ECE 2201 – PRELAB 5B

BIPOLAR JUNCTION TRANSISTOR (BJT) FUNDAMENTALS

P1. **β Meter**

The circuit of Figure P5-1 can be used to measure the current gain β of the BJT. Determine values for resistors R1 and R2 to meet the following conditions:

- The base current $I_B \approx 10\mu A$ (choose R1 as the closest standard value from your lab kit)
- The voltage drop across R2, expressed in mV, gives the BJT current gain β. That is,

$$V_{DVM} = (1mV) \cdot \beta$$

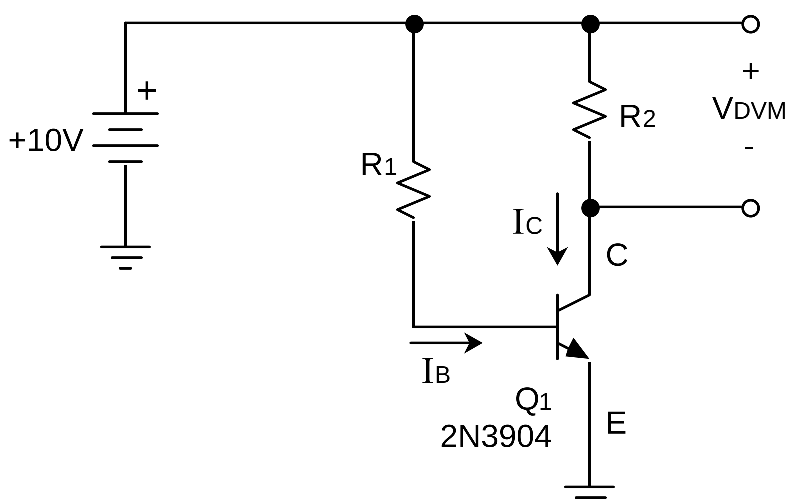


Figure P5-1.

NOTE: Originally written by Prof. J. McNeill
Modified by S. J. Bitar

ECE 2201 – LAB 5B

BIPOLAR JUNCTION TRANSISTOR (BJT)
FUNDAMENTALS AND APPLICATIONS

PURPOSE:

The purpose of this laboratory assignment is to investigate the NPN bipolar junction transistor (BJT). Upon completion of this lab you should be able to:

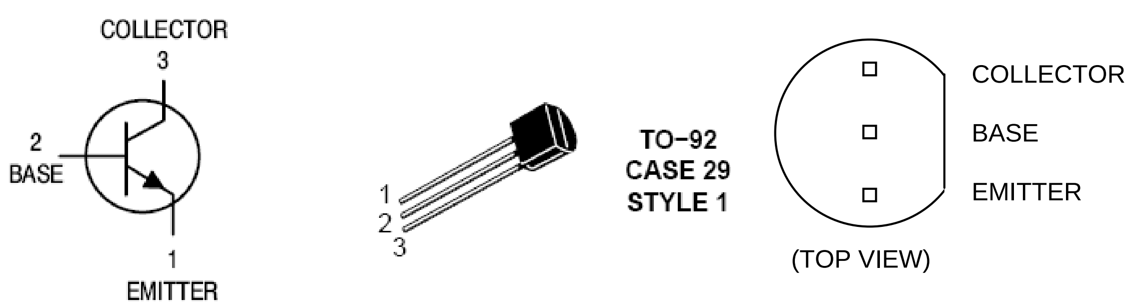
- Measure the current gain β of the BJT.
- Extract BJT parameter I_S from v_{BE}-i_C measurements.

MATERIALS:

- ECE Lab Kit
- DC Power Supply
- DMM
- Function Generator
- Oscilloscope

NOTE: Be sure to record ALL results in your laboratory notebook.

2N3904 BJT terminal designation reminder:



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BIPOLAR JUNCTION TRANSISTOR (BJT): i_C-v_{BE} CHARACTERISTIC

L1. Build the BJT circuit shown in Fig. 5B-1, using the 2N3904 NPN BJT. By using different values for resistors R_B and R_C, you will measure the base current i_B, collector current i_C, and base-emitter voltage v_{BE} over a range of DC collector currents. BE SURE TO measure the actual voltage of the +10V power supply for V_{CC}.

Note: Capacitors C_{BP1} and C_{BP2} are open at DC, and don't affect your measurements of DC current or voltage. Their purpose is to filter out high frequency noise that can be coupled into this (high gain) circuit when measurements are being made.

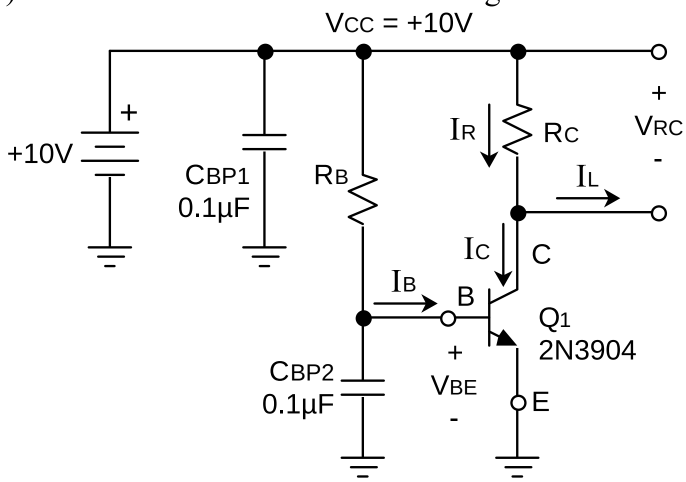

Figure 5B-1.

L2. Vary R_B and R_C using the range of values shown in the table below. For each set of values, measure V_{BE} and V_{RC}. Calculate I_B and I_C and β using:

(1) $I_B = V_{RB}/R_B$ (2) $I_C = (V_{RC})/R_C$ (3) $\beta = I_C/I_B$

Note that Eq. (2) assumes I_L is negligible, so that $I_C \approx I_R$.

Nominal		Actual (Measured)		Measured		Calculated		
R_B	R_C	R_B	R_C	V_{RB}	V_{RC}	I_B	I_C	β
43 kΩ	* 25 Ω							
100 kΩ	51 Ω							
200 kΩ	100 Ω							
430 kΩ	200 Ω							
1 MΩ	510 Ω							

* for 25Ω, use two 51Ω in parallel.

NOTE: TRANSISTOR BETA IS GREATLY AFFECTED BY TEMPERATURE. THEREFORE, MAKE YOUR MEASUREMENTS QUICKLY AND DISCONNECT THE POWER SUPPLY BETWEEN MEASUREMENTS, BEFORE THE TRANSISTOR WARMS UP, SIGNIFICANTLY.

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β Meter

L3. Modify the circuit of Figure 5B-1 by changing the values of R_B and R_C to implement your β meter design from the prelab.

TRIMMING

For the resistor value that is not standard, you will need to trim to an exact value by using series and parallel combination of resistors in your kit. Since you know from your results in part L2 what the correct value of β is, you can start calibration of your β meter circuit by making the collector resistor a few percent higher than the "exact" value. This will give a β reading on the DVM higher than the correct β. Then you can adjust (trim) by adding resistance in parallel to reduce the total collector resistance until the correct β is displayed.

Trimming hint: it can be shown that (for large x), if a resistor of value R needs to be reduced to a value (1 - 1/x)R, this can be achieved by adding a resistor of value xR in parallel. For example, to reduce a resistor value R by 5%, add a resistor of value 20R in parallel. You can do the same thing with a series trim, but inserting resistors in series requires you to break connections – not easy to do on a printed circuit board in a production environment!

An additional advantage to trimming from the output is that you will also take into account the effect of tolerance errors on the value of R_B, as well as variations in V_{BE} away from the 0.7V value assumed in the prelab.

L4. Compare the performance of your trimmed circuit to the measurements from part L2. How do the resistor values you used in lab compare to the design values from prelab?

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LAB WRITEUP

β MEASUREMENTS

W1. Plot i_C as a function of v_{BE} on a semilog scale. Determine the scale current parameter I_S (assume n=1), and plot the prediction of the $i_C \cong I_S e^{v_{BE}/nV_T}$ model on the same axes as your data. How well does the model agree with your data?

W2. Plot your calculated β as a function of I_C. How constant is the "constant" β? Over the current range for which you took measured data, what (constant) value for β would you use, and how much error would you make in assuming β constant?

β Meter

W3. Compare the performance of your trimmed circuit to the measurements from part L2. How do the resistor values you used in lab compare to the design values from prelab?

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