## 6.6 MATLAB Laboratory Experiments on Convolution

**Purpose:** In this section we design two experiments dealing with continuous- and discrete-time convolutions and their applications to linear continuous- and discrete-time dynamic systems. The purpose of the first experiment is to present the convolution operator, and to demonstrate some of its properties in both continuous- and discrete-time domains. By writing and modifying the corresponding MATLAB programs, students will master every step of the convolution process. In the second experiment, the convolution method will be used to determine the zero-state responses of both continuous- and discrete-time linear dynamic systems by using the famous formula that states that *the response of a linear system at rest due to an arbitrary input is the convolution of that input with the system impulse response*.

## 6.6.2. Convolution for Linear Dynamic Systems

In this experiment, students are required to use the convolution operator to find the system zero-state response for both continuous- and discrete-time linear dynamic systems. MATLAB programs developed for the convolution of two signals in the previous experiment can be used in this experiment, subject to minor modifications.

**Part 1.** Continuous-Time Systems

The output of a linear continuous-time system at rest due to any input $f(t)$ is given by the convolution formula

$$y_{zs}(t) = \int_0^t f(\tau)h(t-\tau)d\tau \tag{6.33}$$

Consider the continuous-time system at rest represented by the differential equation

$$\ddot{y}(t) + 4\dot{y}(t) + 3y(t) = \dot{f}(t) + 5f(t)$$

Take $t = 5\,\mathrm{s}$ and discretize integral (6.33) as given in (6.31) with $T = 0.1$. Use MATLAB and the convolution procedure to find and plot

**(a)** the impulse response of the system;

**(b)** the step response of the system; and

**(c)** the system zero-state response due to the input $\sin(2t)$.

For (b) and (c) use the MATLAB program from Section 6.5.

Verify the results obtained by using the MATLAB functions `step` and `lsim`.

**Part 2.** Discrete-Time Systems

Consider the discrete-time system represented by the difference equation

$$y[k+2] - 0.5y[k+1] + 0.06y[k] = f[k+1] - 4f[k]$$

Use the convolution technique and MATLAB to find and plot

**(a)** the impulse response of the system;

**(b)** the step response of the system;

**(c)** the zero state response to the input $\sin(2k)$.

Plot the zero-state responses during the first ten discrete-time instants. Verify the results using the MATLAB functions `dstep` and `dlsim`. Submit all plots and comment on the results obtained.

SUPPLEMENT:

$$f_1(kT) * f_2(kT) \approx T \sum_{i=k_0}^{k} f_1(iT) f_2[(k-i)T] \tag{6.31}$$