VLSI for DSP Homework No.1

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Design the linearly connected network for the convolution of vectors a and x .

Ans.

Assume **A** is an *5 x 5* matrix with band width $w = p + q - 1 = 5$.

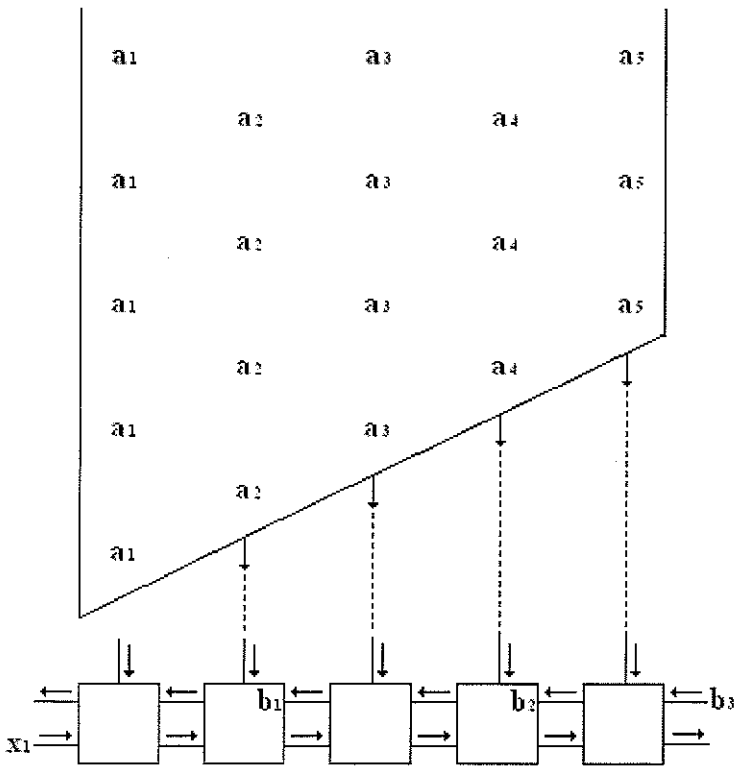
The convolution of vectors *a* and *x*.

$$\underbrace{\begin{bmatrix} a_1 & & & & \\ a_2 & a_1 & & 0 & \\ a_3 & a_2 & a_1 & & \\ a_4 & a_3 & a_2 & a_1 & \\ a_5 & a_4 & a_3 & a_2 & a_1 \end{bmatrix}}_{\mathbf{A}} \underbrace{\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix}}_{\mathbf{x}} = \underbrace{\begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix}}_{\mathbf{b}}$$

p over the columns, q over the rows

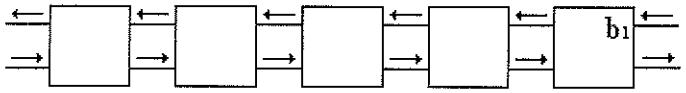
$$b_1 = a_1 x_1$$
$$b_2 = a_2 x_1 + a_1 x_2$$
$$b_3 = a_3 x_1 + a_2 x_2 + a_1 x_3$$
$$b_4 = a_4 x_1 + a_3 x_2 + a_2 x_3 + a_1 x_4$$
$$b_5 = a_5 x_1 + a_4 x_2 + a_3 x_3 + a_2 x_4 + a_1 x_5$$

The linearly connected network for the convolution of vectors a and x.



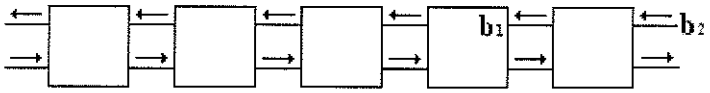
The first 9 steps of the convolution of vectors a and x.

Step 0



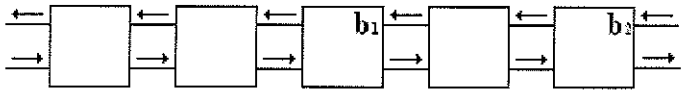
b_1 **enters processor 5.**

Step 1



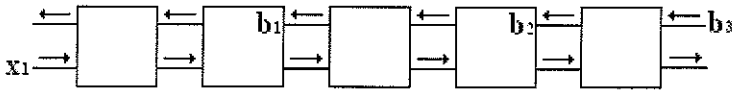
b_1 **moves left one position.**

Step 2



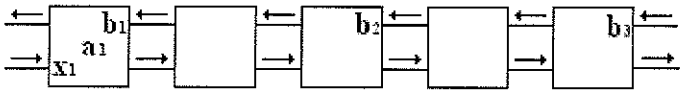
b_1 **moves left one position.**
b_2 **enters processor 5.**

Step 3



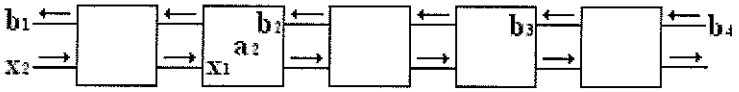
b_1 **moves left one position.**
b_2 **moves left one position.**

Step 4



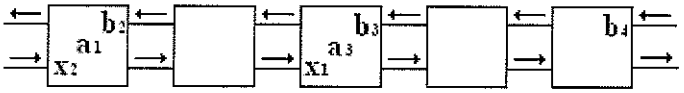
$b_1 = a_1 x_1$

Step 5



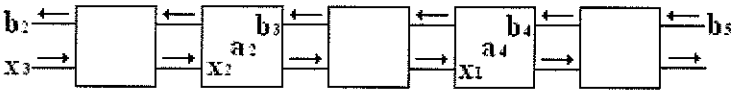
b_1 **is output.**
$b_2 = a_2 x_1$

Step 6



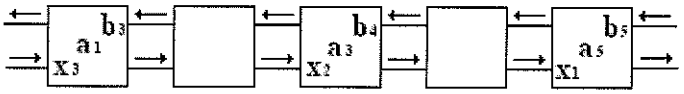
$b_2 = a_2 x_1 + a_1 x_2$
$b_3 = a_3 x_1$

Step 7



b_2 **is output.**
$b_3 = a_3 x_1 + a_2 x_2$
$b_4 = a_4 x_1$

Step 8



$b_3 = a_3 x_1 + a_2 x_2 + a_1 x_3$
$b_4 = a_4 x_1 + a_3 x_2$
$b_5 = a_5 x_1$

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assign matrix ⇒ 5×5

$$\begin{bmatrix} a_1 & & & & \\ a_2 & a_1 & & 0 & \\ a_3 & a_2 & a_1 & & \\ a_4 & a_3 & a_2 & a_1 & \\ a_5 & a_4 & a_3 & a_2 & a_1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix}$$

$w = p + q - 1 = 5$

$b_1 = a_1 \cdot x_1$

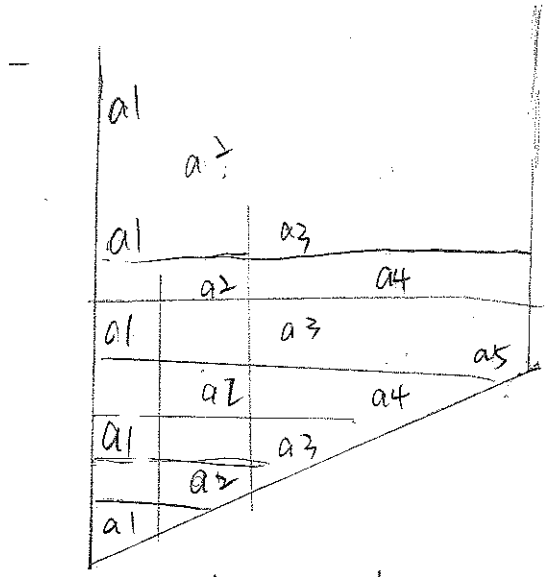
$b_2 = a_2 \cdot x_1 + a_1 \cdot x_2$

$b_3 = a_3 \cdot x_1 + a_2 \cdot x_2 + a_1 x_3$

$b_4 = a_4 \cdot x_1 + a_3 \cdot x_2 + a_2 \cdot x_3 + a_1 \cdot x_4$

$b_5 = a_5 \cdot x_1 + a_4 \cdot x_2 + a_3 \cdot x_3 + a_2 \cdot x_4 + a_1 \cdot x_5$

B



$b_1 = a_1 \cdot x_1$ ① out.

$b_2 = a_2 \cdot x_1$

$b_2 = a_2 \cdot x_1 + a_1 \cdot x_2$ ② out.

$b_3 = a_3 x_1$

$b_3 = a_3 x_1 + a_2 \cdot x_2$

$b_4 = a_4 \cdot x_1$

$b_3 = a_3 x_1 + a_2 \cdot x_2 + a_1 \cdot x_3$ ③ out.

$b_4 = a_4 \cdot x_1 + a_3 \cdot x_2$

$b_4 = a_4 \cdot x_1 + a_3 \cdot x_2 + a_2 \cdot x_3$

$b_5 = a_5 \cdot x_1$

$b_4 = a_4 \cdot x_1 + a_3 \cdot x_2 + a_2 \cdot x_3 + a_1 x_4$ ④ out.

$b_5 = a_5 \cdot x_1 + a_4 \cdot x_2$

step.

8. 

9 

$b_5 = a_5 \cdot x_1 + a_4 \cdot x_2 + a_3 \cdot x_3$

$b_5 = a_5 \cdot x_1 + a_4 \cdot x_2 + a_3 \cdot x_3 + a_2 \cdot x_4$

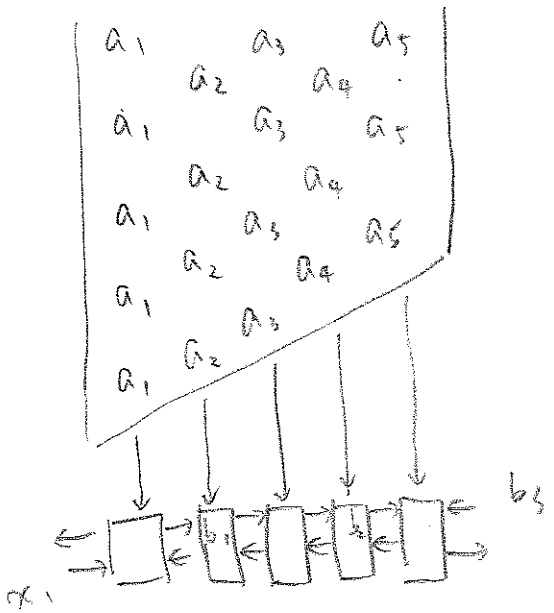
$b_5 = a_5 \cdot x_1 + a_4 \cdot x_2 + a_3 \cdot y_3 + a_2 \cdot x_4 + a_1 \cdot x_5$

⑤ output.

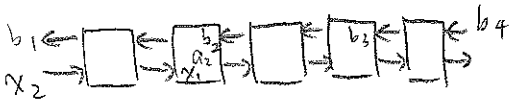
Homework 1

$$\begin{bmatrix} a_1 & & & & \\ a_2 & a_1 & & 0 & \\ a_3 & a_2 & a_1 & & \\ a_4 & a_3 & a_2 & a_1 & \\ a_5 & a_4 & a_3 & a_2 & a_1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix}$$

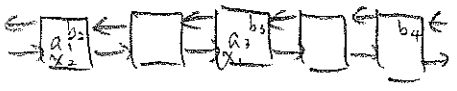
B



$b_1 = a_1 x_1$



$b_2 = a_2 x_1$
b_1 output



$b_2 = a_2 x_1 + a_1 x_2$
$b_3 = a_3 x_1$

⋮

VLSI for DSP

Homework 1

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(a) Design the linearly connected network for the convolution of vectors a and x .

Ans: