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Title: Study of common source amplifier circuit and negative feedback multistage amplifier circuit using common source amplifier in each stage.

Abstract:

A MOSFET amplifier circuit is shown in Fig. 1 below. The MOSFET is used as a common source amplifier. The voltage divider based on two resistors R1 and R2 is used to define the Q-point or the operating point of the gate-to-source voltage V_{GSQ}. The Q-point on the input side will define the Q-point of the drain-to-source voltage V_{DSQ} on the output side. This experiment gives an excellent simulation and practical realization of the common source amplifier circuit. A common source MOSFET amplifier circuit will be designed, simulated, and practically experimented on trainer board to measure output impedance, phase relationships, and gain of the amplifier. It is a without feedback configuration were frequency response curve will also be generated.

In this experiment the effect of negative feedback on input-output impedance and bandwidth of feedback amplifier s also analyzed. Here we are using a two stage common source amplifier for this purpose. Then frequency response curves of voltage series feedback amplifier and current series feedback amplifier are plotted experimentally. Then the effect of negative feedback on the frequency response is analyzed based on a comparison between with feedback and without feedback frequency response curves.

Introduction:

The objective of the experiment is to
1) Design a common source amplifier
2) Simulate and practically implement the designed common source amplifier to measure the output impedance, phase relationships, and gain of the amplifier.
3) Frequency response curve will be drawn.
4) Two common source amplifiers will be cascaded to observe the negative feedback effect in voltage series and current series configurations.

Theory and Methodology:

The operating point of the MOSFET circuit can be graphically extracted from the graph in figure shown below. In this amplifier circuit, cut-off occurs when $I_D = 0$. Subsequently, the output voltage reaches its maximum value Vout = V_{DD}. On the other hand, if the input voltage increases, the output voltage swings along the line to reached the Vout = V_{DSmin} = V_{GS}-V_T, the pinch-off value. As an amplifier operates in the saturation region, the Q-point of the drain-to-source voltage has to be in the range between V_{DSmin} and V_{DSmax}.
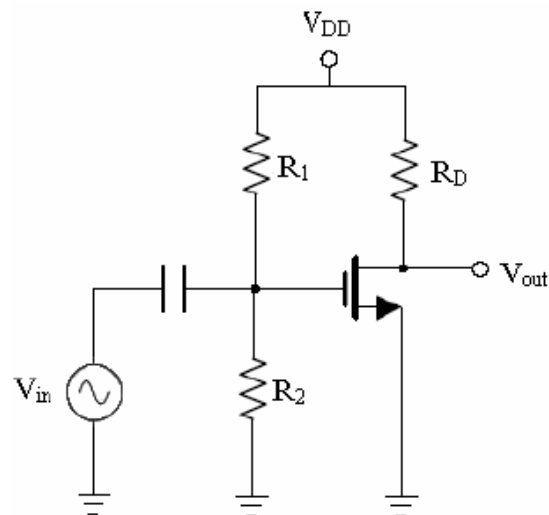
Fig 1: A common-source Amplifier

In order not to disturb dc bias current and voltages, the signal to be amplified, shown as voltage source Vin with an internal resistance, is connected to the gate through a large capacitor. Similarly, the drain can also be connected to load resistance via a large capacitor. These capacitors are called coupling capacitors. The resistances connected to the base are used to provide a suitable dc bias to the transistor to make it operate in the saturation region.
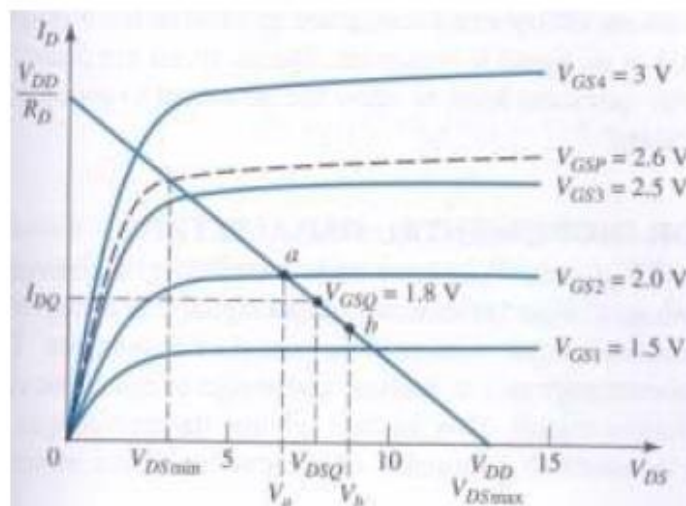

Fig 2: Output curves of an n-enhancement MOSFET.

When any increase in the output signal results into the input in such a way as to cause the decrease in the output signal, the amplifier is said to have negative feedback.

The advantages of providing negative feedback are that the transfer gain of the amplifier with feedback can be stabilized against variations in the hybrid parameters of the transistor or the parameters of the other active devices used in the circuit. The most advantage of the negative feedback is that by proper use of this, there is significant improvement in the frequency response and in the linearity of the operation of the amplifier. The disadvantage of the negative feedback is that the voltage gain is decreased.

In Voltage-Series feedback, the input impedance of the amplifier is decreased and the output impedance is increased. Noise and distortions are reduced considerably. In Current-Series feedback, the input impedance of the amplifier is decreased and the output impedance is decreased. Noise and distortions are reduced considerably.
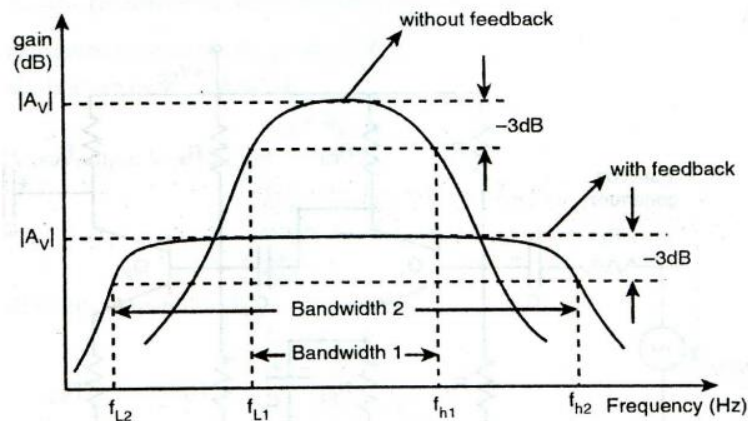

Figure 3: Comparison between with negative feedback and without feedback response curves

Pre-lab Homework:

Implement the circuit using PSpice (Figure 3). Fill up the table which is given in the experimental procedure section using the simulation tool.

Read about the characteristics of voltage series feedback amplifier and current series feedback amplifier from "Integrated Electronics" by Millman-Halkias and use PSPICE_9.1_STUDENT_VERSION to generate the output of the circuits provided in this lab sheet. Compare frequency response obtained from simulation result with theoretical frequency response. Find cut-off frequencies and bandwidth using simulation. Save the simulation results and bring it to the lab

Apparatus:

Common source amplifier

1)	Trainer Board	:		
2)	MOSFET	:	IRF540	[1pc]
3)	Resistors	:	1KΩ	[1pc]
			1M	[1pc]
4)	DC Power Supply			
5)	Power Supply Cable	:		[1 pc]
6)	Multimeter			
7)	Signal Generator			
8)	Oscilloscope			
9)	Probes	:		[2pcs]
10)	Capacitor	:	10μF	[2pcs]

Feedback amplifier

1)	C828 or C829	1[pcs]
2)	Oscilloscope	
3)	DC regulated IC Transistor Power Supply	

4)	Resistors – 100K, 33K, 1K, 2.7K, 8.2K, and 10K (pot)	2[pcs each]
	Capacitors – 10uF	4[pcs]
5)	Trainer Board	
6)	Signal Generator	

Precautions:

Have your instructor check all your connections after you are done setting up the circuit and make sure that you apply only enough voltage to turn on the chip, otherwise it may get damaged. For feedback amplifier circuit following precautions should be taken:

1. Biasing of the op-amps should be done carefully and oscilloscopes should be properly calibrated using the information provided at the calibration port before obtaining the wave shapes using the experimental set up.
2. While taking the observations for the frequency response , the input voltage must be maintained constant at 20mV.
3. The frequency should be slowly increased in steps.
4. The three terminals of the transistor should be carefully identified.
5. All the connections should be correct.

Experimental Procedure:

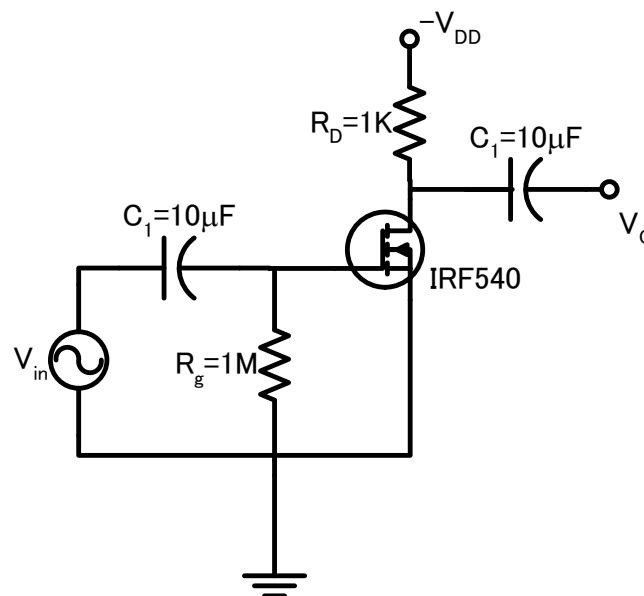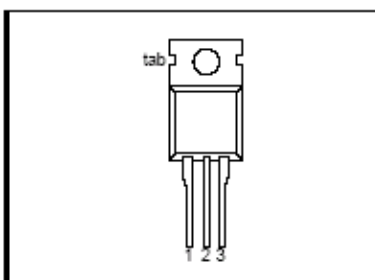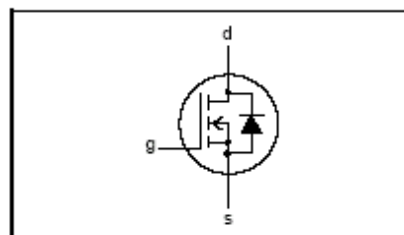**Circuit Diagram and procedure for common source amplifier:**

Fig.4: Common Source Amplifier Circuit.

PINNING

PIN	DESCRIPTION
1	gate
2	drain[1]
3	source
tab	drain

QUICK REFERENCE DATA

$V_{DSS} = 100 \text{ V}$

$I_D = 23 \text{ A}$

$R_{DS(ON)} \leq 77 \text{ m}\Omega$

1) Construct the circuit as shown in Fig. 3.
2) Set the signal generator frequency at 5 kHz. Apply the input signal to 0.5 V (p-p). Observe the wave shapes.
3) Measure the peak value of both V_{in} and V_0.
4) Connect the 10KΩ potentiometer from V_0 to ground. Adjust the 10KΩ potentiometer until V_O is half the open circuit value. Measure the potentiometer resistance.
5) Change the input frequency to 50 Hz and measure the voltage gain. Measure voltage gains at different frequencies.

Data Table 1 (Without feedback):

Frequency	V_i	V_o	$A_v = \dfrac{V_o}{V_i}$	A_{vmid}	$dB = 20\log\left(\dfrac{A_v}{A_{vmid}}\right)$

Circuit diagram and procedure for feedback amplifier:
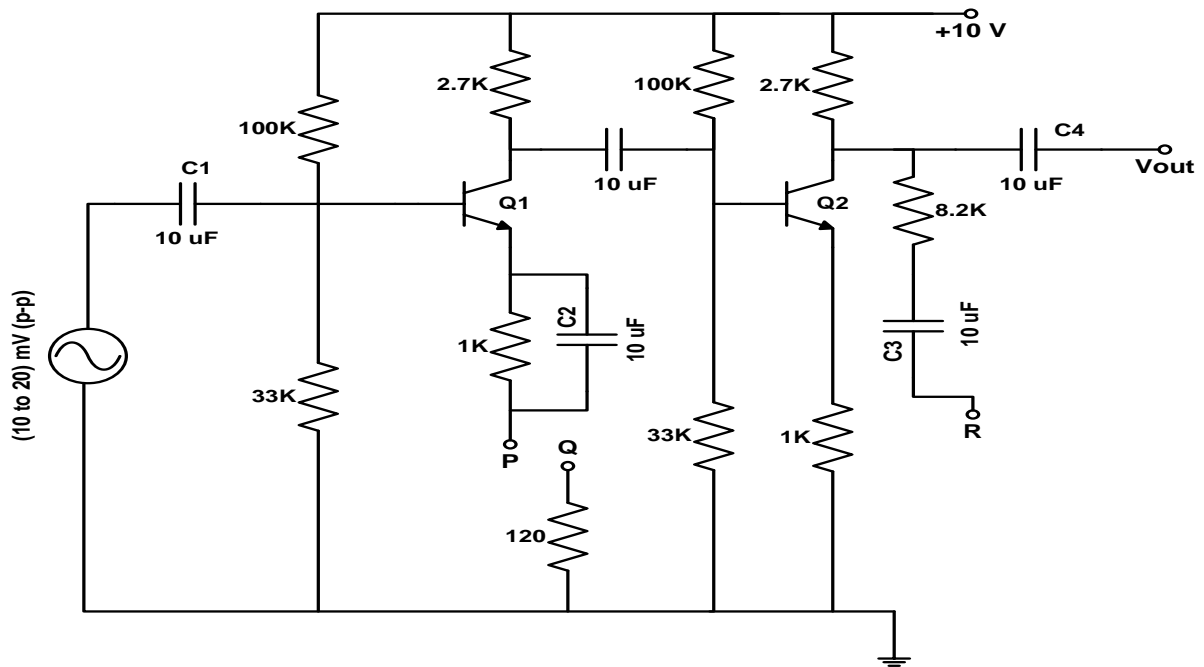
Fig5: Circuit diagram for voltage series and current series feedback amplifier.

1. Connect the circuit diagram. Apply current series feedback by connecting P and Q.
2. Connect the 10K potentiometer to the output terminal; vary the pot until the voltage is half of the open circuit voltage. The resistance value of the pot is output impedance.
3. From function generator, apply a sinusoidal input signal of 1 KHz. Amplitude of input voltage should be 20 mV (p-p).
4. Keep the amplitude constant during the experiment.
5. Keeping the input voltage constant increase the frequency of the input.
6. Measure the corresponding output voltage V_o for each frequency.
7. For different frequencies, note down the output voltage and calculate the gain by using the expression Gain (dB), $A_v = 20\log (V_0 / V_i)$ dB
8. Apply voltage series feedback by connecting P, Q, R and then repeat steps 2 to 8.
9. Plot the frequency response curve for each of the three configurations by taking frequency on x-axis and gain(dB) on y-axis on a semi log graph paper.
10. The bandwidth of the amplifier is calculated from the graph using the expression bandwidth, $B.W = f_2 - f_1$.

    Where f_1 is lower cut off frequency

    f_2 is upper cut off frequency

Data Table 2 (Current Series Feedback):

Frequency	V_i	V_o	$A_v = \dfrac{V_o}{V_i}$	A_{vmid}	$dB = 20\log\left(\dfrac{A_v}{A_{vmid}}\right)$

Data Table 1 (Voltage Series Feedback):

Frequency	V_i	V_o	$A_v = \dfrac{V_o}{V_i}$	A_{vmid}	$dB = 20\log\left(\dfrac{A_v}{A_{vmid}}\right)$

Simulation and Measurement:

Compare the frequency response curves obtained in this experiment. Also compare the simulation results. Comment on the differences in each case.

Questions for Report Writing:

1) Plot the frequency response of the circuit on semi-log graph paper.
2) What is the output impedance, phase relationship and gain of common source amplifier circuit?
3) Comment on the bandwidth of this amplifier.

Discussion and Conclusion:

Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set. Discuss any mistake you might have made while conducting the investigation and describe ways the study could have been improved

References

1. American International University–Bangladesh (AIUB) Electronic Devices Lab Manual.
2. A.S. Sedra, K.C. Smith, Microelectronic Circuits, Oxford University Press (1998)
3. J. Keown, ORCAD PSpice and Circuit Analysis, Prentice Hall Press (2001)
4. P. Horowitz, W. Hill, The Art of Electronics, Cambridge University Press (1989).

5. Integrated Electronics by Millman and Halkias.