THAKOR PAL

Objective: Coupled nonlinear resistor network

1. Project Overview

This project focuses on determining the operating point (Q-point) of a nonlinear diode circuit using the **Bisection Method** in MATLAB.

The circuit consists of:

- A DC source voltage $V_s = 9V$
- A linear resistor $R_1 = 100\Omega$
- A semiconductor diode modeled using the Shockley diode equation.

Since the diode equation is nonlinear, the operating voltage across the diode cannot be found directly using simple algebra. Therefore, a numerical method (Bisection Method) is used to determine the diode voltage at which:

$$I_R = I_D$$

The program also plots the variation of current with diode voltage.

2. Objective

The main objectives of this project are:

1. To determine the diode voltage using the **Bisection Method**.
2. To find the operating current through the diode and resistor.
3. To solve nonlinear circuit equations numerically.
4. To plot the current variation with respect to diode voltage.
5. To understand numerical techniques for solving engineering problems.

3. Mathematical Formulation

Step 1: Resistor Current Equation

From Ohm's Law:

$$I_R = \frac{V_s - V_D}{R_1}$$

Where:

- $V_s = 9V$
- $R_1 = 100\Omega$
- V_D= Diode voltage

Step 2: Diode Current Equation (Shockley Equation)

$$I_D = I_s\left(e^{\frac{V_D}{V_T}}-1\right)$$

Where:

- $I_s = 10^{-6}A$(Reverse saturation current)
- $V_T = 0.026V$(Thermal voltage at room temperature)

Step 3: Condition for Operating Point

At Q-point:

$$I_R = I_D$$

So,

$$\frac{V_s - V_D}{R_1} = I_s\left(e^{\frac{V_D}{0.026}}-1\right)$$

This equation is nonlinear and cannot be solved directly.
Hence, the **Bisection Method** is used between:

$$V_L = 0.3V, V_U = 0.7V$$

4. Working Principle of Bisection Method

The bisection method:

1. Takes two initial guesses $V_L$and V_U
2. Finds midpoint:

$$V_{mid} = \frac{V_L + V_U}{2}$$

3. Checks whether:

$$I_R > I_D$$

or

$$I_R < I_D$$

4. Replaces the interval accordingly.
5. Repeats until error condition:

$$| V_U - V_L | < 0.01$$

5. Pal Thakor 3rd year Mechanical Engineering Student Computational Engineering Laboratory Project

6.**Project Summary:**This project determines the operating point (Q-point) of a diode-resistor circuit using the Bisection Method in MATLAB. Since the diode equation is nonlinear, a numerical method is used to find the voltage at which resistor current equals diode current. The program calculates the diode voltage, corresponding current, and plots the convergence graph.

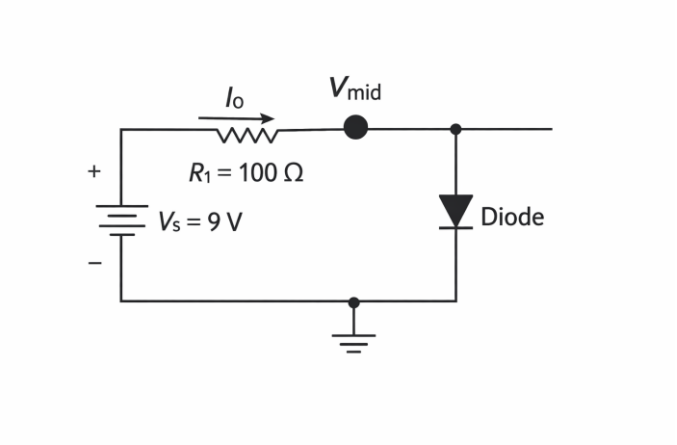

Figure 1:CIRCUIT DIAGRAM

CODE:

```
clc;
clear;
% Source Voltage
Vs = 9;
% Linear Resistance
R1 = 100;   % Ohm
% Diode voltage range for plotting
Vd = linspace(0.3,0.7,50);
% Bisection initial values
Vl = 0.3;
Vu = 0.7;
err = 0.01;
iter = 0;
% Store values for graph
Vmid_values = [];
Io_values = [];

while abs(Vu - Vl) > err
    Vmid = (Vl + Vu) / 2;   % Midpoint voltage
    % Current through resistor
    Ir = (Vs - Vmid)/R1;
```

```
    % Assume simple diode model (Is = 1e-6)
    Is = 1e-6;
    Io = Is*(exp(Vmid/0.026) - 1);

    % Store values
    Vmid_values = [Vmid_values Vmid];
    Io_values = [Io_values Ir];

    % Bisection condition
    if Ir > Io
        Vl = Vmid;
    else
        Vu = Vmid;
    end

    iter = iter + 1;
end

fprintf('resistor current value = %f A\n', Ir);
fprintf('diode current value = %e A\n', Io);

disp(Ir)
disp(Io)

% Plot Graph
figure;
plot(Vmid_values, Io_values,'-o');
xlabel('V_{mid} (Volts)');
ylabel('I_o (Amps)');
title('I_o vs V_{mid}');
grid on;
```

RESULT:

```
Best resistor current value = 0.086938 A
Best diode current value = 1.304622e-01 A
    0.0869

    0.1305
```

GRAPH:

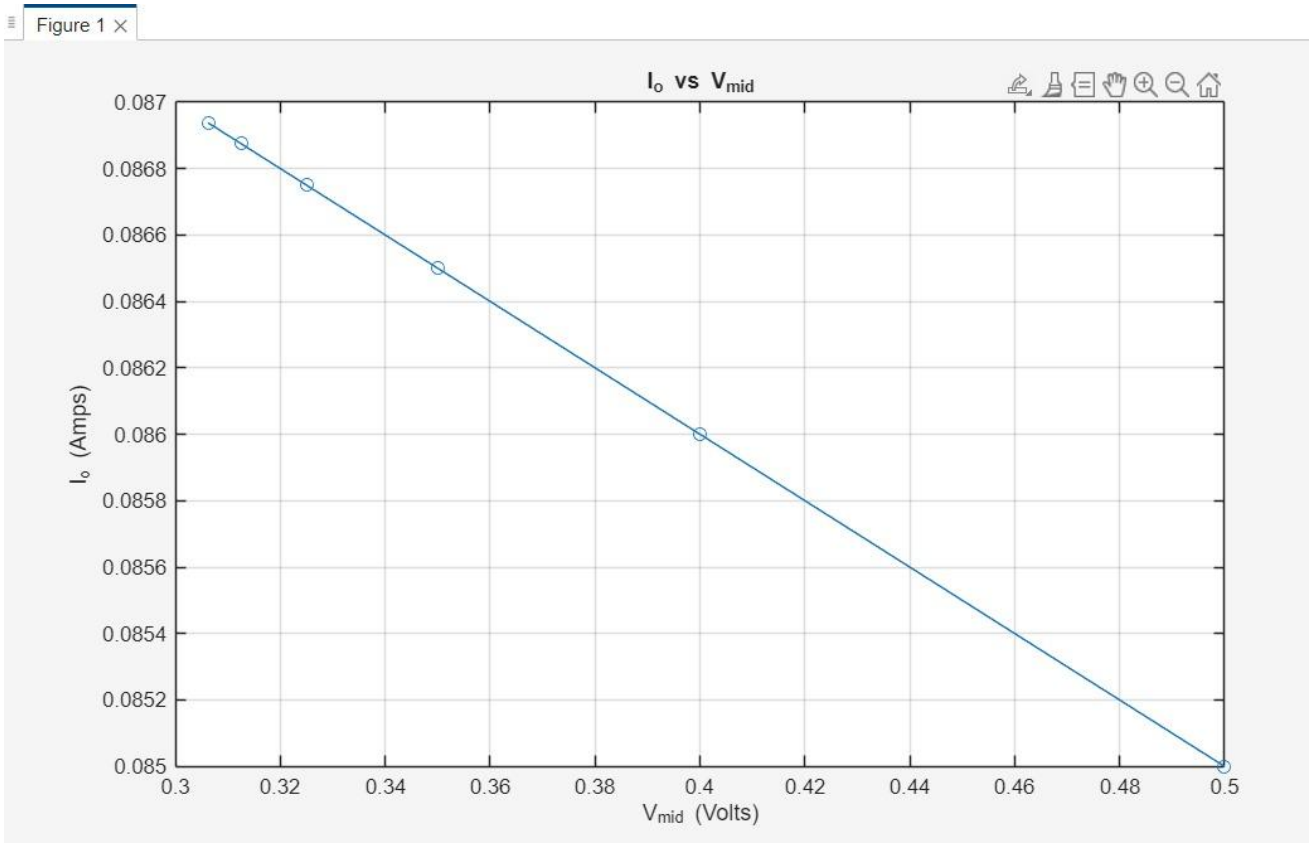
Figure 1
I_o vs V_{mid}
0.087
0.0868
0.0866
0.0864
0.0862
0.086
0.0858
0.0856
0.0854
0.0852
0.085
I_o (Amps)
0.3
0.32
0.34
0.36
0.38
0.4
0.42
0.44
0.46
0.48
0.5
V_{mid} (Volts)