BSM307
İşaretler ve Sistemler

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z-Domeninde Sistem Analizi

İçerik

- Fark Denklemlerinden $H(z)$
- Devre (Diyagram)dan $H(z)$
- Durum Denklemlerinden $H(z)$
- Doğal ve Zorlanmış Çözüm
- Temel Sistem Özellikleri
  - Hafızalılık
  - Nedensellik
  - Kararlılık

Fark Denkleminden $H(z)$

- $H(z) = \mathcal{Z}\{h(n)\}$
- $\sum_{k=0}^{N} a_k y(n-k) = \sum_{k=0}^{N} b_k x(n-k)$

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- Doğrusallıktan

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- Doğrusallıktan
  - $\sum_{k=0}^{N} a_k \mathcal{Z}\{y(n-k)\} = \sum_{k=0}^{N} b_k \mathcal{Z}\{x(n-k)\}$

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- Doğrusallıktan
  - $\sum_{k=0}^{N} a_k\, \mathcal{Z}\{y(n-k)\} = \sum_{k=0}^{N} b_k\, \mathcal{Z}\{x(n-k)\}$
- $\sum_{k=0}^{N} a_k\, z^{-k} Y(z) = \sum_{k=0}^{N} b_k\, z^{-k} X(z)$

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  - $\sum_{k=0}^{N} a_k \, \mathcal{Z}\{y(n-k)\} = \sum_{k=0}^{N} b_k \, \mathcal{Z}\{x(n-k)\}$
- $\sum_{k=0}^{N} a_k \, z^{-k} Y(z) = \sum_{k=0}^{N} b_k \, z^{-k} X(z)$
- $Y(z)\left(\sum_{k=0}^{N} a_k \, z^{-k}\right) = X(z)\left(\sum_{k=0}^{N} b_k \, z^{-k}\right)$
- $H(z) =$

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  - $\sum_{k=0}^{N} a_k \, \mathcal{Z}\{y(n-k)\} = \sum_{k=0}^{N} b_k \, \mathcal{Z}\{x(n-k)\}$
- $\sum_{k=0}^{N} a_k \, z^{-k} Y(z) = \sum_{k=0}^{N} b_k \, z^{-k} X(z)$
- $Y(z)\left(\sum_{k=0}^{N} a_k \, z^{-k}\right) = X(z)\left(\sum_{k=0}^{N} b_k \, z^{-k}\right)$
- $H(z) = \frac{Y(z)}{X(z)} = \frac{\sum_{k=0}^{N} b_k z^{-k}}{\sum_{k=0}^{N} a_k z^{-k}}$

Örnek 1

- $y(n) + ay(n-1) = x(n)$ ise $H(z) = ?$

Örnek 1

- $y(n) + ay(n-1) = x(n)$ ise $H(z) = ?$
- $Y(z) + \cdots$

Örnek 1

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- $Y(z) + az^{-1}Y(z) = X(z) \;\rightarrow$

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- $y(n) + ay(n-1) = x(n)$ ise $H(z) = ?$
- $Y(z) + az^{-1}Y(z) = X(z) \rightarrow Y(z)(1 + az^{-1}) = X(z)$
- $H(z) = \frac{1}{1+az^{-1}}$
- $h(n) = ?$

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- $h(n) = \mathcal{Z}^{-1}\left\{\frac{1}{1+az^{-1}}\right\} =$

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- $H(z) = \frac{1}{1+az^{-1}}$
- $h(n) = \mathcal{Z}^{-1}\left\{\frac{1}{1+az^{-1}}\right\} = (-a)^n u(n)$

Örnek 2

- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$ ise $H(z) =?$
- $Y(z)$ …

Örnek 2

- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$ ise $H(z) = ?$
- $Y(z) - 3z^{-1}Y(z) - 4z^{-2}Y(z) = X(z) + 2z^{-1}X(z)$

Örnek 2

- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$ ise $H(z) =?$
- $Y(z) - 3z^{-1}Y(z) - 4z^{-2}Y(z) = X(z) + 2z^{-1}X(z)$
- $Y(z)(1 - 3z^{-1} - 4z^{-2}) = X(z)(1 + 2z^{-1})$
- $H(z) =$

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- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$ ise $H(z) = ?$
- $Y(z) - 3z^{-1}Y(z) - 4z^{-2}Y(z) = X(z) + 2z^{-1}X(z)$
- $Y(z)(1 - 3z^{-1} - 4z^{-2}) = X(z)(1 + 2z^{-1})$
- $H(z) = \frac{1+2z^{-1}}{1-3z^{-1}-4z^{-2}}$
- $h(n) = ?$

Örnek 2

- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$ ise $H(z) =?$
- $Y(z) - 3z^{-1}Y(z) - 4z^{-2}Y(z) = X(z) + 2z^{-1}X(z)$
- $Y(z)(1 - 3z^{-1} - 4z^{-2}) = X(z)(1 + 2z^{-1})$
- $H(z) = \frac{1+2z^{-1}}{1-3z^{-1}-4z^{-2}} = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}}$

Örnek 2

- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$ ise $H(z) = ?$
- $Y(z) - 3z^{-1}Y(z) - 4z^{-2}Y(z) = X(z) + 2z^{-1}X(z)$
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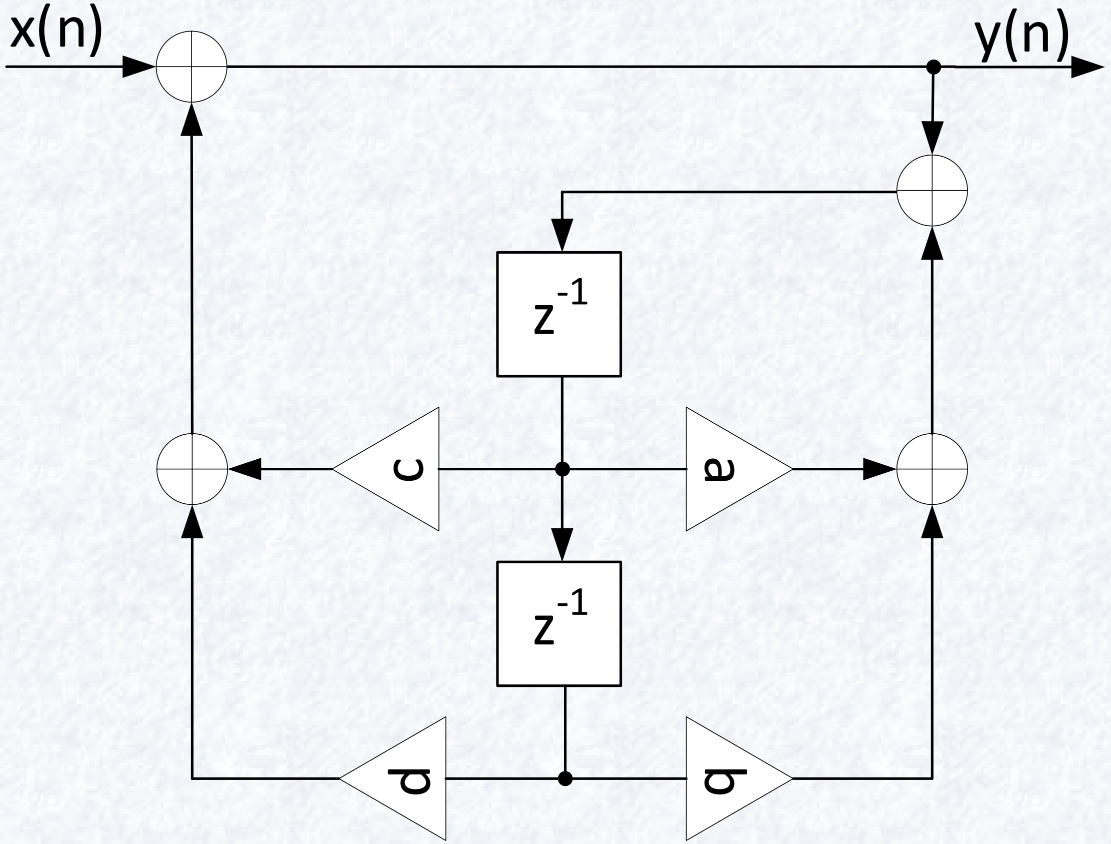
- $H(z) = \frac{1+2z^{-1}}{1-3z^{-1}-4z^{-2}} = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}}$
- $h(n) = A(-1)^n u(n) + B(4)^n u(n)$

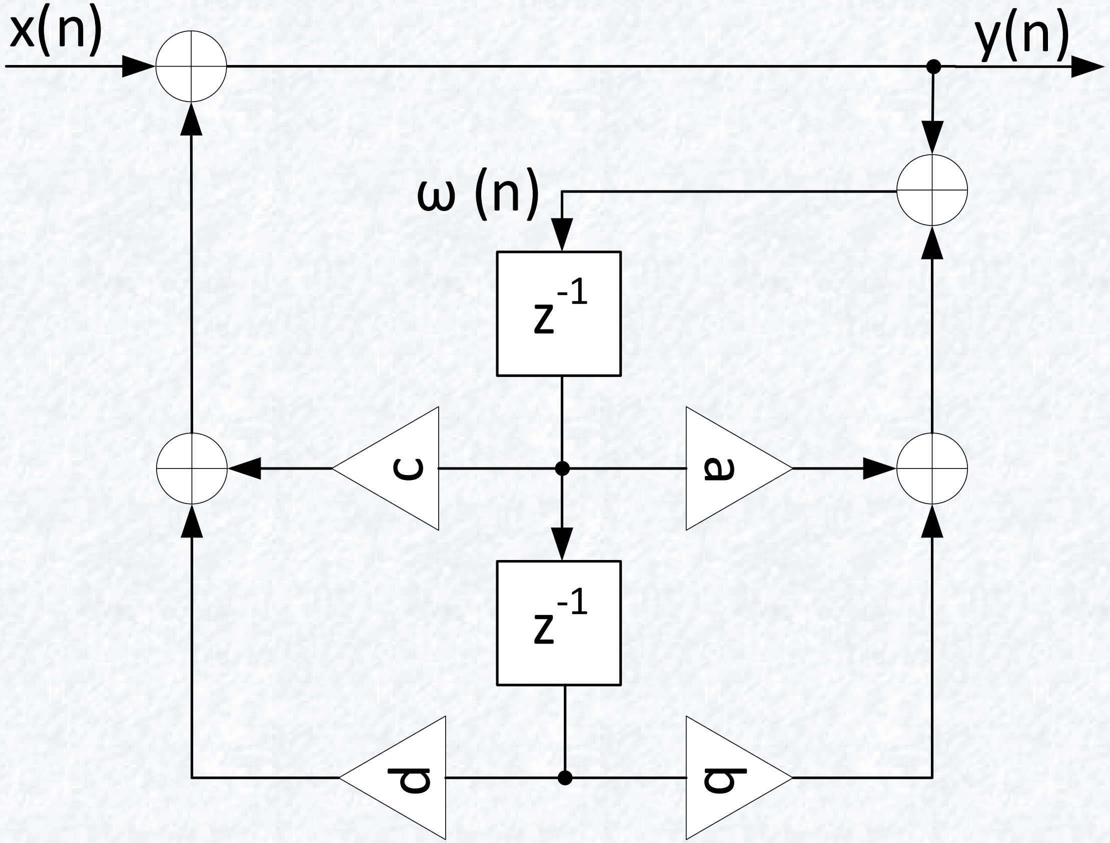
Diyagramdan $H(z)$

- $H(z) = ?$



Diyagramdan $H(z)$

- $\omega(n) =$



Diyagramdan $H(z)$

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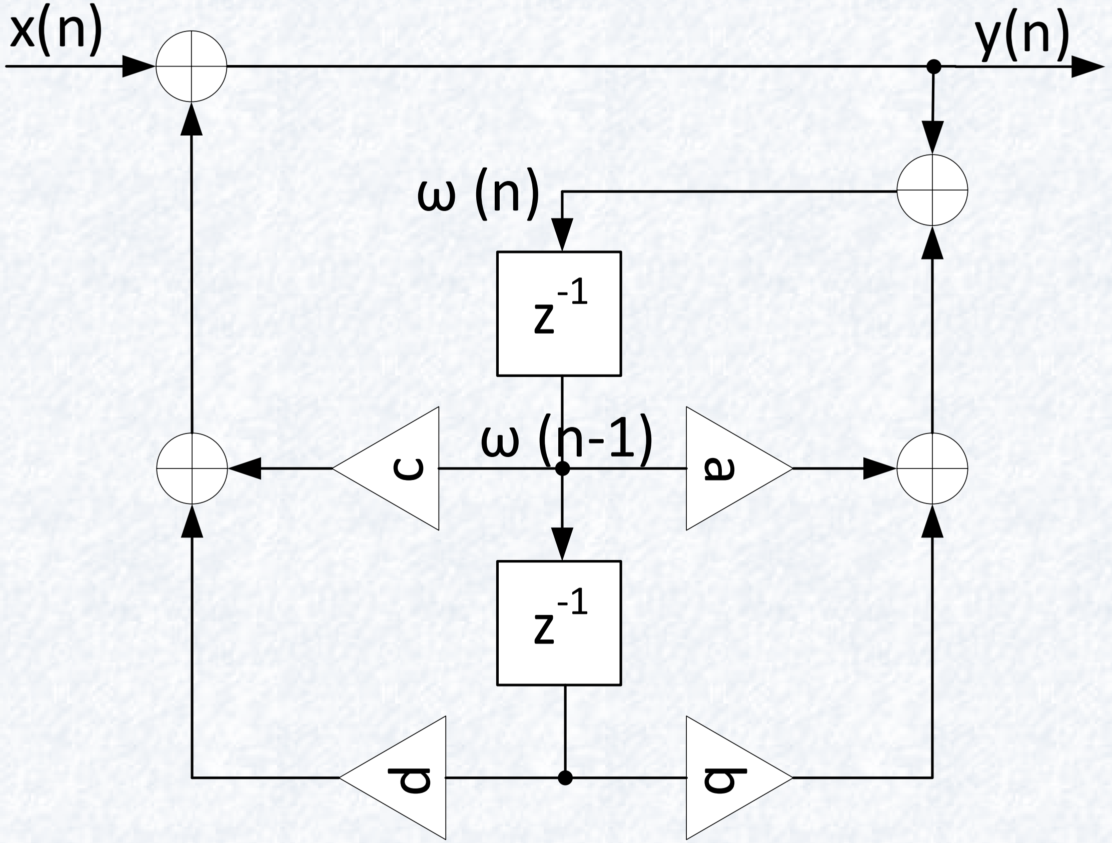

Diyagramdan $H(z)$

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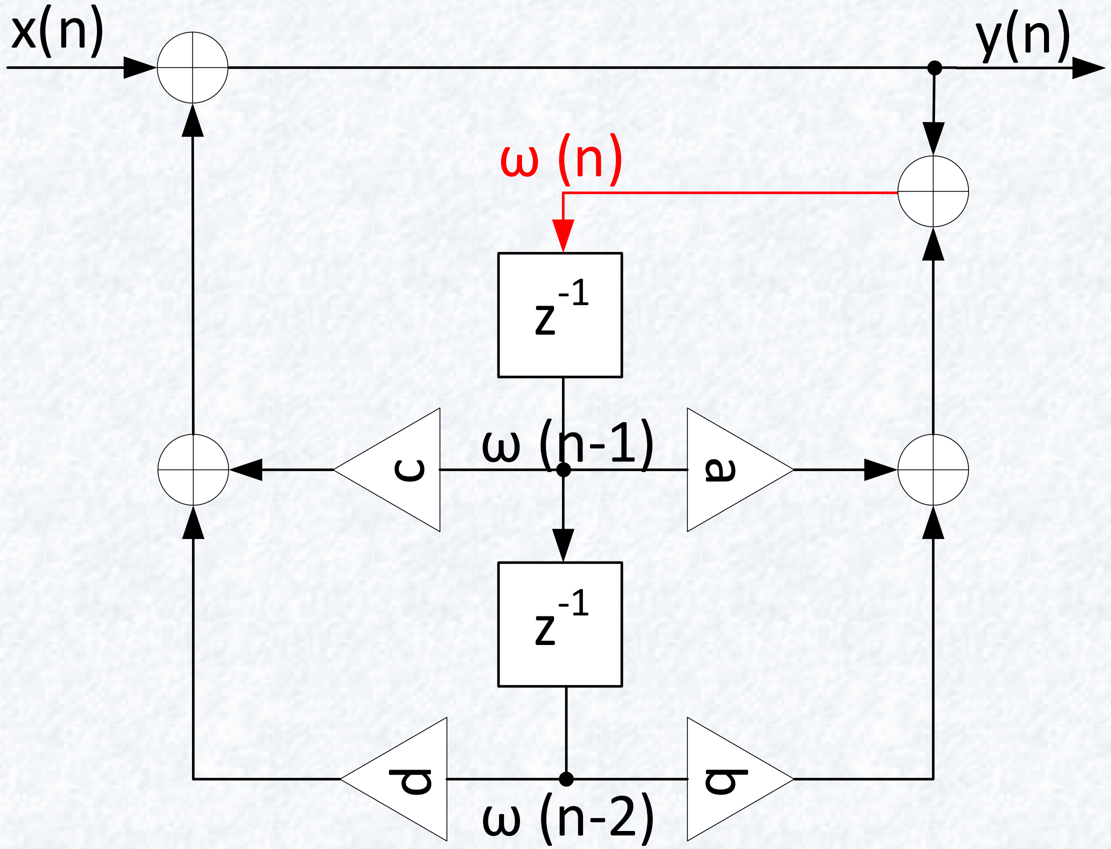
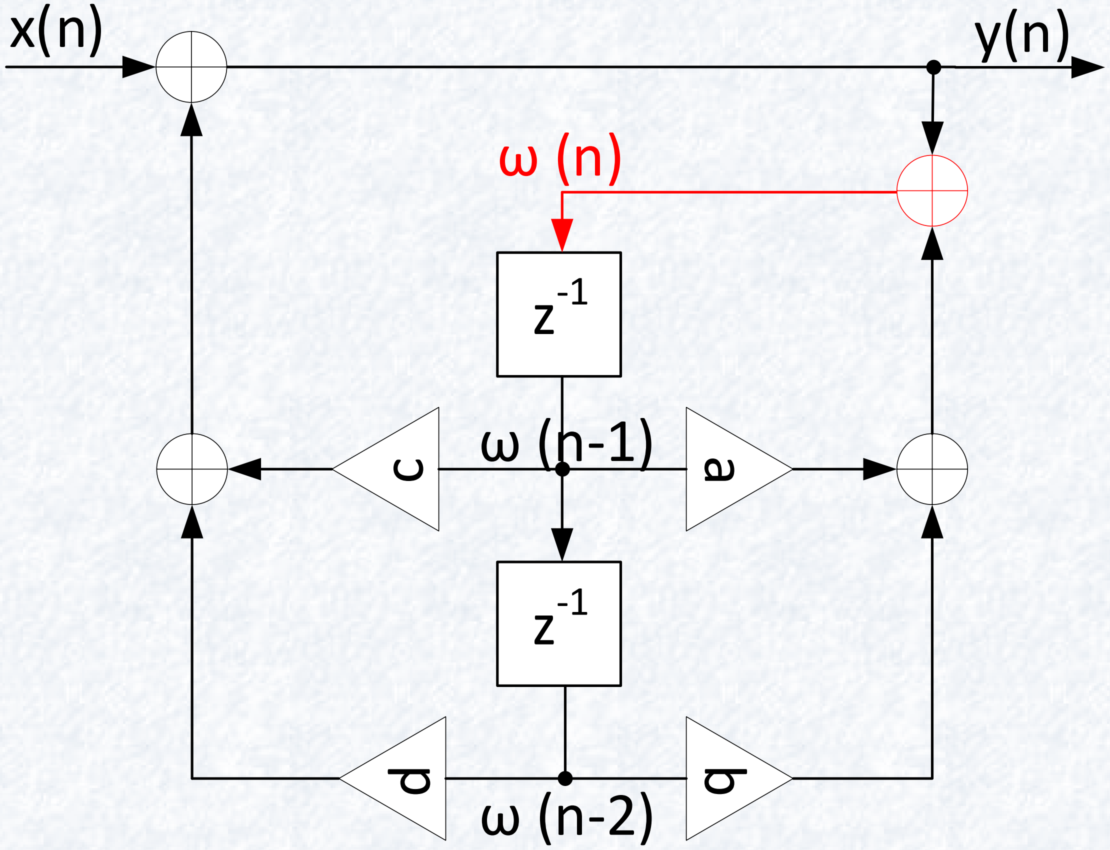


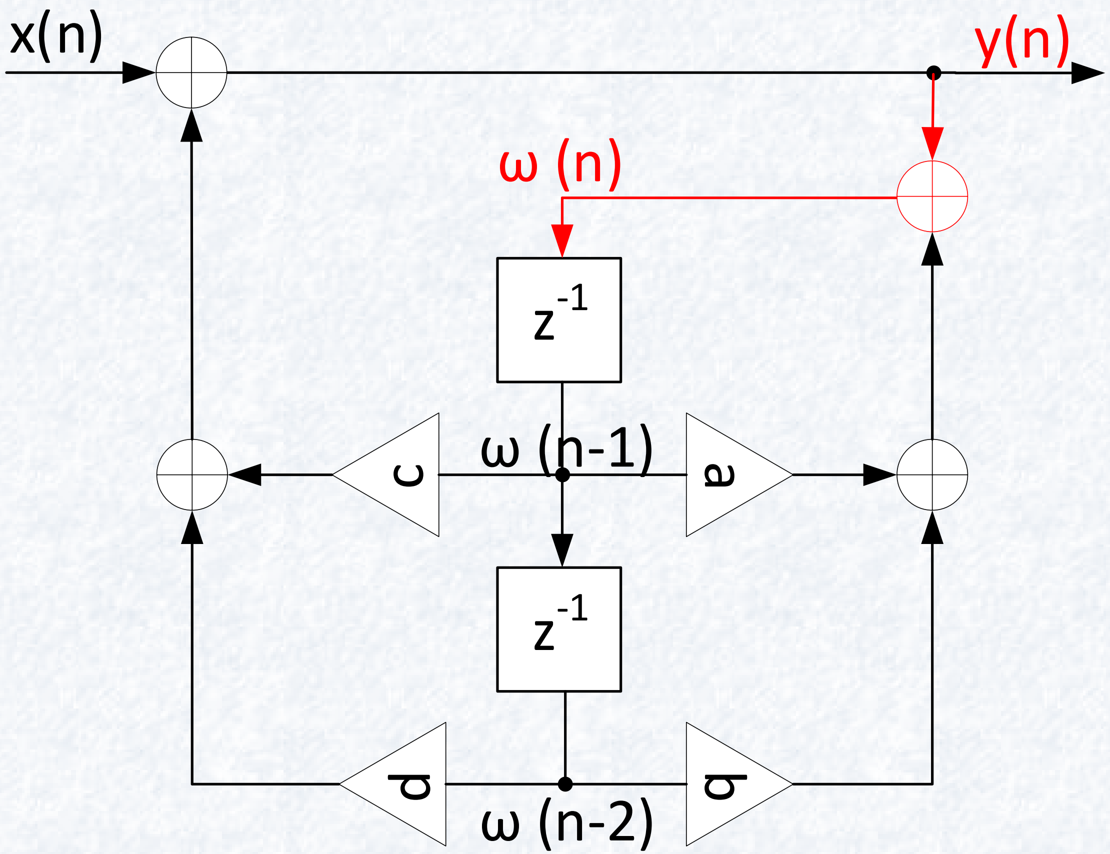
Diyagramdan $H(z)$

- $\omega(n) = \square + \square$



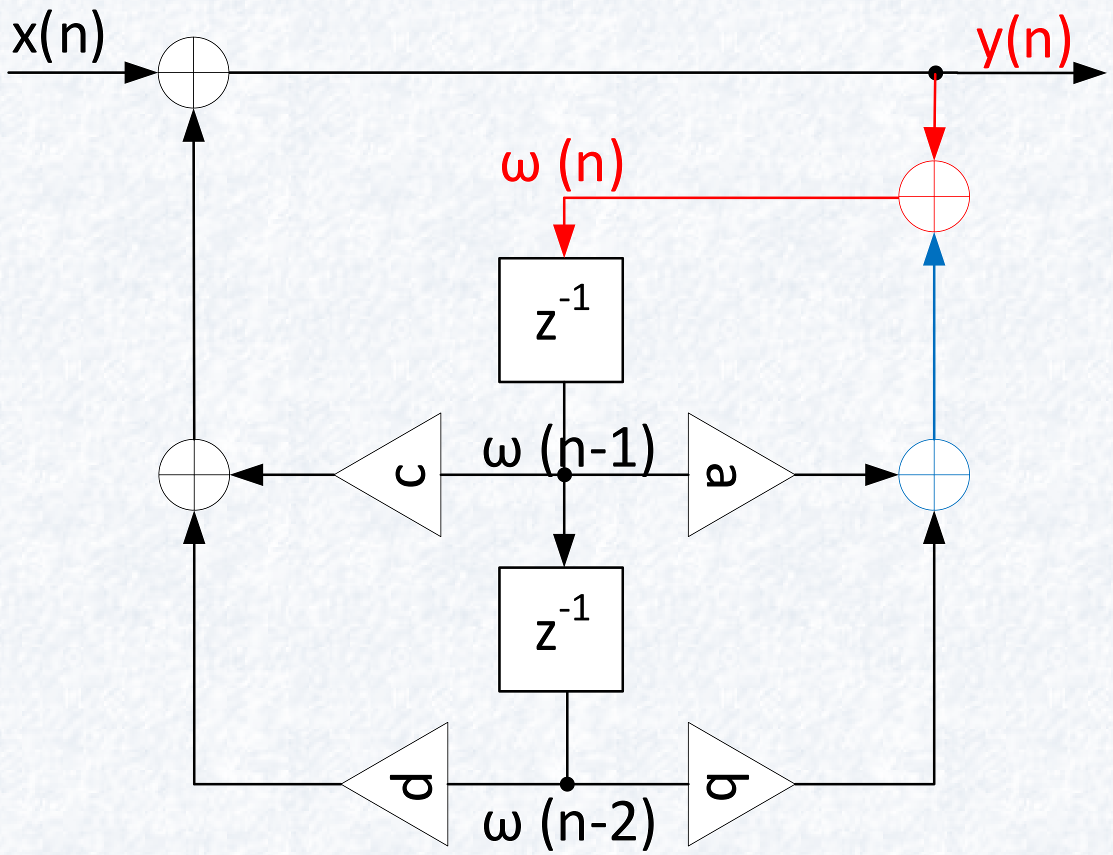
Diyagramdan $H(z)$

- $\omega(n) = y(n) + \square$



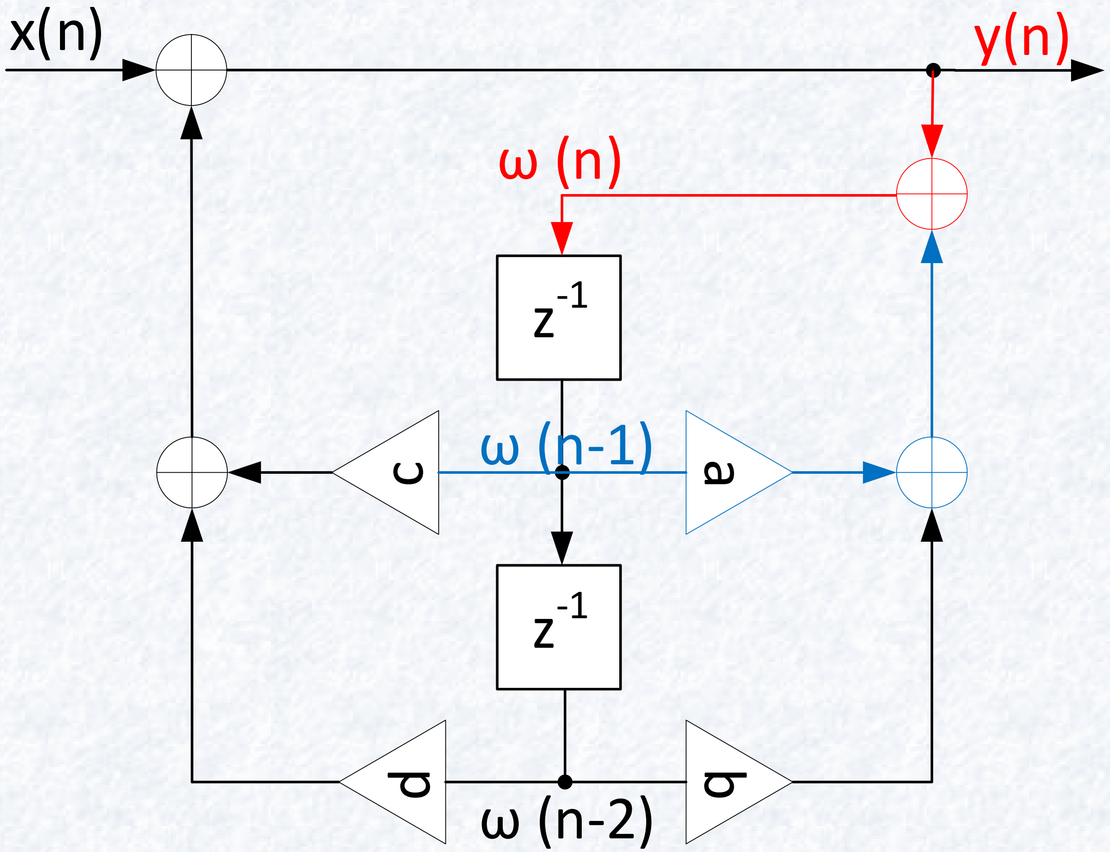
Diyagramdan $H(z)$

- $\omega(n) = y(n) + (\square + \square)$



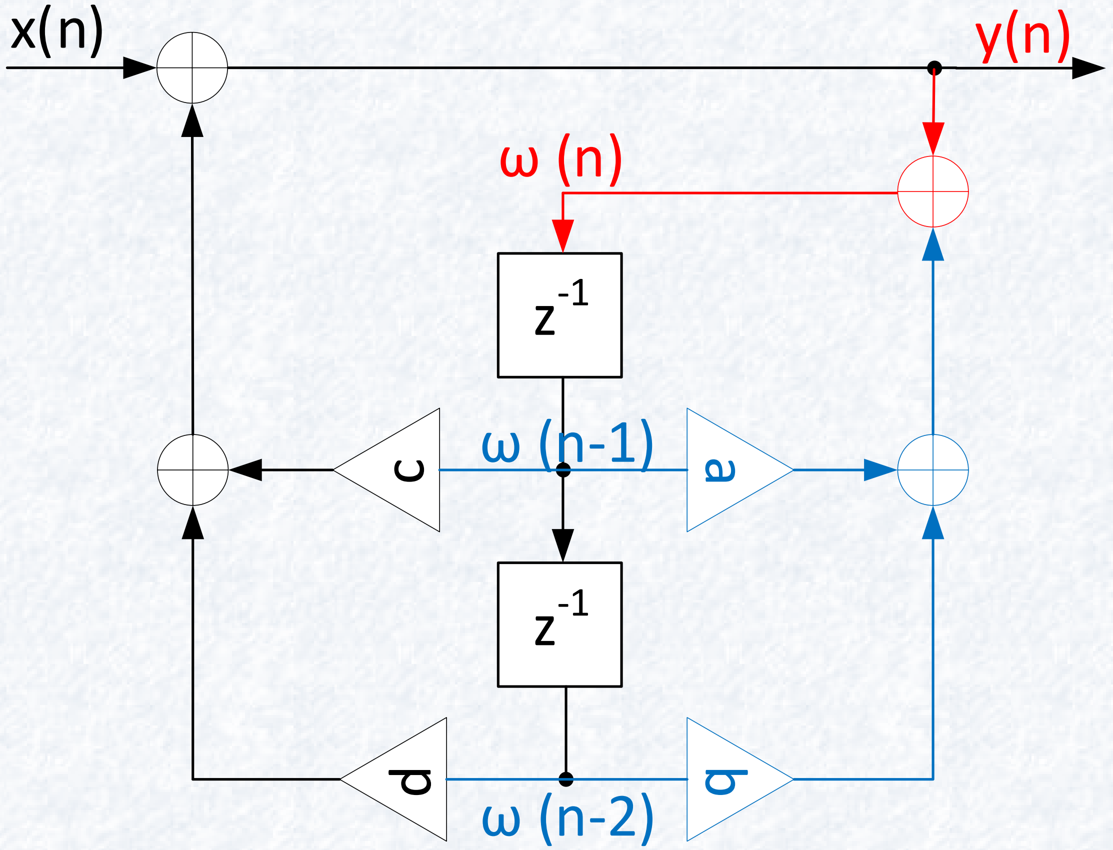
Diyagramdan $H(z)$

- $\omega(n) = y(n) + \left(a\omega(n-1) + \boxed{}\right)$



Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$



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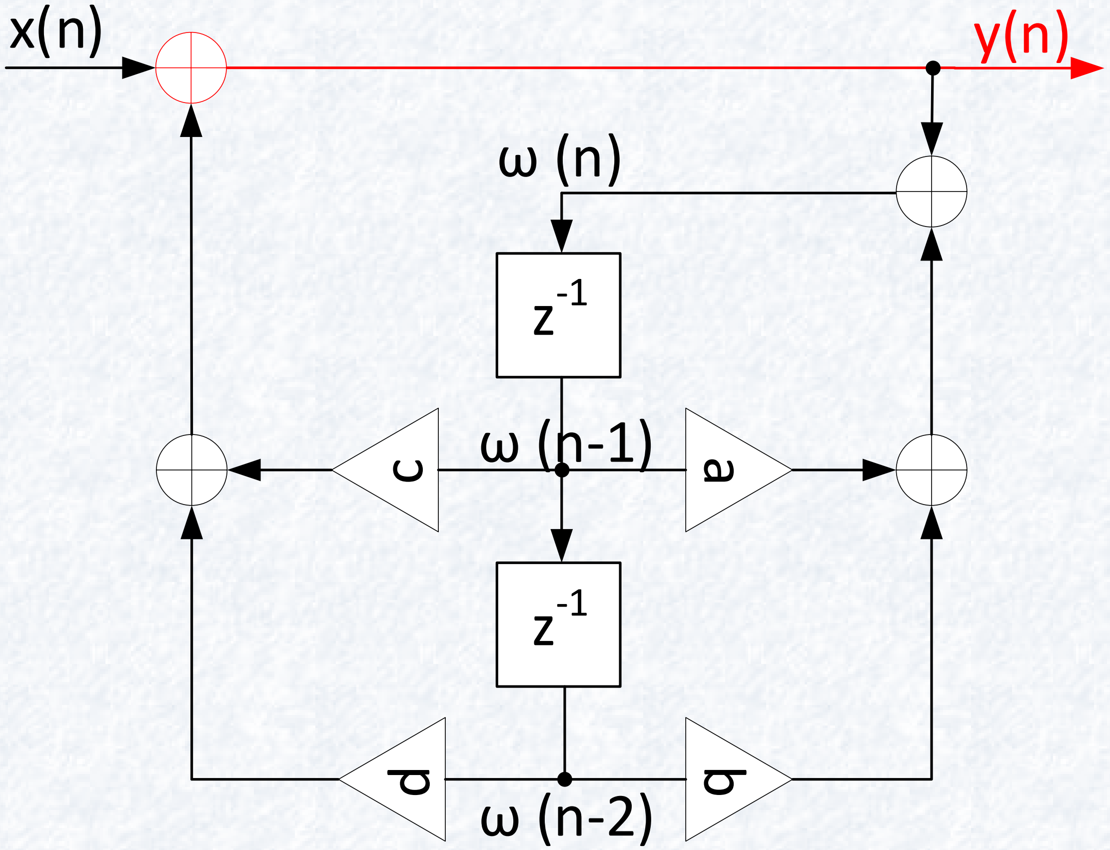

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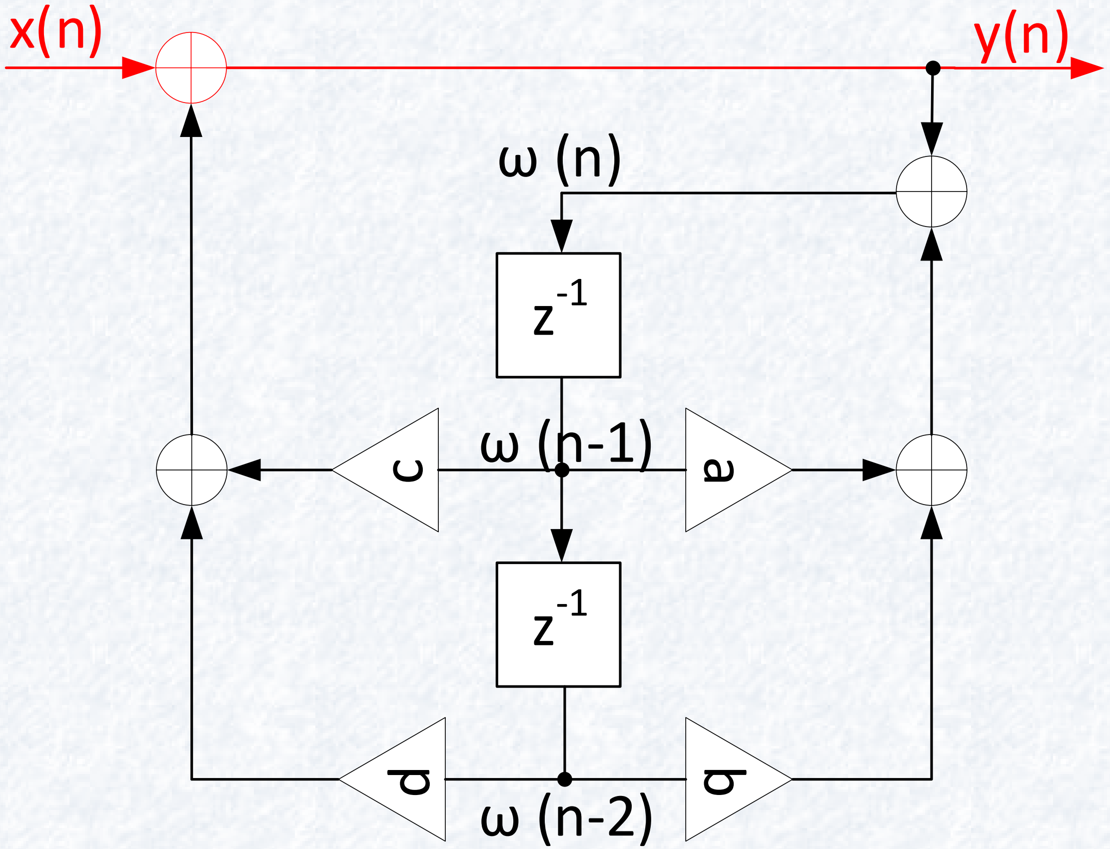

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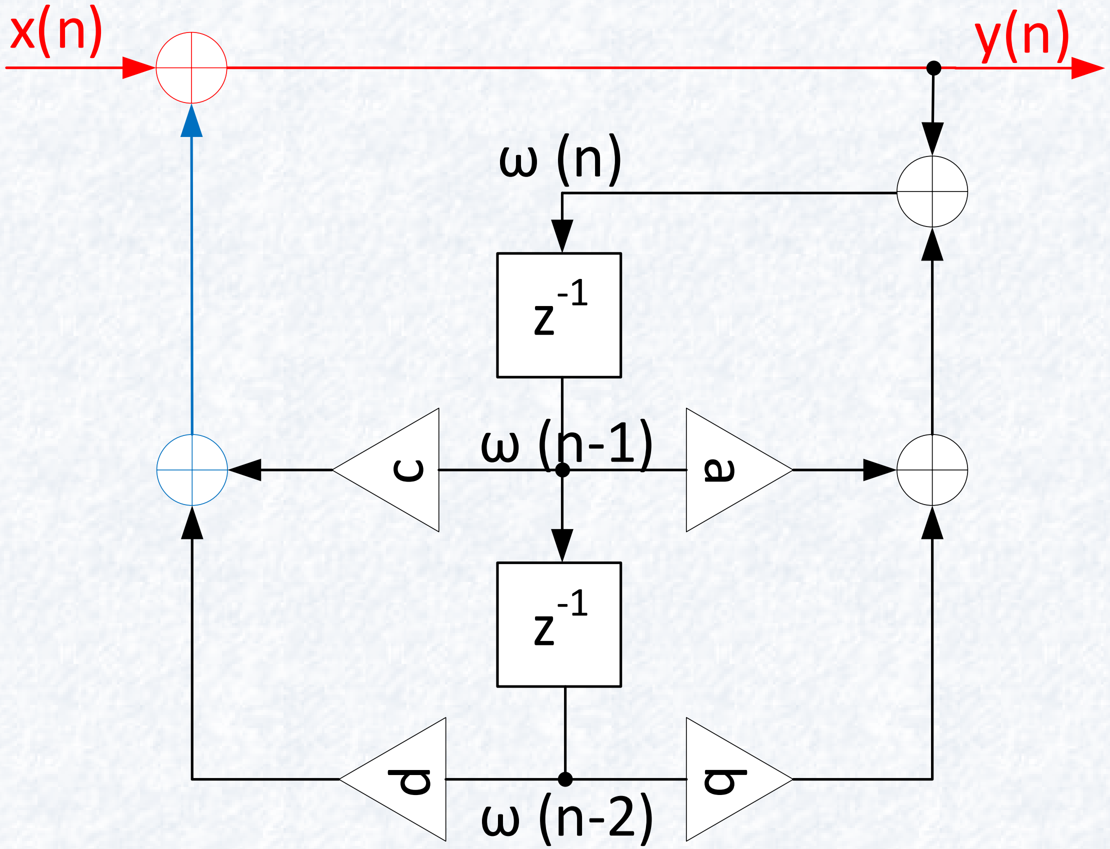
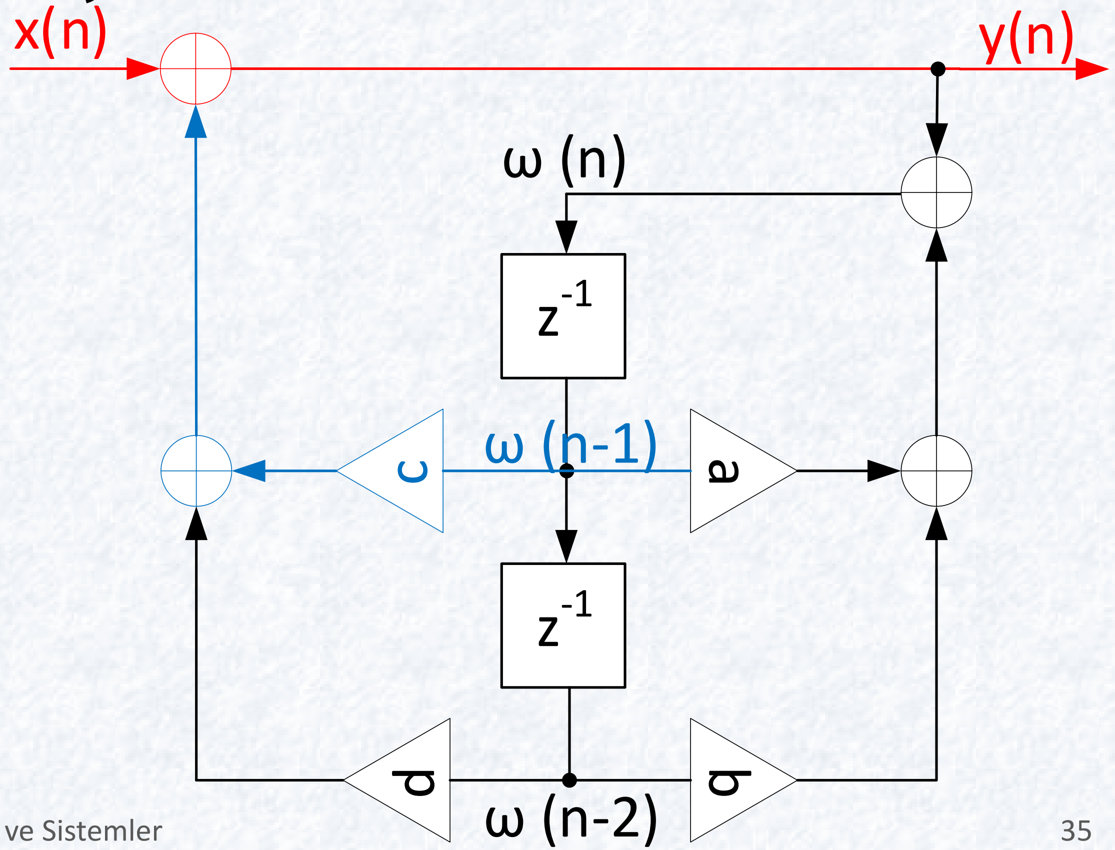


Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$
- $y(n) = x(n) + \big(c\omega(n-1) + \square\big)$



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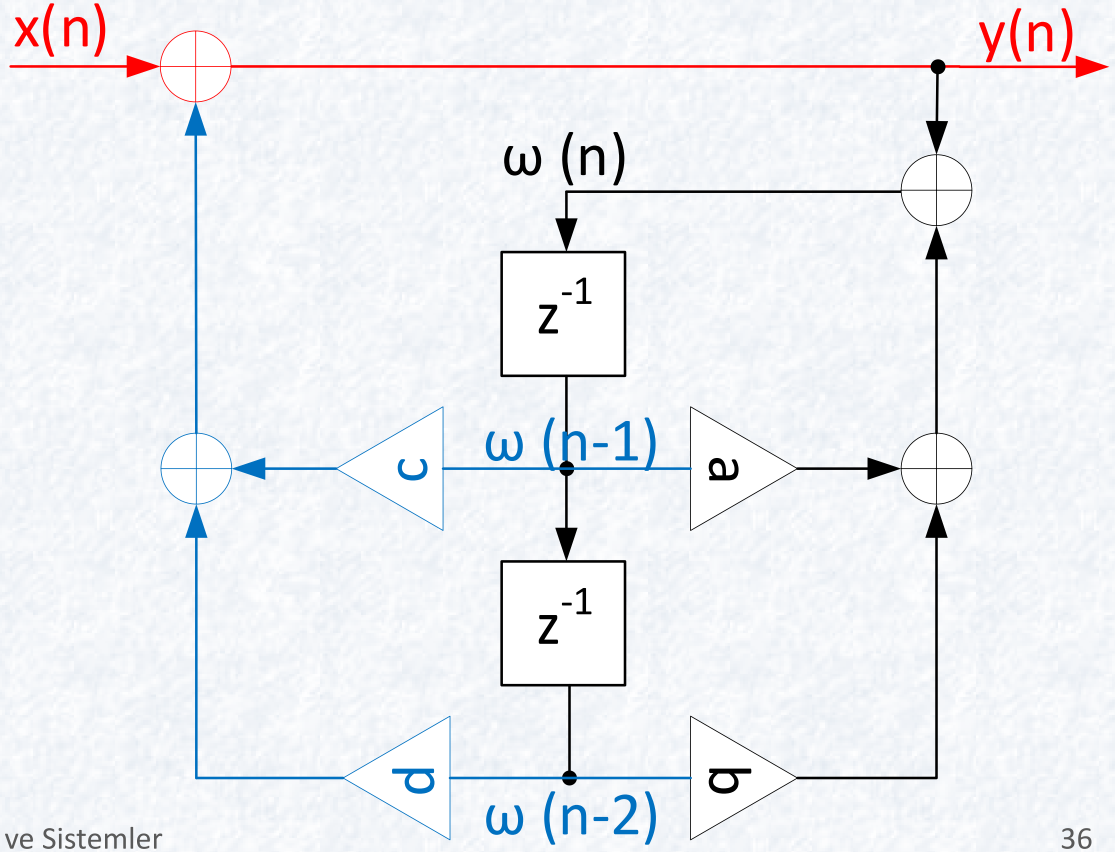

Diyagramdan $H(z)$

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- $W(z) =$

Diyagramdan $H(z)$

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- $W(z) = Y(z) +$

Diyagramdan $H(z)$

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- $Y(z) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$

Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$
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- $W(z) = Y(z) + az^{-1}W(z) + bz^{-2}W(z)$
  - ♦ $W(z) - az^{-1}W(z) - bz^{-2}W(z) = Y(z)$
  - ♦ $W(z)(1 - az^{-1} - bz^{-2}) = Y(z)$
- $Y(z) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$

Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$
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  - ♦ $W(z)(1 - az^{-1} - bz^{-2}) = Y(z)$
- $Y(z) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$
  - ♦ $W(z)(1 - az^{-1} - bz^{-2}) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$

Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$
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- $W(z) = Y(z) + az^{-1}W(z) + bz^{-2}W(z)$
  - ♦ $W(z) - az^{-1}W(z) - bz^{-2}W(z) = Y(z)$
  - ♦ $W(z)(1 - az^{-1} - bz^{-2}) = Y(z)$
- $Y(z) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$
  - ♦ $W(z)(1 - az^{-1} - bz^{-2}) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$
  - ♦ $W(z)(1 - az^{-1} - bz^{-2}) + W(z)(cz^{-1} + dz^{-2}) = X(z)$

Diyagramdan $H(z)$

- $\omega(n) = y(n) + \left(a\omega(n-1) + b\omega(n-2)\right)$
- $y(n) = x(n) + \left(c\omega(n-1) + d\omega(n-2)\right)$
- $W(z) = Y(z) + az^{-1}W(z) + bz^{-2}W(z)$
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  - $W(z)(1 - az^{-1} - bz^{-2}) = Y(z)$
- $Y(z) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$
  - $W(z)(1 - az^{-1} - bz^{-2}) = X(z) + cz^{-1}W(z) + dz^{-2}W(z)$
  - $W(z)(1 - az^{-1} - bz^{-2}) - W(z)(cz^{-1} + dz^{-2}) = X(z)$
  - $W(z)(1 - (a+c)z^{-1} - (b+d)z^{-2}) = X(z)$

Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$
- $y(n) = x(n) + \big(c\omega(n-1) + d\omega(n-2)\big)$
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- $W(z)(1 - (a+c)z^{-1} - (b+d)z^{-2}) = X(z)$
- $H(z) = \frac{Y(z)}{X(z)} =$

Diyagramdan $H(z)$

- $\omega(n) = y(n) + \big(a\omega(n-1) + b\omega(n-2)\big)$
- $y(n) = x(n) + \big(c\omega(n-1) + d\omega(n-2)\big)$
- $W(z)(1 - az^{-1} - bz^{-2}) = Y(z)$
- $W(z)(1 - (a+c)z^{-1} - (b+d)z^{-2}) = X(z)$
- $H(z) = \frac{Y(z)}{X(z)} = \frac{1-az^{-1}-bz^{-2}}{1-(a+c)z^{-1}-(b+d)z^{-2}}$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $\boxed{} = \mathbf{A}\mathbf{Q}(z) + \mathbf{B}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $z\mathbf{Q}(z) = \mathbf{A}\mathbf{Q}(z) + \mathbf{B}X(z)$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $z\mathbf{Q}(z) = \mathbf{A}\mathbf{Q}(z) + \mathbf{B}X(z)$
  - $z\mathbf{Q}(z) - \mathbf{A}\mathbf{Q}(z) = \mathbf{B}X(z)$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{Aq}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{Cq}(n) + \mathbf{D}x(n)$

- $z\mathbf{Q}(z) = \mathbf{AQ}(z) + \mathbf{B}X(z)$
  - $z\mathbf{Q}(z) - \mathbf{AQ}(z) = \mathbf{B}X(z)$
  - $(\boxed{})\mathbf{Q}(z) = \mathbf{B}X(z)$
- $Y(z) = \mathbf{CQ}(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $z\mathbf{Q}(z) = \mathbf{A}\mathbf{Q}(z) + \mathbf{B}X(z)$
  - $z\mathbf{Q}(z) - \mathbf{A}\mathbf{Q}(z) = \mathbf{B}X(z)$
  - $(z\mathbf{I} - \mathbf{A})\mathbf{Q}(z) = \mathbf{B}X(z)$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $z\mathbf{Q}(z) = \mathbf{A}\mathbf{Q}(z) + \mathbf{B}X(z)$
  - $z\mathbf{Q}(z) - \mathbf{A}\mathbf{Q}(z) = \mathbf{B}X(z)$
  - $(z\mathbf{I} - \mathbf{A})\mathbf{Q}(z) = \mathbf{B}X(z)$
  - $\mathbf{Q}(z) =$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $z\mathbf{Q}(z) = \mathbf{A}\mathbf{Q}(z) + \mathbf{B}X(z)$
  - ♦ $z\mathbf{Q}(z) - \mathbf{A}\mathbf{Q}(z) = \mathbf{B}X(z)$
  - ♦ $(z\mathbf{I} - \mathbf{A})\mathbf{Q}(z) = \mathbf{B}X(z)$
  - ♦ $\mathbf{Q}(z) = (z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B}X(z)$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $\mathbf{Q}(z) = (z\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{B}X(z)$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$
- $Y(z) =$

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- $Y(z) = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B}X(z) + \mathbf{D}X(z)$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
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- $Y(z) = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-\mathbf{1}}\mathbf{B}X(z) + \mathbf{D}X(z)$
- $Y(z) = (\quad)X(z)$
- $H(z) =$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
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- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$
- $Y(z) = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B}X(z) + \mathbf{D}X(z)$
- $Y(z) = \left(\mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B} + \mathbf{D}\right)X(z)$
- $H(z) =$

Durum Denkleminden $H(z)$

- $\mathbf{q}(n+1) = \mathbf{A}\mathbf{q}(n) + \mathbf{B}x(n)$
- $y(n) = \mathbf{C}\mathbf{q}(n) + \mathbf{D}x(n)$

- $\mathbf{Q}(z) = (z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B}X(z)$
- $Y(z) = \mathbf{C}\mathbf{Q}(z) + \mathbf{D}X(z)$
- $Y(z) = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B}X(z) + \mathbf{D}X(z)$
- $Y(z) = (\mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B} + \mathbf{D})X(z)$
- $H(z) = \frac{Y(z)}{X(z)} = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B} + \mathbf{D}$

Örnek 2

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix}}_{A} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} x(n)$

- $y[n] = \underbrace{\begin{bmatrix} 3 & 2 \end{bmatrix}}_{C} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{1}_{D}\, x(n)$ ise $H(z) = ?$

Örnek 2

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix}}_{A} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} x(n)$

- $y[n] = \underbrace{[3 \quad 2]}_{C} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{1}_{D} x(n)$ ise $H(z) = ?$

- $z\mathbf{I} - \mathbf{A} = z \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix} =$

Örnek 2

- $$\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix}}_{A} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} x(n)$$

- $y[n] = \underbrace{\begin{bmatrix} 3 & 2 \end{bmatrix}}_{C} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{1}_{D} x(n)$ ise $H(z) = ?$

- $$z\mathbf{I} - \mathbf{A} = z \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix} = \begin{bmatrix} z & -1 \\ -3 & z-2 \end{bmatrix}$$

Örnek 2

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix}}_{A} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} x(n)$

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- $(z\mathbf{I} - \mathbf{A})^{-1} =$

Örnek 2

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix}}_{A} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} x(n)$
- $y[n] = \underbrace{\begin{bmatrix} 3 & 2 \end{bmatrix}}_{C} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{1}_{D} x(n)$ ise $H(z) = ?$
- $z\mathbf{I} - \mathbf{A} = z \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix} = \begin{bmatrix} z & -1 \\ -3 & z-2 \end{bmatrix}$
- $(z\mathbf{I} - \mathbf{A})^{-1} = \frac{1}{z(z-2)-3} \begin{bmatrix} z-2 & 1 \\ 3 & z \end{bmatrix}$
- $H(z) = \frac{Y(z)}{X(z)} = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B} + \mathbf{D} = \frac{1}{z(z-2)-3} \begin{bmatrix} 3 & 2 \end{bmatrix} \begin{bmatrix} z-2 & 1 \\ 3 & z \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} + 1$

Örnek 2

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \underbrace{\begin{bmatrix} 0 & 1 \\ 3 & 2 \end{bmatrix}}_{A} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 1 \end{bmatrix}}_{B} x(n)$

- $y[n] = \underbrace{\begin{bmatrix} 3 & 2 \end{bmatrix}}_{C} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \underbrace{1}_{D} x(n)$ ise $H(z) = ?$

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Örnek 2

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- $H(z) = \frac{1}{z(z-2)-3} \begin{bmatrix} 3 & 2 \end{bmatrix} \begin{bmatrix} 1 \\ z \end{bmatrix} + 1 = \frac{3+2z}{z(z-2)-3} + 1 = \frac{z^2}{z(z-2)-3}$

Örnek 3

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} x(n)$
- $y[n] = \begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + x(n)$ise $H(z) =$?

Örnek 3

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} x(n)$
- $y[n] = \begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + x(n)$ise $H(z) =?$
- $z\mathbf{I} - \mathbf{A} = z\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} z & -1 \\ -4 & z-3 \end{bmatrix}$

Örnek 3

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} x(n)$
- $y[n] = \begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + x(n)$ ise $H(z) = ?$
- $z\mathbf{I} - \mathbf{A} = z \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} z & -1 \\ -4 & z-3 \end{bmatrix}$
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- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} x(n)$
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- $z\mathbf{I} - \mathbf{A} = z \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} z & -1 \\ -4 & z-3 \end{bmatrix}$
- $(z\mathbf{I} - \mathbf{A})^{-1} = \frac{1}{z(z-3)-4} \begin{bmatrix} z-3 & 1 \\ 4 & z \end{bmatrix}$

Örnek 3

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} x(n)$
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- $z\mathbf{I} - \mathbf{A} = z\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} = \begin{bmatrix} z & -1 \\ -4 & z-3 \end{bmatrix}$
- $(z\mathbf{I} - \mathbf{A})^{-1} = \frac{1}{z(z-3)-4}\begin{bmatrix} z-3 & 1 \\ 4 & z \end{bmatrix}$
- $H(z) = \frac{Y(z)}{X(z)} = \mathbf{C}(z\mathbf{I} - \mathbf{A})^{-1}\mathbf{B} + \mathbf{D} = \frac{1}{z(z-3)-4}\begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} z-3 & 1 \\ 4 & z \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} + 1$

Örnek 3

- $\begin{bmatrix} q_1(n+1) \\ q_2(n+1) \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 4 & 3 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} x(n)$
- $y[n] = \begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} q_1(n) \\ q_2(n) \end{bmatrix} + x(n)$ise $H(z) =?$
- $H(z) = \frac{Y(z)}{X(z)} = \frac{1}{z(z-3)-4} \begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} z-3 & 1 \\ 4 & z \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} + 1$
- $H(z) = \frac{1}{z(z-3)-4} \begin{bmatrix} 4 & 5 \end{bmatrix} \begin{bmatrix} 1 \\ z \end{bmatrix} + 1 = \frac{4+5z}{z(z-3)-4} + 1 = \frac{z^2+2z}{z(z-3)-4}$

Doğal ve Zorlanmış Çözüm

- $H(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = X(z)H(z) =$

Doğal ve Zorlanmış Çözüm

- $H(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}\dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}} + \frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}$

Doğal ve Zorlanmış Çözüm

- $H(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\dfrac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \dfrac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\dfrac{\beta_1}{1-q_1 z^{-1}} + \cdots + \dfrac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
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- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) =$

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) = \alpha_1 (p_1)^n u(n) + \cdots + \alpha_N (p_N)^n u(n) =$

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) = \alpha_1 (p_1)^n u(n) + \cdots + \alpha_N (p_N)^n u(n) = \sum_{k=1}^{N} \alpha_k (p_k)^n u(n)$

Doğal ve Zorlanmış Çözüm

- $H(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \dfrac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}\dfrac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\dfrac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \dfrac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\dfrac{\beta_1}{1-q_1 z^{-1}} + \cdots + \dfrac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) = \alpha_1 (p_1)^n u(n) + \cdots + \alpha_N (p_N)^n u(n) = \sum_{k=1}^{N} \alpha_k (p_k)^n u(n)$
  - $\forall k$ için $|p_k| < 1$ ise $y_d(n)$, geçici cevap

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
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- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}\frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) = \alpha_1(p_1)^n u(n) + \cdots + \alpha_N(p_N)^n u(n) = \sum_{k=1}^{N} \alpha_k(p_k)^n u(n)$
  - $\forall k$ için $|p_k| < 1$ ise $y_d(n)$, geçici cevap
- $y_z(n) =$

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) = \alpha_1 (p_1)^n u(n) + \cdots + \alpha_N (p_N)^n u(n) = \sum_{k=1}^{N} \alpha_k (p_k)^n u(n)$
  - $\forall k$ için $|p_k| < 1$ ise $y_d(n)$, geçici cevap
- $y_z(n) = \beta_1 (q_1)^n u(n) + \cdots + \beta_L (q_L)^n u(n) =$

Doğal ve Zorlanmış Çözüm

- $H(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})}$
- $X(z) = \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = H(z)X(z) = \frac{A(z)}{\prod_{k=1}^{N}(1-p_k z^{-1})} \frac{B(z)}{\prod_{k=1}^{L}(1-q_k z^{-1})}$
- $Y(z) = \underbrace{\frac{\alpha_1}{1-p_1 z^{-1}} + \cdots + \frac{\alpha_N}{1-p_N z^{-1}}}_{Y_d(z)} + \underbrace{\frac{\beta_1}{1-q_1 z^{-1}} + \cdots + \frac{\beta_L}{1-q_L z^{-1}}}_{Y_z(z)}$
- $y_d(n) = \alpha_1 (p_1)^n u(n) + \cdots + \alpha_N (p_N)^n u(n) = \sum_{k=1}^{N} \alpha_k (p_k)^n u(n)$
  - $\forall k$ için $|p_k| < 1$ ise $y_d(n)$, geçici cevap
- $y_z(n) = \beta_1 (q_1)^n u(n) + \cdots + \beta_L (q_L)^n u(n) = \sum_{k=1}^{L} \beta_k (q_k)^n u(n)$
  - $\forall k$ için $|q_k| < 1$ ise $y_z(n)$, kalıcı durum cevabı

Örnek 4

- $n \geq 0$ için
- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$
- $x(n) = \cos\left(\frac{\pi}{3}n\right)u(n)$ ise z-dönüşümü ile doğal ve zorlanmış çözüm?

Örnek 4

- $n \geq 0$ için
- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$
- $x(n) = \cos\left(\frac{\pi}{3}n\right)u(n)$ ise z-dönüşümü ile doğal ve zorlanmış çözüm?
- $H(z) =$

Örnek 4

- $n \geq 0$ için
- $y(n) - 3y(n-1) - 4y(n-2) = x(n) + 2x(n-1)$
- $x(n) = \cos\left(\frac{\pi}{3}n\right)u(n)$ ise z-dönüşümü ile doğal ve zorlanmış çözüm?
- $H(z) = \frac{1+2z^{-1}}{1-3z^{-1}-4z^{-2}}$
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Örnek 4

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Örnek 4

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Örnek 4

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Örnek 4

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- $Y(z) = \frac{1+2z^{-1}}{1-3z^{-1}-4z^{-2}} \frac{1-\frac{1}{2}z^{-1}}{1-z^{-1}+z^{-2}} = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$

Örnek 4

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- $Y(z) = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}} + \frac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \frac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$

Örnek 4

- $Y(z) = \dfrac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \dfrac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$
- $Y(z) = \dfrac{A}{1+z^{-1}} + \dfrac{B}{1-4z^{-1}} + \dfrac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \dfrac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$
- $A = \dfrac{1+2z^{-1}}{(1-4z^{-1})} \dfrac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=-1} = -\dfrac{1}{10}$
- $B = \dfrac{1+2z^{-1}}{(1+z^{-1})} \dfrac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=\frac{1}{4}} = \dfrac{21}{13}$

Örnek 4

- $Y(z) = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$
- $Y(z) = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}} + \frac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \frac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$
- $A = \frac{1+2z^{-1}}{(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=-1} = -\frac{1}{10}$
- $B = \frac{1+2z^{-1}}{(1+z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=\frac{1}{4}} = \frac{21}{13}$
- $y_d(n) =$

Örnek 4

- $Y(z) = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$
- $Y(z) = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}} + \frac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \frac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$
- $A = \frac{1+2z^{-1}}{(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=-1} = -\frac{1}{10}$
- $B = \frac{1+2z^{-1}}{(1+z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=\frac{1}{4}} = \frac{21}{13}$
- $y_d(n) = -\frac{1}{10}(-1)^n u(n) + \frac{21}{13}(4)^n u(n)$

Örnek 4

- $Y(z) = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$
- $Y(z) = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}} + \frac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \frac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$
- $C = \left.\frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}\right|_{z^{-1}=e^{-j\frac{\pi}{3}}} = 0{,}2118e^{-j117°}$
- $D = \left.\frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)}\right|_{z^{-1}=e^{j\frac{\pi}{3}}} = 0{,}2118e^{j117°}$
- $y_z(n) =$

Örnek 4

- $Y(z) = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$
- $Y(z) = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}} + \frac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \frac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$
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- $y_z(n) = 0{,}2118e^{-j117°}e^{j\frac{\pi}{3}n}u(n) + 0{,}2118e^{j117°}e^{-j\frac{\pi}{3}n}u(n)$
- $y_z(n) =$

Örnek 4

- $Y(z) = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)\left(1-e^{-j\frac{\pi}{3}}z^{-1}\right)}$
- $Y(z) = \frac{A}{1+z^{-1}} + \frac{B}{1-4z^{-1}} + \frac{C}{1-e^{j\frac{\pi}{3}}z^{-1}} + \frac{D}{1-e^{-j\frac{\pi}{3}}z^{-1}}$
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- $D = \frac{1+2z^{-1}}{(1+z^{-1})(1-4z^{-1})} \frac{1-\frac{1}{2}z^{-1}}{\left(1-e^{j\frac{\pi}{3}}z^{-1}\right)}\Bigg|_{z^{-1}=e^{j\frac{\pi}{3}}} = 0{,}2118e^{j117°}$
- $y_z(n) = 0{,}2118e^{-j117°}e^{j\frac{\pi}{3}n}u(n) + 0{,}2118e^{j117°}e^{-j\frac{\pi}{3}n}u(n)$
- $y_z(n) = 0{,}4236\cos\left(\frac{\pi}{3}n - 117°\right)u(n)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Hafızalılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$

Ayrık Zaman DZD Temel Sistem Özellikleri

Hafızalılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Hafızasız
    - Sistem çıkışının, giriş işaretinin zamanın sadece o andaki bilgisine bağlı olması
  - ♦ Hafızalı
    - Sistem çıkışının, giriş işaretinin ötelenmiş hallerine bağlı olması
- Birim Darbe Cevabına Göre, $h(n)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Hafızalılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Hafızasız
    - Sistem çıkışının, giriş işaretinin zamanın sadece o andaki bilgisine bağlı olması
  - ♦ Hafızalı
    - Sistem çıkışının, giriş işaretinin ötelenmiş hallerine bağlı olması
- Birim Darbe Cevabına Göre, $h(n)$
  - ♦ $\forall n \neq 0$ için $h(n) = 0$ ise Hafızasız. $h(n) = K\delta(n)$
  - ♦ $\exists n \neq 0$ için $h(n) \neq 0$ ise Hafızalı.

Ayrık Zaman DZD Temel Sistem Özellikleri

Hafızalılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Hafızasız
    - Sistem çıkışının, giriş işaretinin zamanın sadece o andaki bilgisine bağlı olması
  - ♦ Hafızalı
    - Sistem çıkışının, giriş işaretinin ötelenmiş hallerine bağlı olması
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  - ♦ $\exists n \neq 0$ için $h(n) \neq 0$ ise Hafızalı.
- Transfer Fonksiyonuna Göre, $H(z)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Hafızalılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - Hafızasız
    - Sistem çıkışının, giriş işaretinin zamanın sadece o andaki bilgisine bağlı olması
  - Hafızalı
    - Sistem çıkışının, giriş işaretinin ötelenmiş hallerine bağlı olması
- Birim Darbe Cevabına Göre, $h(n)$
  - $\forall n \neq 0$ için $h(n) = 0$ ise Hafızasız. $h(n) = K\delta(n)$
  - $\exists n \neq 0$ için $h(n) \neq 0$ ise Hafızalı.
- Transfer Fonksiyonuna Göre, $H(z)$
  - $H(z) = K$ ise Hafızasız.
  - $H(z) \neq K$ ise Hafızalı.

Ayrık Zaman DZD Temel Sistem Özellikleri

Nedensellik

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$

Ayrık Zaman DZD Temel Sistem Özellikleri

Nedensellik

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Nedensel
    - Sistem çıkışının, giriş işaretinin zamanın o andaki ve/veya geçmişteki bilgisine bağlı olması
  - ♦ Nedensel olmayan
    - Sistem çıkışının, giriş işaretinin gelecekteki bilgisine bağlı olması
- Birim Darbe Cevabına Göre, $h(n)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Nedensellik

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - Nedensel
    - Sistem çıkışının, giriş işaretinin zamanın o andaki ve/veya geçmişteki bilgisine bağlı olması
  - Nedensel olmayan
    - Sistem çıkışının, giriş işaretinin gelecekteki bilgisine bağlı olması
- Birim Darbe Cevabına Göre, $h(n)$
  - $\forall n < 0$ için $h(n) = 0$ ise Nedensel. Sağ taraflı
  - $\exists n < 0$ için $h(n) \neq 0$ ise Nedensel Değil.
- Transfer Fonksiyonuna Göre, $H(z)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Nedensellik

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Nedensel
    - Sistem çıkışının, giriş işaretinin zamanın o andaki ve/veya geçmişteki bilgisine bağlı olması
  - ♦ Nedensel olmayan
    - Sistem çıkışının, giriş işaretinin gelecekteki bilgisine bağlı olması
- Birim Darbe Cevabına Göre, $h(n)$
  - ♦ $\forall n < 0$ için $h(n) = 0$ ise Nedensel. Sağ taraflı
  - ♦ $\exists n < 0$ için $h(n) \neq 0$ ise Nedensel Değil.
- Transfer Fonksiyonuna Göre, $H(z)$
  - ♦ YB: $|z| > |\alpha|$ ise Nedensel.
  - ♦ YB: $|z| \ngtr |\alpha|$ ise Nedensel Değil.

Ayrık Zaman DZD Temel Sistem Özellikleri

Kararlılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$

Ayrık Zaman DZD Temel Sistem Özellikleri

Kararlılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Kararlı
    - $\forall n, |x[n]| < N$ iken $\forall n, |y[n]| < M$ ise
  - ♦ Kararsız
    - $\forall n, |x[n]| < N$ iken $\forall n, |y[n]| \rightarrow \infty$ ise
- Birim Darbe Cevabına Göre, $h(n)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Kararlılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - ♦ Kararlı
    - $\forall n, |x[n]| < N$ iken $\forall n, |y[n]| < M$ ise
  - ♦ Kararsız
    - $\forall n, |x[n]| < N$ iken $\forall n, |y[n]| \rightarrow \infty$ ise
- Birim Darbe Cevabına Göre, $h(n)$
  - ♦ $\sum_{n=-\infty}^{\infty} |h(n)| < \infty$ ise Kararlı.
  - ♦ $\sum_{n=-\infty}^{\infty} |h(n)| \rightarrow \infty$ ise Kararsız.
- Transfer Fonksiyonuna Göre, $H(z)$

Ayrık Zaman DZD Temel Sistem Özellikleri

Kararlılık

- Dönüşüm Denklemine Göre, $\mathrm{T}\{x(n)\}$
  - Kararlı
    - $\forall n, |x[n]| < N$ iken $\forall n, |y[n]| < M$ ise
  - Kararsız
    - $\forall n, |x[n]| < N$ iken $\forall n, |y[n]| \rightarrow \infty$ ise
- Birim Darbe Cevabına Göre, $h(n)$
  - $\sum_{n=-\infty}^{\infty} |h(n)| < \infty$ ise Kararlı.
  - $\sum_{n=-\infty}^{\infty} |h(n)| \rightarrow \infty$ ise Kararsız.
- Transfer Fonksiyonuna Göre, $H(z)$
  - YB, birim çemberi içeriyorsa Kararlı.
  - YB, birim çemberi içermiyorsa Kararsız.

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$

Hafızalı	Nedensel	Kararlı

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$

Hafızalı	Nedensel	Kararlı
✓		

Örnek 5

- $H(z) = \dfrac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$

Hafızalı	Nedensel	Kararlı
✓	✗	

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✗	✓

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3\ h(n) = ?$
- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}} = \frac{A}{1-\frac{1}{2}z^{-1}} + \frac{B}{1-3z^{-1}}$
- $A =$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$ $h(n) = ?$
- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}} = \frac{A}{1-\frac{1}{2}z^{-1}} + \frac{B}{1-3z^{-1}}$
- $A = \left.\frac{3-4z^{-1}}{1-3z^{-1}}\right|_{z^{-1}=2} = 1$ $\quad B =$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$ $h(n) =?$

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}} = \frac{A}{1-\frac{1}{2}z^{-1}} + \frac{B}{1-3z^{-1}}$

- $A = \left.\frac{3-4z^{-1}}{1-3z^{-1}}\right|_{z^{-1}=2} = 1$ $\qquad B = \left.\frac{3-4z^{-1}}{1-\frac{1}{2}z^{-1}}\right|_{z^{-1}=\frac{1}{3}} = 2$

- $H(z) = \frac{1}{\underbrace{1-\frac{1}{2}z^{-1}}_{YB:?}} + \frac{2}{\underbrace{1-3z^{-1}}_{YB:?}}$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$ $h(n) = ?$
- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}} = \frac{A}{1-\frac{1}{2}z^{-1}} + \frac{B}{1-3z^{-1}}$
- $A = \left.\frac{3-4z^{-1}}{1-3z^{-1}}\right|_{z^{-1}=2} = 1$ $\quad B = \left.\frac{3-4z^{-1}}{1-\frac{1}{2}z^{-1}}\right|_{z^{-1}=\frac{1}{3}} = 2$
- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\,|z|>\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|<3} \rightarrow h(n) = ?$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$ $h(n) = ?$
- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}} = \frac{A}{1-\frac{1}{2}z^{-1}} + \frac{B}{1-3z^{-1}}$
- $A = \left.\frac{3-4z^{-1}}{1-3z^{-1}}\right|_{z^{-1}=2} = 1 \quad B = \left.\frac{3-4z^{-1}}{1-\frac{1}{2}z^{-1}}\right|_{z^{-1}=\frac{1}{3}} = 2$
- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\,|z|>\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|<3} \rightarrow h(n) = \left(\frac{1}{2}\right)^n u(n) +$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $\frac{1}{2} < |z| < 3$ $h(n) = ?$
- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}} = \frac{A}{1-\frac{1}{2}z^{-1}} + \frac{B}{1-3z^{-1}}$
- $A = \left.\frac{3-4z^{-1}}{1-3z^{-1}}\right|_{z^{-1}=2} = 1 \quad B = \left.\frac{3-4z^{-1}}{1-\frac{1}{2}z^{-1}}\right|_{z^{-1}=\frac{1}{3}} = 2$
- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\ |z|>\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|<3} \rightarrow h(n) = \left(\frac{1}{2}\right)^n u(n) - 2(3)^n u(-n-1)$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $h(n) =?$

Hafızalı	Nedensel	Kararlı

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓		

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✓	

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✓	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:?} + \frac{2}{\underbrace{1-3z^{-1}}_{YB:?}}$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✓	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\,|z|>\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|>3} \rightarrow h(n) =$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $h(n) =?$

Hafızalı	Nedensel	Kararlı
✓	✓	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\,|z|>\frac{1}{2}} + \frac{2}{\underbrace{1-3z^{-1}}_{YB:|z|>3}} \rightarrow h(n) = \left(\frac{1}{2}\right)^{n} u(n) +$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| > 3$ $\quad h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✓	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\,|z|>\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|>3} \rightarrow h(n) = \left(\frac{1}{2}\right)^n u(n) + 2(3)^n u(n)$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $\; h(n) = ?$

Hafızalı	Nedensel	Kararlı

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $h(n) =?$

Hafızalı	Nedensel	Kararlı
✓		

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $h(n) =?$

Hafızalı	Nedensel	Kararlı
✓	✗	

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $\quad h(n) =?$

Hafızalı	Nedensel	Kararlı
✓	✗	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:?} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:?}$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $\quad h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✗	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\, |z|<\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB: |z|<3}$
- $h(n) =$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✗	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\ |z|<\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|<3}$
- $h(n) = -\left(\frac{1}{2}\right)^n u(-n-1) +$

Örnek 5

- $H(z) = \frac{3-4z^{-1}}{1-\frac{7}{2}z^{-1}+\frac{3}{2}z^{-2}}$, YB: $|z| < \frac{1}{2}$ $h(n) = ?$

Hafızalı	Nedensel	Kararlı
✓	✗	✗

- $H(z) = \underbrace{\frac{1}{1-\frac{1}{2}z^{-1}}}_{YB:\,|z|<\frac{1}{2}} + \underbrace{\frac{2}{1-3z^{-1}}}_{YB:|z|<3}$

- $h(n) = -\left(\frac{1}{2}\right)^n u(-n-1) - 2(3)^n u(-n-1)$