Modified TLH

DSP First, 2/e

Lecture Chapter 5

FIR Filtering Intro

Impulse response

PRESENTATION 2

SIGNALS USED TO CHARACTERIZE A SYSTEM

- Signals
  - Sinuoidal signals
  - Exponential signals
  - Complex exponential signals
  - Unit step and unit ramp
  - Impulse functions

SPECIAL INPUT SIGNALS

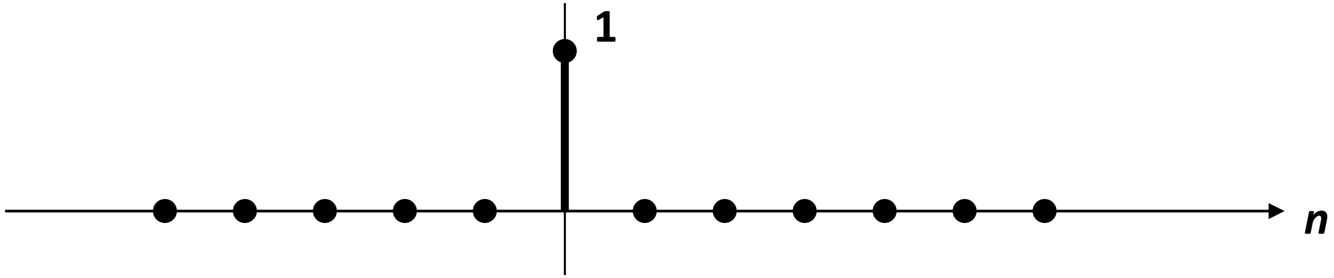
Another Test Signal

- x[n] = SINUSOID
- x[n] has only one NON-ZERO VALUE

FREQUENCY RESPONSE (LATER)

$$\delta[n] = \begin{cases} 1 & n = 0 \\ 0 & n \neq 0 \end{cases}$$

UNIT-IMPULSE



UNIT IMPULSE SIGNAL **δ[n]**

n	...	−2	−1	0	1	2	3	4	5	6	...
$\delta[n]$	0	0	0	1	0	0	0	0	0	0	0
$\delta[n-3]$	0	0	0	0	0	0	1	0	0	0	0

$n = 3$

δ[n] is NON-ZERO When its argument is equal to ZERO

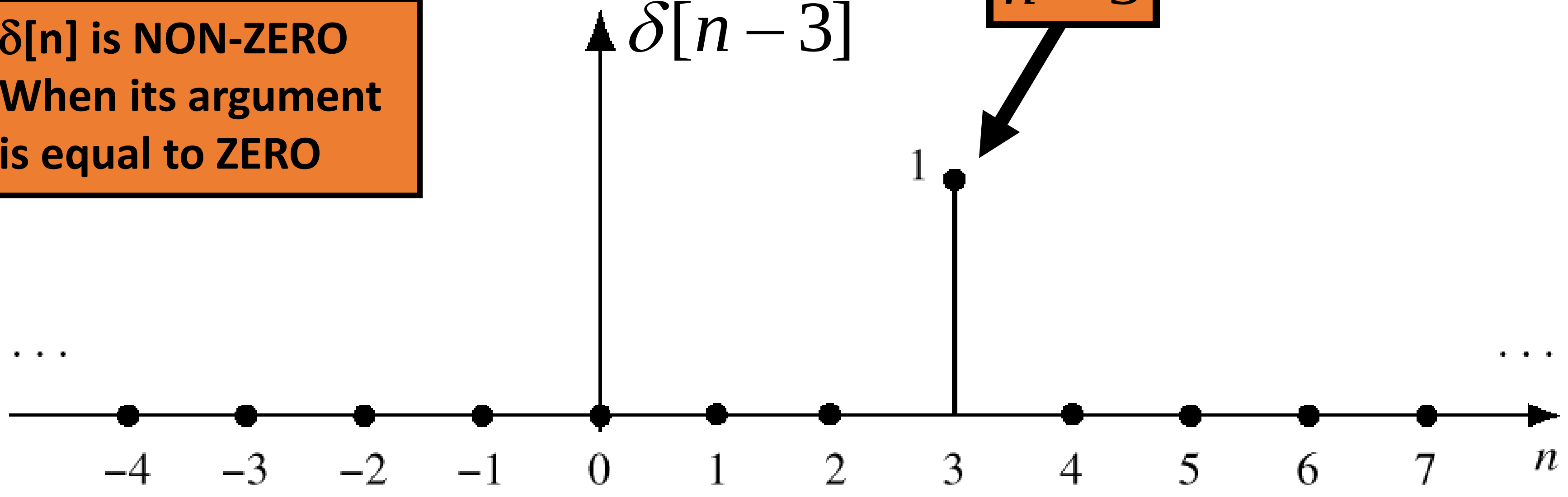
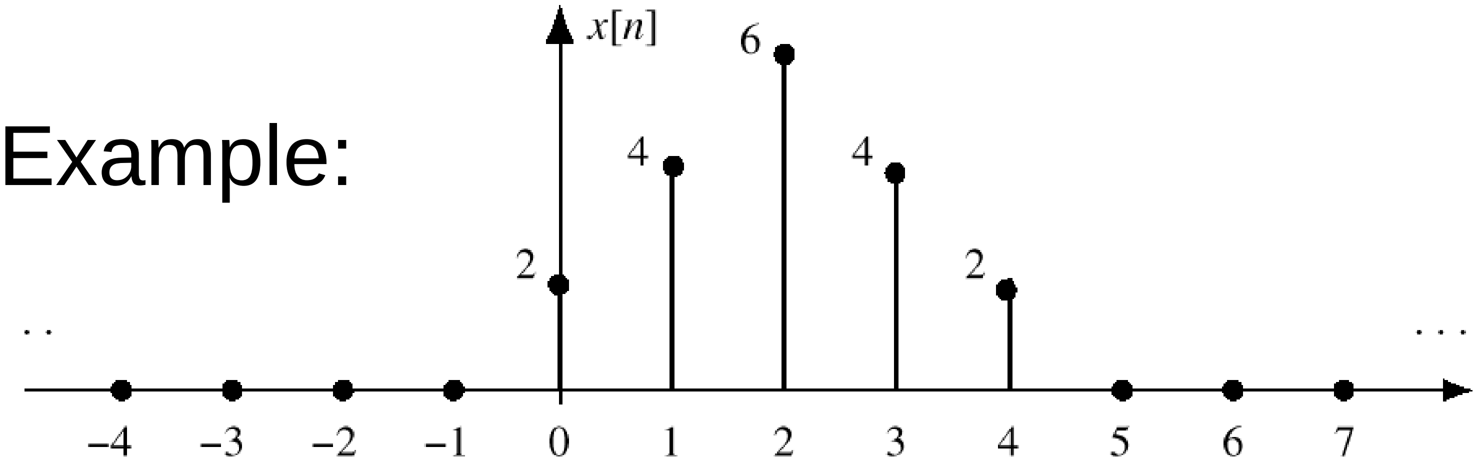


Figure 5.7 Shifted impulse sequence, $\delta[n-3]$.

Sequence Representation **TO GIVE MATHEMATICAL FORMULA FOR AMPLITUDE VALUES**

Example:



$$x[n=0]=x[0]=2 \qquad x[n=1]=x[1]=4$$

$$x[n=2]=x[2]=6 \qquad x[n=3]=x[3]=4$$

JUST NUMBERS

$$x[n]=\cdots+\ \mathbf{0}\ \delta[n+1]+\ \mathbf{2}\ \delta[n]+\ \mathbf{4}\ \delta[n-1]$$

$$+\ \mathbf{6}\ \delta[n-2]+\mathbf{4}\ \delta[n-3]+\cdots$$

AN EQUATION

FIR IMPULSE RESPONSE

h[n] CHARACTERIZES THE SYSTEM

$$y[n] = \sum_{k=0}^{M} b_k x[n-k]$$

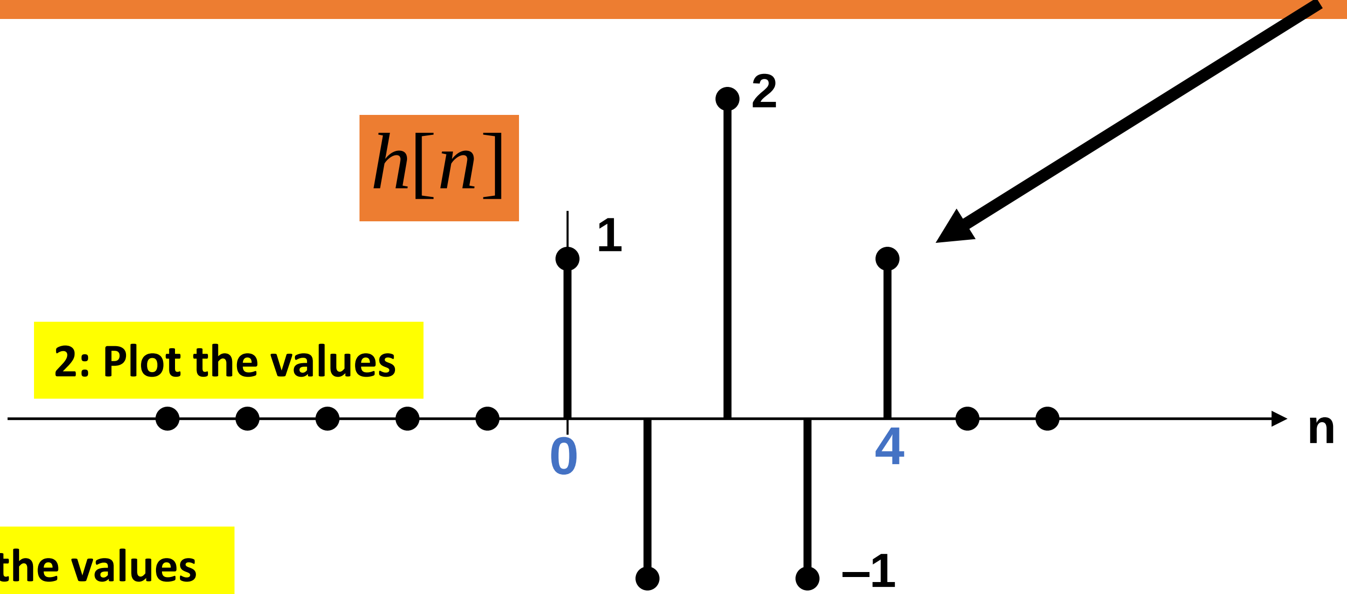
$$h[n] = \sum_{k=0}^{M} b_k \delta[n-k]$$

n	$n < 0$	0	1	2	3	$\ldots$	M	$M+1$	$n > M+1$
$x[n] = \delta[n]$	0	1	0	0	0	0	0	0	0
$y[n] = h[n]$	0	b_0	b_1	b_2	b_3	$\ldots$	b_M	0	0

3 Ways to Represent the FIR filter

1 Use SHIFTED IMPULSES to write $\boldsymbol{h[n]}$

$$h[n] = \delta[n] - \delta[n-1] + 2\delta[n-2] - \delta[n-3] + \delta[n-4]$$



2: Plot the values

3: List the values

$$b_k = \{\, 1, -1, 2, -1, 1 \,\}$$

True for any signal, x[n]

FILTERING EXAMPLE

- 7-point AVERAGER
  - Removes cosine
    - By making its amplitude (A) smaller

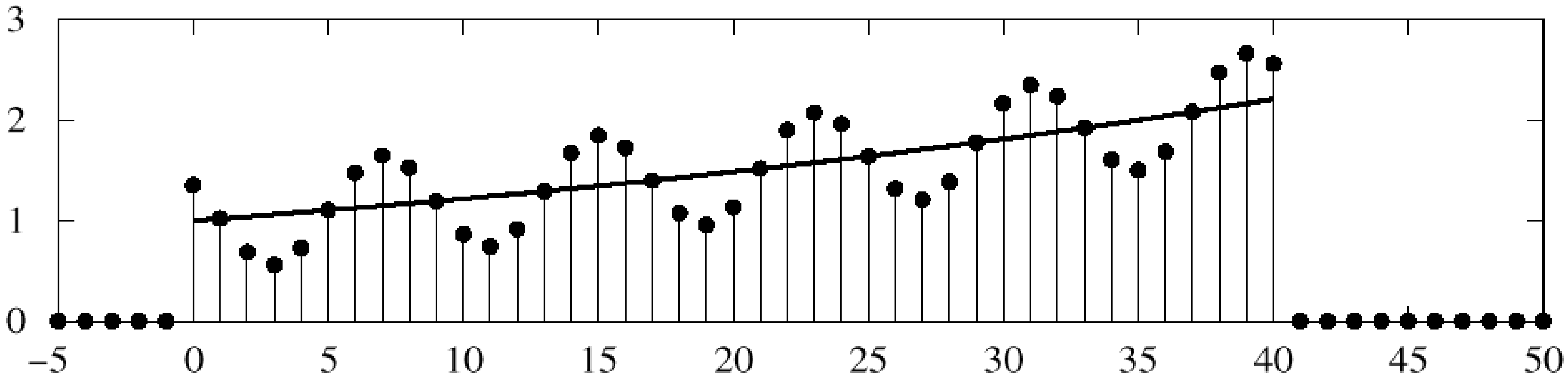
$$y_7[n] = \sum_{k=0}^{6} \left(\tfrac{1}{7}\right) x[n-k]$$

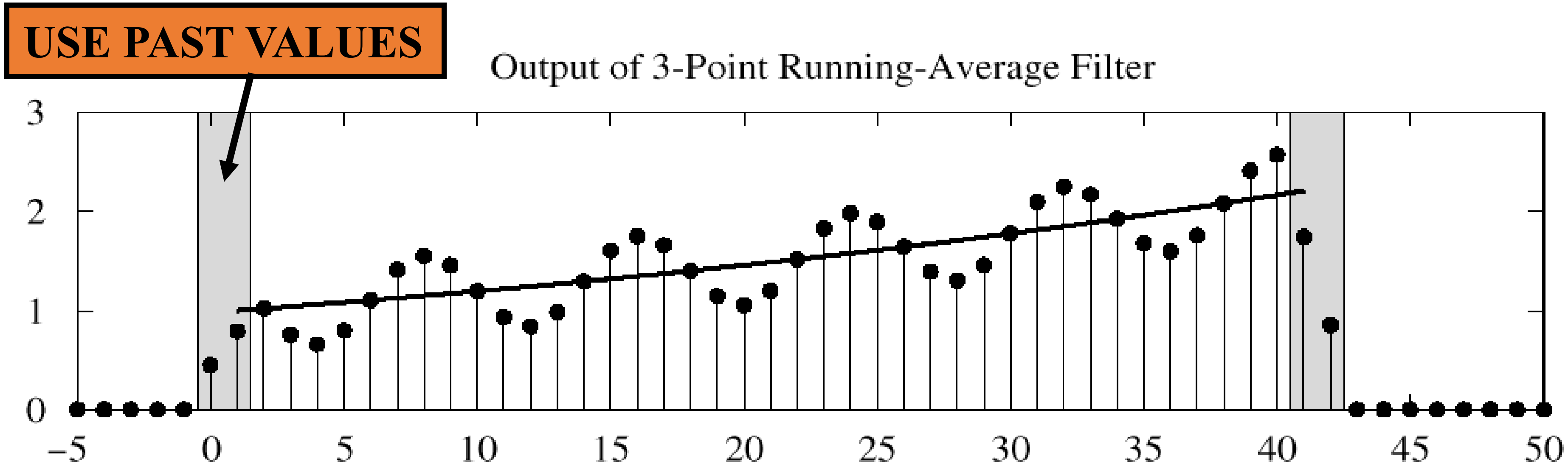
- 3-point AVERAGER
  - Changes A slightly

$$y_3[n] = \sum_{k=0}^{2} \left(\tfrac{1}{3}\right) x[n-k]$$

3-pt AVG EXAMPLE

$$\text{Input}: x[n] = (1.02)^n + \cos(2\pi n/8 + \pi/4) \quad \text{for } 0 \le n \le 40$$





7-pt FIR EXAMPLE (AVG)

$$\text{Input}: x[n] = (1.02)^n + \cos(2\pi n/8 + \pi/4) \quad \text{for } 0 \le n \le 40$$