

## EE328 – Properties of Discrete-Time Systems – DePiero

A brief assessment of system properties is often needed, prior to additional analysis or to implementation. For example, most analysis tools in EE328 are useful for LTI (linear time-invariant) systems only. Hence this is an important first check prior to analysis.

A number of system properties affect transient response. For example, a dynamic system will typically include a transient response, but instantaneous systems do not. FIR systems have a relatively brief transient response compared to IIR. FIR systems with symmetric or anti-symmetric coefficients have desirable delay properties, also.

With regard to implementation, only causal systems can be implemented in an on-line processing system. Also, unstable systems are generally avoided in practice ☺ Note that FIR systems are always stable.

' $A_k$ ' and ' $B_k$ ' appearing below are coefficients of a difference equation. The operator notation also appears below to describe a generic processing operation, as in  $y(n) = O\{x(n)\}$ . This is used to describe generic form of system operation, beyond just a standard difference equation.

In situations where multiple criteria may be used, these are enumerated under 'Test'.

Property	Test
FIR vs. IIR	1) Is the duration of $h(n)$ finite [FIR] or (theoretically) infinite [IIR]? 2) If $A_k = 0$ for $k > 0$ then FIR
Linearity	1) Nonlinear if difference equation contains either: <ul style="list-style-type: none"> <li>• A constant term</li> <li>• Products of the input or output such as <math>x(n)y(n-1)</math> or <math>x^2(n)</math></li> </ul> 2) Linear if $O\{a x_1(n) + b x_2(n)\} = a O\{x_1(n)\} + b O\{x_2(n)\}$ , and hence obeying superposition.
Time Invariance	1) If $A_k$ or $B_k$ are explicit functions of $n$ then system is time varying. 2) The impulse response <i>sequence</i> must not change with time, for time invariance. 3) Time-scaled inputs or output such as $y(2n)$ make a system time varying.
Causality	1) $h(n) = 0$ for $n < 0$ , for causality 2) Difference equation yielding $y(n)$ , can not use future values such as $x(n+1)$ or $y(n+1)$ , for causality
Dynamic vs. Instantaneous	If $y(n)$ depends only on the current input $x(n)$ , then instantaneous
BIBO Stability	1) If LTI and $h(n)$ is absolutely summable, then stable. 2) If LTI and all poles have magnitude less than one, then stable. 3) FIR systems are always stable. 4) System must remain bounded for any bounded input.