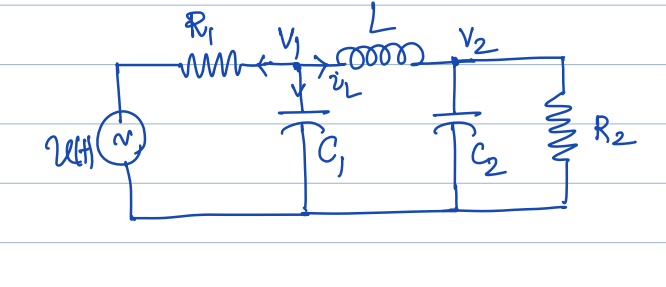
**EE49001: Control and Electronic System Design**

Assignment-7: RLC Circuit Control

Submitted By:

21EE30004: Anirvan Krishna | 21EE30001: Aditya Kumar

# State-Space Representation and Controllability



**Fig.** Circuit Diagram

We have the circuit parameters as follows: . The states for the state space considered are: .

The state space:

Therefore, we can write the equations as follows:

Here, ,

Controllability check is executed in MATLAB using the following snippet.

**MATLAB Code**

|  |
| --- |
| clear; close all; clc;  R1 = 1e3; C1 = 1e-3;  R2 = 2e3; C2 = 4e-3;  L = 0.5;  A = [  -1/(R1\*C1), 0, -1/C1;  0, -1/(R2\*C2), 1/C2;  1/L, -1/L, 0;  ];  B = [1/(R1\*C1); 0; 0];  D = 0;  Co = ctrb(A,B);  disp("Rank of the controllability matrix is: "+rank(Co)); |

On executing the above code, we get the rank of the controllability matrix . Hence, the system is controllable.

# Estimation of Observability

We need to find if the system is observable for the following choice of outputs:

voltage across

voltage across

current across

For different output states, we have different vectors . We can write output as:

Since . We have matrix for each case as follows:

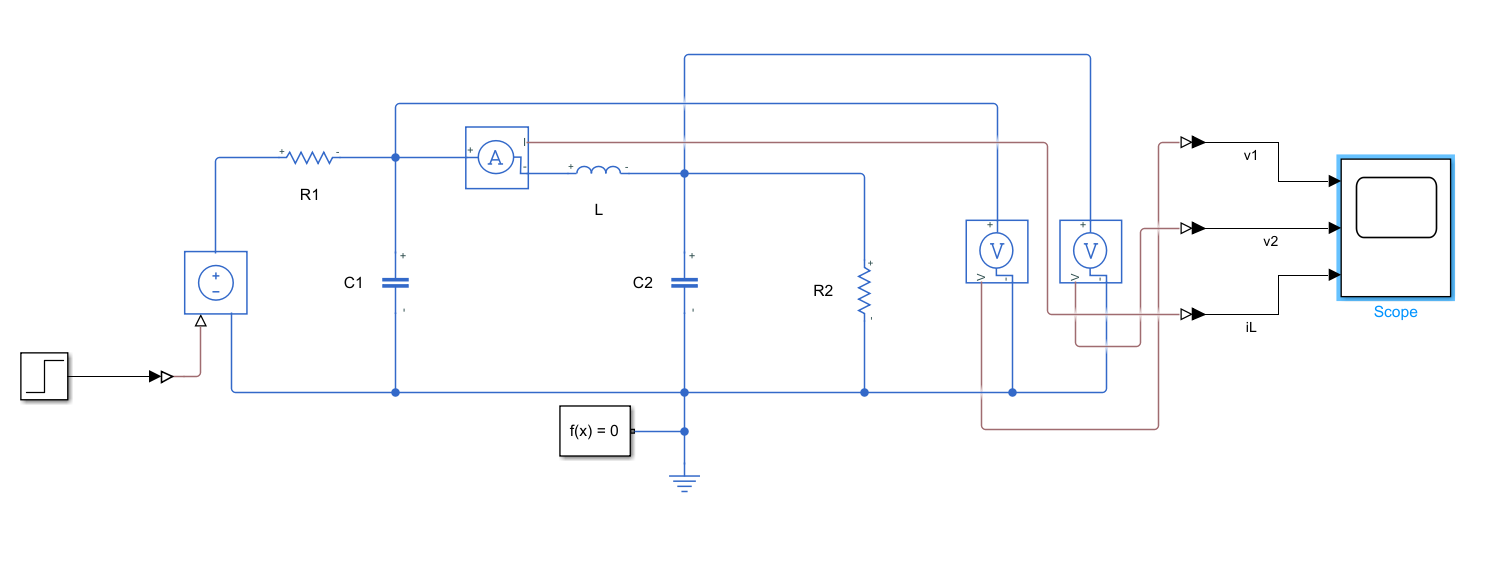
For all the three cases, the rank of the observability matrix is calculated by running the following script:

**MATLAB Code**

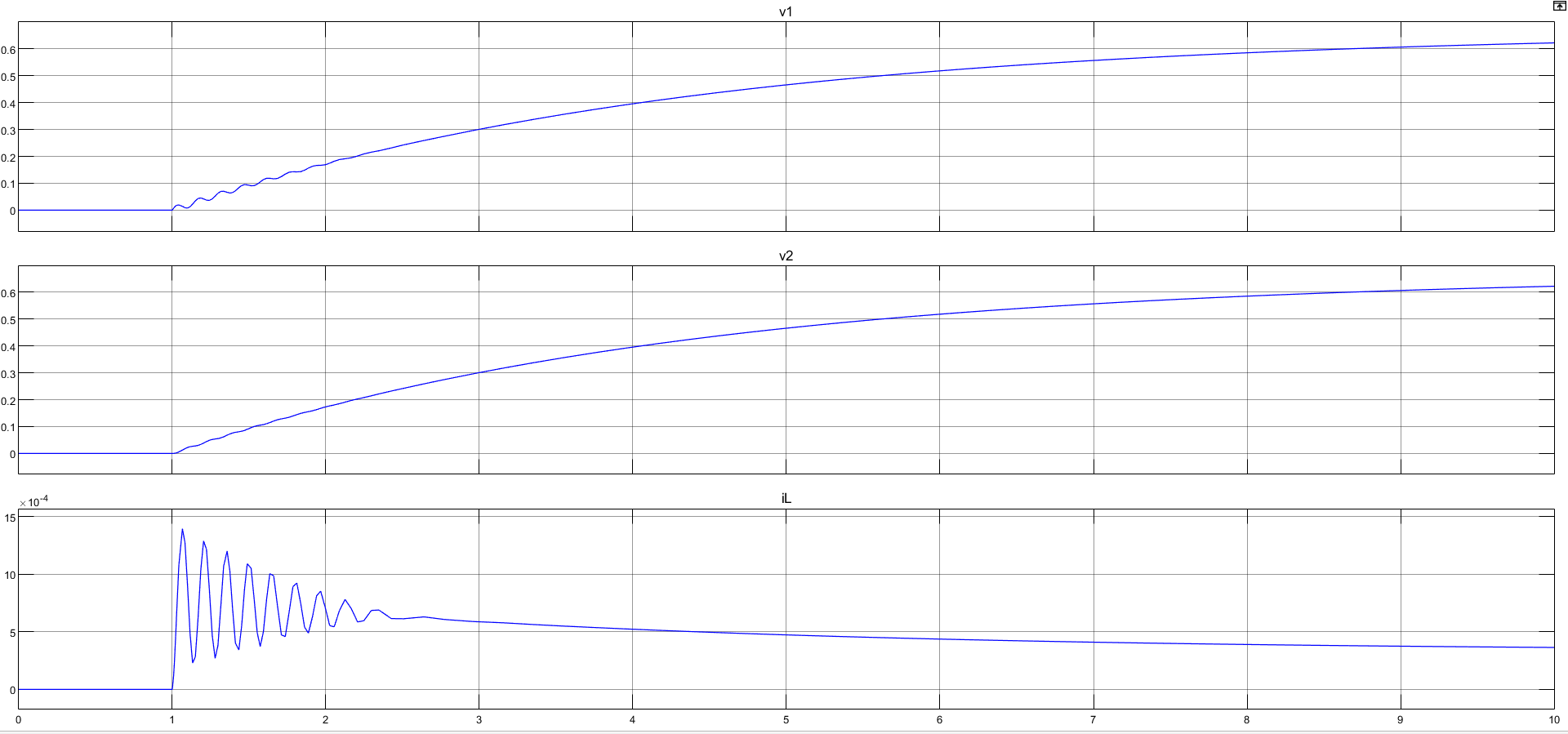
|  |
| --- |
| clear; close all; clc;  R1 = 1e3; C1 = 1e-3;  R2 = 2e3; C2 = 4e-3;  L = 0.5;  A = [  -1/(R1\*C1), 0, -1/C1;  0, -1/(R2\*C2), 1/C2;  1/L, -1/L, 0;  ];  B = [1/(R1\*C1); 0; 0];  D = 0;  Co = ctrb(A,B);  disp("Rank of the controllability matrix is: "+rank(Co));  C11 = [1, 0,0]; Ob1 = obsv(A,C11);  C12 = [0, 1,0]; Ob2 = obsv(A,C12);  C13 = [1,-1,0]; Ob3 = obsv(A,C13);  disp("Rank of the observability matrix when output is v1: "+rank(Ob1));  disp("Rank of the observability matrix when output is v2: "+rank(Ob2));  disp("Rank of the observability matrix when output is iL: "+rank(Ob3)); |

From the MATLAB output, we find that the rank of observability matrix in all the three cases: Therefore, we can infer that the system is observable with these output variables.

# Simulink Implementation



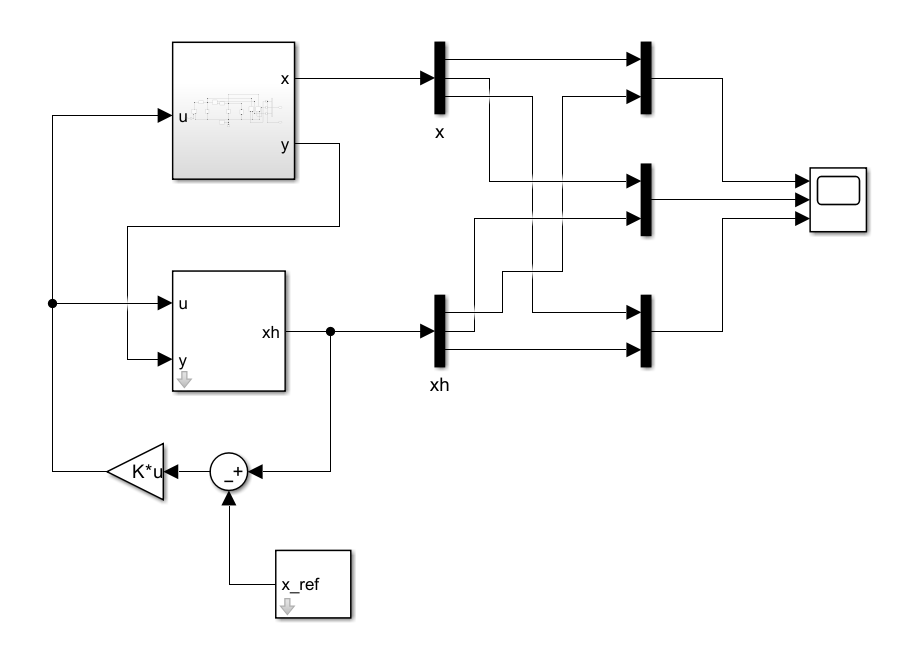
**Fig:** Simulink Model implementation



**Fig:** Output Voltages at steady state across

# Design of State-Feedback Controller

We are required to implement a state feedback controller to regulate the voltage when the voltage across i.e. is known after being sampled at .



**Fig.** State Feedback Controller Design

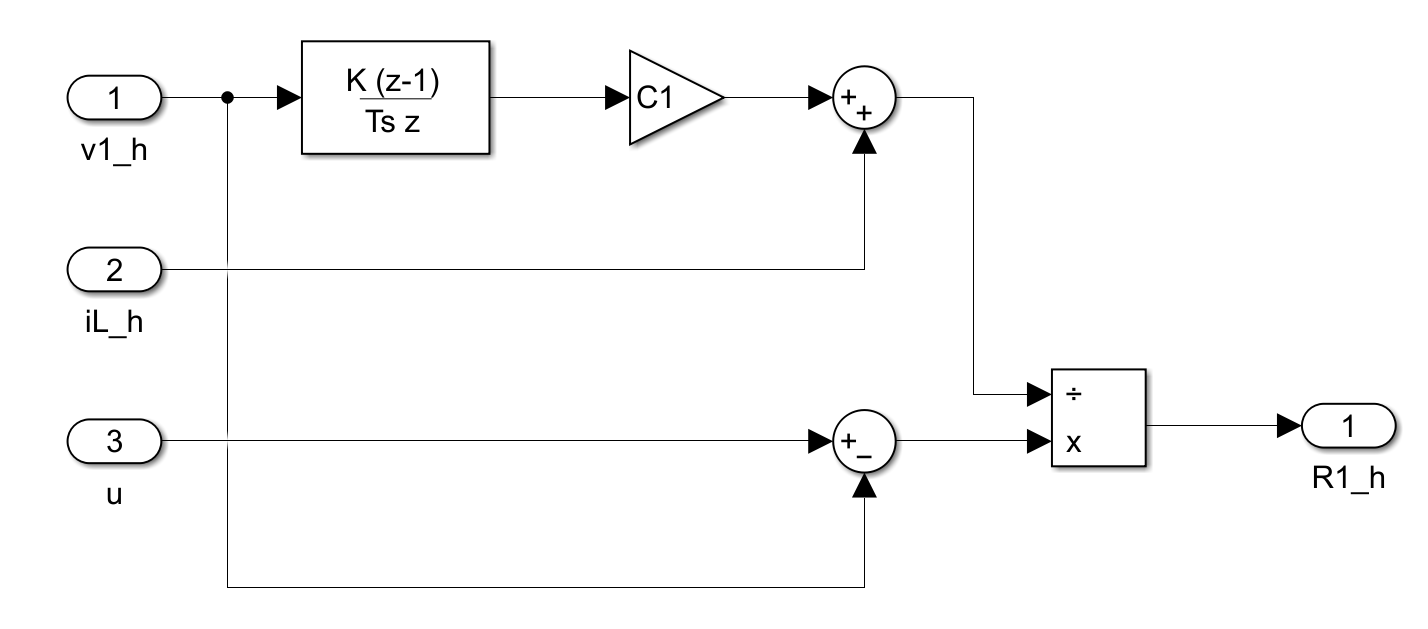


**Fig.** Trajectory of the three states after application of state feedback controller

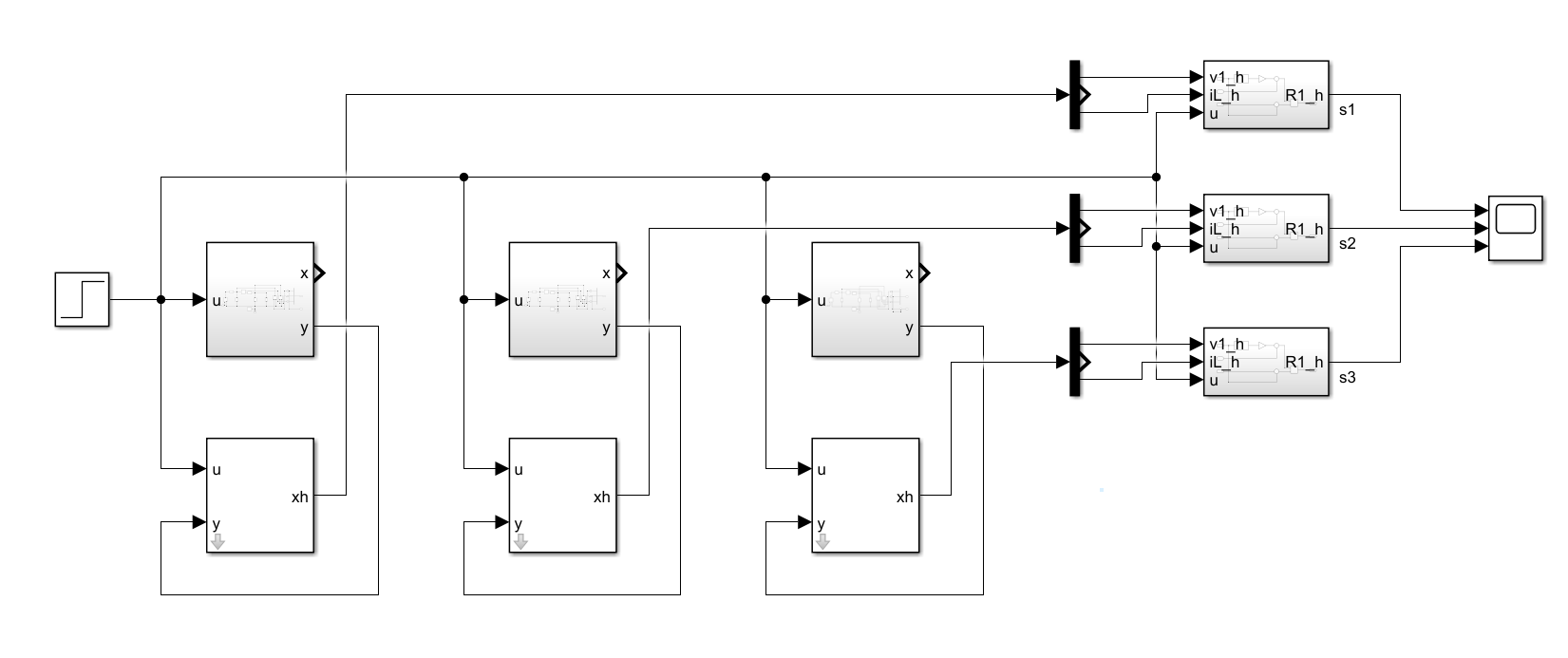
We observe that the voltage finally settles to the required value i.e. .

# Estimator for estimating the value of

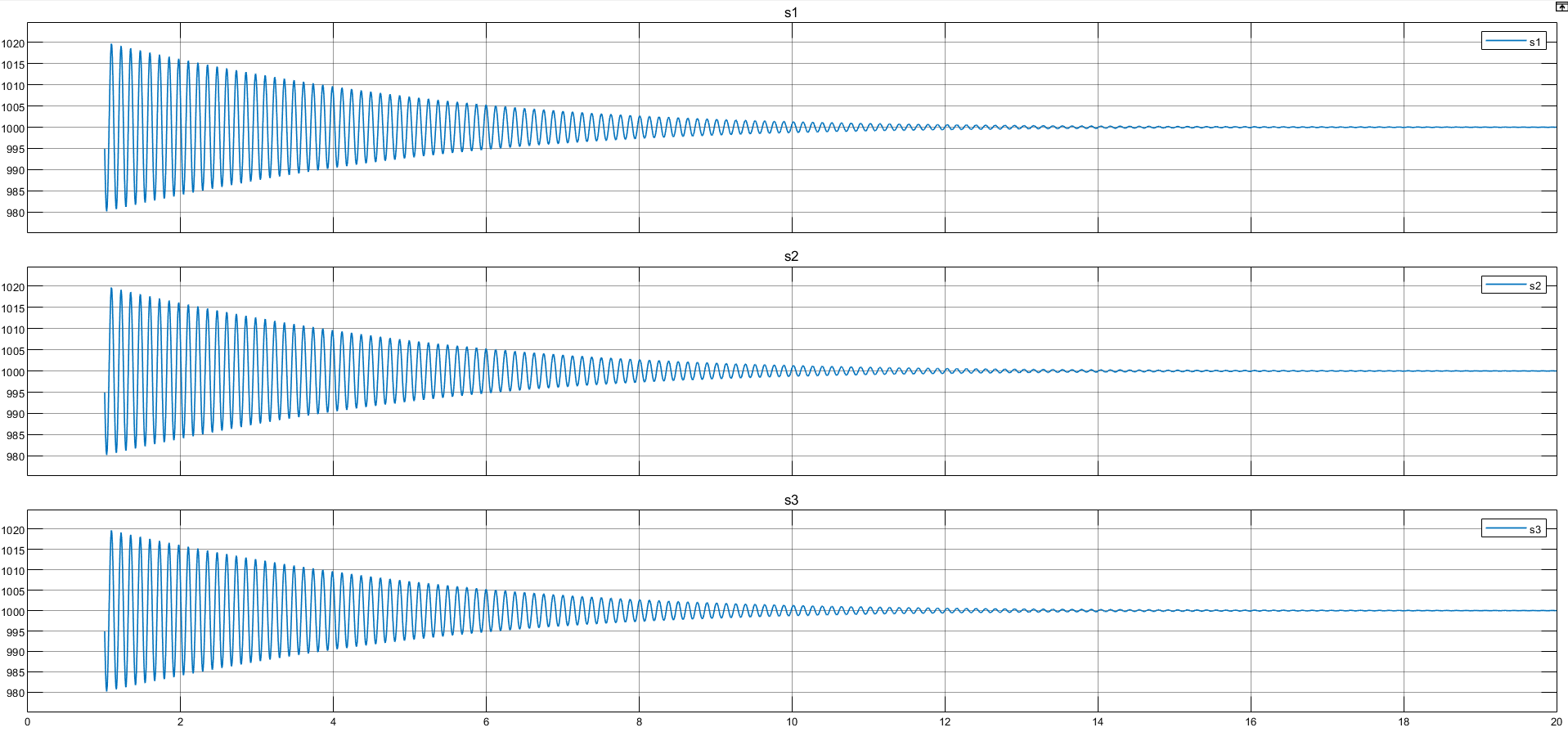
We need to estimate the value of using the control input and the three estimators i.e. .



**Fig.** Estimator Subsystem



**Fig.** Estimator Model with different observer for observing different outputs



**Fig.** Estimated value of from different observed quantities

In all the three cases, i.e. by observing the states , we can see the variation in the estimated value of . As evident from the three plots attached above, the value of oscillates and finally settles to its actual value i.e. .