Lab 7 The Emitter Follower

Name ______________________________ Section ______

Purpose:

To demonstrate the ac operation of the emitter follower.
To demonstrate the ac operation of the emitter follower.
To demonstrate some of the common fault symptoms that may occur in the emitter follower.

Equipment:

- * 1 dc Power Supply
- * 1 Digital Multimeter (DMM)
- * 1 Variable ac Signal Generator
- * 1 Dual Trace Oscilloscope
- * 1 2N3904 npn Transistor

Resistors

1 -47 Ω	1 - 4.7 k Ω
2 - 470 Ω	2 - 10 k Ω

Capacitors
1 - 10 μF
1 - 470 μF

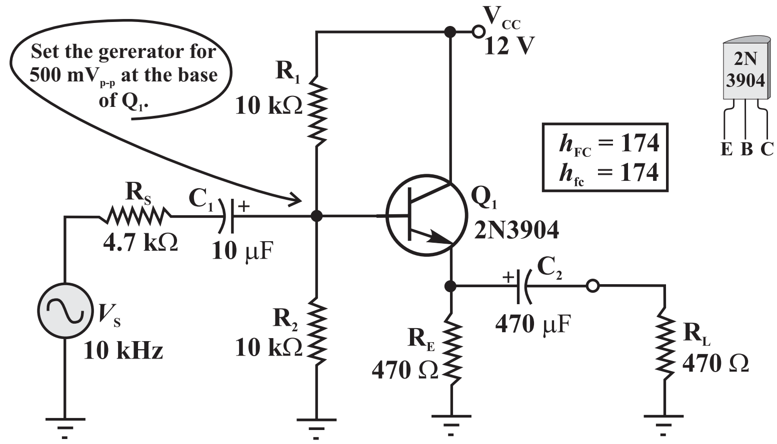

Figure 1

Prelab:

- Construct the circuit shown in Figure 1 on your breadboard.
- Perform the dc analysis and complete the calculated portion of Table 1.
  Show all calculations.
- Perform the ac analysis and complete the calculated portion of Table 1.
- The worksheet on ac analysis will take you step-by-step through the process.
  Show all calculations.

Discussion:

The emitter follower has a high input impedance, a low output impedance and low non-linear distortion. The current gain of the emitter follower is relatively high, while the voltage gain is always less than one.

The emitter follower is usually wired so that the transistor collector is tied directly to V_{CC}. The output is taken from the emitter of the transistor. The emitter follower is often used as a buffer stage between a high impedance source and a low impedance load.

In this lab, you will build an emitter follower stage and verify its various operating characteristics.

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Complete the dc analysis here. Be sure to include the calculation for R_{in}. ***Show all calculations***
You must find R_{EQ} for this circuit

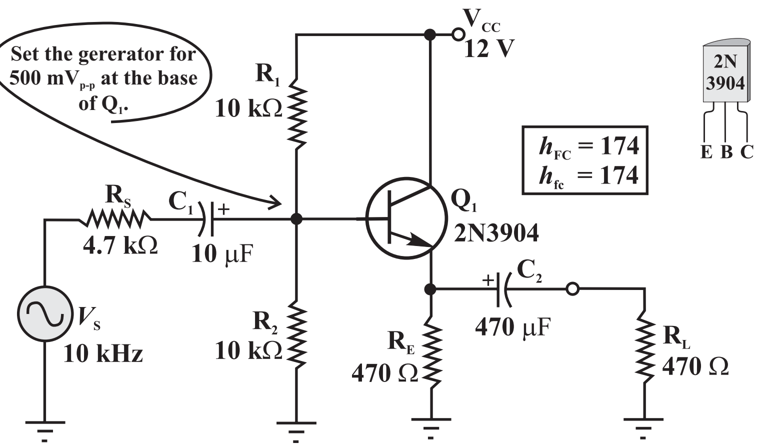


Figure 1

Table 1 dc Values	V_B	V_E	V_C	r'_e
Calculated				
Measured				

Table 2 ac Values	V_B	V_E	V_C	A_V	Z_{out}
Calculated					
Measured					

AC Analysis Worksheet

Find the terminal voltages v_b, v_e, & v_c and the values of A_V and $Z_{out.}$ Enter these values in Table 2

- ☐ $V_{B)}$ is at 500 $mV_{p\text{-}p}$ since you set generator to provide this signal level at the base of Q_1. All capacitors in this amplifier are operating well above $10f_C$ and appear as short circuits to the ac signal.

- ☐ $V_{C)}$ is at $0V_{p\text{-}p}$ since the the collector of the transistor is connected directly to V_{CC}. Since V_{CC} is a ground to the ac signal, any ac signal will be shorted to ground.

$V_{e)}$ is found by using A_V.

The formula for voltage gain is $A_V = \dfrac{r_E}{r_E + r'_e}$

We know that the emitter follower has a voltage gain that is slightly less than one, so substituting the circuit values into the formula should produce a value slightly less than one. Do this now.

A_V = ____________________

$V_{e)}$ is found by using the formula $V_e = A_V V_b$

V_e = ____________________

Find Z_{out}

The output impedance is found by the following formula. $Z_{out} = R_E \| \left(r_e' + \frac{R_1 \| R_2 \| R_S}{h_{fc}} \right)$

Z_{out} ______________________

Procedure: Do this part in the Lab

1) Measure and record the dc values shown in Table 1. Do this with the signal generator disconnected from the circuit.

2) Connect the signal generator to the circuit and set the input voltage so that ***500 mVp-p appears at the base of Q_1.***

3) Measure and record the ac values of v_b, v_c and v_e shown in Table 2.

4) Using the measured values of v_b and v_e, Calculate A_V (loaded). Enter this value in Table 2.

A_V **(loaded)** ______________________

5) Compare the measured value of A_V with the calculated value that you predicted. List 2 reasons that could account for any differences?

6) Connect your oscilloscope to the input and output. What is the phase relationship between the input and output signals? ______________________

7) Remove the load resistor R_L. Measure and record the following:

v_{in} (v_b) ______________________

v_{out} (v_e) ______________________ **(Unloaded)**

8) Using the values determined from step 7, Calculate the unloaded voltage gain of the emitter follower.

A_V **(unloaded)** ______________________

9) Compare the ***loaded*** gain with the ***unloaded*** gain. They should be almost the same value. Why are they almost the same voltage value?

What characteristic of the emitter follower is shown here?

Measuring Zout

At this point you will measure the output impedance of the amplifier. This can be done reasonably accurately using the following procedure.

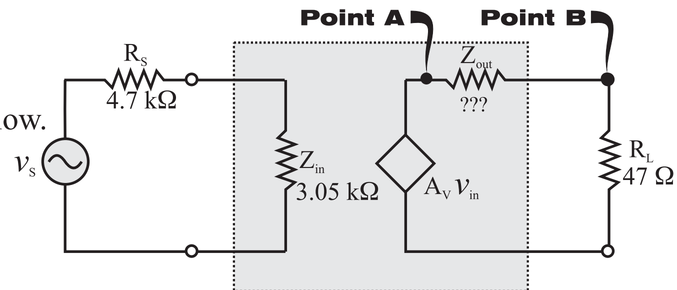
a) Reset the generator to produce an output of 100 mV_{pp} at the base of Q_1

b) Remove the load resistor and measure the ***unloaded*** output voltage.
v_{out} (v_e) ________________ **(Unloaded)**

c) Connect a load resistance of 47Ω across the output.

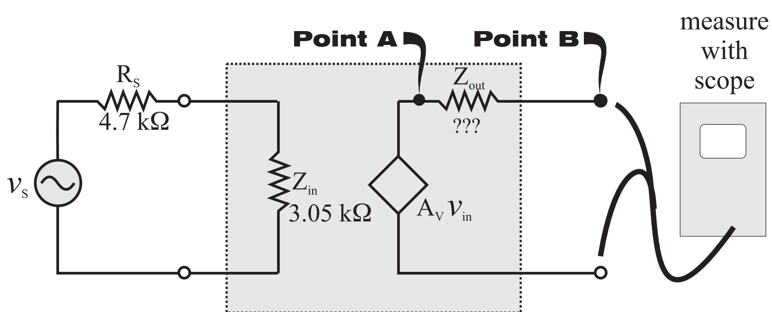
d) Measure the ***loaded*** output voltage.
v_{out} (v_e) ________________ **(Loaded)**

Calculate the output impedance using the method shown below.



$A_V = 0.95$
Figure 4

The amplifier shown in Figure 4 is the general model of the amplifier. We are interested in finding the output impedance (here it is marked ???)



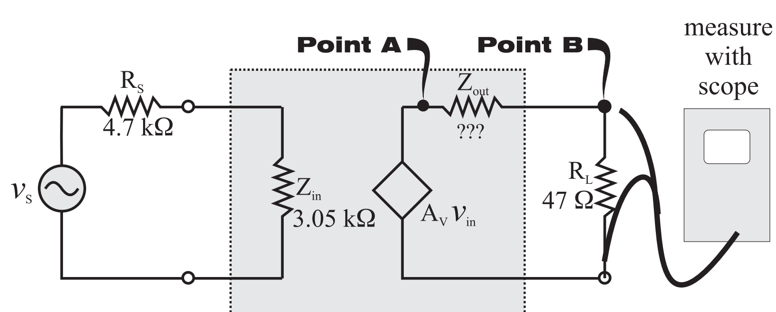
$A_V = 0.95$
Figure 5

Lets look at the output when it is unloaded. We remove the load resistor as shown in Figure 5 and measure the output with the scope from ***point B to ground***.. No current is flowing through Z_{out} because the circuit is open without R_L. With no current flowing in z_{out}, there is no voltage drop across it.
.This means the voltage at ***point A*** is the same as it is at ***point B***. This is important because we now know the voltage output of our amplifier before z_{out}. This is ***point A***. Remember that this is inside the amplifier at a point that we cannot get at to measure. You recorded this value as v_{out} **(Unloaded).**

Figure 6 shows the measurement of the output when it is loaded. A 47Ω load resistor has been added that will load down the output by drawing ac current from the amplifier. This current must pass through Z_{out} and a voltage drop across it will result. When you measured the ac voltage at point B, you found it lower than it was in Figure 5. You recorded this value as v_{out} **(Loaded).**

We know that the voltage at ***point A*** is the same as before, so the new lower value at point B has to be the result of a voltage drop across Z_{out}.

We now know the voltage drop now across Z_{out} and with it, we can find the current in the circuit. With these values, we can find the ohmic value of z_{out}.



$A_V = 0.95$
Figure 6

Do the following.

Find the total current in the circuit when R_L is connected.

This find the total ac current in the circuit since v_{out} (loaded) is the voltage appearing across R_L

$$i_{out\ p\text{-}p} = \frac{v_{out\ p\text{-}p\ (Loaded)}}{R_L}$$

i_{out} ______________________

Find the voltage drop across Z_{out}

This is the difference voltage between v_{out} (loaded) and v_{out} (unloaded)

$$v_{(Zout)p\text{-}p} = v_{out\ p\text{-}p(unLoaded)} - v_{out\ p\text{-}p\ (Loaded)}$$

$v_{(Z\ out)}$ ______________________

$$z_{out} = \frac{v_{(Zout)\ p\text{-}p}}{i_{out\ p\text{-}p}}$$

Find Z_{out}

$v_{(Z\ out)}$ is the voltage across Z_{out} and i_{out} is the current through it.

Use Ohm's Law to determine the measured value of Z_{out}. Insert this in Table 1.

Z_{out} ______________________

How would you account for the differences between the measured and calculated value of $Z_{(out)}$

Is the value of Z_{out} consistent with what you have learned about the output impedance of an emitter follower?

Based on what you have learned in lecture and what you have learned in this exercise, what is the practical function of the emitter follower?