

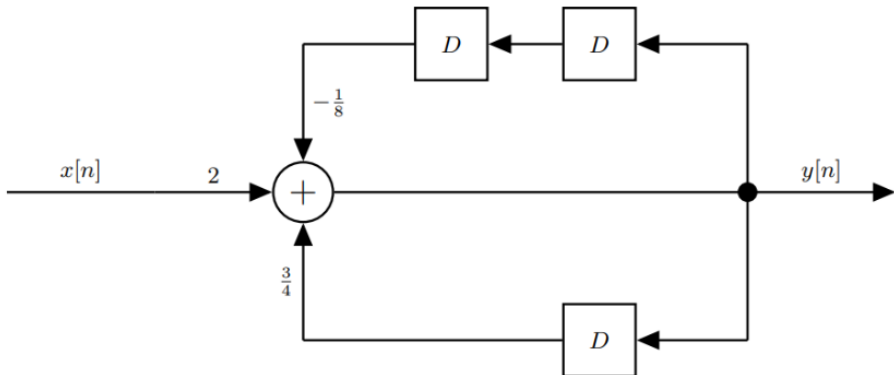
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Question: Consider an LTI system given by the following block diagram: ...

Consider an LTI system given by the following block diagram:



where  $D$  is the unit-delay operator.

- (a) Find the difference equation which represents this system.
- (b) Find the frequency response of this system.
- (c) Find the impulse response of this system from its frequency response.
- (d) Find the output  $y[n]$  for the input  $x[n] = (\frac{1}{4})^n u[n]$  using the frequency response.

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Expert Answer

Vasumathi answered this  
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ⓐ

Difference equation

$$2x(n) + \frac{3}{4}y(n-1) - \frac{1}{8}y(n-2) = y(n)$$

b)

Frequency Response

Apply DTFT,

$$2Xe^{j\omega} + \frac{3}{4}e^{-j\omega}Y(e^{j\omega}) - \frac{1}{8}e^{-2j\omega}Y(e^{j\omega}) = Y(e^{j\omega})$$
$$Y(e^{j\omega})\left[1 - \frac{3}{4}e^{-j\omega} + \frac{1}{8}e^{-2j\omega}\right] = 2X(e^{j\omega})$$
$$H(e^{j\omega}) = \frac{Y(e^{j\omega})}{X(e^{j\omega})} = \frac{2}{1 - \frac{3}{4}e^{-j\omega} + \frac{1}{8}e^{-2j\omega}}$$

c)

Impulse Response

Apply inverse DTFT on  $H(e^{j\omega}) = \frac{2}{(1 - \frac{1}{2}e^{-j\omega})(1 - \frac{1}{4}e^{-j\omega})}$

$$H(e^{j\omega}) = \frac{A}{(1 - \frac{1}{2}e^{-j\omega})} + \frac{B}{(1 - \frac{1}{4}e^{-j\omega})}$$
$$A = \frac{H(e^{j\omega})(1 - \frac{1}{2}e^{-j\omega})}{e^{-j\omega}} = 2$$
$$= \frac{2}{(1 - \frac{1}{4}e^{-j\omega})} \bigg|_{e^{-j\omega}=2} = \frac{2}{1 - \frac{1}{4}(2)} = \frac{2}{\frac{1}{2}} = 4$$
$$B = \frac{H(e^{j\omega})(1 - \frac{1}{4}e^{-j\omega})}{e^{-j\omega}} = 4$$
$$= \frac{2}{1 - \frac{1}{2}e^{-j\omega}} \bigg|_{e^{-j\omega}=4} = \frac{2}{1 - \frac{1}{2}(4)} = \underline{\underline{-2}}$$
$$H(e^{j\omega}) = \frac{4}{1 - \frac{1}{2}e^{-j\omega}} - \frac{2}{1 - \frac{1}{4}e^{-j\omega}}$$

↓ IDFT

$$h(n) = 4\left(\frac{1}{2}\right)^n u(n) - 2\left(\frac{1}{4}\right)^n u(n)$$

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$$x(e^{j\omega}) = \frac{1}{1 - \frac{1}{4}e^{-j\omega}}; \quad y(e^{j\omega}) = x(e^{j\omega}) H(e^{j\omega})$$
$$= \frac{2}{(1 - \frac{1}{2}e^{-j\omega})(1 - \frac{1}{4}e^{-j\omega})^2}$$

Apply partial fraction expansion,

$$y(e^{j\omega}) = \frac{A}{(1 - \frac{1}{2}e^{-j\omega})} + \frac{B_0}{(1 - \frac{1}{4}e^{-j\omega})} + \frac{B_1}{(1 - \frac{1}{4}e^{-j\omega})^2}$$
$$B_1 = y(e^{j\omega}) \left(1 - \frac{1}{4}e^{-j\omega}\right)^2 \Big|_{e^{-j\omega}=4}$$
$$= \frac{2}{1 - \frac{1}{2}e^{-j\omega}} \Big|_{e^{-j\omega}=4} = \frac{2}{1 - \frac{1}{2}(4)} = -2$$
$$B_0 = \frac{d}{d\omega} \left( y(e^{j\omega}) \left(1 - \frac{1}{4}e^{-j\omega}\right)^2 \right) \Big|_{e^{-j\omega}=4}$$
$$= \frac{d}{d\omega} \left( \frac{2}{1 - \frac{1}{2}e^{-j\omega}} \right) \Big|_{e^{-j\omega}=4} = \frac{-2(-\frac{1}{2}e^{-j\omega})}{(1 - \frac{1}{2}e^{-j\omega})^2} \Big|_{e^{-j\omega}=4} = \frac{2}{1 - \frac{1}{2}(4)} = 4$$
$$A = y(e^{j\omega}) \left(1 - \frac{1}{2}e^{-j\omega}\right) \Big|_{e^{-j\omega}=2}$$
$$= \frac{2}{(1 - \frac{1}{4}e^{-j\omega})^2} \Big|_{e^{-j\omega}=2} = \frac{2}{(1 - \frac{1}{4}(2))^2} = \frac{2}{1/4} = 8$$
$$y(e^{j\omega}) = \frac{8}{1 - \frac{1}{2}e^{-j\omega}} + \frac{4}{1 - \frac{1}{4}e^{-j\omega}} + \frac{(-2)}{(1 - \frac{1}{4}e^{-j\omega})^2}$$

↓ Inv. DFT

$$y(n) = 8 \left(\frac{1}{2}\right)^n u(n) + \left(\frac{1}{4}\right)^n u(n) + (-2)(n+1) \left(\frac{1}{4}\right)^n u(n)$$

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Q: 1. (20 pts) Consider an LTI system given by the following block diagram: y(t) r(t) (a) (5 pts) Find the differential equation which represents this system. (b) (15 pts) Find the output y(t), when the input x(t) = (e-4e-2t)a(t). Assume that the system is initially at rest.

A: [See answer](#) 100% (1 rating)

Q: I need help with this signals and systems analysis problem. Thanks!

A: [See answer](#) 100% (1 rating)

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