ANALOG & DIGITAL ELECTRONICS
(ELEC 2102)

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) In a 4 variable K-map, a 2 variable product term is produced by
(a) a 2 cell group of 1s (b) a 4 cell group of 1s
(c) an 8 cell group of 1s (d) a 16 cell group of 1s.

(ii) Minimum number of NAND gates required to realize an XOR gate is
(a) 3 (b) 4 (c) 2 (d) 5.

(iii) A digital multiplexer is a combinational circuit that selects
(a) many digital information and convert them into one
(b) one digital information from several sources and transmits the selected one via a single output
(c) many decimal inputs and transmits the selected information
(d) many decimal outputs and accepts the selected information.

(iv) An asynchronous sequential circuit is
(a) a combinational circuit without feedback
(b) a combinational circuit with feedback
(c) one that uses a clock
(d) none of the above.

(v) For a J-K flip flop, Q_n is the output at time step t_n. Which of the following Boolean expression represents the characteristic equation for Q_{n+1}?
(a) $JQ_n + K\overline{Q_n}$ (b) $J\overline{Q_n} + \overline{K}Q_n$
(c) $\overline{J}Q_n + K\overline{Q_n}$ (d) $JQ_n + \overline{K}\,\overline{Q_n}$.

(vi) Pin number 3 of IC 555 is called
(a) output (b) control (c) threshold (d) ground.

(vii) If the differential gain = 100 and CMRR = 100dB, then the common mode gain of a differential amplifier is
(a) 0.001 (b) 0.01 (c) 0.1 (d) 1.

(viii) The input impedance of a voltage series amplifier is given by
(a) $R_{iF} = R_i * (1 + A\beta)$ (b) $R_{iF} = R_i / (1 + A\beta)$
(c) $R_{iF} = R_i / A\beta$ (d) $R_{iF} = R_i * A\beta$.

(ix) The loop gain of a 3-stage RC phase shift oscillator should be
(a) 1 (b) 2 (c) 3 (d) 29.

(x) The output of an integrator circuit with square wave input is
(a) Triangular wave (b) Impulse
(c) Parabola (d) Step.

Fill in the blanks with the correct word

(xi) 2's complement of the number $(1010101)_2$ is _____.

(xii) The octal equivalent of the decimal number $(149)_{10}$ is _____.

(xiii) The number of select lines required in a 32:1 multiplexer is _____.

(xiv) The fundamental frequency of a crystal oscillator is _____ proportional to the thickness of the crystal.

(xv) The first stage in the block diagram of an operational amplifier is a _____ input balanced output differential amplifier.

Group - B

2. (a) Model the linear differential equation using minimum number of operational amplifiers:

$$2\frac{d^2y}{dt^2} + \frac{dy}{dt} + 2y = 3$$

[(CO2)(Apply/IOCQ)]

(b) The transistor circuit shown in Fig.1 uses 5.3V Zener diode. Consider base to emitter voltage drop to be 0.6 V, determine the value of the current gain β.

[(CO1)(Apply/IOCQ)]

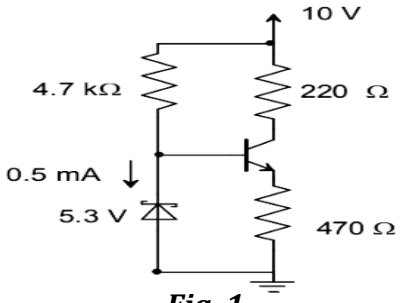

Fig. 1

(c) Explain the working principle of the circuit shown in Fig.2. Also draw its transfer characteristics.

[(CO2)(Evaluate/HOCQ)]

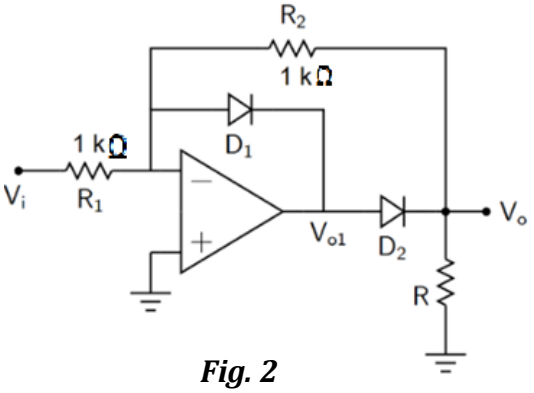

Fig. 2

4 + 4 + 4 = 12

3. (a) Design a non- inverting adder circuit to obtain an output voltage V_o where $V_o = 2V_1 + 3V_2$ where V_1 and V_2 are the input voltages. *[(CO2)(Apply/IOCQ)]*

(b) Calculate the values of I, I_Z and I_L for the circuit shown in Fig.3. It is given that breakdown voltage of the zener diode is 5V, R = 1.5 kΩ and R_L = 1kΩ. *[(CO1) (Apply/IOCQ)]*

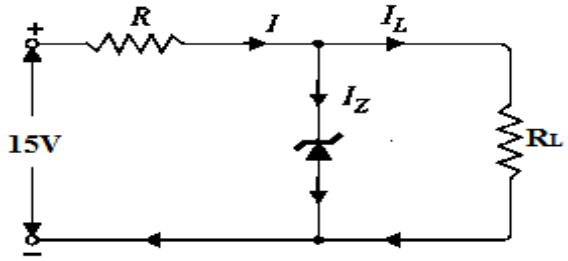

Fig. 3

(c) Consider an inverting Schmitt trigger circuit as shown in Fig.4. If V_i = 20V (p-p), 1kHz sine wave signal and V_{ref} = 3V, compute the upper and lower threshold voltages. Draw the output voltage waveform. Also compute the time duration of the positive and negative portion of the output voltage waveform. Consider $\pm V_{sat}$ = ±15V. *[(CO2)(Evaluate/HOCQ)]*

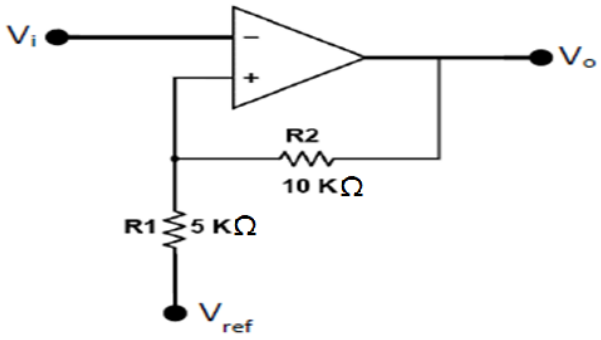

Fig. 4

4 + 4 + 4 = 12

Group - C

4. (a) Derive the expression of oscillation frequency for the Wien bridge oscillator using an operational amplifier. Also determine the gain for sustained oscillation. *[(CO3)(Apply/IOCQ)]*

(b) State and explain Barkhausen criteria. *[(CO3)(Remember/LOCQ)]*

8 + 4 = 12

5. (a) Discuss the principle of operation of an astable multivibrator using operational amplifier with the help of a neat circuit diagram. Sketch the output and capacitor voltage waveforms. Derive the expressions of time period of the output waveform and the duty cycle. *[(CO3)(Analyse/IOCQ)]*

(b) Draw the pin diagram of IC LM566. *[(CO3)(Remember/LOCQ)]*

8 + 4 = 12

Group - D

6. (a) Realize the following function using 2 input NAND gates only $F = \overline{A} + BC$. *[(CO4)(Understand/LOCQ)]*

(b) Illustrate the design of a 8:1 multiplexer using 4:1 multiplexer. Use block diagram of the components. *[(CO5)(Apply/IOCQ)]*

(c) Determine the canonical SOP form of the function Y=A+BC. *[(CO4)(Create/HOCQ)]*

4 + 5 + 3 = 12

7. (a) Implement the following Boolean expression using a 8×1 MUX:
$F(A,B,C,D) = \Sigma_m (0,1,2,3,4,10,11,14,15)$ *[(CO5)(Understand/LOCQ)]*

(b) Apply the knowledge of K map to solve the following Boolean expression and implement the circuit using suitable logic gate.
$F = \Sigma_m (1,5,6,12,13,14) + \Sigma_d (2,4)$ *[(CO4)(Apply/IOCQ)]*

(c) Design a single bit magnitude comparator circuit using NAND gate only. *[(CO5)(Create/HOCQ)]*

4 + 5 + 3 = 12

Group - E

8. (a) Describe the working of an $\overline{S}$-$\overline{R}$ latch using NAND gates. *[(CO6)(Remember/LOCQ)]*

(b) Construct a D flip-flop using J-K flip-flop. *[(CO6)(Apply/IOCQ)]*

(c) Develop the characteristic equation of T flip flop. *[(CO6)(Create/HOCQ)]*

4 + 5 + 3 = 12

9. (a) Explain with necessary logic diagram the working of a 3 bit parallel in serial out (PISO) shift register. *[(CO6)(Remember/LOCQ)]*

(b) Design and implement a Mod-6 synchronous up counter using JK flip flop. *[(CO6) (Create/HOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	27.08	48.96	23.96

Course Outcome (CO):

After the completion of the course students will be able to

1. Recall basic principles of diodes, transistors and OPAMPs.
2. Understand basic principles of OPAMP based circuits for linear and nonlinear operations and analyze their implications.
3. Acquire knowledge about different waveform generators, 555 timers, ADCs and DACs and their applications.
4. Recall number systems and Boolean algebra.
5. Understand Boolean algebra based realisation of logic gates and design of various arithmetic and combinational circuits.
6. Design and analyze various sequential circuits like synchronous and asynchronous counters, shift registers using flip flops.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*