of duty cycle. Duty cycle is measured in percentage. The percentage duty cycle specifically describes the percentage of time a digital signal is HIGH during a complete period. If a digital signal spends 7 seconds as HIGH and 3 seconds as LOW, we would say the digital signal has a duty cycle of 70%. We can define the duty cycle of the square wave and triangular wave in figure 2 by the expressions:

$$Triangular\ Wave,\ D_T = \left(\frac{W_1}{W_1 + W_2}\right) \times 100\% \tag{2}$$

$$Square\ Wave,\ D_S = \left(\frac{W_2}{W_1 + W_2}\right) \times 100\% \tag{3}$$

Procedure:

1. Construct the circuit as shown in figure 1.
2. Connect the outputs of the op-amp 1 (A) and op-amp 2 (B) with the two channels of the oscilloscope.
3. Observe the wave shapes and collect the plots from the oscilloscope. Measure the frequency F and time period T of the waves on the oscilloscope.

Data Tables

Fill up the table for the Triangular Wave.

Theoretical Frequency	Experimental Time Period, T (ms)	Experimental Frequency, F (Hz)	HIGH Time (ms)	LOW Time (ms)
132.978	7.5 ms	~~0.133 kHz~~ 133.33	3.56	4.09

Table 1: Data Table for Triangular Wave Generator

$$\frac{1}{10^3 \times 9 \times 10 \times 0.47 \times 10^{-6}} \times \frac{16}{4} = 132.978$$

Signature

Report

Please answer the following questions briefly in the given space.

1. Draw the output wave shapes at point A and B in the given graph paper. Keep the time in the horizontal axis and the voltage in the vertical axis.

2. Measure the HIGH and LOW times of the two waves and calculate the duty cycles. Explain if there is any relation between the two values

Ans.

$W_1 = 3.56$ ms, $W_2 = 4.04$ ms

Time period, $T = W_1 + W_2 = 7.6$ ms

For triangular wave, $D_T = \left(\frac{W_1}{W_1+W_2}\right) \times 100\% = \left(\frac{3.56}{3.56+4.04}\right) \times 100\%$

$= 46.842\%$

For square wave, $D_T = \left(\frac{W_2}{W_1+W_2}\right) \times 100\% = \left(\frac{4.04}{3.56+4.04}\right) \times 100\%$

$= 53.158\%$

The relation between high time value(W_1) and low time value(W_2) is that they are almost equal.

3. Suppose, we need a square wave which is HIGH when The Triangular wave is rising and is LOW otherwise. Could we feed our observed square wave as input to one of the circuits from our previous experiments for this?

Ans.

From the graph we can observe, when triangular wave high, square wave low & when triangular wave low, square wave is high. But it is a square wave that we want to input.

Therefore, we can feed our ~~observed~~ observed circuit square wave as input to one of the previous experiments such as inverter.

4. What will be the frequency of the output Triangula wave if R_2 is 2kΩ? Explain briefly. [hint: read the theory carefully!]

Ans.

$R_1 = 10k\Omega$, $R_2 = 2k\Omega$, $R_3 = 4k\Omega$ & $C = 0.47\mu F$

$$\text{So, } F = \left(\frac{1}{4R_1C}\right) \propto \left(\frac{R_2}{R_3}\right) = \left(\frac{1}{4 \times 10 \times 0.47 \times 10^{-6} \times 10^{3}}\right) \left(\frac{2 \times 10^3}{4 \times 10^3}\right)$$

$$= 26.586$$

$$\simeq 26.59 \text{ Hz}$$

Here, we must maintain $R_1 > R_3$ but if $R_2 = 2k\Omega$ then it does not justify $R_1 > R_3$.
Therefore, frequency will be low in the output, compared with previous.

5. Can it be possible to use the above circuit to create a variable frequency wave generator? Justify your answer.

Ans.

As, for R_1, R_2, R_3 & capacitor the frequency remain same.

Therefore, it is possible to use the above circuit to create a variable frequency wave generator.
As, when R_1 & R_2 constant, frequency depends on R_1 & capacitor, so it will be easy to change R_1 value.

6. Change the value of R_1 to 22KΩ and measure the frequency of the output waves. Does the effect on frequency match with the theory?

Ans.

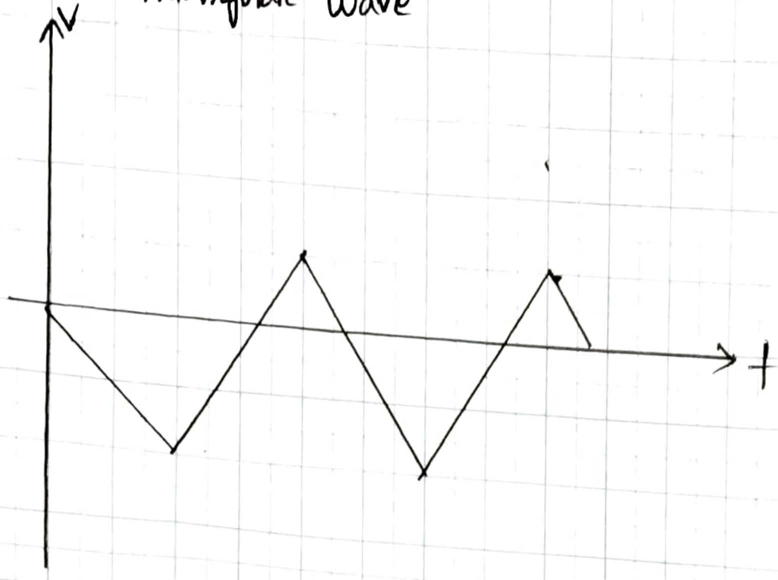
$R_1 = 22k\Omega$, in experiment $\longrightarrow$ F in experiment $= 132.278$ Hz

$$\text{So, } F = \left(\frac{1}{4 \times 22 \times 10^3 \times 0.47 \times 10^{-6}}\right) \propto \left(\frac{10 \times 10^3}{4 \times 10^3}\right)$$

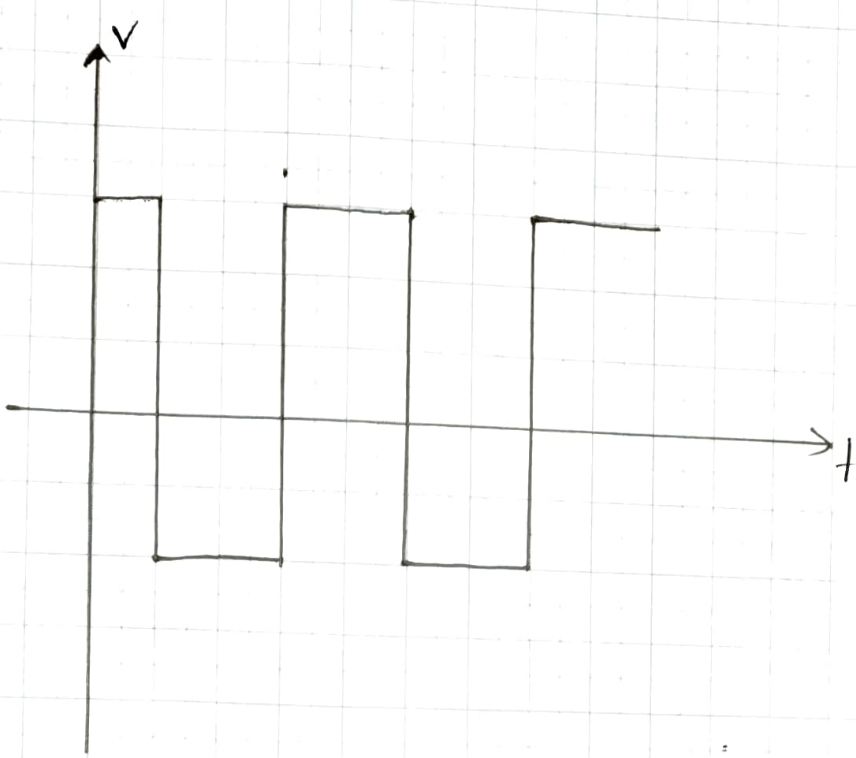
$$= 60.443 \text{ Hz}.$$

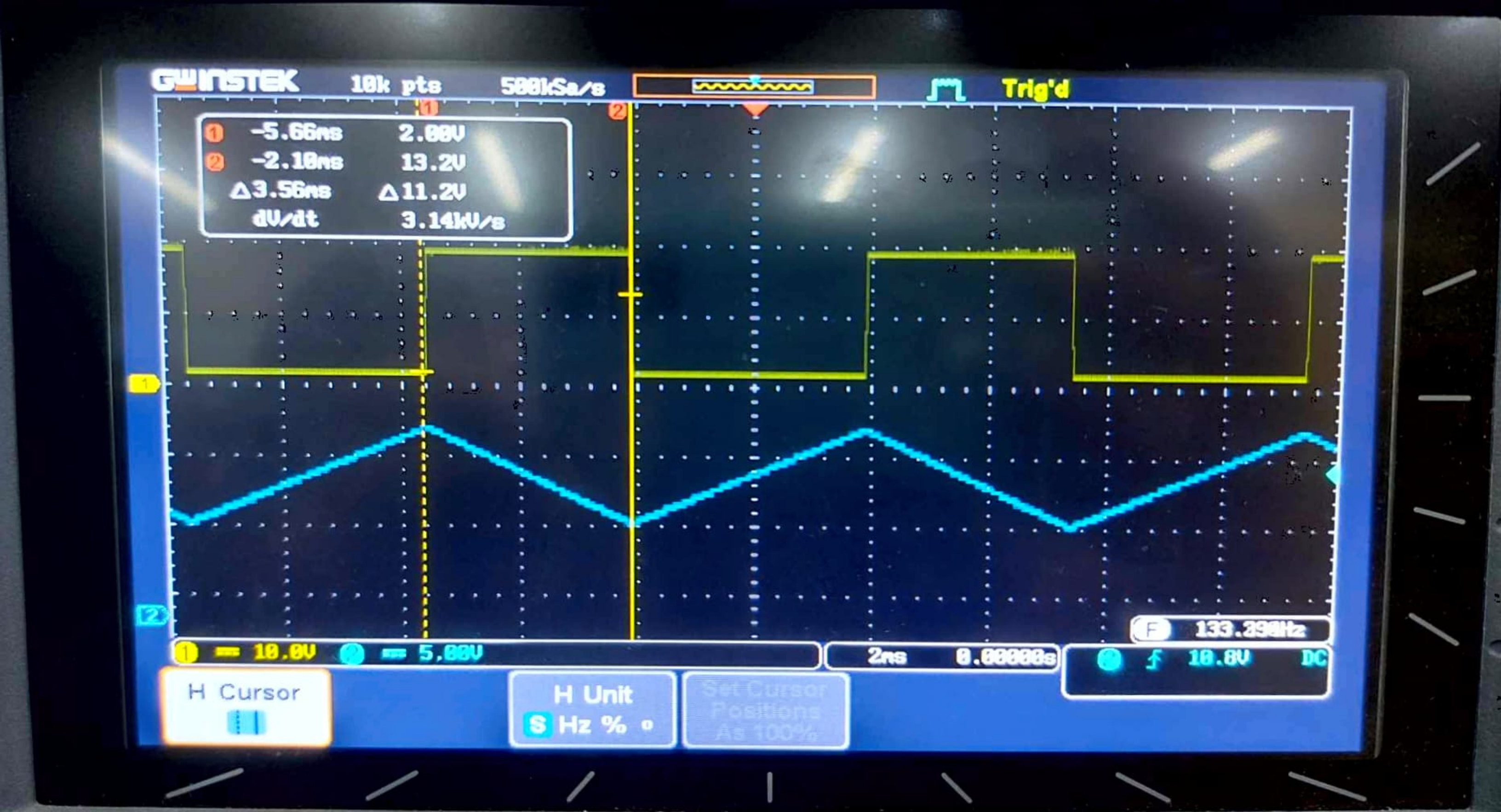
This frequency is lower than experiment frequency but this only will effect on time period.

Triangular wave



Square wave




GW INSTEK
10k pts
500kSa/s
Trig'd
-5.66ms 2.00V
-2.10ms 13.2V
Δ3.56ms Δ11.2V
dV/dt 3.14kV/s
133.398Hz
10.0V
5.00V
2ms 0.00000s
10.8V DC
H Cursor
H Unit
S Hz % °
Set Cursor Positions As 100%

GW INSTEK
10k pts
500kSa/s
Trig'd
-5.56ms 19.2V
1.94ms 19.2V
Δ7.50ms Δ0.00V
dV/dt 0.00V/s
133.235Hz
10.0V
5.00V
2ms
0.00000s
10.8V
DC
H Cursor
H Unit
S Hz % °
Set Cursor Positions As 100%