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ELECTRONIC CIRCUITS
Design of single stage amplifier

25^{th} **June, 2020** **Numerical**

1. Design a single RC coupled JFET amplifier for the following specifications:
   $V_o = 2.2\text{V},\ f_l \leq 20$ Hz, $|A_v| \geq 9$
   Calculate A_v, R_i, R_o

Solution:

1) Data:
$V_o = 2.2\text{V},\ f_l \leq 20$ Hz, $|A_v| \geq 9$

2) Selection of JFET:
We select n channel JFET BFW11 from the datasheet with the following specifications:
$g_{mo} = 5600\mu\mho, V_p = -2.5V, r_d = 50k\Omega, IDSS = 7mA$

3) Selection of baising circuit:
Self bais circuit is selected to give mid point baising

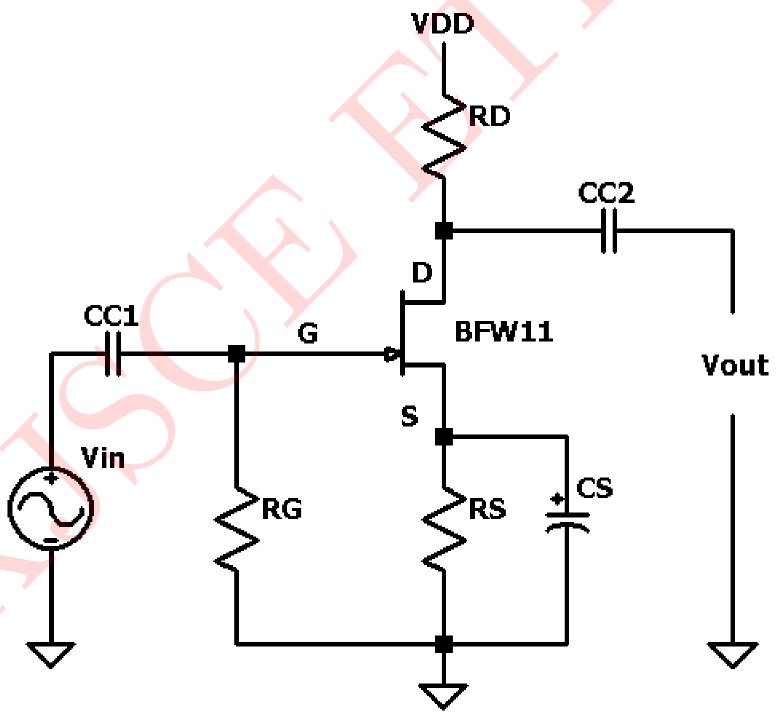

Figure 1: Self baised Circuit 1

4) Selection of Q point:

a) For mid point baising : $I_D = \dfrac{I_{DSS}}{2} = \dfrac{7}{2} = 3.5\text{mA}$

b) $I_D = I_{DSS}\left(1 - \dfrac{V_{GS}}{V_p}\right)^2$

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$$\frac{3.5}{7} = \left(1 - \frac{V_{GS}}{V_p}\right)^2$$

$$0.5 = \left(1 - \frac{V_{GS}}{V_p}\right)^2$$

$$V_{GS} = V_p\left(1 - \sqrt{\frac{I_D}{I_{DSS}}}\right)$$

$$V_{GS} = -2.5\left(1 - \sqrt{\frac{1}{2}}\right)$$

$$V_{GS} = -0.732\text{V}$$

c) Calculation g_m:

$$g_m = g_{mo}\left(1 - \frac{V_{GS}}{V_p}\right)$$

$$g_m = 5600 \times 10^{-6}\left(1 - \frac{-0.732}{-2.5}\right)$$

$$g_m = 3.96\text{m}\mho$$

5) Selection of R_S:

$V_{GS} = V_G - V_S \qquad (V_G = 0 \because \text{ self baised})$

$V_{GS} = -V_S$

$V_{GS} = -I_D R_S$

$R_S = -V_{GS}/I_D = -(-0.732)/3.5mA = 209.142\Omega$, 1/4 W (H.S.V)

Select $R_S = 220\Omega$, 1/4 W (H.S.V)

6) Selection of R_D:

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

$-9 = -3.96 \times 10^{-3}(50 \times 10^3||R_D)$

$$-9 = -3.96 \times 10^{-3}\left(\frac{50 \times 10^3 \times R_D}{50 \times 10^3 + R_D}\right)$$

$R_D = 2.380f\Omega$

Select $R_D = 2.7k\Omega$, 1/4 W (H.S.V)

7) Selection of R_G:

Select $R_G = 1\text{M}\Omega$, 1/4 W (H.S.V)

8) Selection of V_{DD}:

$V_{DS} \geq V_{o(peak)} + |V_p|$

$V_{DS} = 1.5(V_{o(peak)} + 2.5)$

$V_{DS} = 1.5(2\sqrt{2} + 2.5)$

$V_{DS} = 8.416V$

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Applying KVL to the DS loop

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

$V_{DD} = V_{DS} + I_D(R_D + R_S)$

$V_{DD} = 3.416 + 3.5 \times 10^{-3}(2.7 \times 10^3 + 220)$

$V_{DD} = 18.636V$

Select $V_{DD} = 20V$

9) Selection of C_S:

$X_{CS} \leq 0.1R_S$

$\dfrac{1}{2\pi \times f_{LCS}C_S} \leq 0.1R_S \qquad (f_{LCS} = f_L \leq 20Hz)$

$C_S \geq \dfrac{1}{2\pi \times 0.1R_S} \geq \dfrac{1}{2\pi \times 0.1 \times 220}$

$C_S \geq 361.715\mu F$

Select C_S = 390μF, 25V (H.S.V)

10) Selection of C_{C1}:

$C_{C1} = \dfrac{1}{2\pi \times f_{LCC1}R_{eq}} \qquad (f_{LCC1} = f_L \leq 20Hz)$

$R_{eq} = R_G = 1M\Omega$

$C_{C1} = \dfrac{1}{2\pi \times 20 \times 1 \times 10^6}$

C_{C1} = 7.9 nF

Small signal equivalent circuit:

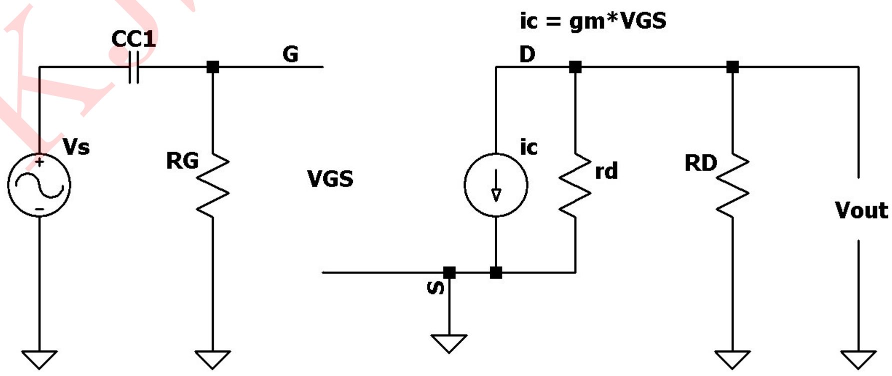

Figure 2: Small signal equivalent circuit for CC1

Select C_{C1} = 8.2 nF, 25V (H.S.V)

11) Selection of C_{C2}:

$$C_{C2} = \frac{1}{2\pi \times f_{LCC2} R_{eq}} \qquad (f_{LCC2} = f_L \leq 20Hz)$$

$$R_{eq} = r_d || R_D = 2.7 \times 10^3 || 20 \times 10^3 = 2.56k\Omega$$

$$C_{C2} = \frac{1}{2\pi \times 2.56 \times 10^3 \times 20}$$

$$C_{C2} = 3.107\text{nF}$$

Small signal equivalent circuit:

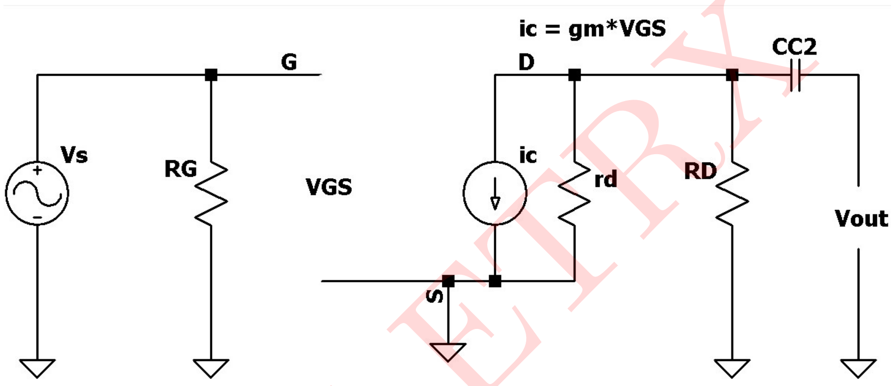

Figure 3: Small signal equivalent circuit for CC2

Select $C_{C2} = 3.3$nF, 25V (H.S.V)

12) Designed Circuit is:

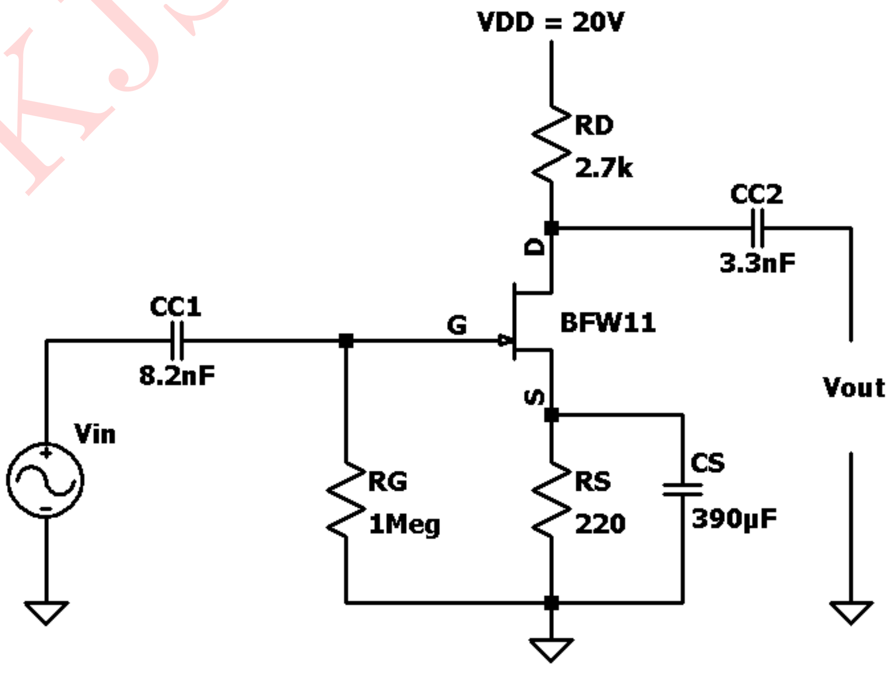

Figure 4: Designed circuit 1

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SIMULATED RESULTS:

Above circuit is simulated in LTspice and results are as follows

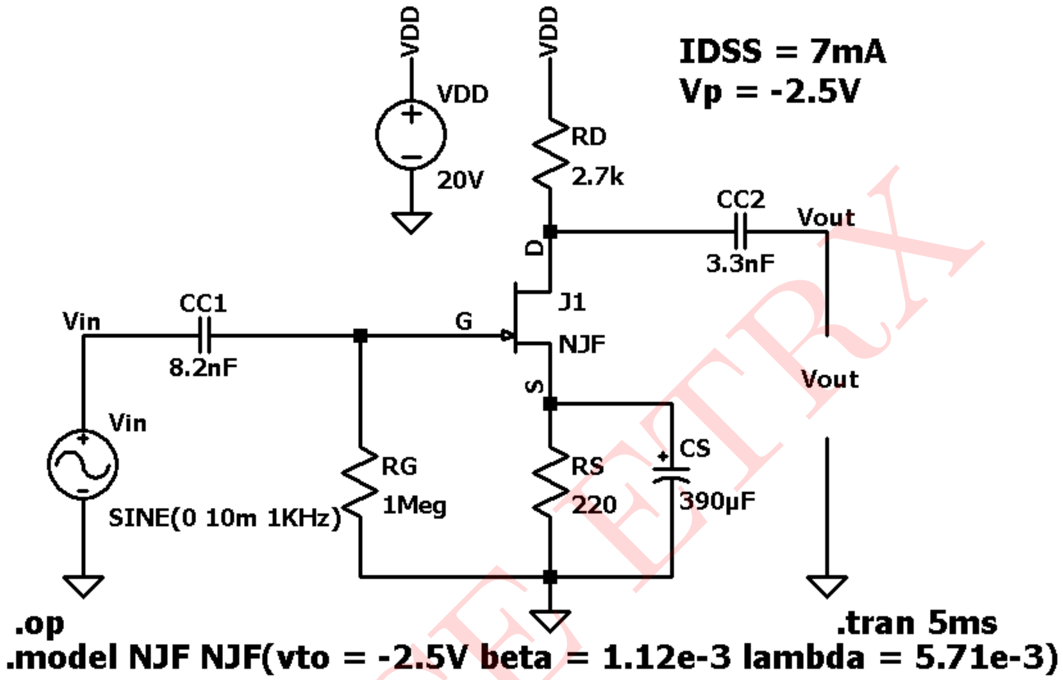

Figure 5: Circuit schematic 1

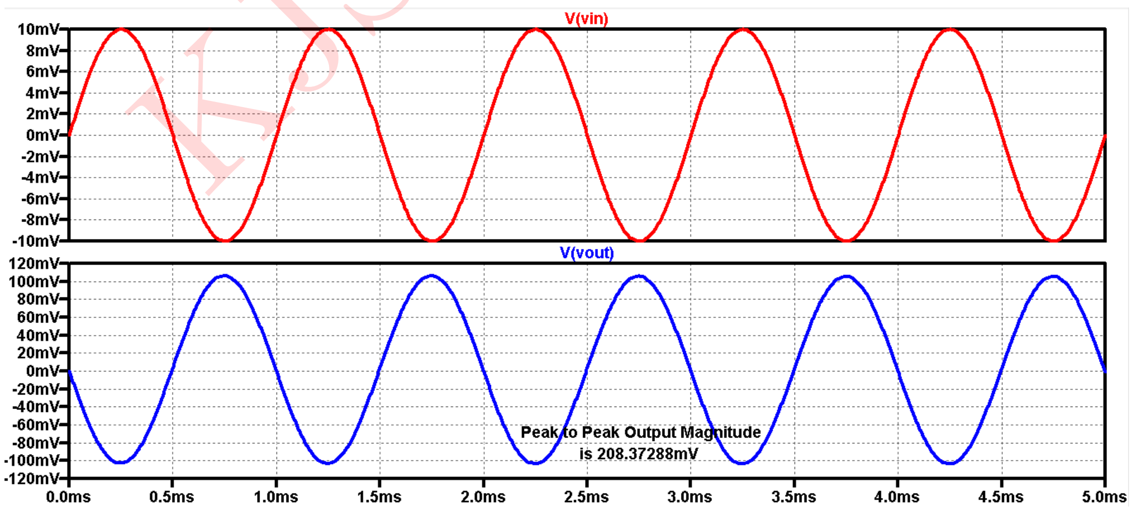

Figure 6: Circuit Schematic: Input Output Waveform

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Comparsion between simulated and theoretical values :

Parameters	Simulated	Theoretical
I_{DQ}	3.420mA	3.5mA
A_v	10.418	$\geq$9

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