HANOI UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF INFORMATION AND COMMUNITCATION TECHNOLOGY

UNIT 6

IMPLEMENTATION OF DISCRETE-TIME SYSTEM

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❑ Contents

❑ Learning Objectives

After completing this lesson, you will have a grasp of the following concepts:

- The definition and methods for implementing a non-recursive system.
- The definition and methods for implementing a recursive system.

1. Non recursive system FIR (Finite Impulse Response)

- Constant-Coefficient Linear Differential Equation:

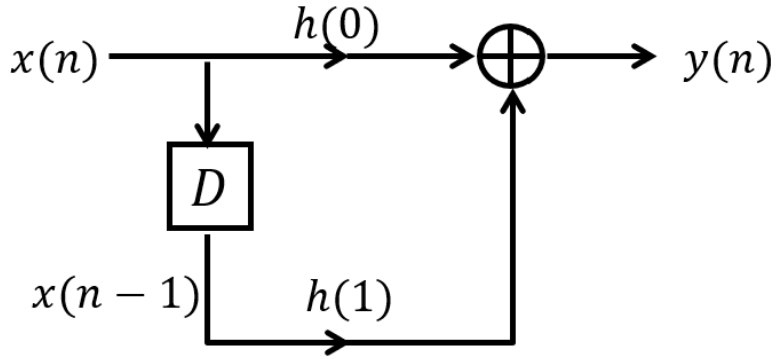
$$\sum_{k=0}^{N} a_k y(n-k) = \sum_{k=0}^{M} b_k x(n-k)$$

$$N = 0\text{: FIR,} \qquad N > 0\text{: IIR}$$

- Non-recursive system: $N = 0$

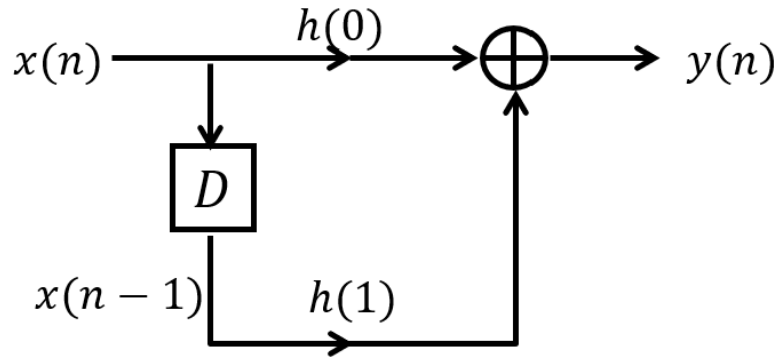
$$y(n) = \sum_{k=0}^{M} \frac{b_k}{a_0} x(n-k) = \sum_{k=0}^{M} h(k)x(n-k)$$

- Example: $M = 1 \Longrightarrow y(n) = h(0)x(n) + h(1)x(n-1)$
- Diagram:



Pseudo code for system implementation (FIR)

```
Const
  h0 = 0.5;  (* Filter coefficients *)
  h1 = 0.5;  (* calculated based design *)
Var
  xn, xnt1, yn: real;
Begin
  xnt1 := 0;
  Repeat
    (* Enter input signal from keyboard*)
    Write(Input signal xn = ');
    Readln(xn);
    (* Compute output signal *)
    yn:= h0 * xn + h1 * xnt1;
    (* Delay the signal*)
    xnt1 := xn;
  Until End;
End.
```



C code for system implementation (FIR)

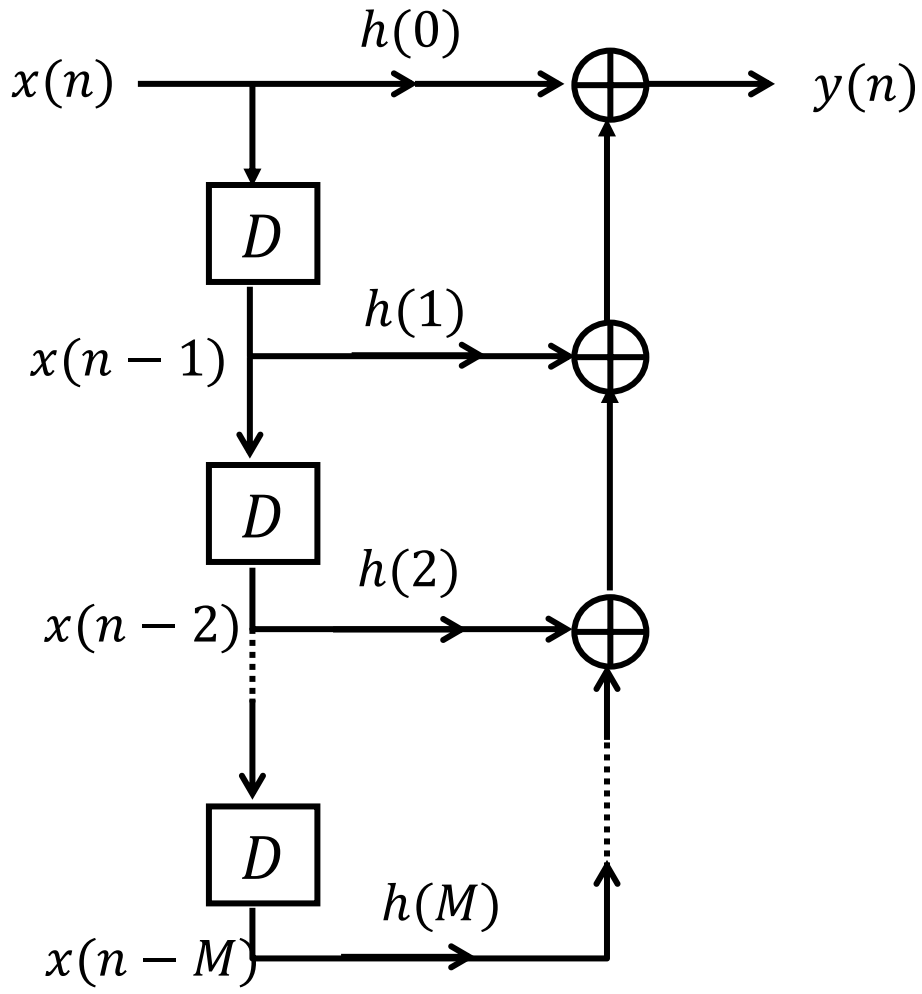
```c
#include <stdio.h>
#include <stdlib.h>
#define h0 0.5 /* Filter coefficients        */
#define h1 0.5 /* calculated based on design */
float xn, xnt1, yn;
void main(void)
{
    xnt1 = 0;
    while (1)
    {
        /* Enter input signal from keyboard */
        printf("Input signal xn = ");
        scanf("%f", &xn);
        /* Compute output signal */
        yn = h0 * xn + h1 * xnt1;
        /* Delay signal */
        xnt1 = xn;
    }
}
```

Diagram for system implementation FIR

- The general case

$$y(n) = \sum_{k=0}^{M} h(k)x(n-k)$$

$$y(n) = h(0).x(n) + h(1).x(n-1) + \ldots + h(M).x(n-M)$$



2. Implementation of IIR (Infinite Impulse Response) system

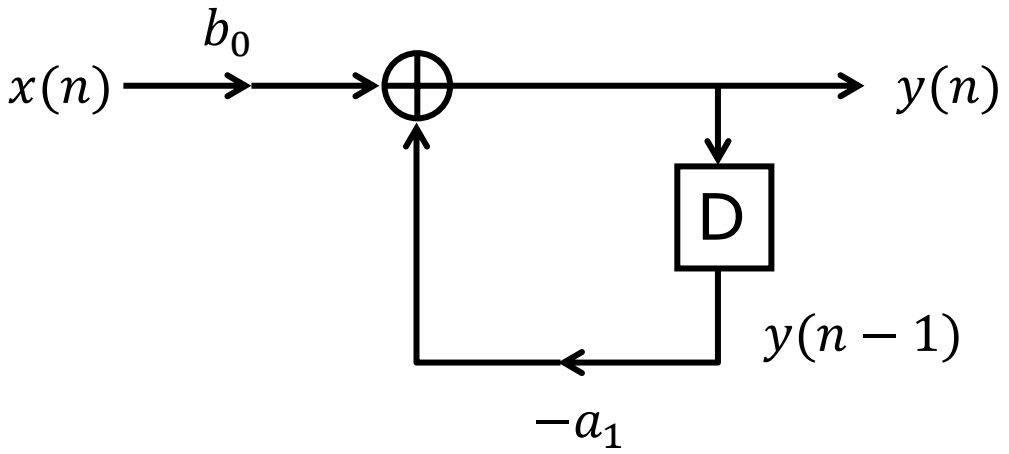
- $\mathrm{N} = 1, \mathrm{M} = 0$:

$$\mathrm{a_0 y(n) + a_1 y(n-1) = b_0 x(n)}$$

- Assuming that $\mathrm{a_0} = 1$:

$$\mathrm{y(n) = -a_1 y(n-1) + b_0 x(n)}$$

- Diagram



Implementation of IIR system

- $N = M = 1$:

$$a_0 y(n) + a_1 y(n-1) = b_0 x(n) + b_1 x(n-1)$$

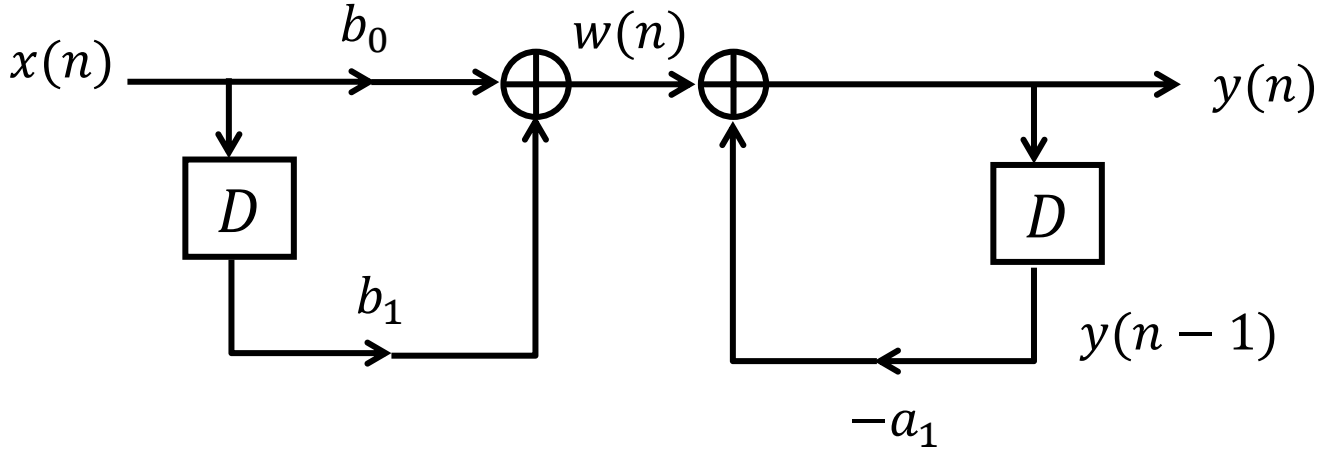
- Assuming that $a_0 = 1$:

$$y(n) = -a_1 y(n-1) + b_0 x(n) + b_1 x(n-1)$$

$$= -a_1 y(n-1) + w(n)$$

với $w(n) = b_0 x(n) + b_1 x(n-1)$.

- Diagram



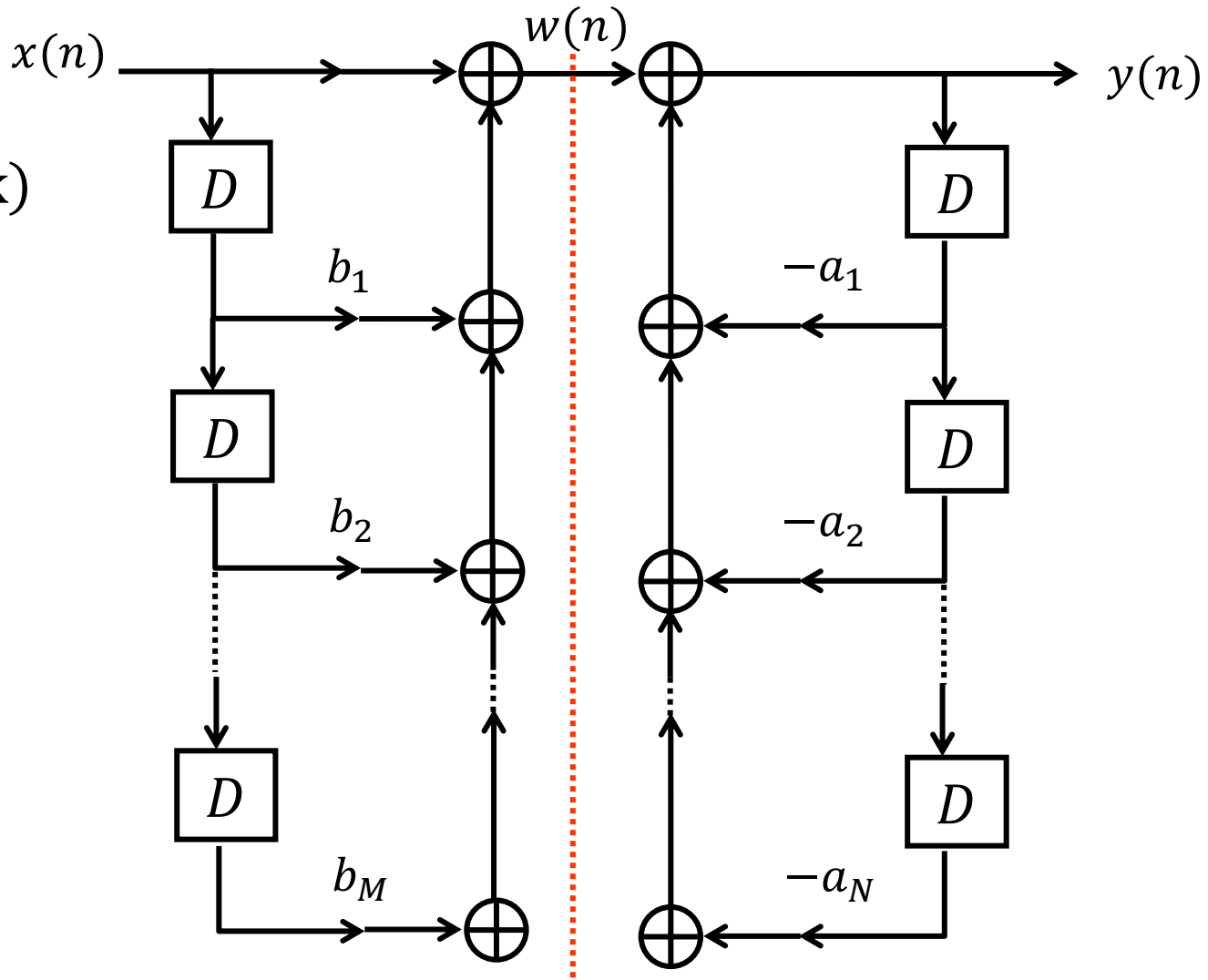
Implementation of IIR system

$$\sum_{k=0}^{N} a_k y(n-k) = \sum_{k=0}^{M} b_k x(n-k)$$

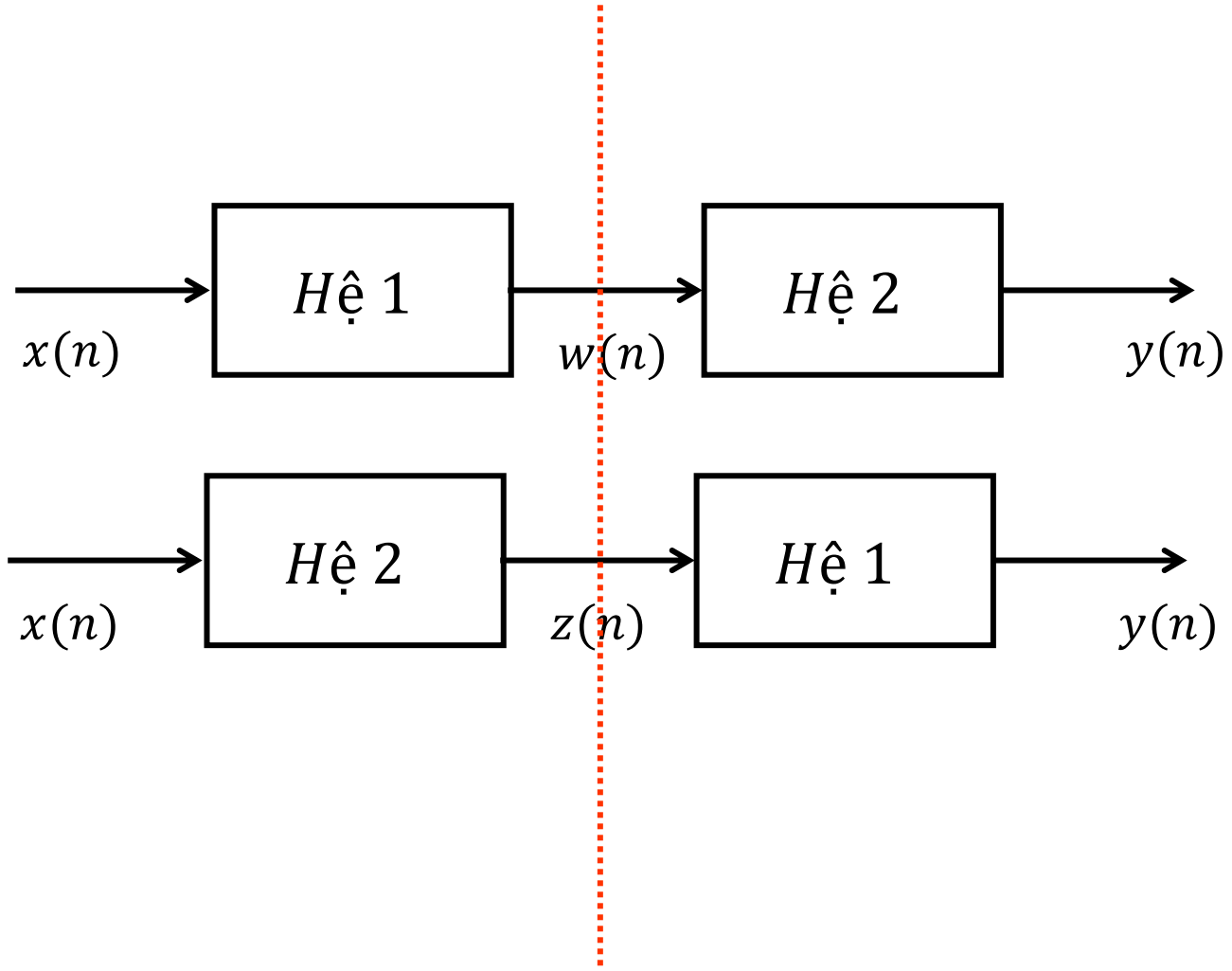
$$y(n) = w(n) - \sum_{k=1}^{N} a_k y(n-k)$$

$$w(n) = \sum_{k=0}^{M} b_k x(n-k)$$

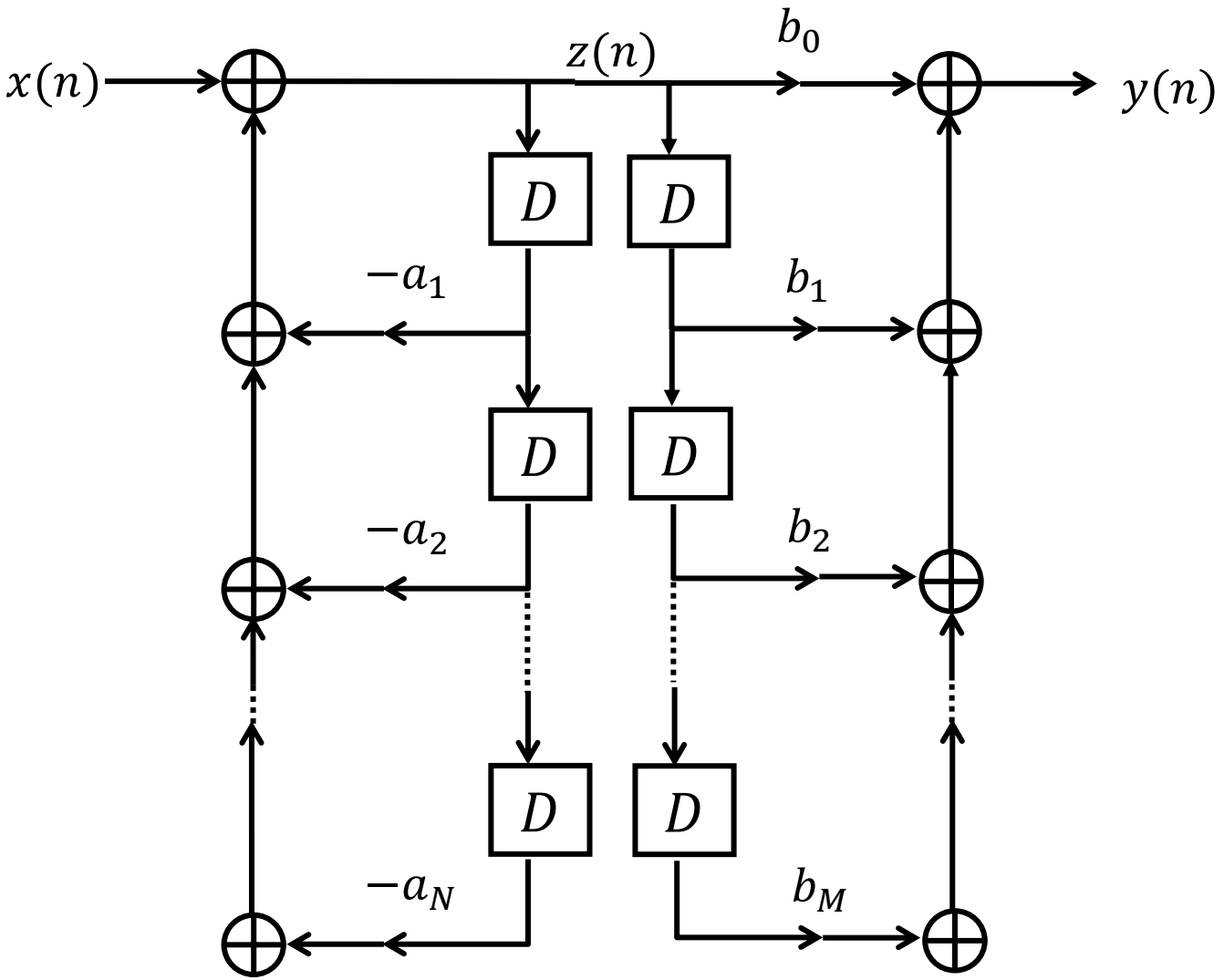
Dạng trực tiếp 1



Implementation of IIR system

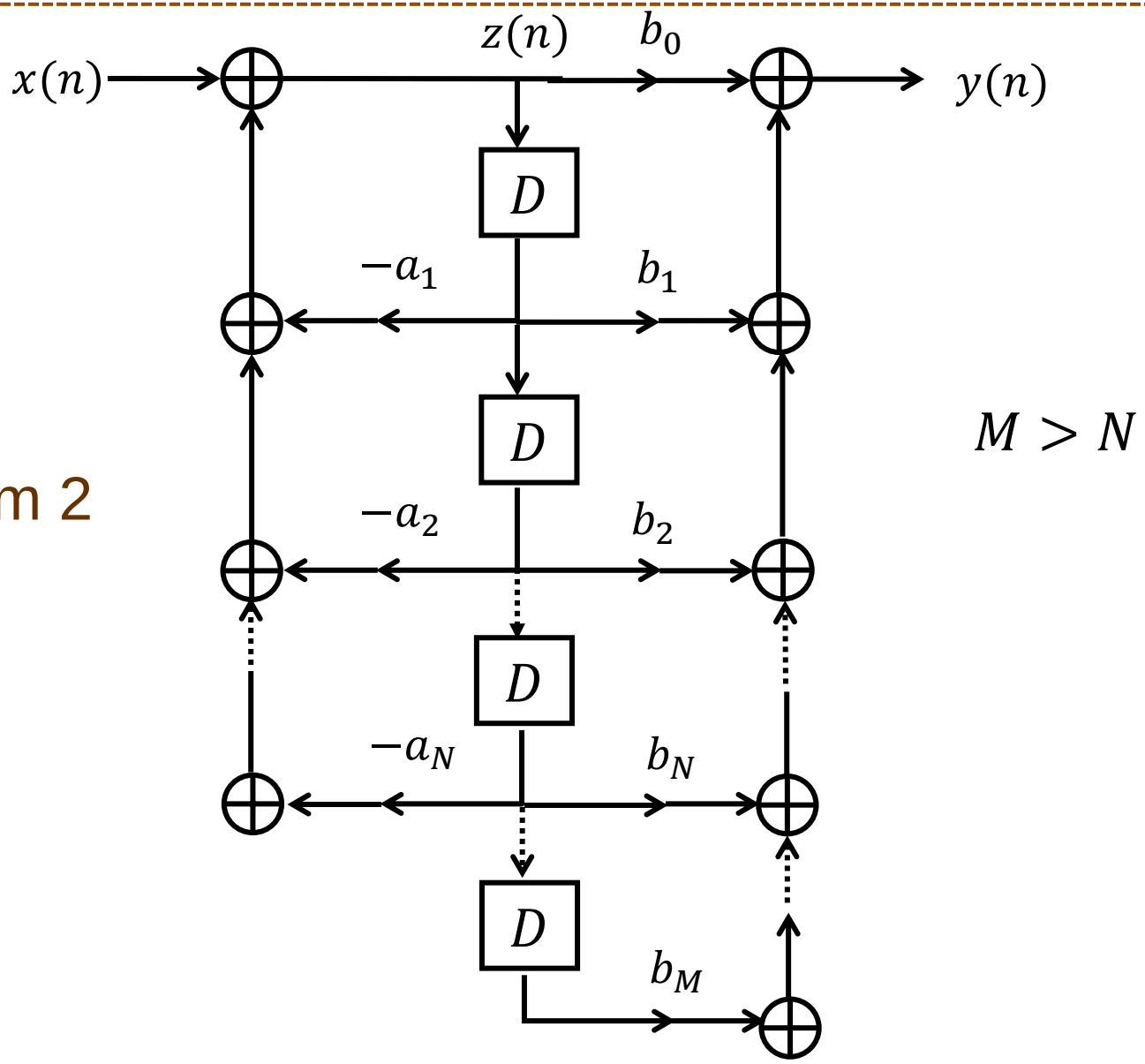


Implementation of IIR system



Implementation of IIR system

Direct form 2



$M > N$

4. Summary

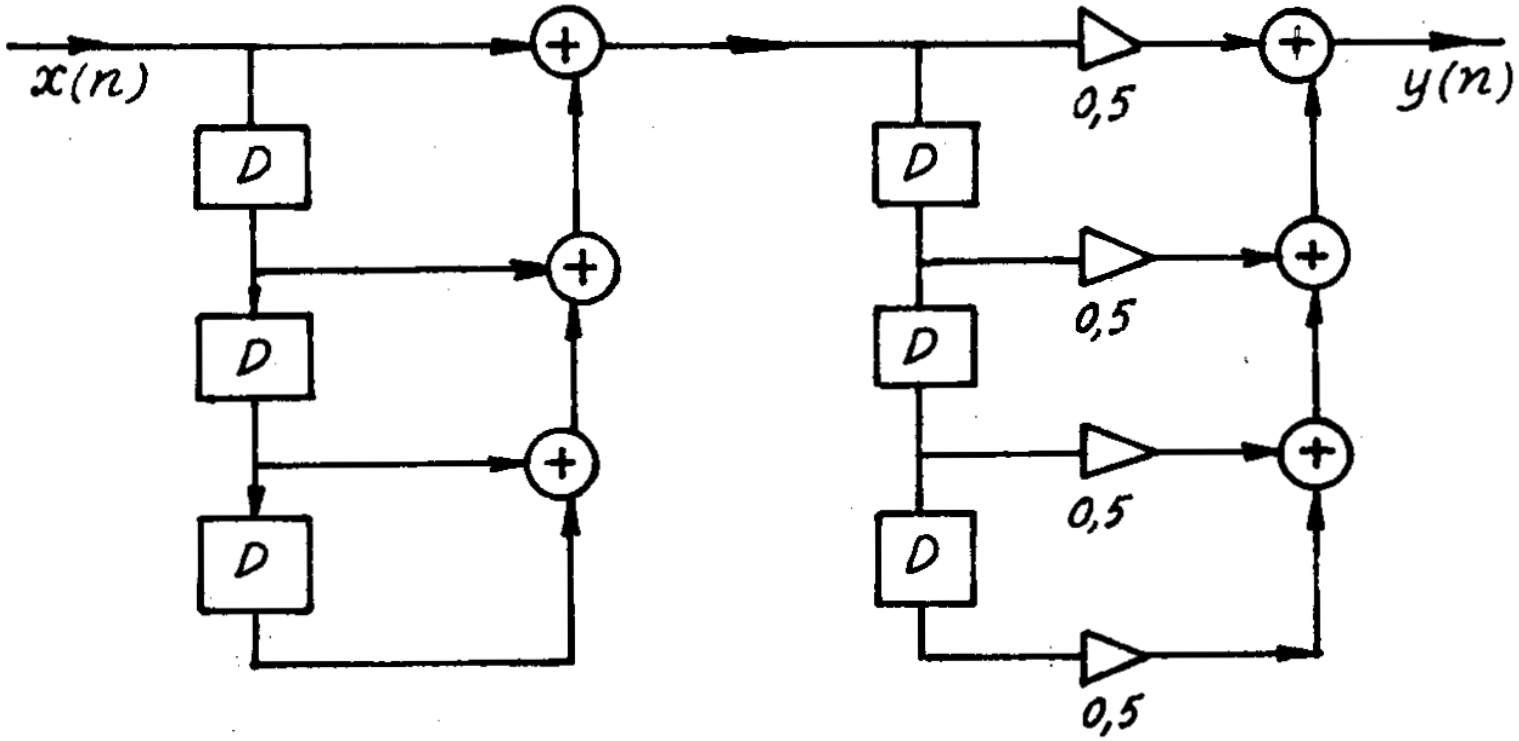
- Discrete-time systems are classified into finite impulse response (FIR) systems and infinite impulse response (IIR) systems.
- FIR systems can be implemented using pseudo code, software, or block diagrams.
- Block diagrams for implementing IIR systems include two forms: direct form I and direct form II.

5. Assignment

- Assignment 1
  - ❑ Draw the block diagrams for direct form I and II, and write the pseudo code to implement the following systems.
    a. $y(n) - 2y(n-1) + 3y(n-2) = x(n) + x(n-1) + 2x(n-4)$
    b. $5y(n) + 3y(n-1) + 6y(n-4) = x(n) + 3x(n-2) + 5x(n-3)$
    c. $2y(n) + 6y(n-3) + 3y(n-4) = x(n)$
    d. $3y(n) = x(n-1) + 3x(n-3) + 4x(n-5)$

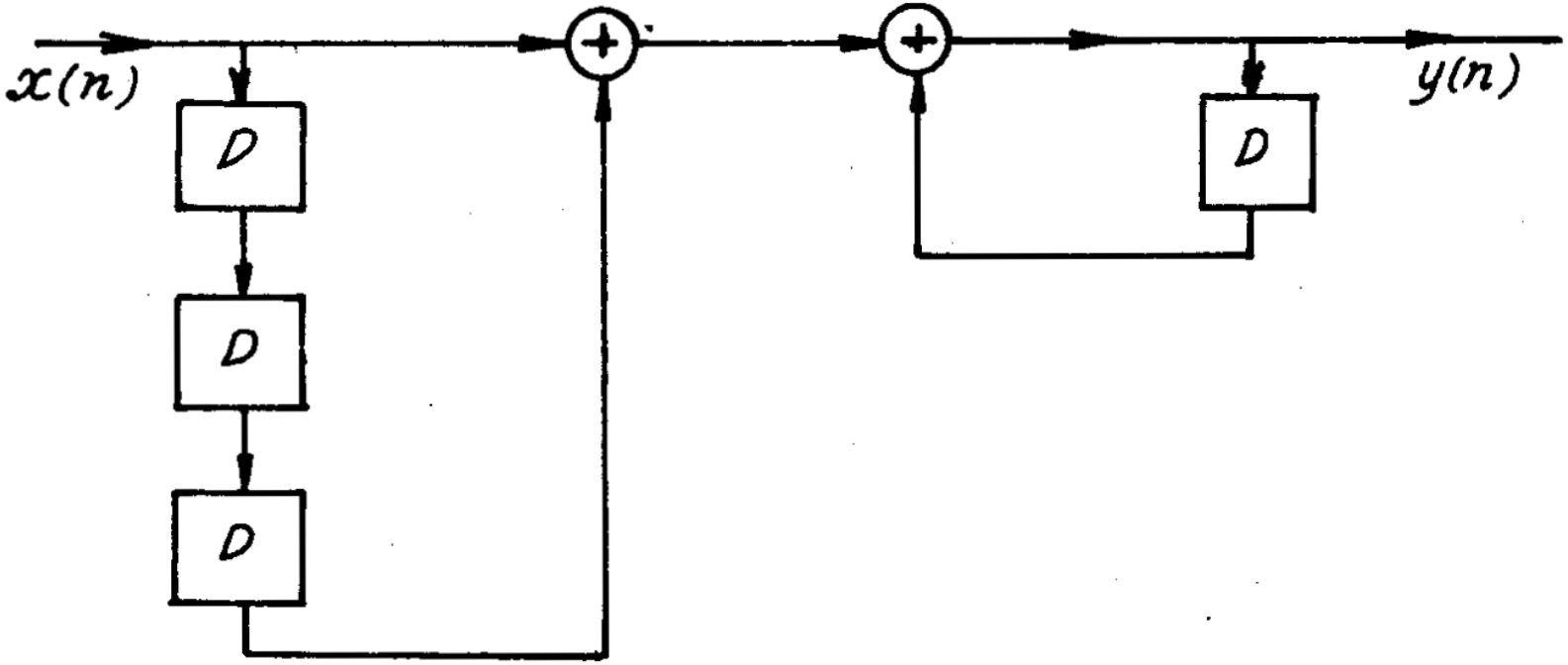
Homework

- Assignment 2
  - ❑ Compute the impulse response and examine the stability of the following system



Homework

- Assignment 3
  - ❑ Compute the impulse response and examine the stability of the following system

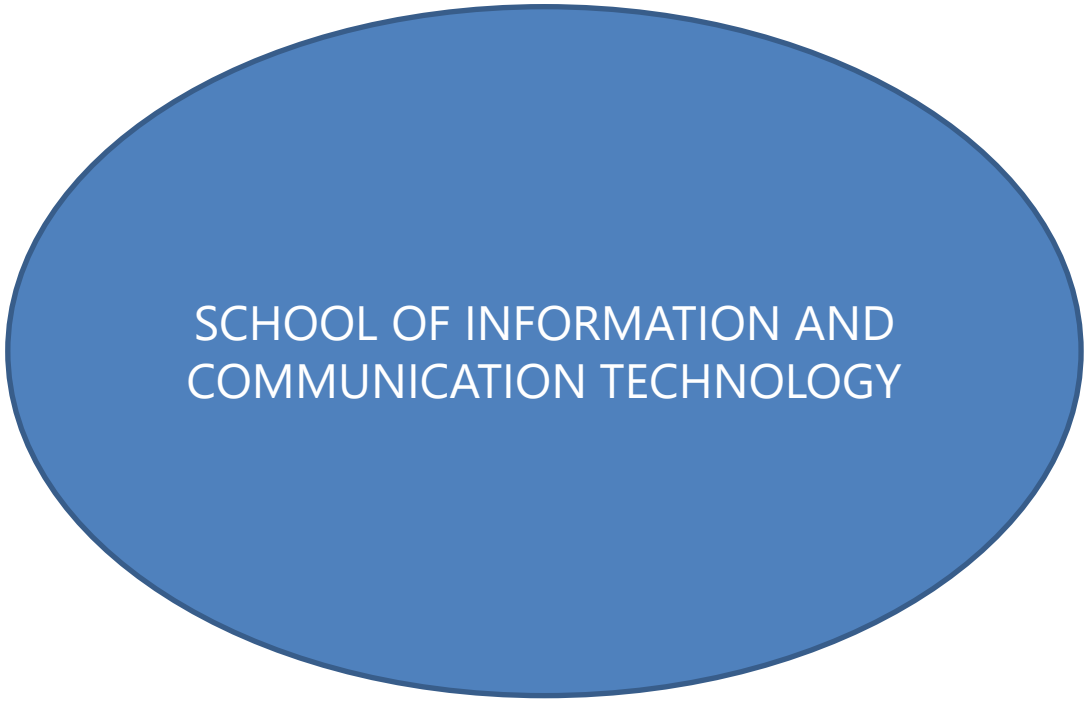


The next unit. 7

Z TRANSFORM

References:

- ***Nguyễn Quốc Trung (2008), Xử lý tín hiệu và lọc số, Tập 1, Nhà xuất bản Khoa học và Kỹ thuật, Chương 1 Tín hiệu và hệ thống rời rạc.***
- ***J.G. Proakis, D.G. Manolakis (2007), Digital Signal Processing, Principles, Algorithms, and Applications, 4th Ed, Prentice Hall, Chapter 1 Introduction.***



Wishing you all the best in your studies!