

EE 324 LAB 1

Introduction to Modeling Systems in MATLAB Simulink

In this lab you will familiarize yourselves with Simulink, derive common representations for seemingly unrelated systems, and simulate the system response to various inputs.

Please review and be familiar with the lab policies on the course webpage.

Prelab:

Before lab, familiarize yourself with Simulink. In Simulink Help go over the “Getting Started”, “Simulink Basics”, and “How Simulink Works”. Make sure you have a good understanding of Simulink Solvers, by reviewing “Simulating Dynamic Systems”.

In EE 224, you learned about various LTI systems. One such system is an integrator. The definition of an integrator is:

$$y(t) = \int_{-\infty}^t x(\tau) d\tau$$

Where $x(t)$ denotes an input that is integrable in time and $y(t)$ is the output.

For the prelab assignment:

1. Show that the integrator system is LTI and therefore it is characterized by its impulse response.
2. Verify that the integrator’s impulse response (response to an impulse input) is a unit step, which denoted by $u(t)$. Do the verification both analytically and by using Simulink with a block to approximate impulse and a scope block.
(Impulse may be approximated using the steps: $N \left[u(t) - u \left(t - \frac{1}{N} \right) \right]$, with $N \cong 10^6$).
3. Compute the Laplace transform of the integrator and show that it is $H(s) = \frac{1}{s}$. What is its region of convergence (read text)?

Laboratory Assignment:

1. Consider the circuit in Figure 1. First, derive the integro-differential equation associated with the circuit. Note that $i(t)$ is a current. The equation should relate $i(t)$ to the voltage, $v(t)$, across the components. The voltage has a time derivative, $\frac{dv}{dt}$, and a time integral, $\int_{-\infty}^t v(\tau) d\tau$.

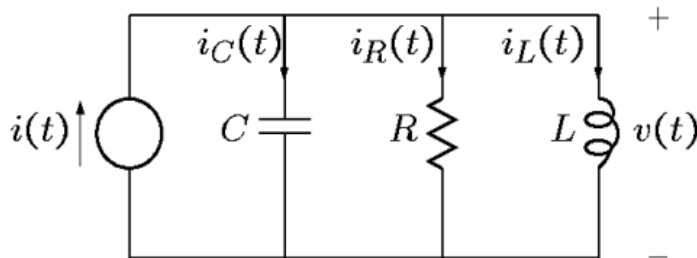


Figure 1 An Electrical System

2. Second, implement the block diagram for the integro-differential equation in Simulink. Note that $i(t)$ is the system input. A good way to derive the block diagram is to solve the equation for $\frac{dv}{dt}$, use an integration block to obtain $v(t)$ and another integration block to obtain $\int_{-\infty}^t v(\tau)d\tau$.
3. Thirdly, set the value of the resistor, capacitor, and inductor to the following: $R = 1\text{ k}\Omega$, $C = 1\text{ }\mu\text{F}$, and $L = 100\text{ mH}$. Place a scope to measure the voltage $v(t)$, and simulate the unit step response of the system. Include, in your report, the plot of the step response in an appropriate scale. You may need to change the simulation parameters to get better plots.
4. Fourthly, change the value of R to $1\text{ M}\Omega$. What do you observe about the step response in this case as compared to the previous one?

To verify that different systems can have the same block diagram, consider the mechanical system in Figure 2. Here, the input is the force $f(t)$. Write the integro-differential equation relating $f(t)$ to the mass velocity, $v(t)$, acceleration (its derivative), and position (its integral). Note that the inertial force is $M\frac{dv}{dt}$, the spring force is $K\int_{-\infty}^t v(\tau)d\tau$, and the viscous drag force is $Bv(t)$.

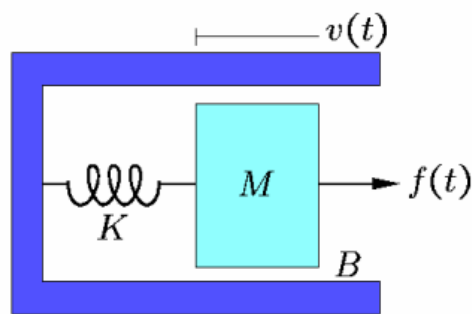


Figure 2 A Mechanical System

Compare the two equations and derive the relation between M , K , and B of the mechanical system with R , L , and C of the electrical system.

Print and report the block diagram of the mechanical system, when $M = 1\text{ kg}$, $B = 0.1\frac{\text{Ns}}{\text{m}}$, and $K = 1\text{ N/m}$. Also simulate and plot its step-response.

$$\text{KCL: } i = C \frac{dv}{dt} + \frac{v}{R} + \frac{1}{L} \int_{-\infty}^t v(\tau) d\tau \Leftrightarrow C \frac{d^2v}{dt^2} + \frac{1}{R} \frac{dv}{dt} + \frac{1}{L} v = \frac{di}{dt} \equiv \left[\sum_{j=0}^n a_j \frac{d^j y}{dt^j} = \sum_{j=0}^n b_j \frac{d^j x}{dt^j} \right]$$

