Name: *Roll#*

Laboratory Assignment 5

Transistor I-V characteristics

Marks **A:** /6 **B:** /4 **C:** /5 **Tot=** **/10**

Goal:

In this assignment we will apply some of the techniques learnt in Assignment 4 to determine the IV characteristics of an NPN BJT transistor in Active Mode. Our aim is to determine the Voltage/Current (V_{CE} /I_C) relationship while manually controlling the current input to the base I_B

Part A: Setup Transistor in Active Mode for I-V characterization

Suggested times: Part A: 90 min, Part B: 40 min

Fig (1) shows the circuit symbol for an NPN transistor, and a function generator. Applying the techniques you learnt when determining I/V characteristics of a diode, complete and design the rest of the circuit to measure the transistor characteristics. Our aim is:

1) Setup the circuit such that the transistor is in active mode: B-E junction forward biased and CB junction reverse biased.
2) To determine the variation of I_C as a function of the Collector to Emitter voltage V_{CE}
3) To measure the gain $\beta = I_C/I_B$ - ratio of the collector current to base current for a few chosen values of I_B. β is called the current gain of the transistor.

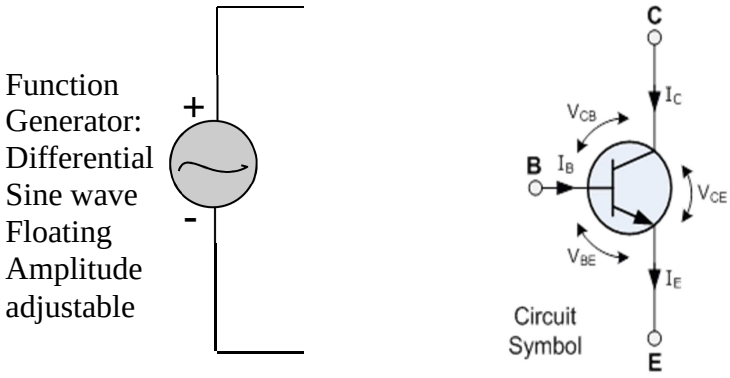

Fig 1: NPN Transistor characteristics (Note that extra components are be needed)

Note:

1. Transistors are very sensitive to the quantity of current at terminals –
   Typical values of I_B are ~ *10's of* μ*A* and I_C values are ~ *10's of mA. Choose your component values accordingly!*
2. As in the circuit for I-V characteristics of a diode, you will need to use the *differential signal* over the three-pin XLR connector (thick red cable) from the back panel.
3. You must make sure to *not* apply very large amplitude of input voltage. In the negative polarity of the input voltage, both PN junctions in the transistor will be in reverse bias. This is bad for the transistor's health.

Part A) Complete the circuit of Fig 1 with required connections & components 6 marks

a) You will need an adjustable power supply to put the BE junction in forward bias. Use a suitable current limiting resistor to restrict I_B to less than 50 μA
b) Recall the connections for R_{ref} and a part *X* to determine the I-V characteristics of part *X* that we used for determining the I-V characteristics of a diode. With the base independently controlled, the C and E connections of the transistor effectively make it a two terminal device.
c) Your circuit diagram must indicate clearly where the DSO probes for channel 1, channel 2 and ground will be attached, and which channel will have to be inverted when making the observations in the DSO's X-Y display mode.

Draw your diagram here and get it examined before making the connections:

Part B) Measurement I_C v/s V_{CE} characteristics 4 marks

Wire up the circuit of Part A. Measure and draw the I-V characteristic observed on the DSO here.

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Measure the I-V curves for a few select values of I_B. The ratio of I_C measured in the flat part of the characteristic to the corresponding set value of I_B gives the current gain of the device: $\beta = I_C/I_B$
Record the β values obtained here:

Part C) Resolution of peculiar features in I_C-V_{CE} characeteristic

A textbook diagram of the I_C-V_{CE} characteristic would indicate a smooth rising of the I-V curve as I_B increases.
In your circuit as setup in Part A, you will (likely) observe a truncated characteristic in Part B: For large values of I_B the characteristic does not reach the flat part of the active region.

I) Figure out the reason why this occurs: **2 marks**

II) Devise a method of fixing the problem.
Revise your circuit diagram of Part A and draw it here.
Redo your measurement for large values of I_B to demonstrate that your fix works
3 marks

Hint: This requires just adding one active component to the circuit and changing the probe connection point for one of the channels.

Homework for next time: Read up on setting up an NPN transistor at the correct operating point
http://www.allaboutcircuits.com/worksheets/bjtbias.html