**Power system load flow analysis**

Information:

1. Solve power flow equation(Newton-raphson/Gauss-seida).
2. Inputs:Bus ,line data.
3. Output:Bus voltage,power losses,efficiency.
4. Libraies:numpy,scipy,matplotlib.
5. Applicaton:Transmission line and grid analysis.

**Source code:**

import numpy as np

n = 3

bus\_type = [0, 1, 2]

V\_mag = np.array([1.06, 1.00, 1.00])

V\_ang = np.radians(np.array([0.0, 0.0, 0.0]))

V = V\_mag \* np.exp(1j \* V\_ang)

P\_spec = np.array([0.0, 0.5, -0.6])

Q\_spec = np.array([0.0, 0.0, -0.25])

Y = np.array([

    [10-20j, -5+10j, -5+10j],

    [-5+10j, 10-20j, -5+10j],

    [-5+10j, -5+10j, 10-20j]

], dtype=complex)

tolerance = 1e-6

max\_iter = 100

for iteration in range(max\_iter):

    V\_prev = V.copy()

    for i in range(n):

        if bus\_type[i] == 0:

            continue

        sum\_YV = 0

        for j in range(n):

            if j != i:

                sum\_YV += Y[i, j] \* V[j]

        if bus\_type[i] == 2:

            S = P\_spec[i] + 1j \* Q\_spec[i]

            V[i] = (1 / Y[i, i]) \* ((S / np.conj(V[i])) - sum\_YV)

        elif bus\_type[i] == 1:

            Q\_calc = -np.imag(np.conj(V[i]) \* sum(Y[i, j] \* V[j] for j in range(n)))

            S = P\_spec[i] + 1j \* Q\_calc

            V\_temp = (1 / Y[i, i]) \* ((S / np.conj(V[i])) - sum\_YV)

            V[i] = V\_mag[i] \* np.exp(1j \* np.angle(V\_temp))

    error = np.max(np.abs(V - V\_prev))

    if error < tolerance:

        print(f"\n Power flow converged in {iteration+1} iterations.\n")

        break

else:

    print("\n Did not converge within max iterations.\n")

for i in range(n):

    print(f"Bus {i+1}: |V| = {abs(V[i]):.4f} pu, Angle = {np.degrees(np.angle(V[i])):.4f}°")

**Output:**

Power flow converged in 7 iterations.

Bus 1: |V| = 1.0600 pu, Angle = 0.0000°

Bus 2: |V| = 1.0000 pu, Angle = -0.8631°

Bus 3: |V| = 1.0276 pu, Angle = -1.9890°

**Conclusion:**

The Gauss-Seidel power flow program successfully calculated the voltages and angles for a small 3-bus power system. It updated the bus voltages step-by-step until the results stabilized. The method worked well for this small system, keeping voltage levels fixed where needed. While it’s easy to use and understand, Gauss-Seidel is slower for bigger systems. This program helps to learn how power flow analysis works in electrical networks.