# EE2703 - Applied Programming Lab
# Assignment-2: Spice Simulation

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## 1 Introduction

In this assignment, our goal was to solve purely resistive circuits with independent current and voltage sources, using KVL and KCL equations, with the help of matrix libraries like numpy.

## 2 Problem Description

We have a circuit file (.ckt), that follows the spice convention, of .circuit and .end tags, that encloses a description of the circuit. We are required to read this circuit, and parse the different components, and store them in a list of dictionaries.
We are then supposed to put the KCL and KVL equations into the matrix form. We are required to solve for the currents through the voltage sources and voltages at different nodes. At the ground we make the assumption of voltage being 0

## 3 Solution

When parsing the .ckt file, we create a list of all variables that needs to be found(variable vector V), this will help us index, the rows and columns of the matrix, to the variables defined in the .ckt file.
One thing to notice, about these circuits is that they all are reciprocal, that is, in the Z matrix, which contains the coefficients of the equations, $Z_{ij} = Z_{ji}$, for $i \neq j$. This was taught as a part of our EE2015: Electric circuits and Networks course.
This fact can be used to generate a upper triangular matrix, and later copy those values to the lower half.

The general form of the solution can be written as:

$$Z * V = B$$

where,
$V$ is the matrix that contains all variables
$Z$ is the matrix with all the coefficients
$B$ is the matrix with the RHS value in the different KCL and KVL equations

After Setting up the above equations, we can solve, for the different variables, by simply finding $Z^{-1}$ and multiplying on both sides of the equation.

In case, we cannot find the inverse, that will mean, no unique solution to the circuit exists.
In the process of finding the equations, the following assumptions regarding the direction of current and voltage sources were made:

**1.** The positive terminal of the voltage source is attached to the first node.

**2.** Current in a voltage source flowing from positive to the negative terminal is considered as +ve.

**3.** In a current source, we assume the current to be flowing from the first node to the second node.

**4.** The first node refers to the node that comes first when parsing the .ckt file

# 4 Edge Cases I tried the solver with

## 4.1 When there is a voltage source that is not connected to the ground on both ends

A case like this was NOT a part of the test cases given to us.

```
.circuit
    R1   2 GND 1
    V1   1 GND dc 4
    V2   1 2 dc 3
.end
```

## 4.2 When there is no unique solution possible, although circuit is valid

Here we can expect multiple values of currents through the voltage sources, so our solver must again return a ValueError.

```
.circuit
    V1   1 GND dc 3
    V2   GND 1 dc 3
.end
```

### 4.3 When the current source is just connected to two nodes

In such a case, the current simply flows to the nodes and accumulation of charge occurs.

```
.circuit
    I1 1 GND dc 1
.end
```

### 4.4 When the circuit does not end in a loop

In such a case, we must make sure, that the currents through the wires are 0, since, charge must NOT accumulate at the nodes.

```
.circuit
    R1 n1 GND 1
    R2 n2 n1 2
    R3 n2 n1 3
    V1 n3 n2 dc 1
.end
```

## 5 References


**1.** Some discussions with my classmates: EE23B045 (Mayank S), EE23B030 (Karthik K), EE23B047(Navin K), EE23B058(Pratyaksh J) were very helpful.

**2.** `https://www.overleaf.com/` was used to create the LATEX document

**3.** `https://ngspice.sourceforge.io/` was the primary site with info about spice

**4.** `https://claude.ai/new` an excellent code assistant, particularly when confused about the syntax

**5.** `https://stackoverflow.com/` the site to solve all programming doubts

**6.** Our EE2015:Electric Circuits and Networks, covered quite a bit of material that is useful for this assignment.