Lab Report 1: Introduction to DSO, Breadboard and RC Circuit Experiment

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Aim:

The aim is to study the Digital Storage Oscilloscope (DSO), understand how a breadboard works, and analyze the charging and discharging behavior of an RC circuit by comparing the theoretical and practical values of the time constant and cutoff frequency.

Components Used:

1. Breadboard
2. Resistors (various values)
3. Capacitors (ceramic and polarized, various values)
4. Digital Storage Oscilloscope (DSO)
5. Function Generator

Procedure:

1. Connect the RC circuit on the breadboard as shown in the lab handout.
2. Use the function generator to apply a square wave input.
3. Observe the waveform of the capacitor on the DSO screen.
4. For each R and C combination:
   4.1. Calculate the theoretical time constant ($\tau = RC$).
   4.2. Measure the practical time constant from the DSO waveform.
   4.3. Calculate the theoretical cut-off frequency ($f_c = \frac{1}{2\pi RC}$).
   4.4. Measure the practical cutoff frequency using the DSO.
   4.5. Record all the values in the observation table.
5. Repeat steps 4 and 5 for three different combinations of R-C.

Circuit Diagram:

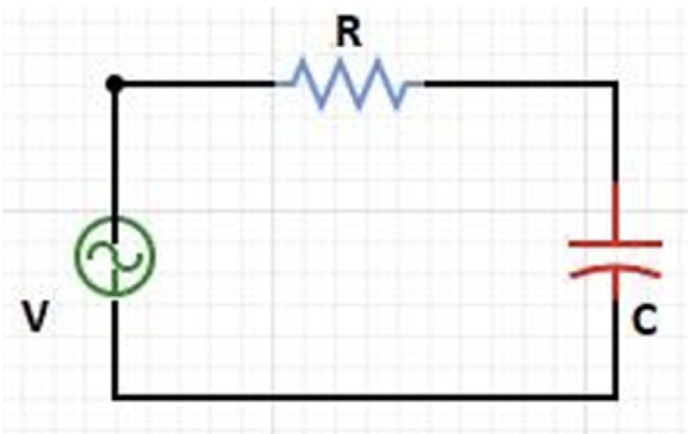
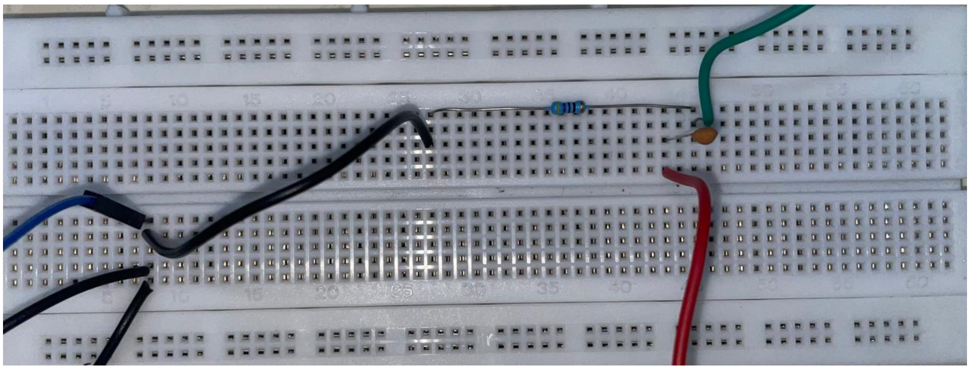
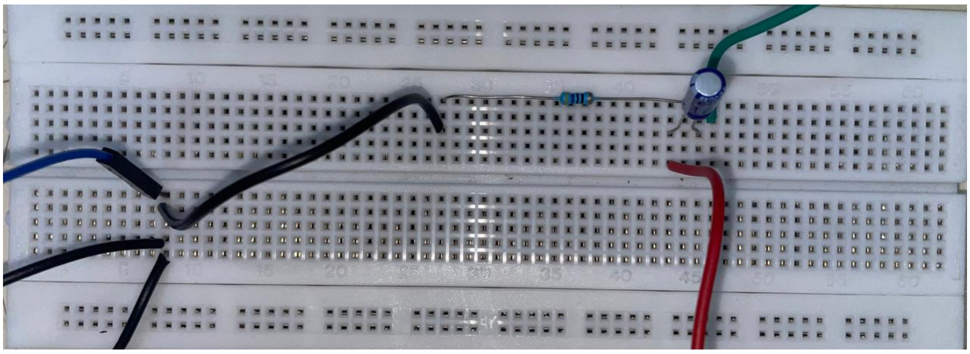


Figure 1: Physical RC circuit implemented on PCB.

Physical Circuit:



(a) Ceramic capacitor used in Case 1.

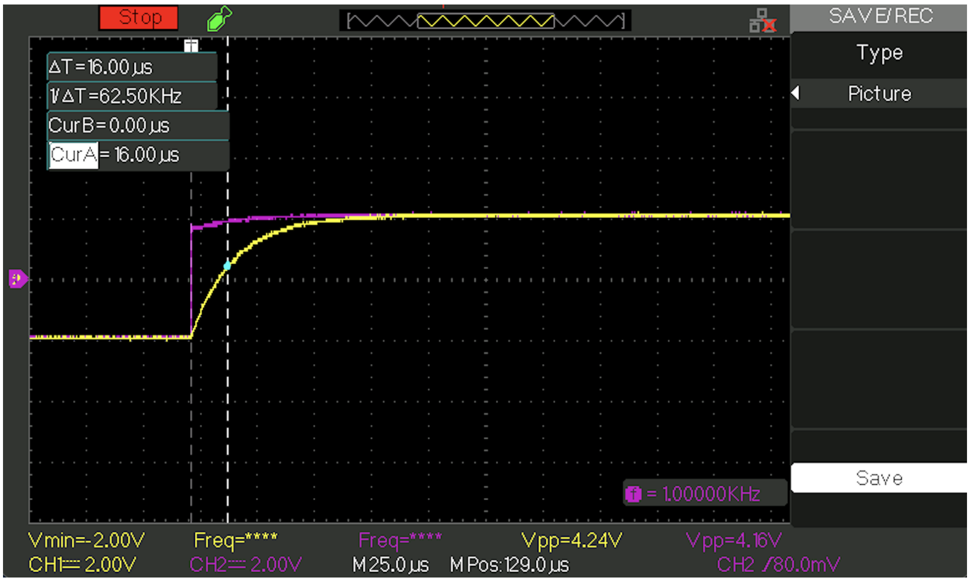


(b) Polarized capacitor used in Case 2.

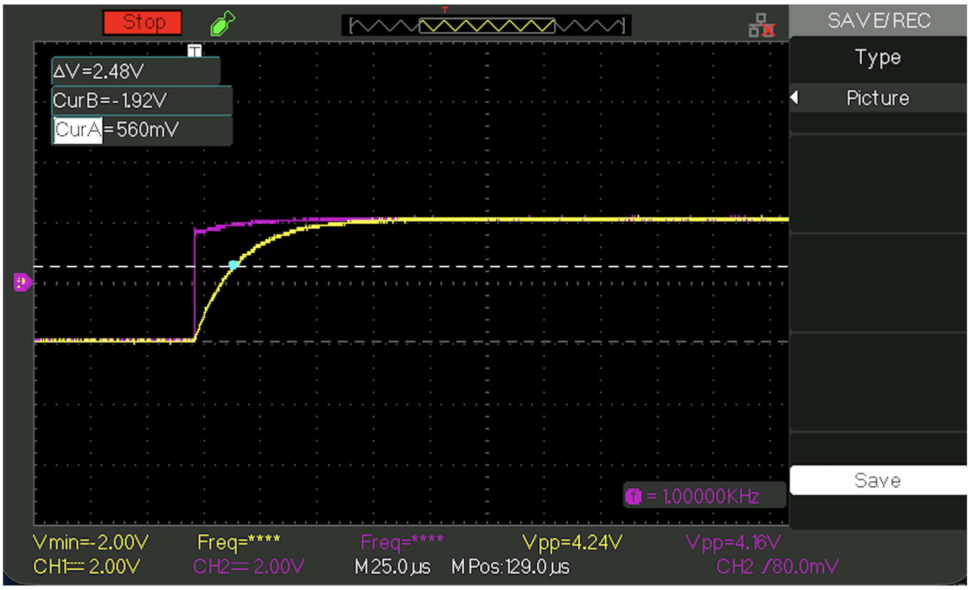
Figure 2: Types of capacitors used in the RC circuit.

Observation:

Experimental Waveforms:

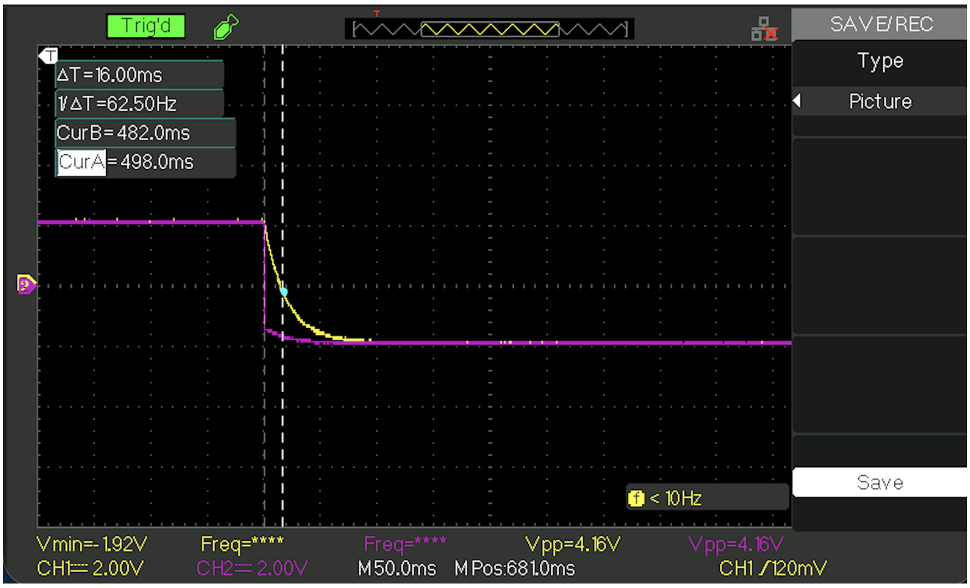


(a) Time response for Case 1 (Δt)

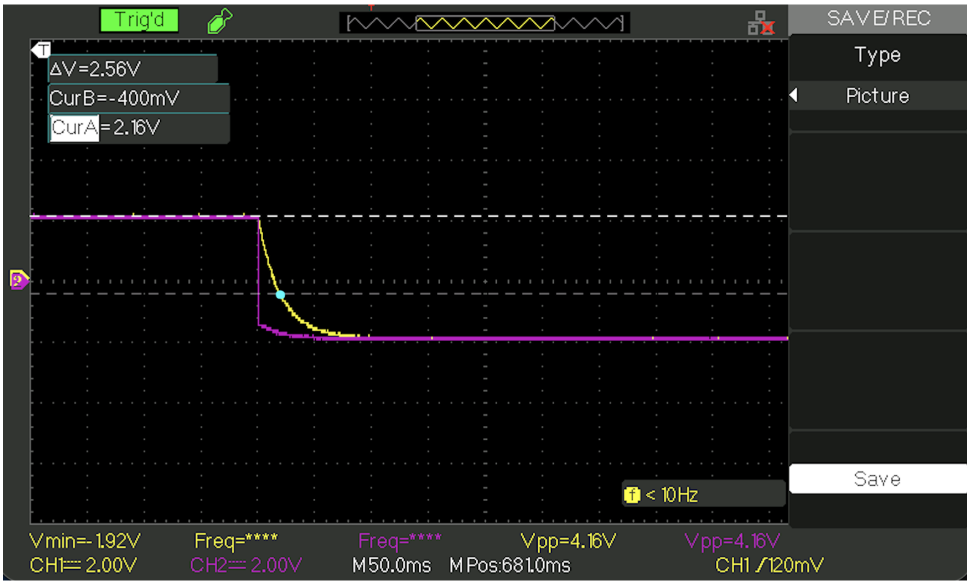


(b) Voltage response for Case 1 (ΔV)

Figure 3: Experimental waveforms of the RC circuit for Case 1.



(a) Time response for Case 2 (Δt)

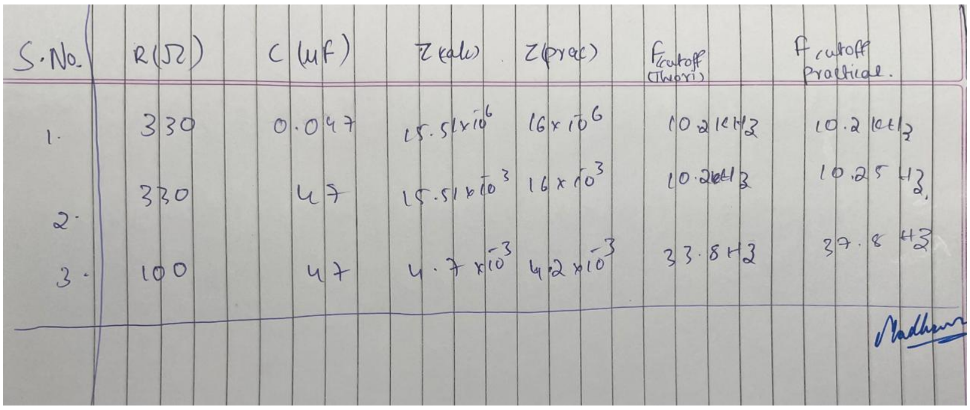


(b) Voltage response for Case 2 (ΔV)

Figure 4: Experimental waveforms of the RC circuit for Case 2.

Observation Table:

Theoretical and practical values of the time constant and cutoff frequency were measured for different combinations of resistors and capacitors. The results are tabulated below:



S.No.	R(Ω)	C(μF)	τ (calc)	τ (prac)	f_{cutoff} (Theory)	f_{cutoff} Practical.
1.	330	0.047	15.51×10^{-6}	16×10^{-6}	10.2 kHz	10.2 kHz
2.	330	47	15.51×10^{-3}	16×10^{-3}	10.2 kHz	10.25 Hz
3.	100	47	4.7×10^{-3}	4.2×10^{-3}	33.8 Hz	37.8 Hz

Figure 5: Observation table of RC circuit on PCB.

Explanation:

The behavior of an RC circuit can be understood using its time constant, cutoff frequency, and transfer function.

Time Constant:

The time constant τ is defined as:

$$\boxed{\tau = R \times C} \tag{1}$$

During charging, the capacitor voltage is:

$$\boxed{V_c(t) = V_{in}\left(1 - e^{-t/\tau}\right)} \tag{2}$$

which shows that the capacitor charges up to about 63.2% of the input voltage in one time constant.
During discharging, the capacitor voltage is:

$$\boxed{V_c(t) = V_{in} e^{-t/\tau}} \tag{3}$$

which means that about 36.8% of the initial voltage remains after one time constant.

Cutoff Frequency:

The cutoff frequency f_c of the RC circuit is:

$$\boxed{f_c = \frac{1}{2\pi RC}} \tag{4}$$

At this frequency, the output amplitude is reduced to about $\frac{1}{\sqrt{2}}$ (approximately 70%) of the input, which corresponds to a reduction of 3 dB.

Conclusion:

- Gained an understanding of the functioning and basic controls of the Digital Storage Oscilloscope (DSO).
- Learned the structure and application of the breadboard for making circuit connections.
- Analyzed the charging and discharging behavior of RC circuits.
- Compared theoretical and practical values of the time constant (τ) and cutoff frequency (f_c).
- Minor deviations between theoretical and experimental results were observed due to:
  - Resistor and capacitor tolerances
  - Parasitic effects in the setup
  - Measurement limitations

References:

- Lab manual: Introduction to DSO, Breadboard and RC Circuit Experiment
- Engineering Circuit Analysis by William Hayt et al.
- Signals and Systems by V.A. Oppenheim et al.