B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING
SECOND YEAR SECOND SEMESTER – 2024

ANALOG INTEGRATED CIRCUITS

Time : Three hours **Full Marks : 100**

ALL MODULES ARE COMPULSORY.

Module – I (for CO #1) (8 Marks)

[CO1 : describe the salient features of analog integrated circuits and the fundamentals of Operational Amplifier.]

Q1(a) In Fig. P1(a), the input V_i is a variable frequency ac sinusoidal signal. "The inverting and non-inverting input terminals of the Op-Amp used in this circuit will always remain in virtual short condition." Comment on this statement. (4)

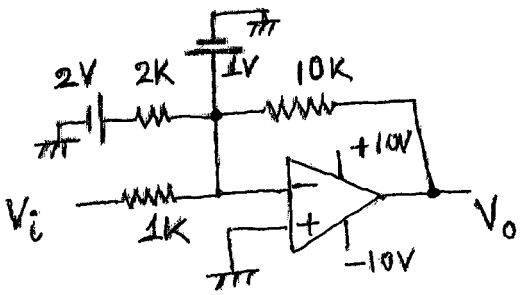

Fig. P1(a)

(b) The Op-Amp used in Fig. P1(b) has slew rate of 0.5V/μs. Find out the value of the maximum allowable input frequency for which there will be no distortion in the output wave shape. (4)

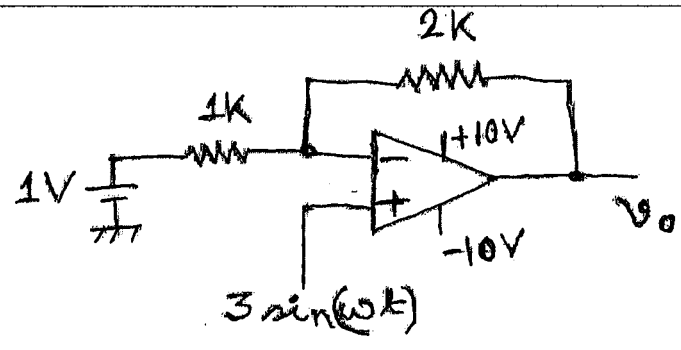

Fig. P1(b)

Module – II (for CO #2) (26 Marks)

[CO2 : **construct** and **analyze** various linear analog circuits, e.g. amplifiers, adder, instrumentation amplifiers, integrators, differentiators, etc.]

Q2 (a) For the circuit shown in Fig. P2(a), R = 1 kΩ and C = 0.1 μF. For a dc gain of −10, what will be the 3 dB cut-off frequency ? (5)

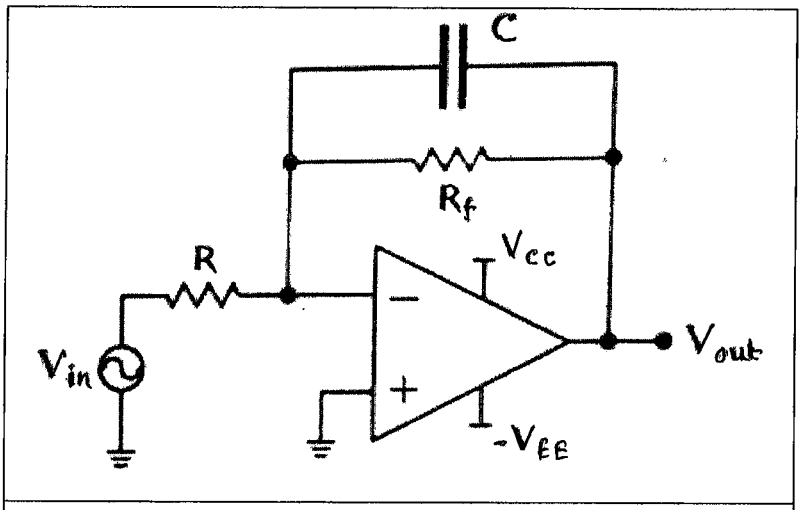

Fig. P2(a)

(b) For the circuit shown in Fig. P2(b), assume the Op-Amp is ideal and the initial charge on the capacitor is zero. Find out the output voltage at time t = 2 ms. (5)

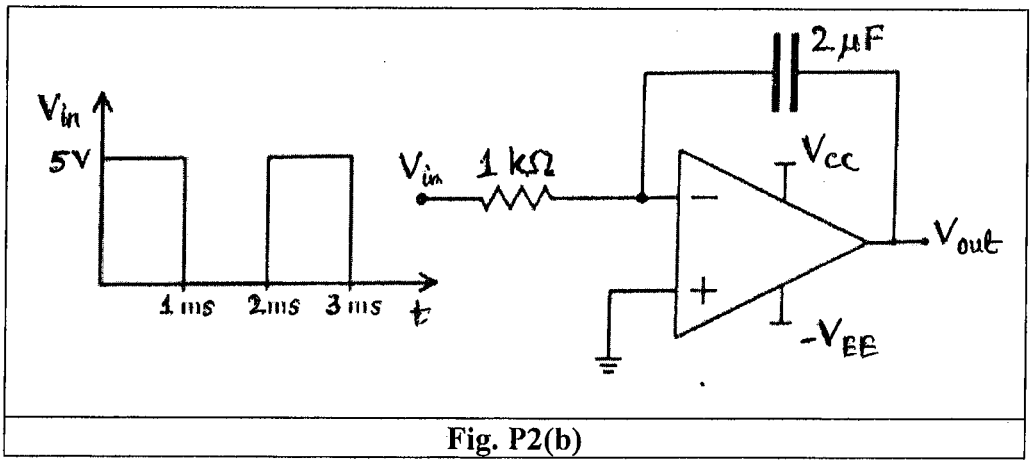

Fig. P2(b)

Q3. (a) For the circuit shown in Fig. P3(a), the switch is initially closed. It is opened at $t = 0$ s and remains open thereafter. Find out the time (in milliseconds) at which the output voltage V_{out} switches to -5V. (8)

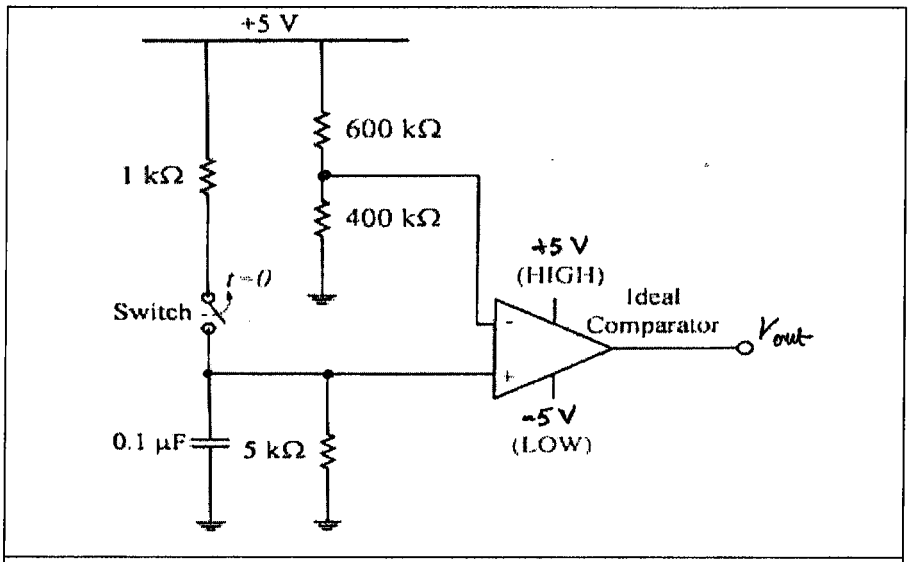

Fig. P3(a)

(b) Find out the expression of the output voltage V_O for the circuit shown in Fig. P3(b). (8)

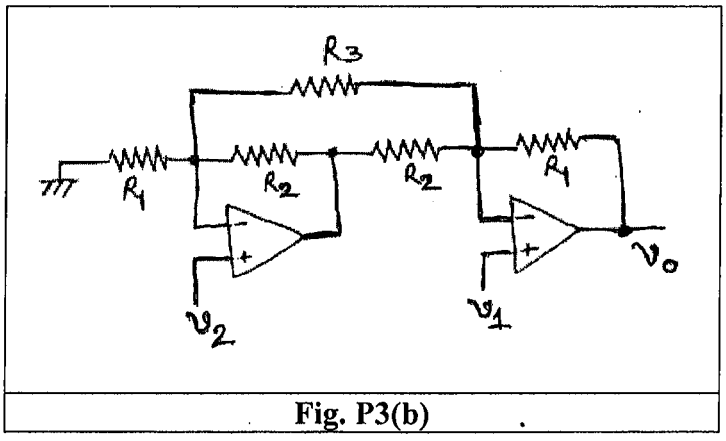

Fig. P3(b)

Module – III (for CO #3) (36 Marks)

[Answer Question No. 4 and ANY ONE from 5 and 6]

[CO3 : construct and **analyze** various nonlinear analog circuits, e.g. comparators with positive feedback, multivibrators, oscillators, other waveform generators, active filters, precision rectifiers, etc.]

Q4. (a) Using analog multipliers and operational amplifiers realize the following function.

$$f(x, y, z) = \frac{2}{5}(x^3 y^{\frac{2}{3}})/z$$

Assume that the inputs x, y and z are available as positive voltage sources. (10)

(b) For the circuit shown in Fig. P4(b), the Op-Amp used is an ideal one. Find out the difference between the maximum and the minimum values of the capacitor voltage V_C. The diodes used in this circuit are also ideal. (6)

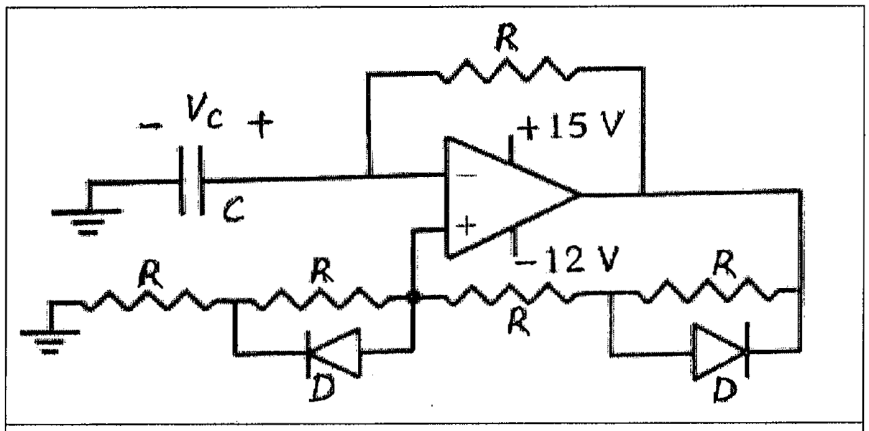

Fig. P4(b)

Q5. With the help of necessary circuit diagram and waveforms, explain the operation of the high input impedance precision full wave rectifier. (20)

Q6. Realize the 5th order Butterworth polynomial in normalized s-domain. Use this polynomial to realize a 5th order Butterworth low-pass filter having 60Hz cutoff frequency and pass band gain 20. Show the final circuit diagram for the filter with all component values. Give the analysis of any assumed circuit block. (5 + 15)

Module – IV (for CO #4) (30 Marks)

[CO4 : describe the critical aspects of the limitations of practical Operational Amplifiers, study the timer circuits and DAC – ADC modules.]

Q7. With the help of the relevant portion of the internal block diagram of IC-555, explain the operation of a 555-timer based mono-shot generator generating a shot of duration 10ms. Draw necessary circuit diagrams and waveforms. (15)

Q8. In Fig. P8, both the Op-Amps A1 and A2 are ideal, except that the Op-Amp A1 has an offset voltage (V_{os}) of 1 mV, as shown in this figure. For $V_{in} = 0$ V, find out the values of the output voltages V_{out1} and V_{out2}. (5)

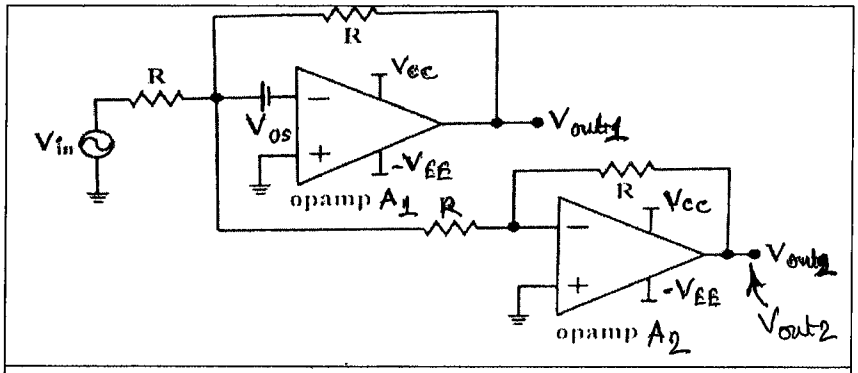

Fig. P8

Q9. (a) With the help of necessary block diagram, briefly explain the operation of a successive approximation type ADC. (6)

(b) For the circuit shown in Fig. P9(b) assume that the Op-Amp used is an ideal one. Find out the output voltage. (4)

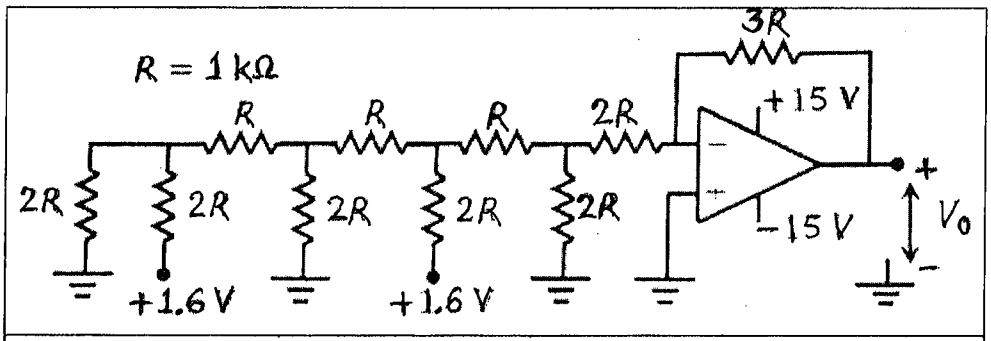

Fig. P9(b)