BSM307
İşaretler ve Sistemler

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z-Dönüşümü Özellikleri

İçerik

- Doğrusallık
- Zamanda Öteleme
- z-Domeninde Ölçekleme
- Zamanda Ters Çevirme
- z-Domeninde Türev
- İki işaretin konvolüsyonu

Doğrusallık

- $x_1(n) \ \rightarrow$ YB1 ve $x_2(n) \ \rightarrow$ YB2

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- $x_1(n) \rightarrow$ YB1 ve $x_2(n) \rightarrow$ YB2
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- $x_1(n) \ \rightarrow X_1(z)$, YB1 ve $x_2(n) \ \rightarrow X_1(z)$, YB2
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- $X(z) = aX_1(z) + bX_2(z) \rightarrow$ YB: YB1 ∩ YB2

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- $x(n) = (3(2)^n - 4(3)^n)u(n) \;\; \rightarrow X(z) =$? ve YB=?

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Örnek 2

- $x(n) = \cos(\omega_0 n)\, u(n) \;\; \rightarrow X(z)$ =? ve YB=?

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- $x(n) = \cos(\omega_0 n)\, u(n) \ \rightarrow X(z)$ =? ve YB=?
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- $x(n) = \frac{e^{j\omega_0 n} + e^{-j\omega_0 n}}{2} u(n) = \frac{1}{2} e^{j\omega_0 n} u(n) + \frac{1}{2} e^{-j\omega_0 n} u(n)$

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Zamanda Öteleme

- $\mathcal{Z}\{x(n)\} = X(z)$ ve YB biliniyorsa

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- $\mathcal{Z}\{x(n-k)\} = z^{-k}X(z)$, YB $\cap \begin{cases} z \neq 0, & k > 0 \\ z \neq \infty, & k < 0 \end{cases}$

Örnek 3

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) =$

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB:

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \; \rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_1(n) = 4\left(\frac{1}{2}\right)^n u(n-2) \rightarrow X_1(z) =$

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
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- $X_1(z) = z^{-2}X(z) = \frac{z^{-2}}{1-\frac{1}{2}z^{-1}}$, YB:

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Örnek 4

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \ \rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = \left(\frac{1}{2}\right)^n u(n-2) \ \rightarrow \ X_2(z) =$

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = \left(\frac{1}{2}\right)^n u(n-2) = \frac{1}{4}\left(\frac{1}{2}\right)^{n-2} u(n-2) =$

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- $X_2(z) = \frac{1}{4}z^{-2}\frac{1}{1-\frac{1}{2}z^{-1}} = \frac{\frac{1}{4}z^{-2}}{1-\frac{1}{2}z^{-1}}$, YB:

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- $X_2(z) = \frac{1}{4}z^{-2}\frac{1}{1-\frac{1}{2}z^{-1}} = \frac{\frac{1}{4}z^{-2}}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$

z-Domeninde Ölçekleme

- $\mathcal{Z}\{x(n)\} = X(z)$ ve YB: $b_2 < |z| < b_1$ biliniyorsa

z-Domeninde Ölçekleme

- $\mathcal{Z}\{x(n)\} = X(z)$ ve YB: $b_2 < |z| < b_1$ biliniyorsa
- $\mathcal{Z}\{a^n x(n)\} = X(a^{-1}z)$, YB: $|a|b_2 < |z| < |a|b_1$

Örnek 5

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = (-4)^n \left(\frac{1}{2}\right)^n u(n)$
- $X_3(z) =$

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \ \rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = (-4)^n \left(\frac{1}{2}\right)^n u(n)$
- $X_3(z) = X\left(-\frac{1}{4}z\right) =$

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- $x_3(n) = (-4)^n \left(\frac{1}{2}\right)^n u(n)$
- $X_3(z) = X\left(-\frac{1}{4}z\right) = \frac{1}{1+\frac{1}{2}4z^{-1}}$

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- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = (-4)^n \left(\frac{1}{2}\right)^n u(n)$
- $X_3(z) = X\left(-\frac{1}{4}z\right) = \frac{1}{1+\frac{1}{2}4z^{-1}} = \frac{1}{1+2z^{-1}}$, YB:

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- $x_3(n) = (-4)^n \left(\frac{1}{2}\right)^n u(n)$
- $X_3(z) = X\left(-\frac{1}{4}z\right) = \frac{1}{1+\frac{1}{2}4z^{-1}} = \frac{1}{1+2z^{-1}}$, YB:$|z| > 2$

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- $\mathcal{Z}\{x(n)\} = X(z)$ ve YB: $b_2 < |z| < b_1$ biliniyorsa
- $\mathcal{Z}\{x(-n)\} = X(z^{-1})$ ve YB: $\frac{1}{b_1} < |z| < \frac{1}{b_2}$

Örnek 6

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_4(n) = (2)^n u(-n)$
- $X_4(z) =$

Örnek 6

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \ \rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_4(n) = (2)^n u(-n) = x(-n)$
- $X_4(z) =$

Örnek 6

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_4(n) = (2)^n u(-n) = x(-n)$
- $X_4(z) = X(z^{-1})$

Örnek 6

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_4(n) = (2)^n u(-n) = x(-n)$
- $X_4(z) = X(z^{-1}) = \frac{1}{1-\frac{1}{2}z}$, YB:

Örnek 6

- $x(n) = \left(\frac{1}{2}\right)^n u(n) \ \rightarrow X(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_4(n) = (2)^n u(-n) = x(-n)$
- $X_4(z) = X(z^{-1}) = \frac{1}{1-\frac{1}{2}z}$, YB: $|z| < 2$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z) =$? ve YB=?

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \; \rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3)$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB:

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n)$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) \;\rightarrow X_3(z) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) \;\rightarrow X_3(z) = X_2(z^{-1}) = \frac{z^{-3}}{1-\frac{1}{2}z}$, YB:

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) \;\rightarrow X_3(z) = X_2(z^{-1}) = \frac{z^{-3}}{1-\frac{1}{2}z}$,

  YB: $|z| < 2$
- $x_3(n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) = \left(\frac{1}{2}\right)^3 (2)^n u(-n+3) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) \;\rightarrow X_3(z) = X_2(z^{-1}) = \frac{z^{-3}}{1-\frac{1}{2}z}$, YB: $|z| < 2$
- $x_3(n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) = \left(\frac{1}{2}\right)^3 (2)^n u(-n+3) = \frac{1}{8}x(n)$
- $x(n) = 8x_3(n) \;\rightarrow X(z) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) \;\rightarrow X_3(z) = X_2(z^{-1}) = \frac{z^{-3}}{1-\frac{1}{2}z}$, YB: $|z| < 2$
- $x_3(n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) = \left(\frac{1}{2}\right)^3 (2)^n u(-n+3) = \frac{1}{8}x(n)$
- $x(n) = 8x_3(n) \;\rightarrow X(z) = 8X_3(z) = \frac{8z^{-3}}{1-\frac{1}{2}z}$, YB:

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 1. yol
- $x_1(n) = \left(\frac{1}{2}\right)^n u(n) \;\rightarrow X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_2(n) = x_1(n+3) = \left(\frac{1}{2}\right)^{n+3} u(n+3) \;\rightarrow X_2(z) = z^3 X_1(z) = \frac{z^3}{1-\frac{1}{2}z^{-1}}$, YB: $|z| > \frac{1}{2}$
- $x_3(n) = x_2(-n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) \;\rightarrow X_3(z) = X_2(z^{-1}) = \frac{z^{-3}}{1-\frac{1}{2}z}$, YB: $|z| < 2$
- $x_3(n) = \left(\frac{1}{2}\right)^{-n+3} u(-n+3) = \left(\frac{1}{2}\right)^3 (2)^n u(-n+3) = \frac{1}{8}x(n)$
- $x(n) = 8x_3(n) \;\rightarrow X(z) = 8X_3(z) = \frac{8z^{-3}}{1-\frac{1}{2}z}$, YB: $|z| < 2$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \ \rightarrow X_1(z) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \;\rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB:

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \;\rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \ \rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3) \ \rightarrow X_2(z) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \ \rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3) \ \rightarrow X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3) \rightarrow X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) = \frac{1}{16} x(n)$
- $x(n) = 16 x_2(n) \rightarrow X(z) =$

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3) \rightarrow X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4} (2)^n u(-n+3) = \frac{1}{16} x(n)$
- $x(n) = 16 x_2(n) \rightarrow X(z) = 16 X_2(z) = \frac{-16z^{-4}}{1-2z^{-1}}$, YB:

Örnek 7

- $x(n) = (2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \ \rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3) \ \rightarrow X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) = \frac{1}{16} x(n)$
- $x(n) = 16x_2(n) \ \rightarrow X(z) = 16X_2(z) = \frac{-16z^{-4}}{1-2z^{-1}}$, YB: $|z| < 2$

z-Domeninde Türev

- $\mathcal{Z}\{x(n)\} = X(z)$ ve YB: $b_2 < |z| < b_1$ biliniyorsa
- $\mathcal{Z}\{nx(n)\} = -z\dfrac{\partial X(z)}{\partial z}$, YB: $b_2 < |z| < b_1$

Örnek 8

- $x(n) = n(2)^n u(-n+3)$ ise $X(z)$ =? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \;\rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3)$
- $X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) = \frac{1}{16} x_3(n)$
- $x_3(n) = 16x_2(n) \;\rightarrow X_3(z) = 16X_2(z) = \frac{-16z^{-4}}{1-2z^{-1}}$, YB: $|z| < 2$
- $x(n) = nx_3(n) \rightarrow X(z) =$

Örnek 8

- $x(n) = n(2)^n u(-n+3)$ ise $X(z) =$? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \ \rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3)$
- $X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) = \frac{1}{16} x_3(n)$
- $x_3(n) = 16x_2(n) \ \rightarrow X_3(z) = 16X_2(z) = \frac{-16z^{-4}}{1-2z^{-1}}$, YB: $|z| < 2$
- $x(n) = nx_3(n) \rightarrow X(z) = -z\frac{\partial X_3(z)}{\partial z} = -z\frac{\partial}{\partial z}\left(\frac{-16z^{-4}}{1-2z^{-1}}\right) =$

Örnek 8

- $x(n) = n(2)^n u(-n+3)$ ise $X(z) =$? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \;\rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3)$
- $X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) = \frac{1}{16} x_3(n)$
- $x_3(n) = 16x_2(n) \;\rightarrow X_3(z) = 16X_2(z) = \frac{-16z^{-4}}{1-2z^{-1}}$, YB: $|z| < 2$
- $x(n) = nx_3(n) \rightarrow X(z) = -z\frac{\partial X_3(z)}{\partial z} = -z\frac{\partial}{\partial z}\left(\frac{-16z^{-4}}{1-2z^{-1}}\right) = \frac{106z^{-5} - 64z^{-4}}{(1-2z^{-1})^2}$, YB:

Örnek 8

- $x(n) = n(2)^n u(-n+3)$ ise $X(z) =$? ve YB=?
- 2. yol
- $x_1(n) = (2)^n u(-n-1) \;\rightarrow X_1(z) = \frac{-1}{1-2z^{-1}}$, YB: $|z| < 2$
- $x_2(n) = x_1(n-4) = (2)^{n-4} u(-n+3)$
- $X_2(z) = z^{-4} X_1(z) = \frac{-z^{-4}}{1-2z^{-1}}$, YB:$|z| < 2$
- $x_2(n) = (2)^{-4}(2)^n u(-n+3) = \frac{1}{16} x_3(n)$

- $x_3(n) = 16x_2(n) \;\rightarrow X_3(z) = 16X_2(z) = \frac{-16z^{-4}}{1-2z^{-1}}$, YB: $|z| < 2$
- $x(n) = nx_3(n) \rightarrow X(z) = -z\frac{\partial X_3(z)}{\partial z} = -z\frac{\partial}{\partial z}\left(\frac{-16z^{-4}}{1-2z^{-1}}\right) = \frac{106z^{-5}-64z^{-4}}{(1-2z^{-1})^2}$, YB: $|z| < 2$

Örnek 9

- $x(n) = |n| \left(\frac{1}{2}\right)^{|n|}$ ise $X(z) =$? Ve YB=?

Örnek 9

- $x(n) = |n| \left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $x(n) = n \left(\frac{1}{2}\right)^{n} u(n) + \cdots$

Örnek 9

- $x(n) = |n|\left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $x(n) = \underbrace{n\left(\frac{1}{2}\right)^{n} u(n)}_{x_1(n)} - n(2)^{n}u(-n-1)$
- $X_1(z) =$

Örnek 9

- $x(n) = |n| \left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?

- $x(n) = \underbrace{n\left(\frac{1}{2}\right)^{n} u(n)}_{x_1(n)} - n(2)^{n} u(-n-1)$

- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1:

Örnek 9

- $x(n) = |n|\left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $x(n) = \underbrace{n\left(\frac{1}{2}\right)^{n} u(n)}_{x_1(n)} + \underbrace{n\left(-(2)^{n} u(-n-1)\right)}_{x_2(n)}$
- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1: $|z| > \frac{1}{2}$
- $X_2(z) =$

Örnek 9

- $x(n) = |n| \left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?

- $x(n) = \underbrace{n\left(\frac{1}{2}\right)^{n} u(n)}_{x_1(n)} + \underbrace{n\left(-(2)^{n} u(-n-1)\right)}_{x_2(n)}$

- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1: $|z| > \frac{1}{2}$

- $X_2(z) = \frac{1}{1-2z^{-1}}$, YB2:

Örnek 9

- $x(n) = |n|\left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $x(n) = \underbrace{n\left(\frac{1}{2}\right)^{n} u(n)}_{x_1(n)} + \underbrace{n\left(-(2)^n u(-n-1)\right)}_{x_2(n)}$
- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1: $|z| > \frac{1}{2}$
- $X_2(z) = \frac{1}{1-2z^{-1}}$, YB2: $|z| < 2$

Örnek 9

- $x(n) = |n| \left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1: $|z| > \frac{1}{2}$
- $X_2(z) = \frac{1}{1-2z^{-1}}$, YB2: $|z| < 2$
- $x(n) = nx_1(n) + nx_2(n)$
- $X(z) =$

Örnek 9

- $x(n) = |n|\left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1: $|z| > \frac{1}{2}$
- $X_2(z) = \frac{1}{1-2z^{-1}}$, YB2: $|z| < 2$
- $x(n) = nx_1(n) + nx_2(n)$
- $X(z) = -z\frac{\partial}{\partial z}\left(\frac{1}{1-\frac{1}{2}z^{-1}}\right) - z\frac{\partial}{\partial z}\left(\frac{1}{1-2z^{-1}}\right) = \frac{\frac{1}{2}z^{-1}}{\left(1-\frac{1}{2}z^{-1}\right)^2} + \frac{2z^{-1}}{(1-2z^{-1})^2}$
- YB:

Örnek 9

- $x(n) = |n|\left(\frac{1}{2}\right)^{|n|}$ ise $X(z)$ =? ve YB=?
- $X_1(z) = \frac{1}{1-\frac{1}{2}z^{-1}}$, YB1: $|z| > \frac{1}{2}$
- $X_2(z) = \frac{1}{1-2z^{-1}}$, YB2: $|z| < 2$
- $x(n) = nx_1(n) + nx_2(n)$
- $X(z) = -z\frac{\partial}{\partial z}\left(\frac{1}{1-\frac{1}{2}z^{-1}}\right) - z\frac{\partial}{\partial z}\left(\frac{1}{1-2z^{-1}}\right) = \frac{\frac{1}{2}z^{-1}}{\left(1-\frac{1}{2}z^{-1}\right)^2} + \frac{2z^{-1}}{(1-2z^{-1})^2}$
- YB: $|z| > \frac{1}{2} \cap |z| < 2 \equiv \frac{1}{2} < |z| < 2$

Örnek 10

- $x(n) = \frac{1}{n}u(n-1)$ ise $X(z) =$? ve YB: ?

Örnek 10

- $x(n) = \frac{1}{n}u(n-1)$ ise $X(z)$ =? ve YB: ?
- $nx(n) = u(n-1)$

Örnek 10

- $x(n) = \frac{1}{n}u(n-1)$ ise $X(z) =$? ve YB: ?
- $\mathcal{Z}\{nx(n)\} = \mathcal{Z}\{u(n-1)\}$

Örnek 10

- $x(n) = \frac{1}{n}u(n-1)$ ise $X(z) =$? ve YB: ?
- $\mathcal{Z}\{nx(n)\} = \mathcal{Z}\{u(n-1)\}$
- $-z\frac{\partial X(z)}{\partial z} =$

Örnek 10

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- $-z\frac{\partial X(z)}{\partial z} = \frac{z^{-1}}{1-z^{-1}} \rightarrow \frac{\partial X(z)}{\partial z} = -\frac{z^{-2}}{1-z^{-1}}$

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- $X(z) =$

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- $X(z) = \int \frac{\partial X(z)}{\partial z} = -\int \frac{z^{-2}}{1-z^{-1}} =$

Örnek 10

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- $X(z) = \int \frac{\partial X(z)}{\partial z} = -\int \frac{z^{-2}}{1-z^{-1}} = -\log(1-z^{-1})$
- YB:

Örnek 10

- $x(n) = \frac{1}{n}u(n-1)$ ise $X(z)$ =? ve YB: ?
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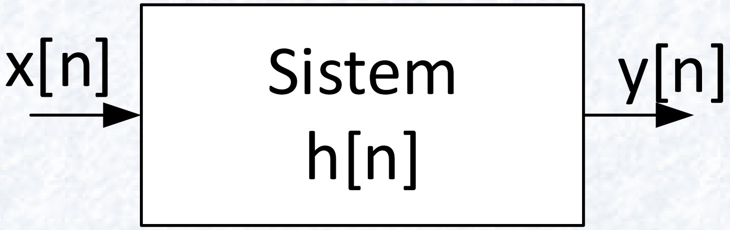
- $-z\frac{\partial X(z)}{\partial z} = \frac{z^{-1}}{1-z^{-1}} \rightarrow \frac{\partial X(z)}{\partial z} = -\frac{z^{-2}}{1-z^{-1}}$
- $X(z) = \int \frac{\partial X(z)}{\partial z} = -\int \frac{z^{-2}}{1-z^{-1}} = -\log(1-z^{-1})$
- YB: $|z| > 1$

Konvolüsyon

- $\mathcal{Z}\{x_1(n)\} = X_1(z)$ ve YB1 biliniyorsa
- $\mathcal{Z}\{x_2(n)\} = X_2(z)$ ve YB2 biliniyorsa
- $\mathcal{Z}\{x_1(n) * x_2(n)\} = X_1(z)X_2(z)$, YB: YB1 ∩ YB2

Konvolüsyon

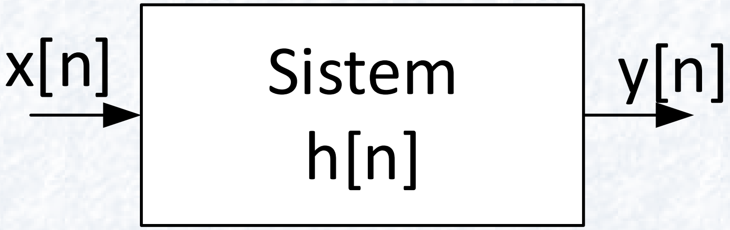
- $\mathcal{Z}\{x_1(n)\} = X_1(z)$ ve YB1 biliniyorsa
- $\mathcal{Z}\{x_2(n)\} = X_2(z)$ ve YB2 biliniyorsa
- $\mathcal{Z}\{x_1(n) * x_2(n)\} = X_1(z)X_2(z)$, YB: YB1 ∩ YB2



- $y(n) =$

Konvolüsyon

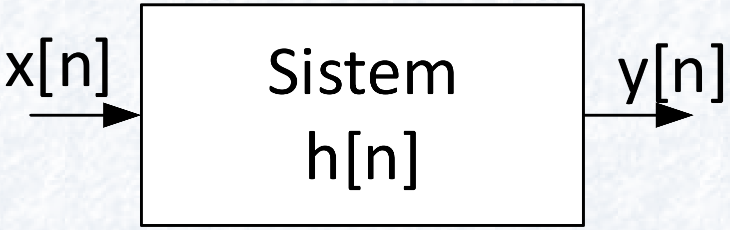
- $\mathcal{Z}\{x_1(n)\} = X_1(z)$ ve YB1 biliniyorsa
- $\mathcal{Z}\{x_2(n)\} = X_2(z)$ ve YB2 biliniyorsa
- $\mathcal{Z}\{x_1(n) * x_2(n)\} = X_1(z)X_2(z)$, YB: YB1 ∩ YB2



- $y(n) = x(n) * h(n)$
- $Y(z) =$

Konvolüsyon

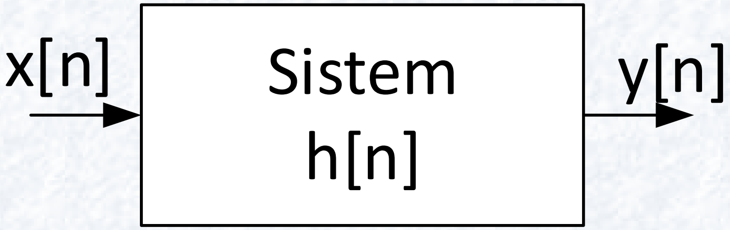
- $\mathcal{Z}\{x_1(n)\} = X_1(z)$ ve YB1 biliniyorsa
- $\mathcal{Z}\{x_2(n)\} = X_2(z)$ ve YB2 biliniyorsa
- $\mathcal{Z}\{x_1(n) * x_2(n)\} = X_1(z)X_2(z)$, YB: YB1 ∩ YB2



- $y(n) = x(n) * h(n)$
- $Y(z) = X(z)H(z)$

Konvolüsyon

- $\mathcal{Z}\{x_1(n)\} = X_1(z)$ ve YB1 biliniyorsa
- $\mathcal{Z}\{x_2(n)\} = X_2(z)$ ve YB2 biliniyorsa
- $\mathcal{Z}\{x_1(n) * x_2(n)\} = X_1(z)X_2(z)$, YB: YB1 ∩ YB2



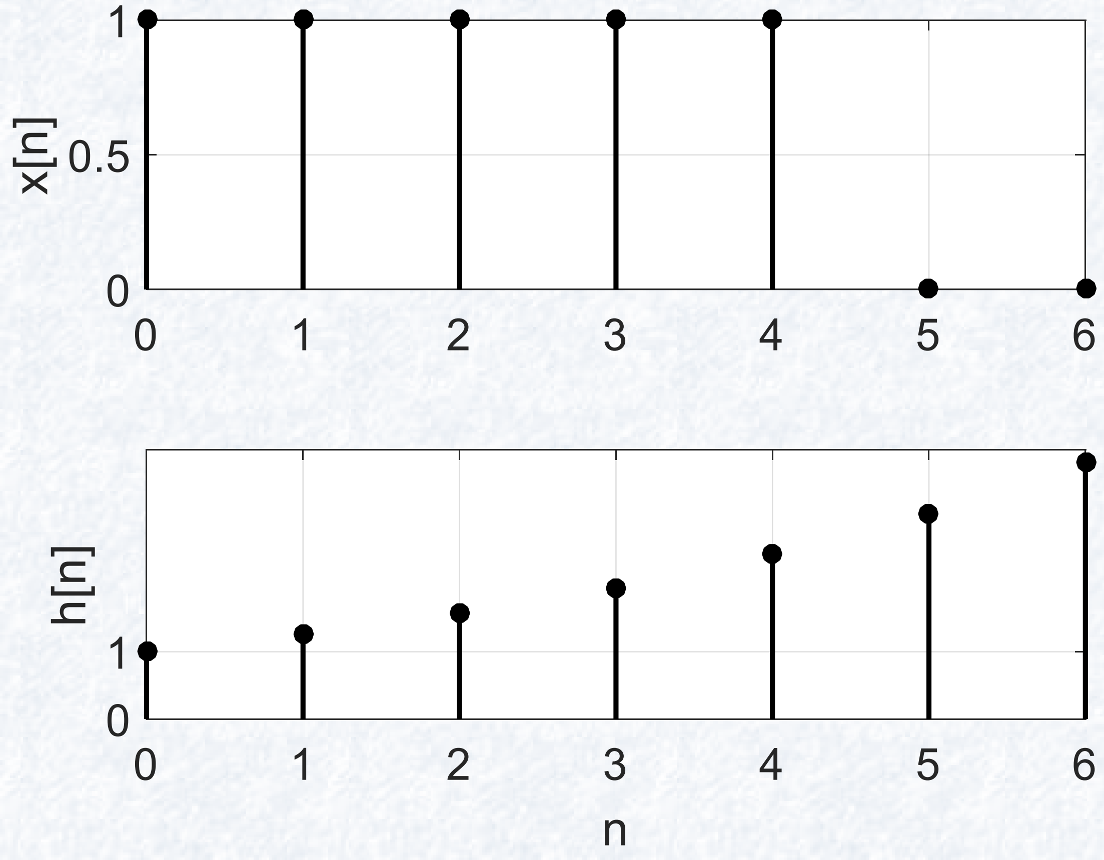
- $y(n) = x(n) * h(n)$
- $Y(z) = X(z)H(z) \;\rightarrow H(z) = \frac{Y(z)}{X(z)}$, Transfer Fonksiyonu

Örnek 11

- $x[n] = \begin{cases} 1, & 0 \le n \le 4 \\ 0, & \text{diğer} \end{cases}$

- $h[n] = \begin{cases} \alpha^n, & 0 \le n \le 6 \\ 0, & \text{diğer} \end{cases}$

- $Y(z) = ?$



Örnek 11

- $x[n] = \begin{cases} 1, & 0 \leq n \leq 4 \\ 0, & \text{diğer} \end{cases}$

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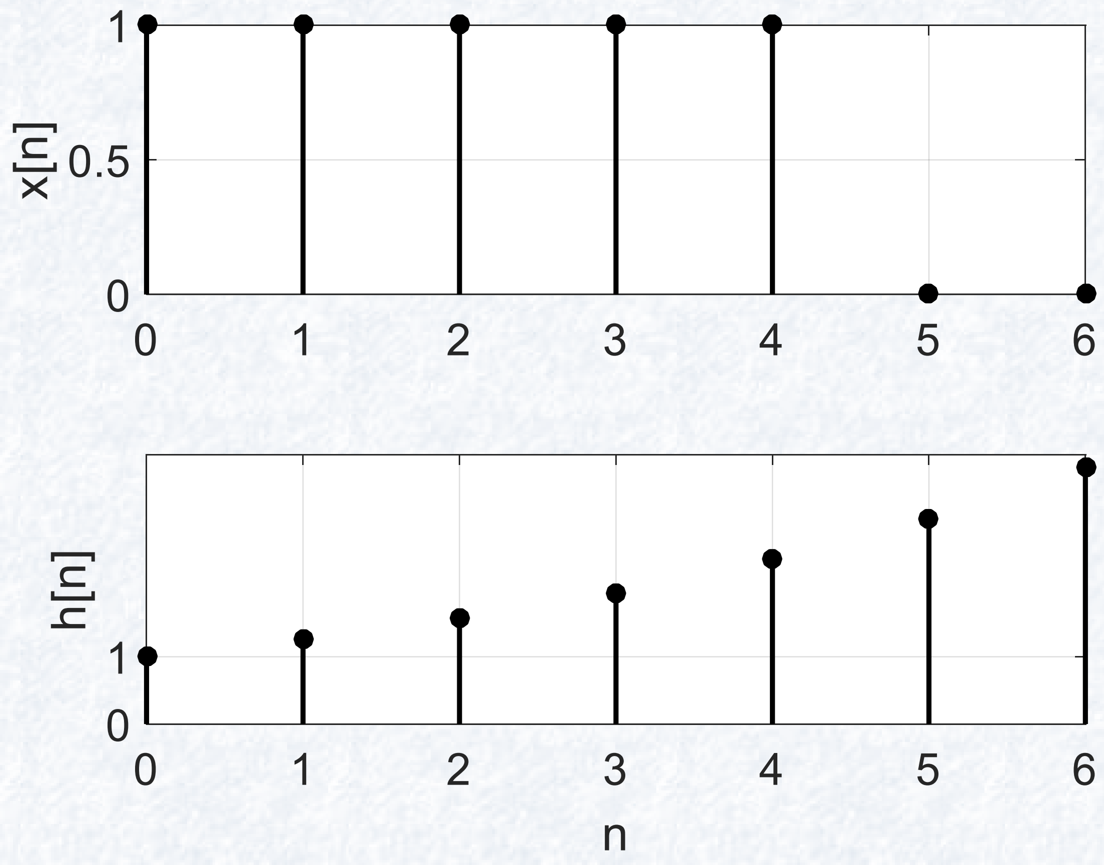
- $Y(z) = X(z)H(z)$
- $X(z) = ?$



Örnek 11

- $x[n] = \begin{cases} 1, & 0 \leq n \leq 4 \\ 0, & \text{diğer} \end{cases}$

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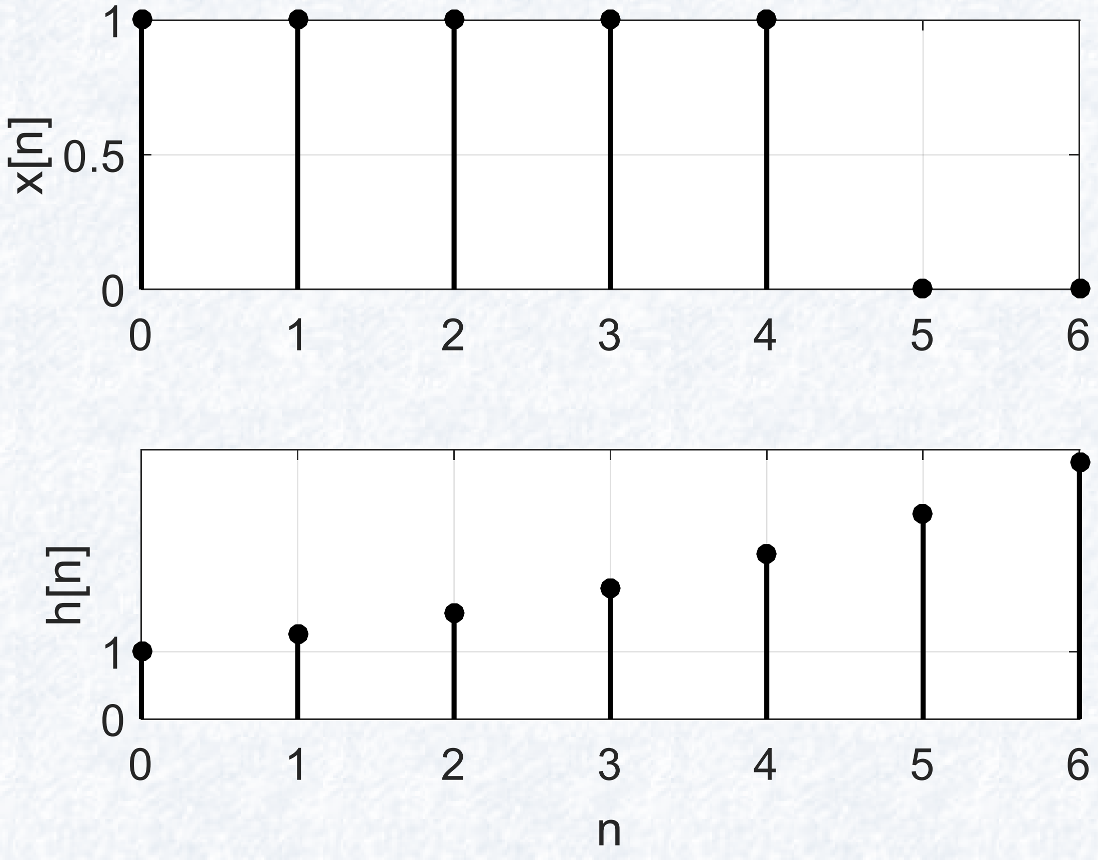
- $Y(z) = X(z)H(z)$
- $X(z) = \sum_{n=0}^{4} 1z^{-n} =$



Örnek 12

- $x[n] = \begin{cases} 1, & 0 \leq n \leq 4 \\ 0, & \text{diğer} \end{cases}$
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- $Y(z) = X(z)H(z)$
- $X(z) = \sum_{n=0}^{4} 1z^{-n} = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4}$
- $H(z) = ?$

Örnek 12

- $x[n] = \begin{cases} 1, & 0 \leq n \leq 4 \\ 0, & \text{diğer} \end{cases}$
- $h[n] = \begin{cases} \alpha^n, & 0 \leq n \leq 6 \\ 0, & \text{diğer} \end{cases}$
- $Y(z) = X(z)H(z)$
- $X(z) = \sum_{n=0}^{4} 1z^{-n} = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4} = \frac{1-z^{-5}}{1-z^{-1}}$
- $H(z) = \sum_{n=0}^{6} \alpha^n z^{-n} =$

Örnek 12

- $x[n] = \begin{cases} 1, & 0 \leq n \leq 4 \\ 0, & \text{diğer} \end{cases}$
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- $Y(z) = X(z)H(z)$
- $X(z) = \sum_{n=0}^{4} 1z^{-n} = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4} = \frac{1-z^{-5}}{1-z^{-1}}$
- $H(z) = \sum_{n=0}^{6} \alpha^n z^{-n} = 1 + \alpha z^{-1} + \alpha^2 z^{-2} + \cdots + \alpha^6 z^{-6} = \frac{1-(\alpha z^{-1})^7}{1-\alpha z^{-1}}$

Örnek 12

- $x[n] = \begin{cases} 1, & 0 \leq n \leq 4 \\ 0, & \text{diğer} \end{cases}$
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- $H(z) = \sum_{n=0}^{6} \alpha^n z^{-n} = 1 + \alpha z^{-1} + \alpha^2 z^{-2} + \cdots + \alpha^6 z^{-6} = \frac{1-(\alpha z^{-1})^7}{1-\alpha z^{-1}}$
- $Y(z) = \frac{1-z^{-5}}{1-z^{-1}} \frac{1-(\alpha z^{-1})^7}{1-\alpha z^{-1}} = \frac{1-z^{-5}-\alpha^7 z^{-7}+\alpha^7 z^{-12}}{(1-z^{-1})(1-\alpha z^{-1})}$