ANALOG CIRCUITS
(ECE2101)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) An integrator circuit is basically a
(a) low pass filter (b) high pass filter
(c) band pass filter (d) none of the above.

(ii) In a BJT biasing circuit, what does the Q-point represent?
(a) The point of maximum power dissipation in the transistor
(b) The operating point where the transistor functions in its active region
(c) The point where the transistor switches between cutoff and saturation
(d) The point where the transistor is biased for minimum current flow.

(iii) Which oscillator circuit uses a capacitive voltage divider to determine the frequency of oscillation?
(a) Phase-shift oscillator (b) Wien-Bridge oscillator
(c) Hartley oscillator (d) Colpitt oscillator

(iv) In a Wien-Bridge oscillator, the frequency of oscillation is primarily determined by:
(a) Inductance and capacitance of the circuit
(b) A resistive-capacitive (RC) network
(c) A tapped inductor
(d) A quartz crystal

(v) In an ideal Op-amp, which is not true?
(a) Open loop voltage gain is infinite (b) Input resistance is infinite
(c) Slew rate is infinite (d) CMRR is zero.

(vi) Which of the following OPAMP circuits can be used to convert a sinusoidal input into a square wave output?
(a) Adder (b) Instrumentation amplifier
(c) Schmitt Trigger (d) Integrator

(vii) The slew rate of an operational amplifier determines:
(a) The maximum frequency response of the op-amp
(b) The maximum rate of change of the output voltage
(c) The input impedance of the op-amp
(d) The offset voltage of the op-amp

(viii) Which of the following amplifier classes operates with the transistor conducting for the entire cycle of the input signal?
(a) Class A (b) Class B
(c) Class AB (d) Class C

(ix) The cross-over distortion in a Class B amplifier occurs because:
(a) Both transistors conduct simultaneously
(b) Neither transistor conducts near zero input signal
(c) The input signal amplitude is too high
(d) The bias voltage is excessive

(x) The condition for sustained oscillation in an RC-phase shift oscillator is:
(a) βA = 0 (b) βA = 1
(c) βA > 1 (d) βA < 1

Fill in the blanks with the correct word

(xi) In an operational amplifier's _____ configuration, the output is connected back to the inverting input, and the voltage gain is determined by the ratio of two resistors.

(xii) The low-frequency response of a CE amplifier is mainly determined by the _____ capacitors of the biasing network.

(xiii) In a Class B amplifier, the transistor conducts for _____ degrees of the input signal cycle.

(xiv) The total phase shift provided by the feedback network in an ideal Wien-bridge oscillator at the resonant frequency is _____ degrees.

(xv) The Common Mode Rejection Ratio (CMRR) of a differential amplifier is mathematically defined as the ratio of the differential gain to the _____.

Group - B

2. (a) Using proper circuit diagram, explain operations of series and parallel clipper circuits. In each case, compare the output waveform with the input waveform.
[(CO1)(Remember/LOCQ)]

(b) In the circuit indicated in Fig. 1, a Bipolar Junction Transistor (BJT) is biased using a voltage-divider configuration. The circuit parameters are: $V_{CC} = 12\,V$, $R_1 = 50k\Omega, R_2 = 10k\Omega$, $R_C = 2.2k\Omega$, $R_E = 1k\Omega$, $\beta = 100$ (current gain of the transistor), $V_{BE} \approx 0.7\,V$.
(i) Calculate the base current I_B, the collector current I_C, and the emitter current I_E.
(ii) Determine the Q-point (collector-emitter voltage V_{CE} and collector current I_C) of the transistor.
[(CO2)(Analyze/IOCQ)]

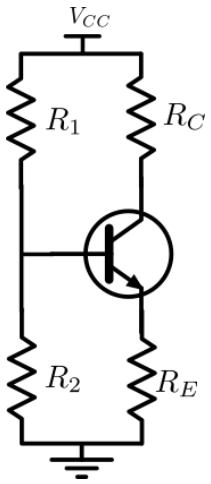

Fig. 1

6 + 6 = 12

3. (a) Prove mathematically that the operating point in a potential divider biasing circuit is independent of β. Assume relevant assumptions. *[(CO2)(Apply/IOCQ)]*

(b) In the amplifier circuit as shown in Fig. 2, the values of R_C and R_B are such that the transistor is operating at V_{CE}=3V and I_C =1.5mA, when its β=150. For a transistor with β=200, determine the operating point, consider V_{CC}=6V.

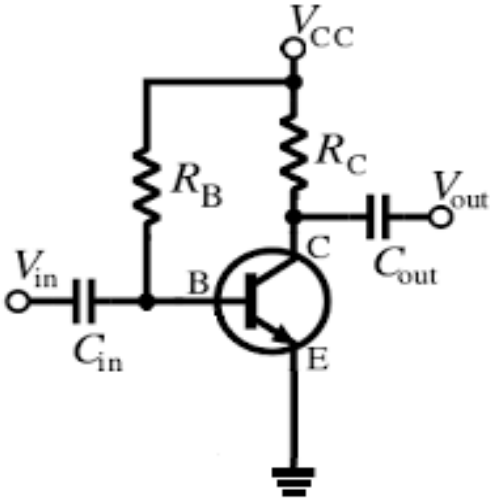

Fig. 2

[(CO2)(Apply/IOCQ)]

(2 + 4) + 6 = 12

Group - C

4. (a) Write short notes on the following: (i) Crystal oscillator (ii) Role of coupling capacitors, wiring, and parasitic capacitances in limiting frequency response of BJT amplifier circuits. *[(CO4)(Evaluate/HOCQ)]*

(b) Design a Phase-Shift Oscillator to generate a frequency of 10 kHz. Assume the necessary component values and show the calculations. *[(CO4)(Analyze /IOCQ)]*

8 + 4 = 12

5. (a) Compare the frequency stability and amplitude stability of Hartley and Colpitts oscillators. Why Crystal oscillators are stable oscillators? *[(CO4)(Analyse/IOCQ)]*

(b) A Colpitts oscillator uses L = 200 μH, C1 = 100 pF, and C2 = 100 pF. (i) Derive the expression for oscillation frequency and (ii) calculate the frequency in kHz. *[(CO4)(Apply/IOCQ)]*

(5 + 3) + 4 = 12

Group - D

6. (a) What are the advantages of differential amplifier? Draw the circuit of dual input balanced output differential amplifier. *[(CO5)(Remember/LOCQ)]*

(b) Design the equation with a suitable block diagram in which output voltage, Vout = $(V_1^{2/3}+V_2^{3/4})$, where, V_1 and V_2 are the input voltages. *[(CO5)(Create/HOCQ)]*

(2 + 4) + 6 = 12

7. (a) Explain the working of an op-amp based voltage comparator with hysteresis. Derive expressions for the upper and lower threshold voltages. *[(CO5)(Analyze/IOCQ)]*

(b) Using a suitable op-amp configuration, design a circuit whose output is the product of two input voltages. *[(CO5)(Analyze/IOCQ)]*

6 + 6 = 12

Group - E

8. (a) Explain the working principles of Class A, Class B, and Class AB amplifiers. Compare their operating points and conduction angles with the help of appropriate diagrams. *[(CO6)(Apply/IOCQ)]*

(b) Discuss the advantages and disadvantages of each amplifier class in terms of efficiency, linearity, and distortion. *[(CO6)(Remember/LOCQ)]*

6 + 6 = 12

9. (a) Draw the circuit diagram and explain the operation of an astable multivibrator using a 555 timer IC. Derive the expression for duty cycle. *[(CO4)(Analyze/IOCQ)]*

(b) Determine the pulse width of a monostable multivibrator circuit having R = 20 kΩ and C=0.1μF. *[(CO4)(Analyze/IOCQ)]*

8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	18.75	66.67	14.58