ECE 3274
Common-Collector (Emitter-Follower) Amplifier Project

1. Objective

This project will show the biasing, gain, frequency response, and impedance properties of a common collector amplifier.

2. Components

Qty	Device
1	2N2222 BJT Transistor

3. Introduction

The common collector amplifier is one of the most useful small-signal amplifier configurations. The main characteristics of the common collector amplifier are high input impedance, low output impedance, less than unity voltage gain, and high current gain. This amplifier is most often used as a buffer or isolation amplifier to connect a high impedance source to a low impedance load without loss of signal. The load seen by the amplifier's signal source is the input impedance of the amplifier. With a high input impedance, the CC amplifier loads the source very lightly. Therefore the signal source is largely isolated or buffered from the rest of the circuit. The maximum current gain for the CC amplifier is Beta + 1. This high current gain allows the CC amplifier to increase the power of the signal. These power and current gains make the CC amplifier a practical choice as an output stage amplifier driving several devices.

The same biasing scheme and frequency response approximation technique as used for the common emitter amplifier can also be used for the common collector amplifier. The only change that needs to be made in biasing is that the voltage across the emitter resistor R_e is usually larger for the common collector to allow a greater output voltage swing.

You should refer to your lab lecture notes, your Electronics II Lecture notes, your textbook, the course website, and other reference material to determine how best to design your amplifier. This lab is intended as a design project and not as a step-by-step guide.

4. Requirements

Your amplifier design must meet the following requirements.

Requirement	Specification
Voltage Gain	$\lvert A_v \rvert > 0.5$ V/V
Low Frequency Cutoff	Between 100 Hz and 200 Hz
High Frequency Cutoff	Between 50 kHz and 150 kHz
Input Impedance	Greater than 4 kΩ
Output Voltage Swing	Greater than 2.0 V_{pk}
Load Resistance	180 Ω
Power Supply Voltage	12 V_{dc}

Table 1. Common-collector amplifier requirements.

5. Prelab Design Project

Design a common-collector amplifier using the schematic shown in Figure 1 and meeting the requirements in section 4. You should refer to your class notes, textbook, instructor, and other reference material to help you design the circuit. Start with the DC design and then move onto the AC design.

You may use a MATLAB (or similar) program to run calculations if you would like, but your code and output must be included, and you must comment your code to indicate where all equations came from and any assumptions you made. Units must be included as well (it is permissible to generate a table of final values for clarity if you would prefer, but again, all work must be shown clearly somewhere). Use the following fixed component values in your circuit:

Component	Value
R_{flt}	100Ω
R_i	47Ω
C_{byp}	0.1μF
C_{flt}	4.7nF

Table 2. Fixed component values.

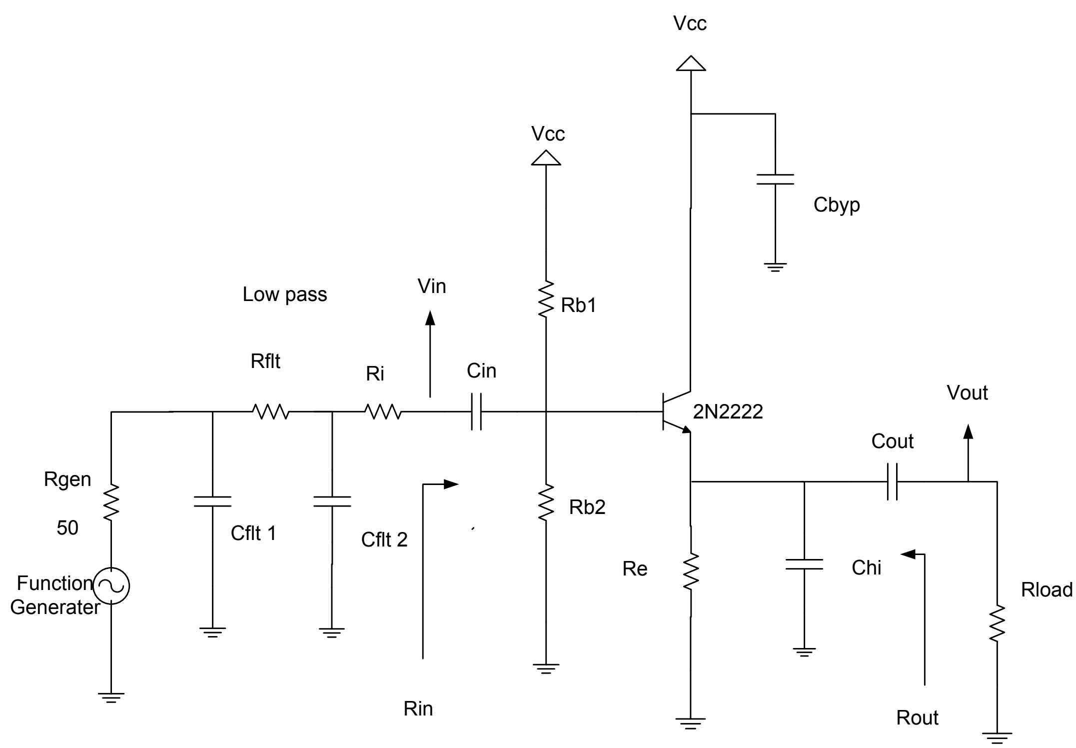

Figure 1. Common-emitter amplifier circuit.

5.1 DC Bias

Begin by designing the DC bias for the amplifier. Once you have designed the DC bias network, use the transistor characteristics for the 2N2222 transistor to determine the transistor parameters for where you are operating. Note that there is no single correct answer and that your design may differ significantly from your colleagues'. You should show all work and walk through all calculations. You must calculate and show all of the following values.

Component Values	Amplifier Parameters	Voltages and Currents
R_{b1}	Beta dc	V_{ce}
R_{b2}	Beta ac	V_{be}
R_e	r_π	V_e
	r_o	I_b
		I_c

Table 3. DC Bias and Amplifier Parameters

5.2 AC Design

Design the ac characteristics of the amplifier. You must calculate and show all of the following values..

Component Values	Amplifier Parameters	Voltages, Currents, and Power
C_{in}	Voltage Gain	v_{in}
C_{out}	Current Gain	v_{out}
C_{hi}	Power Gain (in dB)	i_{in}
	Low Frequency Cutoff	i_{out}
	High Frequency Cutoff	p_{in}
	Input Resistance	p_{out}
	Output Resistance	

Table 4. Small Signal (ac) Amplifier Parameters

5.5 Computer-aided Analysis

Once you have completed your three amplifier designs, use PSpice to analyze their performance. Generate the following plots:

(a) A time-domain plot of the input and output, with the output voltage of $2.0V_{pk}$ or greater at 1 kHz. The output should not have any distortion or clipping. Calculate the midband gain and indicate it on the plot. Compare this to your calculated values.

(b) An FFT of your time-domain waveform. Circle and indicate the height of any strong harmonics, in dB relative to your fundamental frequency at 1 kHz.

(c) A frequency sweep of the amplifier from 10 Hz to 1 MHz. Indicate the high and low frequencies on the plot (these should correspond to the half-power, or -3dB points). Compare these to your calculated values.

5.6 Prelab Questions

(a) How can you achieve maximum power transfer from the input signal source to the amplifier circuit? Is the load resistance a factor in the answer? Show your calculations.

(b) Compare the results of the current gain found in prelab with the maximum possible gain of Beta + 1. Comment on any differences. Under what conditions is this possible?

6. Lab Procedure

6.1. Construct the CC amplifier shown in Figure 1. Remember that R_{src} is internal to the function generator and is not in your circuit. Record the values of the bias network resistors and the capacitors you used in the circuit.

6.2. Measure the following values:

- **(a)** Q-point: Vce, Vbe, Ve, Ib, and Ic.
- **(b)** Voltage, current, and power gains.
- **(c)** Maximum undistorted peak-to-peak output voltage.
- **(d)** Input and output resistance.
- **(e)** Low and high cutoff frequencies (half power point).

Recall that input impedance is given by $R_{in} = v_{in}/i_{in}$, output impedance is given by $R_{out} = (v_{oc}-v_{load})/i_{out}$, voltage gain is given by $A_v = v_{out}/v_{in}$, and current gain is given by $A_i = i_{out}/i_{in}$.

Additionally, plot the following:

- **(a)** Input and output waveform at the maximum undistorted value.
- **(b)** FFT showing the fundamental and first few harmonics.
- **(c)** Frequency response from 10 Hz to 1 MHz (set the input voltage to a value that does not cause distortion across the entire passband of the amplifier).

6.3. Replace the load resistor, RL, with a 47Ω and a 820Ω resistor, and measure the maximum output swing and voltage gain without clipping. Comment on the loading effect, and remember to change back to a 180Ω load resistor after this step.

ECE 3274
Common Collector Amplifier Lab
Data Sheet

Name:____________________ **Lab Date:**____________ **Grade:**_____/100
Partner:____________________

Remember to include units for all answers and to label all printouts. There are a total of nine (9) printouts in this lab. Only one set of printouts is required per group.

6.1. Component Values

R_{b1}: ________ **R_{b2}:** ________ **R_e:** ________ **R_L:** ________
C_{in}: ________ **C_{out}:** ________ **C_{hi}:** ________

6.2. Common-collector amplifier. There are three printouts here.

Q-Point:	V_{ce}:	________	V_{be}:	________	V_e:	________
	I_b:	________	I_c:	________		________
Gain:	Voltage:	________	Current:	________	Power:	________
Voltage Output Swing:	Max:	________				
Resistance:	Input	________	Output	________		
Frequency Response:	Low:	________	High:	________		

6.3. Common-collector amplifier with a variable load resistor. There are no printouts here.

47Ω Resistor:

Gain:	Voltage:	________	Current:	________	Power:	________
Voltage Output Swing:	Max:	________				

820Ω Resistor:

Gain:	Voltage:	________	Current:	________	Power:	________
Voltage Output Swing:	Max:	________				