MSS Lab **Part A: Lumped Element Simulation (Saber)** **Exercise 3: Basic transistor investigations**		Prof. Dr.-Ing. G.Schmitz **Flugzeug- Elektrik und Elektronik**
Last Name	First Name	Matr.-Nr.
Date	Confirmation (Testat)	

1 Introduction

In this lab we want to get familiar with characteristic curves of transistors and some basic circuits with and without mechanical components. During this lab we also want to learn the basics of plotting x-y diagrams and making calculations with the curves.

2 Execution of the exercises

In the exercise you will first design a simple transistor circuit and analyze it using the “Transient Analysis Function”. After this you will try to design basic circuits for switching and amplification..

2.1 Simulation of a basic transistor circuit

First use a BC237 transistor for a simulation of a simple circuit where the emitter of the transistor is connected to ground, the base is connected via a resistor of 10kΩ to a PWL-Voltage source, and the collector is connected via a 100Ω resistor to a 20V constant voltage source. Now set the PWL that you get a voltage rising linearly from 0V to 10V in a time period of 10 seconds.

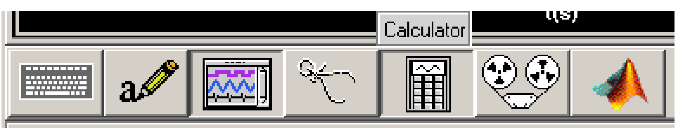
2.1.1 Start the transient analysis and calculate the current gain

Use the settings “End-Time = 10” and "Time Step = 0.1m”. Now the current is important, too. So don’t forget to select “all variables” as output”

What is the result? Try to calculate the current gain B for a base current of 500µA!

2.1.2 Use the calculator for displaying the result for B versus the time

To use the calculator first invoke it from the menu bar below the graph:

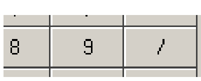


Then copy the curve of the collector current to the clipboard. Use the menu-bar (Edit->Copy) since CRTL-C doesn’t work (most of the time).

Paste it into the calculator also using the menu-bar of the calculator:

Do the same with the curve for the base current.

Then divide the curves simply by pressing the “/” sign at the calculator:



Then you have the quotient of all data points in the calculator. To display it you have to click onto the curve symbol below the menu bar of the calculator:

Now you should get a new curve in the plot area.

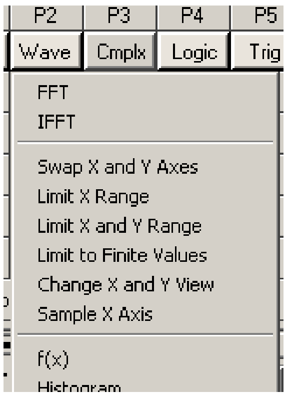
2.1.3 Display the Collector current versus the Base current

Again copy the curve of the collector current to the clipboard. Use the menu-bar (Edit->Copy) since CRTL-C doesn't work (most of the time).

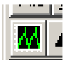
Paste it into the calculator also using the menu-bar of the calculator:

Do the same with the curve for the base current.

Then click to the "Wave"- Button and chose the entry f(x):

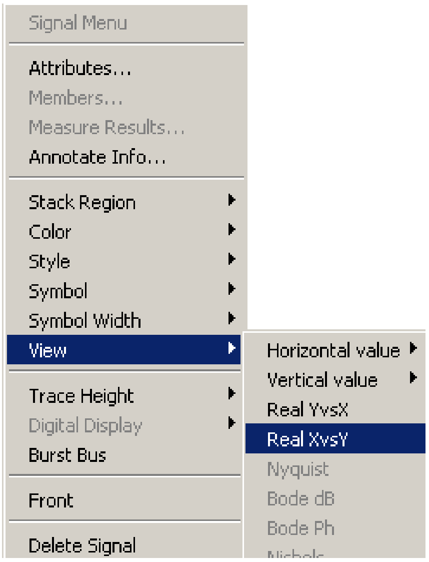


Then you have x-y pairs of all data points in the calculator. To display it you have to click onto the curve symbol below the menu bar of the calculator:



Now you should get a new curve in the plot area.

Note: If you have done the copying and pasting in the wrong sequence, you will have a curve with exchanged axes and you see the Base current versus the Collector current. To correct this there is no need to redo all the steps in the correct order. Instead you can use a function of the menu for the curves. By right click to the signal name of the y-axis you will get a drop down menu where you can choose the other kind of display X vs Y:



2.1.4 Display the Input charactertistic

Now find a possibility for displaying the characteristic input Curve, where the Base current is diplayed versus the Input Voltag of the Transistor V_{BE}.

2.2 Display of characteristic curves

For the next simulations you should modify the design: Connect the Collector of the transistor directly to a new PWL-Voltage source (replace the resistor at the collector as well as the constant voltage supply by the PWL-source). You can use a setting where a voltage is rising from 0 to 40V in a time period of 10s.

2.2.1 Display one curve of the Output characteristic for the transistor

Now connect the Base of the Transistor to a Current source. Now you can start a simulation with a base current of 10uA. Display a curve where the Collector Current I_C is displayed versus the Collector Emitter Voltage V_{CE} of the transistor.

2.2.2 Display an array of curves of the Output characteristic for the transistor

Find out a solution for displaying an array of curves for the output characteristic with the Base current as a parameter.

2.2.3 Display the characteristic curves for input, gain and output characteristics (array) for a Darlington Transistor

Amend the circuit with another BC237 Transistor yielding a Darlington circuit. Now find the current gain B as numerical value, plot reasonable curves for the input characteristic, the current gain (I_C versus I_B) and the array of curves for the output diagram. (*Pay attention to the maximum collector current of the transistor I_{Cmax} = 100mA!*) What happens to the minimum V_{CE} where the transistor “opens”?

2.2.4 Display the characteristic curves for a MOSFET

Now think about reasonable experiments for the investigation of a MOSFET transistor and perform those investigations with the BSN20 MOSFET.