

### Project – Common Collector Amplifier

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

**Components:** 2N2222 BJT

#### Introduction:

The common collector amplifier is one of the most useful small-signal amplifier configurations. 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. 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.

#### Design and Prelab:

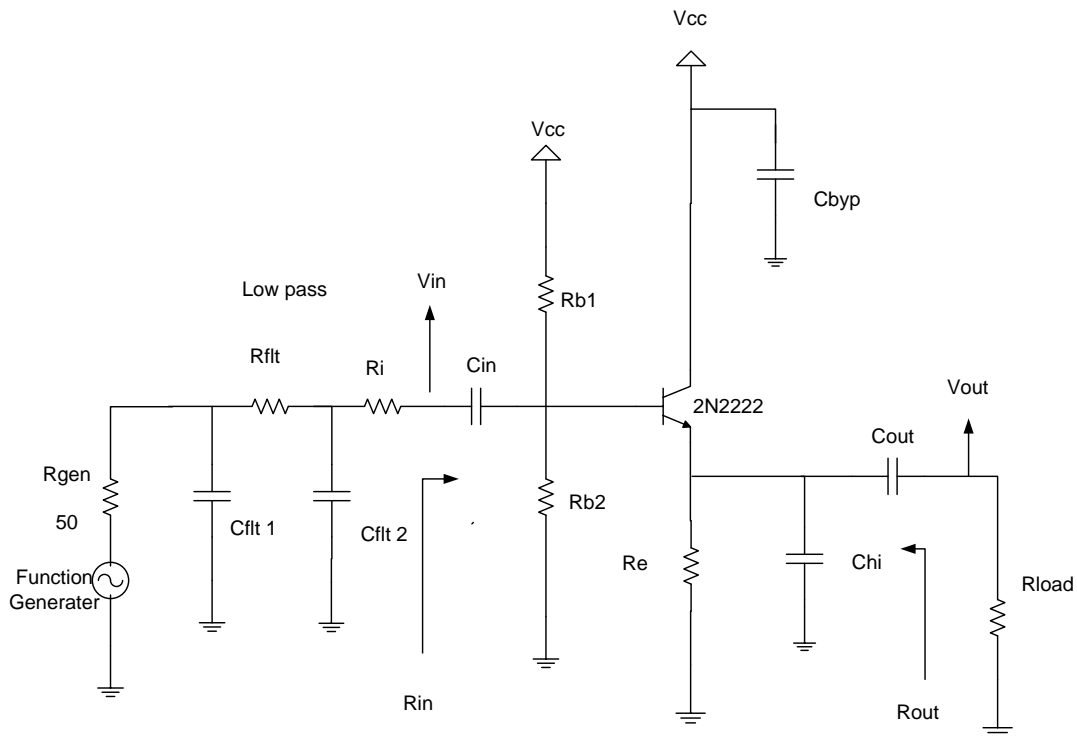
1. From the digital curve tracer find the value of  $\beta_{dc}$  and  $\beta_{ac}$  at the designed Q-point (use  $I_{Cmax} = 50mA$  and  $V_{CEmax} = 20V$  for the curve) of a CE amplifier. Remember  $\beta_{dc} = I_C/I_B$  and  $\beta_{ac} = \Delta I_C / \Delta I_B$ .
2. From the digital curve tracer determine the values of  $h_{oe}$  and  $h_{ie}$ . The slope of the transistor  $I_C$ - $V_{CE}$  curves in the active region at the Q-Point is  $h_{oe}$ . Find  $h_{ie}$  by looking at the base emitter junction as a diode on the curve tracer. The tangent slope of the  $I_B$ - $V_{BE}$  curve at the  $I_{BQ}$  point is  $h_{ie}$ .

**Note you must calculate:  $A_v$ ,  $A_i$ ,  $V_{in}$ ,  $F_L$ ,  $I_{CQ}$ ,  $V_E$ ,  $V_B$ ,  $V_C$ ,  $R_{b1}$ ,  $R_{b2}$ ,  $R_e$ ,  $C_{in}$ ,  $C_{out}$ ,  $R_{\pi}$ ,  $R_{IN}$ , and  $R_{OUT}$ .** Design a common collector amplifier with the following specifications:

Show all work.

1. Use a 2N2222 BJT and  $V_{cc} = 12$  volt dc supply with a 0.1uF capacitor to bypass the power supply on the board.  $R_{flt}=100$ ,  $R_i = 47$ ,  $C_{byp}= 0.1uF$ ,  $C_{flt} 1 = 0.0047uF$ , and  $C_{flt} 2 = 0.0047uF$
2. Midband gain  $V_o/V_{in} \geq 0.5$
3. Low frequency cutoff  $F_L$  between 100 Hz and 200 Hz  
 $F_{Cin} = F_{Cout} = F_L / 2$
4. High frequency cutoff  $F_H$  between 50 kHz and 150 kHz  
 $F_{Chi} = F_H$
5. Input impedance seen by the source  $R_{IN} \geq 4 k\Omega$
6.  $V_o$  non-clipping volatge  $\geq 2.0$  volts peak (4 V pp)

7. Load resistor  $R_{Load} = 180 \Omega$
8. Sampling resistance  $R_i = 47 \Omega$  (this is in addition to 50 ohm function generator's internal resistance)
9. Use PSPICE to verify the gain of the amplifier by adjusting the input signal voltage such that the output waveform at  $4 V_{pp}$  at 1 KHz and is not clipping. Adjust the  $V_S$  such that the  $V_{OUT}$  is  $4 V_{pp}$ .
10. Use PSPICE to verify the frequency response of the amplifier. Mark on the plot the  $F_L$ ,  $F_H$  and  $A_v$ .
11. 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.
12. 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?



**Figure 1: Common Collector Amplifier**

**ECE 3274 lab 6 Project Common Collector Amplifiers – Fall 2008** (Modification - DCF)**Lab Procedure:**

**Somewhere** on this sheet of paper, write the equations you used to calculate  $I_E$ ,  $I_{in}$ ,  $I_{load}$ ,  $R_{in}$ ,  $R_{out}$ ,  $P_{Load}$ ,  $F_H$ ,  $G$ .

1. Construct the CC amplifier of Figure 1. Remember  $R_{flt}$ , and  $R_i$  are installed by you; the  $R_{gen} = 50 \Omega$  is the internal the resistance of the function generator. Verify the amplifier operation by measuring the Q-point,  $V_B$ ,  $V_C$ ,  $V_E$ , and calculating  $I_E$ .
2. Adjust the input signal level to get a symmetric  $\geq \pm 2.0$  volt peak output voltage swing (4Vpp) . Make sure that the output waveform is not clipped.  
 Capture the input and output waveforms from the oscilloscope.  
 Save the capture as a jpeg and use the cursor positions to show the output level.  
 On the jpeg, note and describe any distortion in the output waveform.
3. Observe the loading affect for  $R_L = 47 \Omega$ ,  $180 \Omega$ , and  $820 \Omega$ . Measure **at maximum peak unclipped output voltage** for each load value.

**Comment on the loading effect.** i.e. What changes occur in the output signal amplitude, shape, or gain? As  $R_L$  increases/decreases, which directions produce maximum voltage gain, maximum  $V_o$ , and maximum power transfered to the load? What value of  $R_L$  will produce maximum power transfer for your circuit.

4. Return  $R_L$  to  $180 \Omega$  and  $V_o$  to  $2V_p$  ( $4 V_{pp}$ ). **Use the Fluke voltmeter** to measure voltages and determine the midband:
  - Voltage gain ( $A_V = V_{load}/V_{in}$ )
  - Current gain ( $A_i = I_L/I_S$  [measure  $I_{in}$  by looking at the current through  $R_i$ ])
  - Input impedance ( $R_{in} = V_{in} / I_{in}$ )
  - Output impedance  $R_{out}$  (Thevenin equivalent) seen by the load resistor
  - Overall power gain  $G$
5. **Option 1:** Use Labview to record and plot the frequency response. Sweep from 10Hz to 300 kHz in at least 20 steps/decade with a  $100mV_{pp}$  generator voltage. When the sweep completes, measure  $V_{in}$  with the meter to get the reference voltage for gain.  
  
 Find and mark (on the print) the corner frequencies, bandwidth, and midband voltage gain (use you your measured  $V_{in}$  to calculate the gain). Use the cursors to find and mark the corner frequencies. Label  $F_L$ ,  $F_H$ , bandwidth, and midband voltage gain to verify that the specifications have been met.  
**Option 2:** Use the Venable Frequency Response Analyzer.  
 Set the **AC Volts OUT** =  $0.5V_p$
6. Calculate  $F_H$  using measured  $R_{out}$  value from step 4.  $F_H = 1/(2\pi(R_{out} \parallel R_{load})C_{in})$ .
7. Optional: Run the frequency sweep again with the generator set to  $3V_{pp}$ , and measure  $F_H$ . Compare your calculated  $F_H$  obtained from  $R_{out}$  with the  $F_H$  measured with a  $3V_{pp}$  input frequency sweep. Which  $F_H$  is closer to the theoretical  $R_{out}$ ? Why? i.e. what causes the increase in your measured  $R_{out}$  and decrease in  $F_H$ . With a large signal input?
8. **Before you leave: Shut down Windows, return cables to racks, return parts to correct drawer bins, return adapters to container, turn off bench power, clear bench, and place seat under bench. (5 point deduction)**

**ECE 3254 Report Project 6 Common Collector Amplifiers.**

Name: \_\_\_\_\_ Partner \_\_\_\_\_ Date \_\_\_\_\_

Remember to submit your prelab assignment.

- 1.
- Values of components use to build CC amplifier.**
- $R_i = 47\Omega$
- $R_{flt} = 100\Omega$

$$R_{B1} = \text{_____} \quad R_{B2} = \text{_____} \quad R_E = \text{_____} \quad R_L = \text{_____}$$

$$C_{flt} = 0.0047\mu\text{F} \quad C_{hi} = \text{_____} \quad C_{in} = \text{_____} \quad C_{out} = \text{_____}$$

**Q-Point Measurement**

$$\text{Measured } V_B = \text{_____} \quad V_E = \text{_____} \quad V_C = \text{_____} \quad \text{Calculated } I_E = \text{_____}$$

- 2.
- Capture  $V_{in}$  and  $V_{out}$ .**
- $V_{in} = \text{_____}$
- $V_{out} = \text{_____}$
- Frequency used = \_\_\_\_\_

- 3.
- Load Voltage Measurement.**
- (You will need to adjust
- $V_{in}$
- ). (Volts measured in
- $V_{rms}$
- )

$$R_{load} = 180\Omega \quad V_{OUT} = \text{_____} \quad V_{in} = \text{_____} \quad A_V = \text{_____} \quad P_{load} = \text{_____}$$

$$R_{load} = 47\Omega \quad V_{OUT} = \text{_____} \quad V_{in} = \text{_____} \quad A_V = \text{_____} \quad P_{load} = \text{_____}$$

$$R_{load} = 820\Omega \quad V_{OUT} = \text{_____} \quad V_{in} = \text{_____} \quad A_V = \text{_____} \quad P_{load} = \text{_____}$$

**Comment on the loading effect.** Max power transferred predicted when  $R_L = \text{_____}$ 

- 4.
- Midband:**

$$\text{Measured } V_{in} = \text{_____} \quad V_{47\Omega} = \text{_____} \quad V_{load} = \text{_____} \quad V_{OC} = \text{_____}$$

$$\text{Calculated } I_{in} = \text{_____} \quad R_{in} = \text{_____} \quad I_{load} = \text{_____} \quad R_{out} = \text{_____}$$

$$\text{Calculated } A_V = \text{_____} \quad A_i = \text{_____} \quad \text{Power gain } G = \text{_____}$$

**What other method could be used to determine  $R_{out}$ ?**

- 5.
- AC Sweep**
- Measured
- $V_{in} = \text{_____}$
- $F_L = \text{_____}$
- $F_H = \text{_____}$
- 
- @100mV
- <sub>pp</sub>
- input

- 6.
- Calculated  $F_H$**
- using
- $R_{out}$
- $F_H = \text{_____}$

- 7.
- Optional:**
- Measured
- $F_H = \text{_____}$
- with generator @3V
- <sub>pp</sub>
- . Comment.

**Compare your measurements** for parts 1 – 5 to the predicted values (amplitude, gain, freq response, bias points, etc) from the prelab calculations and Pspice simulations.