School of Electronic &
Electrical Engineering
FACULTY OF ENGINEERING

UNIVERSITY OF LEEDS

ELEC5333M

Lab Notes and Exercises

Lab 5: Non-linear Effects and FEM Simulation

Non-Linear Effects

1. Background

Many active components, such as amplifiers and mixers, are often important in radio frequency engineering. However often they can introduce distortation problems, meaning the output signal is not directly proportional to the input signal. You have seen this in the frequency domain in Laboratory two with intermodulation products, this week we are going to investigate distortation in the time-domain.

2. Exercises

Exercise 1:

For the circuit below:

- Perform DC and AC analysis, as in previous Lab. Calculate Base Current IB, Collector Current IC and Emitter Current IE and Voltage gain Av.
- Design and simulate the circuit below in ADS.
- Plot the transient input and output voltages, vary the amplitude of the input signal until the signal distortion is observed, record these two cases. (use tuning tool)
- Plot automatically all values by using **ParamSweep** Component. Set the start value to 0.1V, with a step of 0.2V and stop value to 2V.
- Explain why the signal is distorted and how this would create intermodulation products and higher frequency harmonics.

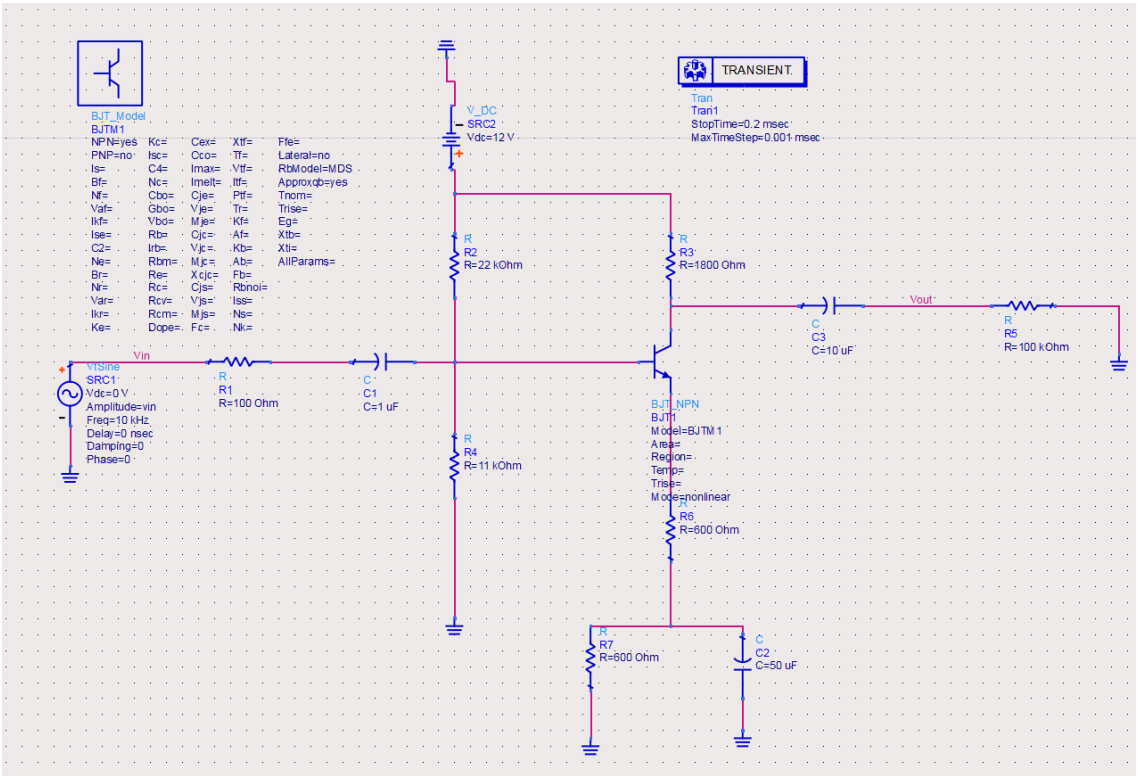

Figure 1 ADS Exercise 1.1 BJT configuration

FEM Simulation

1. Background

Microstrip antennas are increasingly in use in the mobile phone industry due to their relatively low production cost and simple fabrication processing.

A patch or microstrip antenna is comprised of a feedline connected to a radiating patch on one side of a dielectric. The other side of the dielectric contains a grounding plane. The radiating patch can be any arbitrary 2D shape, for this lab we will be using a simple rectangular shape

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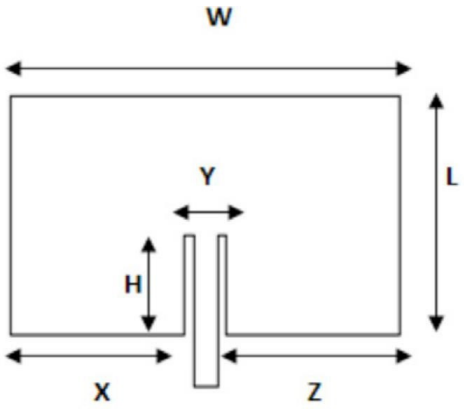
Figure 2. Rectangular patch antenna design



The design equations are as follows:

$$W = L = \frac{c}{2f_r\sqrt{\varepsilon_r}}$$

$$H = 0.822 \times L/2$$

$$Y = W/5$$

$$X = Z = 2W/5$$

The characteristics of the FR4 substrate are as follows:

- Height: h = 1.6 mm
- Metal thickness: t = 0.7 mil
- Metal conductivity: σ = 5.7 x 10^7 S/m
- Relative permittivity: $\varepsilon_{r=}$ 4.6
- Loss tangent: Tanδ = 0.001
- Length of feed line: 20 mm
- Width of feed line = 3.00 mm

2. Exercises

Exercise 2.1:
Use the above design equations and characteristics to calculate the physical dimensions of the patch antenna with a resonant frequency (f_r) of 2.4 GHz.

Exercise 2.2:
Using the parameters of the microstrip create the patch antenna geometry in a layout cell in ADS layout cell to verify your calculations. Display S_{11} (dB and phase) against frequency and the antenna radiation pattern at the resonant frequency. Can you explain your results?

Instructions:

1. **First** in the ADS main window open **Options->Technology->Technology Setup…** and ensure "millimetre" is selected in the units. **This must be done before opening a new layout.**
2. In the ADS main window open a new layout cell by selecting **File->New->Layout**
3. Draw out the patch antenna by selecting **Insert->Polygon**, and **Insert->Coordinate Entry**
4. Insert the patch antenna corner coordinates by clicking apply to draw out the patch antenna (it is easier to calculate the coordinates of the corners of your patch antenna before doing this)
5. Insert a pin onto the centre of your feed line. **Insert->Pin**
6. Modify the substrate and conducting material by selecting **EM->Substrate…** click New to accept the alumina template. Click on the dielectric material and modify the properties to our design. Do the same for the top and bottom conductor.
7. Set the simulation frequency range. **EM->Simulate setup…** Add an adaptive frequency plan over an apropriate frequency sweep to simulate over. In addition to this also add a single frequency plan at 2.4 GHz. Click simulate when you are ready to view S_{11}
8. To view the antenna radiation pattern select **EM->Post processing->Far field…** Select the resonant frequency in **Solution Setup** on the bottom tab. You can view the antenna radiation patern in **Plot Properties**

See the video tutorial on the VLE for more help. **Please note the the patch antenna parameters in this video are just an example and are different from the specifications in this lab.**