EXPERIMENT 6
COMMON-BASE AND EMITTER-FOLLOWER (COMMON-COLLECTOR) TRANSISTOR AMPLIFIERS

Std. No.                  Name & Surname:
1
2
3

Group No : 
Submitted to : 
Date : 

Spring, 2013
OBJECTIVE

To measure DC and AC voltages in common-base and emitter-follower (common-collector) amplifier. To obtain measured values of voltage amplification ($A_v$), input impedance ($Z_i$) and output impedance ($Z_o$).

EQUIPMENT REQUIRED

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

(1) 100 Ω

(1) 1 kΩ

(2) 3 kΩ

(2) 10 kΩ

(1) 33 kΩ

(2) 15 µF

(1) 100 µF

RESUME OF THEORY

The common-base (CB) transistor amplifier configuration is used primarily for higher frequency operation. It provides large voltage gain at low input and moderate output impedance. Its voltage gain is

$$A_v = \frac{R_C}{r_e}$$  \hspace{1cm} (1.1)

AC Input Impedance: The ac input impedance is

$$Z_i = r_e \text{ (ground based terminal)}$$  \hspace{1cm} (1.2)

AC Output Impedance: The AC output impedance is

$$Z_o = R_C$$  \hspace{1cm} (1.3)

The common-collector (CC) or emitter-follower (EF) transistor amplifier configuration is used primarily for impedance matching operation. It provides voltage gain near unity, high input and low output impedance.

AC Voltage Gain: The AC voltage gain of CC amplifier is calculated as

$$A_v = \frac{R_E}{R_E + r_e}$$  \hspace{1cm} (1.4)

AC Input Impedance: The AC input impedance is calculated as

$$Z_i = R_1 \parallel R_2 \parallel \beta (R_E + r_e)$$  \hspace{1cm} (1.5)
AC Output Impedance: The AC output impedance is

\[ Z_o = r_e \]  

(1.6)

PROCEDURE

Part 1. Common-Base DC Bias

a. Calculate DC bias values for the circuit of Fig 1. Record calculated values below:

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

Calculate \( r_e \) using \( \frac{26 \text{mV}}{I_E \text{(mA)}} \)

\[ r_e \text{ (calculated)} = \text{__________} \]

b. Wire up the circuit of Fig 1. Set \( V_{CC} = 10 \text{ V} \). Check the DC bias of the circuit measuring the values of
Calculate the DC emitter current using

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

\[ I_E = \text{___________} \]

Calculate the AC dynamic resistance, \( r_c \)

\[ r_c = \frac{26 \text{mV}}{I_E \text{mA}} \]

\[ r_c = \text{___________} \]

Compare the DC voltages, current \( I_E \), and dynamic resistance \( r_c \) calculated in step 1(a) with the values obtained in step 1(b).

**Part 2. Common-Base AC Voltage Gain**

a. Calculate the AC voltage gain of CB amplifier in Fig 1 using Eq 1.1.

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

b. Apply an AC input signal, \( V_{sig} = 50 \text{ mV}, \text{rms} \). Measure the resulting AC output voltage, \( V_o \).

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

Calculate the circuit AC voltage gain

\[ A_v = \frac{V_o}{V_{sig}} \]
\[ A_v = \text{__________} \]

Compare the voltage gain calculated in step 2(a) with that measured in step 2(b).

Using the oscilloscope, observe and sketch the input waveform, \( V_{\text{sig}} \), and output waveform, \( V_o \), in Fig 2.

**Fig 2**

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

- a. Obtain the AC input impedance of the CB amplifier in Fig 1 using Eq.1.2.

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

- b. To measure \( Z_i \) connect input measurement resistor, \( R_i=100\Omega \) as shown in Fig 3. Apply input
$V_{\text{sig}} = 50 \text{ mV, rms at frequency } f = 1 \text{ kHz. Measure } V_r.$

Calculate using

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

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

Remove resistor $R_s.$

Compare the AC input impedance calculated in step 3(a) with that measured in step 3(b).
Part 4. CB Output Impedance, $Z_o$

a. Determine the AC output impedance of the CB amplifier in Fig 1 using Eq.1.3.

\[ Z_o(\text{calculated}) = \ldots \]

b. For an input of $V_{\text{sig}}$=20 mV, rms measure the output voltage, $V_o$, with no load connected.

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

Now connect load $R_L = 3$ kΩ and measure $V_L$.

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

The output impedance can be calculated from

\[ V_L = \frac{R_L}{Z_o + R_L} V_o \]

Hence,

\[ Z_o = \frac{V_o - V_L}{V_L} R_L \]

\[ Z_o = \ldots \]

Compare the AC output impedance calculated in step 4(a) with the measured in step 4(b).

Part 5. Emitter-Follower DC Bias

a. Calculate DC bias values for the EF circuit of Fig 4. Record calculated values below.
Fig 4

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

Calculate \( r_e \) using \( r_e = 26\text{(mV)}/I_E\text{(mA)} \).

\[ r_e \text{(calculated)} = \quad \]

**b.** Wire up the circuit of Fig. 4. Set \( V_{CC} = 10\text{V} \). Check the DC bias of the circuit measuring the values of

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

Calculate using

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

\[ I_E = \quad \]
Determine the value of $r_e$ using $r_e = \frac{26\text{mV}}{I_E\text{mA}}$.

\[ r_e = \text{____________________} \]

Compare the DC voltages and current calculated in step 5(a) with those measured in step 5(b).

**Part 6. Emitter-Follower AC Voltage Gain**

a. Calculate the AC voltage gain of EF amplifier in Fig 1 using Eq 1.4.

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

b. Apply an AC input signal, $V_{\text{sig}} = 1\text{ V}$, rms. Measure the resulting AC output voltage, $V_o$.

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

Calculate the circuit AC voltage gain

\[ A_v = \frac{V_o}{V_{\text{sig}}} \]

\[ A_v = \text{____________________} \]

Compare the voltage gain calculated in step 6(a) with that measured in step 6(b).

Observe and sketch the input waveform, $V_{\text{sig}}$, and output waveform, $V_o$, in Fig 5.
Part 7. Emitter-Follower EF Input Impedance, $Z_i$

c. Obtain the AC input impedance of the EF amplifier in Fig 4 using Eq.1.5.

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

d. To measure $Z_i$, connect input measurement resistor, $R_i=10\,k\Omega$ as shown in Fig 6. Apply input $V_{\text{sig}}=2\,V$, rms at frequency $f=1\,\text{kHz}$. Measure $V_{\text{i}}$. 
\[ V_i = \frac{Z_i}{(Z_i + R_s)} V_{sig} \]

\[ Z_i = \frac{V_i}{(V_{sig} - V_i)} R_s \]

\[ Z_i = \text{____________} \]

Compare the AC input impedance of a CC amplifier calculated in step 7(a) with that measured in step 7(b).

**Part 8. Emitter-Follower EF Output Impedance, \( Z_o \)**

**c.** Determine the AC output impedance of a CC amplifier in Fig 4 using Eq.1.6.

\[ Z_o \text{(calculated)} = \text{____________} \]
d. For an input of $V_{\text{sig}}=20$ mV, rms at frequency $f=1$ kHz measure the output voltage, $V_o$.

$$V_o(\text{measured}) = \phantom{0000}$$

Now connect load $R_L=100$ Ω and measure $V_L$.

$$V_L(\text{measured}) = \phantom{0000}$$

The output impedance can be calculated from

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

Hence,

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

$$Z_o = \phantom{0000}$$

Compare the CC output impedance calculated in step 8(a) with the measured in step 8(b).
CONCLUSION

Student Name and ID:
CONCLUSION

Student Name and ID:
CONCLUSION

Student Name and ID: