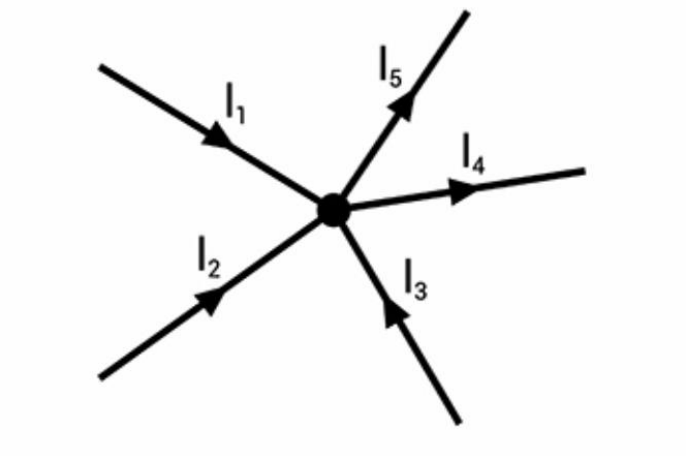
EE105: Introduction to Electrical Engineering

Module 1 Circuit Analysis

Objective:

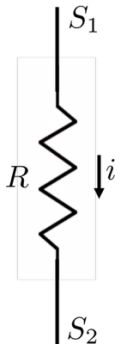
In this lab, we will systematically analyze the circuits in Module 1 by applying Kirchhoff's Current Law and Ohm's Voltage Law. We will assign variables to voltages at each node and currents through each resistor, then formulate KCL and Ohm's law as a linear system of equations. Then, we will solve this system using Python's symbolic computation toolbox to obtain exact solutions.

Kirchhoff's Current Law (KCL): The algebraic sum of all currents entering and leaving a node (junction) in a circuit equals zero.



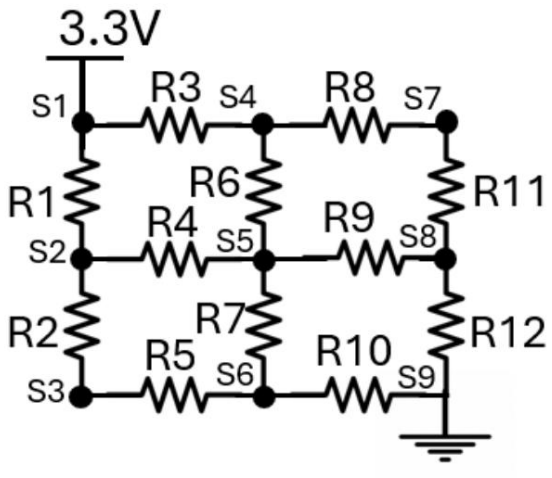
$I_1 + I_2 + I_3 = I_4 + I_5$

Ohm's Voltage Law: The voltage across a resistor is directly proportional to the current flowing through it.



$$S_1 - S_2 = iR$$

Analysis of Networks on Module 1:



Checkpoint1: Write Kirchhoff's Current Law (KCL) equations
it = i1 + i3
...

Checkpoint2: Ohm's Law (Voltage) equations
i1 × r1 = s1 - s2
...

Checkpoint3: Solve these equations using SymPy

```
from sympy import symbols, Eq, solve

# Define the variables
i1, i2, i3, i4, i5, i6, i7, i8, i9, i10, i11, i12, it = symbols(
    'i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12 it'
    )
s1, s2, s3, s4, s5, s6, s7, s8, s9 = symbols('s1 s2 s3 s4 s5 s6 s7 s8 s9')

# assign resistance values
# TODO
# r1, ..., = ...

# Define the equations
# TODO:
# equations = [
#     Eq(it, i1 + i3),
#     ....
# ]

# Substitute s1 = 3.3, s9 = 0
substitutions = {s1: 3.3, s9: 0}

# Solve the system of equations
solution = solve(equations, (i1, i2, i3, i4, i5, i6, i7, i8, i9, i10, i11,
i12, it, s2, s3, s4, s5, s6, s7, s8))

# Substitute the known values
solution_substituted = {k: v.subs(substitutions) for k, v in
solution.items()}
solution_substituted
```

Additional SymPy Syntax:

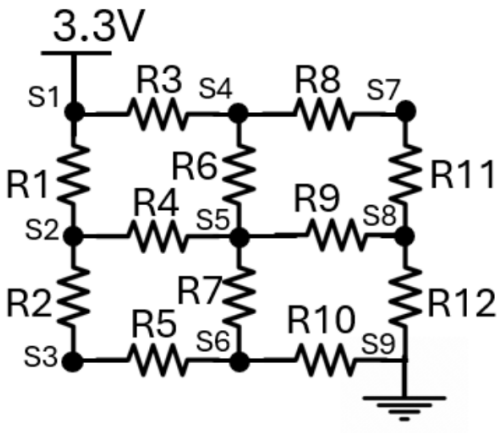
```
Lt(x, y)   # equivalent to x < y  - Less than
Le(x, y)   # equivalent to x <= y - Less than or equal
Gt(x, y)   # equivalent to x > y  - Greater than
Ge(x, y)   # equivalent to x >= y - Greater than or equal
Ne(x, y)   # equivalent to x != y - Not equal
```

Checkpoint4:

a) The first circuit is Network1 of Module1 on your demo board. In the given circuit, calculate the voltage values at each node (S_1 to S_9) , and the current through each branch (I_1 to I_{12}).

$R_1 = R_2 = R_6 = R_7 = R_{11} = R_{12} = 100\Omega$

$R_3 = R_4 = R_5 = R_8 = R_9 = R_{10} = 50\Omega$



b) The second circuit is Network2 of Module1 on your demo board.

In the given circuit, calculate the voltage values at each node (S_1 to S_9) , and the current through each branch (I_1 to I_{12}).

$R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = R_7 = R_8 = R_9 = R_{10} = R_{11} = R_{12} = 100\Omega$