Electronics Design Principles

Astable Multivibrator

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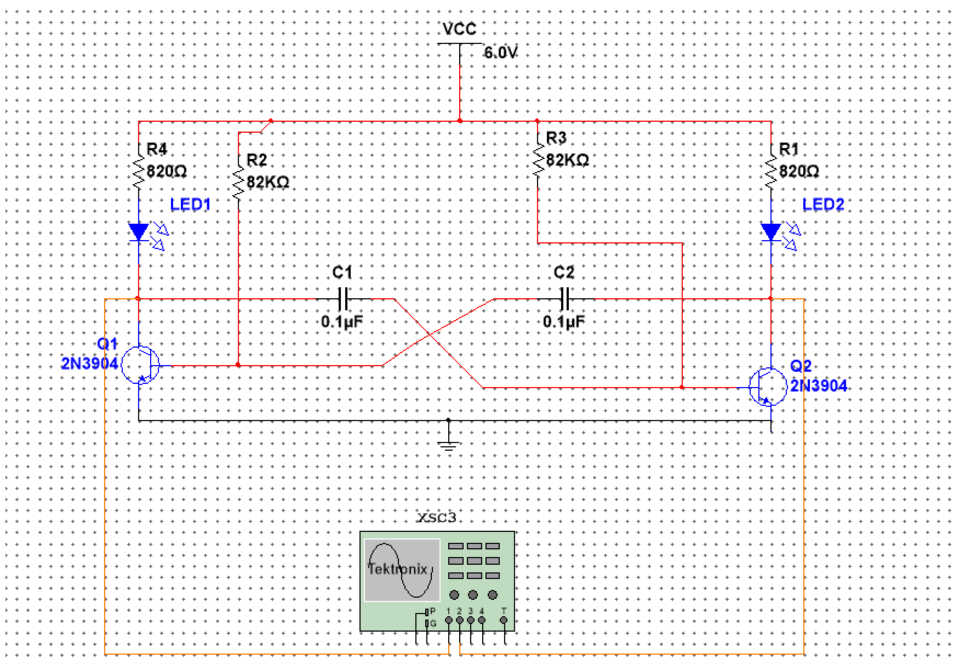
Object: Build an Astable Multivibrator using 2 BJTs, 2 LEDs, and 2 Capacitors.
Design and redraw your own circuit diagram by adding LEDs to blink.
Show your choice of values for capacitors and resistors based on calculations/reasons.
Show your results on oscilloscope CH1 (input) and CH2 (output).

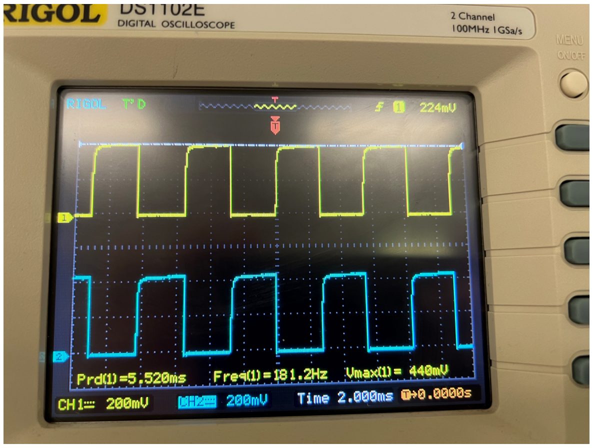
Equipment: Oscilloscope, power supply, 4 resistors, 2 LEDs, 2 Capacitors, 2 NPN Transistors, wires, breadboard.

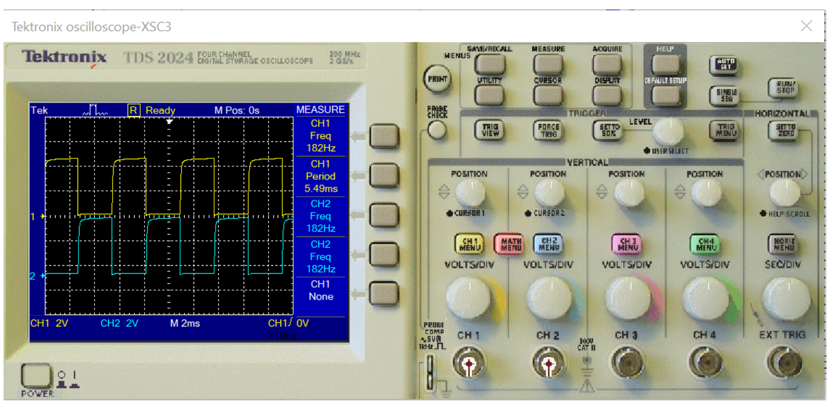
Schematic:



Output:

Case 1:





Real Values

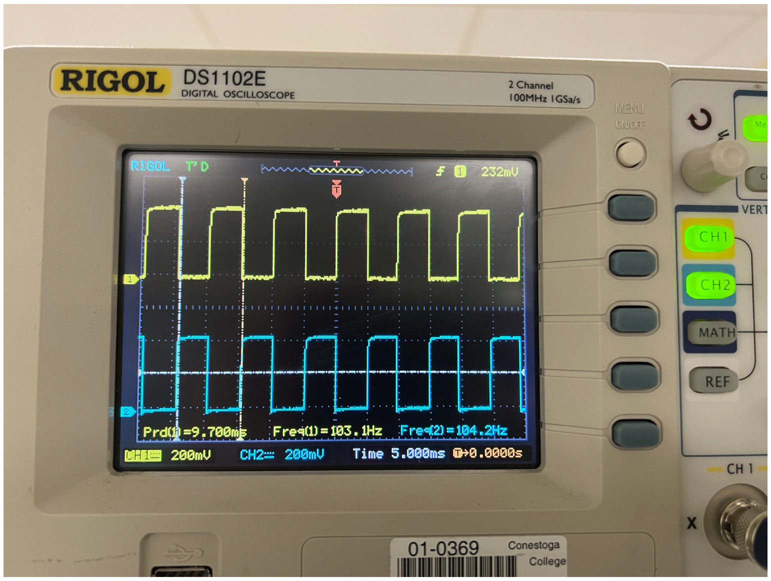
Type	CH1	CH2
V_{max}	440mV	448mV
V_{min}	0.00V	-8.0V
V_{pp}	440mV	456mV
V_{top}	434mV	439mV
V_{base}	13.5mV	4.03mV
V_{amp}	420mV	435mV
V_{avg}	219mV	217mV
V_{rms}	301mV	305mV

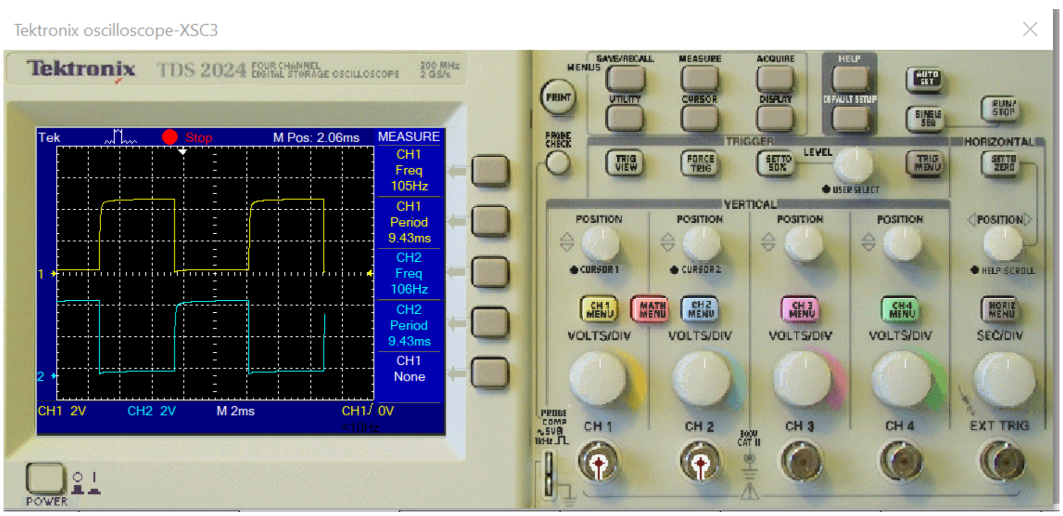
Type	CH1	CH2
V_{ovr}	1.5%	1.0%
V_{pre}	1.5%	1.0%
Period	5.520ms	5.480ms
Frequency	181.2Hz	182.5Hz
Rise Time	<200.0us	<200.0us
Fall Time	<120.0us	<120.0us
Pos width	2.720ms	2.720ms
Neg width	2.800ms	2.800ms

Multisim Value

Type	CH1	CH2
Frequency	182Hz	182Hz
Period	5.49ms	5.49ms
Mean	2.32V	2.32V
Pk-Pk	4.59V	4.59V
Cyc RMS	2.2V	2.2V
Min	50.0mV	50.0mV
Max	4.64V	4.64V
Rise Time	165us	165us
Fall Time	4.09ns	4.05ns
Pos Width	2.72ms	2.72ms
Neg Width	2.77ms	2.77ms

Case 2:





Real Value

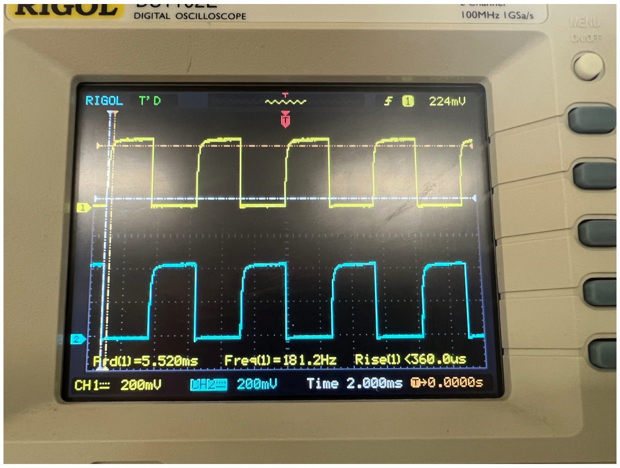
Type	CH1	CH2
V_{max}	448mV	448mV
V_{min}	0.00mV	-8.0mV
V_{pp}	448mV	456mV
V_{top}	437mV	442mV
V_{base}	16.0mV	10.7mV

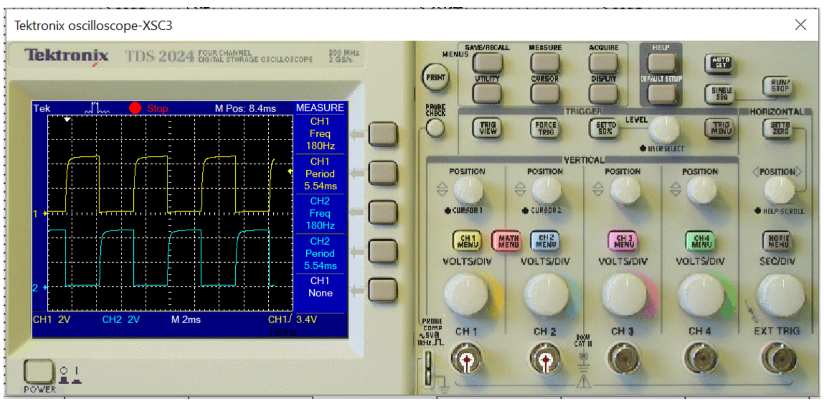
Type	CH1	CH2
V_{amp}	423mV	432mV
V_{avg}	230mV	216mV
V_{rms}	310mV	305mV
V_{ovr}	2.5%	4.0%
V_{pre}	2.7%	0.2%
Period	9.800ms	9.600ms
Frequency	102.0Hz	104.2Hz
Rise Time	<400.0us	<400.0us
Fall Time	<300.0us	<300.0us
Pos width	5.00ms	4.600ms
Neg width	4.700ms	5.200ms

Multisim Value

Type	CH1	CH2
Frequency	106Hz	106Hz
Period	9.43ms	9.43ms
Mean	2.37V	2.37V
Pk-Pk	4.63V	4.63V
Cyc RMS	2.21V	2.21V
Min	50.0mV	50.0mV
Max	4.68V	4.68V
Rise Time	176us	176us
Fall Time	4.2ns	4.17ns
Pos Width	4.69ms	4.69ms
Neg Width	4.74ms	4.74ms

Case 3:





Real Value

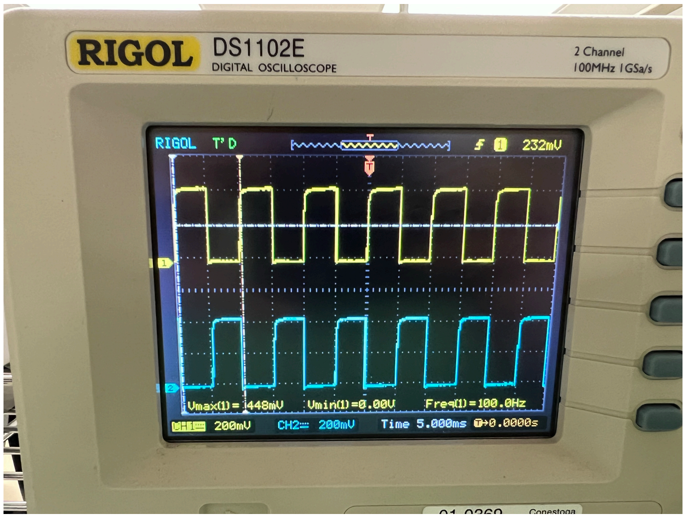
Type	CH1	CH2
V_{max}	440mV	448mV
V_{min}	0.00V	-8.00V
V_{pp}	440mV	456mV
V_{top}	430mV	438mV
V_{base}	11.2mV	2.67mV
V_{amp}	419mV	435mV
V_{avg}	214mV	212mV
V_{rms}	296mV	301mV
V_{ovr}	2.0%	2.4%

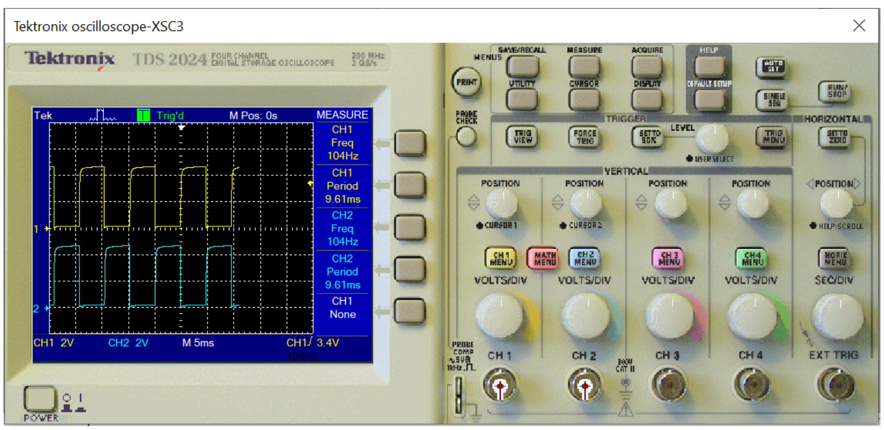
Type	CH1	CH2
V_{pre}	2.0%	0.7%
Period	5.520ms	5.520ms
Frequency	181.2Hz	181.2Hz
Rise Time	<280.0us	<280.0us
Fall Time	<120.0us	<120.0us
Pos width	2.720ms	2.720ms
Neg width	2.800ms	2.880ms

Multisim Value

Type	CH1	CH2
Frequency	180Hz	180Hz
Period	5.54ms	5.54ms
Mean	2.27V	2.27V
Pk-Pk	4.59V	4.59V
Cyc RMS	2.2V	2.2V
Min	44.0mV	44.0mV
Max	4.64V	4.64V
Rise Time	262us	262us
Fall Time	6.07ns	6.07ns
Pos Width	2.72ms	2.72ms
Neg Width	2.84ms	2.82ms

Case 4:





Real Value

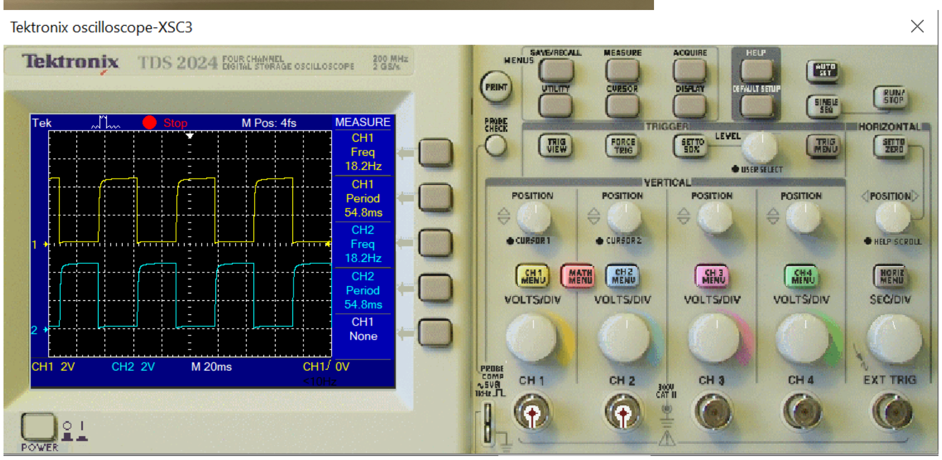
Type	CH1	CH2
V_{max}	448mV	448mV
V_{min}	0.00V	-8.0mV
V_{pp}	448mV	456mV
V_{top}	437mV	441mV
V_{base}	9.19mV	5.18mV
V_{amp}	427mV	436mV
V_{avg}	223mV	212mV

Type	CH1	CH2
V_{rms}	307mV	302mV
V_{ovr}	1.0%	3.1%
V_{pre}	2.6%	1.2%
Period	10.0ms	9.800ms
Frequency	100.0Hz	102.0Hz
Rise Time	<300.0us	<500.0us
Fall Time	<300.0us	<300.0us
Pos width	5.000ms	4.600ms
Neg width	5.000ms	5.200ms

Multisim Value

Type	CH1	CH2
Frequency	104Hz	104Hz
Period	9.61ms	9.61ms
Mean	2.33V	2.33V
Pk-Pk	4.63V	4.63V
Cyc RMS	2.21V	2.21V
Min	43.9mV	43.9mV
Max	4.67V	4.67V
Rise Time	278us	278us
Fall Time	6.42ns	6.32ns
Pos Width	4.76ms	4.73ms
Neg Width	4.86ms	4.87ms

Case 5:



Real Value

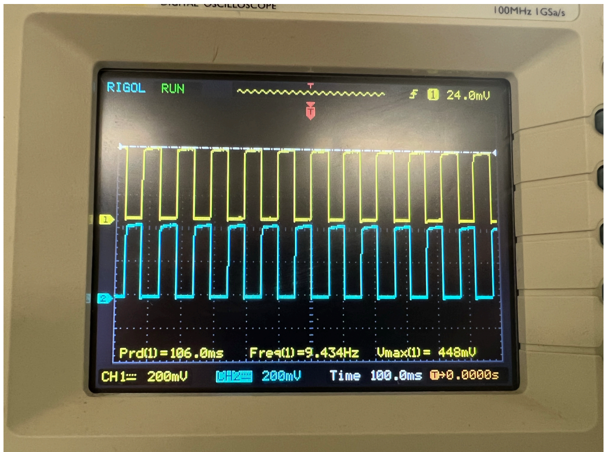
Type	CH1	CH2
V_{max}	448mV	448mV
V_{min}	0.00V	0.00V
V_{pp}	448mV	448mV
V_{top}	436mV	436mV
V_{base}	10.7mV	10.1mV
V_{amp}	425mV	426mV
V_{avg}	220mV	215mV
V_{rms}	304mV	301mV

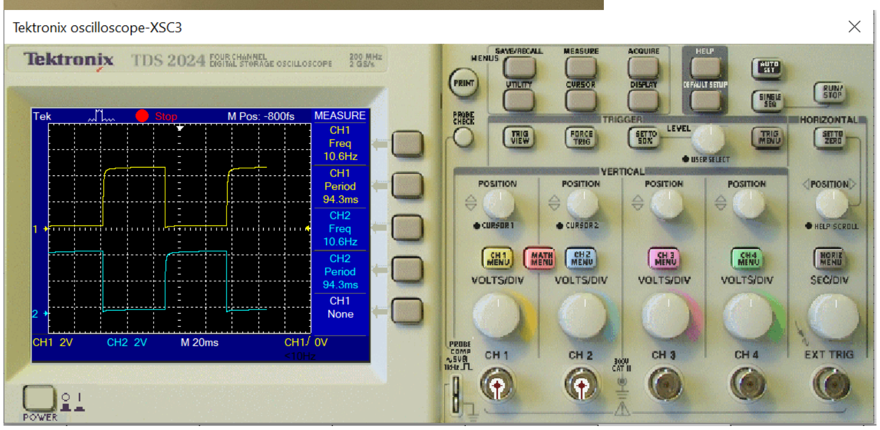
Type	CH1	CH2
V_{ovr}	1.0%	2.4%
V_{pre}	2.7%	0.5%
Period	60.00ms	60.00ms
Frequency	17.24Hz	17.24Hz
Rise Time	<6.000ms	<6.000ms
Fall Time	<6.000ms	<6.000ms
Pos width	30.00ms	30.00ms
Neg width	30.00ms	30.00ms

Multisim Value

Type	CH1	CH2
Frequency	18.2Hz	18.2Hz
Period	54.8ms	54.8ms
Mean	2.32V	2.32V
Pk-Pk	4.59V	4.6V
Cyc RMS	2.2V	2.2V
Min	49.9mV	49.9mV
Max	4.64V	4.64V
Rise Time	1.61ms	1.61ms
Fall Time	3.51ns	3.53ns
Pos Width	27.1ms	27.1ms
Neg Width	27.7ms	27.7ms

Case 6:





Real Value

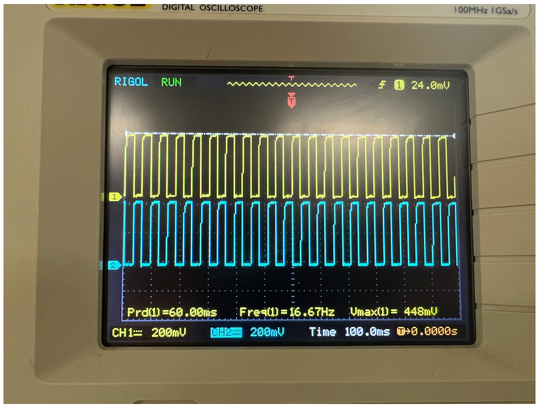
Type	CH1	CH2
V_{max}	448mV	448mV
V_{min}	0.00V	0V
V_{pp}	448mV	448mV
V_{top}	438mV	440mV
V_{base}	12.2mV	11.3mV
V_{amp}	428mV	430mV
V_{avg}	232mV	214mV
V_{rms}	316mV	300mV
V_{ovr}	1.0%	1.6%

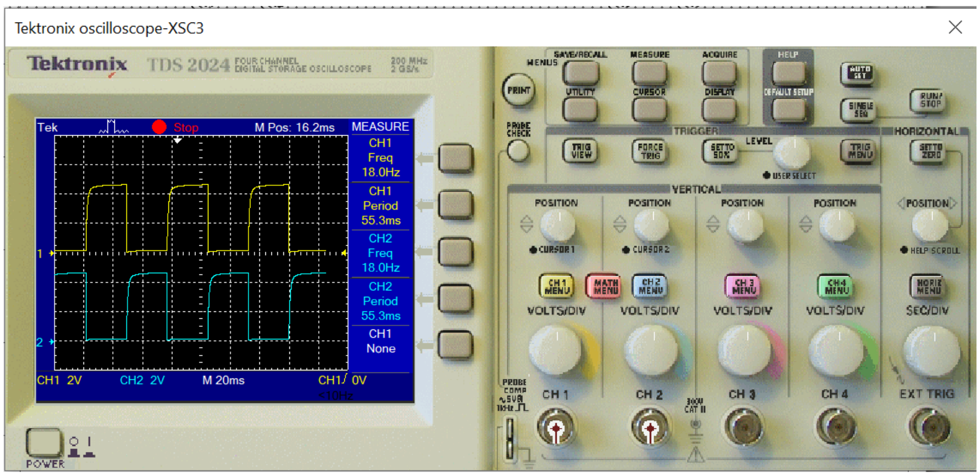
Type	CH1	CH2
V_{pre}	1.0%	1.9%
Period	102.0ms	104.0ms
Frequency	9.615Hz	9.615Hz
Rise Time	<6.000ms	<6.000ms
Fall Time	<6.000ms	<6.000ms
Pos width	54.00ms	50.00ms
Neg width	52.00ms	56.00ms

Multisim Value

Type	CH1	CH2
Frequency	10.6Hz	10.6Hz
Period	94.3ms	94.3ms
Mean	2.37V	2.37V
Pk-Pk	4.63V	4.63V
Cyc RMS	2.21V	2.21V
Min	50.0mV	50.0mV
Max	4.68V	4.68V
Rise Time	1.72ms	1.72ms
Fall Time	3.5ns	3.5ns
Pos Width	46.8ms	26.8ms
Neg Width	47.4ms	47.4ms

Case 7:





Real Value

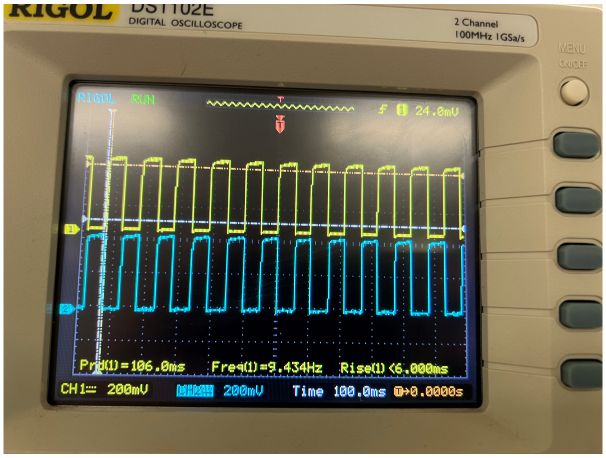
Type	CH1	CH2
V_{max}	448mV	448mV
V_{min}	0.00V	0.00V
V_{pp}	448mV	448mV
V_{top}	436mV	435mV
V_{base}	8.00mV	4.00mV
V_{amp}	425mV	431mV
V_{avg}	215mV	210mV
V_{rms}	300mV	298mV
V_{ovr}	1.0%	1.0%

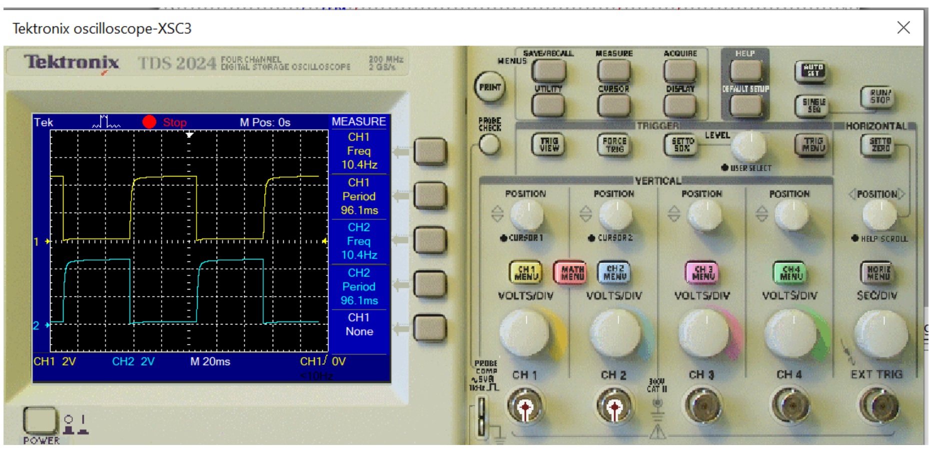
Type	CH1	CH2
V_{pre}	1.3%	1.0%
Period	60.00ms	60.00ms
Frequency	16.67Hz	16.67Hz
Rise Time	<6.000ms	<6.000ms
Fall Time	<6.000ms	<6.000ms
Pos width	28.00ms	28.00ms
Neg width	28.00ms	32.00ms

Multisim Value

Type	CH1	CH2
Frequency	18Hz	18Hz
Period	55.3ms	55.3ms
Mean	2.27V	2.27V
Pk-Pk	4.59V	4.59V
Cyc RMS	2.2V	2.2V
Min	43.9mV	44mV
Max	4.64V	4.64V
Rise Time	2.61ms	2.61ms
Fall Time	6.2ms	6.2ns
Pos Width	27.1ms	27.1ms
Neg Width	28.2ms	28.2ms

Case 8:





Real Value

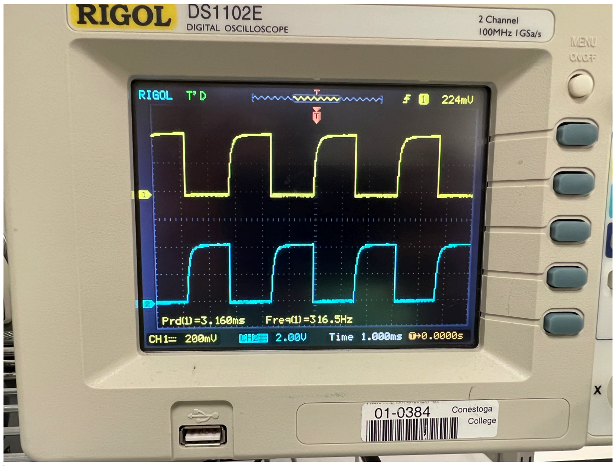
Type	CH1	CH2
V_{max}	448mV	448mV
V_{min}	0.00mV	0.00mV
V_{pp}	448mV	448mV
V_{top}	440mV	438mV
V_{base}	11.5mV	6.22mV
V_{amp}	428mV	431mV
V_{avg}	231mV	207mV
V_{rms}	313mV	298mV

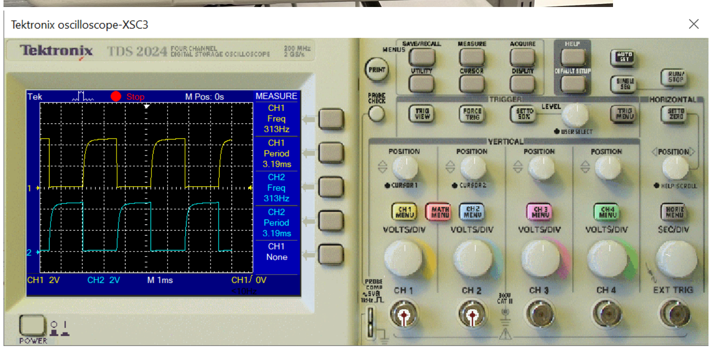
Type	CH1	CH2
V_{ovr}	0.8%	0.2%
V_{pre}	0.7%	2.1%
Period	108ms	108ms
Frequency	9.434Hz	9.434Hz
Rise Time	<6.000ms	<6.000ms
Fall Time	<6.000ms	<6.000ms
Pos width	56.00ms	50.00ms
Neg width	52.00ms	56.00ms

Multisim Value

Type	CH1	CH2
Frequency	10.4Hz	10.4Hz
Period	96.1ms	96.1ms
Mean	2.33V	2.33V
Pk-Pk	4.63V	4.63V
Cyc RMS	2.2V	2.2V
Min	43.8mV	43.8mV
Max	4.67V	4.67V
Rise Time	2.77ms	2.77ms
Fall Time	6.11ns	6.11ns
Pos Width	47.2ms	47.2ms
Neg Width	48.3ms	48.6ms

Case 9:





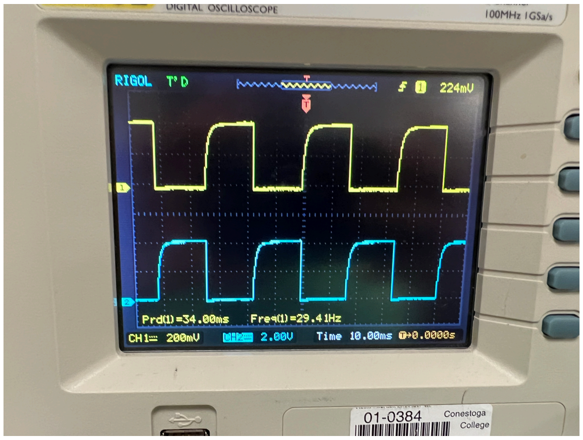
Real Value:

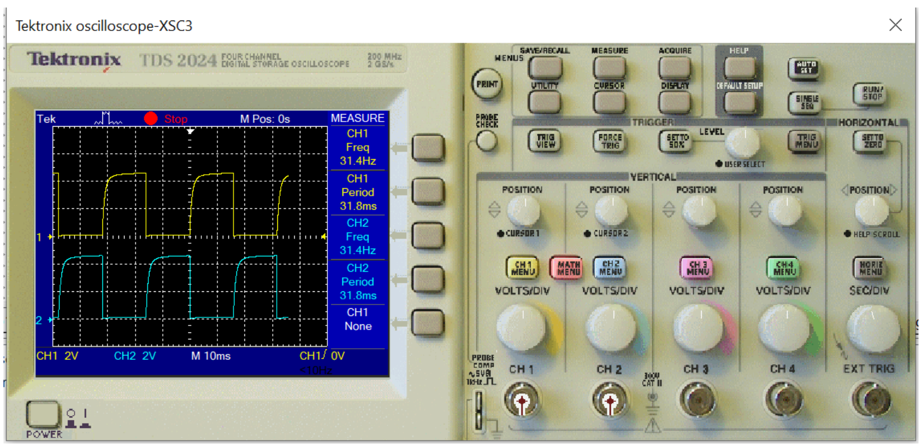
Type	CH1	CH2
Frequency	316.5Hz	316.5Hz
Period	3.160ms	3.160ms

Multisim Value:

Type	CH1	CH2
Frequency	313Hz	313Hz
Period	3.19ms	3.19ms

Case 10:





Real Value:

Type	CH1	CH2
Frequency	29.4Hz	29.4Hz
Period	34.00ms	34.00ms

Multisim Value:

Type	CH1	CH2
Frequency	31.3Hz	31.3Hz
Period	31.9ms	31.9ms

Input:

Case 1: R1 - R4 470 ohm, R2 - R3 47K ohm, C1 - C2 0.1uF
Case 2: R1 - R4 470 ohm, R2 - R3 82K ohm, C1 - C2 0.1uF
Case 3: R1 - R4 810 ohm, R2 - R3 47K ohm, C1 - C2 0.1uF
Case 4: R1 - R4 820 ohm, R2 - R3 82K ohm, C1 - C2 0.1uF
Case 5: R1 - R4 470 ohm, R2 - R3 47K ohm, C1 - C2 1uF
Case 6: R1 - R4 470 ohm, R2 - R3 82K ohm, C1 - C2 1uF
Case 7: R1 - R4 820 ohm, R2 - R3 47K ohm, C1 - C2 1uF
Case 8: R1 - R4 820 ohm, R2 - R3 82K ohm, C1 - C2 1uF
Case 9: R1 - R4 820 ohm, R2 - R3 27K ohm, C1 - C2 0.1uF
Case 10: R1 - R4 820 ohm, R2 - R3 27K ohm, C1 - C2 1uF

Observations:

From the observation we can see that changing R1,R4 neither the frequency or the period is changed or altered. And only with the change with the value of R2, R3, C1 and/or C2 have any change in the frequency and the period within the output.

Thus I will add 2 new cases where can be seen as case 9 and case 10.

Calculations:

Below are the following equations retrieved from www.circuitsgeek.com/tutorials/astable-multivibrator/

Periodic Time, $T = t_1 + t_2$

Where $t1 = 0.69C_1R_3$

Where $t2 = 0.69C_2R_2$

Freq = $1/T = 1/1.38RC$

Case 1:

Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 0.1 * 47000)
= 1000/6.486 Hz
= 154.1782 Hz
Where Period = 1/Freq = 1/154.1782 = 6.486 ms(millisecond)

Case 2:

Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 0.1 * 82000)
= 1000/11.316 Hz
= 88.37 Hz
Where Period = 1/Freq = 1/88.37 = 11.3 ms(millisecond)

Case 3:

Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 0.1 * 47000)
= 1000/6.486 Hz
= 154.1782 Hz
Where Period = 1/Freq = 1/154.1782 = 6.486 ms(millisecond)

Case 4:

Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 0.1 * 82000)
= 1000/11.316 Hz
= 88.37 Hz
Where Period = 1/Freq = 1/88.37 = 11.3 ms(millisecond)

Case 5:

Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 1 * 47000)
= 1000/64.86 Hz
= 15.41782 Hz
Where Period = 1/Freq = 1/15.41782 = 64.86 ms(millisecond)
Case 6:
Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 1 * 82000)
= 1000/113.16 Hz
= 8.837 Hz
Where Period = 1/Freq = 1/8.837 = 113 ms(millisecond)

Case 7:
Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 1 * 47000)
= 1000/64.86 Hz
= 15.41782 Hz
Where Period = 1/Freq = 1/15.41782 = 64.86 ms(millisecond)
Case 8:
Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 1 * 82000)
= 1000/113.16 Hz
= 8.837 Hz
Where Period = 1/Freq = 1/8.837 = 113 ms(millisecond)
Case 9:
Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 0.1 * 27000)
= 1000/3.726 Hz
= 268.384326 Hz
Where Period = 1/Freq = 1/268.384326 = 3.726 ms(millisecond)
Case 10:
Freq = 1/T = 1/(1.38 * C * R)
= 1 * 1000000/ (1.38 * 1 * 27000)
= 1000/37.26 Hz
= 26.8384326 Hz
Where Period = 1/Freq = 1/26.8384326 = 37.26 ms(millisecond)

Theory Vs Practical:

If we look at the values from our calculations and the frequencies we get from the oscilloscope than we can see the frequency are very different when the capacitor is 0.1uF but if the capacitor has the value of 1uF than the difference in Frequency is closer. Following table can clarify each case how the theory differs from practical.

Case 1:

Type	Theory	Practical
Frequency	154.1782Hz	181.2Hz
Period	6.486ms	5.520ms

Case 2:

Type	Theory	Practical
Frequency	88.37Hz	104.2Hz
Period	11.3ms	9.600ms

Case 3:

Type	Theory	Practical
Frequency	154.1782Hz	181.2Hz
Period	6.486ms	5.520ms

Case 4:

Type	Theory	Practical
Frequency	88.37Hz	104.2Hz
Period	11.3ms	9.600ms

Case 5:

Type	Theory	Practical
Frequency	15.41782Hz	17.24Hz
Period	64.86ms	60.00ms

Case 6:

Type	Theory	Practical
Frequency	8.837Hz	9.615Hz
Period	113ms	104.0ms

Case 7:

Type	Theory	Practical
Frequency	15.41782Hz	17.24Hz
Period	64.86ms	60.00ms

Case 8:

Type	Theory	Practical
Frequency	8.837Hz	9.615Hz
Period	113ms	104ms

Case 9:

Type	Theory	Practical
Frequency	268.384326Hz	316.5Hz

Type	Theory	Practical
Period	3.726ms	3.160ms

Case 10:

Type	Theory	Practical
Frequency	26.8384326Hz	316.5Hz
Period	37.26ms	31.9ms

Conclusions:

We can conclude that the frequency of the astable multivibrator is only dependent on the resistors connect to the capacitor and the capacitor itself. If we increase the capacitor farad than the frequency would be decrease and if we increase the resistance of the resistor which is connected to the capacitor than the frequency will decrease and since the time period is the inverse of frequency than the opposite will happen for the case.

Thus increasing the capacitance will increase the time period and increasing the resistance will also increase the time period.