**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 (*VCE /IC*) relationship while manually controlling the current input to the base *IB*

**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 *IC* as a function of the Collector to Emitter voltage *VCE*
3. To measure the gain β *= IC/IB* - ratio of the collector current to base current for a few chosen values of *IB*. β is called the current gain of the transistor.

Note:

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

Function

Generator:

Differential

Sine wave

*voltage*

Amplitude

**+**

**-**

1. Transistors are very sensitive to the quantity of current at terminals –
Typical values of *IB* are ~ *10's of μA* and *IC* 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.

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

1. You will need an adjustable power supply to put the BE junction in forwardbias. Use a suitable current limiting resistor to restrict *I­B* to less than 100 μA
2. Recall the connections for *Rref* 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.
3. 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:**

R1

R2

Function Generator

Differential
Floating

X

Y

 *R1 chosen to limit current through transistor*

 *R1 ~ 1 kΩ*

*R2 ~ 100 kΩ and variable DC power supply*

*Channel X must be inverted.*

 0

DC power supply floating

**Part B) Measurement IC v/s VCE characteristics**Wire up the circuit of Part A. Measure and draw the I-V characteristic observed on the DSO here.

IC

*As IB is increased,*

*trace rises.*

*Sufficient to measure
~ 4 traces and take IC in the flat part*

VCE

In particular, make one measurement of the I-V characteristic with *IB* set close to zero (~ 2μA).
 This corresponds to the transistor in the cut-off (OFF) state as we found in the assignment last week when using the transistor as a switch.

Measure the I-V curves for a few select values of *IB.* The ratio of *IC* measured in the flat part of the characteristic to the corresponding set value of *IB* gives the current gain of the device: β *= IC/IB*

Record the βvalues obtained here:

**Part C) Resolution of peculiar features in IC-VCE characeteristic**A textbook diagram of the IC-VCE characteristic would indicate a smooth rising of the I-V curve as *IB* increases.

In your circuit as setup in Part A, you will (likely) observe a truncated characteristic in Part B: For large values of *VCE* the characteristic does not reach the flat part of the active region.

1. Figure out the reason why this occurs: **2 marks***Let us call the applied Function Generator signal amplitude VCC* *A) For large IB, IC is large. So voltage drop across RC is large
 i.e. a large part of VCC is dropped as ICRC across RC and only a small
 portion appears across the CE of BJT**B) VCC**swings in polarity and goes large negative. So we are
 restricted from making VCC amplitude too large.*
2. 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 *IB*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.*

R1

R2

Function Generator

Differential
Floating

X

Y

0

DC power supply floating

*Adding a diode as shown to positive rectify VCC saves us from applying large negative VCC to the BJT and releasing its magic smoke. Now we can increase amplitude of VCC from the function generator and recover the truncated part of the characteristic measured in Part B.
Note that probe position Y has shifted to R1 – don’t want to include diode characteristic!*

*Homework for next time: Read up on setting up an NPN transistor at the correct operating point*

<http://www.allaboutcircuits.com/worksheets/bjtbias.html>