unit 2 tutorial sheet

30 November 2024 09:05 AM

unit 2 tutorial s...

Elements of Electronics Engineering [22EC13]

Tutorial-2

1. An enhancement type NMOS transistor with V_T=0.8V and k=2mA/V^2, find the drain current for each of the followingcases:
   a. V_{GS}=5V andV_{DS}=1V. c. V_{GS}=2V and V_{DS}=1.2V.
   b. V_{GS}=0.6V andV_{DS}=0.2V. d. V_{GS}=V_{DS}=3V.

2. An N-channel enhancement type MOSFET with Vth=1V conducts a current I_D=100µA when V_{GS}=V_{DS}=1.5V. Find the value of I_D for V_{GS}=2.5V and V_{DS}=4V. Also calculate the value of r_{DS} for small values of V_{DS}, whenV_{GS}=3V.

3. An n-channel MOSFET is used as an amplifier with a drain resistance of 20KΩ. It is biased such that V_{GS}=4V and V_{DS}=5V.If V_{th}= 0.8V and k=1.5mA/V^2 for the MOSFET, determine the trans-conductance, gm, and the voltage gain.

4. An N-channel enhancement type MOSFET with Vth=0.7, I_D=100µA when V_{GS}=V_{DS}=1.2V. Find I_D and g_m when V_{GS}=1.5V andV_{DS}=3V.

5. Find r_{ds} for the small value of V_{DS} when Vth=0.7, V_{GS} =3.2V and k=2mA/V^2.

6. A voltage amplifier needs 10 mV input to give a certain output. When negative feedback is provided to this amplifier, it needs 4V to deliver the same output. If the closed loop gain of the amplifier is 40dB, determine the open loop gain of the amplifier and the feedback factor.

7. An amplifier with an open loop gain of 1000 delivers a certain output power at 10% harmonic distortion when the input signal is 10mV. If 40dB negative voltage series feedback is provided to this amplifier, determine the required input signal so that the output power remains the same and also find the new % harmonic distortion.
   $(1+A\beta)$ β

8. An amplifier has a gain of 40dB, bandwidth of 300KHz, distortion of 15%, input impedance of 10KΩ and an output impedance of 1KΩ. If voltage series negative feedback of 3.9% is given to this amplifier, calculate the gain, input impedance, output impedance, bandwidth and distortion of the amplifier with negative feedback.

open loop → A
closed loop → A_f

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1) V_{DS} $V_{GS}-V_t$

a) $1 < 5-0.8=4.2$
⇒ ohmic / triode rg.
$I_D = k\left[(V_{GS}-V_t)V_{DS}-\frac{1}{2}V_{DS}^2\right]$
$= 2m\left[(4.2)(1)-\frac{1}{2}(1)^2\right]$
$= 2m(4.2-0.5)$ $\quad 3.7 \times 2 = 7.4$
$I_D = 7.4mA$

b) 0.2 $\quad 0.6-0.8<0$
cutoff → $I_D=0$

c) $1.2 = 2-0.8$
sat ~~/ cutoff?~~

d) $3 > 3-0.8=2.2$
⇒ saturation
$I_D = \frac{k}{2}(V_{GS}-V_t)^2$
$= \frac{2m}{2}(2.2)^2$ $\quad 2.2 \times 2.2 = 4.84$
$I_D = 4.84mA$

2) V_{DS} $V_{GS}-V_t$
$1.5 > 1.5-1$
→ saturation
$I_D = \frac{k}{2}(V_{GS}-V_t)^2$
$100\mu = \frac{k}{2}(1.5-1)^2$
$k = 800\mu = 0.8m$

V_{DS} $V_{GS}-V_t$
$4 > 2.5-1$
Saturation
$I_D' = \frac{k}{2}(V_{GS}'-V_t')^2$
$= \frac{800\mu}{2}(2.5-1)^2$
$= \frac{\cancel{800\mu}}{\cancel{2}} \times \frac{9}{\cancel{4}}$ $\quad 100\mu$
$= 900\mu A$
$I_D' = 0.9mA$

$r_{DS} = \frac{1}{g_m} = \frac{1}{k(V_{GS}-V_t)}$
$= \frac{1}{0.8m(3-1)}$
$= \frac{1000}{1.6}$
$r_{DS} = 625$

3) $g_m = k(V_{GS}-V_t)$
$= 1.5m(4-0.8)$
$= 1.5m \times 3.2$
$g_m = 4.8m$

$r_{DS} = \frac{1}{g_m} = \frac{1}{4.8m} = 0.21K$

$A_V = -g_m R_D$
$= -4.8m \times 20k$
$A_V = -96$

8) $A = 40dB$ $\quad 40 = 20\log(A)$
$A = 100$ $\quad A = 100$
$BW = 300KHz$
$D = 15\%$
$Z_i = 10K\Omega$
$Z_o = 1K\Omega$
$\beta = 3.9\% = 0.039$

→ $1+A\beta = 1+(100)(0.039) = 4.9$
→ $A_f = \frac{A}{1+A\beta} = \frac{100}{4.9} = 20.4$
→ $BW_f = BW(1+A\beta) = 1.47MHz$
→ $D_f = \frac{15\%}{4.9} = 3.06\%$
→ $Z_{of} = \frac{1K}{4.9} = 204.08\Omega$
→ $Z_{if} = (10k)(4.9) = 49k\Omega$

7) $A = 1000$
$D = 10\%$
$V_{in} = 10mV$

$1+A\beta = 40dB = 100$
$40 = 20\log(amt)$
$amt = 100$

$A_f = \frac{A}{1+A\beta} = \frac{1000}{100}$
$A_f = 10$

$V_{inf} = ?$
$V_o = V_{of}$
$D_f = ?$

$A \times V_{in} = A_f \times V_{inf}$
$1000 \times 10m = 10 \times V_{inf}$
$V_{inf} = 1V$

$D_f = \frac{D}{1+A\beta} = \frac{10\%}{100} = 0.1\%$

4) V_{DS} $V_{GS}-V_t$
$1.2 > 1.2-0.7 = 0.5$
⇒ saturation.

$I_D = \frac{k}{2}(V_{GS}-V_t)^2$
$100\mu = \frac{k}{2}(0.5)^2$
$k = 800\mu$

$I_D = \frac{k}{2}(V_{GS}'-V_t)$
$= \frac{800\mu}{2}(1.5-0.7)^2$
$= 400\mu \times 0.8^2$
$= 400\mu \times 0.64$
$I_D = 0.256mA$

$g_m = k(V_{GS}'-V_t)$
$= 800\mu(1.5-0.7)$
$= 800\mu(0.8)$
$= 0.64m$

5) $r_{DS} = \frac{1}{g_m} = \frac{1}{k(V_{GS}-V_t)}$
$= \frac{1}{2m(3.2-0.7)}$
$= \frac{1}{2m \times 2.5}$
$r_{DS} = 0.2K$

6) $V_{in} = 10mV$; $A_{f\,dB} = 40dB$
$V_{inf} = 4V$ $\quad A?$ $\beta?$

$A_f = \frac{V_{of}}{V_{inf}}$, $A = \frac{V_o}{V_{in}}$

$A_{f\,dB} = 40dB$
$A_{f\,dB} = 20\log\left(\frac{V_o}{V_i}\right)$
$\cancel{2}40 = \cancel{20}\log(A_f)$
$A_f = 10^2 = 100$

$V_{of} = V_o$
$A_f V_{inf} = A V_{in}$
$100(4) = A(0.01)$
$A = 40k$

$A_f = \frac{A}{1+A\beta}$
$100 = \frac{40k}{1+40k(\beta)}$

$1+40k(\beta) = 400$
$40k(\beta) = 399$
$\beta = 9.975 \times 10^{-3}$
$= 0.009975$