Realization of Discrete-Time Systems

# 1. Basic Components in Discrete-Time Systems

(a) Adder: Adds two or more signals. Output = Sum of inputs.

(b) Constant Multiplier: Multiplies signal by a constant. Output = k × input.

(c) Unit Delay Element: Delays signal by one sample. Represented as z⁻¹.

# 2. Types of IIR System Realizations

* 1. Direct Form-I Structure
* 2. Direct Form-II Structure
* 3. Transposed Form Structure
* 4. Cascade Form Structure
* 5. Parallel Form Structure
* 6. Lattice Structure
* 7. Ladder Structure

# 3. Direct Form-I Structure

• Uses separate delay lines for input and output.

• Viewed as cascade of Non-recursive (FIR) and Recursive (IIR) systems.

• Memory inefficient but structurally clear.

# 4. Direct Form-II Structure

• Uses shared delay line for both input and output.

• More efficient in memory usage.

• Viewed as cascade of Recursive (IIR) and Non-recursive (FIR) systems.

# 5. Comparison: Direct Form-I vs Direct Form-II

Direct Form-I:

• More delays (M+N–2)

• Memory inefficient

• Non-canonical structure

Direct Form-II:

• Fewer delays (max(M–1, N–1))

• Memory efficient

• Canonical structure

# 6. Example IIR System Realization

Given: y(n) = -a₁y(n-1) - a₂y(n-2) + b₀x(n) + b₁x(n-1) + b₂x(n-2)

• Direct Form-I: Separate delay lines for x(n) and y(n).

• Direct Form-II: Shared delay line using intermediate W(z).

# 7. Other Realization Forms

• Cascade Form: Factor into 2nd-order sections, connected in series.

• Parallel Form: Use partial fraction expansion, implement each section independently.