

ANALOGUE ELECTRONICS CIRCUITS

Full Marks : 70

Time : 3 hours

Group—A is compulsory and answer any five questions from Group—B

*The figures in the right-hand margin indicate marks*

Symbols used throughout carry usual meaning

State assumptions clearly in choosing any component value or data if not specified

GROUP—A

1. Answer the following: 2 × 10

(a) State Barkhausen criterion, i.e., the condition necessary to sustain sinusoidal oscillation.

(b) What is the concept of virtual ground?

(c) Define the safe operating area of a transistor with suitable sketches.

(Turn Over)

$$A_v = - \frac{R_c \parallel R_o}{r_e}$$

$$= 3.6$$

$$Z_o = R_c \parallel R_o$$

$$Z_i = R_c$$

$$A(1 + \beta R_e) :$$

$$100(1 + \beta R_e) = \frac{9}{10}$$

IWL

(d) Draw the electrical model of a piezo-electric crystal.

(c) State three advantages of class B power amplifier over class A.

(f) Explain the origin of crossover distortion? How can this be minimized?

(g) How do coupling and bypass capacitors affect frequency response of an amplifier stage?

(h) What kind of circuit is used in the output stage of an OPAMP and why?

(i) Mention typical bandwidth for an audio amplifier, TV set, for an 80 column monitor and an oscilloscope amplifier.

(j) Adding a pre-amplifier to an audio amplifier increases the voltage gain by 60 dB. What is the corresponding factor by which the voltage is increased?

### GROUP—B

2. For the network of Fig. 1

(a) Determine  $r_e$

(b) Calculate  $Z_i$  and  $Z_o$

(c) Find  $A_v$  and  $A_{i_s}$

(d) Repeat parts (b) and (c) above with  $r_o = 25 \text{ k}\Omega$ .

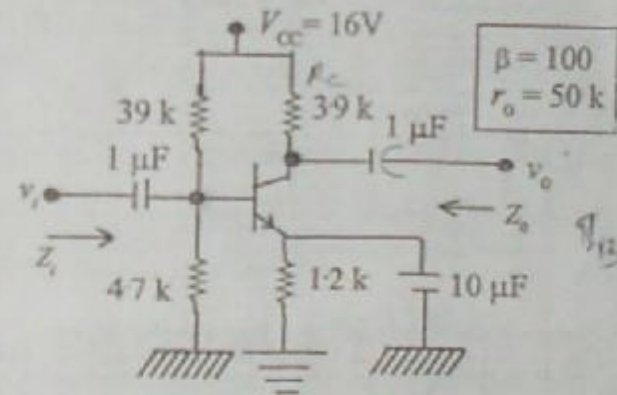


Fig. 1

10

3. (a) For the circuit in Fig. 2, the parameters are:  $V^+ = 10 \text{ V}$  and  $V^- = -10 \text{ V}$ ,  $R_S = 0$ ,  $R_E = 5 \text{ k}\Omega$ . The transistor parameters are  $V_{BE(on)} = 0.7 \text{ V}$  and  $V_A = \infty$  and the transistor current gain  $\beta$  is in the range of  $75 \leq \beta \leq 125$ . (i) Determine the value of  $C_E$  such that the low-frequency 3 dB point is  $f_B \leq 200 \text{ Hz}$ , (ii) From the results of part (i), determine the range in frequencies  $f_B$  and  $f_A$ .

( 4 )

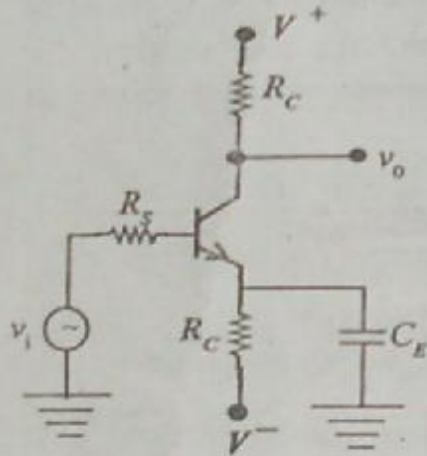


Fig.2

(b) For the circuit in Fig. 3 the transistor parameters are:  $K_n = 0.5 \text{ mA/V}^2$ ,  $V_{TN} = 2\text{V}$  and  $\lambda = 0$ . Determine the maximum value  $C_L$  such that the bandwidth is at least  $\text{BW} = 5 \text{ MHz}$ . State any approximations or assumptions that you make. What is the magnitude of the small-signal midband voltage gain? 5+5

( 5 )

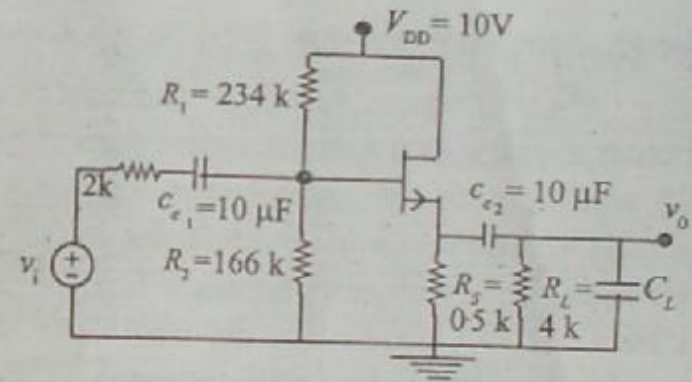


Fig.3

4. (a) For the OPAMP in the voltage follower circuit in Fig. 4, the open loop gain is  $10^4$ ,  $R_1 = 100 \text{ k}\Omega$ , and  $R_0 = 200 \Omega$ . Determine the closed loop voltage gain,  $R_{of}$  and  $R_{if}$ .

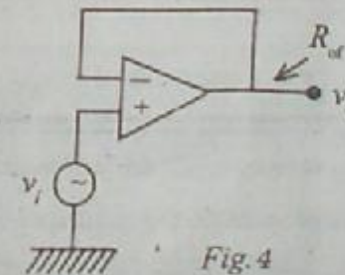


Fig.4

( 6 )

(b) It is desired to design a summing circuit (using OPAMP) whose output in volts is the class average on a quiz. The class size is 25 and all grades are integers between one and ten. The maximum output voltage is 10 V and the minimum resistance that can be used is 1 kΩ. Design the circuit. Now check your design with following grade distribution.

Number of students:	0	1	0	2	1	4	7	4	3	3
Quiz Grade :	1	2	3	4	5	6	7	8	9	10

(c) Sketch the phase-shift oscillator using (i) an OPAMP, (ii) a JFET. At what frequency will the circuit oscillate? 2+4+4

5. (a) Sketch the topology of a generalized resonant circuit oscillator, using impedances  $Z_1, Z_2, Z_3$ . Reduce this circuit to Hartley and Colpitts oscillator choosing components suitably? At what frequency will these circuits oscillate?

( 7 )

(b) Derive an expression for  $v_o$  in terms of input signals and the four resistors for the instrumentation amplifier shown in Fig. 5.

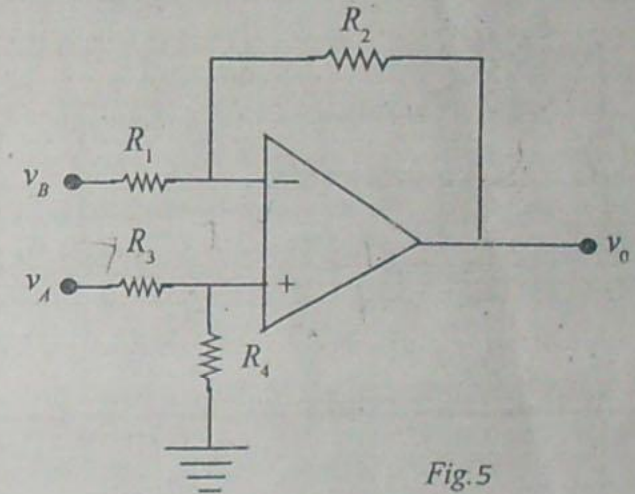


Fig.5

(c) If the above circuit is to be used as subtractor, for  $R_1 = R_3 = 10\text{ k}$  find  $R_2 = R_4$  so that  $v_o = 2v_A - 3v_B$ .

$$4 + 2 \frac{1}{2} + 2 \frac{1}{2} + 1$$

6. The JFET in the amplifier circuit of Fig. 6 has  $V_p = -4\text{ V}$  and  $I_{DSS} = 12\text{ mA}$ , and at  $I_D = 12\text{ mA}$  the output resistance  $r_o = 25\text{ k}$ . 10

- (a) Determine the dc bias quantities  $V_g$ ,  $I_D$ ,  $V_{gs}$  and  $V_D$ .
- (b) Determine the values of  $g_m$  and  $r_o$ .
- (c) Replace the JFET with its small signal model, thus obtaining the small-signal equivalent circuit of the amplifier.
- (d) Use the equivalent circuit in (c) to determine  $R_{in}$  and  $v_g/v_{in}$ .
- (e) Use the equivalent circuit to determine  $v_o/v_g$ .
- (f) Find the overall gain  $v_o/v_{in}$ .

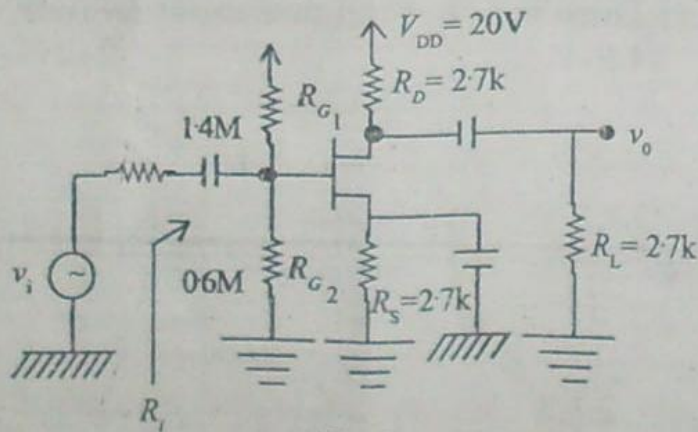


Fig. 6

7. (a) For the class-A amplifier shown in Fig. 7, show that the maximum theoretical conversion efficiency for a symmetrical square wave input is 50 per cent.

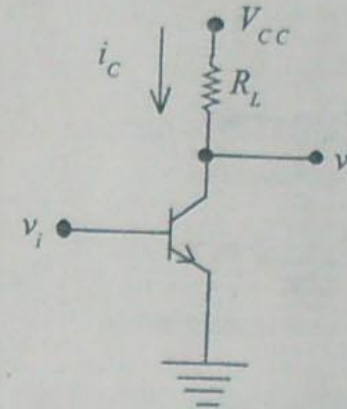


Fig. 7

- (b) Design the idealized class-B output stage, as shown in Fig. 8, to deliver an average of 25 W to an 8 ohm speaker. The peak output voltage must be no larger than 80 per cent of supply voltage  $V_{CC}$ . Determine
- The required value of  $V_{CC}$
  - The peak current in each transistor
  - The average power dissipated in each transistor

(iv) The power conversion efficiency.

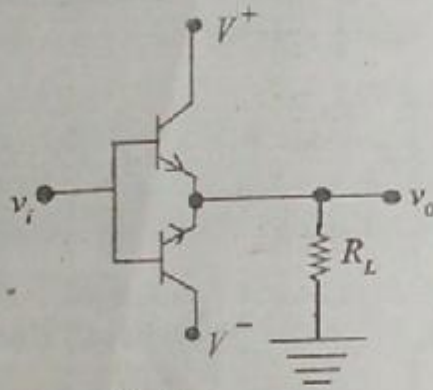


Fig. 8

(c) Define the safe operating area of a transistor with suitable sketches, graphs etc.  $2\frac{1}{2} + 5 + 2\frac{1}{2}$

8. (a) Consider a general feedback system with parameters  $A = 10^6$  and  $A_f = 100$ . If the magnitude of  $A$  decreases by 20 per cent, what is the corresponding per cent change in  $A_f$ .

(b) Draw the schematic of a series-shunt feedback topology. Derive expressions for closed loop voltage gain, input resistance and output resistance after feedback.

(c) A series-shunt feedback amplifier represented by Fig. 9 and using an basic voltage amplifier operates with  $V_s = 100$  mV,  $V_r = 90$  mV and  $V_o = 10$  V. What are the values of  $A$  and  $\beta$ .

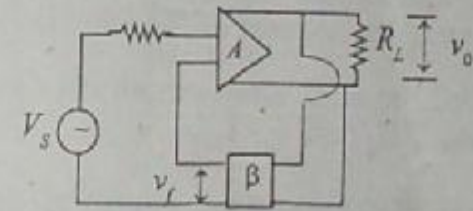


Fig. 9

(d) Draw the pin configuration for OPAMP LF-411.  $2+2+4+2$