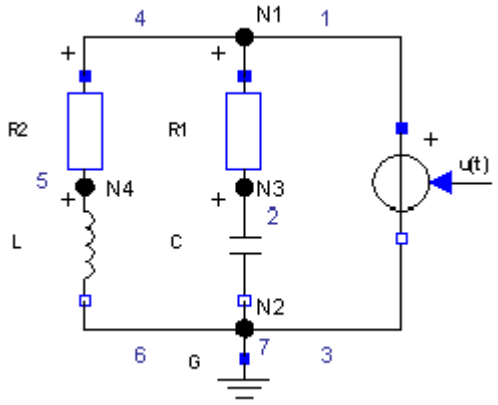
Exercises 3 - Classes and Simple Circuit

1 Add Components to SimpleCircuit

Add a capacitor between the R2 component and the R1 component and an inductor between the R1 and voltage component. Use the SimpleCicuit model and Modelica standard library components.




```
loadModel(Modelica);
```

```
model SimpleCircuit "This model shows how a model generated from
the graphic model editor can appear"
  import Modelica.Electrical.Analog;
  Analog.Basic.Resistor  R1(R = 10);
  Analog.Basic.Capacitor C(C = 0.01);
  Analog.Basic.Resistor  R2(R = 100);
  Analog.Basic.Inductor  L(L = 0.1);
  Analog.Sources.SineVoltage AC(V = 220);
  Analog.Basic.Ground    G;
equation
  connect(AC.p, R1.p);
  connect(R1.n, C.p);
  connect(C.n, AC.n);
  connect(R1.p, R2.p);
  connect(R2.n, L.p);
  connect(L.n, C.n);
  connect(AC.n, G.p);
end SimpleCircuit;
```

You can verify the result in the model editor. This example illustrates how inconvenient it is to use textual modeling sometimes.

The exercise below is to perform this manually, textually, a lot more work, but has the advantage that you learn to understand what is actually happening.

2 Build Electrical Components by Hand

This excercise consists of building a number of electrical componenets. Here follows the equations that describe each component. You can skip section 2.1 if you are familiar with the equations.

2.1 Equations

The ground element

$$v_p = 0$$

where v_p is the potantial of the ground element.

A resistor

$$i_p + i_n = 0$$

$$u = v_p - v_n$$

$$u = R\, i_p$$

where $i_p$and $i_n$represents the currents into the positive and negative pin (or port) of the resistor, $v_p$and v_n the corresponding potentials, u the voltage over the resistor, and R the resistance.

An inductor

$$i_p + i_n = 0$$

$$u = v_p - v_n$$

$$u = L \frac{di_p}{dt}$$

where $i_p$and $i_n$represents the currents into the positive and negative pin (or port) of the inductor, $v_p$and v_n the corresponding potentials, u the voltage over the inductor, and L the inductance.

A voltage source

$$i_p + i_n = 0$$

$$u = v_p - v_n$$

$$u = V$$

where $i_p$and $i_n$represents the currents into the positive and negative pin (or port) of the voltage source, $v_p$and v_n the corresponding potentials, u the voltage over the voltage source, and V the constant voltage.

Build Modelica models of the above components. A Connector component representing an electrical pin should be defined. Observe that the first two equations defining each electrical component with two pins above are equal. Utilize this observation to build a partial model, TwoPin, to be used in the definition of any electrical two pin component. Hence, totally six components (Pin, Ground, TwoPin, Resistor, Inductor, and a VoltageSource) should be built.

Use the defined components to build a model of a circuit diagram and simulate the behavior of the circuit.

2.2 Implementation

2.2.1 User-Defined Types

Define the types Voltage and Current.

```
type Voltage = Real;
type Current = Real;
```

2.2.2 Pin

The Pin has a potential, v and current variable, i. According to Kirchhoff's laws potentials are set equal and currents sum to zero at connections. Hence, v is an effort variable and i is a flow variable.

```
connector Pin
   ...
   ...
end Pin;
```

2.2.3 Ground

The Ground component has a positive Pin and a simple equation.

```
model Ground
   Pin p;
equation
   ...
end Ground;
```

2.2.4 TwoPin

The TwoPin element has a positive and negative Pin, a voltage u and a current i defined (the current i does not appear in the equations above and is only introduced to simplify notation).

```
model TwoPin
   Pin p, n;
   ...
   ...
equation
   ...
   ...
   ...
end TwoPin;
```

2.2.5 Resistor

To define the resistor the partial model TwoPin is extended and we only add a declaration of the parameter R together with Ohm's law that relates voltage and current to each other.

```
model Resistor
   extends TwoPin;
   ...
```

```
equation
   ...
end Resistor;
```

An equivalent model without use of a partial model would look like

```
model Resistor
   ....
   ....
   ....
   ....
   ....
equation
   ....
   ....
   ....
   ....
end Resistor;
```

Note: The Extends command could be thought of as just copying and pasting information from the partial model.

2.2.6 Inductor

The equation relating voltage and current for an inductor together with the inductance L are added to the partial model.

```
model Inductor
   ....
   ....
equation
   ....
end Inductor;
```

2.2.7 VoltageSource

Here the partial model is extended with the trivial equation that the voltage between the positive and negative pin of the voltage source is kept constant.

```
model VoltageSource
   ....
   ....
equation
   ....
end VoltageSource;
```

2.2.8 A Circuit

An example of a simple circuit where we instantiate the parameters of the components to other values than the default.

```
model Circuit
   Resistor R1(R=0.9);
   Inductor L1(L=0.01);
   Ground G;
   VoltageSource EE(V=5);
equation
   connect(EE.p, R1.p);
   connect(R1.n, L1.p);
   connect(L1.n, G.p);
   connect(EE.n, G.p);
end Circuit;
```

Simulate the circuit

```
simulate(Circuit, startTime=0, stopTime=1)
```

The signals that can be plotted.

Plot the current through the resistor:

```
plot(R1.i)
```