University of Dublin, Trinity College

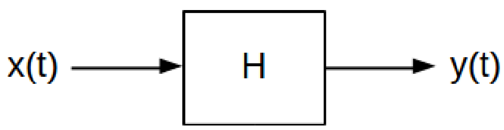
JS Engineering: 3C1 Signals & Systems

S1: LTI Systems

Author:
Edmond O'Flynn 12304742

Lecturer:
William Dowling

November 24, 2015



Contents

1 Abstract

2 Matlab

In this laboratory, the scripting language *Matlab* was used which gets compiled at its runtime. This makes for a language that is great for rapid-prototyping and extensive functionality within arithmetic, graphing, and graphical user interfaces. During this report, Matlab code snippets will be occasionally shown.

3 Signals

3.1 Deterministic Sine Wave Signals

3.1.1 Plotting the Sine Wave x_1

- Generate a deterministic signal $x_1 = 3sin(5t)$ over the range $0 \leq t \leq 6$ seconds.

```
t = (0:0.01:6); % range 0-6 with steps of 0.01s
x1 = 3 * sin(5 * t);
figure(1); plot(t,x1);
title('Sine Wave Seconds v Voltages');
xlabel('Seconds (s)'); ylabel('Volts (V)');
```

3.1.2 Properties

- Voltage extrema
  - Maximum: 3V
  - Minimum: -3V
- Frequency
  - 1.256s for 1 oscillation
  - $\frac{1}{1.256} \approx 0.796$Hz
  - Also determined from $\frac{5}{2\pi}$, where 5 refers to the factor before t, which also results in 0.796 Hz
- Periodicity
  - Time for one cycle of the wave is 1.256s.

3.1.3 Expanding to x_2

- Generate a deterministic signal $x_2 = Asin(\omega_1 t + \phi)$ over the range $0 \leq t \leq 6$ seconds.

```
w1 = 5;
phi = -3;
A = 3;
x2 = A * sin(w1 * t + phi);
hold on;plot(t,x2,'r');title('Sine Wave Seconds v Voltages');
xlabel('Seconds (s)');ylabel('Volts (V)');
```

Note that the same plot is overlaid using the hold on command for the plot given a previous one.

3.1.4 Properties

- Frequency
  - 1.256s for 1 oscillation
  - $\frac{1}{1.256} \approx 0.796$Hz
  - Also determined from $\frac{5}{2\pi}$, where 5 refers to the factor before t, which also results in 0.796 Hz
- Periodicity
  - Time for one cycle of the wave is 1.256s.
- Differences between x_1 and x_2
  - x_1 is a regular sine wave that has no offsets or lags. x_2 however, is offset such that it has almost become inverted. They two signals share the same amplitude and frequency.
- Is there a phase lag?
  - Yes there is. x_2 contains a lag ϕ that is not present in x_1.
- Is this a delay or an advance?
  - This is a delay with respect to x_1.

3.1.5 Delay

Between x_2 and x_1, there is about 0.657s lag time. I picked one point common to both signals (-3V), and recorded the difference in time between the two signals to reach this.

3.1.6 Expanding Further to x_3

- Generate a deterministic signal $x_3 = Asin(\omega_1 t + \phi)$ over the range $0 \leq t \leq 6$ seconds.

```
w1 = 5;
phi = -3 + (2 * 3.14);
A = 3;
x3 = A * sin(w1 * t + phi);
hold on;plot(t,x3,'r');title('Sine Wave Seconds v Voltages');
xlabel('Seconds (s)');ylabel('Volts (V)');
```

3.1.7 Properties

The function generated by x_3 is identical to x_2. The only difference is that x_3 has been shifted by 2π.

4 Linear Time Invariant Systems

4.1 LTI Systems

4.2 Discussion

4.3 Results

4.4 Gain & Phase as a Function of a Frequency

5 Discussion

1. What does frequency and phase mean with respect to a pure sinusoidal signal?
2. How does an LTI system affect a pure sinosoid?
3. What is the definition of an LTI system?
4. What do the terms *phase shift* and *gain* mean?
5. How are the step and impulse response of system characterised?

6 Bibliography

References

[1] Ben G. Streetman & Sanjay Kumar Banerjee, *Solid State Electronic Devices, 6th edition*, Prentice Hall (2006), Pages 154-388.