Name ______________________

Date ______________________

Instructor ______________________

EXPERIMENT

17

Common-Emitter Transistor Amplifiers

OBJECTIVE

To measure AC and DC voltages in a common-emitter amplifier. To obtain measured values of voltage amplification (A_v), input impedance (Z_i), and output impedance (Z_o) for loaded and unloaded operation.

EQUIPMENT REQUIRED

Instruments

Oscilloscope
DMM
Function generator
DC power supply

Components

Resistors

(2) 1-kΩ
(2) 3-kΩ
(1) 10-kΩ
(1) 33-kΩ

Capacitors

(2) 15-μF
(1) 100-μF

Transistors

(2) NPN (2N3904, 2N2219, or equivalent general purpose transistor)

EQUIPMENT ISSUED

Item	Laboratory serial no.
DC power supply	
Function generator	
Oscilloscope	
DMM	

RÉSUMÉ OF THEORY

The common-emitter (CE) transistor amplifier configuration is widely used. It provides large voltage gain (typically tens to hundreds) and provides moderate input and output impedance. The AC signal voltage gain is defined as

$$A_v = V_o/V_i$$

where V_o and V_i can both be rms, peak, or peak-peak values. The input impedance, Z_i, is that of the amplifier (as seen by the input signal). The output impedance, Z_o, is that seen looking from the load into the output of the amplifier.

For the voltage-divider DC bias configuration (see Fig. 17.1), all DC bias voltages can be approximately determined without knowing the exact value of transistor beta. The transistor's AC dynamic resistance, r_e, can be calculated using

$$r_e = \frac{26(\text{mV})}{I_{E_Q}(\text{mA})} \tag{17.1}$$

AC Voltage Gain: The AC voltage gain of a CE amplifier (under no-load) can be calculated using

$$A_v = \frac{-R_C}{(R_E + r_e)}$$

If R_E is bypassed by a capacitor use $R_E = 0$ in the above equation.

Thus: $$A_v = \frac{-R_C}{r_e} \tag{17.2}$$

AC Input Impedance: The AC input impedance is calculated using

$$Z_i = R_1 \| R_2 \| \beta(R_E + r_e)$$

If R_E is bypassed by a capacitor use $R_E = 0$ in the above equation.

Thus: $$Z_i = R_1 \| R_2 \| \beta r_e \tag{17.3}$$

AC Output Impedance: The AC output impedance is

$$Z_o = R_C \tag{17.4}$$

PROCEDURE

Part 1. Common-Emitter DC Bias

a. Insert measured values of each resistor in Fig. 17.1.

R_1 = ________
R_2 = ________
R_C = ________
R_E = ________

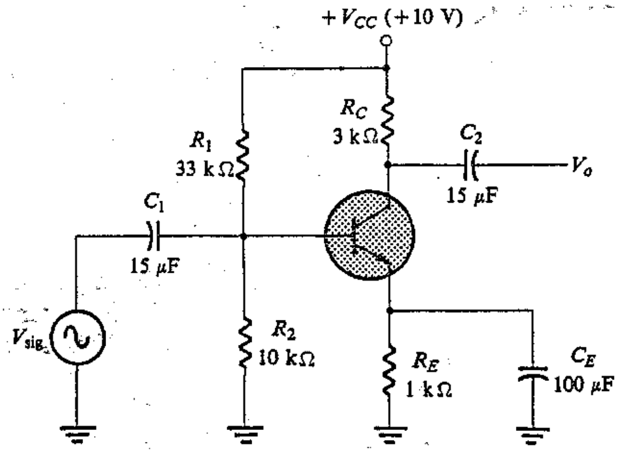


Figure 17-1

b. Calculate DC bias values for the circuit of Fig. 17.1. Record calculated values below.

V_B (calculated) = ________
V_E (calculated) = ________
V_C (calculated) = ________
I_E (calculated) = ________

Calculate r_e using Eq. 17.1 and the calculated level of I_E.

r_e (calculated) = ________

c. Wire up the circuit of Fig. 17.1. Set $V_{CC} = 10$ V. Check the DC bias of the circuit measuring values of

V_B (measured) = ________

V_E (measured) = ________

V_C (measured) = ________

Check that these values compare well with those calculated in step 1(**b**). Calculate the DC emitter current using

$$I_E = V_E/R_E$$

I_E = ________

Calculate the AC dynamic resistance, r_e, using the measured value of I_E.

$$r_e = \frac{26(\text{mV})}{I_E(\text{mA})}$$

r_e = ________

Compare r_e with that calculated in step 1(**b**).

Part 2. Common-Emitter AC Voltage Gain

a. Calculate the amplifier voltage gain for a fully bypassed emitter using Eq. 17.2.

A_v (calculated) = ________

b. Apply an AC input signal, V_{sig} = 100 mV, pk-pk at f = 1 kHz. Observe the output waveform on the scope to be sure that there is no distortion (if there is, reduce the input signal or check the DC bias). Measure the resulting AC output voltage, V_o, using the scope or a DMM.

V_o (measured) = ________

Calculate the circuit no-load voltage gain using measured values.

$$A_v = \frac{V_o}{V_{sig}}$$

A_v = ________

Compare the measured value of A_v with that calculated in step 2(a).

Part 3. AC Input Impedance, Z_i

a. Calculate Z_i using Eq. 17.3. Use the beta measured with a transistor curve tracer, beta tester, or the nominal listed value in specification sheets (say, β = 150).

Z_i (calculated) = ________

b. To measure Z_i connect an input measurement resistor, R_x = 1 kΩ, as shown in Fig. 17.2. Apply input V_{sig} = 20 mV, rms. Observe the output waveform with a scope to ensure that no distortion is present (adjust input amplitude if necessary). Measure V_i.

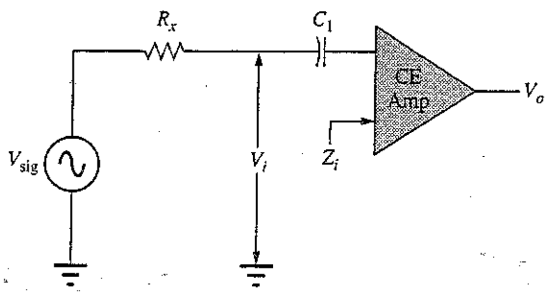


Figure 17-2

V_i (measured) = ________

Solving for V_i using

$$V_i = \frac{V_{sig}}{(Z_i + R_x)} Z_i$$

we get

$$Z_i = \frac{V_i}{(V_{sig} - V_i)} R_x$$

Z_i = ________

Compare the measured value of Z_i with that calculated in step 3(a).

Part 4. Output Impedance, *Zo*

a. Calculate Z_o using Eq. 17.4.

Z_o (calculated) = ________

b. Remove input measurement resistor, R_x. For input of $V_{sig} = 20$ mV rms, measure the output voltage, V_o. Check output waveform to ensure that no distortion is present.

V_o [measured] (unloaded) = V_o = ________

Now connect load $R_L = 3\ \text{k}\Omega$ and measure V_o.

V_o [measured] (loaded) = V_L = ________

The output impedance can be obtained from

$$V_L = \frac{R_L}{(Z_o + R_L)} V_o$$

for which

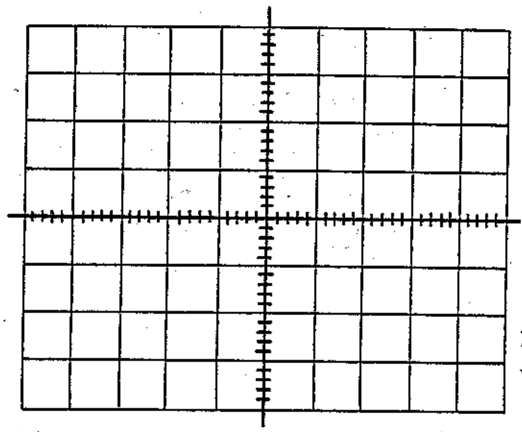
$$Z_o = \frac{V_o - V_L}{V_L} R_L$$

Z_o = ________

Compare the measured value of Z_o with that calculated in step 4(a).

Part 5. Oscilloscope Measurement

Connect the amplifier of Fig. 17.1. For input of V_{sig} = 20 mV, p-p, at a frequency of f = 1 kHz, sketch the waveforms for V_{sig} and V_o in Fig. 17.3.



Horizontal ________

Vertical ________

Figure 17-3

Part 6. Computer Analysis

Perform a PSpice Windows analysis of the network of Fig. 17.1.