Analog Electronic Circuits Lab (EC2.103, Spring 2024)

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Instructions:

1. Systematically record all your observations in the lab book (mandatory)
2. Save results in USB or take pictures
3. Make meaningful tables to summarize your findings and show it to the instructor(s) during the lab session only
4. Bring your calculators and DMM (if available)
5. Handle equipment carefully and report in case of any incidence
6. Enjoy your time in lab and strengthen your understanding about circuits

Experiment-7
Common Source Amplifier

1. **Effect of Body effect on gain of CS amplifier**

   Fig. 1 shows a CS amplifier using an NMOS (CD4007BE). Realize the circuit on breadboard and connect the body terminal (V_{SS}) to ground.

   It is given that $Vdd = 5V$, $V_{BIAS} = 2.5\ V$, $V_T = 1.8\ V$, $R_L = 4.7\ k\Omega$.

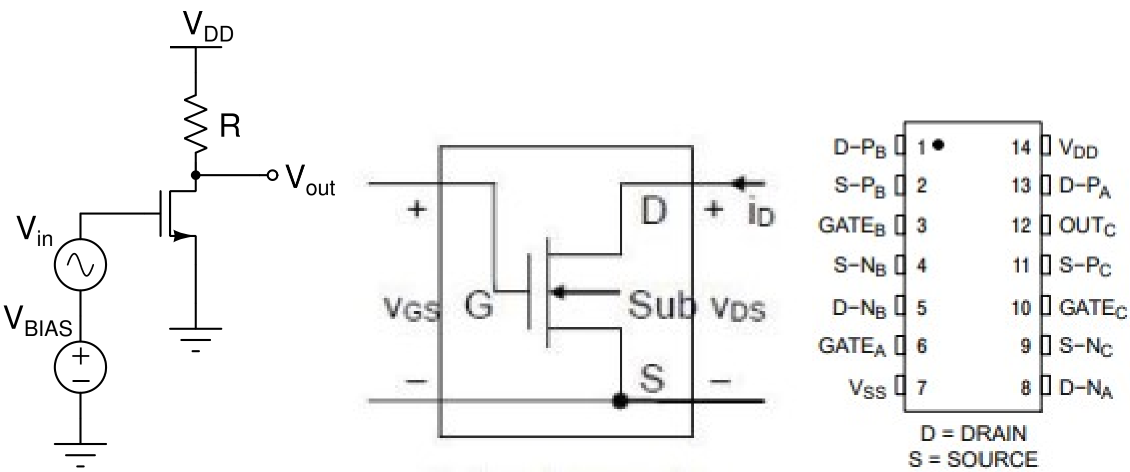

Figure 1: Common source NMOS based amplifier with resistive load

   (a) Measure the DC value of V_{DS}. Find drain current $I_{DS} = \frac{VDD - V_{DS}}{R_L}$ and using saturation region drain current equation find $\mu_n C_{ox}\frac{W}{L}$ for the given transistor. Also calculate $g_m = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_T)$.

   (b) Apply an ac signal (v_{in} with 50 mV_{pp} amplitude and 1 kHz frequency). Report gain ($A_v = \frac{v_{out}}{v_{in}} = g_m \times R_L$) and calculate $g_m\ (effective)$ (does it match closely with the value obtained in previous step?).

$Body\,Voltage\;(V_{SS})$	v_{out}	$Gain$	$g_m(effective)$
0			
0.4			
-0.4			

Table 1

(c) In order to see the body effect, connect V_{SS} to a DC supply. (Caution: Before connecting to the supply, ensure that the voltage is near 0 V). As shown in table 3, use given values of V_{SS} and report the corresponding amplitude of v_{out}, gain and $g_m\ (effective)$. Note that due to the body effect, $g_m\ (effective) = g_m + g_{mb}$. Comment on the effect of body-effect over gain.

2. **Effect of BIAS points on Gain of common source amplifier**

   (a) For different values of input BIAS voltage and a fixed small signal input voltage (v_{in} with 100 mV_{pp} amplitude and 1 kHz frequency), $V_{DD} = 5\ V$, plot the output and find the gain for each value of V_{BIAS}.

   (b) Calculate the value of g_m for each value of V_{BIAS} from gain ($gain = -g_m R_L$), where $R_L = 4.7\ k\Omega$.

   (c) Using the measured values, plot g_m vs $V_{GS}\ (BIAS)$ in your notebook.

   (d) Tabulate the corresponding values of V_{out} for each value of V_{BIAS}

$V_{BIAS}\ (V)$	V_{out}	$Gain$	g_m
1.5			
1.8			
2.5			
3.1			
4			

Table 2

3. **Effect of small signal input swing on gain of common source amplifier**

   (a) For a $V_{BIAS} = 2.5\ V$, apply the input signal ($100\ mV$) with step size of $100\ mV$ between the different inputs until clipping can be observed. Find the output swing and the corresponding gain value.

   (b) Tabulate the corresponding values of gain and output swing for each v_{in}.

   (c) Explain the reason of clipping and trend of gain values.

$V_{input\ ac}$	$V_{output\ ac}$	$Gain$	g_m

Table 3

4. **CS amplifier with external coupling**

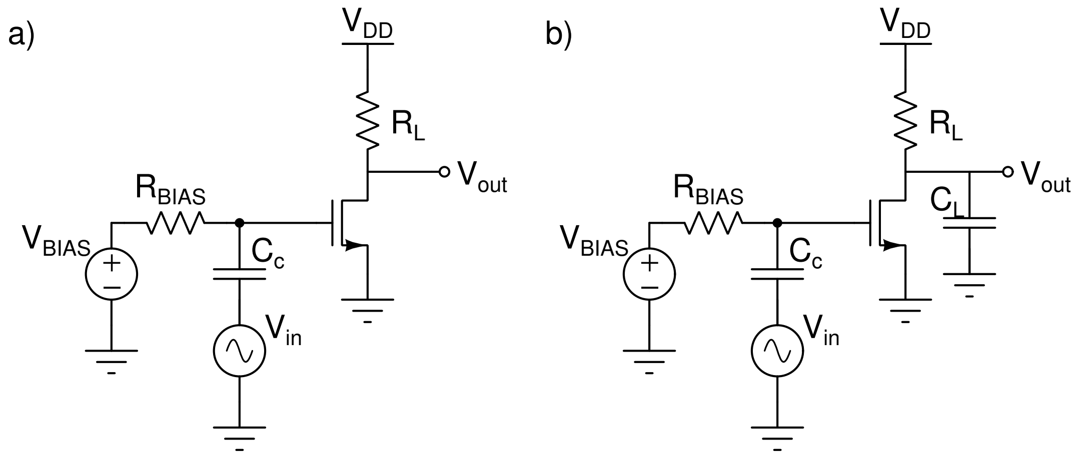

Figure 2: CS amplifier with external coupling capacitance and resistor

(a) To the CS amplifier as in figure.1 instead of giving a sinusoidal signal with a DC offset we bias the amplifier with external DC source. We connect an external coupling capacitance C_c of value around 10 μF in series with V_{in} and a bias resistor R_{BIAS} of value around few 100 Ω in series with V_{BIAS} as shown in figure.2.

(b) We give a sinusoidal input signal v_{in} of amplitude 100 mV V_{p-p}, V_{BIAS} of value 2.5 V and load resistance R_L of value 4.7 KΩ for supply voltage (V_{DD}) of 5 V. Measure the value of gain ($\frac{V_{out}}{V_{in}}$) and from gain calculate the value of g_m. Do you observe any difference in the values of gain and g_m from the values you obtained from previous results.

(c) Measure the value of V_{DS} and determine the value of I_{DS} and $\mu C_{ox}\frac{W}{L}$.

(d) As shown in Fig. 2(b), connect a load capacitor $C_L = 470\ pF$ and plot the frequency response of the amplifier gain. Find the 3-dB bandwidth from measured plots and verify it with the estimated pole of the transfer function ($\frac{v_{out}}{v_{in}}(s)$). *(hint: To plot, use analyze option in DSO, in frequency response analysis chart, set start frequency as 100 Hz, stop frequency as 20 MHz, Amplitude as 10 mV, Output load as High-Z and points as 50. Select the gain channel and move the marker to get the readings)*