RC CIRCUITS

Objectives:-

You will be able to

- Draw voltage & Current graphs for a capacitor being changed via a resistor from a dc voltage source & explain the shape of the graphs.
- Write the equation for instantaneous capacitor voltage in a series RC Circuit with a DC voltage source. Calculate the capacitor and resistor voltages at any time from the instant of supply switch-on when the capacitor is initially uncharged and when it is already partially charged.
- Define the time constant for a series RC Circuit and derive equations relating various levels of capacitor voltage, charging time, and time constant. Perform calculations involving the circuit time constant.
- Show how the input circuit of an amplifier can be represented as an RC Circuit. Perform calculations involving R, C, the circuit upper cutoff frequency the rise time at the output, the circuit lower cutoff frequency and the tilt on the top of a rectangular output waveform.
- Sketch differentiating & integrating circuits explain their operation and determine the expected output voltages for given inputs.

Introduction:-

When a capacitor is charged from a dc voltage source through a resistor the Instantaneous level of capacitor voltage may be calculated at any given time. There is a definite relationship between the time constant of an RC circuit and the times required for the capacitor to charge to approximately 63% and 99% of the input voltage. Also, an important relationship exists between the time constant of a circuit and the rise time of the output voltage from the circuit. Depending upon the arrangement of the RC circuit, it may be employed as an integrator or a differentiator.

Experiment No.1

RC CIRCUITS

Aim:- To design an integrator and a differentiator and observe the output for Square wave inputs.

Components and Equipments:-Resistors, Capacitors, function generator, CRO, Groove board, BNC, Patch cards, clips.

1) Circuit diagram:-

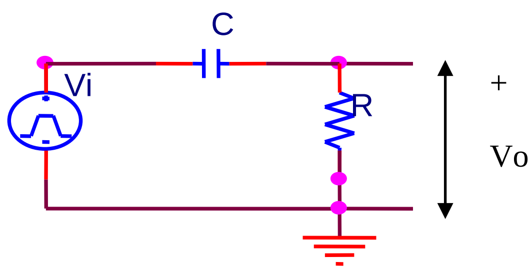


Fig1.1: High pass RC Circuit

Design:- Let the lower 3db frequency (f_c) = 5kHz

$$f_c = 1/2\pi RC$$

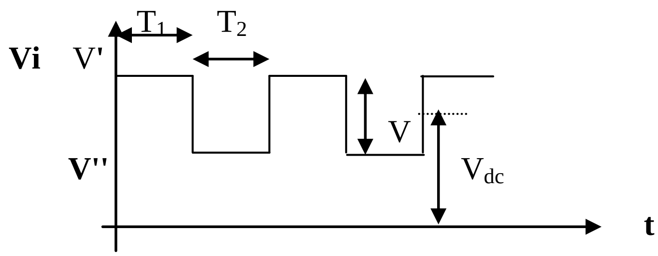
Assume C= 10nF then R = 3.183KΩ

Procedure1:-

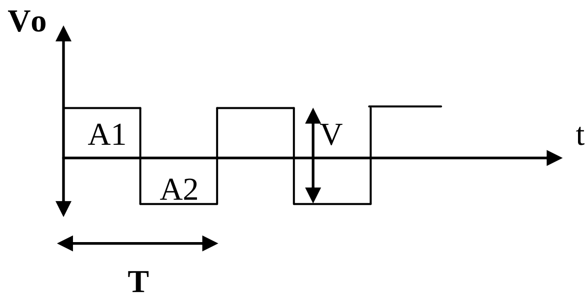
Differentiating circuit:

- Construct an RC differentiating circuit as in figure1.1 using R = 2.2KΩ and C = 0.1μf.
- Apply a ±10V, 500Hz square wave input and monitor both input & output waveform on a (dc- coupled) Oscilloscope.
- Sketch the input and output waveform for f = 500Hz carefully noting the amplitude and the phase relationship between input & output.
- Change the signal frequency to 50 Hz, 5KHz & 50KHz in turn. Sketch the input & Output waveforms in each case.
- Change the input to triangular waveform and again repeat the above procedures .

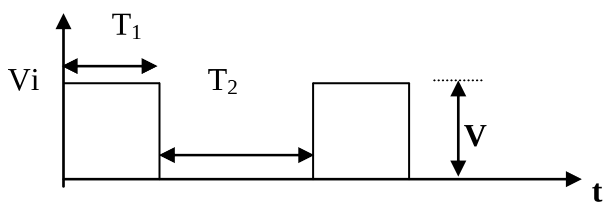
Square wave input:-



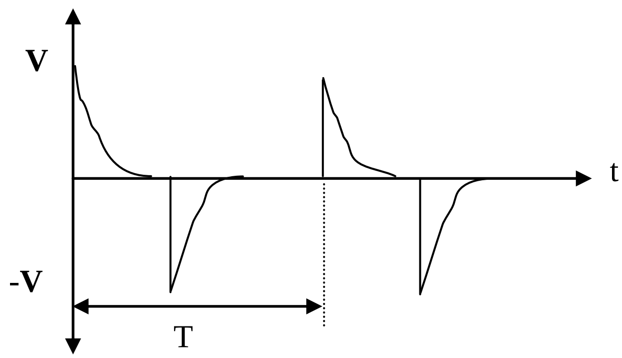
When τ >>T



Input wave



O/p wave (peaking of
The square wave result
from a time constant small
Compared with T)



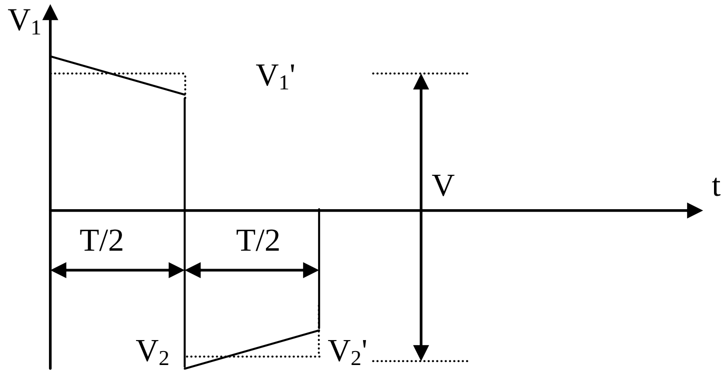
The square wave response of a high pass RC circuit. The dashed curve would represent the o/p if RC>>T

The percentage tilt P is defined by

$$\mathbf{P = (V_1 - V_1')/V/2 \times 100 \approx T/\,2RC \times 100\%}$$

$$\mathbf{\approx \pi\, fc/f \times 100\%}$$

Where f = 1/T is the frequency of the applied input square wave

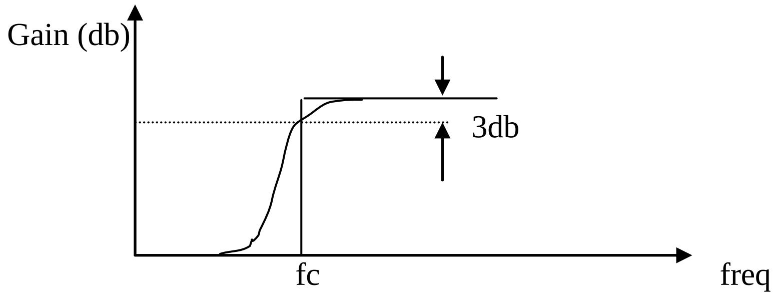


Observations:-

i/p voltage: ________(p-p)

Frequency (Hz)	o/p (V)	gain (db)	Phase (deg)

Expected wave form:-



Results:-

Lower 3db frequency (fc) =________KHz

Phase shift at cut off freq =________

Time constant of the circuit =_____ μsec

Percentage of Tilt (P) =______

Conclusion:- 1) It acts as a differentiator, when τ<<T

2) The dc component of the o/p is always is zero.

2) Circuit diagram:-

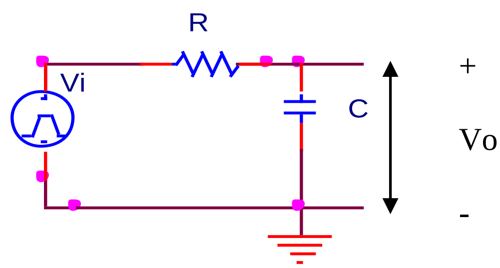


Fig1.2: Low Pass RC Cicrcuit

Design:- Let the upper 3db frequency (fc) = 5KHz

$$Fc = 1/2\pi RC$$

Assume C = 10nF then R = 3.183KΩ

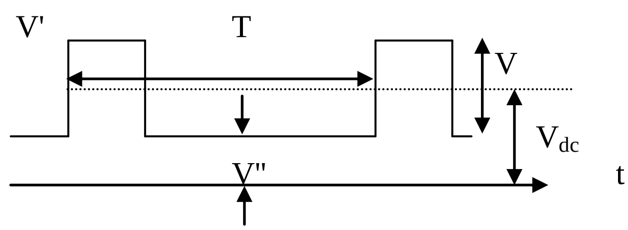
Procedure2:-

Integrating circuit:

2-1.Rearrange R & C as an integrating circuit as illustrated in fig 1.2.

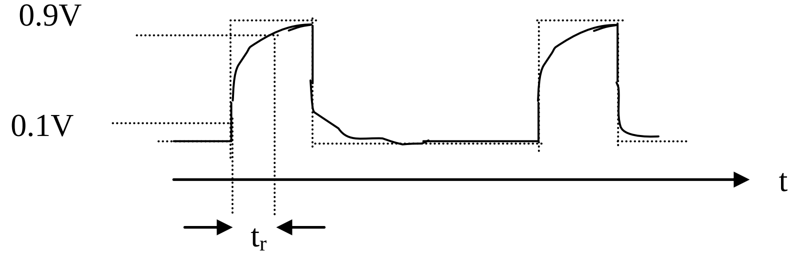
2-2. Repeat procedures 1-2 through 1-5 for the integrating circuit.

Square wave I/P:-



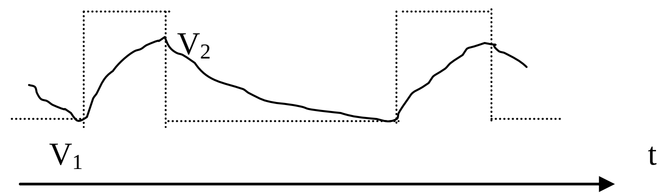
O/P waveform:-

(i) RC<<T

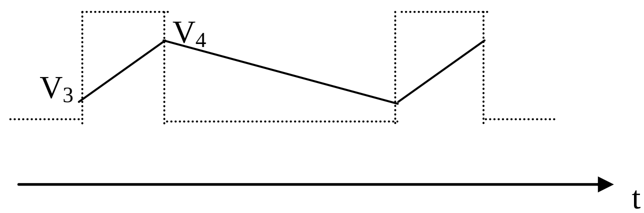


(ii)

RC = T



(iii) RC >> T

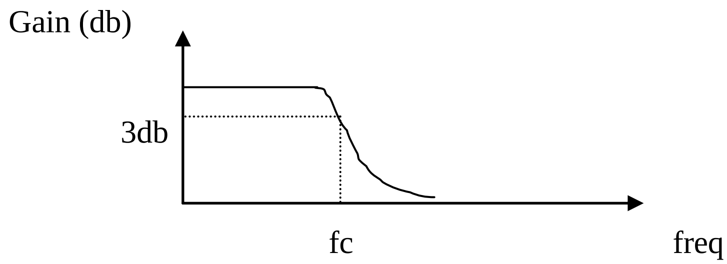


Observations:-

I/P voltage =_______(p-p)

Frequency (Hz)	Output (V)	Gain (db)	Phase (deg)

Typical frequency response: -



Results:-

Upper 3db frequency (fc) =_____kHz

Phase shift at cutoff freq =______ ^{o}

Time constant of the circuit =_____μsec

Rise time (t_r) =______ns.

Analysis:-

- Discuss each output waveform in comparison to the input & explain the shape of the outputs in terms of the circuit time constant.
- Calculate the expected output amplitude with the 500Hz triangular wave input to the differentiating circuit. Compare to the measured output amplitude.
- Calculate the expected output amplitude when the 50KHz square wave input is applied to the integrating circuit. Compare to the measured output amplitude.

Conclusion:-

The low pass RC circuit acts as an integrator when RC >>T.