CMR INSTITUTE OF TECHNOLOGY

USN										

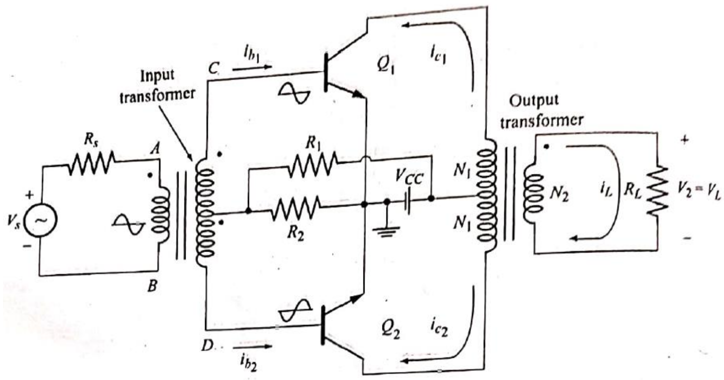
Internal Assessment Test - III

Sub:	**Analog Electronic Circuits and Op-Amps**							Code:	**21EE32**
Date:	07.02.2023 8.30am – 10am	Duration:	90 mins	Max Marks:	50	Sem:	III	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	Explain the operation of Class B push pull amplifier. Prove that the maximum efficiency of Class B amplifier is 78.5%		CO4	L3

Solution:



2

During Positive half cycle - Q_1 conducts and Q_2 is off.

$$i_L = \frac{N_1}{N_2} i_{c1}$$

During Negative half cycle – Q_1 is off and Q_2 conducts.

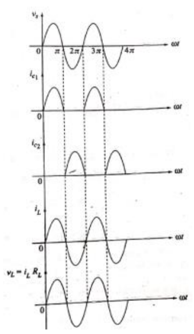
$$i_L = -\frac{N_1}{N_2} i_{c2}$$

Combining both equations

$$i_L = \begin{cases} \frac{N_1}{N_2} i_{c_1} & \text{for } 0 \le \omega t \le \pi \\ -\frac{N_1}{N_2} i_{c_2} & \text{for } \pi \le \omega t \le 2\pi \end{cases}$$

2

or $$i_L = \frac{N_1}{N_2} [i_{c_1} - i_{c_2}]$$



2

$$\%\eta = \frac{P_{o(ac)}}{P_{i(dc)}} \times 100\%$$

AC output power

$$P_{o(ac)} = \frac{V_{CE(p)} I_{C(p)}}{2}$$

DC input power

$$P_{i(dc)} = V_{CC} I_{dc}$$

average current in each transistor is $\frac{I_{C(p)}}{\pi}$

$$\therefore I_{dc} = 2\,[\text{average current in each transistor}]$$

$$= \frac{2 I_{C(p)}}{\pi}$$

$$P_{i(dc)} = \frac{2}{\pi} V_{CC} I_{C(p)}$$

$$\%\eta = \frac{\left(\frac{V_{CE(p)} I_{C(p)}}{2}\right)}{\frac{2}{\pi} V_{CC} I_{C(p)}} \times 100\%$$

$$\%\eta = \frac{\pi}{4} \frac{V_{CE(p)}}{V_{CC}} \times 100\%$$

$$V_{CE(p)} = V_{CC}$$

$$\%\eta_{max} = \frac{\pi}{4} \times 100\% = 78.54\%$$

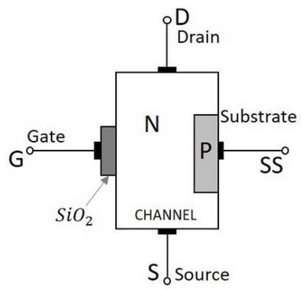
4

2 With the help of neat diagrams, explain the construction, working and characteristics of N-channel depletion type MOSFET. CO5 L2

Solution:

- Metal Oxide Semiconductor Field Effect Transistor (or) Metal Oxide Silicon Field Effect Transistor.
- Also called as IGFET (Insulated Gate Field Effect Transistor).
- Operated in both Depletion mode and Enhancement modes of operation.
- ✓ D-MOSFET
- ✓ E-MOSFET

2



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- An oxide layer is deposited on the substrate to which the gate terminal is connected.
- This oxide layer acts as an insulator (sio$_2$ insulates from the substrate), and hence the MOSFET has another name as IGFET

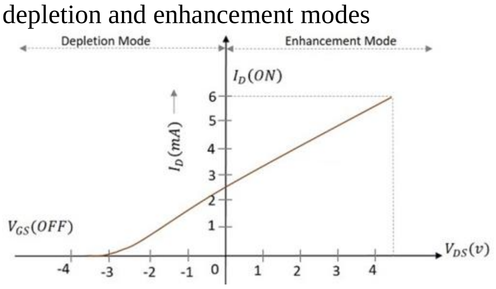
In the construction of MOSFET, a lightly doped substrate, is diffused with a heavily doped region. Depending upon the substrate used, they are called as **P-type** and **N-type** MOSFETs.

2

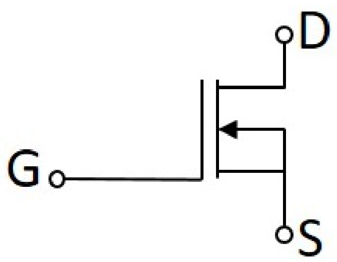
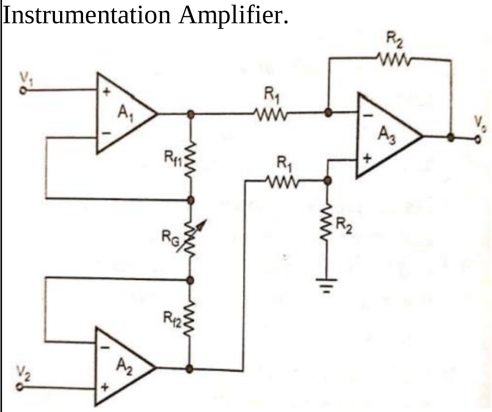
- The voltage at gate controls the operation of the MOSFET.
- In this case, both positive and negative voltages can be applied on the gate as it is insulated from the channel.

With negative gate bias voltage, it acts as **Depletion mode** while with positive gate bias voltage it acts as an **Enhancement mode**.

Transfer characteristics define the change in the value of $\mathbf{V_{DS}}$ with the change in $\mathbf{I_D}$ and $\mathbf{V_{GS}}$ in both depletion and enhancement modes



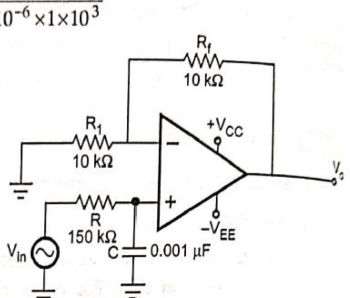
2

	Symbol of N-Channel D-MOSFET  	2		
3	A series fed Class A amplifier operates from dc source and applied sinusoidal input signal generates peak base current 9mA, Calculate I_{CQ}, V_{CEQ}, P_{dc}, P_{ac} and efficiency. Given values are $R_B = 1.5K\Omega$, $R_L = 16\Omega$, $\beta = 50$, $V_{BE} = 0.7V$, $V_{CC} = 20V$. **Solution:**		CO4	L3
	$I_B = \frac{V_{CC}-V_{BE}}{R_B} = \frac{20-0.7}{1.5K\Omega} = 12.8mA.$ $I_{CQ} = \beta I_B = 50\times 12.8 = 640mA.$	2		
	$V_{CEQ} = V_{CC} - I_{CQ}R_L = 20-(640\times 16\Omega) = 9.76V.$	2		
	$P_{dc} = V_{CC}\times I_{CQ} = 20\times 640 = 12800 mW.$	2		
	$P_{ac} = \frac{(I_{CP})^2 R_L}{2}$ $I_{C(P)} = \beta I_{B(P)} = 50\times 9 = 450mA.$ $P_{ac} = \frac{(450)^2(16\Omega)}{2} = 1620mW.$	2		
	$\%\eta = \frac{P_{ac}}{P_{dc}}\times 100 = \frac{1620}{12800}\times 100 = 12.66\%$	2		
4	Explain the 3 Op-Amp instrumentation amplifier and derive the expression for output voltage. **Solution:**		CO6	L2
	Instrumentation amplifier is a high gain differential amplifier with high CMRR value and also allows to adjust the gain of the amplifier circuit without having to change more than one resistor value. The op-amps A1 & A2 are the non-inverting amplifier forming the first stage of the Instrumentation Amplifier. The op-amp A3 is the normal difference amplifier forming the output stage of the Instrumentation Amplifier.	2		
	 	2		
	$V_o = \frac{R_2}{R_1}(V_{o2} - V_{o1})$	1		

<table>
<tr><td></td><td>Applying Ohm's law between the nodes E and F we get,
$$I = \frac{V_{o1} - V_{o2}}{R_{f1} + R_G + R_{f2}}$$
Let $R_{f1} = R_{f2} = R_f$
$$\therefore \quad I = \frac{V_{o1} - V_{o2}}{2R_f + R_G}$$
Now from the observation of nodes G and H,
$$I = \frac{V_G - V_H}{R_G} = \frac{V_1 - V_2}{R_G}$$
Equating the two equations (1.30.4) and (1.30.5),
$$\frac{V_{o1} - V_{o2}}{2R_f + R_G} = \frac{V_2 - V_1}{R_G}$$
$$\therefore \quad \frac{V_{o2} - V_{o1}}{2R_f + R_G} = \frac{V_1 - V_2}{R_G}$$
$$\therefore \quad V_{o2} - V_{o1} = \frac{(2R_f + R_G)(V_2 - V_1)}{R_G}$$
Substituting the $V_{o2} - V_{o1}$, in the equation (1.30.1),
$$V_o = \frac{R_2}{R_1} \cdot \left[\frac{2R_f + R_G}{R_G}\right](V_2 - V_1)$$
$$\therefore \quad V_o = \frac{R_2}{R_1} \cdot \left(1 + \frac{2R_f}{R_G}\right)(V_2 - V_1)$$</td><td>2

3</td><td></td><td></td></tr>
<tr><td>5</td><td>Design a first order low pass Butterworth filter at a cutoff frequency of 1KHz with pass band gain of 2 and also draw its circuit diagram.

Solution:

Solution : Step 1 : Cut-off frequency $f_H = 1$ kHz
Step 2 : Choose C = 0.001 μF
Step 3 : $f_H = \frac{1}{2\pi RC}$ i.e. $R = \frac{1}{2\pi \times 0.001 \times 10^{-6} \times 1 \times 10^3}$
$\therefore$ R = 159.15 kΩ (Use 150 kΩ)
Step 4 : $A_F = 2$ but $A_F = 1 + \frac{R_f}{R_1}$
$\therefore \quad \frac{R_f}{R_1} = 1$ i.e. $R_f = R_1$
Choose $R_f = R_1 = 10$ kΩ
The designed circuit is shown in the

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2
2
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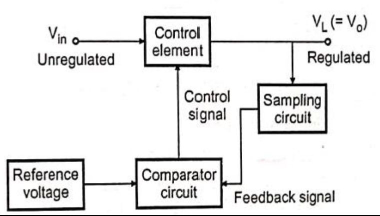
2</td><td>CO6</td><td>L6</td></tr>
<tr><td>6</td><td>Explain the op-amp series voltage regulator with neat circuit diagram.
Define Line regulation and Load regulation with respect to voltage regulator.

Solution:


</td><td>3</td><td>CO6</td><td>L2</td></tr>
</table>

	The unregulated d.c. voltage is the input to the circuit. The control element, controls the amount of the input voltage, that gets to the output. The sampling circuit provides the necessary feedback signal. The comparator circuit compares the feedback with the reference voltage to generate the appropriate control signal. For example, if the load voltage tries to increase the comparator generates a control signal based on the feedback information. This control signal causes the control element to decrease the amount of the output voltage. Thus the output voltage is maintained constant. **Two basic categories of voltage regulation are:** ❖**Line regulation and** ❖**Load regulation** The purpose of line regulation is to maintain a constant output voltage when the input voltage changes. The purpose of load regulation is to maintain a nearly constant output voltage when the load varies	3 2 2			