UNIVERSITY OF UTAH
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
ECE 2280

A. Rasmussen/A. Stolp
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Lab #3 {115 pts} BJT Transistors

OBJECTIVES:

- Become familiar with the operation of the BJT transistor.
- Testing the BJT transistor in a circuit.
- Investigating the use of the BJT for impedance matching.
- Building and testing an amplifier.

PRELAB: (15 pts)

Procedure:

1. (5 pts) Determine a **PARTS LIST** for this laboratory.

2. (10 pts) Analyze the circuit shown in **Fig 4**. Determine voltages at each node and the currents through all branches. Assume β=400.

BACKGROUND INFORMATION:

Bipolar junction (BJT) transistor internals are explained, testing a BJT transistor, measuring input resistance, measuring output resistance, and circuit noise issues are discussed.

Bipolar Junction (BJT) Transistor Internals:

At its heart a bipolar junction (BJT) transistor consists of two pn junctions (see **Fig. 1**) which can each individually act as diodes. These diodes can be tested just like any other diode. In particular, they can be tested with most multimeters. If both diodes test OK, and you measure no conductivity between the collector and emitter, then the transistor is almost always OK as well. This is a quick and dirty way to test a transistor and a good way to determine some important information about an unknown bipolar junction transistor.

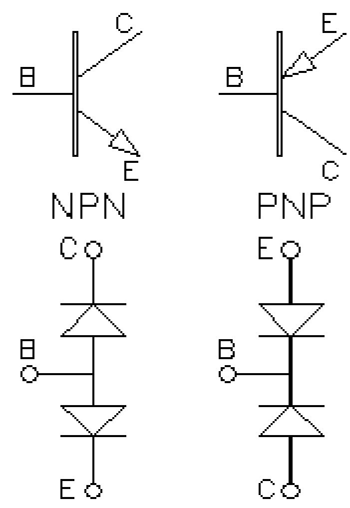


Fig. 1

Meter Diode Setting:

Recall from an earlier lab that most multimeters do not use enough voltage in the regular ohmmeter setting to forward bias a diode, so they give you a special setting to test diodes. If you don't use the special setting then the meter may show little or no conduction for either diode direction. Look for a diode symbol on your meter and set the meter to that position (it's a blue shift setting on the HP meter).

To Measure Input Resistance:

Add a resistor (R_{test}) between the source and the circuit input (as shown in **Fig. 2**). Measure the ac signal voltage on both sides of R_{test} using the scope (peak-to-peak is alright).

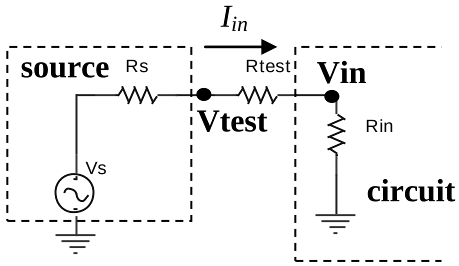


Fig. 2

R_{in} is the value you are trying to find.
To find R_{in}, use **Formula 1.0.**

Formula 1.0

$$I_{in} = \frac{V_{test} - V_{in}}{R_{test}} \qquad R_{in} = \frac{V_{in}}{I_{in}}$$

IMPORTANT: *Be sure to measure AC signal voltages (peak-to-peak is alright).*

To Measure Output Resistance:

Measure the signal voltage output without R_L. This is the *open-circuit* output (V_{TH}). Remember that the open circuit voltage relates directly to the Thévenin voltage of a Thévenin equivalent circuit.

Reconnect R_L and measure the loaded output (V_L). Use these two measurements to calculate the output resistance (R_o) of this amplifier, using **Formula 1.1**.

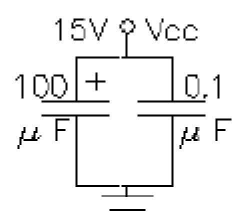
Formula 1.1

$$R_o = \frac{V_{TH} - V_L}{V_L} \cdot R_L$$

IMPORTANT: *Be sure to measure AC signal voltages (peak-to-peak is alright).*

Circuit Noise Problems:

Circuit noise can manifest itself in a variety of irritating ways. Sometimes it's just fuzz on the scope that does little more than mess up the scope's peak-to-peak voltage measurements, forcing you to take them manually. Sometimes noise problems can be so severe that even DC voltmeter readings become weird. Just connecting the meter's leads may cause the noise (check with the scope). Usually capacitors are the solution to noise problems.



In **Lab #2** (the Op Amp Lab), you placed some filter capacitors across the power supply right on the breadboard. That's a good idea for all the circuits that you build, especially those with high gain factors. A 100 µF electrolytic or tantalum in parallel with a 0.1 or 1 µ F low-inductance ceramic disk is a good start. Shorten or eliminate all the leads that you can. This may mean the removal of measuring leads or substitution boxes. If you still have problems, you may have to place some small ceramic disk caps right in your circuit, from a noisy spot to ground. Be careful, though, this can seriously affect your circuit's frequency response.

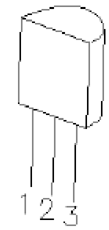
IMPORTANT: *Remember to compensate your 10x probes before using them to make frequency dependent measurements.*

EXPERIMENT 1 TRANSISTOR DIODE TEST: (30 pts)

Procedure:

1. (30 pts) Multimeter transistor test

(1a) Set your multimeter or ohmmeter to its diode test setting. Make a sketch of the transistor showing the leads as 1, 2, & 3, and a small table like **Fig. 3**.



RED +	BLK −	Meter Shows Conduction?
1	2	
1	3	
2	3	
2	1	
3	1	
3	2	

Fig. 3

(1b) Measure the conductivity all six ways and record the meter readings in your table. The meter should only indicate significant conductivity in two of the six cases. The common lead to those two cases is the base.

- Determine which lead is the base. Determine from your data if the transistor is an NPN (base is + lead in both cases) or a PNP (base is - lead in both cases). Also, your lowest meter reading will often indicate the base/collector junction, and thus which lead is the collector.

(1c) Look at the data sheet for this transistor to see if you were correct.

(1d) Comment in your notebook about the usefulness of this procedure. (Note that h_{FE} is similar to β)

EXPERIMENT 2 BASIC OPERATION OF BJT: (70 pts)

Procedure:

1. (10 pts) Connect the circuit at the right.

(1a) Measure all currents and voltages and compare these values to your theoretical values. Explain any differences.

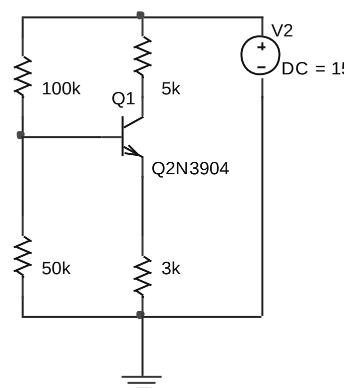


Fig 4.

2. (60 pts) Replace the 50k resistor with a potentiometer.

(2a) Turn the potentiometer to a value that puts the transistor well into the active region (above the threshold pts between saturation and active (close to 50 k).

- Place a capacitor in parallel to the 3k resistor at the source.

- Apply an input signal (A value in the mVpp amplitude range, 1kHz frequency) coupled through a capacitor at the gate. Any capacitor above 1microF is acceptable. *(Note: A voltage divider with the function generator as the source can be used to reduce the amplitude of the sinusoidal input)*

  - (15 pts) Measure the signal seen at the collector. Explain what you see and why it looks like it does.

(2b) (25 pts) Measure the input and output resistance. Compare these results to the hand analysis.

(2c) (20 pts) Measure the circuit to find the low frequency pole locations and compare to hand analysis.