Kafrelsheikh University
Faculty of Engineering
Department of electrical eng.
Year: 2nd   Subject: Electronic eng.
Examiner: **Dr. Bedir Bedir Yousif**

Date: 14/1/2017
Time allowed: 3 Hours
Full mark: 70 Mark
Final term: Two pages
Academic Number:ECE2103

Solve the following questions:-

Question One (20 Mark)

1. Determine the output voltage for the circuit in Fig. 1, (6 marks)

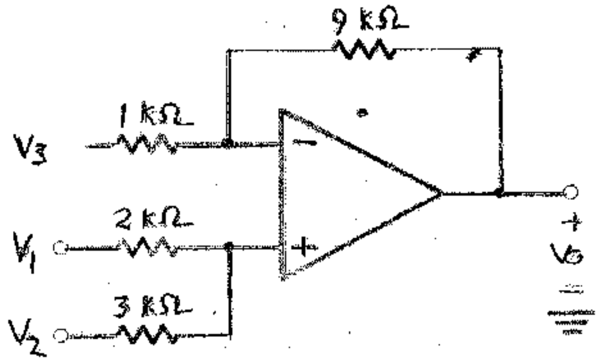


Fig . 1

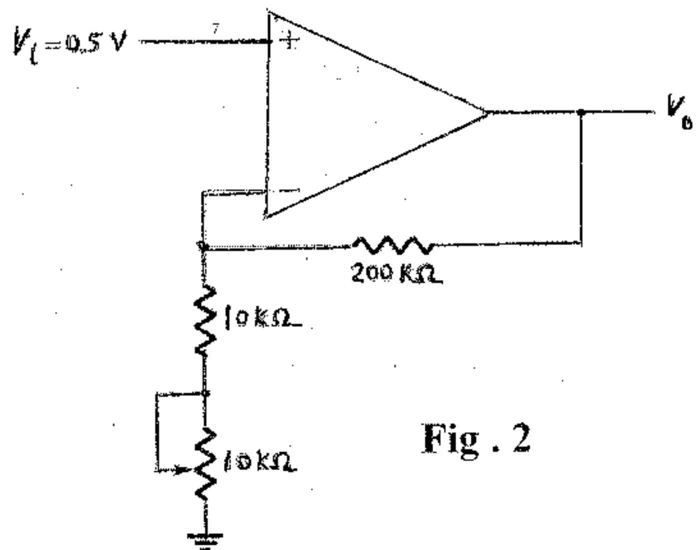


Fig . 2

2. What range of output voltage is developed in the circuit of Fig. 2 (7 marks)
3. Define CMRR and how to experimentally measure CMRR? (7 marks)

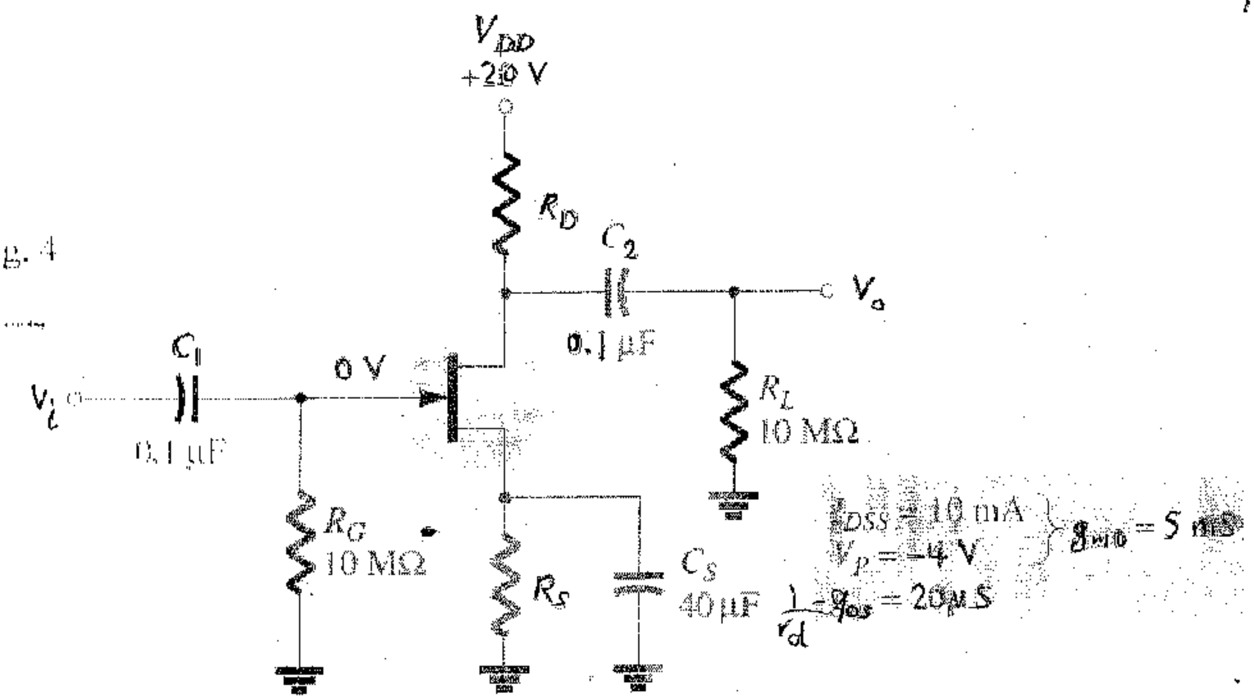
Question Two (~~30~~ 20 Mark)

1. Calculate the efficiency of a class B amplifier for a supply voltage of V_{CC} =22 V driving a 4 Ω load with peak output voltages of: a. $V_L(p)$ = 20 V. b. $V_L(p)$ = 4 V. 7
2. A transformer-coupled class A amplifier drives a 16- Ω speaker through a 3.87:1 transformer. Using a power supply of V_{CC} = 36 V, the circuit delivers 2 W to the load. Calculate: 7
   a. P(ac) across transformer primary.
   b. V_L(ac).
   c. V(ac) at transformer primary.
   d. The rms values of load and primary current.
3. Explain briefly three different configurations of practical class B power amplifier 6

Question Three (30 Mark)

1- Choose the values of R_D and R_S for the network of Fig. 3 that will result in a gain of 8 using a relatively high level of g_m for this device defined at $V_{GSQ} = 0.25V_P$. 7

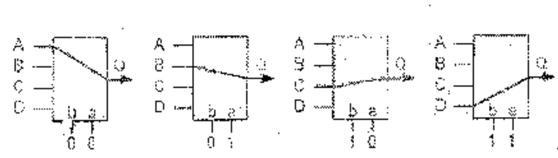
Fig. 4



2- An analog switch uses an n-channel MOSFET with $V_{GS(th)} = 4$ V. A voltage of +8 V is applied to the gate. Determine the maximum peak-to-peak input signal that can be applied if the drain-to-source voltage drop is neglected. 8

3- An analog switch is used to sample a signal with $x(t)=10+5\cos 2000t + 8\cos 8000t$. Determine the minimum frequency of the pulses applied to the MOSFET gate. 5

4- Design a quad time division multiplexer using an n-channel MOSFET with $V_{GS(th)} = 3$ V. A voltage of +8 V is applied to the gate of each MOSFET during 0.25 µs. Calculate the sampler frequency and maximum signal frequency. 10



Best wishes of success

Dr. Bedir yousif

$V = 2 \times \frac{V_2}{5}(1+9) = 4V_2$

$= \frac{3V_1}{5}(1+9) = 6V_2$

هندسة الكترونية -

Model answer

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Q1-1:

If in the circuit of Fig. E2.9 the 1-kΩ resistor is disconnected from ground and connected to a third signal source v_3, use superposition to determine v_O in terms of v_1, v_2, and v_3.

Ans. $v_O = 6v_1 + 4v_2 - 9v_3$ $= 6V_1 + 4V_2 - 9V_3$

Q1-2:

$$V_o = \left(1 + \frac{R_F}{R_1}\right) V_1$$

For $R_1 = 10\ \text{k}\Omega$:

$$V_o = \left(1 + \frac{200\ \text{k}\Omega}{10\ \text{k}\Omega}\right)(0.5\ \text{V}) = 21(0.5\ \text{V}) = \mathbf{10.5\ V}$$

For $R_1 = 20\ \text{k}\Omega$:

$$V_o = \left(1 + \frac{200\ \text{k}\Omega}{20\ \text{k}\Omega}\right)(0.5\ \text{V}) = 11(0.5\ \text{V}) = \mathbf{5.5\ V}$$

V_o ranges from 5.5 V to 10.5 V.

Q1-3: **Common-Mode Rejection Ratio**

The ratio between A_d and A_c is the common-mode rejection ratio (CMRR),

CMRR = A_d / A_c

1. To measure Ad: Set $Vi1 = -Vi2 = Vs = 0.5$ V, so that

$V_d = (Vi1 - Vi2) = (0.5\ \text{V} - (-0.5\ \text{V}) = 1$ V

and

$Vc = 1/2(Vi_1 + Vi_2) = 1/2[0.5\ \text{V} + (-0.5\ \text{V})] = 0$ V

Under these conditions the output voltage is

$V_o = A_dV_d + A_cV_c = A_d\,(1\ \text{V}) + A_c(0) = A_d$

Thus, setting the input voltages $Vi_1 = -Vi_2 = 0.5$ V results in an output voltage numerically equal to the value of A_d.

2. To measure A c : Set $Vi_1 = Vi_2 = Vs = 1$ V, so that

$V_d = (Vi_1 - Vi_2) = (1\ \text{V} - 1\ \text{V}) = 0$ V

and $V_c = 1/2(Vi_1 + Vi_2) = ½\,(1\ \text{V} + 1\ \text{V}) = 1$ V

Under these conditions the output voltage is

$Vo = A_dV_d + A_cV_c = A_d\,(0\ \text{V}) + A_c(1\ \text{V}) = A_c$

Thus, setting the input voltages $Vi_1 = Vi_2 = 1$ V results in an output voltage numerically equal to the value of A_c.

CMRR = A_d / A_c

Q2-1:

(a) $V_{L(\text{peak})} = 20\text{ V}$

$$P_i = V_{CC}I_{dc} = V_{CC}\left[\frac{2}{\pi}\cdot\frac{V_L}{R_L}\right]$$

$$= (22\text{ V})\left[\frac{2}{\pi}\cdot\frac{20\text{ V}}{4\ \Omega}\right] = 70\text{ W}$$

$$P_o = \frac{V_L^2}{2R_L} = \frac{(20\text{ V})^2}{2(4\ \Omega)} = 50\text{ W}$$

$$\%\eta = \frac{P_o}{P_i}\times 100\% = \frac{50\text{ W}}{70\text{ W}}\times 100\% = \mathbf{71.4\%}$$

(b) $P_i = (22\text{ V})\left[\frac{2}{\pi}\cdot\frac{4\text{ V}}{4\ \Omega}\right] = 14\text{ W}$

$$P_o = \frac{(4)^2}{2(4)} = 2\text{ W}$$

$$\%\eta = \frac{P_o}{P_i}\times 100\% = \frac{2\text{ W}}{14\text{ W}}\times 100\% = \mathbf{14.3\%}$$

Q2-2

(a) $P_{pri} = P_L = \mathbf{2\ W}$

(b) $P_L = \frac{V_L^2}{R_L}$

$$V_L = \sqrt{P_L R_L} = \sqrt{(2\text{ W})(16\ \Omega)}$$

$$= \sqrt{32} = \mathbf{5.66\ V}$$

(c) $R_2 = a^2 R_1 = (3.87)^2(16\ \Omega) = \mathbf{239.6\ \Omega}$

$$P_{pri} = \frac{V_{pri}^2}{R_{pri}} = 2\ \text{W}$$

$$V_{pri}^2 = (2\ \text{W})(239.6\ \Omega)$$

$$V_{pri} = \sqrt{479.2} = \mathbf{21.89\ V}$$

[or, $V_{pri} = aV_L = (3.87)(5.66\ \text{V}) = 21.9\ \text{V}$]

(d) $P_L = I_L^2 R_L$

$$I_L = \sqrt{\frac{P_L}{R_L}} = \sqrt{\frac{2\ \text{W}}{16\ \Omega}} = \mathbf{353.55\ mA}$$

$$P_{pri} = 2\ \text{W} = I_{pri}^2 R_{pri} = (239.6\ \Omega)\, I_{pri}^2$$

$$I_{pri} = \sqrt{\frac{2\ \text{W}}{239.6\ \Omega}} = \mathbf{91.36\ mA}$$

$$\text{or, } I_{pri} = \frac{I_L}{a} = \frac{353.55\ \text{mA}}{3.87} = \mathbf{91.36\ mA}$$

Solution: The operating point is defined by

$$V_{GS_Q} = \frac{1}{4}V_P = \frac{1}{4}(-4\text{ V}) = -1\text{ V}$$

and $$I_D = I_{DSS}\left(1 - \frac{V_{GS_Q}}{V_P}\right)^2 = 10\text{ mA}\left(1 - \frac{(-1\text{ V})}{(-4\text{ V})}\right)^2 = 5.625\text{ mA}$$

Determining g_m, we obtain

$$g_m = g_{m0}\left(1 - \frac{V_{GS_Q}}{V_P}\right)$$

$$= 5\text{ mS}\left(1 - \frac{(-1\text{ V})}{(-4\text{ V})}\right) = 3.75\text{ mS}$$

The magnitude of the ac voltage gain is determined by

$$|A_v| = g_m(R_D \| r_d)$$

Substituting known values results in

$$8 = (3.75\text{ mS})(R_D \| r_d)$$

so that $$R_D \| r_d = \frac{8}{3.75\text{ mS}} = 2.13\text{ k}\Omega$$

The level of r_d is defined by

$$r_d = \frac{1}{g_{os}} = \frac{1}{20\ \mu\text{S}} = 50\text{ k}\Omega$$

and $$R_D \| 50\text{ k}\Omega = 2.13\text{ k}\Omega$$

with the result that

$$R_D = \mathbf{2.2\text{ k}\Omega}$$

which is a standard value.

The level of R_S is determined by the dc operating conditions as follows:

$$V_{GS_Q} = -I_D R_S$$

$$-1\text{ V} = -(5.625\text{ mA})R_S$$

and $$R_S = \frac{1\text{ V}}{5.625\text{ mA}} = 177.8\ \Omega$$

The closest standard value is **180 Ω**. In this example, R_S does not appear in the ac design because of the shorting effect of C_S.

Q3-2: $V_{ip-p} = 8^V$

Q3-3 = $f_{sample_{min}} \geq 2 f_{signal_{max}}$

$\geq \cancel{2}\cdot\frac{8000}{2\pi}\ 4$

$f_{min\ sample} \geq 2.54\text{ KHz}$

Q3-4 $f_{sample} = \frac{1}{0.25\mu S} = 4\text{ MHz}$

$f_{signal\ max} = \frac{4\text{ MHz}}{4} = 1\text{ MHz}$

D S

$2\text{ k}\Omega$

$G = V_P$

$V_{GS} = V_G - V_S > 1^V$

$V_S = V_D = V_P$

$V_G = 8^V$

$8 - V_P = 4$

$V_P = 4^V$

$V_{p-p} < 8^V$