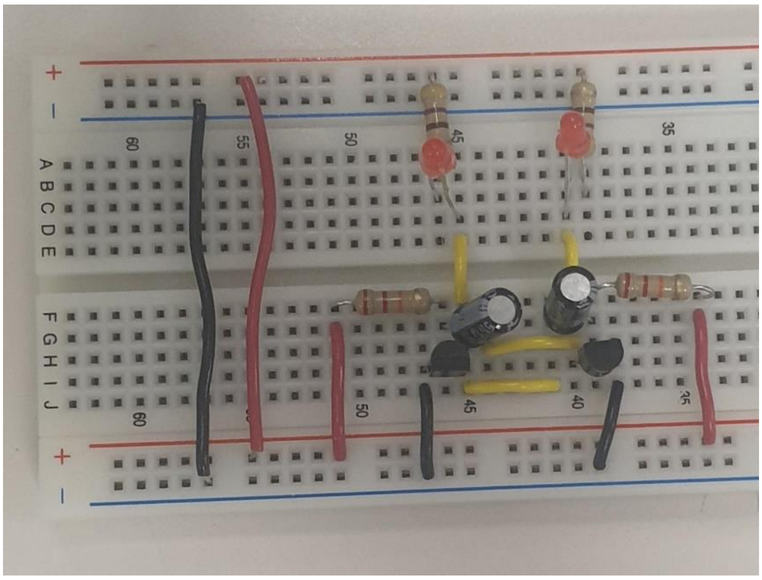

Figure 3-7: Breadboard's design for 33 Hz

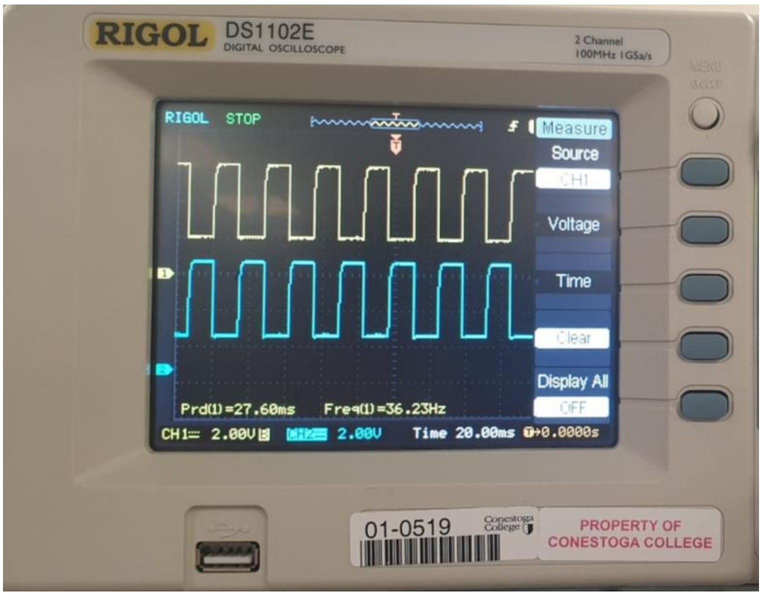

Figure 3-8: Breadboard's output for 33 Hz

### 3.2.4 Result

| Theory expected frequency (Hz) | Multisim expected frequency (Hz) | Breadboard expected frequency (Hz) |
|---|---|---|
| 32.79 Hz | 38.7 Hz | 36.23 Hz |

Table 3-2: Result for 33 Hz

## 3.3 80 Hz

### 3.3.1 Calculation for equipment

Because $R_2 = R_3$ and $C_1 = C_2$ so,

$$t_1 = t_2 = ln(2) \times R_2 \times C_2$$

To design an Astable Multivibrator with 80 Hz, the periodic time will be:

$$T = \frac{1}{f} = \frac{1}{80\ Hz} = 12.5\ (ms)$$

So $t_1$ and $t_2$ will be.

$$T = t_1 + t_2 = 2 \times t_1$$

$$t_1 = \frac{T}{2} = 6.25\ (ms)$$

From the result, choosing $R_2 = 10k\Omega$ and $C_2 = 1\mu F$ will be best:

$$t_1 = ln(2) \times R_2 \times C_2 = 6.93\ (ms)$$

$$f = \frac{1}{T} = \frac{1}{2 \times t_1} = 72.15\ (Hz)$$

### 3.3.2 Multisim Design

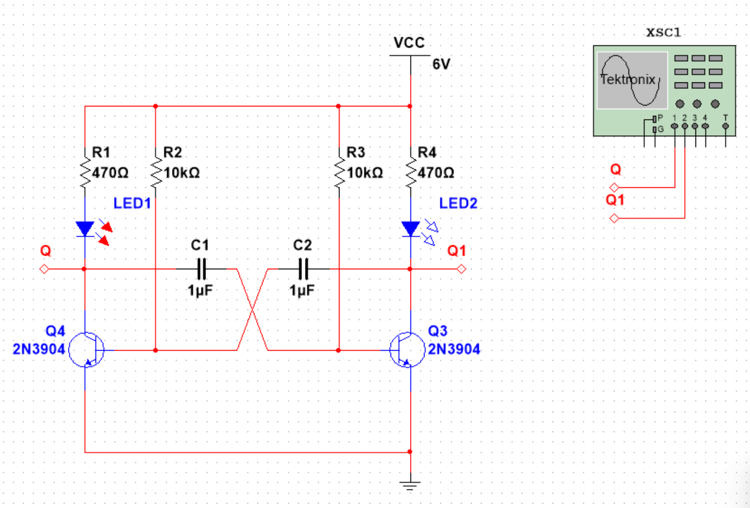


Figure 3-9: Circuit design with $R_2 = 10k\Omega$ and $C_2 = 1\mu F$

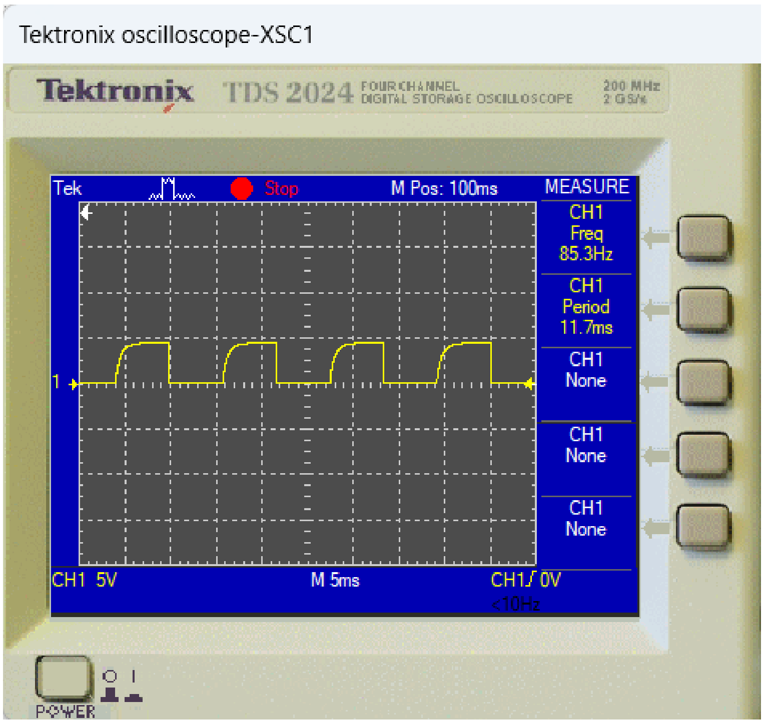

Figure 3-10: Circuit's output for 80 Hz

### 3.3.3 Breadboard Design

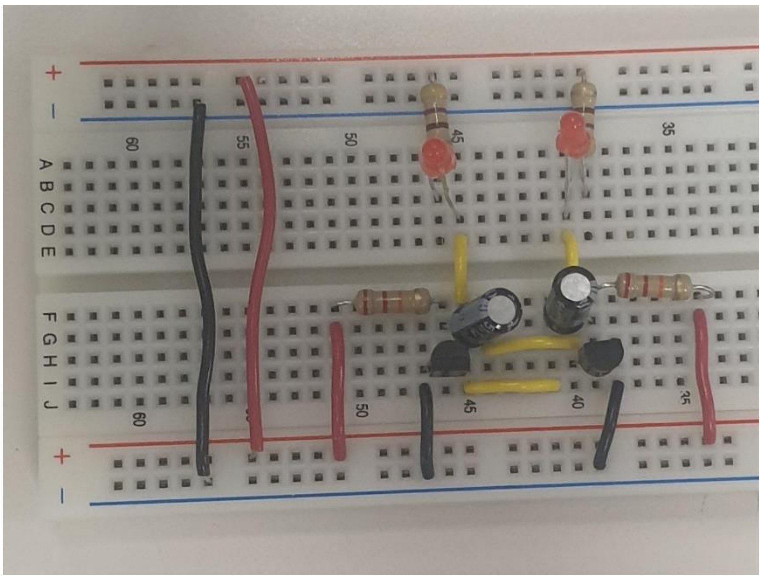
Figure 3-11: Breadboard's design for 80 Hz

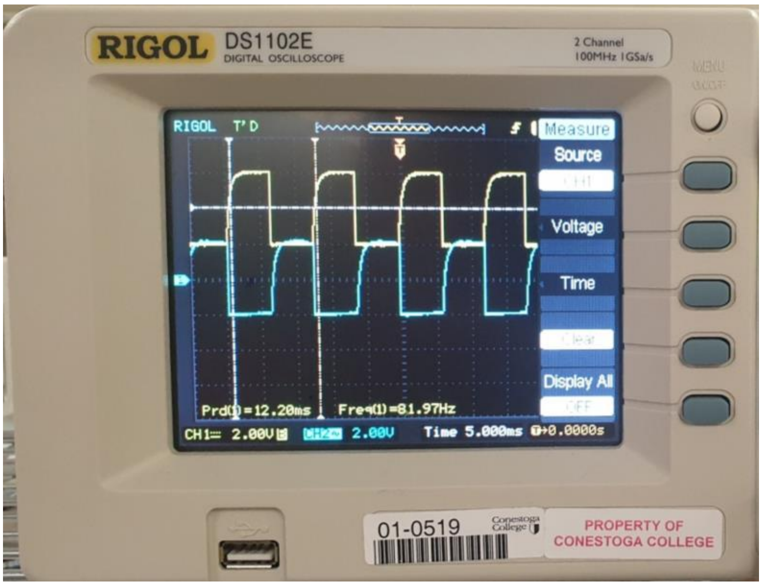


Figure 3-12: Breadboard's output for 80 Hz

### 3.3.4 Result

| Theory expected frequency (Hz) | Multisim expected frequency (Hz) | Breadboard expected frequency (Hz) |
|---|---|---|
| 72.15 Hz | 85.3 Hz | 81.97 Hz |

Table 3-3: Result for 80 Hz

## 3.4 5 Hz

### 3.4.1 Calculation for equipment

Because $R_2 = R_3$ and $C_1 = C_2$ so,

$$t_1 = t_2 = ln(2) \times R_2 \times C_2$$

To design an Astable Multivibrator with 5 Hz, the periodic time will be:

$$T = \frac{1}{f} = \frac{1}{5\ Hz} = 200(ms)$$

So $t_1$ and $t_2$ will be.

$$T = t_1 + t_2 = 2 \times t_1$$

$$t_1 = \frac{T}{2} = 100(ms)$$

From the result, choosing $R_2 = 220k\Omega$ and $C_2 = 1\mu F$ will be best:

$$t_1 = ln(2) \times R_2 \times C_2 = 152.46\ (ms)$$

$$f = \frac{1}{T} = \frac{1}{2 \times t_1} = 6.56\ (Hz)$$

### 3.4.2 Multisim Design

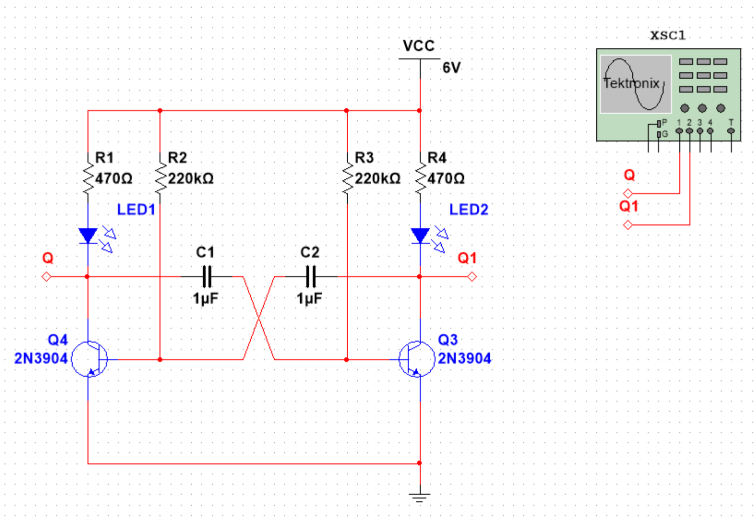


Figure 3-13: Circuit design with $R_2 = 220k\Omega$ and $C_2 = 1\mu F$

## 3. Result

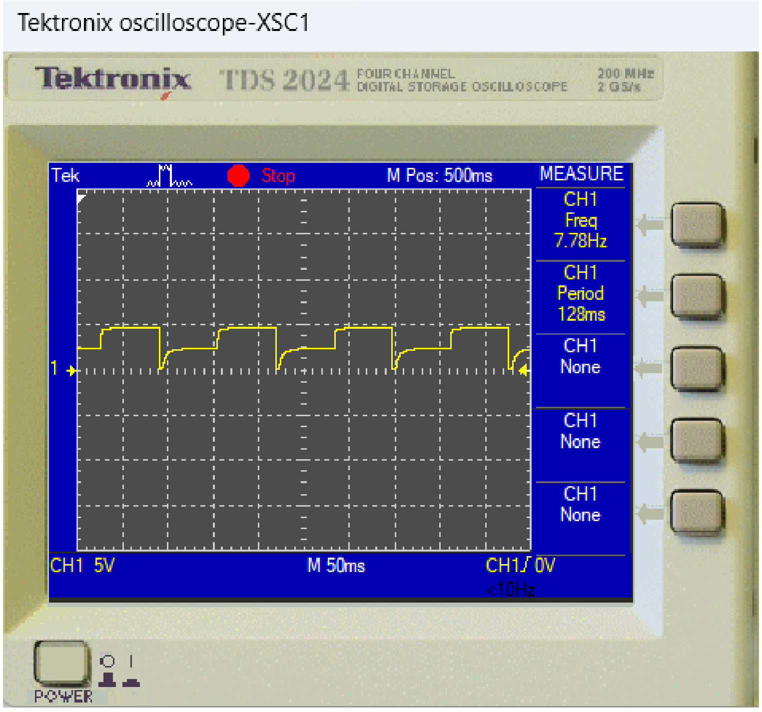


Figure 3-14: Circuit's output for 5 Hz

### 3.4.3 Breadboard Design

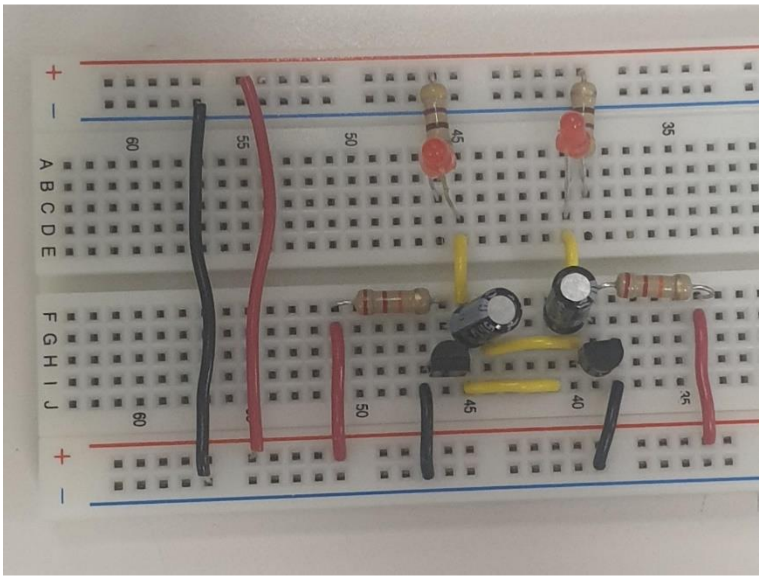

Figure 3-15: Breadboard's design for 5 Hz

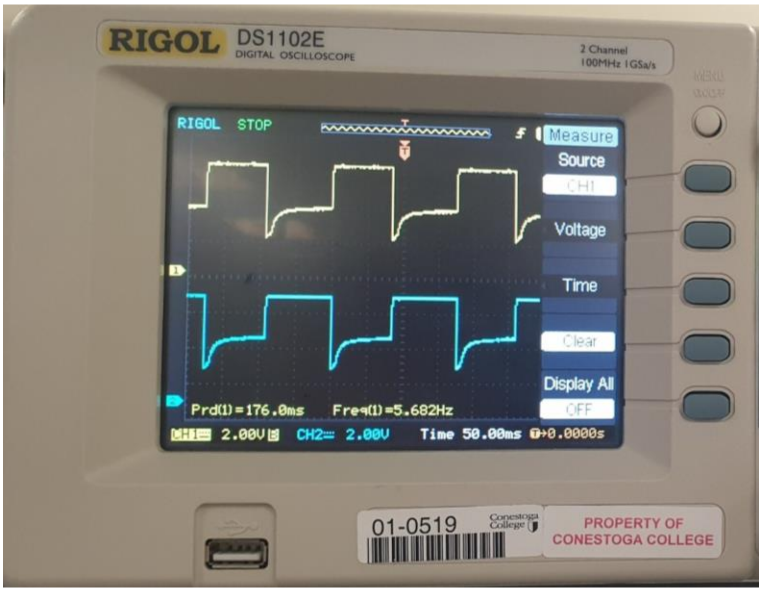


Figure 3-16: Breadboard's output for 5 Hz

### 3.4.4 Result

| Theory expected frequency (Hz) | Multisim expected frequency (Hz) | Breadboard expected frequency (Hz) |
|---|---|---|
| 6.56 Hz | 7.78 Hz | 5.682 Hz |

Table 3-4: Result for 5 Hz

## 3.5 20 Hz (67% ON and 33% OFF)

### 3.5.1 Calculation for equipment

To design an Astable Multivibrator with 25 Hz, the periodic time will be:

$$T = \frac{1}{f} = \frac{1}{20\ Hz} = 50\ (ms)$$

Let $t_1$ is the duration of ON time and $t_2$ is the duration of OFF time,

$$T = t_1 + t_2 = 3 \times t_2$$

$$t_2 = \frac{T}{3} = 16.67\ (ms)$$

$$t_1 = \frac{2 \times T}{3} = 33.33\ (ms)$$

From the result, choosing $R_2 = 47k\Omega$, $C_2 = 1\mu F$ and $R_3 = 22k\Omega$, $C_1 = 1\mu F$ will give the closest result:

$$t_1 = ln(2) \times R_2 \times C_2 = 32.571(ms)$$

$$t_2 = ln(2) \times R_3 \times C_1 = 15.247(ms)$$

$$f = \frac{1}{T} = \frac{1}{t_1 + t_2} = 20.91\ (Hz)$$

### 3.5.2 Multisim Design

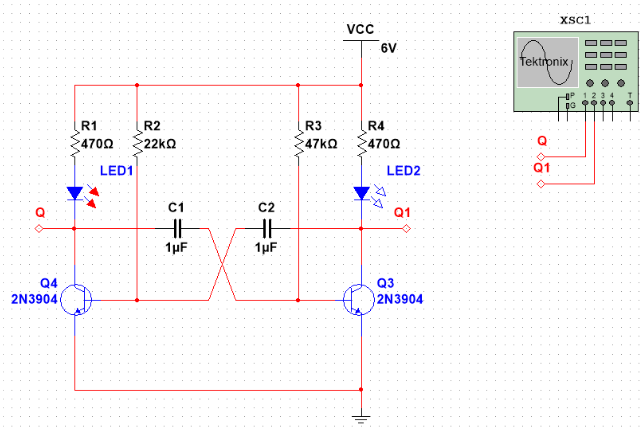


Figure 3-17: Circuit design with $R_2 = 47k\Omega$, $C_2 = 1\mu F$ and $R_3 = 22k\Omega$, $C_1 = 1\mu F$

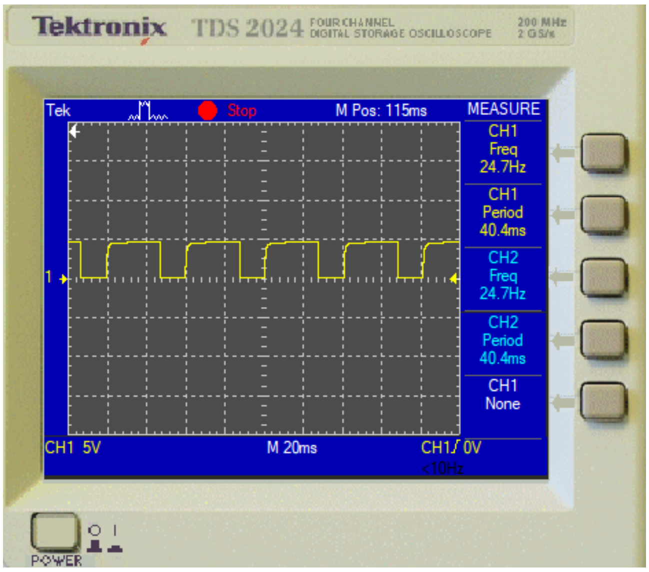


Figure 3-18: Circuit's output of Chanel 1 for 20Hz (67% ON, 33% OFF time)

## 3. Result

Time: 20ms/div

From figure 3-14, T taken up 2 squares with $t_1$ occupied 3/5 square and $t_2$ occupied 7/5 square so,

$$t_1 = \frac{3 \times T}{10} = 12\ (ms)\ (ON\ time)$$

$$t_1 = \frac{7 \times T}{10} = 28\ (ms)\ (OFF\ time)$$

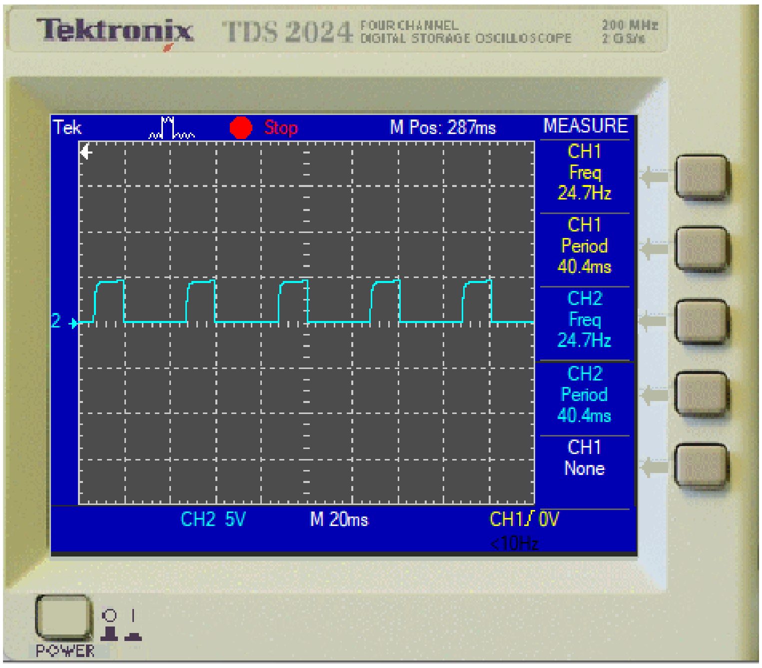


Figure 3-19: Circuit's output of Chanel 2 for 20Hz (33% ON, 67% OFF)

Time: 20ms/div

From figure 3-14, T taken up 2 squares with $t_1$ occupied 3/5 square and $t_2$ occupied 7/5 square so,

$$t_1 = \frac{7 \times T}{10} = 12\ (ms)\ (ON\ time)$$

$$t_1 = \frac{3 \times T}{10} = 28\ (ms)\ (OFF\ time)$$

### 3.5.3 Breadboard Design

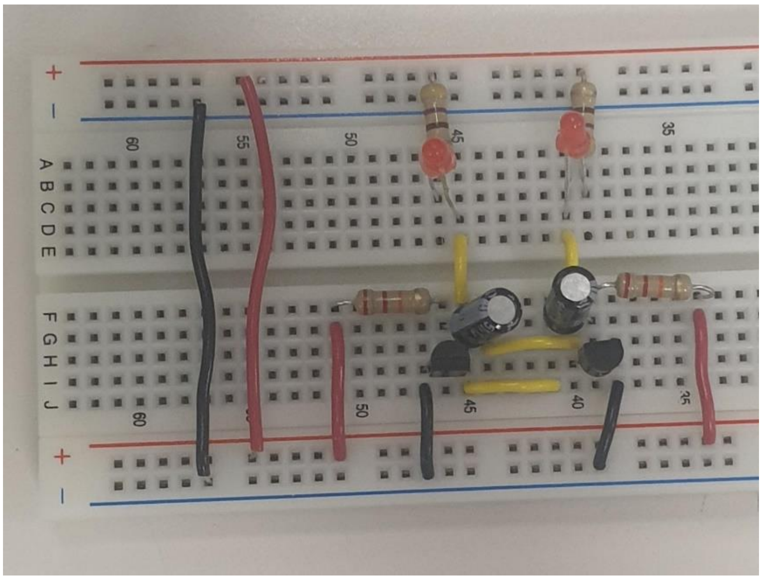

Figure 3-20: Breadboard's design for 20 Hz

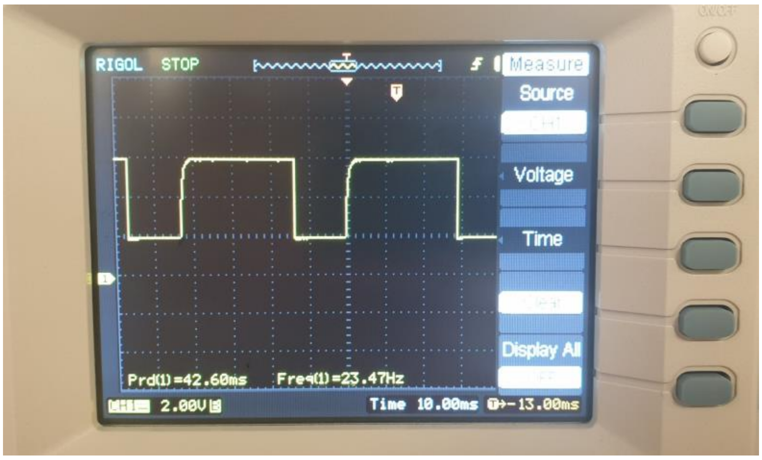


Figure 3-21: Breadboard's output for 20Hz (Channel 1)

Time: 10ms/div

From figure 3-14, T taken up 4.2 squares with $t_1$ occupied 3 square and $t_2$ occupied 1.2 square so,

$$t_1 = \frac{3 \times T}{4.2} = 30.43\ (ms)\ (ON\ time)$$

$$t_1 = \frac{1.2 \times T}{4.2} = \ 12.17\ (ms)\ (OFF\ time)$$

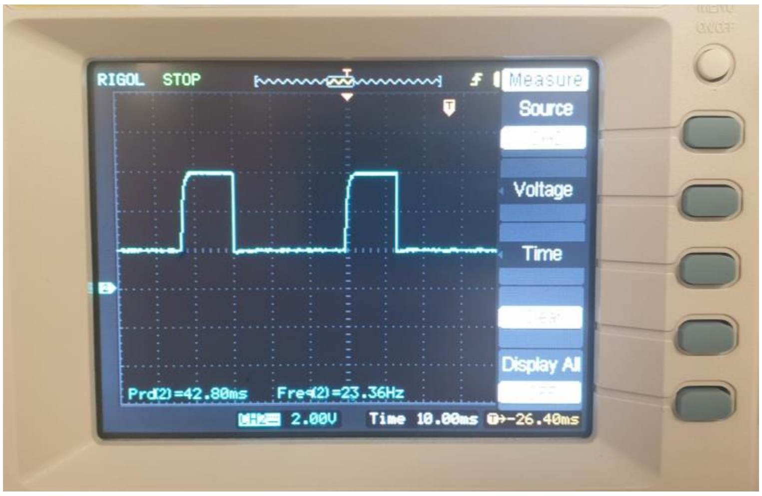


Figure 3-22: Breadboard's output for 20Hz (Channel 2)

Time: 10ms/div

From figure 3-14, T taken up 4.2 squares with $t_1$ occupied 1.2 square and $t_2$ occupied 3 square so,

$$t_1 = \frac{1.2 \times T}{4.2} = 12.17\ (ms)\ (ON\ time)$$

$$t_1 = \frac{3 \times T}{4.2} = 30.43\ (ms)\ (OFF\ time)$$

### 3.5.4 Result

| Theory expected frequency (Hz) | Multisim expected frequency (Hz) (Channel 1) | Breadboard expected frequency (Hz) (Channel 1) |
|---|---|---|
| f = 20.91 Hz<br>$t_1$ = 32.571 ms<br>$t_2$ = 15.247 ms | f = 24.7 Hz<br>$t_1$ = 28 ms<br>$t_2$ = 12 ms | f = 23.47 Hz<br>$t_1$ = 30.43 ms<br>$t_2$ = 12.17 ms |

Table 3-5: Result for 20 Hz

# 4. CONCLUSION

From the result of all 5 cases:

- All 5 cases have Multisim’s result and Breadboard’s result nearly the same.
- Although there is a slight big difference when comparing the error of Theory’s with Multisim’s and Multisim’s with Breadboard’s, the error is still acceptable.

# REFERENCES