Appendix C

This appendix is a brief introduction to **SimPowerSystems**® blockset that operates in the **Simulink**® environment. An introduction to **Simulink** is presented in Appendix B. For additional help with Simulink, please refer to the Simulink documentation.

C.1 Simulation of Electric Circuits with SimPowerSystems

As stated in Appendix B, the MATLAB® and Simulink® environments are integrated into one entity, and thus we can analyze, simulate, and revise our models in either environment at any point. We can invoke **Simulink** from within MATLAB or by typing simulink at the MATLAB command prompt, and we can invoke **SimPowerSystems** from within Simulink or by typing powerlib at the MATLAB command prompt. We will introduce **SimPowerSystems** with two illustrated examples, a DC electric circuit, and an AC electric circuit

Example C.1

For the simple resistive circuit in Figure C.1, $v_S = 12v$, $R_1 = 7\Omega$, and $R_2 = 5\Omega$. From the voltage division expression, $v_{R2} = R_2 \times v_S/(R_1 + R_2) = 5 \times 12/12 = 5v$ and from Ohm's law, $i = v_S/(R_1 + R_2) = 1A$.
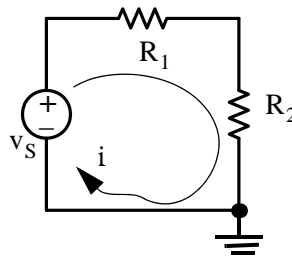

Figure C.1. Circuit for Example C.1

To model the circuit in Figure C.1, we enter the following command at the MATLAB prompt.

powerlib

and upon execution of this command, the powerlib window shown in Figure C.2 is displayed.

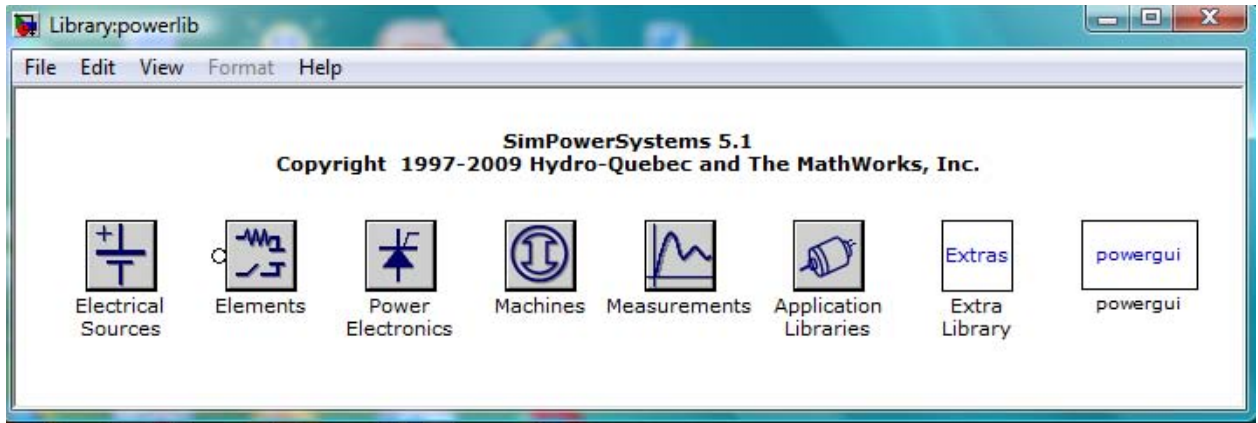From the **File** menu in Figure C.2, we open a new window and we name it Sim_Fig_C3 as shown in Figure C.3.
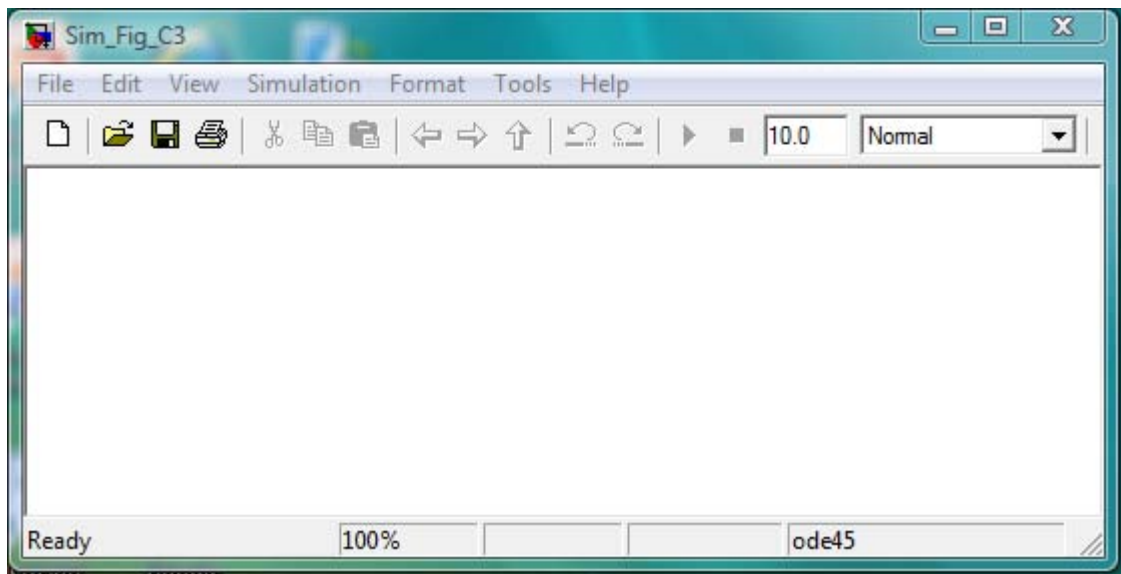
Figure C.2. Library blocks for SimPowerSystems

Figure C.3. New window for modeling the circuit shown in Figure C.1

The powergui block in Figure C.2 is referred to as the **Environmental** block for **SimPowerSystems** models and it must be included in every model containing **SimPowerSystems** blocks. Accordingly, we begin our model by adding this block as shown in Figure C.4.

We observe that in Figure C.4, the powergui block is named Continuous. This is the default method of solving an electric circuit and uses a variable step Simulink solver. Other methods are the Discrete method used when the discretization of the system at fixed time steps is desired, and the Phasors method which performs phasor simulation at the frequency specified by the Phasor frequency parameter. These methods are described in detail in the **SimPowerSystems** documentation.
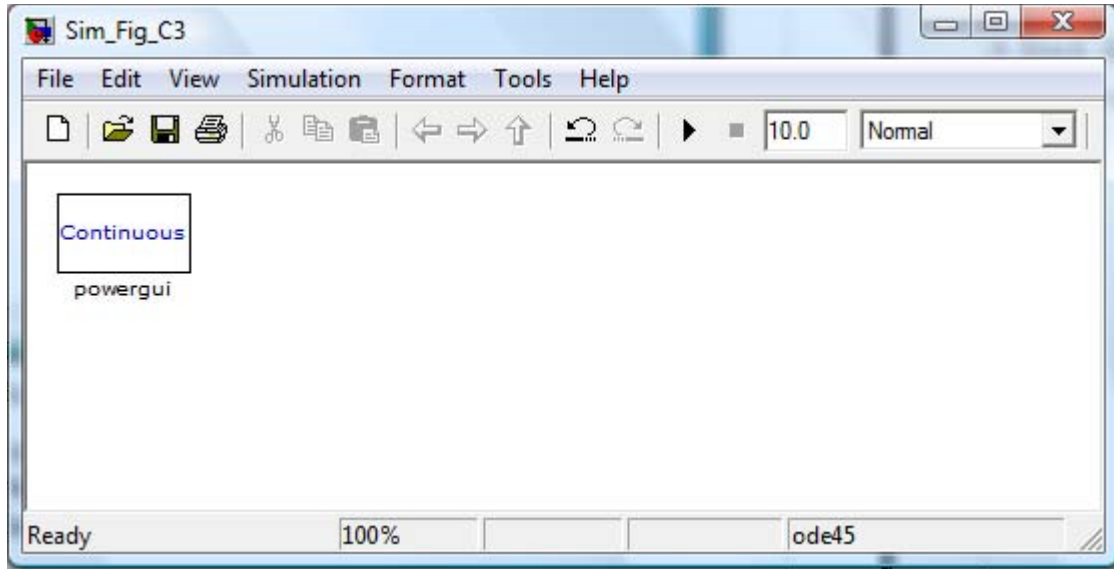
Figure C.4. Window with the addition of the powergui block

Next, we need to the components of the electric circuit shown in Figure C.1. From the Electrical Sources library in Figure C.2 we select the **DC Voltage Source** block and drag it into the model, from the Elements library we select and drag the **Series RLC Branch** block and the **Ground** block, from the Measurements library we select the **Current Measurement** and the **Voltage Measurement** blocks, and from the Simulink Sinks library we select and drag the **Display** block. The model now appears as shown in Figure C.5.
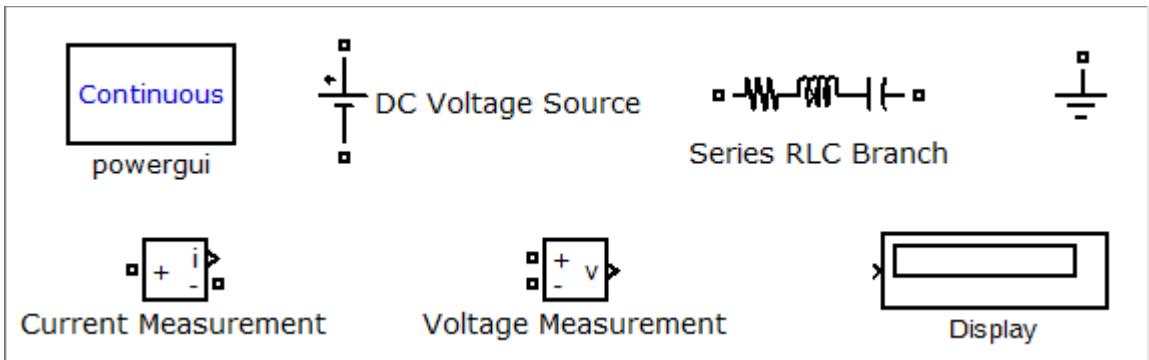

Figure C.5. The circuit components for our model

From the **Series RLC Branch** block we only need the resistor, and to eliminate the inductor and the capacitor, we double click it and from the **Block Parameters** window we select the R component with value set at 7 Ω as shown in Figure C.6.
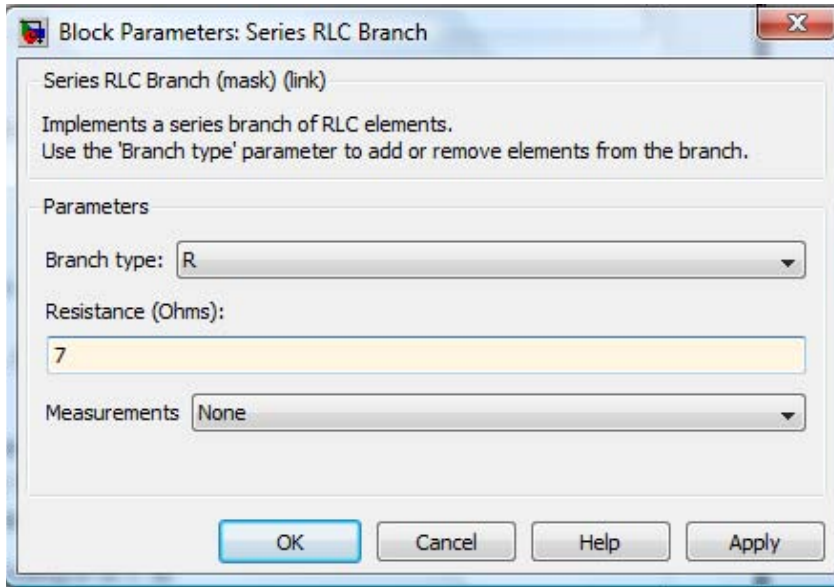
Figure C.6. The Block Parameters window for the Series RLC Branch

We need two resistors for our model and thus we copy and paste the resistor into the model, using the **Block Parameters** window we change its value to $5\ \Omega$, and from the **Format** drop window we click the **Rotate** block option and we rotate it **clockwise**. We also need two **Display** blocks, one for the current measurement and the second for the voltage measurement and thus we copy and paste the **Display** block into the model. We also copy and paste twice the **Ground** block and the model is now as shown in Figure C.7 where we also have renamed the blocks to shorter names.
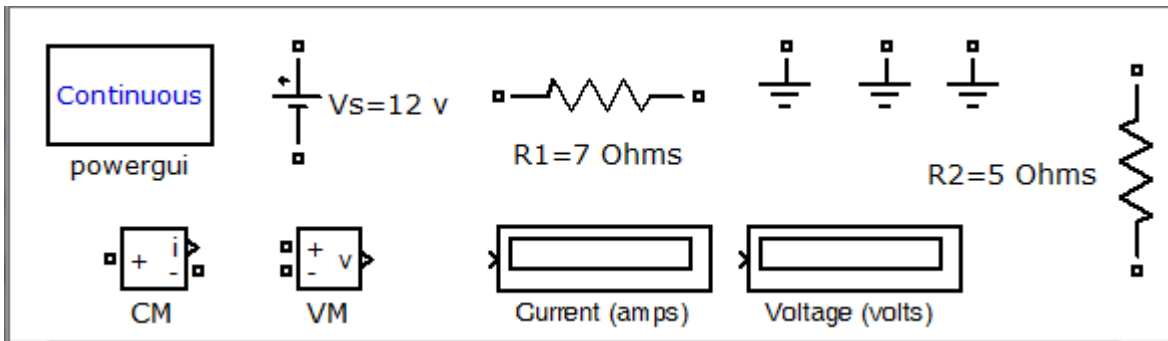

Figure C.7. Model with blocks renamed

From Figure C.7 above, we observe that both terminals of the voltage source and the resistors are shown with small square ( ) ports, the left ports of the CM (Current Measurement), and VM (Voltage Measurement) are also shown with ports, but the terminals on the right are shown with the **Simulink** output ports as **>**. The rules for the **SimPowerSystems** electrical terminal ports and connection lines are as follows:

1. We can connect **Simulink** ports (>) only to other **Simulink** ports.

2. We can connect **SimPowerSystems** ports ( ) only to other **SimPowerSystems** ports.[*]

3. If it is necessary to connect Simulink ports (>) to SimPowerSystems ports ( ), we can use SimPowerSystems blocks that contain both Simulink and SimPowerSystems ports such as the Current Measurement (CM) block and the Voltage Measurement (VM) block shown in Figure C.7.

The model for the electric circuit in Figure C.1 is shown in Figure C.8.
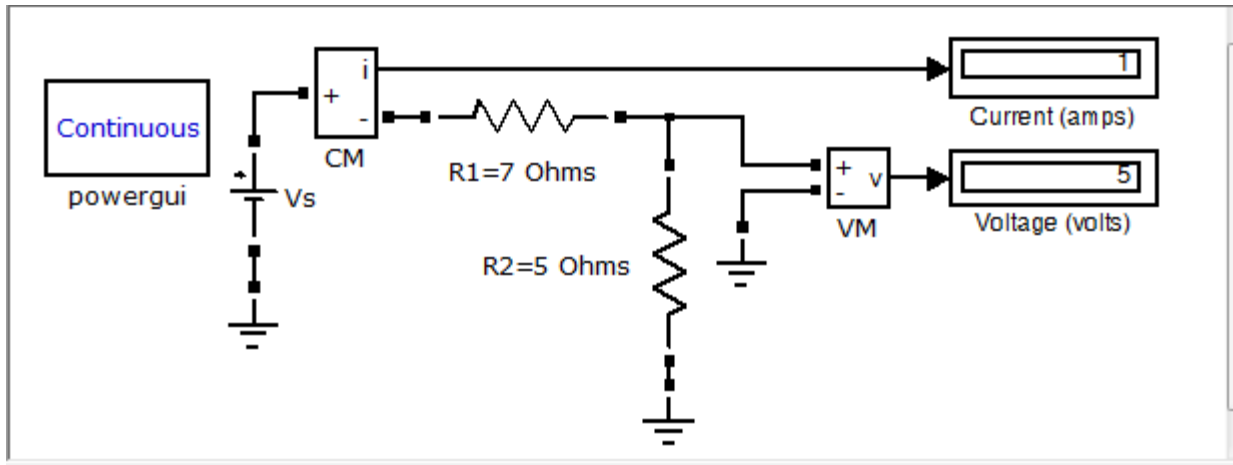

Figure C.8. The final form of the SimPowerSystems model for the electric circuit in Figure C.1

For the model in Figure C.8 we used the **DC Voltage Source** block. The **SimPowerSystems** documentation states that we can also use the **AC Voltage Source** block as a **DC Voltage Source** block provided that we set the frequency at 0 Hz and the phase at 90 degrees in the **Block Parameters** window as shown in Figure C.9.

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[*] *As in Simulink, we can autoconnect two **SimPowerSystems** blocks by selecting the source block, then holding down the **Ctrl** key, and left-clicking the destination block.*
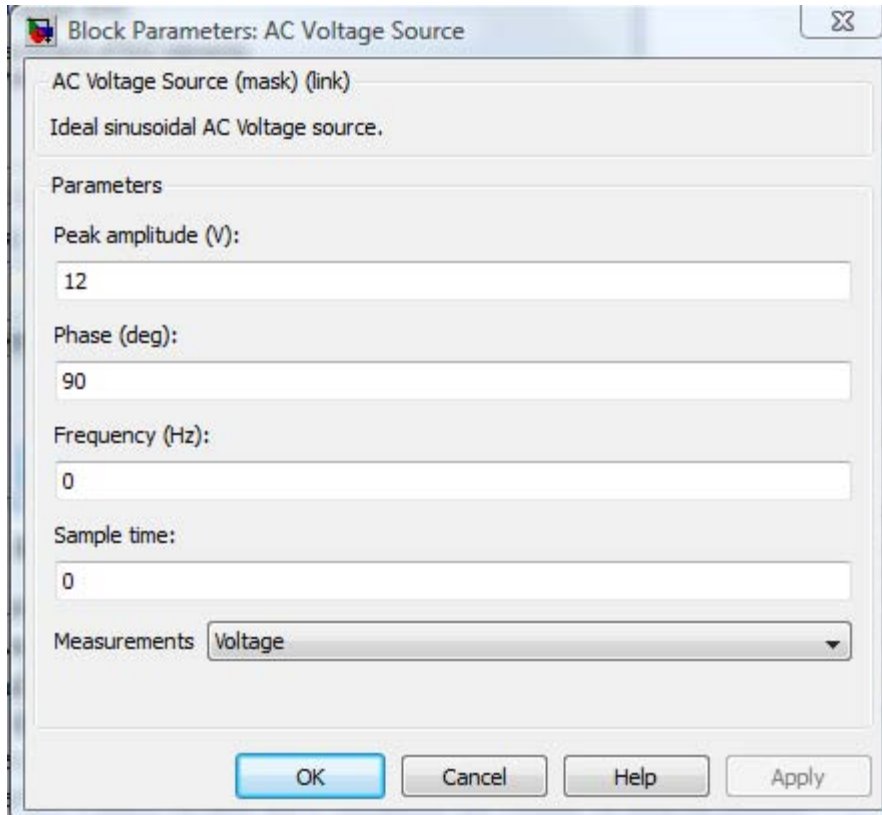
Figure C.9. Block parameter settings when using an **AC Voltage Source** block as a **DC Voltage Source**
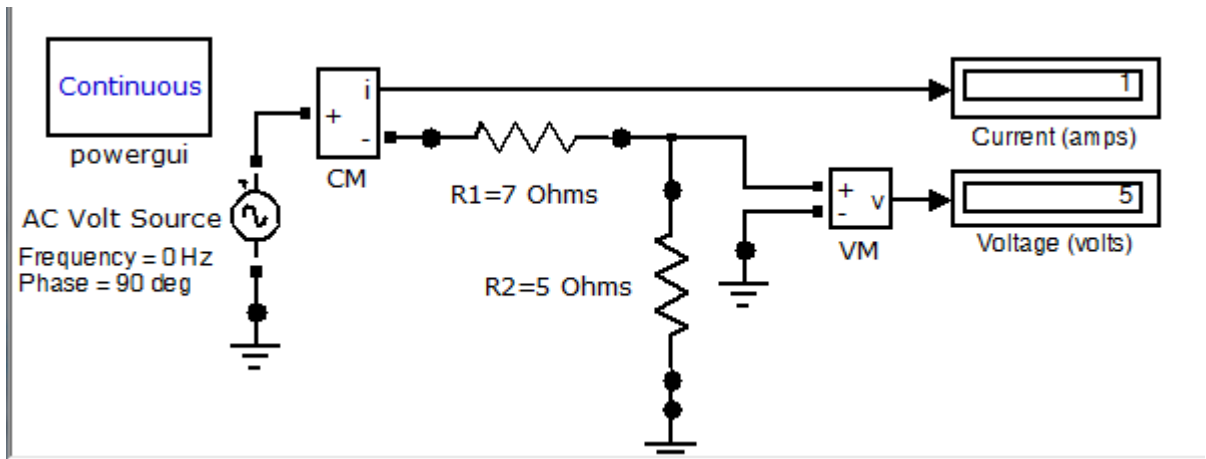

Figure C.10. Model with AC Voltage Source used as DC Voltage Source

A third option is to use a **Controlled Voltage Source** block with a **Constant** block set to the numerical value of the **DC voltage Source** as shown in the model of Figure C.11.
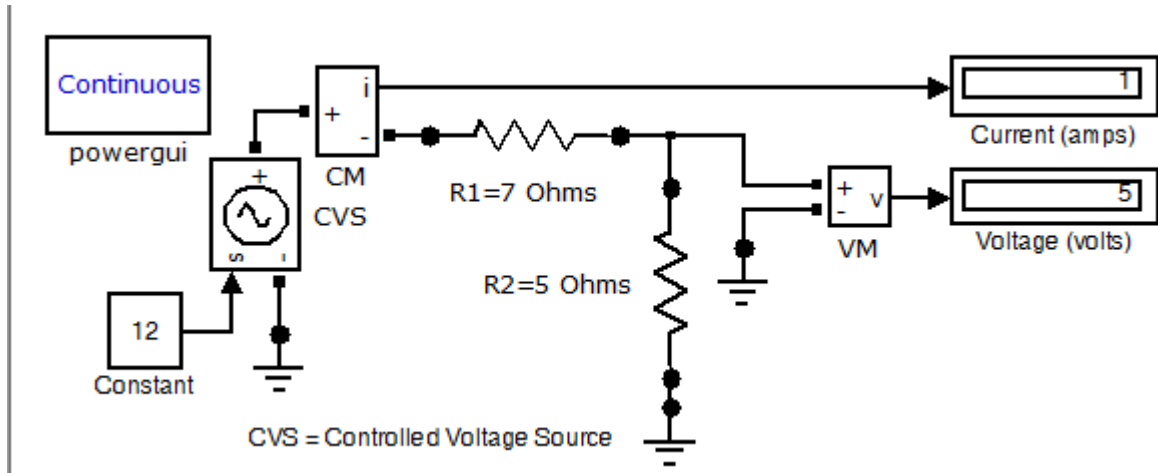
Figure C.11. Model with **Controlled Voltage Source** block

Example C.2

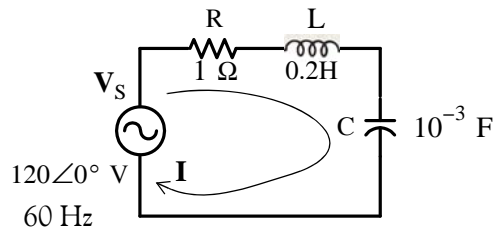Consider the AC electric circuit in Figure C.12

Figure C.12. Electric circuit for Example C.2

The current **I** and the voltage **Vc** across the capacitor are computed with MATLAB as follows:

```
Vs=120; f=60; R=1; L=0.2; C=10^(−3); XL=2*pi*f*L; XC=1/(2*pi*f*C);...
Z=sqrt(R^2+(XL−XC)^2); I=Vs/Z, Vc=XC*I
```

```
I =
    1.6494
Vc =
    4.3752
```

The **SimPowerSystems** model and the waveforms for the current **I** and the voltage **Vc** are shown in Figures C.13 and C.14 respectively.
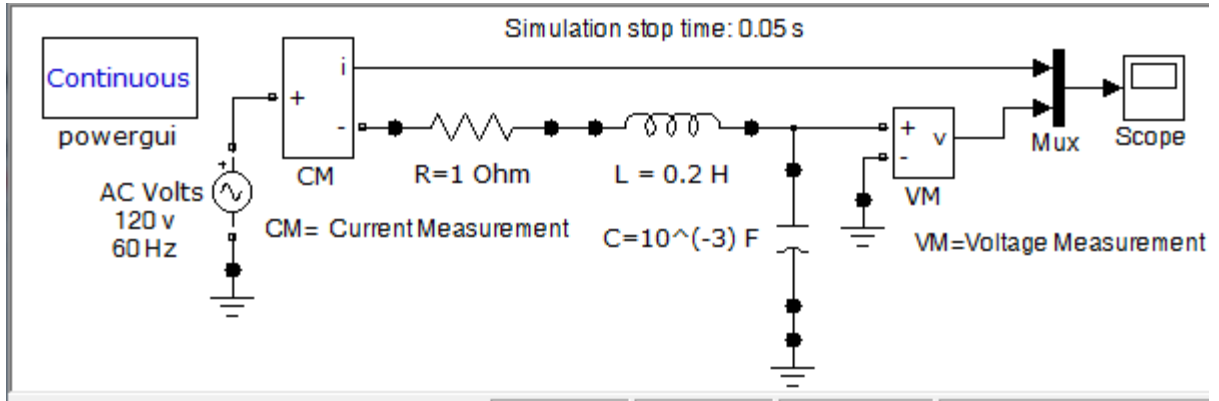
Figure C.13. **SimPowerSystems** model for the electric circuit in Figure C.12
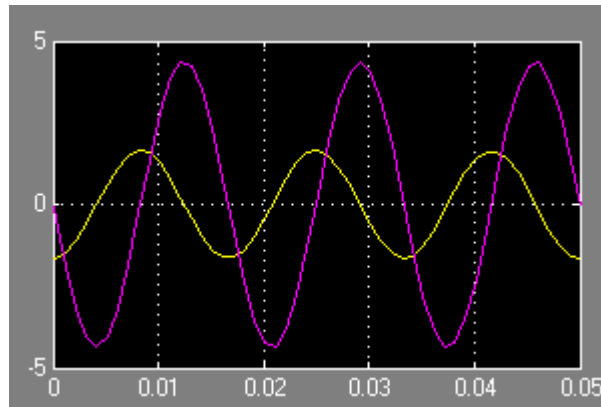

Figure C.14. Waveforms for the current I and voltage Vc across the capacitor in Figure C.12

The same results are obtained if we replace the applied AC voltage source block in the model of Figure C.13 with a **Controlled Voltage Source** (CVS) block as shown in Figure C.15.
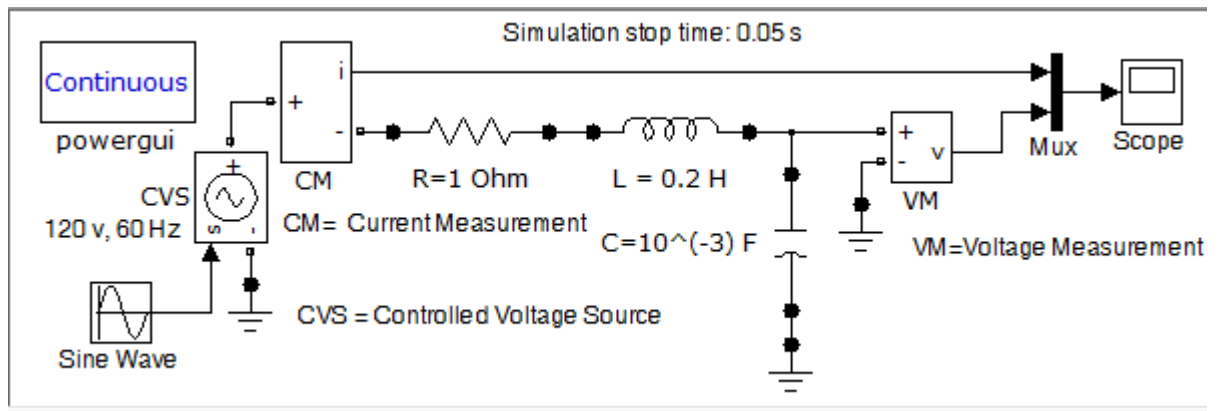

Figure C.15. The model in Figure C.13 with the AC Voltage Source block replaced with a CVS block