Lab 4: Time domain convolution

Preamble

Associated Class Notes

This lab supports the materials covered in Chapter 3.5 The Impulse Response and Convolution (https://cpjobling.github.io/eg-247-textbook/laplace_transform/5/convolution) of the course notes. You may wish to refer to worksheet 8 (https://cpjobling.github.io/eg-247-textbook/worksheets/worksheet8) for additional examples to try.

Other formats

This document is available in HTML (https://cpjobling.github.io/eg-247-textbook/labs/lab04/index) format for online viewing PDF (https://cpjobling.github.io/eg-247-textbook/labs/lab04/lab04.pdf) for printing.

Acknowledgements

These examples have been adapted from Chapter 6 of Stephen Karris, Signals and Systems : With MATLAB Computing and Simulink Modeling (5th Edition) (http://site.ebrary.com/lib/swansea/docDetail.action?docID=10547416)

Matlab/Simulink Concepts Introduced

In this lab you will:

- Explore convolution with the aid of an interactive MATLAB "app"
- Use the `int` and `heaviside` functions from the **Symbolic Toolbox** to perform symbolic computation of convolution integrals.
- Use `laplace` and `ilaplace` to solve convolution problems.
- Use `ezplot` to plot symbolic functions.

Assessment criteria

This will be a self-assessed exercise.

Marks can be claimed according to how many of the parts of Lab Exercises 7 and 8 have been completed.

Detailed marking criteria for this and the other labs and the project are given in the linked Assessment Criteria (https://docs.google.com/spreadsheets/d/1EQzwSfGMdw8oiQds4bUR8sZTCgb2IMv 8hW4/edit?usp=sharing) [Google sheet].

Setup

Before you start

If you haven't already, create a suitable folder structure on your file-store for your labs.

I suggest

```
P:\workspace
    signals-and-systems-lab
        lab01
        lab02
        lab03
        lab04
        :
```

Use folder `p:\workspace\signals-and-systems-lab\lab04` for this lab.

Preparation

Before we start today's lab you will need to download and install the [Graphical demonstration of convolution app (https://github.com/cpjobling/eg-247-textbook/blob/master/content/laplace_transform/matlab/convolution_demo/convolut](https://github.com/cpjobling/eg-247-textbook/blob/master/content/laplace_transform/matlab/convolution_demo/convolut) from the GitHub respository for this module.

To install, right-click button of link as appropriate and save as to your `lab04` folder.

Open and run `convolutiondemo.m`.

If MATLAB issues a message about the need to change the working directory or add a folder to the MATLAB path. Accept the choice given.

Lab Exercises

Lab Exercise 7: Graphical Demonstration of Convolution

In this lab exercise we will use the `convolutiondemo` app demonstrated in class as an aid to understanding and setting up the convolution integral for various systems including the step-response of an RL circuit.

Part 1

Set up the `convolutiondemo` app as described in the notes for the computation of the Convolution Integral for Example 6.4 from the textbook illustrated below. (Refer to Example 2 in the notes (https://cpjobling.github.io/eg-247-textbook/laplace_transform/5/convolution) for the MATLAB settings).

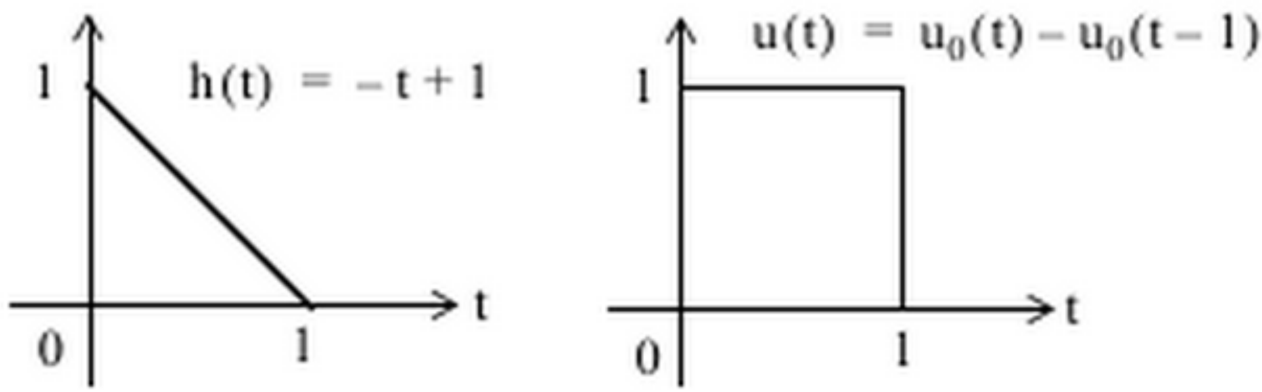

Figure 6.6. Signals for Example 6.4

Use the tool to confirm the convolution result given by this MATLAB script: exercise7.m (exercise7.m).

Part 2

Taking the script exercise7.m (exercise7.m) as a model. Use the `convolutiondemo` tool as an aid to defining the integration limits needed to find and plot the convolution integral for the example shown below (Example 6.5 from the textbook).

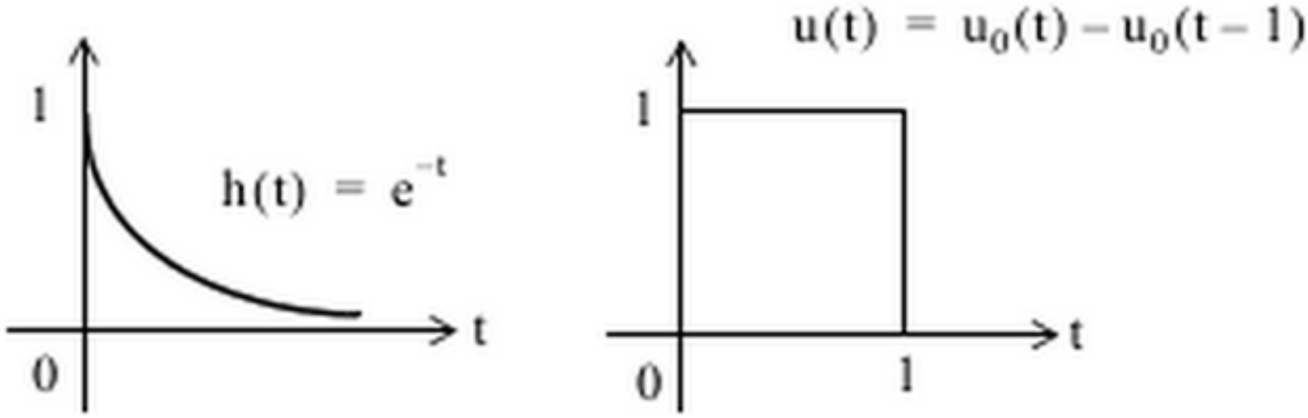

Figure 6.16. Signals for Example 6.5

Part 3

Repeat the procedure for example 6.6 from the textbook.

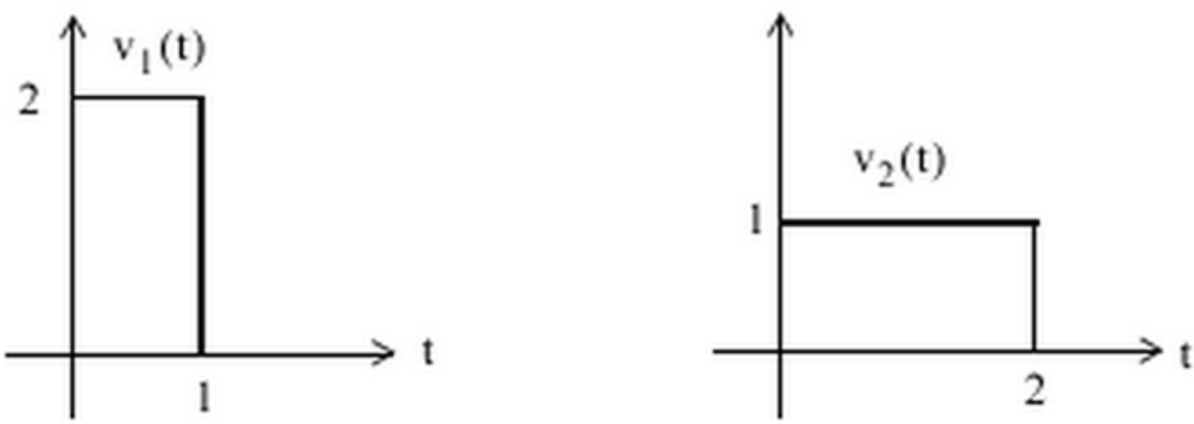

Figure 6.25. Signals for Example 6.6

Part 4

Adapt your procedure to determine the step response of the RC circuit given as Example 6.7 in the textbook.

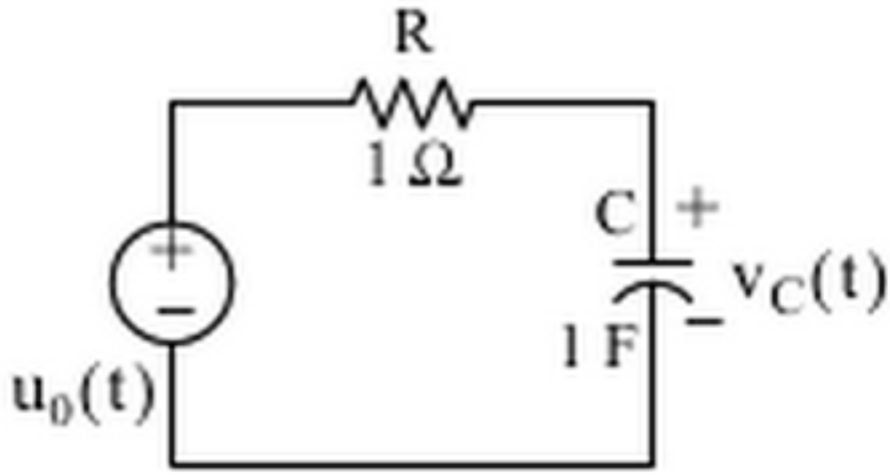

Figure 6.31. Circuit for Example 6.7

Note, Parts 2 to 5 should be done in the same Live Script file as the provided Part 1 example. Separate each exercise by titled sections. Don't forget to add explanatory text to document your work.

Lab Exercise 8: Using Laplace to Solve Convolution Problems

In this lab exercise we will demonstrate that time-convolution of a system response can be solved in the complex frequency domain using Laplace and Inverse Laplace transforms.

- Use the inverse Laplace transform function `ilaplace` to solve the step response of the RC circuit given in exercise 7 Part 4 without convolution. You will need the Laplace transform of the circuit's impulse response $h(t)$ and the unit step $u_0(t)$ (MATLAB `heaviside`).
- Plot the result using `ezplot`
- Confirm the result with a Simulink simulation

What to hand in

Claim

Up to 2 marks can be claimed if you complete Part 2 of Exercise 7, an additional 2 marks for is available for Parts 3 and 4 and 1 additional mark is available for completing Lab Exercise 8.

Submission

You should submit the following to the **Lab 04: Time domain convolution** Assignment on Canvas.

1. Complete the labwork self-assessment claim form and declaration.
2. As evidence of completion of Lab Exercise 7, you should upload `ex7_2.mlx`, `ex7_3.mlx`, `ex7_4.mlx` (can be sections in one Live Script `ex7.mlx`).
3. As evidence of completion of Lab Exercise 8, you should upload `ex8.mlx`, `ex8.slx`.

Deadline

The deadline for claims and submission is **4:00 pm, 20th March**