EXPERIMENT 5
COMMON - EMITTER TRANSISTOR AMPLIFIER

Std. No. Name & Surname:
1 _______ __________________
2 _______ __________________
3 _______ __________________

Group No :__________________
Submitted to:_________________
Date :_____________________

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OBJECTIVE

To measure DC and AC voltages in 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

(2) 3.3kΩ
(1) 10kΩ
(2) 1kΩ
(1) 33kΩ
(1) 100µF
(2) 15 µF
(2) NPN (2N3904, 2N2219, or equivalent general purpose transistor)

RESUME 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. 5.1), 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

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

(5.1)

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:
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:

\[ Z_i = R_1 \| R_2 \| \beta r_e \]  \hspace{1cm} (5.3)

AC Output Impedance: The AC output impedance is

\[ Z_o = R_C \]  \hspace{1cm} (5.4)

PROCEDURE


a. Insert measured values of each resistor in Fig. 5.1

b. Calculate DC bias values for the circuit of Fig. 5.1. Record calculated values below.

\[ V_B (\text{Calculated}) = \]
\[ V_E (\text{Calculated}) = \]
\[ V_C (\text{Calculated}) = \]
\[ I_E (\text{Calculated}) = \]

Calculate \( r_e \) using Eq. 5.1 and the calculated level of \( I_E \).
c. Wire up the circuit of Fig.5.1. Set $V_{CC} = 10 \text{ V}$. Check the DC bias of the circuit measuring values of

\[ V_b(\text{measured}) = \]
\[ V_E(\text{measured}) = \]
\[ V_C(\text{measured}) = \]

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

\[ I_E = \frac{V_E}{R_E} \]

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

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

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

Part 2. Common-Emitter AC Volatage Gain

a. Calculate the amplifier voltage gain for a fully bypassed emitter using Eq. 5.2.

\[ A_v(\text{calculated}) = \]

b. Apply an AC signal, $V_{sig} = 20 \text{ mV}$, rms at $f = 1 \text{ kHz}$. 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 DMM.

\[ V_o(\text{measured}) = \]

Calculate the circuit no-load voltage gain using measured values.
\[ A_v = \frac{V_o}{V_{\text{sig}}} \]

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

**Part 3. AC Input Impedance, \( Z_i \)**

\textbf{a.} Calculate \( Z_i \) using Eq. 5.3. Use the beta measured with a transistor curve tracer, beta tester, or the nominal listed value in specification sheets (say, \( \beta = 150 \)).

\[ Z_i \text{ (calculated)} = \]

\textbf{b.} To measure \( Z_i \) connect an input measurement resistor, \( R_x = 1 \, \text{k} \Omega \), as shown in Fig. 5.2. Apply input \( V_{\text{sig}} = 20 \, \text{mV}, \text{rms} \). Observe the output waveform with a scope to ensure that no distortion is present (adjust input amplitude if necessary). Measure \( V_i \)

\[ V_{\text{measured}} = \]

Solving for \( V_i \) using

\[ V_i = \frac{V_{\text{sig}}}{\left( \frac{Z_i}{Z_i + R_x} \right)} Z_i \]

We get

\[ Z_i = \frac{V_i}{\left( V_{\text{sig}} - V_i \right)} \frac{R_x}{(Z_i + R_x)} \]

\[ Z_i = \]

Compare the measured value of \( Z_i \) with that calculated in step 3(a).
Part 4. Output Impedance, $Z_O$

a. Calculate $Z_O$ using Eq. 5.4.

$$Z_O \text{ (calculated)} = \ldots$$

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

$$V_o \text{ [measured] (unloaded)} = V_o = \ldots$$

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

$$V_o \text{ [measured] (loaded)} = V_L = \ldots$$

The output impedance can be obtained from

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

for which

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

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

Part 5. Oscilloscope Measurement

Connect the amplifier of Fig. 5.1. For input of $V_{\text{sig}} = 20 \text{ mV}$, p-p, at a frequency of $f = 1\text{ kHz}$, sketch the waveforms for $V_{\text{sig}}$ and $V_o$ in Fig. 5.3.
CONCLUSION

Student Name and ID: