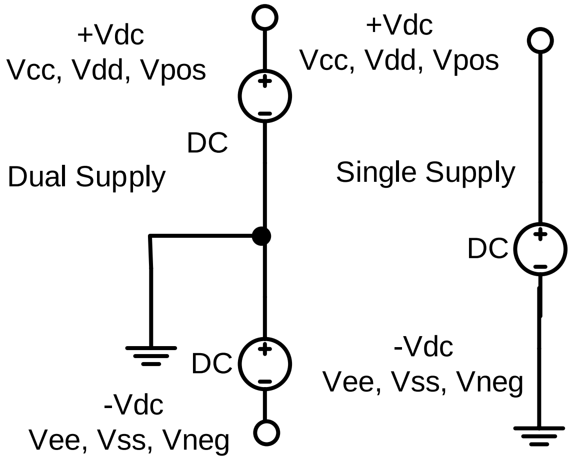
ECE 3274
Common-Collector (Emitter-Follower) Amplifier Project

1. Objective

This project will show the biasing, gain, frequency response, and impedance properties of a common collector amplifier. We will use a single supply in the lab classroom.



2. Components

Qty	Device
1	2N3904 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 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.

4. Requirements

Your amplifier design must meet the following requirements.

Requirement	Specification
Voltage Gain	$\|A_v\| > 0.5$ V/V open loop
Low Frequency Cutoff	Between 100 Hz and 300 Hz
High Frequency Cutoff	Between 75 kHz and 150 kHz
Input Impedance	Between 1KΩ to 3kΩ
Vbe	0.75Vdc
Output Voltage	2.0 V_P
Load Resistance	150Ω
Power Supply Voltage	Single Vcc = +12Vdc Vee = 0Vdc

Table 1. Common-collector amplifier requirements.

5. Prelab Design Project Find r_o, β_{AC} and β_{DC}

Design a common-collector amplifier using the schematic shown in Figure 1 and meeting the requirements in table 1. 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. Find **r_o, β_{AC}** and **β_{DC}** from the CC transistor curves (higher current).

Calculate all components values (it is permissible use a table of final values) for clarity if you would prefer, but again, **all work must be shown** including the **equations used** to calculate the values. **Units must be included**

Use the following fixed component values in your circuit:

Component	Value
R_i	150Ω
Riso	47Ω
C_{byp}	0.1µF , 0.047uF, or 0.01uF

Table 2. Fixed component values.

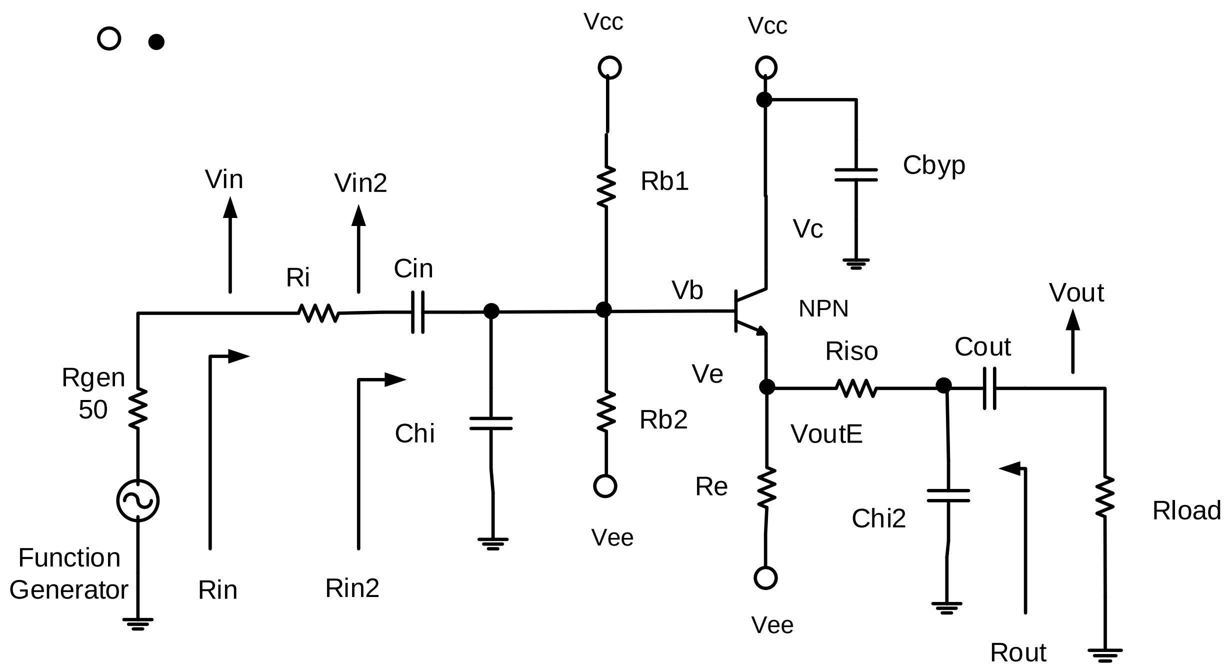


Figure 1. Common-collector amplifier circuit.

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 2N3904 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 classmates. You should show all work and walk through all calculations. You must calculate and show all of the following values. Note the $\mathbf{r_o}$, $\boldsymbol{\beta_{AC}}$ and $\boldsymbol{\beta_{DC}}$ are from the transistor curves at your Q-point. **Choose a design value for Rin** and calculate the Rb1, and Rb2 based on that desired value. Vbe will normally be higher because of the higher Base and Collector currents.

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. We will set the zeros for the low frequency break point at the same frequency.

$BWshrinkage = \sqrt{2^{1/n} - 1}$ Where (n = 2) number of low frequency zeros at the same frequency.
$F_L = (F_{Cin} + F_{Cout}) / (BWshrinkage * n)$.
We need adjust the frequency because of bandwidth shrinkage.
Set Fcin =Fcout = F_L*(BWshrinkage)
Cin = 1/(2π Fcin Rci)   Cout = 1/(2π Fcout Rcout)

We will set the poles for the high frequency break point at the same frequency so we will use the band shrinkage factor.
Fchi = Fchi2 = FH' = FH / $\sqrt{2^{1/n} - 1}$ Where n = 2 number of high frequency poles.

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}
C_{hi2}	Low Frequency Cutoff	iI_{Load}
	High Frequency Cutoff	p_{in}
	Input Resistance	p_{out}
	Output Resistance	

Table 4. Small Signal (ac) Amplifier Parameters

5.3 Computer-aided Analysis (25 points)

Once you have completed your amplifier designs, use LTspice to analyze their performance. Note: **Must include LTspice schematics**. Generate the following plots:

- **(a)** A time-domain plot of the input and output, at the specified output voltage Vout at 5 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 5 kHz.
- **(c)** A frequency sweep of the amplifier from 10 Hz to 1 MHz. Indicate the high and low break frequencies on the plot (these should correspond to the half-power, or the point 3dB below the midband gain). Compare these to your calculated values.

5.4 Prelab Questions

- **(a)** How can you achieve maximum power transfer from the signal source to the input of the amplifier? 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 the maximum possible?

6. Lab Procedure

6.1. Construct the CC amplifier shown in Figure 1. Remember that R_{gen} is internal to the function generator and is not in your circuit. The bypass capacitor C_{BYP} needs to be connected as close to the BJT collector pin as possible. Check the power (I_E^2 Re) in the Re if it is greater than **250mW** use two emitter resistors to equal your design value (Re) ether in series or parallel. Record the values of the bias network resistors and the capacitors you used in the circuit.

6.2. Measure the following values:

(a) Vdc Q-point: Vce, Vbe, Ib, Ie, Ic, Vb, Ve,and Vc Note: Ib = Irb1 – Irb2

Use DC multimeter measure from the reference point the ground between the two power supplies. Note: Calculate the current from a voltage across a resister.

Hint: If your Q-point Vb, Vc, and Ve are not as expected. Remove the BJT and measure Base, Collector and Emitter nodes. Vb = expected bias voltage, Vc = Vcc, and Ve = Vee.

(b) AC gains: Voltage, current, and power.
(c) Maximum undistorted peak-to-peak output voltage at 5kHz. Use scope
(d) Input and output resistance at 5kHz. Use ac multimeter.
(e) Low and high cutoff frequencies (half power point).

Recall that input impedance is given by $R_{in} = v_{in}/i_{in}$, Iin = V_{Ri} / R_i output impedance is given by $R_{out} = (v_{oc}-v_{load})/i_{load}$, voltage gain is given by $A_v = v_{out}/v_{in}$, and current gain is given by $A_i = i_{load}/i_{in}$ Where V_{load} and I_{load} is the voltage across the load and the current thru the load.

Additionally, plot the following:

(a) Input and output waveform at the maximum undistorted output voltage.
(b) Power Spectrum of the output waveform 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, Rload, with a 47Ω and a 820Ω resistor, and measure the maximum output voltage peak-to-peak and voltage gain without clipping. Comment on the loading effect, and remember to change back to the given Rload after this step.

ECE 3274
Common Collector Amplifier Lab
Report Data Sheet

Name:____________________ **Lab Date:**____________ **Bench:**___________

Group:____________________ **CRN:**____________

Remember to include units for all answers and to label all printouts include photo of built circuit. There are a total of three (4) plots (1) photo in this lab.

6.1. Component Values
Remember Rios = 47Ω, Ri = 150Ω, and Cbyp = 0.1µF, 0.047uF, or 0.01uF

R_{b1}:		**R_{b2}:**		**R_e:**		**R_L:**	
C_{in}:		**C_{out}:**		**C_{hi}:**		**C_{hi2}:**	

6.2. Common-collector amplifier. There are three (4) printouts (Vin, Vout, Power spectrum, and ACsweep). Calculate $I_B = I_E - I_C$

Vdc Q-Point:	V_{CE}:		V_{BE}:		V_{CC}:	
	I_B:		I_C:		I_E:	
	V_B:		V_C:		V_E:	
Gain:	Voltage:		Current:		Power:	
Voltage Output $Vout_{PP}$:	Max:					
Resistance at 5kHz:	Input		Output			
Frequency Response:	Low cutoff:		High cutoff:			

6.3. Common-collector amplifier with different load resistors. Measure with scope. There are no printouts here.

47Ω Load resistor:

Gain:	Voltage:		Current:		Power:	
Voltage Output $Vout_{PP}$:	Max:					

820Ω Load resistor:

Gain:	Voltage:		Current:		Power:	
Voltage Output $Vout_{PP}$:	Max:					