Assignment 1

ELG7132D

Topics in Electronics I: Simulation of Radio Frequency Circuits

September 13, 2017

Part (a)

Description of the Assignment

The objective of this assignment is to make the students familiar with the HiSPICE-Matlab interface as a tool to used to extract the circuit mathmatical structures. This is done through executing simple commands to access the mathematical constructs describing a given circuit.

Part (b)

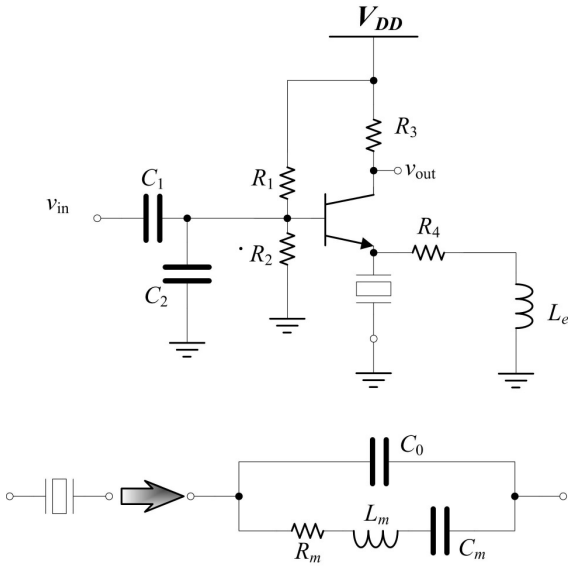

Figure 1: The circuit shcematic

Main Steps

Consider the circuit shown in Figure 1 where the crystal is modelled using the circuit shown in the same figure.[I]

(a) With the help of the netlist file deduce the equivalent circuit model used for the BJT device.

(b) Draw a shcematic for the entire circuit after replacing the BJT and the crystal with their equivalent circuit models. You must use a circuit drawing software (VISIO is recommended).

[I] A netlist file describing the above circuit will be uploaded and made available at BBL.

(c) Count the the total number of circuit unknowns (nodes voltages and currents in special elements, e.g., inductors) and make sure that this number is the same as the number of MNA variables returned from HiSPICE (`MNA_Size`).

(d) Label the nodes on the schematic according to the following instructions.

(i) Nodes labels must be the same labels used in the circuit netlist file.

(ii) Nodes which are internal nodes in the model describing the BJT device or the crystal should be labelled according to the hierarchy of the circuit.

Example: The circuit netlist file includes the following line to describe the Crystal oscillator.

```
xCrystal a1 gnd xtal
```

Where `xCrystal` is defined as an instance of the macro `xtal` described by the following subcircuit.

```
.subckt xtal nA nB
Rm nA nC 120
Cm C1 nB 0.165786399f
Co nA nB 5p
Lm nC C1 6.1115498
.ends
```

It should be obvious that the equivalent circuit model of the crystal includes two internal nodes (`nC` and `C1`) that are not connected to elements at the top-level circuit. Those nodes are typically given special labels by the HiSPICE simulator, which is derived from the instance name (in this case it is `xCrystal`) and the internal node name (in this case `nC` or `C1`) separated by a dot ($\cdot$). This is the labeling scheme that you will have to follow in order to compare your results with HiSPICE. Thus, the nodes labels for the internal nodes inside the crystal should be `xCrystal.nC` and `xCrystal.C1`, respectively.

(e) Label, on the same schematic above, the extra MNA variables used on top of the nodes voltages in the MNA formulation, e.g., currents in independent voltage sources.

(f) Use the HiSPICE Matlab interface to obtain the integer indices assigned to each node and each extra MNA variable.

(g) Write down the MNA formulation mathematical structures, i.e., the matrices $\boldsymbol{G}$, $\boldsymbol{C}$, the nonlinear function vector $\boldsymbol{f}(\boldsymbol{x}(t))$, the source vector $\boldsymbol{b}(t)$ and the vector of unknowns $\boldsymbol{x}(t)$ for the entire circuit.

Part (c)

Submission Instructions

You are required to submit **only one PDF** file that includes the following.

(a) A circuit schematic showing the entire *flattened* circuit, i.e., the circuit where the BJT device and crystal are both replaced by their equivalent circuit models. The nodes on the schematic must all be labelled clearly and following the scheme described above.

(b) A table showing the nodes labels along with the integer number assigned to the node using HiSPICE. For example,

Table 1: An example of the required table.

Node Label	Index Number assigned by HiSPICE
`nVin`	1
`ndd`	4
⋮	⋮

(c) A table similar to the above showing the extra variables along with the values of integer indices assigned to them.

(d) The MNA formulation mathematical structures, i.e., the matrices $\boldsymbol{G}$, $\boldsymbol{C}$, the nonlinear function vector $\boldsymbol{f}(\boldsymbol{x}(t))$, the source vector $\boldsymbol{b}(t)$ and the vector of unknowns $\boldsymbol{x}(t)$ written in a clear format. The ordering of the unknowns MUST be the same ordering used by HiSPICE and listed in the above two tables.

The file must be typed using a word processor, preferable format is LaTeX. No hand-written or scanned submission will be accepted.