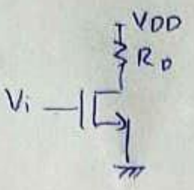
Akshayamathi M. 21BLC1632

Wednesday DA key

C1 - Slot.

Class A power amplifier

9.



$V_{DD} = 10V$ $R_D = 10k\Omega$ $k_n = 0.5 mA/V^2$

$V_T = 1V$ $\lambda = 0$. Assume the output voltage is limited to the range between transition point and $V_{DS} = 9V$ to minimize non linear disortion

$$V_{DS} = V_{DD} - I_D R_D$$

$$V_{DS(sat)} = V_{GS} - V_{TN}$$

$$I_D = K_n (V_{GS} - V_{TN})^2 \Rightarrow I_D = k_n V_{DS(sat)}^2$$

$$V_{DS(sat)} = V_{DD} - K_n V_{DS(sat)}^2 R_D$$

$$k_n R_D V_{DS(sat)}^2 + V_{DS(sat)} - V_{DD} = 0$$

$$(0.5)(10) V_{DS(sat)}^2 + V_{DS(sat)} - 10 = 0$$

$$V_{DS(sat)} = 1.32 \text{ V}.$$

$$V_{DSQ} = \frac{9 + 1.32}{2}$$

Q point lies midway between $V_{DS} = 1.32$ V and $V_{DS} = 9V$.

$$= 5.16 \text{ V}$$

$$V_r = 3.84 \sin \omega t$$

$\left(\because \cancel{5.16 - 1.32} \quad \because 9 - 5.16 \right)$

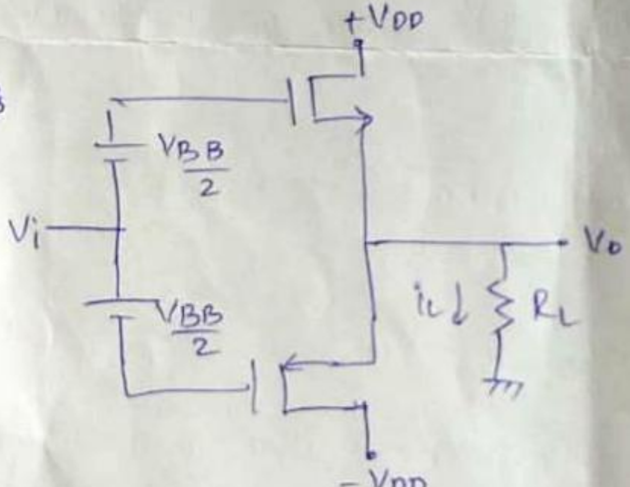
$$\bar{P_L} = \frac{1}{2}\frac{(3.84)^2}{10} = 0.73728 \text{ mW}$$ $\frac{1}{2}\frac{V^2}{R}$

$$I_{DQ} = \frac{10 - 5.16}{10} = 0.484 \text{ mA.}$$ $\frac{V_{DD} - V_{DSQ}}{R_D}$

$$\bar{P_S} = V_{DD} I_{DQ} = (10)(0.484) = 4.84 \text{ mW.}$$

$$\eta = \frac{\bar{P_L}}{P_S} = \frac{0.73728}{4.84} = 15.23\%$$

3



$V_{DD} = 20V$

$R_L = 10\Omega$

$k_n = 0.5 \text{ mA}/V^2$

$V_T = 1 V.$

$V_o = 8 V.$

$$i_L = \frac{V_o}{R_L} = \frac{8}{20} = 0.4 \text{ A.}$$

$$I_Q = \frac{20}{100} i_L = \frac{20}{100} \times 0.4$$

$= 0.08$ when $v_o = 0$.

$$I_{DQ} = 0.08 = k\left(\frac{V_{BB}}{2} - V_T\right)^2$$

$I_{DQ} = 0.08 = 0.5\left(\frac{V_{BB}}{2} - 1\right)^2$

$\left(\frac{V_{BB}}{2} - 1\right)^2 = \frac{0.08}{0.5} = 0.16$

$\frac{V_{BB}}{2} - 1 = 0.4$

$\frac{V_{BB}}{2} = 1.4 \qquad V_{BB} = 2.8$

$V_I = V_0 + V_{GSn} - \frac{V_{BB}}{2}$.

$V_0 = 8V$. $\quad i_{Dn} \cong i_L = 0.4A$

$V_{GSn} = \sqrt{\frac{i_{Dn}}{K}} + V_T = \sqrt{\frac{0.4}{0.5}} + 1$.

$= 0.89 + 1$

$= 1.89\ V$.

$V_{GSp} = V_{BB} - V_{GSn}$

$= 2.8 - 1.89$

$= 0.91\ V$.

$V_I = 8 + 1.89 - 1.4 \qquad V_I = V_0 + V_{GSn} - \frac{V_{BB}}{2}$

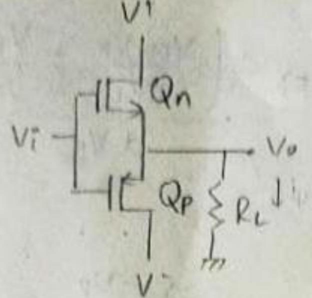
$= 8.49\ V$

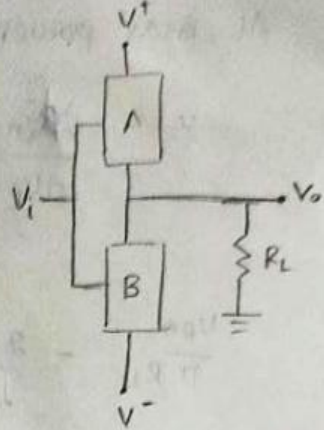
Wednesday DA Answer key

21BLC1632
Akchayamathi M.
C-1 slot

11. Class B power MOSFET

Conversion efficiency:





Instantaneous power dissipated at Qn → P_{Qn}

output voltage for class-B → V_o

$V_o = V_p \sin\omega t$

$i_{Dn} = \frac{V_p \sin\omega t}{R_L}$

$P_{Qn} = V_{DS} i_{Dn}$

$V_{DS} = V_{DD} - i_D R_L \Rightarrow V_{DS} = V_{DD} - \frac{V_p \sin\omega t}{R_L}$

$$P_{Qn} = \left(V_{DD} - \frac{V_p \sin\omega t}{R_L}\right)\left(\frac{V_p \sin\omega t}{R_L}\right)$$

$$i_{Dn} = \begin{cases} \frac{V_p \sin\omega t}{R_L}, & 0 \le \omega t \le \pi \\ 0, & \pi \le \omega t \le 2\pi \end{cases}$$

Average power dissipiation

$$\bar{P}_{Qn} = \frac{1}{2\pi}\int_0^{\pi}\left(\frac{V_{DD} V_p \sin\omega t}{R_L} - \frac{V_p^2 \sin^2\omega t}{R_L}\right) d(\omega t)$$

$$= \frac{1}{2\pi}\int_0^{\pi}\left(\frac{V_{DD} V_p \sin\omega t}{R_L} - \frac{V_p^2}{2R_L}(1 - \cos 2\omega t)\right) d\omega t$$

$\left[\because \sin^2\omega t = \frac{1 - \cos 2\omega t}{2}\right.$

$$\bar{P}_{Qn} = \frac{V_{DD} V_p}{\pi R_L} - \frac{V_p^2}{4R_L}$$

$$\bar{P}_{Qn} = \bar{P}_{Qp}$$

At max power

$$\left.\frac{\partial \bar{P}_{Qn}}{\partial V_P}\right|_{P_{max}} = 0 \Rightarrow \frac{d\left(\frac{V_{DD} V_P}{\pi R_L} - \frac{V_P^2}{4R_L}\right)}{d V_P} = 0$$

$$\frac{V_{DD}}{\pi R_L} - \frac{2 V_P}{4R_L} = 0 \qquad \Rightarrow \frac{V_P}{2R_L} = \frac{V_{DD}}{\pi R_L}$$

$$\Rightarrow V_P = \frac{2 V_{DD}}{\pi}$$

$$P_{Qn(max)} = \frac{V_{DD} V_P}{R_L \pi} - \frac{V_P^2}{4R_L}$$

$$= \frac{V_{DD}}{\pi R_L}\left(\frac{2 V_{DD}}{\pi}\right) - \left(\frac{2 V_{DD}}{\pi}\right)^2 \frac{1}{4 R_L}. \qquad \left[\because V_P = \frac{2 V_{DD}}{\pi}\right]$$

$$\bar{P}_{Qn(max)} = \frac{V_{DD}^2}{\pi^2 R_L} \quad \text{which occurs when } \left. V_P \right|_{\bar{P}_{Qn(max)}} = \frac{2 V_{DD}}{\pi}$$

The avg power delivered to load is

$$\bar{P}_L = \frac{1}{2} \frac{V_P^2}{R_L}$$

Avg power supplied by each source

Avg current is $V_P/\pi R_L$

$$\bar{P}_{S+} = \bar{P}_{S-} = V_{DD}\left(\frac{V_P}{\pi R_L}\right)$$

Total Average power supply by two sources

$$\bar{P}_S = 2 V_{DD}\left(V_P/\pi R_L\right)$$

Conversion efficiency

$$\eta = \frac{P_L}{P_S} = \frac{\frac{1}{2}\frac{V_P^2}{R_L}}{2V_{DD}\left(\frac{V_P}{\pi R_L}\right)} = \frac{\pi}{4}\frac{V_P}{V_{DD}}$$

Maximum possible efficiency occurs when $V_P = V_{DD}$

$$\eta_{max} = \frac{\pi}{4} = 78.5\%$$