EE1200 - ELECTRIC CIRCUITS LAB

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1 Find the RC circuit response with all three cases below for square wave input, and plot the output and input for a transient response for the first five cycles and steady-state response as well.
RC == T
RC >> T
RC << T

1.1 AIM :

To find the RC circuit response with square wave input and plot the output and input for transient response for the first five cycles and steady state response.

1.2 APPARATUS REQUIRED :

- A digital function generator
- A Cathode Ray Oscilloscope
- Connecting wires
- A resistance ($1k\Omega$)
- A capacitor ($1\mu F$)
- Oscilloscope probe

1.3 THEORY :

- RC circuit consists of a resistor (R) and capacitor (C) connected in series. When a square wave input is applied to such a circuit, the response is determined by the charging and discharging behaviour of the capacitor and the associated time constant (τ).
- Time constant for a series RC circuit is the product of the magnitude of Resistance and capacitance.

$$\tau = RC \tag{1}$$

- Voltage across the capacitor varies as

$$V_C(t) = V_0\left(1 - e^{\frac{-t}{\tau}}\right) \text{ for charging} \tag{2}$$

$$V_C(t) = V_0 e^{\frac{-t}{\tau}} \text{ for discharging} \tag{3}$$

- For **High frequency input** (RC << T), the capacitor has enough time to almost fully charge and discharge during each cycle. Hence, the voltage across the capacitor closely resembles the input with rounded edges due to exponential charging/discharging.

- For **Low frequency input** (RC >> T), the capacitor does not have enough time to fully charge or discharge. Hence, the voltage across capacitor appears as a triangular waveform with reduced amplitude.

1.4 PROCEDURE :

- Connect the RC-circuit as shown in (1.4).

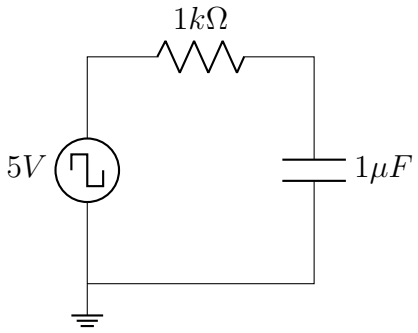


Figure 1: RC Circuit with a 5V Square Wave Input

- Input a square wave of amplitude 5 V from the function generator, with time period equal to RC. The corresponding output is captured from the CRO.
- The experiment is repeated for two more values of frequency such that $RC >> T$ and $RC << T$, and capture them.
- The figures are then compared with those created by python.

1.5 VERIFICATION :

- $RC << T$: We have

$$V = V_0 \left(1 - e^{\frac{-t}{\tau}}\right) \tag{4}$$

Substituting $t = 2.44s, R = 1000\Omega, C = 1\mu F$, we have

$$V \approx 5.0 \tag{5}$$

- $RC == T$: Substituting $t = 740\mu s, R = 1000\Omega, C = 1\mu F$, we have

$$V \approx 3V \tag{6}$$

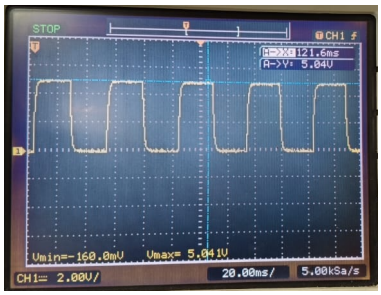
- $RC >> T$: We have

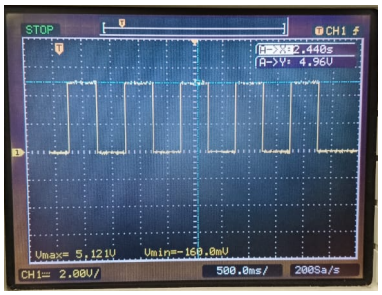
$$V = V_0 \left(1 - e^{\frac{-t}{\tau}}\right) \tag{7}$$

Substituting $t = 220\mu s, R = 1000\Omega, C = 1\mu F$, we have

$$V \approx 2.5V \tag{8}$$

1.6 FIGURES :





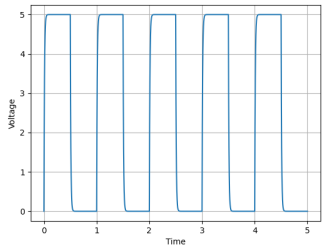
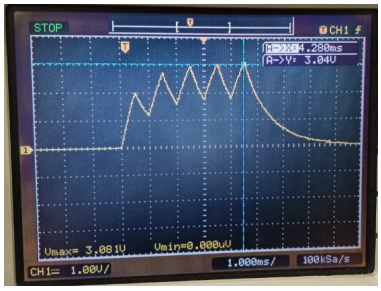
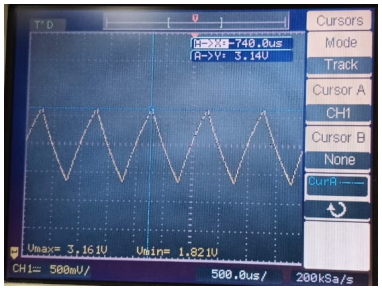


Figure 2: $RC << T$





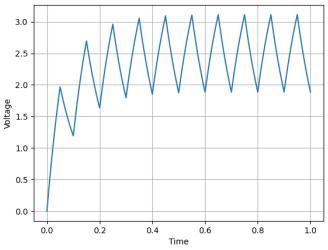
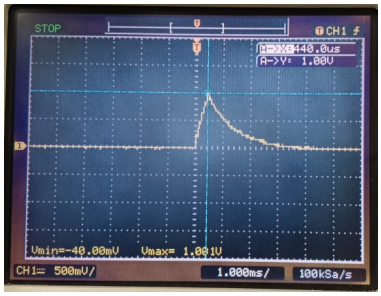
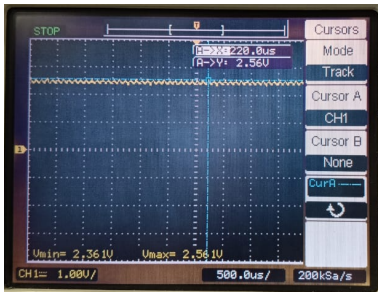


Figure 3: $RC == T$





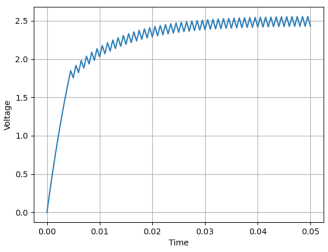


Figure 4: $RC >> T$