Simple Circuit Simulator : Project 1

Project Overview:

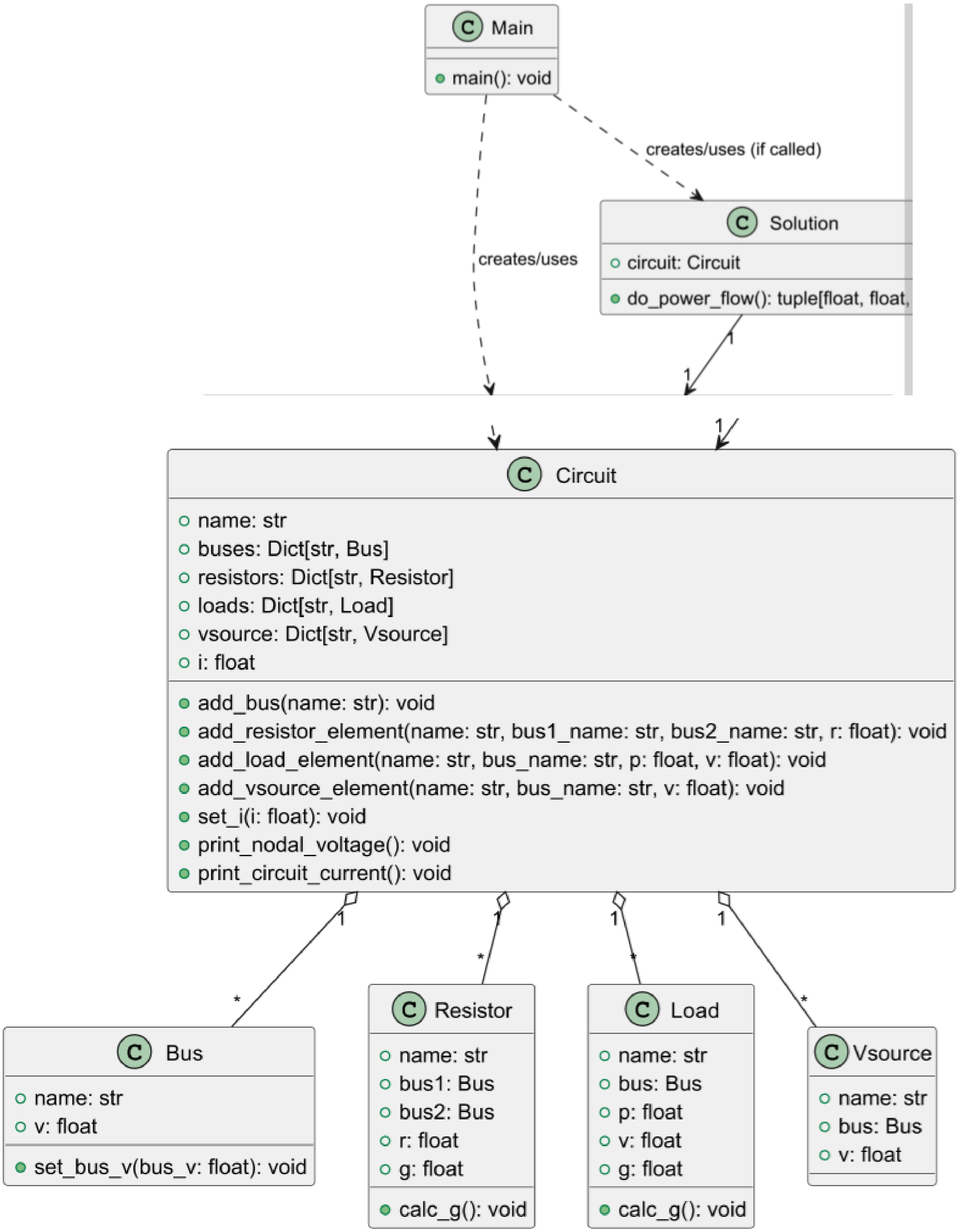
The simple circuit simulator is a Python based program designed to model and solve basic DC electrical circuits using an object oriented programming approach. The primary purpose of the simulator is to calculate nodal voltages and circuit for a simple circuit consisting of buses, a voltage source, a resistor, and a load.

The simulator allows users to define a DC circuit by specifying circuit components such as buses, resistors, loads, and a voltage source. Once the circuit is defined the program applies basic electrical engineering concepts including Ohm's Law and conductance based analysis, to solve for unknown bus voltages and the current flowing through the circuit. The program is structured using separate classes for each of the circuit's components, which helps to organize the code and make the system easier to understand, debug, and add to.

The problem this simulator addresses is the need to analyze a simple DC circuit in a clear and repeatable way without doing these calculations manually. By automating the analysis, the simulator reduces human error and reinforces the relationship between circuit theory and software implementation. This approach is useful for learning how we can represent electrical systems and solve them.

In real world applications, this type of simulation is useful for preliminary circuit design and engineering analysis where quick validations of circuit behavior may be required. While the simulator is mainly focused on a simple circuit construction, the same concepts could be used in more advanced power system analysis.

Class Diagram:



Relevant Equations:

The Simple Circuit Simulator applies fundamental DC circuit equations to compute circuit current and nodal voltages. The equations below describe the mathematical relationships used in the simulator.

Ohm's Law:

This equation is used to calculate voltage drop across resistive elements and determine current flowing through the circuit.

$$V = I \cdot R$$

- V = Voltage (volts)
- I = Current (amperes)
- R = Resistance (ohms)

Power-Voltage Relationship:

This relationship is used to convert the load's rated power and nominal voltage into an equivalent resistance.

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P}$$

- V = Voltage (volts)
- P = Power (Watts)
- R = Resistance (ohms)

Conductance Calculations:

Conductance is the inverse of resistance and is used throughout the simulator to simplify circuit calculations.

$$g = \frac{1}{R}$$

$$g_{load} = \frac{P}{V^2}$$

- V = Voltage (volts)
- g = Conductance (siemens)
- R = Resistance (ohms)

Kirchoff's Voltage Law (KVL)

Kirchhoff's Voltage Law states that the sum of voltages around a closed loop must equal zero.

$$V_a - IR_{ab} - IR_{load} = 0$$

$$I = \frac{V_a}{R_a + R_{load}}$$

$$V_b = V_a - IR_{ab}$$

These equations are used to determine the system current first, followed by the voltage at the unknown bus.

Example Case:

To demonstrate how the Simple Circuit Simulator operates we will now do a test case example. This example uses different values than the validation case to show that the simulator can correctly solve other DC circuits with the same configuration.

The circuit consists of:

- Two buses: Bus A and Bus B
- A voltage source connected to Bus A with a voltage of 50 V
- A resistor connected between Bus A and Bus B with a resistance of 10 Ω
- A constant impedance load connected to Bus B with a power rating of 500 W and a nominal voltage of 50 V

The goal of the simulator is to calculate the voltage at each bus and the current flowing through the circuit.

<u>Conductance Calculation:</u>

First, conductance values are calculated for each element.

$$g = \frac{1}{R} = \frac{1}{10} = 0.1S$$

$$g_{load} = \frac{P}{V^2} = \frac{500}{50^2} = 0.2S$$

<u>Circuit Current Calculation:</u>

The conductance values are converted to equivalent resistances:

$$R_{ab} = \frac{1}{g_{ab}} = 10\Omega$$

$$R_{load} = \frac{1}{g_{load}} = 5\Omega$$

The circuit current is then calculated

$$I = \frac{V_a}{R_{eq}} = \frac{50}{10+5} = 3.33A$$

<u>Bus Voltage Calculation:</u>

Once the current is known, the voltage at Bus B is determined using Ohm's Law:

$$V_b = V_a - IR_{ab}$$

$$V_b = 50 - (3.33 \cdot 10) = 16.67V$$

<u>Simulator Results:</u>

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Bus Voltages:
A = 50.0
B = 16.666666666666664
Circuit Current = 3.3333333333333335
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