Analog Electronics

Laboratory work

BJT Amplifiers

Key objective

1. Compute the dc and ac parameters for a common-emitter (CE) amplifier. Build the amplifier and measure these parameters.

Components needed

1. Resistors: one 100 Ω, one 330 Ω, two 1 kΩ, one 4.7 kΩ, two 10.0 kΩ
   One BC140 npn transistor
   One 10 kΩ potentiometer
   Capacitors: two 1.0 uF, one 47 uF

The Common-Emitter Amplifier

1. Calculate dc quantities listed in Table 1 for the CE amplifier in Figure 1. Because $\beta R_E > 10R_2$, you can use the unloaded voltage-divider analysis method to obtain V_B. Compute I_E by applying Ohm's law to the resistors in the emitter circuit. Enter your computed values in Table 1.

Table 1

DC Quantity	Computed value	Measured value
V_B		
V_E		
I_E		
V_C		
V_{CE}		

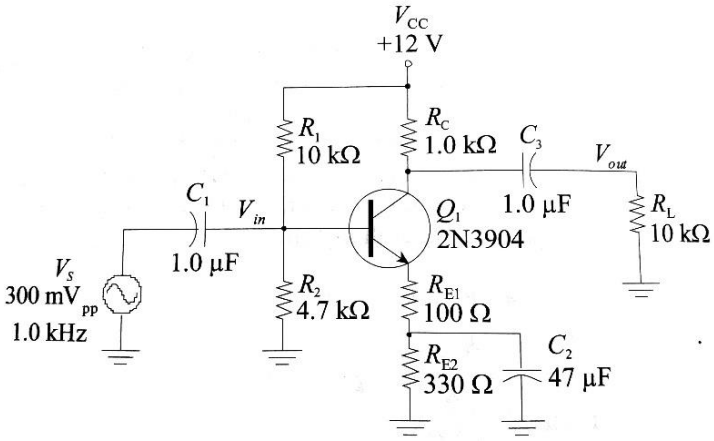

Figure 1

2. Construct the amplifier shown in Figure 1. The signal generator should be turned off. Measure and record the dc voltages listed in Table 1.
3. Calculate the four ac parameters listed in the first column of Table 2. The input signal, V_{in}, is given as 500 mV_{PP}. this is both V_{in} and the ac base voltage, V_B. Multiply Vin by the computed voltage gain to calculate the ac voltage at the collector; this is both V_C and V_{out}.
4. Turn on signal generator and set V_{in} for 500 mV_{PP} at 1 kHz with the generator connected to the circuit. Use the oscilloscope to set the proper voltage and check the frequency. Measure the ac signal voltage at the transistor's emitter and at the collector. Note the signal at the emitter is less than at the base. Use V_{in} and the ac collector voltage (V_{out}) to determine the measured voltage gain, A_V. The measurement of $R_{in(tot)}$ and B_{ac} is explained in step 5 and step 6. Record the measured values in Table 3.

Table 2

AC Quantity	Computed value	Measured value
$V_{in}=V_B$		
V_e		
r_e		
$V_{out}=V_c$		
A_V		
$R_{in(tot)}$		
$\boldsymbol{\beta_{ac}}$		

5. The measurement of $R_{in(tot)}$ is done indirectly because it is an ac resistance that cannot be measured with an ohmmeter. The output signal (V_{out}) is measured with and

oscilloscope and recorded with the amplifier operating normally (no clipping or distortion) A rheostat (R_{test}) is then inserted in series with the source as shown in Figure 2. The rheostat is varied until V_{out} drops to one-half the value prior to inserting R_{test}. With this condition, $V_{in}=V_{test}$ and $R_{in(tot)}$ must be equal to R_{test}. R_{test} can then be removed and measured with an ohmmeter. Using this method, measure $R_{in(tot)}$ and record the result in Table 2.

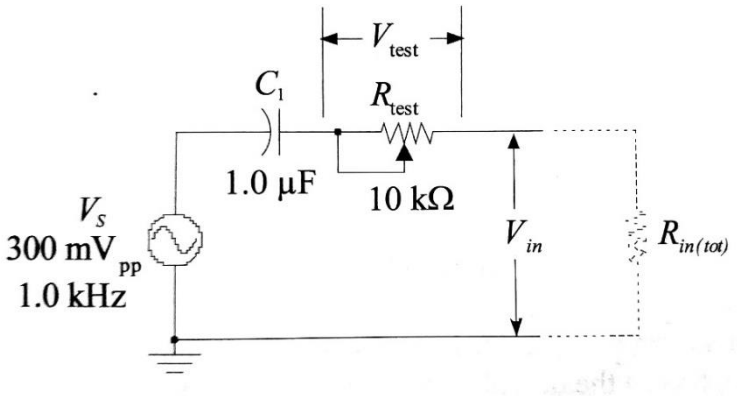

Figure 2

6. You can obtain an estimate of β_{ac} from $R_{in(tot)}$ and the known bias resistor values. Recall that $R_{in(tot)} = \big(\beta(R_{E1} + r_e)\big)||R_1||R_2$. Starting with the parallel resistor formula, you can rearrange it and use it to calculate β_{ac} indirectly. The equation is:

$$\beta_{ac} = \frac{1}{\frac{R_{E1} + r_e}{R_{in(tot)}} - \frac{R_{E1} + r_e}{R_1} - \frac{R_{E1} + r_e}{R_2}}$$

Enter the result as measured value of β_{ac} in Table 2. The result is an approximation of β_{ac}.

Troubleshooting

7. Remove the bypass capacitor, C_2, from the circuit, simulating an open capacitor. Measure the ac signal voltage at the transistor's base, emitter, and collector. Measure the voltage gain of the amplifier. Observations with open C_2:

_____

8. Replace C_2 and reduce R_L to 1 kOhm, simulating a change in load conditions. Observe the ac signal voltage at the transistor's base, emitter, and collector. Observations for smaller load:

_____

9. Replace R_L with the original 10 kOhm resistor and open R_{E1}. Measure the dc voltages at the base, emitter and collector/ is the transistor in cutoff or in saturation? Explain.
   _____

10. Replace R_{E1} and open R_2. Measure the dc voltages at the base, emitter and collector/ is the transistor in cutoff or in saturation? Explain.
   _____

Questions

1. Does the load resistor have any effect on the input resistance? Explain your answer.
2. What is the purpose of the unbypassed emitter resistor R_{E1}? What design advantage does it offer?
3. When the bypass capacitor, C_2, is open, you found that the gain is affected. Explain why.