# Lab 1. Introduction to modelling

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## Specialization: Automation

## Objective

Familiarize yourself with the Simulink software environment and basic methods for modeling linear electrical circuits.

## Theoretical information

A mathematical model of a linear electric circuit as a linear stationary system can be represented in the form of a scalar differential equation of the *nth* order (input-output model) or in the form of a system of *n* differential equations of the 1st order (input-state-output model).

The input-output model has the form

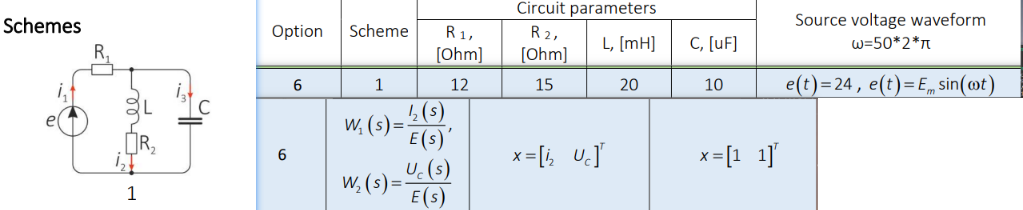
, (1)

where *y* is the output variable, *u* is the input signal, *n* is the order of the system, *m* is the order of the derivative of the output variable, which explicitly depends on *u*   
( ), *a j* , *b j* are constant coefficients.

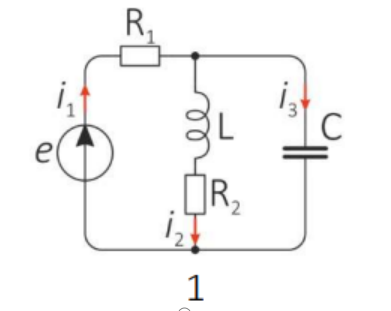
Provided that , the input-state-output model can be represented as

 (2)

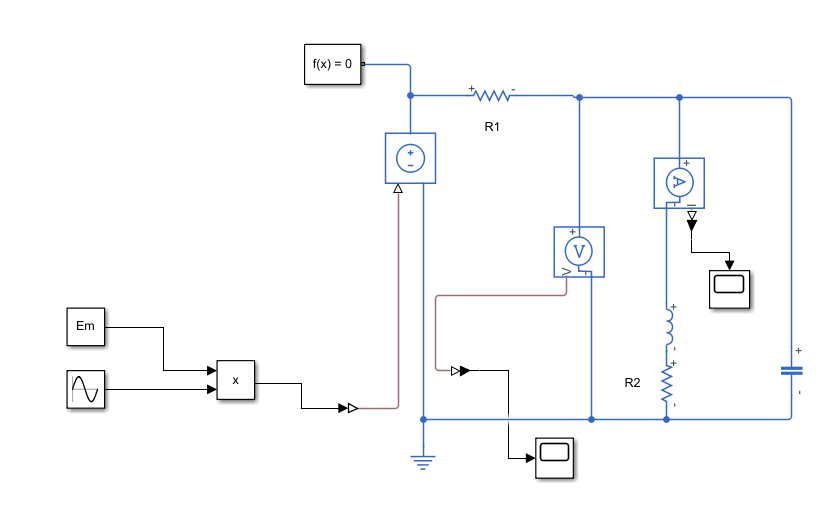
where *x j* are the coordinates of the state vector, α *ij* and β *j* are constant coefficients. System (2) can be represented in a compact vector-matrix form



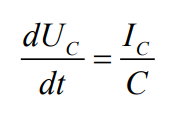
**1. Build a simulation circuit.**

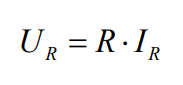


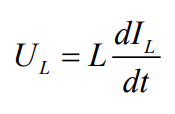
**Figure 1.** Equivalent circuit.

**Figure 2.** Simulation circuit.

**2. Component equations.**







**3. Topological equations.**

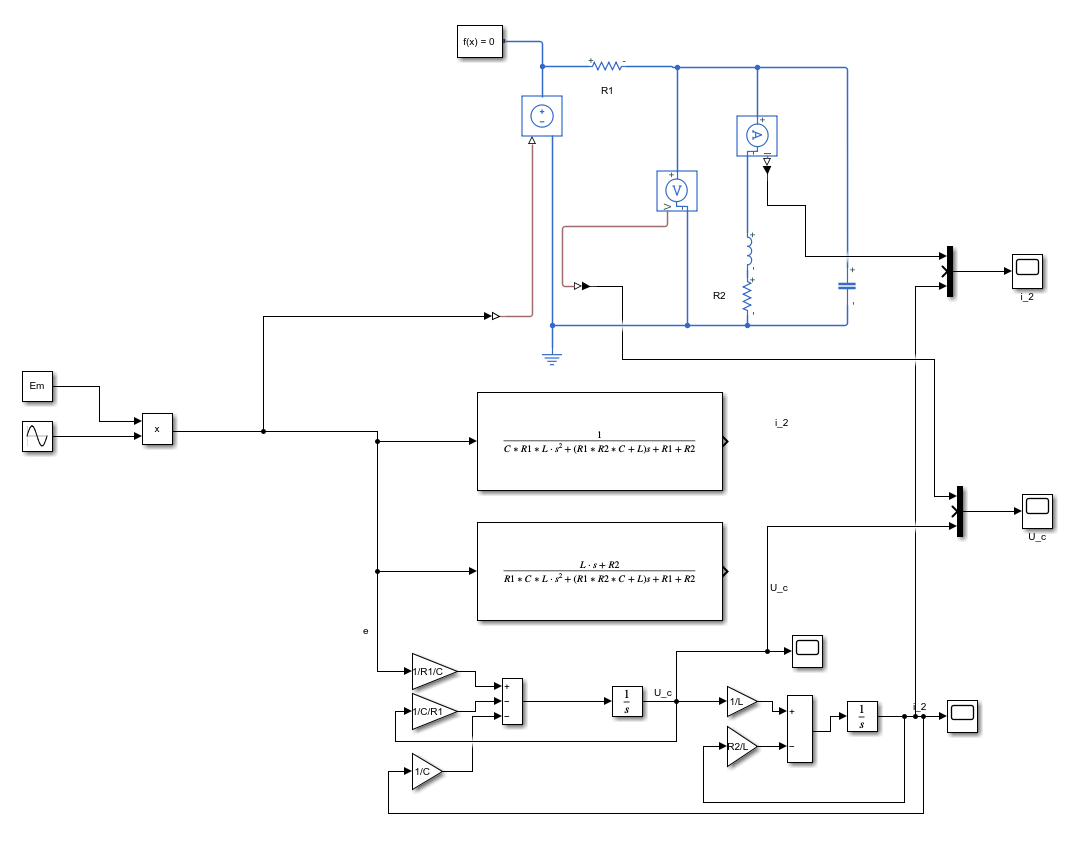
 

**4. State-space model.**

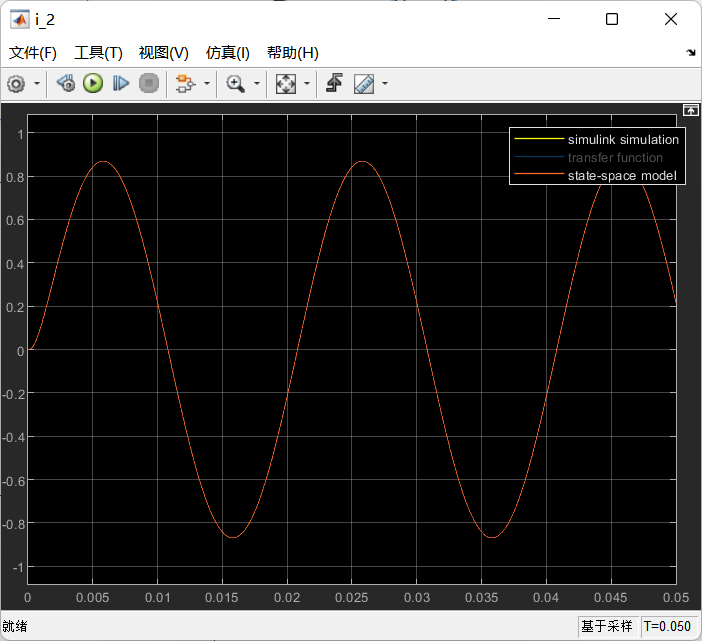
**Solution:**

Solution:

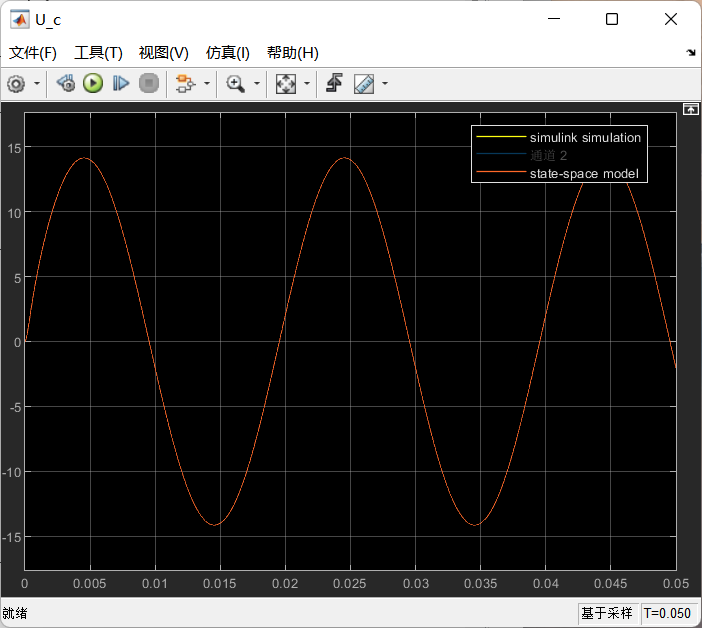
**5. Simulink simulation of the circuit and the state-space model using the predetermined input and zero initial conditions.**



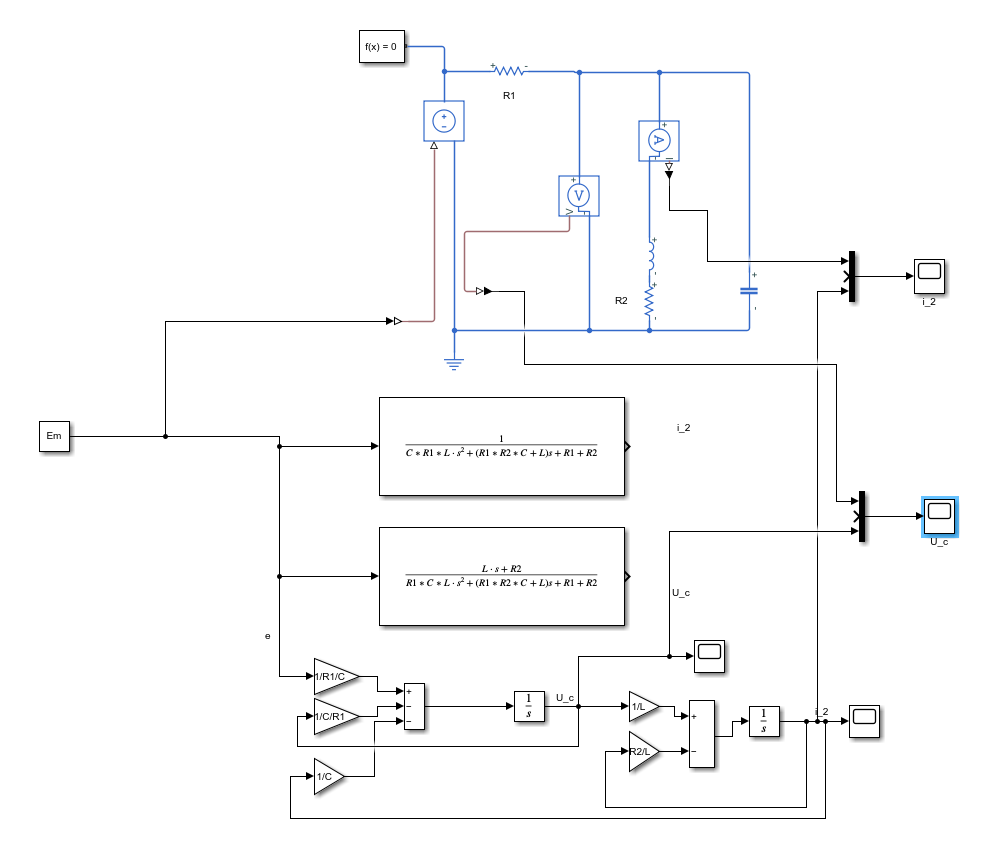
**Figure 3** Modelling with sinusoidal input voltage



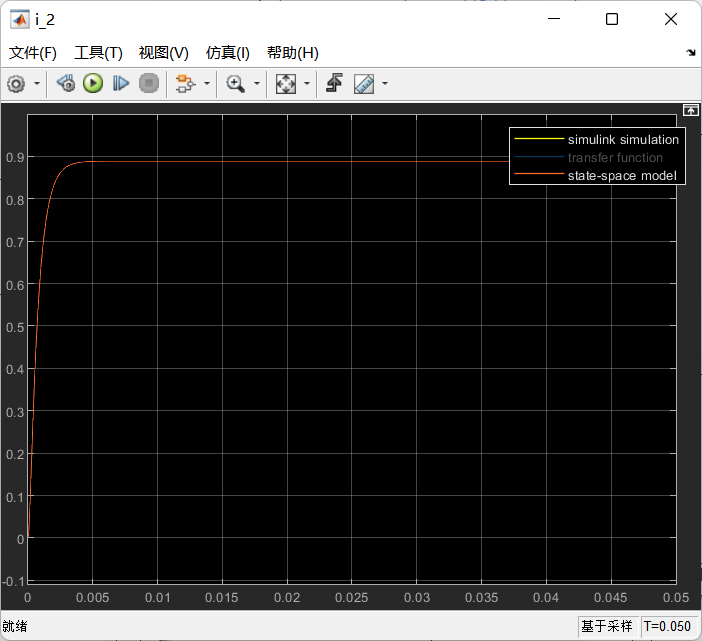
**Figure 4** i\_2 of Simulink simulation of the circuit and the state-space model



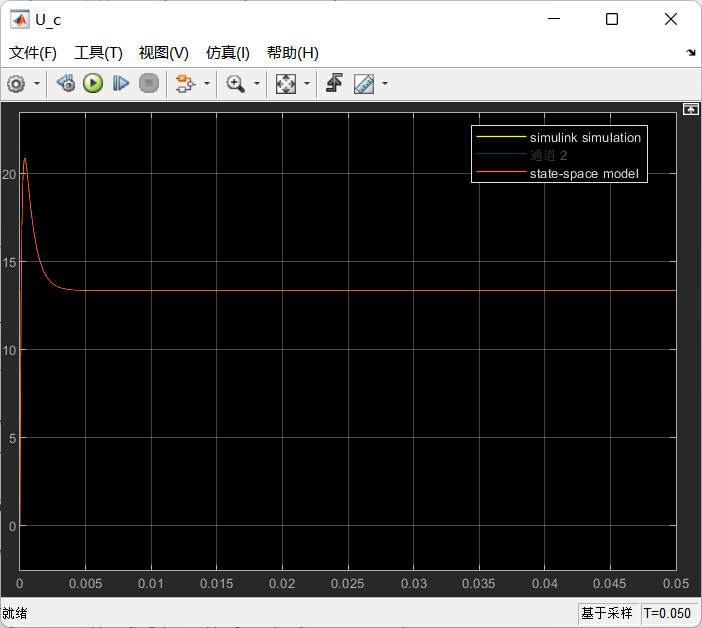
**Figure 5** U\_c of Simulink simulation of the circuit and the state-space model



**Figure 6** Modelling with constant voltage

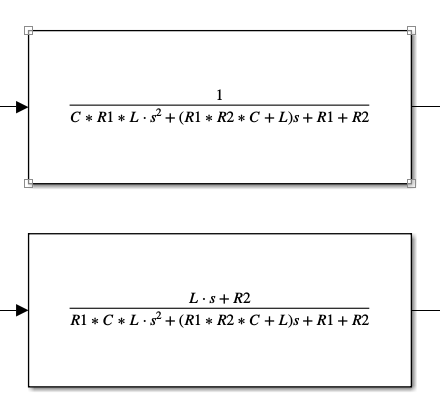


**Figure 7** i\_2 of Simulink simulation of the circuit and the state-space model

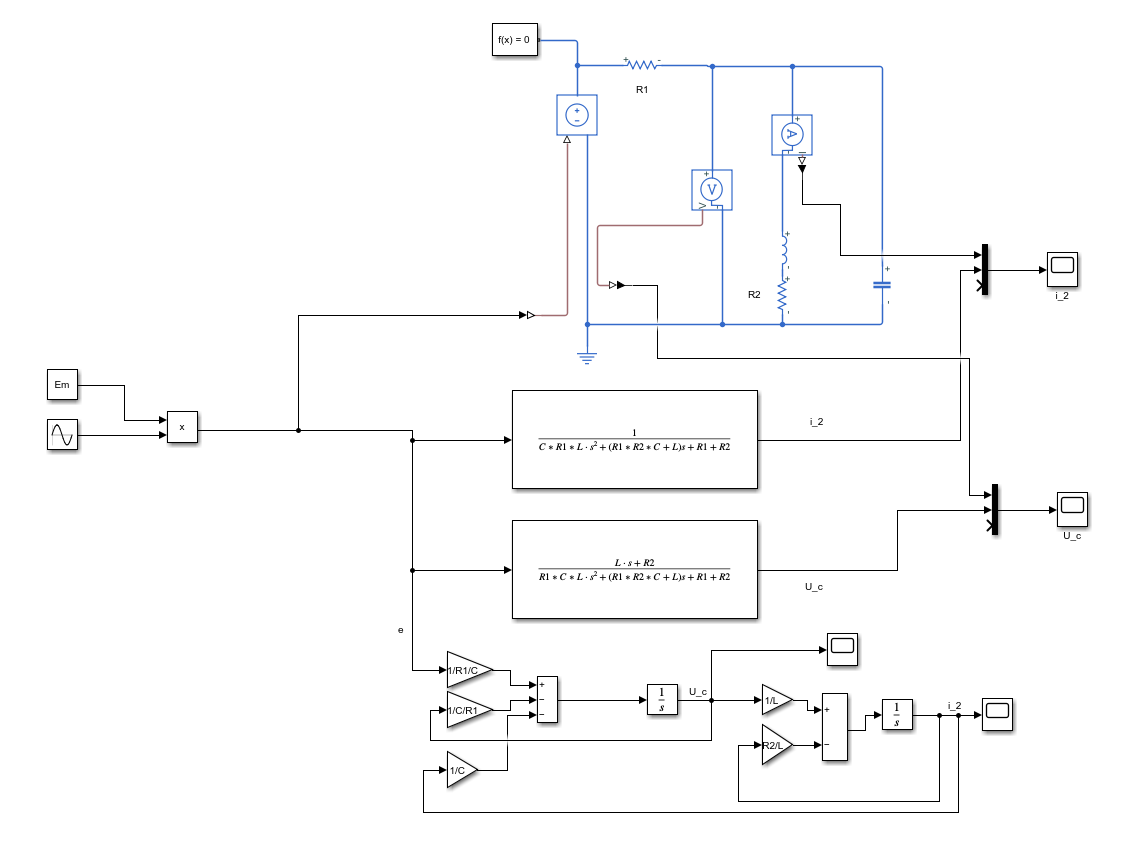


**Figure 8** U\_c of Simulink simulation of the circuit and the state-space model

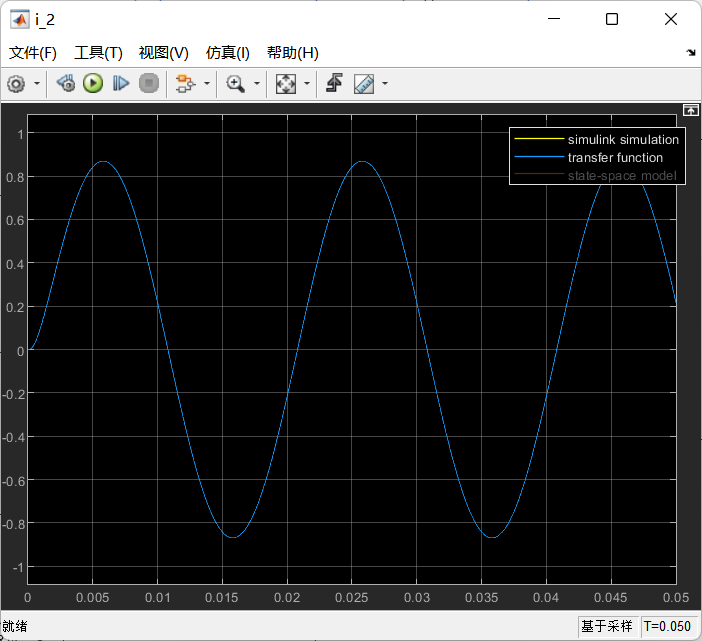
**6. “Input-output" model.**



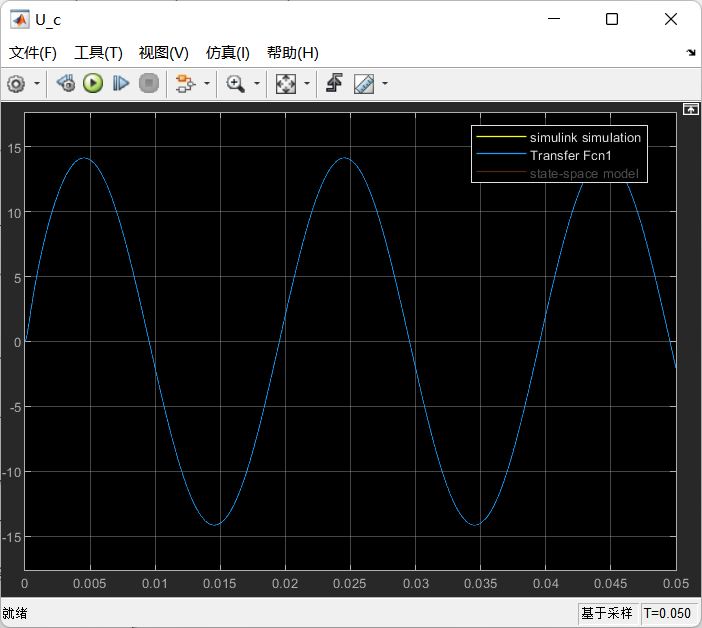
**7. Simulink simulation of the circuit and the resulting** **transfer functions using the predetermined input**



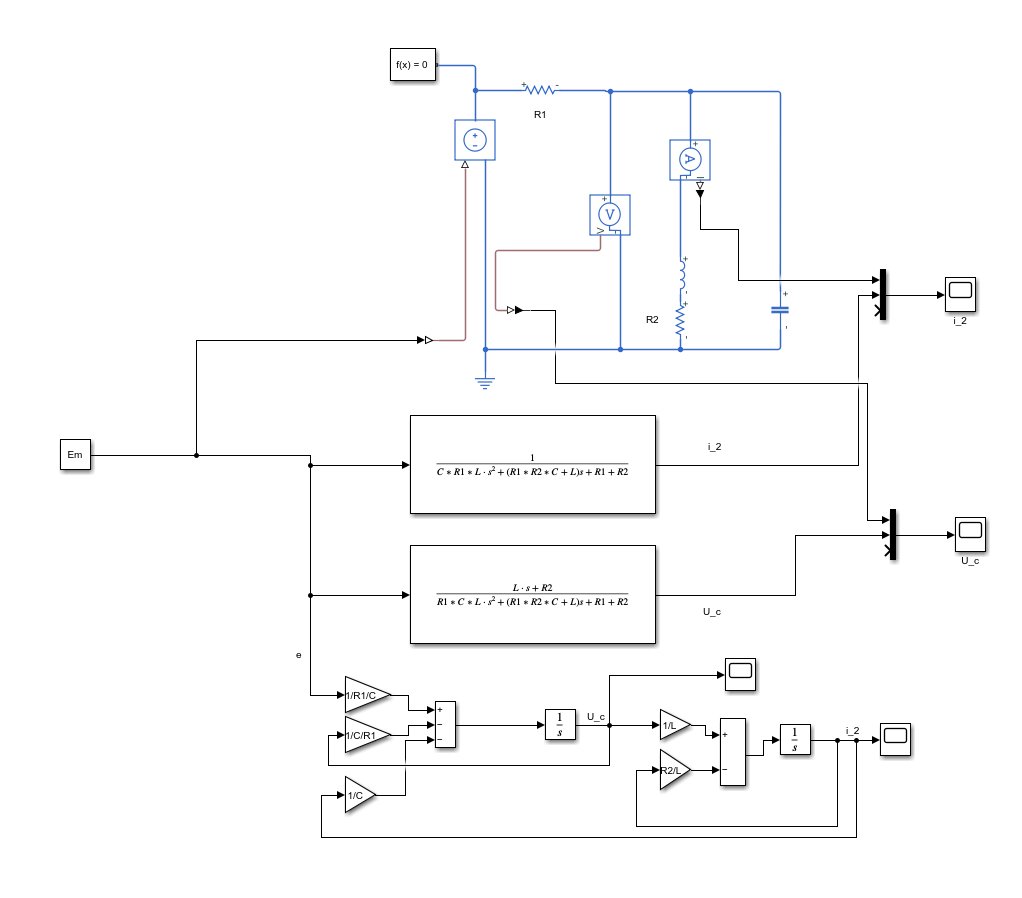
**Figure 9** Modelling with sinusoidal input voltage



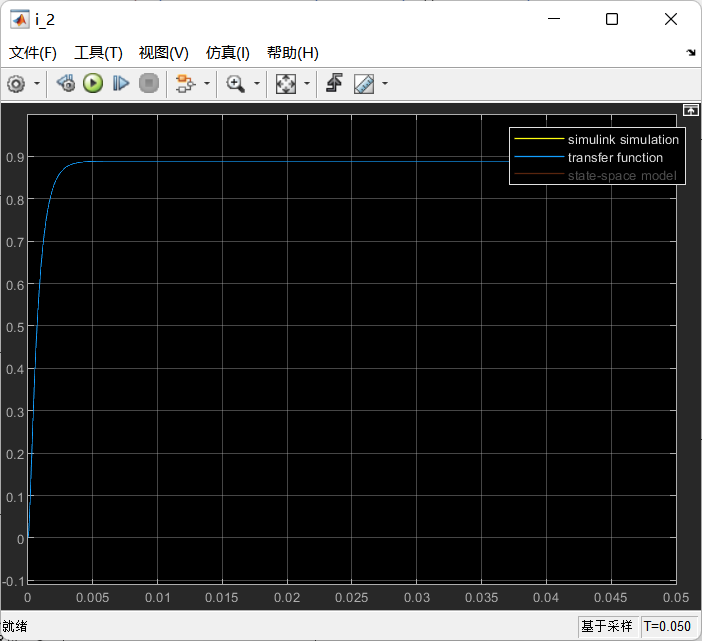
**Figure 10** i\_2 of Simulink simulation of the circuit and transfer functions



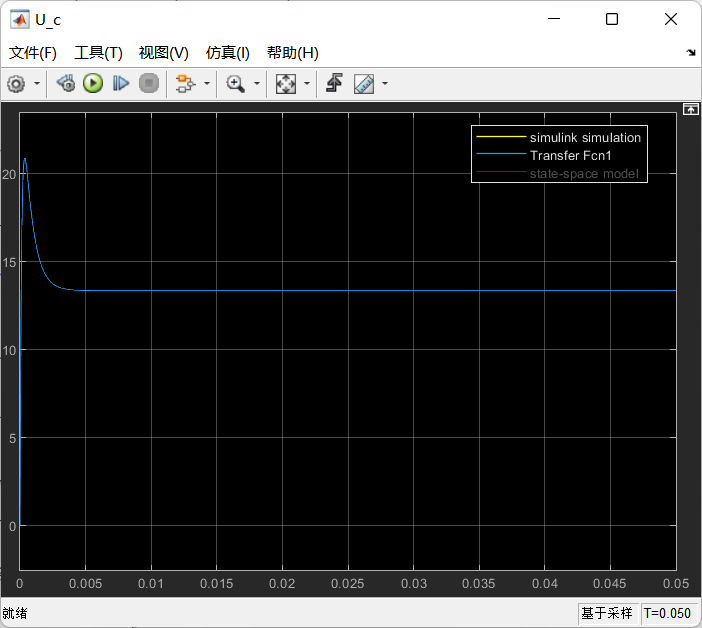
**Figure 11** U\_c of Simulink simulation of the circuit and transfer functions



**Figure 12** Modelling with constant voltage

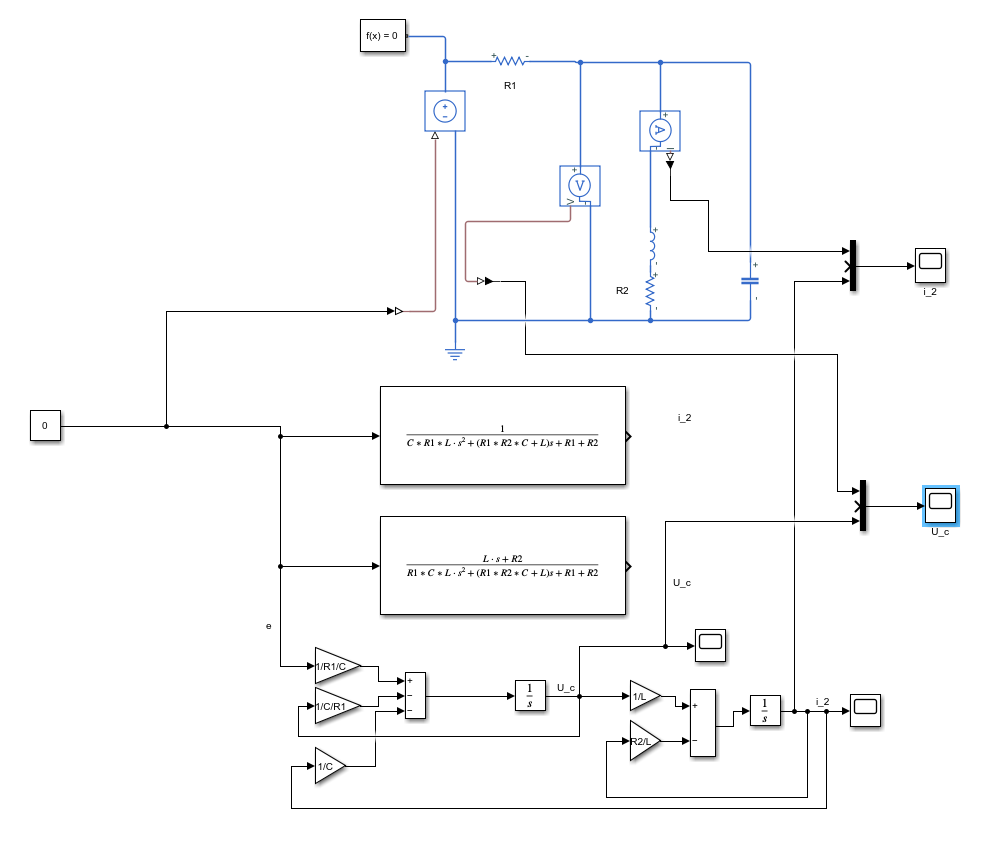


**Figure 13** i\_2 of Simulink simulation of the circuit and transfer functions

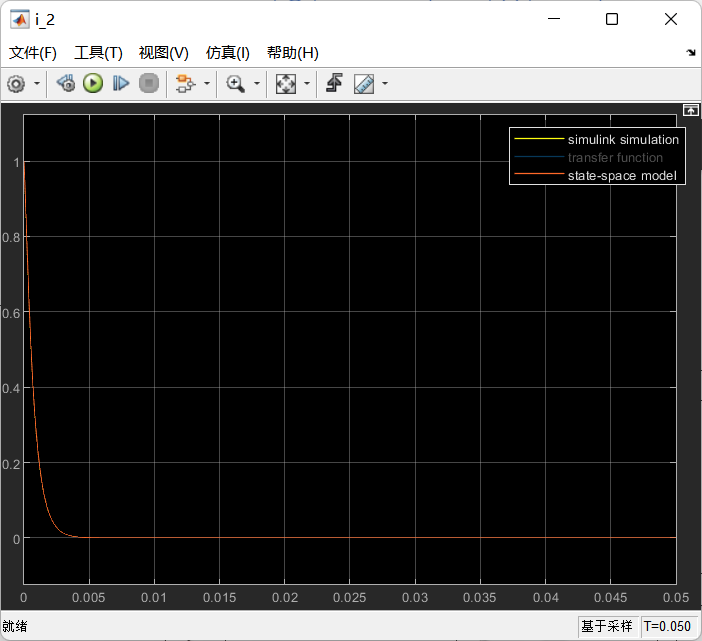


**Figure 14** U\_c of Simulink simulation of the circuit and transfer functions

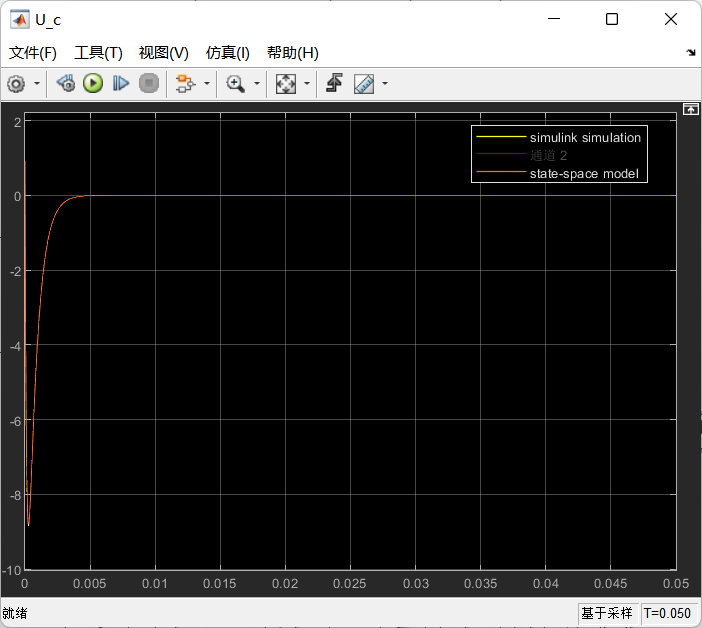
**8. Simulation of the circuit and the state-space model with zero input and non-zero initial conditions.**



**Figure 15** Modelling with zero voltage and nonzero initial conditions



**Figure 16** i\_2 of Simulink simulation of the circuit and the state-space model



**Figure 17** U\_c of Simulink simulation of the circuit and the state-space model

**Conclusions:**

In this lab, I successfully implemented and simulated a linear electrical circuit using three different modeling approaches in Simulink: **Simscape circuit, state-space representation, and transfer function.**

Through the experiments, I observed that all three models produced similar transient and steady-state responses, confirming their theoretical equivalence in circuit analysis.

And I applied different types of input signals to the circuit, including sinusoidal voltage, constant voltage, and zero input with nonzero initial conditions.For sinusoidal voltage,The circuit responded with a steady-state sinusoidal output, maintaining the same frequency as the input but with an amplitude change and a phase shift. For constant voltage,The circuit exhibited transient behavior before reaching a steady-state condition.For zero input with nonzero initial conditions,I observed the system’s natural response, which depends entirely on the circuit’s initial energy stored in capacitors and inductors.