

Project – Two Stage Amplifier

Objective: This project will show the overall gain, frequency response, and coupling of a common source to a common collector amplifier.

Components: 2N2222 BJT, 2N7000 MOSFET

Introduction:

Multistage amplifiers are made up of single transistor amplifiers connected in cascade. The first stage usually provides a high input impedance to minimize loading the source (transducer). The middle stages usually account for most of the desired voltage gain. The final stage provides a low output impedance to prevent loss of signal (gain), and to be able to handle the amount of current required by the load. In analyzing multistage amplifiers, the loading effect of the next stage must be considered since the input impedance of the next stage acts as the load for the current stage. Therefore the ac analysis of a multistage amplifier is usually done starting with the final stage. The individual stages are usually coupled by either capacitor or direct coupling. Capacitor coupling is most often used when the signals being amplified are ac signals. In capacitor coupling the stages are separated by a capacitor, which blocks the dc voltages between each stage. This dc blocking prevents the bias point of each stage from being upset.

The CS-CC cascade two-stage amplifier is a good multistage configuration because the CS and CC amplifiers together provide some very desirable characteristics. The CS amplifier makes up the first stage and is capable of providing high voltage gain. The input impedance of the CS is a function of R_{G1} and R_{G2} and can be for high. The output impedance of the CS is approximately equal to R_D , which is usually in the kilohm range. The CC amplifier makes up the second stage and has the characteristics of high input impedance, low output impedance, high current gain, and a less than unity voltage gain.

In a cascade configuration, the overall voltage and current gains are given by:

$$A_V \text{ overall} = A_V \text{ first stage} * A_V \text{ second stage}$$

$$A_I \text{ overall} = A_I \text{ first stage} * A_I \text{ second stage}$$

Design and Prelab: show all work, include schematics and calculations for all components, C_{in} , C_{out} , C_s , and C_{12} .

A_v of CS, A_v of CC, R_{in} of CC, R_{out} of CS, Bias point for MOSFET V_g , V_d , V_s , V_{gs} , I_d , V_{ds} , g_m , Bias point for BJT V_b , V_c , V_e , V_{be} , I_c , V_{ce} , β

Calculate overall A_v , A_i , power gain, R_{in} , and R_{out} .

- Using the circuits from the previous two labs (CS and CC), calculate the overall voltage gain A_V also calculate the R_{IN1} , R_{OUT2} for the **CS-CC** cascade amplifier. Remember to take into account that the load resistances and input impedances are now different for the multistage amplifier. f_L is between 100Hz and 200Hz. Use $R_L=1k\Omega$. Find a suitable value for C_{12} to capacitive couple the first and second stages. Think of C_{12} as an output coupling capacitor for the first stage and make sure that C_{12} does not cause a dominant pole by making:

$$f_{12} = \frac{f_L}{10}$$

$V_{CC} = 12V_{DC}$

$f_L = 100\text{Hz to } 200\text{Hz}$

$f_H = 50\text{kHz to } 150\text{kHz}$ let $F_{HCcs} = F_{HCcc} = 100\text{kHz}$

R_{in} of CS > **100K Ω**

R_{in} of CC stage > **4K Ω**

Overall $A_v > -5$

V_{out} non-clipped = **3V $_{pp}$**

$R_{load} = 1K\Omega$

- PSPICE simulation** adjust input source for an output of 3V $_{pp}$ at the midband frequency. **Mark the f_L and f_H** on the plots. Calculate the A_v overall from the plots.

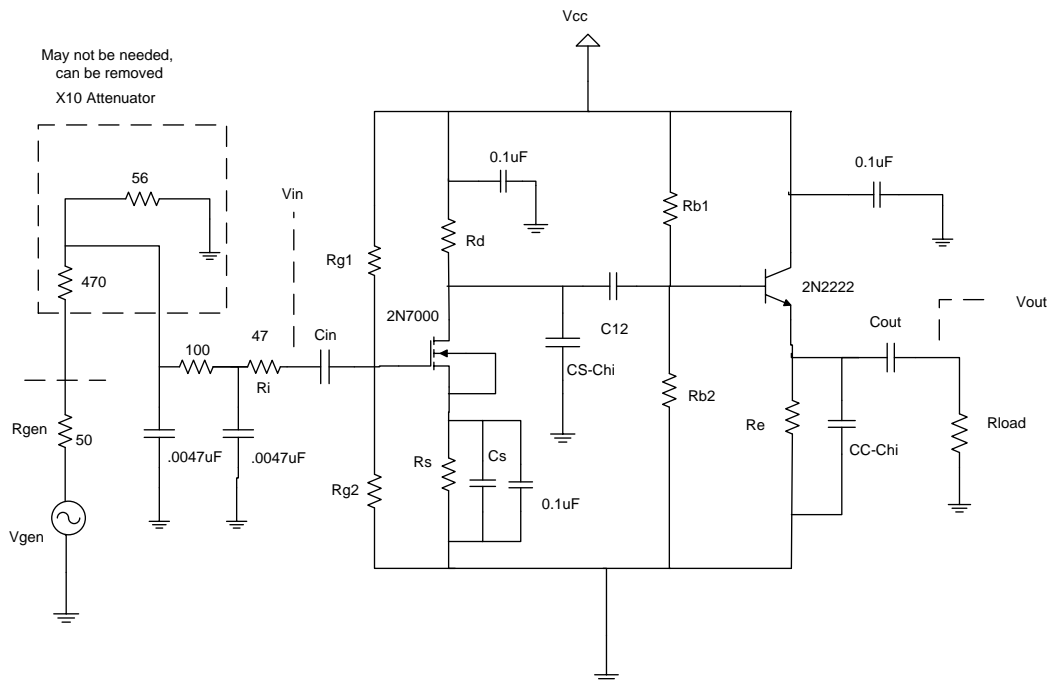


Figure 1: CS – CC Cascade Amplifier

Lab Procedure:

Construct the CS-CC cascade amplifier as shown in Figure1 using the component values from the previous two labs and the value of C_{12} as found in the Design section. Make the following measurements. **Note:** you may need to reduce or remove the CC emitter bypass capacitor, to stop the amplifier from oscillating. This capacitor also reduces the high frequency cutoff.

1. Measure the Q point of the MOSFET and BJT.
2. Adjust the input source to obtain an output of 3Vpp. Measure the midband voltage gains $A_{VCS} = V_{OUTCS}/V_{IN}$, $A_{VCC} = V_{OUT}/V_{INCC}$ for each individual stage and the overall voltage gain $A_V = V_{OUT}/V_{IN}$ for the entire cascade amplifier. Use $R_L = 1K$. Be sure to monitor the output on the oscilloscope to make sure the waveform is **not clipped**.
3. Measure the input impedance seen by the source (i.e. looking into C_{in}) and the output impedance seen by the load resistor (i.e. looking into C_{out}). See CS and CC lab for measurement method. Compare with the results of the previous two labs.
4. Measure the overall midband current gain $A_I = I_{LOAD}/I_{IN1}$. Calculate from the data the overall power gain $G = P_{OUT}/P_{IN} = (A_V)(A_I)$.
5. Use computer control to record and **plot** the frequency response of the cascaded amplifier. Find the corner frequencies and bandwidth.
6. Find the maximum, non-distorted output voltage swing. Record and **plot** the waveform V_{OUT} .

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 points)

Questions:

1. Compare the voltage gains of each stage A_{V1} and A_{V2} to the voltage gains of the previous labs. Why are the gains the same or different?
2. What is the overall A_V voltage gain, A_I overall current gain, and $G = P_{OUT2}/P_{IN1} = (A_V)(A_I)$ overall power gain.
3. For the cascade configuration, can the output impedance of the first stage be matched to the input impedance of the second stage when the cascade amplifier is a CS-CC?

Report Project Two Stage Amplifier.

Name: _____ Date _____ Bench _____

Values of components use to build the Two Stage Amplifiers CS-CC.

$R_i =$ _____ 47 _____ $C_{IN} =$ _____

$R_{G1} =$ _____ $R_{G2} =$ _____

$R_S =$ _____ $R_D =$ _____

$C_S =$ _____

$C_{12} =$ _____

$R_{B1} =$ _____ $R_{B2} =$ _____

$R_E =$ _____ $C_E =$ _____

$C_{OUT} =$ _____

$R_{LOAD} =$ _____

1. Q point

BJT

$V_B =$ _____ $V_E =$ _____ $V_C =$ _____

$V_{BE} =$ _____ $V_{CE} =$ _____ $I_C =$ _____

MOSFET

$V_G =$ _____ $V_S =$ _____ $V_D =$ _____

$V_{GS} =$ _____ $V_{DS} =$ _____ $I_D =$ _____

2. Midband gains.

$V_{IN} =$ _____ $V_{OUT CS} =$ _____

$V_{IN CC} =$ _____ $V_{OUT} =$ _____

$A_V CS =$ _____ $A_V CC =$ _____

$A_V CS-CC =$ _____ overall

3. Measure input and output impedance.

$V_{IN} =$ _____ $V_{47} =$ _____ $I_{IN} =$ _____

$R_{IN} =$ _____

$V_{LOAD} =$ _____ $I_{LOAD} =$ _____ $V_{OC} =$ _____

$R_{OUT} =$ _____

4. Midband overall current gain.

$I_{IN} =$ _____ $I_{LOAD} =$ _____

$A_I CS-CC =$ _____ overall

Midband overall power gain.

$G = P_{out}/P_{in} = (A_V)(A_I) =$ _____

5. AC Frequency response. Include the frequency response plot.

$F_L =$ _____ $F_H =$ _____ $BW =$ _____

Midband Voltage gain $A_V =$ _____

6. Maximum non-clipping output. $V_{OUT} =$ _____ V_{PP}

Include the waveform plot.

Answer the questions at the end of the lab procedure and turn in with the report.