Robotics and Intelligent Systems Lab II
Report 1

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Task 1.1. *Explain why Fig. 1.4 represents the model of a capacitor by writing down the equation it implements.*

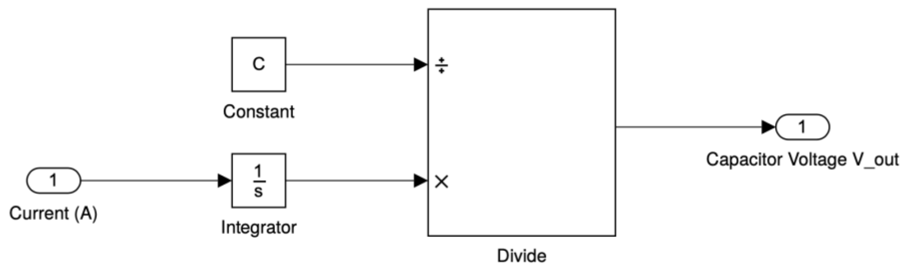


Figure 1.4: The capacitor subsytem.

Formulating the above given Figure to find its equation:

First the Current(I) is multiplied into time^{-1}(1/s) making it

$$\frac{I}{s}$$

Which is multiplied into the 'Divide' which has the standard set value of 1 so the equation remains the same. Next the Capacitance(C) is divided into the 'Divide' making it

$$\frac{I}{Cs}$$

Which equals to an output of Voltage(V) making the final equation to be

$$V = \frac{I}{Cs}$$

Now considering the formula of Capacitance i.e.,

$$\mathrm{C} = \frac{Q}{V}$$

Where Q(Coulomb) is the SI unit of electric charge, equal to the quantity of electricity conveyed in one second by a current of one ampere.

$$Q = \frac{I}{s}$$

After doing substitution,

$$C = \frac{(I/s)}{V}$$

$$C = \frac{I}{Vs}$$

After making Voltage the subject,

$$V = \frac{I}{Cs}$$

The similarity between these two equations conclude that Figure 1.4 represents the model of a capacitor.

Task 1.2. *Proceed as follows:*

- *What is the time-constant of this system? How can you see it in the plot? Change the simulation-time (in input field in the tool-ribbon) from the default 10.0 seconds to 5 times this time-constant.*

- *Run the system by pressing Ctrl+T or by clicking the run-button. Look at the output by double-clicking the scope.*

- *Now change the variables R and C in the workspace and re-run the simulation. Does the scope display change as expected?*

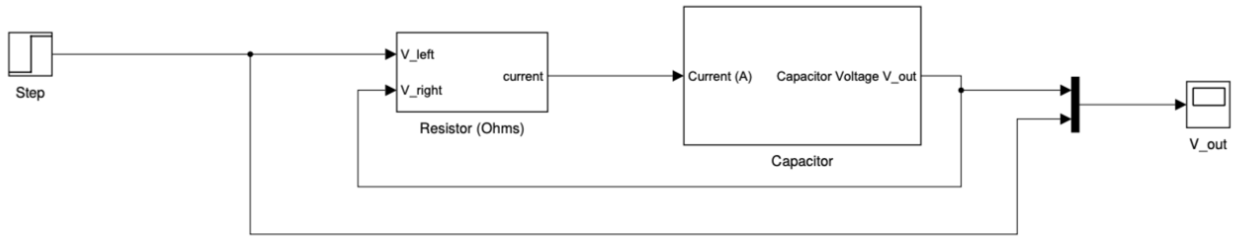


Figure 1.5: The RC circuit.

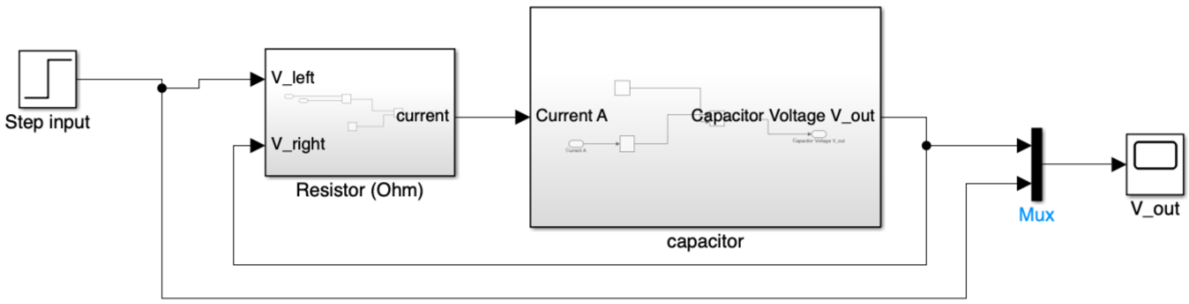


Figure A: MATLAB RC Circuit

In an RC circuit, the time constraint refers to the time it takes for the circuit to reach steady-state or to respond to a change in the input signal. The time constraint depends on the values of the resistance (R) and capacitance (C) components in the circuit.

The time constant (τ) is calculated as the product of the resistance and capacitance:

$$\tau = R \times C$$

By using the above given formula, we get,

$$\tau = (1 \times e^{6})(1 \times e^{-6})$$
$$\tau = 1 \times (e^{6} \times e^{-6})$$
$$\tau = 1$$

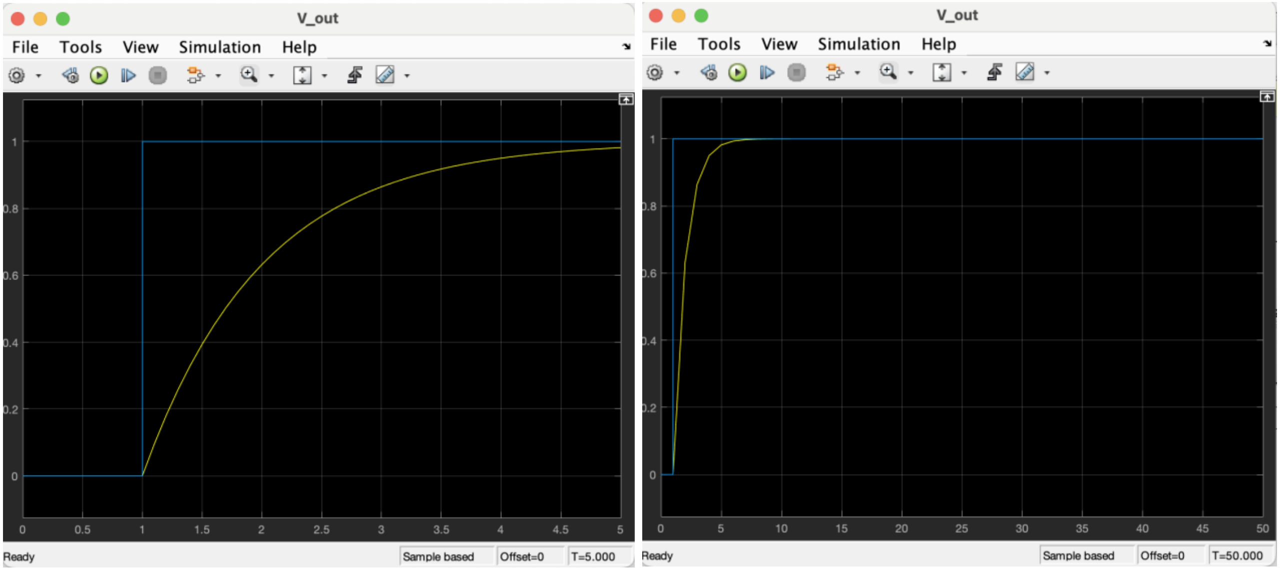
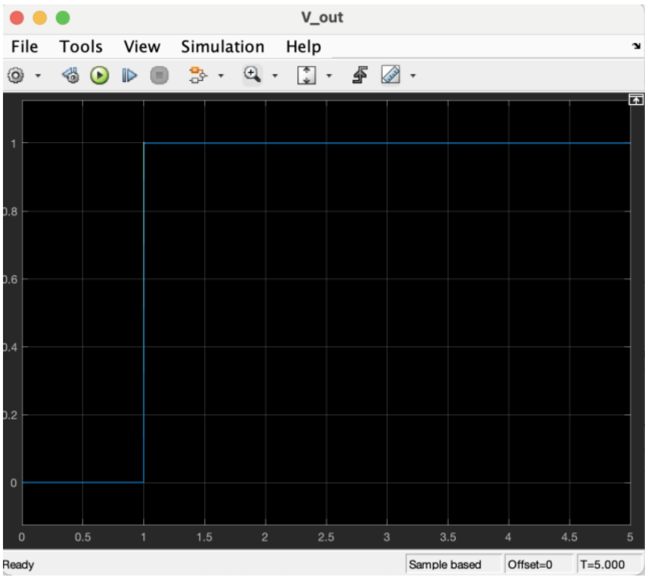


Figure B and C: Plot after changing the simulation-time to 5 seconds and 50 seconds

The time constraint can be seen in the plots above as after a certain time of charge the maximum voltage level will be reached which is 1.



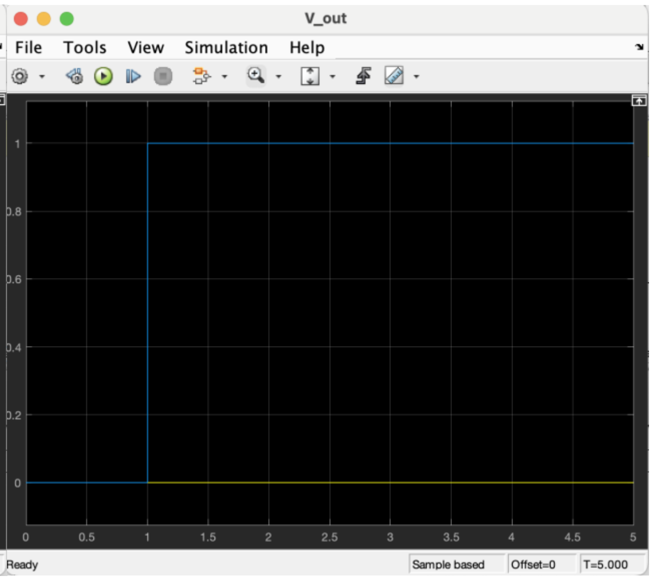


Figure D: C = 1.000 e^{-6}, R = 1

Figure E: C = 1, R = 1.000 e^{6}

The time constraint for Figure D is 0.000001, and Figure E is 1000000. Therefore, for Figure D the maximum voltage is reached very quickly and for Figure E it takes a very long time. The scope does display the changes accordingly.

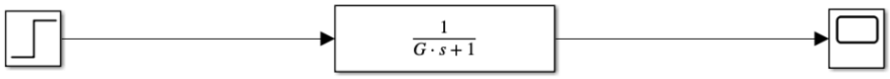


Figure F: MATLAB Transfer Function

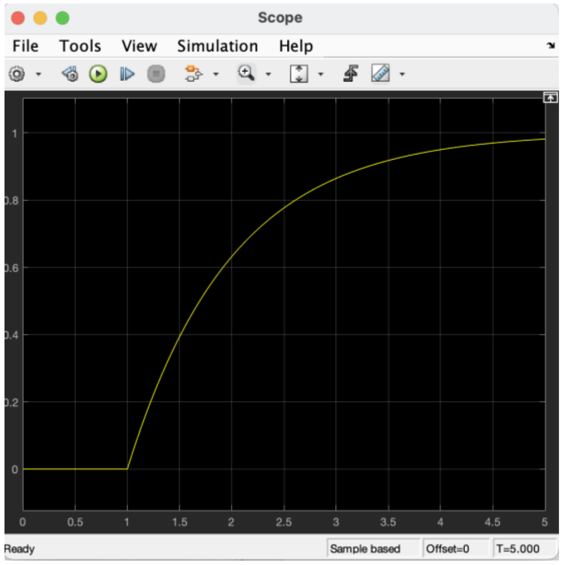


Figure G: Scope of the Transfer Function given in Figure F

We can see in the Scope of the Transfer Function given in Figure G, that it is similar to the one given in Figure B with the same simulation-time i.e., 5 seconds.

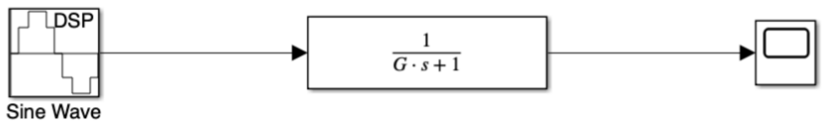


Figure H: sin input of 5V amplitude and 1Hz frequency, where G = RC

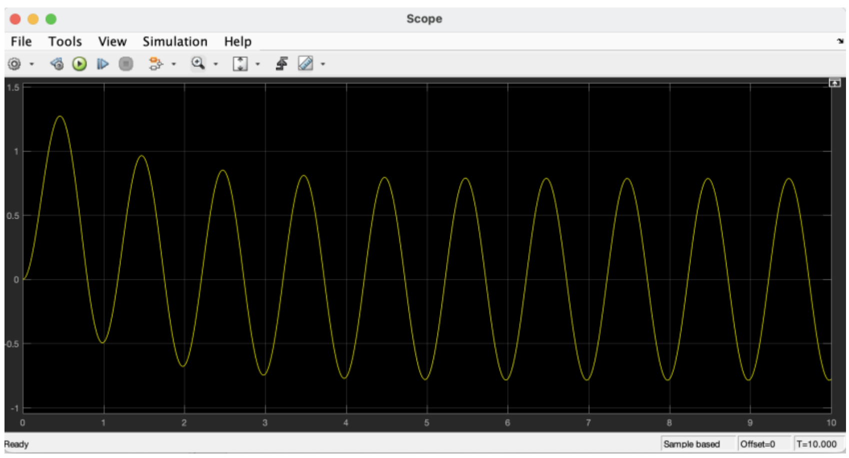


Figure I: the scope of the function given in Figure H

Task 1.3. *Answer the following:*

1. *How many seconds does it take for the initial transient to die off in the output response?*

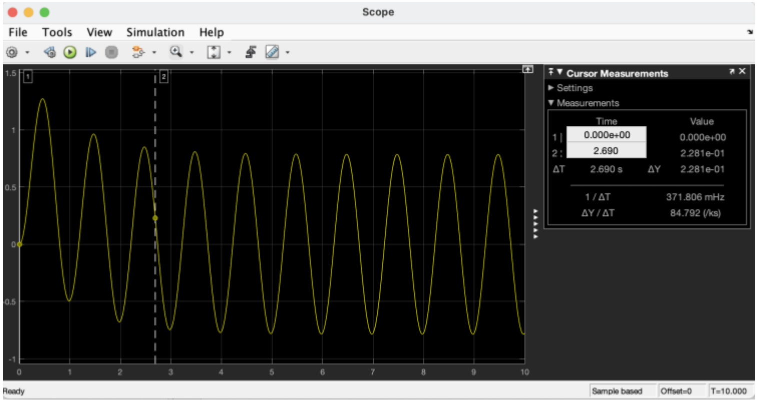


Figure J: the same scope as in Figure I but with Cursor Measurements

The interval between 1 and 2 is an initial transient, in which the process variables have been changed and the system has not yet reached a steady state. The time taken for the initial transient to die off is 2.690s with respect to a cursor measurement tool.

2. *What is the expected gain-ratio (ratio of output to input amplitudes) from theory? You can find this by replacing s by $j\omega$ in the transfer-function and evaluating $|H(j\omega)|$.*

Simplifying the function:

$$\frac{1}{G \cdot s + 1} = \frac{1}{RCs + 1} = \frac{1}{\left((1 \times e^{6})(1 \times e^{-6})\right)s + 1} = \frac{1}{s + 1}$$

Replacing s by $j\omega$ where (1Hz ≈ 6.28 rad/sec), so:

$$\frac{1}{j\omega \ + 1} = \frac{1}{6.28\omega + 1}$$

Now evaluating $|H(j\omega)|$:

$$|H(j\omega)| = \sqrt{real(H(j\omega))^2 + \ imaginary(H(j\omega))^2}$$

$$\frac{1}{6.28\omega + 1} = \frac{1}{6.28\omega + 1} \times \frac{1}{-6.28\omega + 1} = \frac{-6.28j + 1}{6.28 + 1}$$

$$|H(j\omega)| = \sqrt{\left(\frac{1}{6.28\omega + 1}\right)^2 + \ \left(\frac{-6.28}{6.28 + 1}\right)^2} \ = 0.15725$$

3. *Zoom in the scope to find the amplitude ratio of the output wave to the input wave. Is it as expected?*

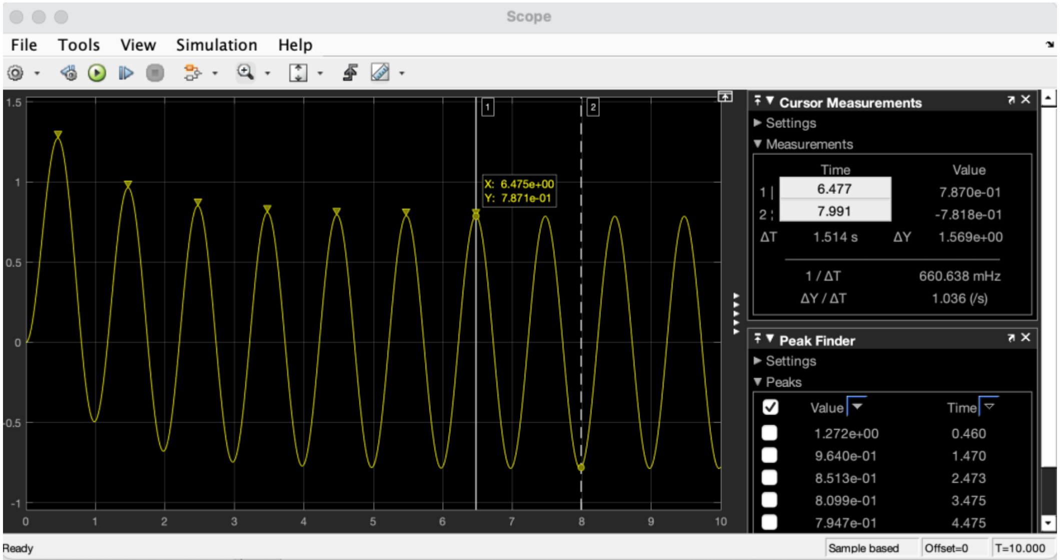


Figure K: zoomed in view of amplitude value

The amplitude can be computed in this way:

$$\frac{(Maxvalue - Minvalue)}{2}$$

$$\frac{(7.870 \times e^{-1}) - (-7.818 \times e^{-1})}{2} = 0.7844$$

The amplitude ratio can be computed this way:

$$\frac{Output\ wave\ amplitude}{Input\ wave\ amplitude}$$

$$\frac{0.7844}{5} = 0.15688$$

It is close to the expected value.