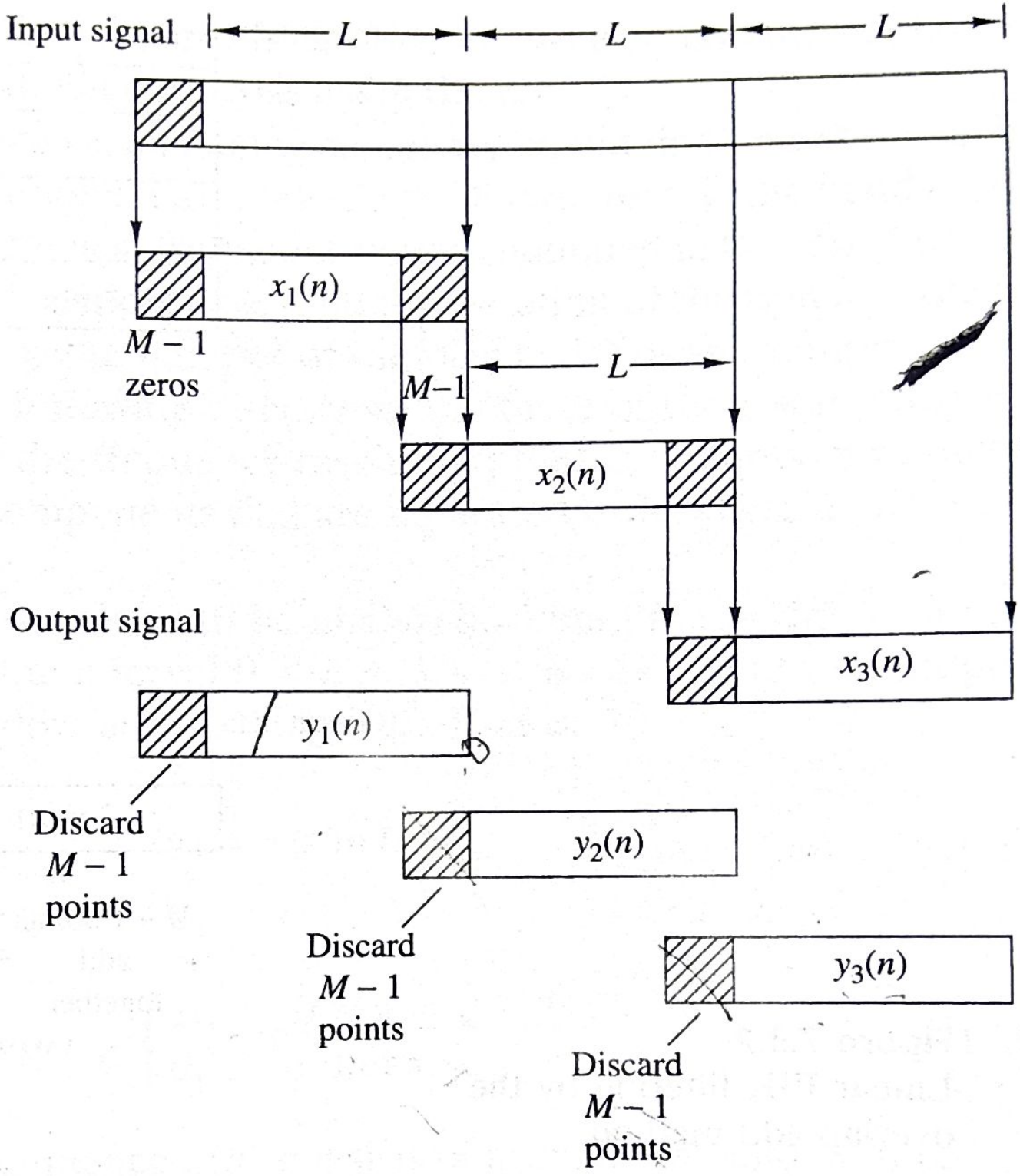
Filtering of Long data sequences
(Block convolution)
(Sectional convolution)

- Practical application involving linear filtering input sequence $x(n)$ is often a very long sequence ($L >> M$)
- due to limited memory of a digital computer i/p must be segmented into fixed size block.
- Each block is processed by DFT-IDFT to form circular convolution; and o/p blocks are filled together to form the overall output signal sequence.

The two method

① overlap - save method

② overlap - add method.


Input signal
L
L
L
$x_1(n)$
$M-1$
zeros
$M-1$
L
$x_2(n)$
$x_3(n)$
Output signal
$y_1(n)$
Discard
$M-1$
points
$y_2(n)$
Discard
$M-1$
points
$y_3(n)$
Discard
$M-1$
points

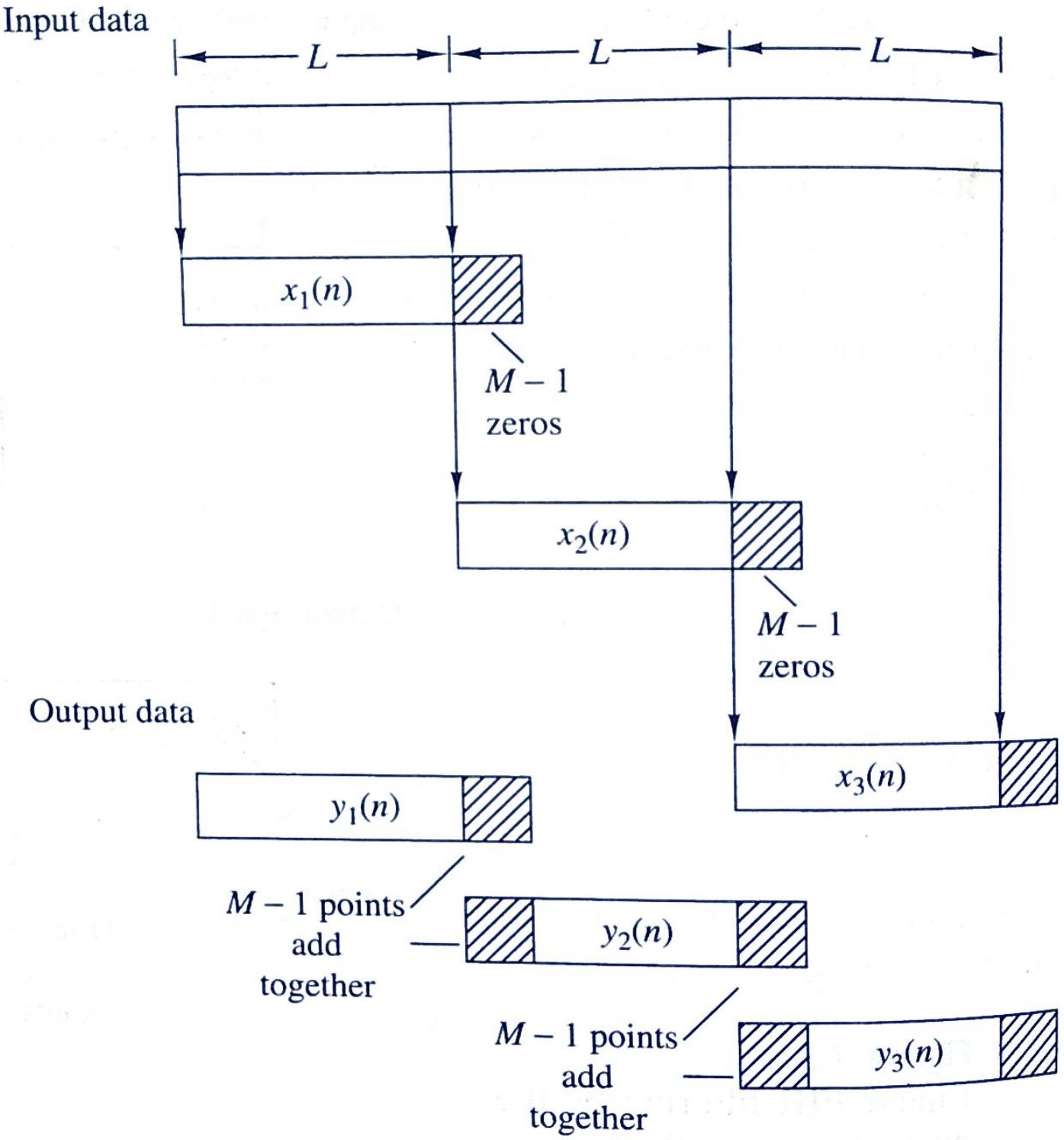


Figure 7.3.2
Linear FIR filtering by the overlap-add method.

Example 3.20 Find the output $y(n)$ of a filter whose impulse response is $h(n) = \{1, 1, 1\}$ and input signal $x(n) = \{3, -1, 0, 1, 3, 2, 0, 1, 2, 1\}$ using (i) overlap-save method (ii) overlap-add method. (Annamalai Unverisity Apr' 03)

Solution

(i) Overlap-save Method

The input sequence can be divided into blocks of data as follows.

$$x_1(n) = \underbrace{\{0, 0}_{M-1=2 \text{ Zeros}} \quad \underbrace{3, -1, 0\}}_{L=3 \text{ data points}}$$

$$x_2(n) = \underbrace{\{-1, 0,}_{\substack{\text{Two datas} \\ \text{from previous} \\ \text{block}}} \quad \underbrace{1, 3, 2\}}_{\substack{\text{3new} \\ \text{data points}}}$$

$x_3(n) = \{3, 2, 0, 1, 2\}$ and $x_4(n) = \{1, 2, 1, 0, 0\}$

given $h(n) = \{1, 1, 1\}$

Increase the length of the sequence to $L + M - 1 = 5$ by adding two zeros.

i.e. $h(n) = \{1, 1, 1, 0, 0\}$

$$y_1(n) = x_1(n) \textcircled{N} h(n) = \{-1, 0, 3, 2, 2\}$$

$$y_2(n) = x_2(n) \textcircled{N} h(n) = \{4, 1, 0, 4, 6\}$$

$$y_3(n) = x_3(n) \textcircled{N} h(n) = \{6, 7, 5, 3, 3\}$$

$$y_4(n) = x_4(n) \textcircled{N} h(n) = \{1, 3, 4, 3, 1\}$$

Note: Circular convolution of the sequences left as an exercise to the students.

$\underbrace{-1, 0, 3, 2, 2}_{\text{discard}}$

$\underbrace{4, 1, 0, 4, 6}_{\text{discard}}$

$\underbrace{6, 7, 5, 3, 3}_{\text{discard}}$

$\underbrace{1, 3, 4, 3, 1}_{\text{discard}}$

$$y(n) = \{3, 2, 2, 0, 4, 6, 5, 3, 3, 4, 3, 1\}$$

(ii) Overlap-Add method

Let the length of data block be 3. Two zeros are added to bring the length to five $(L + M - 1 = 5)$.

Therefore,

$$x_1(n) = \{3, -1, 0, 0, 0\}$$
$$x_2(n) = \{1, 3, 2, 0, 0\}$$
$$x_3(n) = \{0, 1, 2, 0, 0\}$$
$$x_4(n) = \{1, 0, 0, 0, 0\}$$

$$y_1(n) = x_1(n) \textcircled{N} h(n) = \{3, 2, 2, -1, 0\}$$

$$y_2(n) = x_2(n) \textcircled{N} h(n) = \{1, 4, 6, 5, 2\}$$

$$y_3(n) = x_3(n) \textcircled{N} h(n) = \{0, 1, 3, 3, 2\}$$

$$y_4(n) = x_4(n) \textcircled{N} h(n) = \{1, 1, 1, 0, 0\}$$

$\boxed{3, 2, 2, -1, 0}$

↕ ↕ add

$\boxed{1, 4, 6, 5, 2}$

↕ ↕ add

$\boxed{0, 1, 3, 3, 2}$

↕ ↕ add

$\boxed{1, 1, 1, 0, 0}$

$$y(n) = \{3, 2, 2, 0, 4, 6, 5, 3, 3, 4, 3, 1\}$$