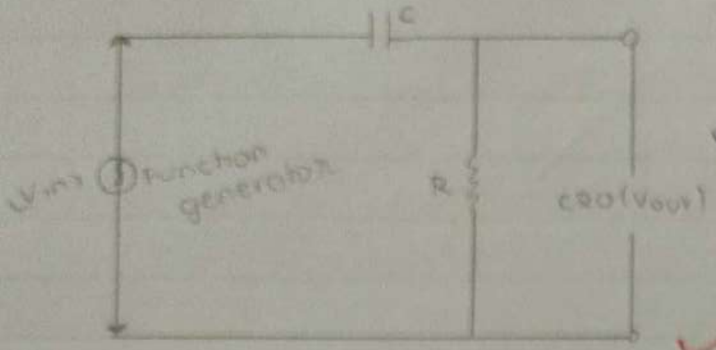
Diagram: (RC Differentiator)



[Please don't correct this experiment as it is complete]

$C = 0.001\,\mu F$

$R = 10\,k\Omega$

(i) $RC = 0.001 \times 10^{-6} \times 10 \times 10^{3}$

$= 10^{-5}\,s$

$T = \frac{1}{f} = \frac{1}{1000} = 10^{-3}\,s$

$\therefore RC << T.$

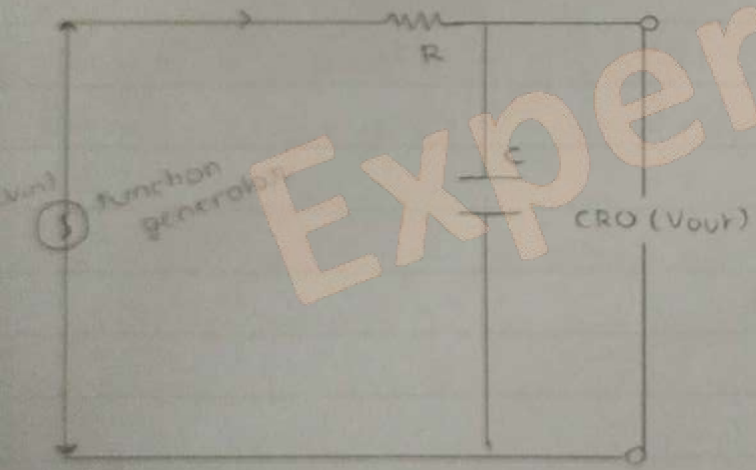
(ii) $X_C = \frac{1}{2\pi f C} = \frac{1}{2(3.14)(1000)(10^{-3} \times 10^{-6})}$

$= \frac{10^{6}}{6.28} = 1.59 \times 10^{5}\,\Omega$

$R = 10^{4}\,\Omega$

$\therefore X_C > 10R.$

(RC Integrator)



$C = 0.1\,\mu F$

$R = 200\,k\Omega$

(i) $RC = 200 \times 10^{3} \times 0.1 \times 10^{-6}$

$= 2 \times 10^{-2}\,s$

$T = 10^{-3}\,s$

$\therefore RC >> T.$

(ii) $X_C = \frac{1}{2\pi f C} = \frac{1}{2(3.14)(1000)(10^{-6} \times 0.1)}$

$= 1.59 \times 10^{3}\,\Omega$

$10X_C = 1.59 \times 10^{4}\,\Omega$

$R = 2 \times 10^{5}\,\Omega$

$\therefore R > 10X_C$

Aim: To study RC circuit as a differentiator and an integrator

Apparatus:

A square wave generator, a CRO, resistors: 10 kΩ & 200 kΩ, capacitors: 0.1 μF & 0.001 μF

Theory:

RC Differentiator:

A circuit that gives an output voltage proportional to the derivative of its input voltage is known as a differentiating circuit or a differentiator, i.e., output $\propto \frac{d}{dt}$(input). The conditions necessary for this circuit to act as a differentiator are:

(i) The time constant RC of the circuit should be much smaller than the time period T of the input signal i.e. $RC << T$.

(ii) The value of the capacitive reactance $X_c = \left(\frac{1}{2\pi f c}\right)$ should be greater than or equal to 10 times R i.e. $X_c \geq 10R$

In V_{in} be the input alternating voltage, i the resulting alternating current, then the instantaneous charge on the capacitor is given as:

$q = CV_c$ where V_c is the instantaneous voltage across the capacitor C

$$i = \frac{dq}{dt} = \frac{d}{dt}(CV_c) = C\frac{dV_c}{dt}$$

Since $X_c >> R$, the voltage across the capacitor may be considered equal to the input voltage, i.e. $V_c = V_{in}$

$$i = C\frac{d}{dt}(V_{in})$$

Output voltage, $V_{out} = iR$, $RC\frac{d}{dt}(V_{in})$

$$V_{out} \propto \frac{d}{dt}(V_{in})$$

Teacher's Signature ____________

RC circuit acts like a differentiator when the output is taken across R. If the input voltage is the square wave, the output wave should be pulses of infinite amplitude and alternating polarity occuring precisely at the steps of the input.

RC Integrator:

A circuit that gives an output voltage directly proportional to the integral of its input voltage is known as an integrating circuit or an integrator. So for an integrator,

$$output \propto \int input$$

The conditions to be fulfilled as:

(i) The time constant RC of the circuit should be very large as compared to the time period T of the input signal i.e., $RC >> T$.

(ii) The values of R should be greater or equal to 10 times the values of the capacitive reactance X_C i.e. $R \geq 10X_C$.

If Vin be the input alternating voltage and i be the resulting alternating current, then $i = \frac{V_R}{R}$ where V_R is the voltage drop across the resistor R.

Since $R >> X_C$, the voltage across R may be considered equal to the input voltage

i.e. $V_R = V_{in}$

$$i = \frac{V_{in}}{R}$$

The charge on the capacitor at any instant is

$$q = \int i\,dt = \frac{1}{R}\int V_{in}\,dt$$

The output voltage, $V_{out} = q/C = \frac{1}{CR}\int V_{in}\,dt$

$$V_{out} \propto \int V_{in}\,dt$$

Thus the RC circuit acts like ~~the~~ an integrator when the output is taken across c. When the input wave is a square wave, the output is a triangular wave.

Precautions & sources of error:

The value of the resistor R & the capacitor C & the frequency of the signal generator should be chosen as such:

(i) The time constant RC of the circuit is much smaller/greater than the time ~~constant RC of the circuit~~ period of the input wave for a diff./integrator. resp.

(ii) The value of X_c at the operating frequency should be such that $X_c \geq 10R$ for a differentiator & $R \geq 10X_c$ for an integrator.

Result:

(i) The input and the output wave forms of RC differentiator are traced. Since the input wave was a square wave, the output wave was pulses of maximum input amplitude, and alternating polarity occuring at the discontinuities of the input. The input wave being a sin wave, the output wave was a cos wave.

(ii) The input and output wave forms of RC integrator are traced. Since the input was a square wave, the output wave was a triangular wave, as the integral of a constant is a linear function of alternating polarity.