THE UNIVERSITY OF HONG KONG

Department of Physics

PHYS2255 Introductory electricity and magnetism

Laboratory report 2255-2: RC circuit

Full name : ______________________

UID : ______________________

Group No. : ______________________

Date : ______________________

* This semi-full report is for reference only. Students are welcome to write their own full report as long as marking standard is met, e.g. appropriate sectioning, statements written in full sentence, and all the questions asked in manual have been answered.
Blanks are provided here for making quick drafts. When submitting the report, students are strongly suggested to type on a computer and print out the hard copies.

1 Objectives

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2 Background

An RC circuit is composed of a resistor R and a capacitor C, sometimes driven by a voltage source which can be either DC or AC. In **??**, the presence of capacitor prohibits any current from passing through, so current $i(t)$ is only significant before the capacitor being fully charged. To analyze this circuit, we begin with

$$\mathcal{E} = V_R(t) + V_C(t) = i(t)R + Q(t)/C ,$$

where $Q(t)$ is the amount of charge piled up at the capacitor as a function of time.

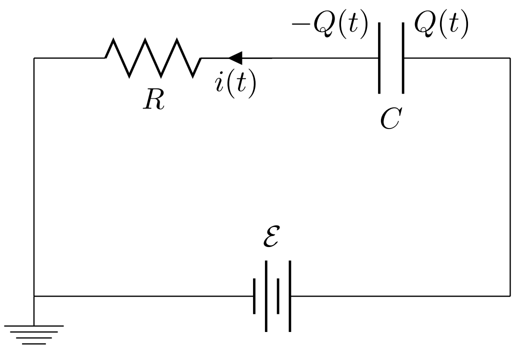

Figure 1: A simple RC circuit. Ground is introduced to define where $V = 0$.

Now, a key step is to realize $i(t) = \frac{dQ(t)}{dt}$. This leads to

$$\frac{dQ(t)}{dt} + \frac{1}{RC}Q(t) = \frac{1}{R}\mathcal{E} \implies Q(t) = \frac{e^{-t/RC}}{R}\int \mathcal{E}e^{t/RC}\, dt . \tag{1}$$

In the remaining parts of this report, **??** shall serve as a starting point for us to derive many interesting properties of RC circuit.

3 Apparatus

- Cathode-ray oscilloscope
- AC signal generator
- ____________________
- ____________________
- ____________________

[May include more if not sufficient.]

4 Measurements and results

[Make sure you include error analysis for every single measurement.]

4.1 Charging and discharging of RC circuit

[Task 1: Plot $V_C(t)$]

Suppose $\mathcal{E}$ is time-independent, then **??** can be simplified into

____

Therefore, when RC circuit is being charged,

$$V_C(t) = \mathcal{E} \cdot \left(1 - e^{-t/\tau}\right) \ ,$$

and when RC circuit is being discharged,

$$V_C(t) = V_C(0) \cdot e^{-t/\tau} \ ,$$

where $\tau \equiv RC$ is ____________________

Figure 2: $V_C(t)$ during charging mode.

Figure 3: $V_C(t)$ during discharging mode.

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[Task 2: Setting up circuit]

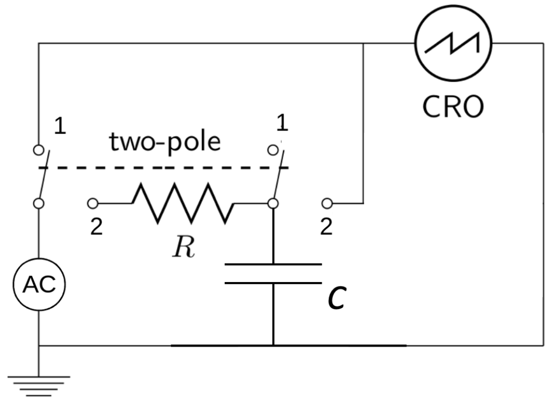

Figure 4: ____

To use the same CRO for monitoring the status of AC generator, we introduce a two-pole switch as shown in **??**. Also, __________ wave AC source has been chosen because ____

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[Task 3: Measuring the internal resistance of signal generator]

Time constant τ is an important parameter for an RC circuit. To measure it, we first need to know the internal resistance R_i of generator. ____

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[Task 4: Measure time constant τ]

Having known the internal resistance, we may revise our prediction for time constant into ________________

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It remains to measure the time constant experimentally. Based on the circuit in **??**, we expect to see some periodic curve on CRO. For each semi-cycle, we should see _______________ or _______________. Therefore, by varying the frequency, hence period T, of AC source while maintaining the same $\tau = RC$, _________________________

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Having understood the aforementioned mechanism, we propose to measure time constant τ as following: _____

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4.2 Differentiating circuit and integrating circuit

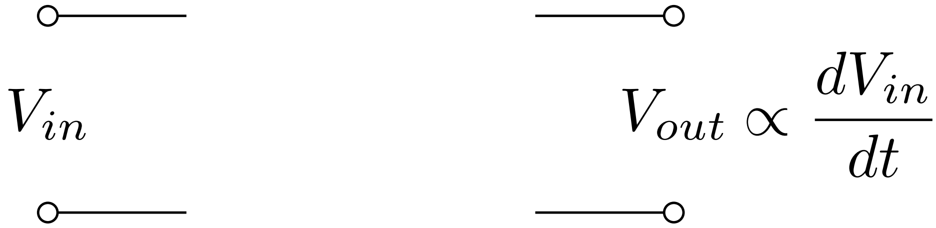

Figure 5: ____

To construct a differentiating circuit, we first notice that for voltage source of any kind, the relation

$$V_R(t) \propto \frac{dV_C(t)}{dt}$$

always holds. This is true because $V_C(t)$ can be rewritten as ____

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Figure 6: ____

Construction of integrating circuit is done in a similar manner. Simply swap ____

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During the laboratory session, we observed that ____

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4.3 Phase shift in RC circuit

To make the phase shift more evident, we will solely be using sinusoidal waves in this part. We wish to experimentally demonstrate the result

$$V_C(t) = \frac{\mathcal{E}_m}{\sqrt{1 + (\omega RC)^2}} \cdot \sin(\omega t - \phi) \ ,$$

where phase shift $\phi = \tan^{-1}(\omega RC)$. For simplicity, we fix at $C = 0.01\,\mu\mathrm{F}$ and $R = 20\,\mathrm{k\Omega}$, and only vary the frequency $\omega = 2\pi f$. ____

We did not measure $V_R(t)$ because for sinusoidal signals, the phase difference between $V_R(t)$ and $V_C(t)$ ______

5 Discussion

6 References