Experiment 2

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1 Aim

Find the RC circuit responce with all the 3 cases below for a square wave input(+5/-5V)

$$RC = T$$
$$RC >> T$$
$$RC << T$$

where,
R = Resistance
C = Capacitance
T = Time period of the input

2 Apparatus/Materials needed

1) Bread Board
2) Resistance (1kΩ used here)
3) Capacitance ($0.1\mu F$ used here)
4) Function Generator
5) CRO

3 Theory

Let the output be V_l at the start of the cycle and V_u in the middle of the cycle after achieving steady-state.

And let $V_i = 5V$ Then,

$$V_l = V_i\left(1 - e^{\frac{-T}{2RC}}\right) + V_u\, e^{\frac{-T}{2RC}} \tag{1}$$
$$V_u = -V_i\left(1 - e^{\frac{-T}{2RC}}\right) + V_l\, e^{\frac{-T}{2RC}} \tag{2}$$

Solving the above 2 equations, we get,

$$V_l = -V_i\,\frac{1 - e^{\frac{-T}{2RC}}}{1 + e^{\frac{-T}{2RC}}} \tag{3}$$
$$V_u = V_i\,\frac{1 - e^{\frac{-T}{2RC}}}{1 + e^{\frac{-T}{2RC}}} \tag{4}$$

We can observe that,

1) If $T >> RC$ then, $V_l \to -V_i$, $V_u \to V_i$
2) If $T << RC$ then, $V_l \to 0$, $V_u \to 0$

Intuvitively, we can tell, the capacitor will reach the input voltage more time we give it to charge. With less time, capacitor doesn't have much time to charge up and it doesn't give output.

Thus this circuit behaves as a low-pass filter, where lower the frequency, less the attenutaiton.

4 Procedure

1) Setup a resistor and a capacitor in series with help of a bread board.
2) Setup the function generator with a square wave of high point as 5V and low point as -5V and with required frequency
3) Connect the Input(red) to the resistor end and ground to the capacitor.
4) Connect the first channel of CRO to across the capacitor to oberve it's responce.
5) Connect the second channel of CRO across the entire circuit to observe the input.

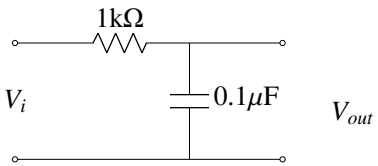

Fig. 1: Circuit Diagram

5 Observations

5.1 $RC = T$

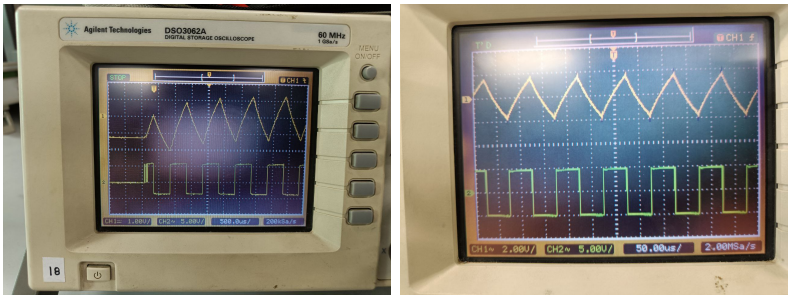

Fig. 2: Transient State and Steady State Observed with CRO

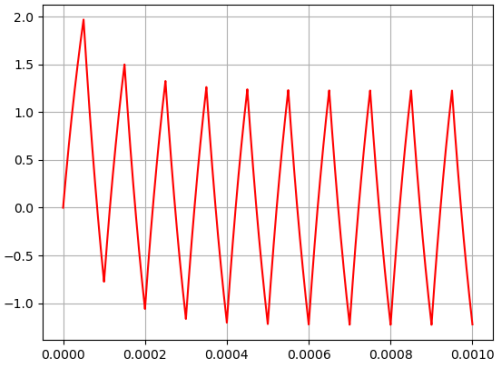

Fig. 3: Simulation

5.2 *RC >> T*

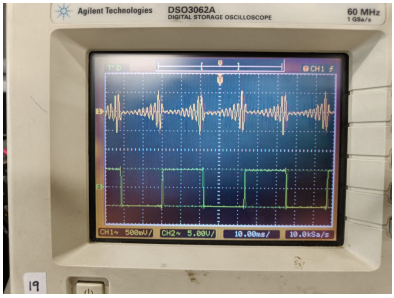

Fig. 4: Steady State Observed with CRO

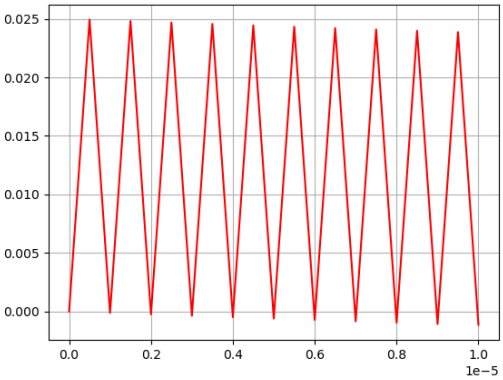

Fig. 5: Simulation

5.3 RC << T

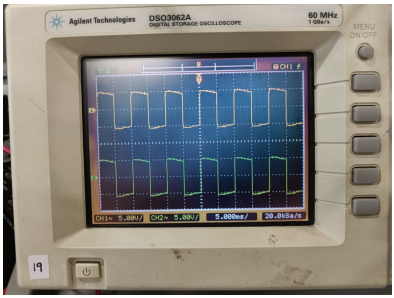

Fig. 6: Steady State Observed with CRO

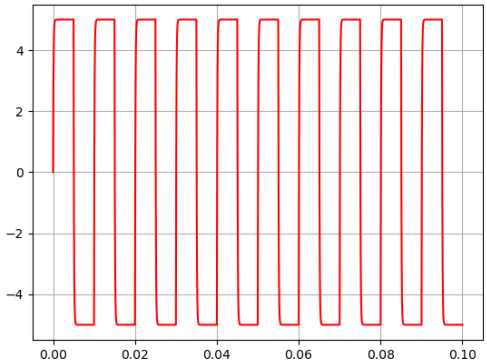

Fig. 7: Simulation

Steady State in case 2 wasn't observed properly due to machine faults.

6 Precautions

1) Use a non polarized capacitor.
2) Make sure the connections are proper
3) Don't use very low frequency inputs or the function will not be generated properly by the function generator.