EEE328
Digital Signal Processing

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

System Properties & Linear-Time Invariant Systems

EEE328 Digital Signal Processing

Lecture 4

Agenda

- System Properties - Continued
- Causality
- Stability
- Linear Time-Invariant Systems
- Linear Constant-Coefficient Difference Equations

System Properties

- Causality

The output $y[n]$ at any time depends only on value of the input $x[n]$ at the past and the present time

System Properties

- Stability

Bounded Input  Bounded Output

$$|x[n]| \leq B_x < \infty, \text{for all } n$$
$$|y[n]| \leq B_y < \infty, \text{for all } n$$

Linear Time-Invariant (LTI) Systems

$$y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$$

Convolution Sum

$$y[n] = x[n] * h[n]$$

Linear Time-Invariant (LTI) Systems

- Proporties of LTI Systems

$$y[n] = x[n] * h[n] = h[n] * x[n]$$

Commutative Property

$$x[n] * (h_1[n] + h_2[n]) = x[n] * h_1[n] + x[n] * h_2[n]$$

Distribituve Property

Linear Time-Invariant (LTI) Systems

- Properties of LTI Systems

$$S = \sum_{k=-\infty}^{\infty} |h[k]| < \infty$$

Stability Check ✓

Sufficient condition for stability

Linear Constant-Coefficient Difference Equations

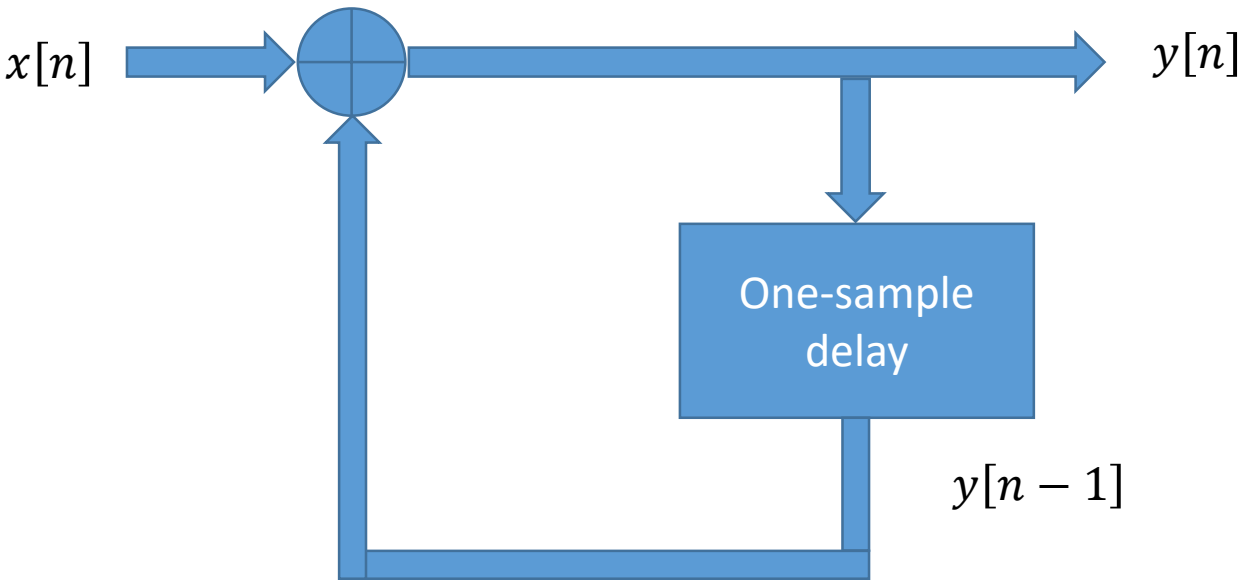
$$\sum_{k=0}^{N} a_k y[n-k] = \sum_{m=0}^{M} b_k x[n-m]$$

Linear Constant-Coefficient Difference Equations

- Example

Accumulator

$$y[n] = \sum_{k=-\infty}^{n} x[k]$$



$$y[n-1] = \sum_{k=-\infty}^{n-1} x[k]$$

$$y[n] = x[n] + \sum_{k=-\infty}^{n-1} x[k]$$

$$y[n] = x[n] + y[n-1]$$

$$y[n] - y[n-1] = x[n]$$

References

- Signals & Systems, Second Edition, A. V. Oppenheim, A. S. Willsky with S. H. Nawab, Prentice Hall, 1997
- Discrete-Time Signal Processing, Second Edition, A. V. Oppenheim, R. W. Schafer with J. R. Buck, Prentice Hall, 1999