2.4 MATLAB Laboratory Experiment on Signals

Purpose: This experiment introduces the graphical representation of common signals used in linear systems. Time shifting, time scaling, signal addition, and signal multiplication will also be demonstrated. It is important to emphasize that signals are mathematical functions—thus, the signal operations given in the following are known from calculus.

Part 1. Use MATLAB to plot the following continuous-time signals in the time interval $t \in [-10 \ \ 10]$.

1. $u(t)$ (unit step signal), $u(t-3),\ u(t-5)$.

2. $p_6(t)$ (unit rectangular pulse), $p_6(t-3), p_6(t+5)$.

3. $r(t)$ (unit ramp signal), $r(t-3),\ r(t+5)$

4. $\Delta_4(t)$ (unit triangular pulse), $\Delta_4(t-3),\ \Delta_4(t+5)$.

Part 2. Plot approximations of the impulse delta signal and the sinc signal.

5. Plot an approximation for $\delta(t)$ (impulse delta signal). *Hint:* $\delta(t)$ can be approximated by a rectangular pulse of width τ and amplitude $1/\tau$ when $\tau \to 0$. Take $\tau = 0.3, 0.2, 0.1$.

6. Use $\text{sinc}(t) = \sin(\pi t)/\pi t$ with `t=-5:0.1:5`; `t=-15:0.1:15`; `t=-30:0.1:30`. The sinc signal can be obtained as $\text{sinc}(t) = \sin(\pi t)./\pi t$. (Note that the operation ./ stands for pointwise division.) MATLAB also has the built-in function `sinc`. To get information about any MATLAB function, type `help function name`; in this case type `help sinc`.

Part 3. In this part, we demonstrate time scaling and time shifting operations. Plot the signals given in the following. Take `t=0:0.1:6.28`.

7. $y_1(t) = \sin(t), y_2(t) = \sin(2t), y_3(t) = \sin(5t)$. Plot all three signals in the same figure. Use `plot(t,y1,'o',t,y2,'-',t,y3)`.

8. $\sin(4(t-1))$, $\sin(2t-3)$. Explain the figures obtained in (7) and (8).

9. $e^{-at}\sin(at)$ for $a = 0.5, 1, 5$. Use .* as pointwise multiplication. Comment on the effect of time scaling.

Part 4. Some signal operations. Plot the following signals.

10. $u(t) + r(t)$.

11. $p_2(t) + \Delta_3(t)$.

12. $\cos(5t + \sin(2t))$. Expand the time axis such that it includes one signal period.

Part 5. Calculate and plot the following discrete-time signals.

13. $u[k-1],\ r[k+2]$.

14. $r[-k-1] * u[k-2]$

15. $(-0.5)^k u[k-2] * u[-k+10]$.

Submit a report composed of fifteen figures for fifteen problems and, where required, comment on the results obtained.