Chapter 06: Time & Frequency Characterization

- The Magnitude-Phase Representation of the Fourier Transform (p.423)
- The Magnitude-Phase Representation of Frequency Response of LTI Systems (p.427)
- Time-Domain Properties of Ideal Frequency-Selective Filters
- Time-Domain and Frequency-Domain Aspects of Non-ideal Filters
- 1st-Order & 2nd-Order Continuous-Time Systems (p.461)
- 1st-Order & 2nd-Order Discrete-Time Systems
- Time- & Frequency-Domain Analysis of Systems
6.17. For each of the following second-order difference equations for causal and stable LTI systems, determine whether or not the step response of the system is oscillatory:

(a) \[ y[n] + y[n - 1] + \frac{1}{4} y[n - 2] = x[n] \]

(b) \[ y[n] - y[n - 1] + \frac{1}{4} y[n - 2] = x[n] \]
6.3. Consider the following frequency response for a causal and stable LTI system:

\[ H(j\omega) = \frac{1 - j\omega}{1 + j\omega}. \]

(a) Show that \(|H(j\omega)| = A\), and determine the value of \(A\).

(b) Determine which of the following statements is true about \(\tau(\omega)\), the group delay of the system. (Note: \(\tau(\omega) = -d(\triangleleft H(j\omega))/d\omega\), where \(\triangleleft H(j\omega)\) is expressed in a form that does not contain any discontinuities.)

1. \(\tau(\omega) = 0\) for \(\omega > 0\)
2. \(\tau(\omega) > 0\) for \(\omega > 0\)
3. \(\tau(\omega) < 0\) for \(\omega > 0\)
6.4: Consider a linear-phase discrete-time LTI system with frequency response $H(e^{j\omega})$ and real impulse response $h[n]$. The group delay function for such a system is defined as

$$\tau(\omega) = -\frac{d}{d\omega} \angle H(e^{j\omega}),$$

where $\angle H(e^{j\omega})$ has no discontinuities. Suppose that, for this system,

$$|H(e^{j\pi/2})| = 2, \quad \angle H(e^{j0}) = 0, \quad \text{and} \quad \tau\left(\frac{\pi}{2}\right) = 2.$$

Determine the output of the system for each of the following inputs:

(a) $\cos\left(\frac{\pi}{2}n\right)$  
(b) $\sin\left(\frac{7\pi}{2}n + \frac{\pi}{4}\right)$
6.21. A causal LTI filter has the frequency response $H(j\omega)$ shown in Figure P6.21. For each of the input signals given below, determine the filtered output signal $y(t)$.

(a) $x(t) = e^{jt}$
(b) $x(t) = (\sin \omega_0 t)u(t)$
(c) $X(j\omega) = \frac{1}{(j\omega)(6+j\omega)}$
(d) $X(j\omega) = \frac{1}{2+j\omega}$

![Filter Frequency Response Diagram]
6.25 By computing the group delay at two selected frequencies, verify that each of the following frequency responses has nonlinear phase.

(a) \( H(j\omega) = \frac{1}{j\omega + 1} \)  
(b) \( H(j\omega) = \frac{1}{(j\omega + 1)^2} \)  
(c) \( H(j\omega) = \frac{1}{(j\omega + 1)(j\omega + 2)} \)