BSM307
İşaretler ve Sistemler

Dr. Seçkin Arı

Fourier Seri Açılımı

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- Farklı frekanstaki sinüsoidal işaretlerin toplamı
- Tüm Sürekli Zaman Periyodik İşaretler
  ♦ Fourier Seri Açılımı ile ifade edilir
  ♦ Frekans spektrumu elde edilir.

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        - $t_2 - t_1 = T_0$ (Bir periyot boyunca integral)

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    ▪ $t_2 - t_1 = T_0$ (Bir periyot boyunca integral)

    ▪ Sabit

    ▪ İlgili frekans bileşeninin ne kadar etkin olduğunu belirler.

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- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$
  $= \cdots + a_{-2} e^{-j2\omega_0 t} + a_{-1} e^{-j\omega_0 t} + a_0 + a_1 e^{j\omega_0 t} + a_2 e^{j2\omega_0 t} + \cdots$

- $a_{\pm 1}$: Birinci harmonik bileşenler, temel bileşenler

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- $a_{\pm 2}$: İkinci harmonik bileşenler

- $\vdots$

- a_0: Frekansı olmayan bileşen
  - ♦ DC bileşen

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  $+ \cdots$
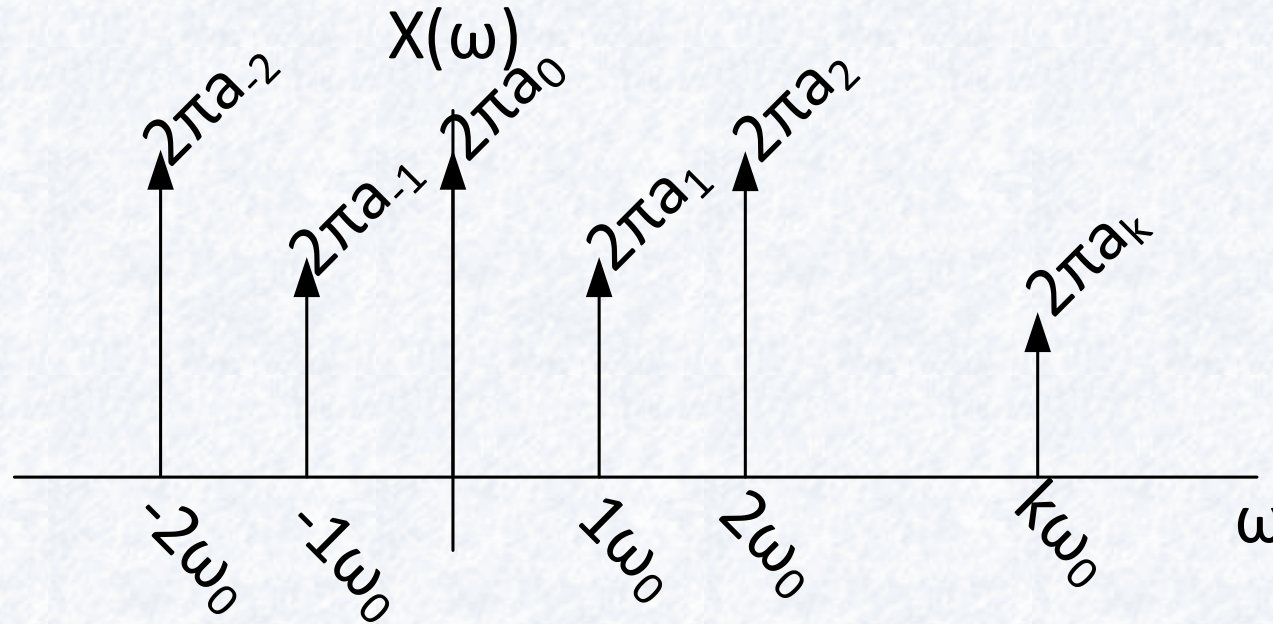
Örnek 1

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- $\omega_0 = 2$
- $x(t) = \cos(2t) = \dfrac{\square}{2}$

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- $x(t) = \cos(2t)$ ise $\omega_0 = ?, a_k = ?$
- $\omega_0 = 2$
- $x(t) = \cos(2t) = \dfrac{e^{j2t} + e^{-j2t}}{2} =$

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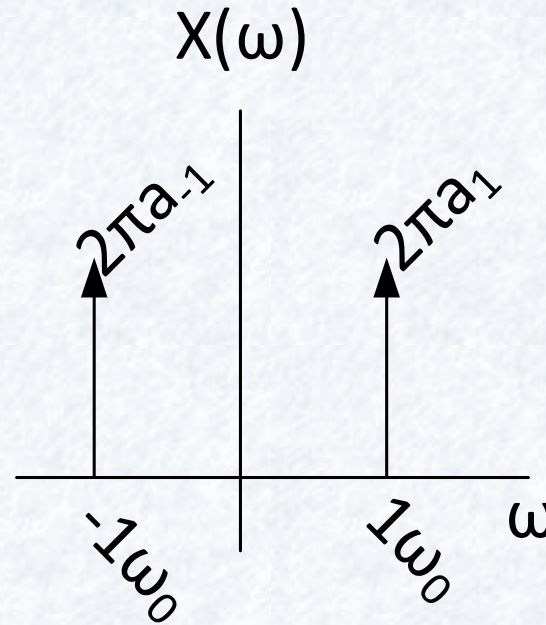- $a_1 = \dfrac{1}{2}, a_{-1} = \dfrac{1}{2}$

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- $a_0 = \boxed{}$, $a_{\pm 2} = \boxed{}$

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- $a_1 = \dfrac{1}{2}$, $a_{-1} = \dfrac{1}{2}$
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- $\forall k \neq \pm 1$ için $a_k = 0$

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- Spektrum?

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X(ω)

π   π

-2   2   ω
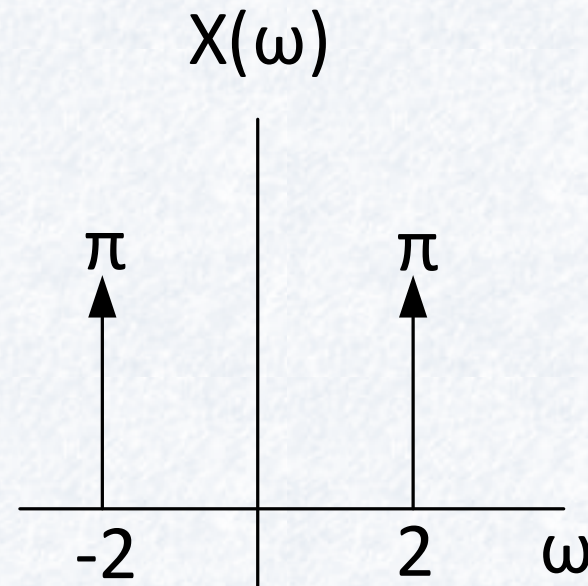
Örnek 2

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- $\omega_0 = 2$

- $x(t) = \sin(2t) = \dfrac{e^{j2t} - e^{-j2t}}{2j}$

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- $x(t) = \sin(2t)$ ise $\omega_0 =?, a_k =?$
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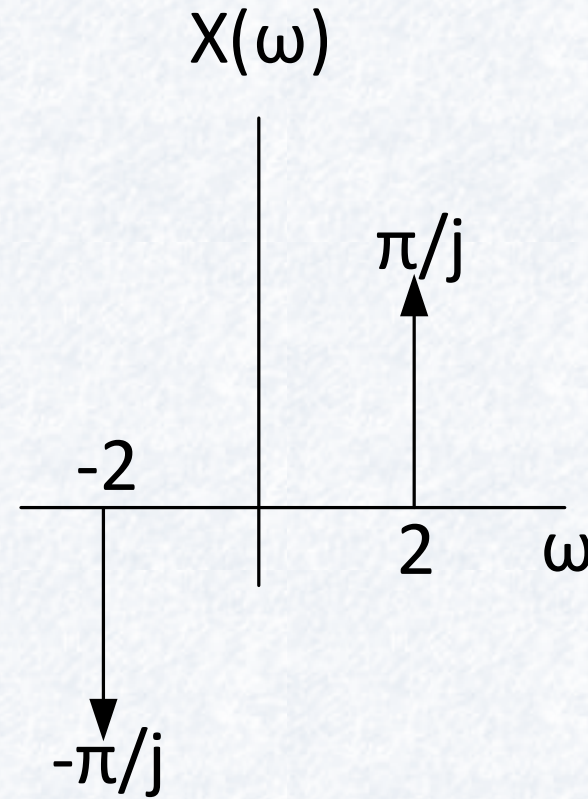
Örnek 3

- $x(t) = \sin\left(2t + \frac{\pi}{4}\right)$ ise $\omega_0 = ?, a_k = ?$

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- $x(t) = \sin(2t) = \dfrac{e^{j\left(2t+\frac{\pi}{4}\right)} - e^{-j\left(2t+\frac{\pi}{4}\right)}}{2j} =$

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$$= \dfrac{e^{j\frac{\pi}{4}}}{2j}e^{j2t} - \dfrac{e^{-j\frac{\pi}{4}}}{2j}e^{-j2t}$$

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- $\omega_0 = 2$

- $x(t) = \sin(2t) = \dfrac{e^{j\left(2t+\frac{\pi}{4}\right)} - e^{-j\left(2t+\frac{\pi}{4}\right)}}{2j} = \dfrac{e^{j2t}e^{j\frac{\pi}{4}} - e^{-j2t}e^{-j\frac{\pi}{4}}}{2j}$

$$= \frac{e^{j\frac{\pi}{4}}}{2j}e^{j2t} - \frac{e^{-j\frac{\pi}{4}}}{2j}e^{-j2t}$$

- $a_1 = \dfrac{e^{j\frac{\pi}{4}}}{2j}, a_{-1} = -\dfrac{e^{-j\frac{\pi}{4}}}{2j}$

- $\forall k \neq \pm 1$ için $a_k = 0$

Örnek 3

- $x(t) = \sin\left(2t + \frac{\pi}{4}\right)$ ise $\omega_0 = ?, a_k = ?$

- $\omega_0 = 2$

- $a_1 = \dfrac{e^{j\frac{\pi}{4}}}{2j}, a_{-1} = -\dfrac{e^{-j\frac{\pi}{4}}}{2j}$

- $\forall k \neq \pm 1$ için $a_k = 0$

- Spektrum?

Örnek 3

- $x(t) = \sin\left(2t + \frac{\pi}{4}\right)$ ise $\omega_0 = ?, a_k = ?$

- $\omega_0 = 2$

- $a_1 = \frac{e^{j\frac{\pi}{4}}}{2j}, a_{-1} = -\frac{e^{-j\frac{\pi}{4}}}{2j}$

- $\forall k \neq \pm 1$ için $a_k = 0$

X(ω)

$\frac{\pi e^{j\frac{\pi}{4}}}{j}$

-2

2   ω

$-\frac{\pi e^{-j\frac{\pi}{4}}}{j}$
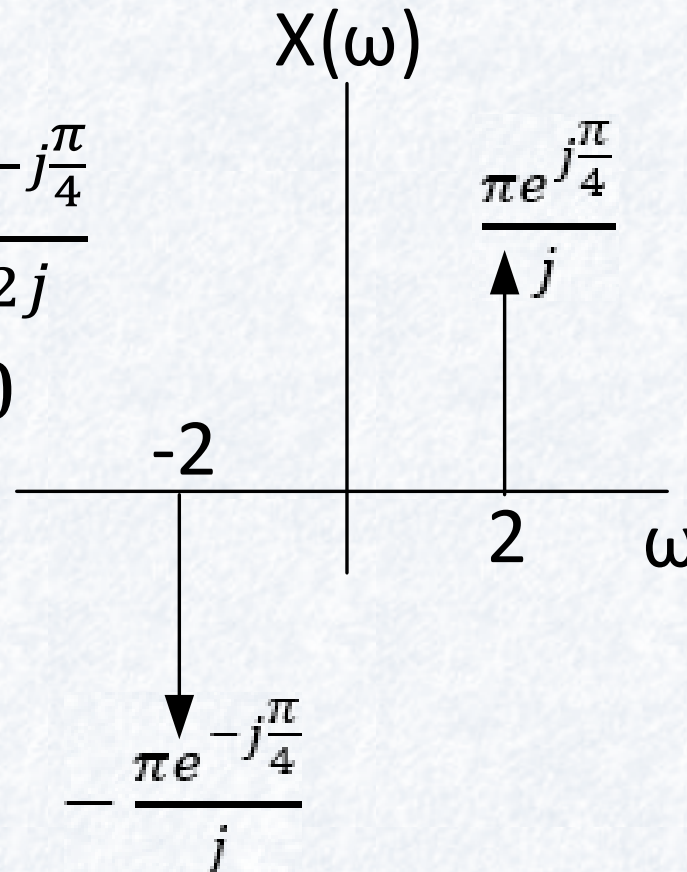
Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 =?, a_k =?$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 =?$, $a_k =?$
- $k\omega_0 = 4t$
- $l\omega_0 = 6t$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 =?, a_k =?$
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  - ♦ EBOB, $\omega_0 = 2$
- $x(t) =$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 = ?, a_k = ?$
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- $x(t) = \dfrac{e^{j4t} + e^{-j4t}}{2} + \dfrac{e^{j6t} - e^{-j6t}}{2j} = \dfrac{1}{2}e^{j4t} + \dfrac{1}{2}e^{-j4t} + \dfrac{1}{2j}e^{j6t} - \dfrac{1}{2j}e^{-j6t}$
- $a_2 =$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 = ?, a_k = ?$
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- $a_2 = \frac{1}{2}, a_{-2} =$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 =?, a_k =?$
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- $a_2 = \dfrac{1}{2}, a_{-2} = \dfrac{1}{2}$
- $a_3 =$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 = ?, a_k = ?$
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- $a_2 = \dfrac{1}{2}, a_{-2} = \dfrac{1}{2}$
- $a_3 = \dfrac{1}{2j}, a_{-3} =$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 = ?, a_k = ?$
- $k\omega_0 = 4t$
- $l\omega_0 = 6t$
  - ♦ EBOB, $\omega_0 = 2$
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- $a_2 = \dfrac{1}{2}, a_{-2} = \dfrac{1}{2}$
- $a_3 = \dfrac{1}{2j}, a_{-3} = -\dfrac{1}{2j}$
- $\forall k \neq \pm 2 \; ve \; \forall k \neq \pm 3$ için $a_k = 0$

Örnek 4

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 =?$, $a_k =?$
- $\omega_0 = 2$
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- Spektrum?

- $x(t) = \cos(4t) + \sin(6t)$ ise $\omega_0 =?, a_k =?$
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  - $\forall k \neq \pm 2 \; ve \; \forall k \neq \pm 3$ için $a_k = 0$
  - $\cos(4t) + \sin(6t)$
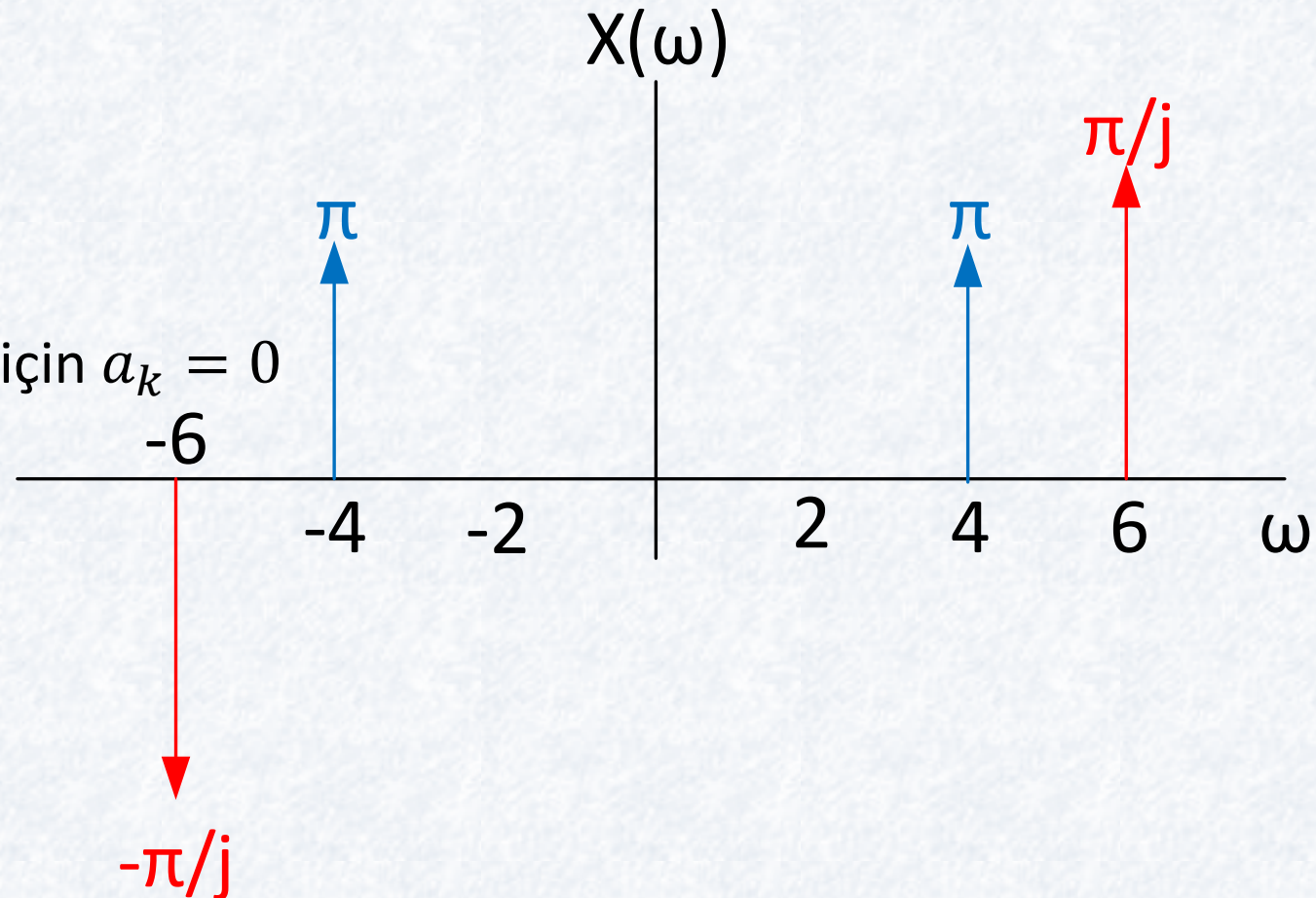
Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 =?, a_k =?$
- $x(t) =$

Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 =?$, $a_k =?$

- $x(t) = \left(\dfrac{e^{j2t} - e^{-j2t}}{2j} \right)^2 =$

Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 =?, a_k =?$

- $x(t) = \left(\dfrac{e^{j2t} - e^{-j2t}}{2j}\right)^2 = \dfrac{e^{j4t} - 2 + e^{-j4t}}{-4} = -\dfrac{1}{4}e^{j4t} + \dfrac{1}{2} - \dfrac{1}{4}e^{-j4t}$
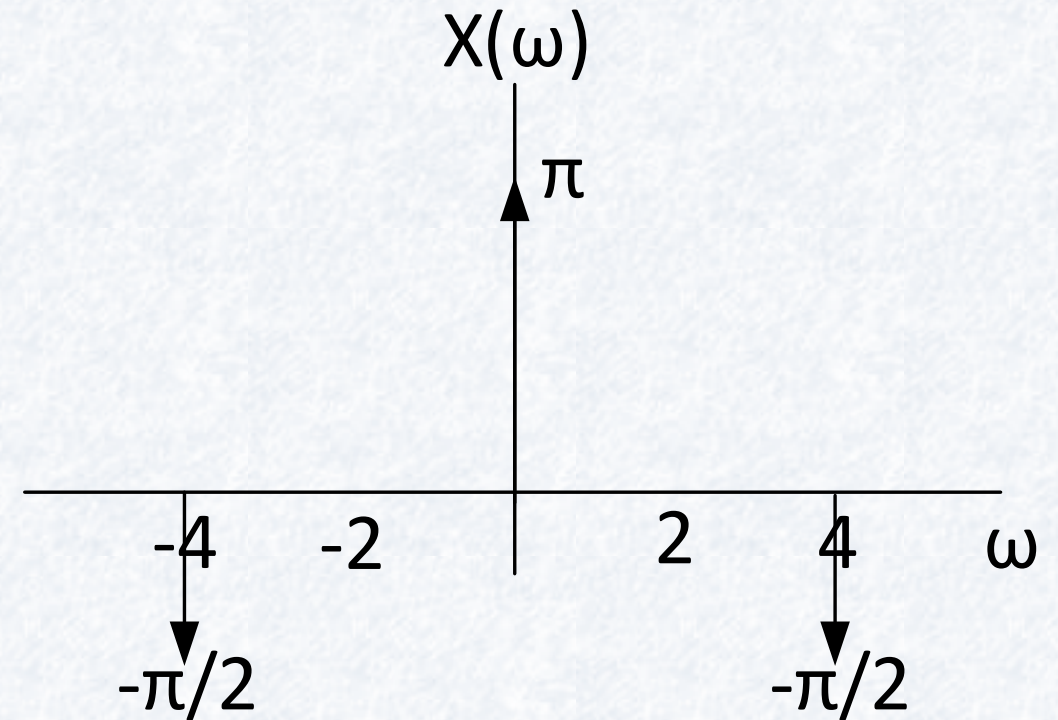
- $\omega_0 = 4$

- $a_1 = -\dfrac{1}{4}, a_{-1} = -\dfrac{1}{4}$

- $a_0 = \dfrac{1}{2}$

- $\forall k \neq \pm 1 \; ve \; \forall k \neq 0$ için $a_k = 0$

Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 = ?$, $a_k = ?$

- $x(t) = \left(\dfrac{e^{j2t} - e^{-j2t}}{2j}\right)^2 = \dfrac{e^{j4t} - 2 + e^{-j4t}}{-4} = -\dfrac{1}{4}e^{j4t} + \dfrac{1}{2} - \dfrac{1}{4}e^{-j4t}$

- $\omega_0 =$

Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 = ?, a_k = ?$

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Örnek 5

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- $\omega_0 = 4$

- $a_1 = -\dfrac{1}{4}, a_{-1} = -\dfrac{1}{4}$

- $a_0 =$

Örnek 5

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- Spektrum?

Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 =?, a_k =?$
- $\omega_0 = 4$
- $a_1 = -\frac{1}{4}, a_{-1} = -\frac{1}{4}$
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- $\forall k \neq \pm 1 \; ve \; \forall k \neq 0$ için $a_k = 0$
- $x(t) =$
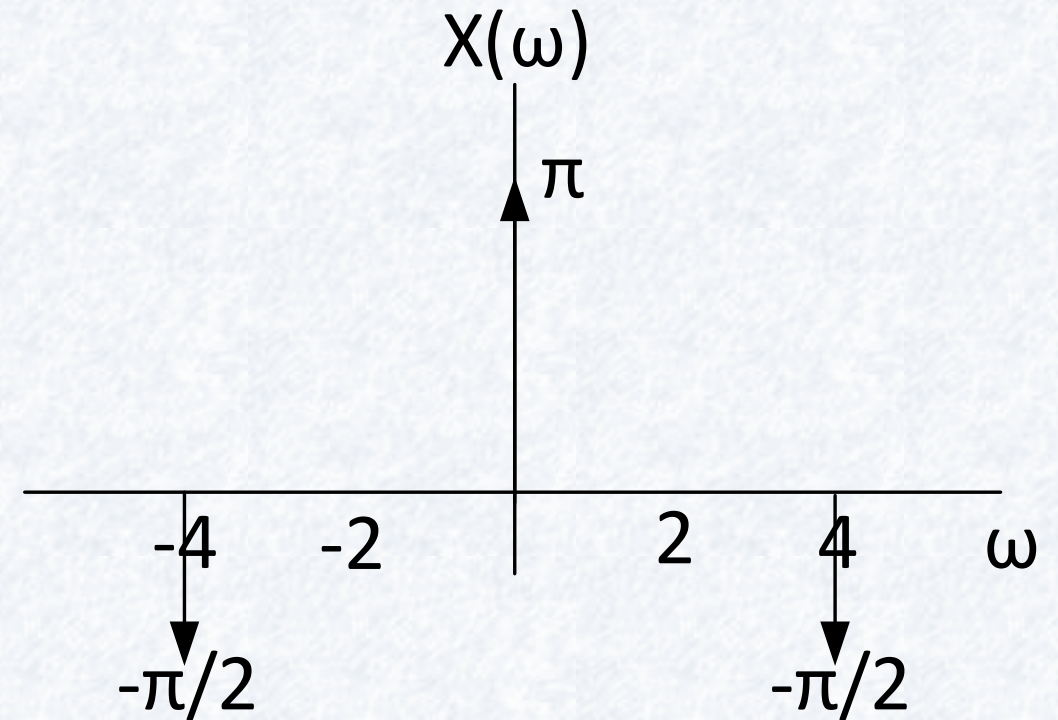
Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 =?, a_k =?$
- $\omega_0 = 4$
- $a_1 = -\frac{1}{4}, a_{-1} = -\frac{1}{4}$
- $a_0 = \frac{1}{2}$
- $\forall k \neq \pm 1 \; ve \; \forall k \neq 0$ için $a_k = 0$
- $x(t) = \frac{1}{2} +$

X(ω)

π

-4   -2   2   4   ω

-π/2   -π/2

Örnek 5

- $x(t) = \sin^2(2t)$ ise $\omega_0 = ?$, $a_k = ?$
- $\omega_0 = 4$
- $a_1 = -\frac{1}{4}, a_{-1} = -\frac{1}{4}$
- $a_0 = \frac{1}{2}$
- $\forall k \neq \pm 1 \ ve \ \forall k \neq 0$ için $a_k = 0$
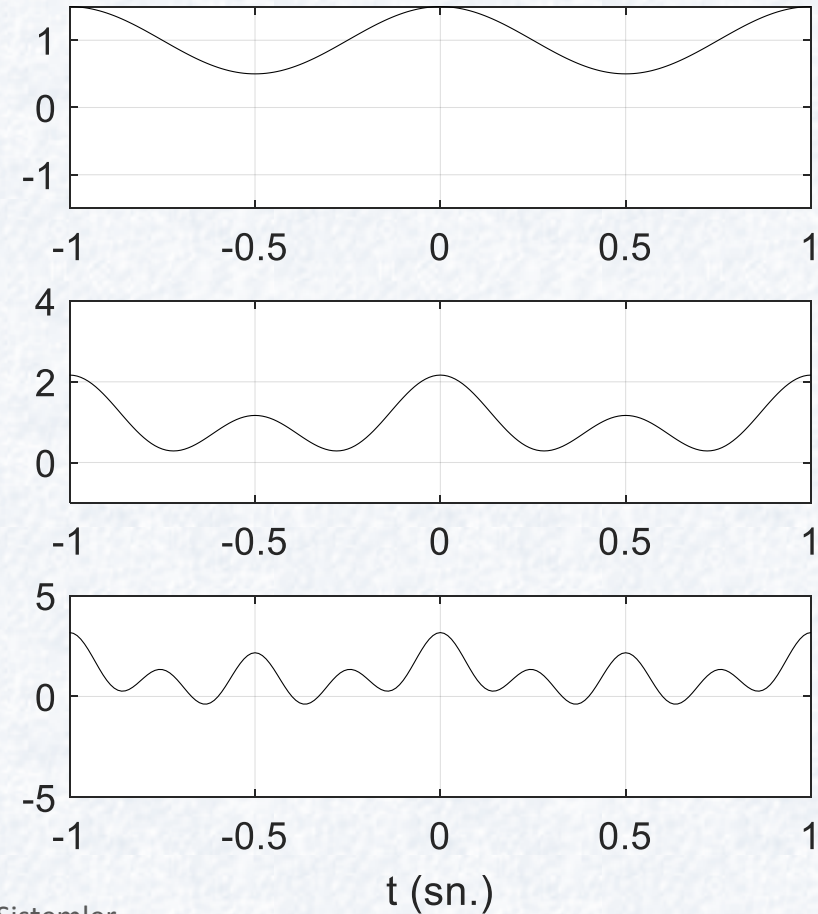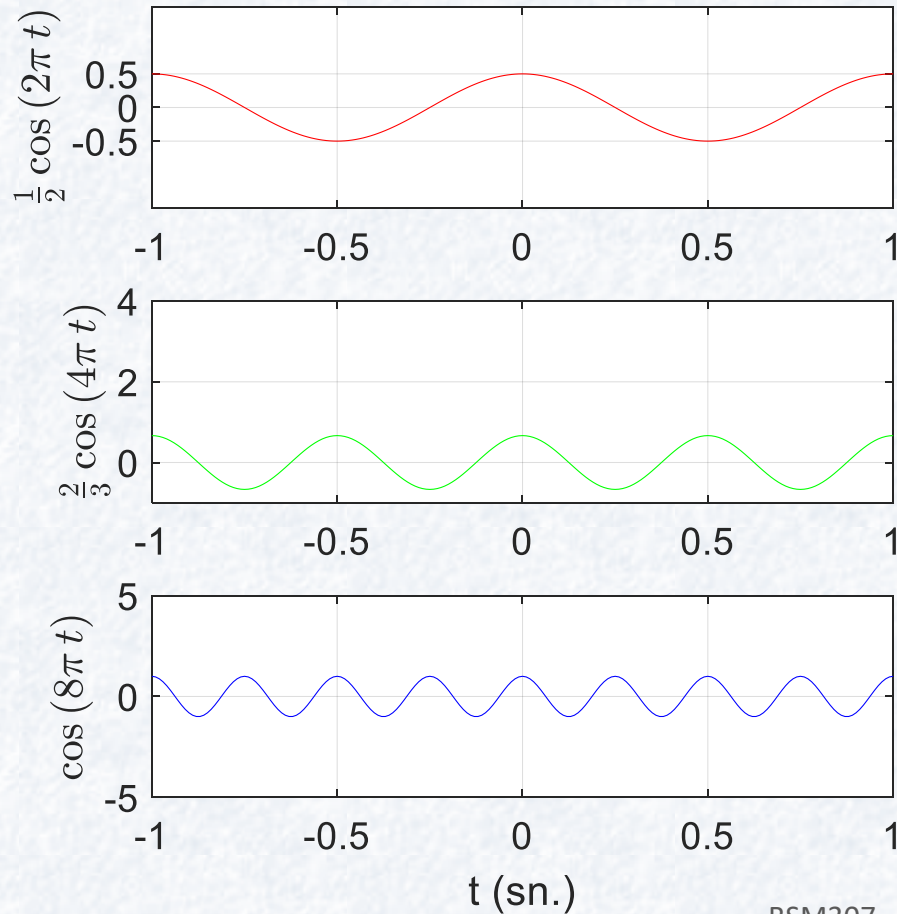- $x(t) = \frac{1}{2} - \frac{1}{2}\cos(4t)$

Örnek 6

- $\omega_0 = 2\pi$
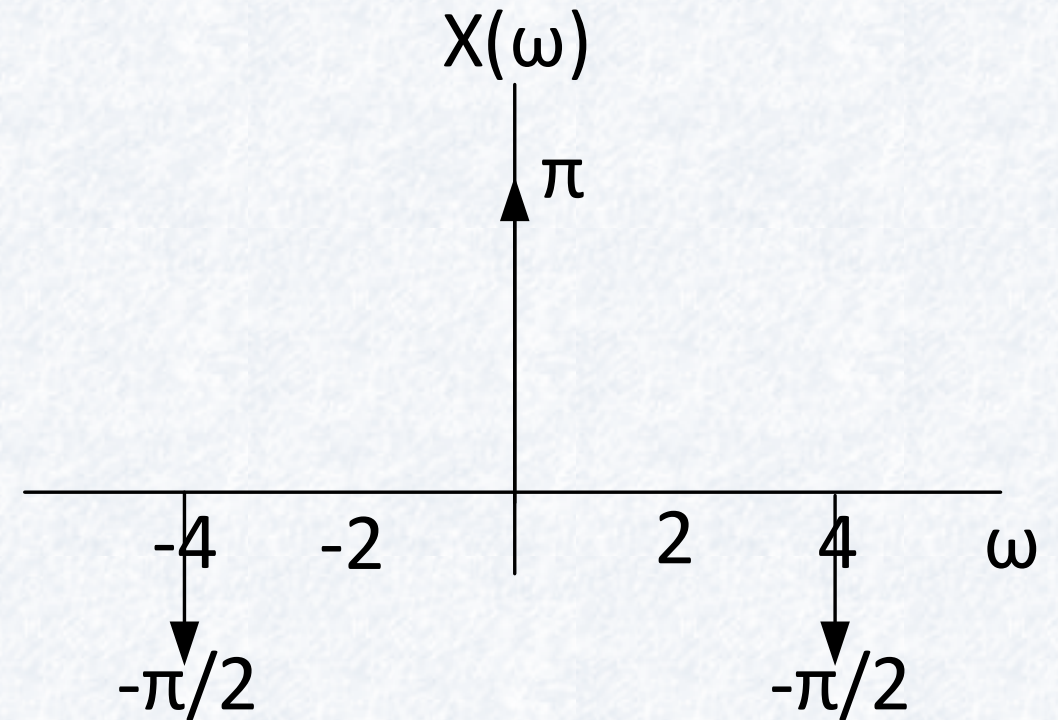
- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) =$?

Örnek 6

- $\omega_0 = 2\pi$
- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) = ?$
- $x(t) = \sum_{k=-4}^{4} a_k e^{jk\omega_0 t}$

Örnek 6

- $\omega_0 = 2\pi$

- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) = ?$

- $x(t) = \sum_{k=-4}^{4} a_k e^{jk\omega_0 t}$
  $= a_{-4}e^{-j8\pi t} + a_{-3}e^{-j6\pi t} + a_{-2}e^{-j4\pi t} + a_{-1}e^{-j2\pi t} + a_0$
  $+ a_4 e^{j8\pi t} + a_3 e^{j6\pi t} + a_2 e^{j4\pi t} + a_1 e^{j2\pi t}$

Örnek 6

- $\omega_0 = 2\pi$

- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) = ?$

- $x(t) = \sum_{k=-4}^{4} a_k e^{jk\omega_0 t}$
  $= a_{-4} e^{-j8\pi t} + a_{-3} e^{-j6\pi t} + a_{-2} e^{-j4\pi t} + a_{-1} e^{-j2\pi t} + a_0$
  $+ a_4 e^{j8\pi t} + a_3 e^{j6\pi t} + a_2 e^{j4\pi t} + a_1 e^{j2\pi t}$
  $= \frac{1}{2} e^{-j8\pi t} + 0 e^{-j6\pi t} + \frac{1}{3} e^{-j4\pi t} + \frac{1}{4} e^{-j2\pi t} + 1$
  $+ \frac{1}{2} e^{j8\pi t} + 0 e^{j6\pi t} + \frac{1}{3} e^{j4\pi t} + \frac{1}{4} e^{j2\pi t}$

Örnek 6

- $\omega_0 = 2\pi$

- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) = ?$

- $x(t) = \frac{1}{2}e^{-j8\pi t} + 0e^{-j6\pi t} + \frac{1}{3}e^{-j4\pi t} + \frac{1}{4}e^{-j2\pi t} + 1 + \frac{1}{2}e^{j8\pi t} + 0e^{j6\pi t} + \frac{1}{3}e^{j4\pi t} + \frac{1}{4}e^{j2\pi t}$

- $x(t) = 1 +$

Örnek 6

- $\omega_0 = 2\pi$

- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) = ?$

- $x(t) = \frac{1}{2}e^{-j8\pi t} + 0e^{-j6\pi t} + \frac{1}{3}e^{-j4\pi t} + \frac{1}{4}e^{-j2\pi t} + 1 + \frac{1}{2}e^{j8\pi t} + 0e^{j6\pi t} + \frac{1}{3}e^{j4\pi t} + \frac{1}{4}e^{j2\pi t}$

- $x(t) = 1 + \frac{1}{2}\cos(2\pi t)$

Örnek 6

- $\omega_0 = 2\pi$

- $a_0 = 1, a_{\pm 1} = \frac{1}{4}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{2}$ ise $x(t) = ?$

- $x(t) = \frac{1}{2}e^{-j8\pi t} + 0e^{-j6\pi t} + \frac{1}{3}e^{-j4\pi t} + \frac{1}{4}e^{-j2\pi t} + 1 + \frac{1}{2}e^{j8\pi t} + 0e^{j6\pi t} + \frac{1}{3}e^{j4\pi t} + \frac{1}{4}e^{j2\pi t}$

- $x(t) = 1 + \frac{1}{2}\cos(2\pi t) + \frac{2}{3}\cos(4\pi t)$

Örnek 6

- $x(t) = 1 + \dfrac{1}{2}\textcolor{red}{\cos(2\pi t)} + \dfrac{2}{3}\textcolor{green}{\cos(4\pi t)} + \textcolor{blue}{\cos(8\pi t)}$

Örnek 6

- $\omega_0 = 2\pi$

- $a_0 = 1, a_{\pm 1} = \frac{1}{2}, a_{\pm 2} = \frac{1}{3}, a_{\pm 4} = \frac{1}{5}$ ise $x(t) = ?$

- $x(t) = \frac{1}{2}e^{-j8\pi t} + 0e^{-j6\pi t} + \frac{1}{3}e^{-j4\pi t} + \frac{1}{4}e^{-j2\pi t} + 1 + \frac{1}{2}e^{j8\pi t} + 0e^{j6\pi t} + \frac{1}{3}e^{j4\pi t} + \frac{1}{4}e^{j2\pi t}$

- $x(t) = 1 + \frac{1}{2}\cos(2\pi t) + \frac{2}{3}\cos(4\pi t) + \cos(8\pi t)$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) + \cos\left(\omega_0 t + \dfrac{\pi}{4}\right)$ Fourier Seri Açılımı?

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$
- $x(t) =$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $x(t) = 1 + \dfrac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} + e^{j2\omega_0 t} + e^{-j2\omega_0 t} -$

$\dfrac{e^{j\omega_0 t} e^{j\frac{\pi}{4}} + e^{-j\omega_0 t} e^{-j\frac{\pi}{4}}}{2} =$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $x(t) = 1 + \frac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} + e^{j2\omega_0 t} + e^{-j2\omega_0 t} - \frac{e^{j\omega_0 t}e^{j\frac{\pi}{4}} + e^{-j\omega_0 t}e^{-j\frac{\pi}{4}}}{2}$

$$= 1 + \left(\frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2}\right)e^{j\omega_0 t} - \left(\frac{1}{2j} + \frac{e^{-j\frac{\pi}{4}}}{2}\right)e^{-j\omega_0 t} + e^{j2\omega_0 t} + e^{-j2\omega_0 t}$$

- $a_0 =$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $x(t) = 1 + \dfrac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} + e^{j2\omega_0 t} + e^{-j2\omega_0 t} - \dfrac{e^{j\omega_0 t}e^{j\frac{\pi}{4}} + e^{-j\omega_0 t}e^{-j\frac{\pi}{4}}}{2}$

$= 1 + \left(\dfrac{1}{2j} - \dfrac{e^{j\frac{\pi}{4}}}{2}\right)e^{j\omega_0 t} - \left(\dfrac{1}{2j} + \dfrac{e^{-j\frac{\pi}{4}}}{2}\right)e^{-j\omega_0 t} + e^{j2\omega_0 t} + e^{-j2\omega_0 t}$

- $a_0 = 1$

- $a_1 =$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $x(t) = 1 + \dfrac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} + e^{j2\omega_0 t} + e^{-j2\omega_0 t} - \dfrac{e^{j\omega_0 t} e^{j\frac{\pi}{4}} + e^{-j\omega_0 t} e^{-j\frac{\pi}{4}}}{2}$

$$= 1 + \left(\frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2}\right) e^{j\omega_0 t} - \left(\frac{1}{2j} + \frac{e^{-j\frac{\pi}{4}}}{2}\right) e^{-j\omega_0 t} + e^{j2\omega_0 t} + e^{-j2\omega_0 t}$$

- $a_0 = 1$

- $a_1 = \frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2} = 0{,}9239 e^{-j112,5°}$

- $a_{-1} =$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $x(t) = 1 + \frac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} + e^{j2\omega_0 t} + e^{-j2\omega_0 t} - \frac{e^{j\omega_0 t}e^{j\frac{\pi}{4}} + e^{-j\omega_0 t}e^{-j\frac{\pi}{4}}}{2} = 1 + \left(\frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2}\right)e^{j\omega_0 t} - \left(\frac{1}{2j} + \frac{e^{-j\frac{\pi}{4}}}{2}\right)e^{-j\omega_0 t} + e^{j2\omega_0 t} + e^{-j2\omega_0 t}$

- $a_0 = 1$

- $a_1 = \frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2} = 0{,}9239 e^{-j112,5°}$

- $a_{-1} = -\frac{1}{2j} - \frac{e^{-j\frac{\pi}{4}}}{2} = 0{,}9239 e^{j112,5°}$

- $a_2 = a_{-2} =$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $x(t) = 1 + \frac{e^{j\omega_0 t} - e^{-j\omega_0 t}}{2j} + e^{j2\omega_0 t} + e^{-j2\omega_0 t} - \frac{e^{j\omega_0 t}e^{j\frac{\pi}{4}} + e^{-j\omega_0 t}e^{-j\frac{\pi}{4}}}{2} = 1 + \left(\frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2}\right)e^{j\omega_0 t} - \left(\frac{1}{2j} + \frac{e^{-j\frac{\pi}{4}}}{2}\right)e^{-j\omega_0 t} + e^{j2\omega_0 t} + e^{-j2\omega_0 t}$

- $a_0 = 1$

- $a_1 = \frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2} = 0{,}9239 e^{-j112{,}5°}$

- $a_{-1} = -\frac{1}{2j} - \frac{e^{-j\frac{\pi}{4}}}{2} = 0{,}9239 e^{j112{,}5°}$

- $a_2 = a_{-2} = 1$

Örnek 7

- $x(t) = 1 + \sin(\omega_0 t) + 2\cos(2\omega_0 t) - \cos\left(\omega_0 t + \frac{\pi}{4}\right)$

- $a_0 = 1$

- $a_1 = \frac{1}{2j} - \frac{e^{j\frac{\pi}{4}}}{2} = 0{,}9239 e^{-j112{,}5°}$

- $a_{-1} = -\frac{1}{2j} - \frac{e^{-j\frac{\pi}{4}}}{2} = 0{,}9239 e^{j112{,}5°}$

- $a_2 = a_{-2} = 1$
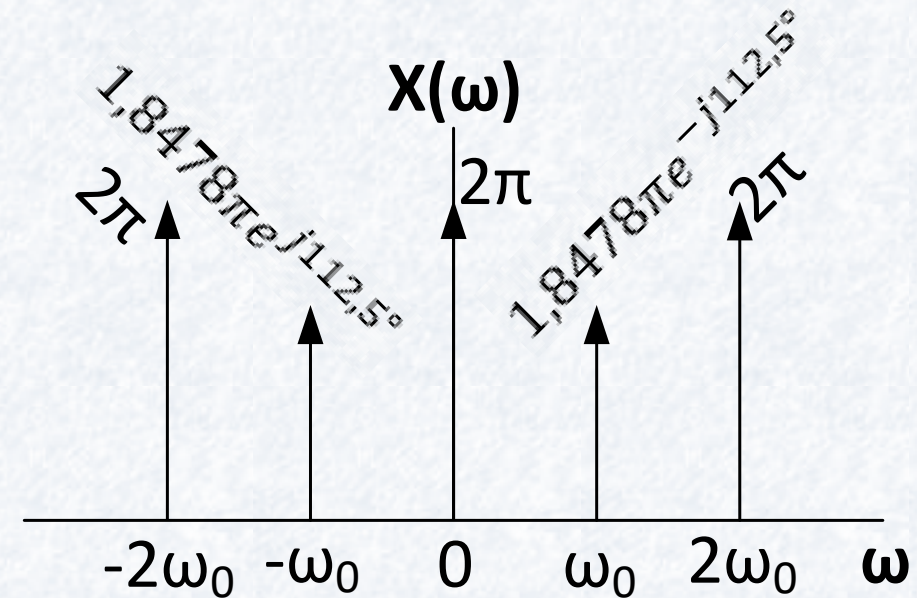
Örnek 8

- Fourier seri açılımı?

- $\omega_0 =$
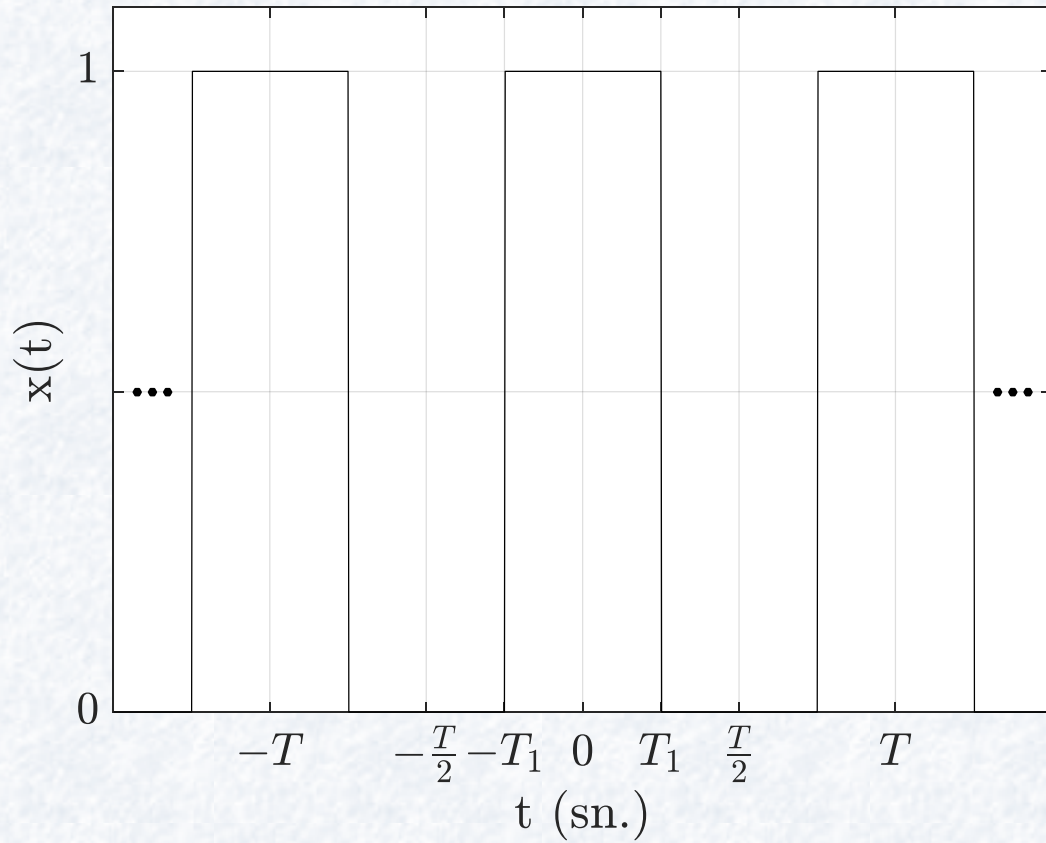
Örnek 8

- Fourier seri açılımı?
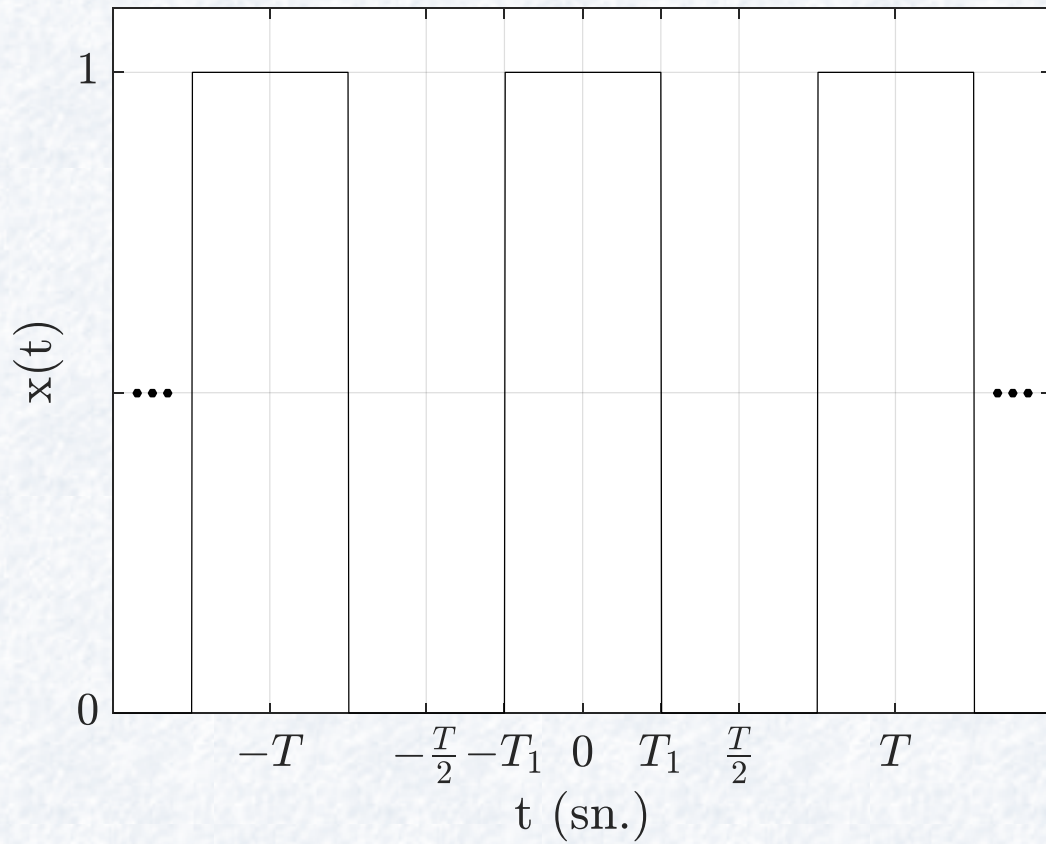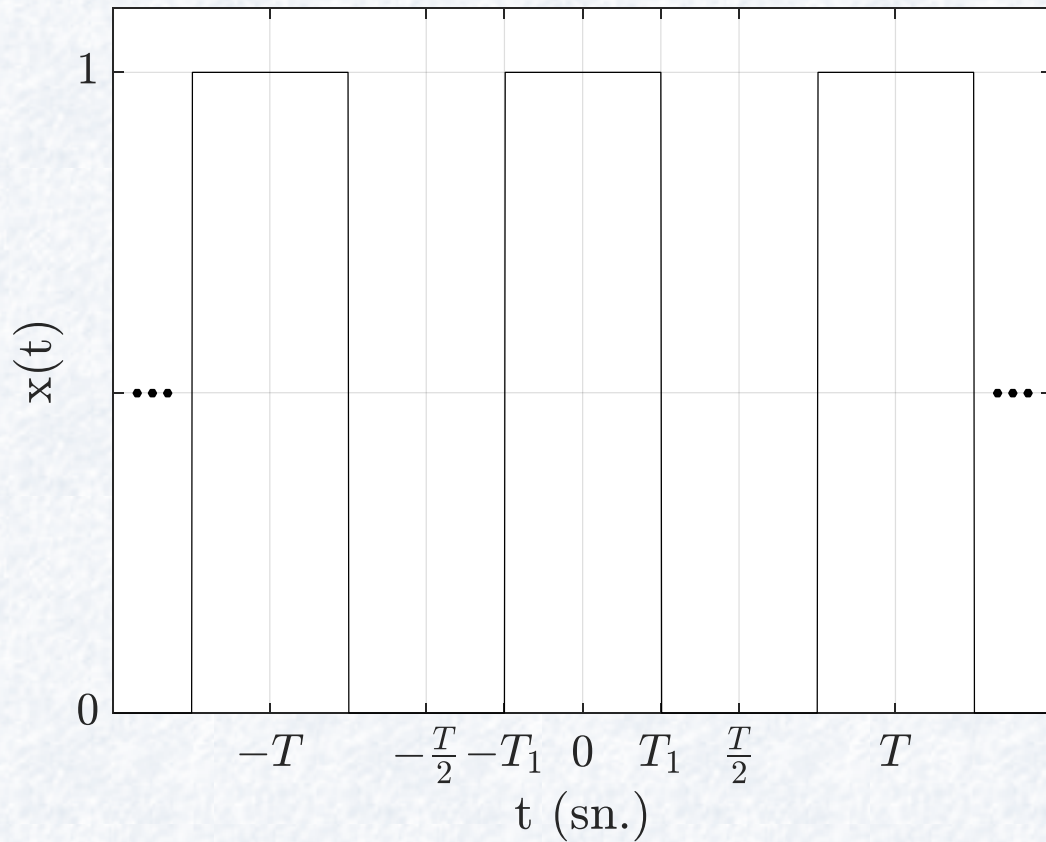
- $\omega_0 = \dfrac{2\pi}{T}$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$
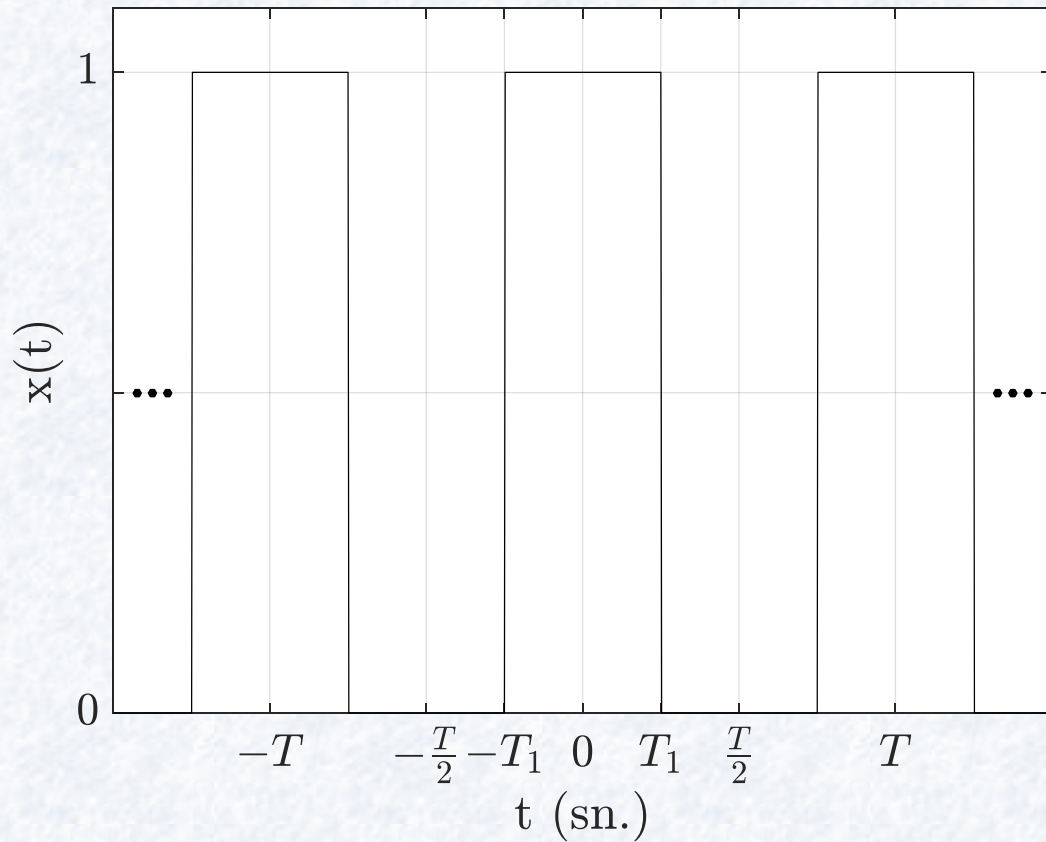
- $a_k = \dfrac{1}{\color{red}{T_0}} \int_{t_1}^{t_2} x(t)\, e^{-jk\omega_0 t}\, dt$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

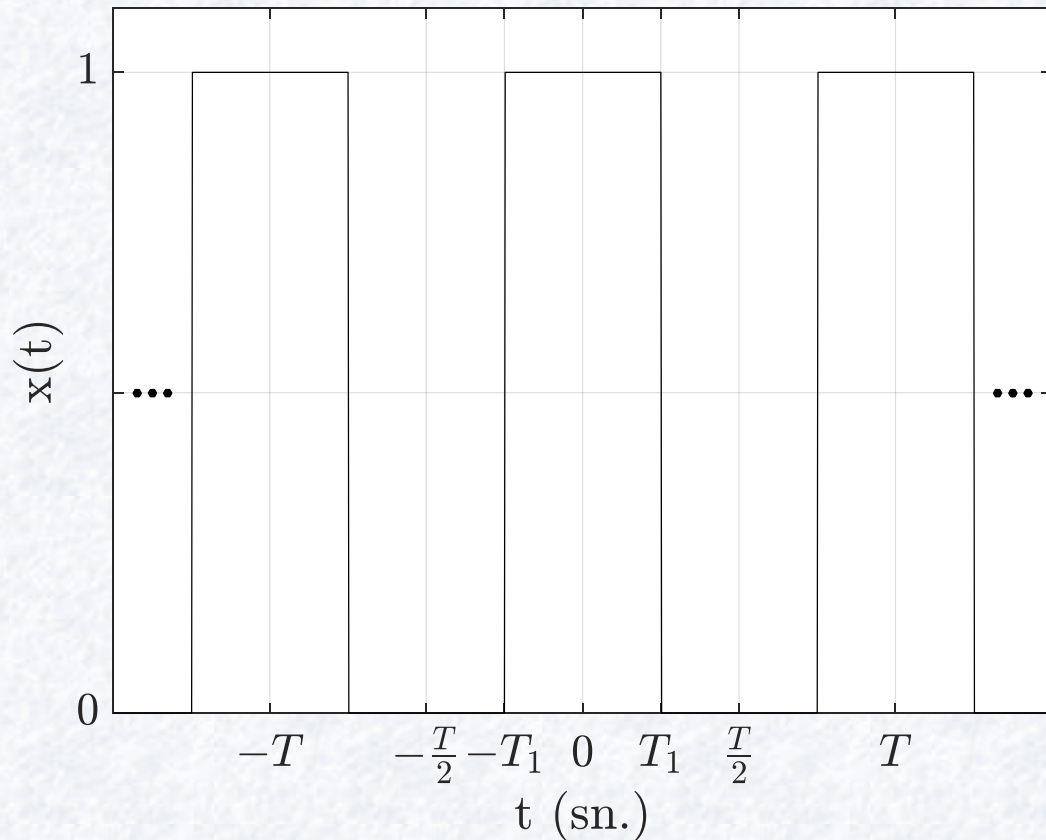- $a_k = \dfrac{1}{T} \int_{t_1}^{t_2} x(t)\, e^{-jk\omega_0 t}\, dt$

Örnek 8
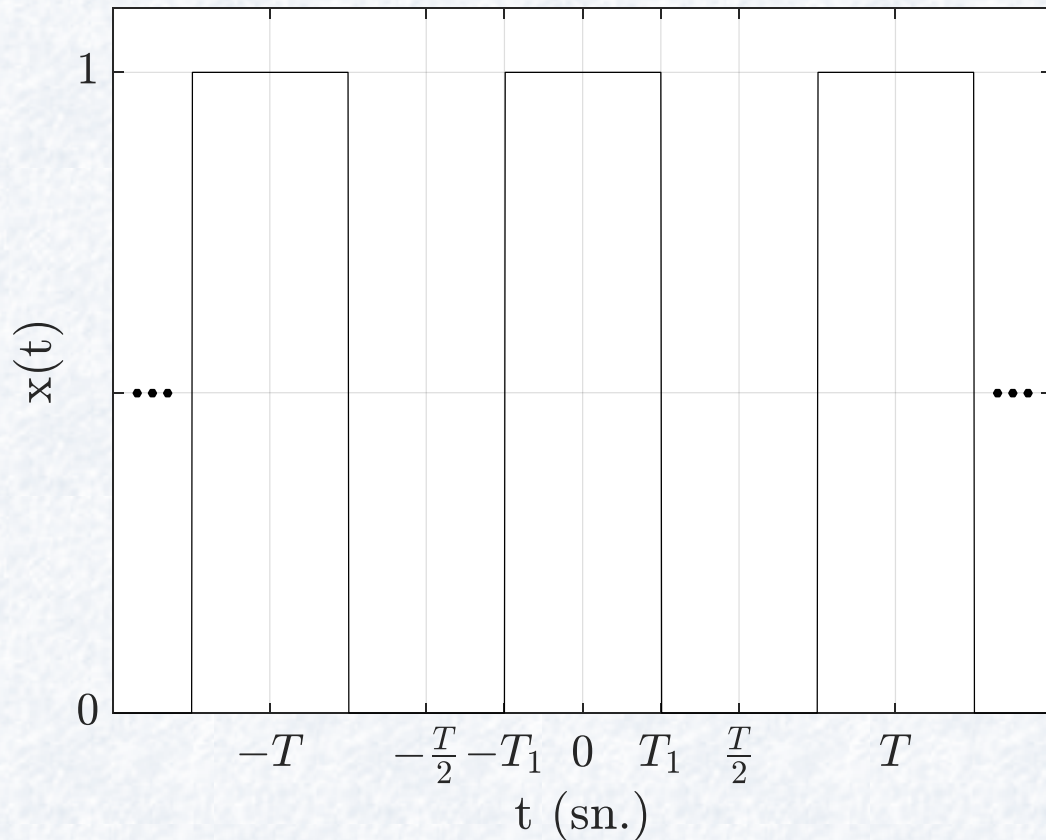
- Fourier seri açılımı?
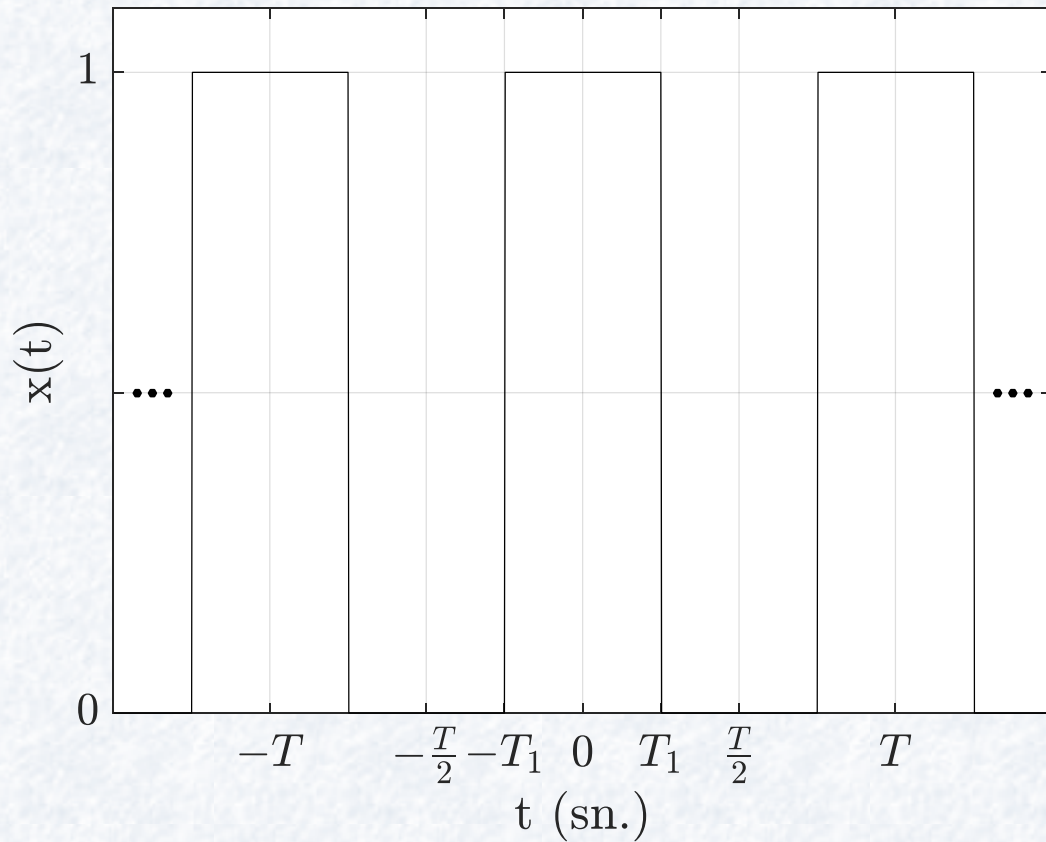
- $\omega_0 = \dfrac{2\pi}{T}$
- $a_k = \dfrac{1}{T}\int_{-T/2}^{T/2} x(t)\, e^{-jk\omega_0 t}\, dt$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \int_{-T/2}^{T/2} x(t)\, e^{-jk\omega_0 t}\, dt$

- $a_k = \dfrac{1}{T} \int_{-T/2}^{-T_1} + \int_{-T_1}^{T_1} + \int_{T_1}^{T/2}$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T}\displaystyle\int_{-T/2}^{T/2} x(t)\, e^{-jk\omega_0 t}\, dt$

- $a_k = \dfrac{1}{T}\displaystyle\int_{-T_1}^{T_1} 1 e^{-jk\omega_0 t}\, dt$

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$
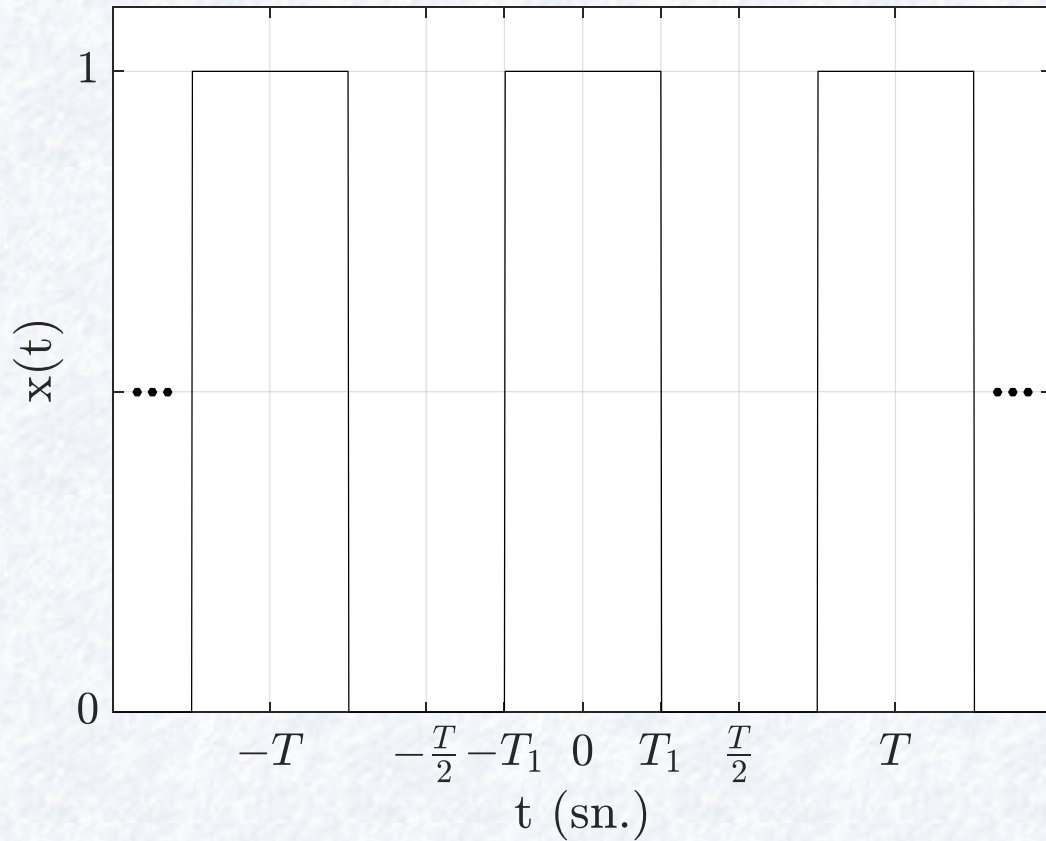
- $a_k = \dfrac{1}{T} \int_{-T/2}^{T/2} x(t)\, e^{-jk\omega_0 t} dt$

- $a_k = \dfrac{1}{T} \int_{-T_1}^{T_1} 1 e^{-jk\frac{2\pi}{T}t} dt$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T}\int_{-T_1}^{T_1} 1e^{-jk\frac{2\pi}{T}t}dt$

- $a_k =$

Örnek 8

- Fourier seri açılımı?
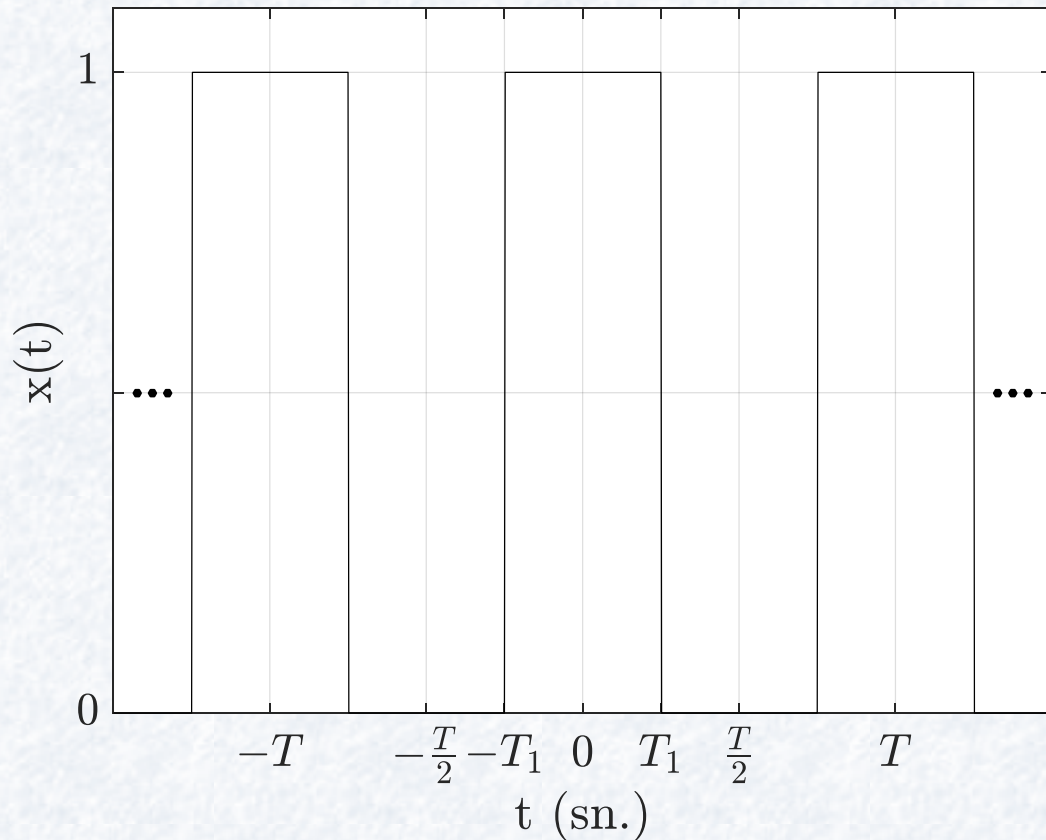
- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \int_{-T_1}^{T_1} 1 e^{-jk\frac{2\pi}{T}t} dt$

- $a_k = \dfrac{1}{T} \dfrac{-1}{jk\frac{2\pi}{T}} e^{-jk\frac{2\pi}{T}t} \Big|_{-T_1}^{T_1}$

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \int_{-T_1}^{T_1} 1 e^{-jk\frac{2\pi}{T}t} dt$

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- $a_k =$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$
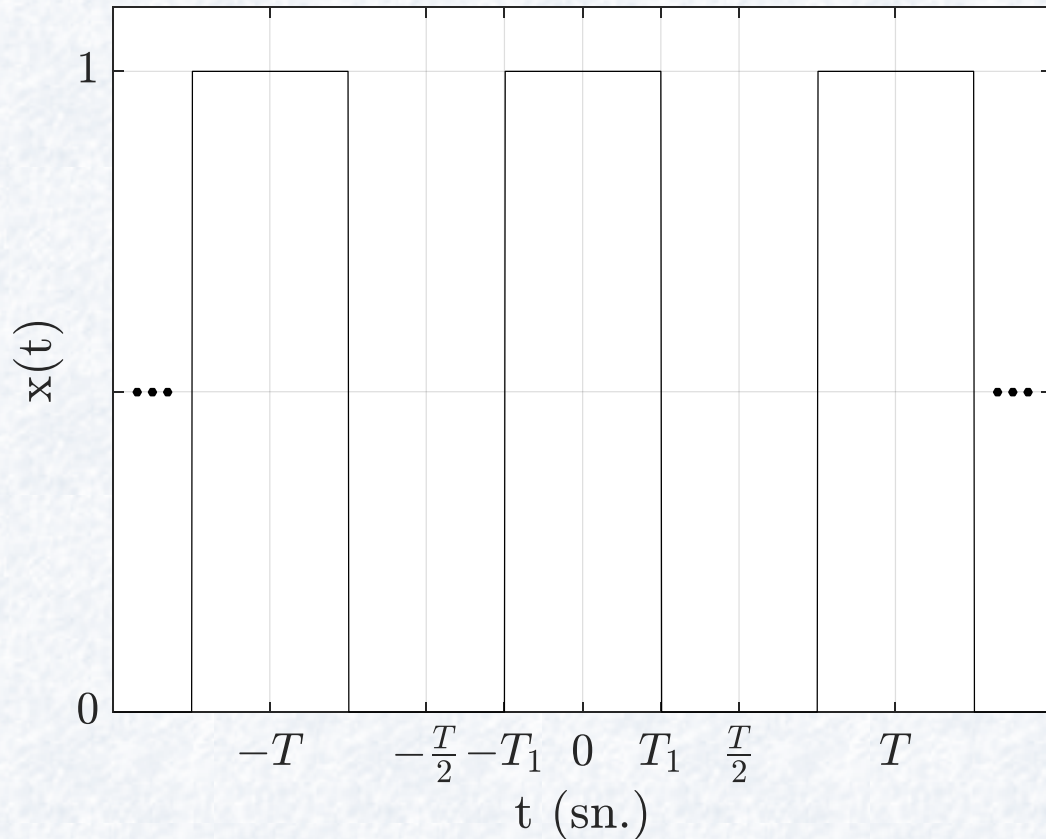
- $a_k = \dfrac{1}{T} \int_{-T_1}^{T_1} 1 e^{-jk\frac{2\pi}{T}t} dt$

- $a_k = \dfrac{1}{T} \dfrac{-1}{jk\frac{2\pi}{T}} e^{-jk\frac{2\pi}{T}t} \Big|_{-T_1}^{T_1}$

- $a_k = \dfrac{-1}{j2\pi k} \left(e^{-jk\frac{2\pi T_1}{T}} - e^{jk\frac{2\pi T_1}{T}} \right)$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$
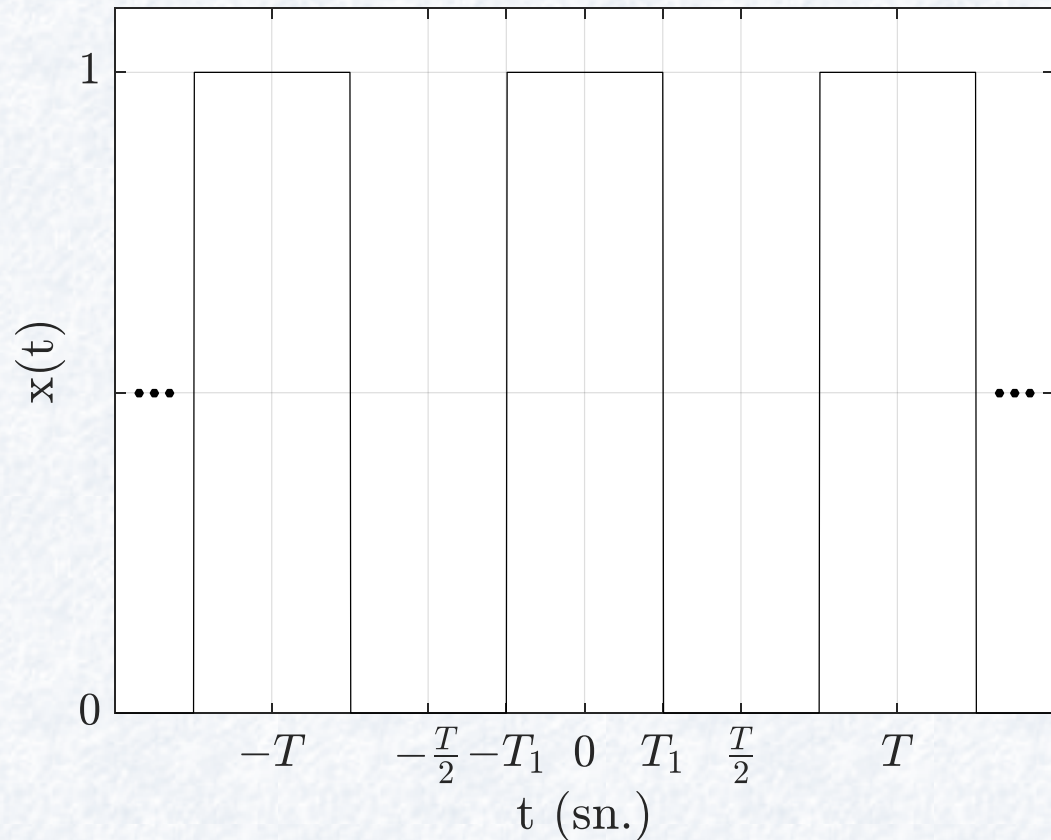
- $a_k = \dfrac{1}{j2\pi k}\left(-e^{-jk\frac{2\pi T_1}{T}} + e^{jk\frac{2\pi T_1}{T}}\right)$

- $a_k = \dfrac{1}{\pi k}\left(\dfrac{e^{jk\frac{2\pi T_1}{T}} - e^{-jk\frac{2\pi T_1}{T}}}{2j}\right)$

- $a_k =$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$
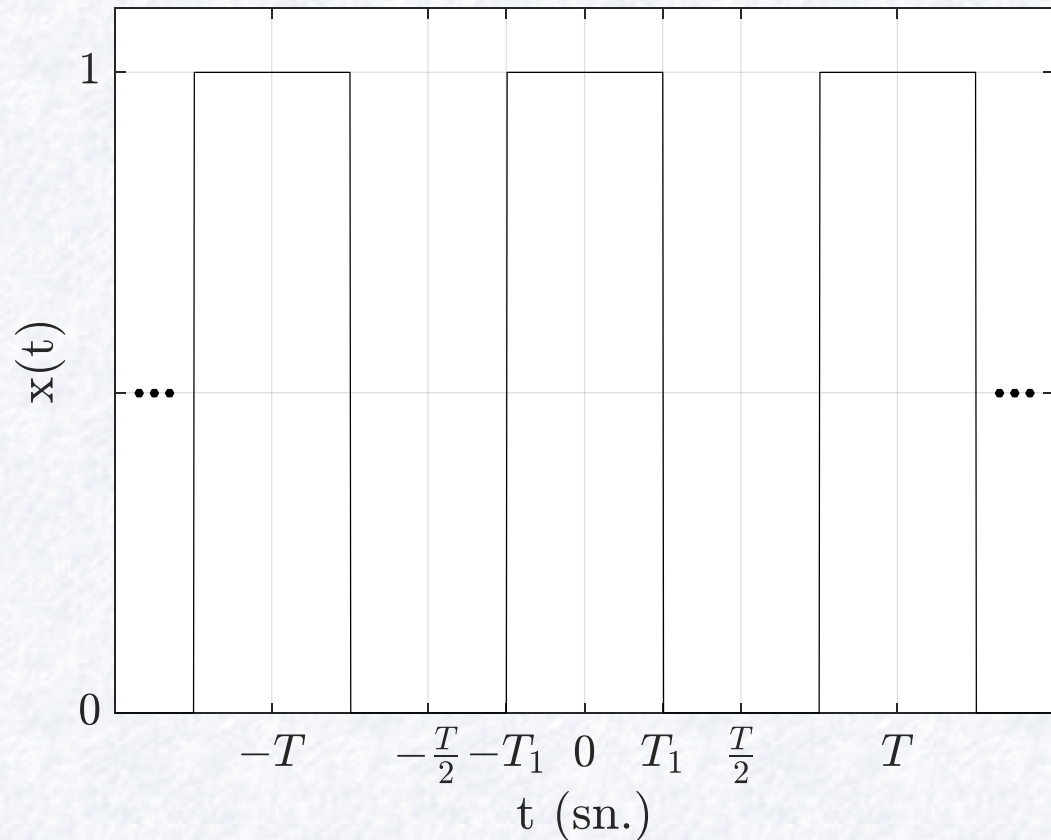
- $a_k = \dfrac{1}{j2\pi k}\left(-e^{-jk\frac{2\pi T_1}{T}} + e^{jk\frac{2\pi T_1}{T}}\right)$

- $a_k = \dfrac{1}{\pi k}\left(\dfrac{e^{jk\frac{2\pi T_1}{T}} - e^{-jk\frac{2\pi T_1}{T}}}{2j}\right)$

- $a_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$

Örnek 8

- Fourier seri açılımı?
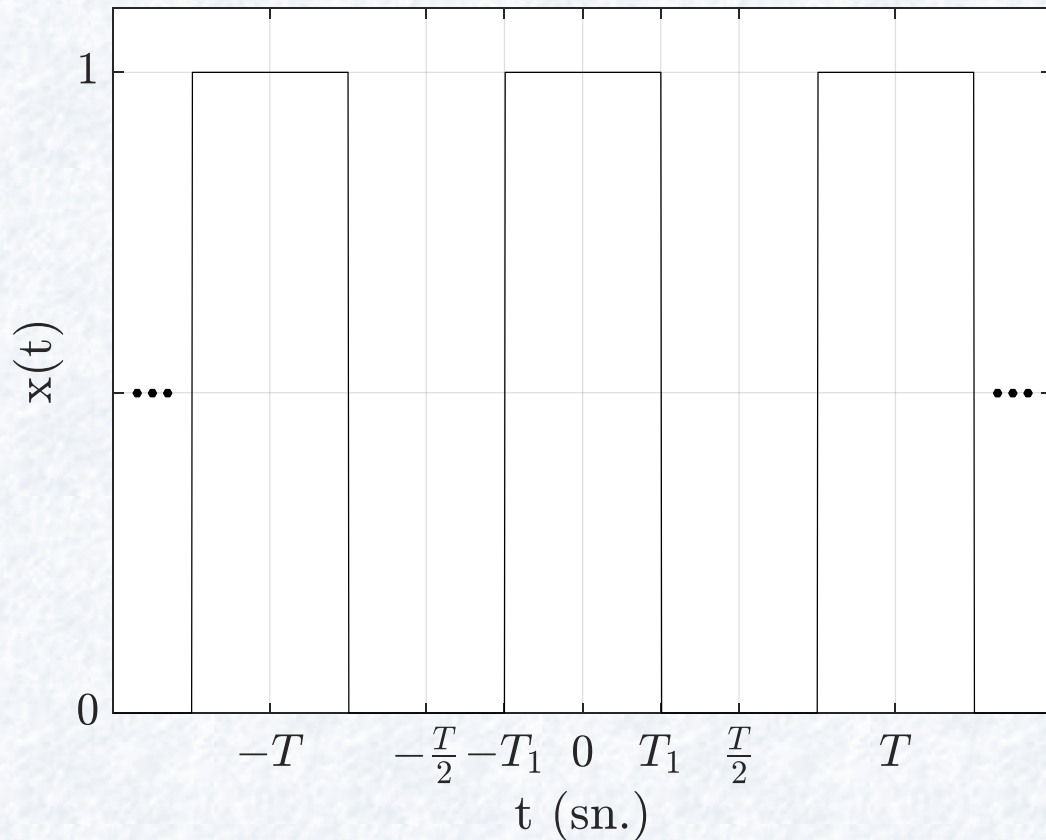
- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$

  ♦ $\text{sinc}(\theta) = \dfrac{\sin(\pi\theta)}{\pi\theta}$
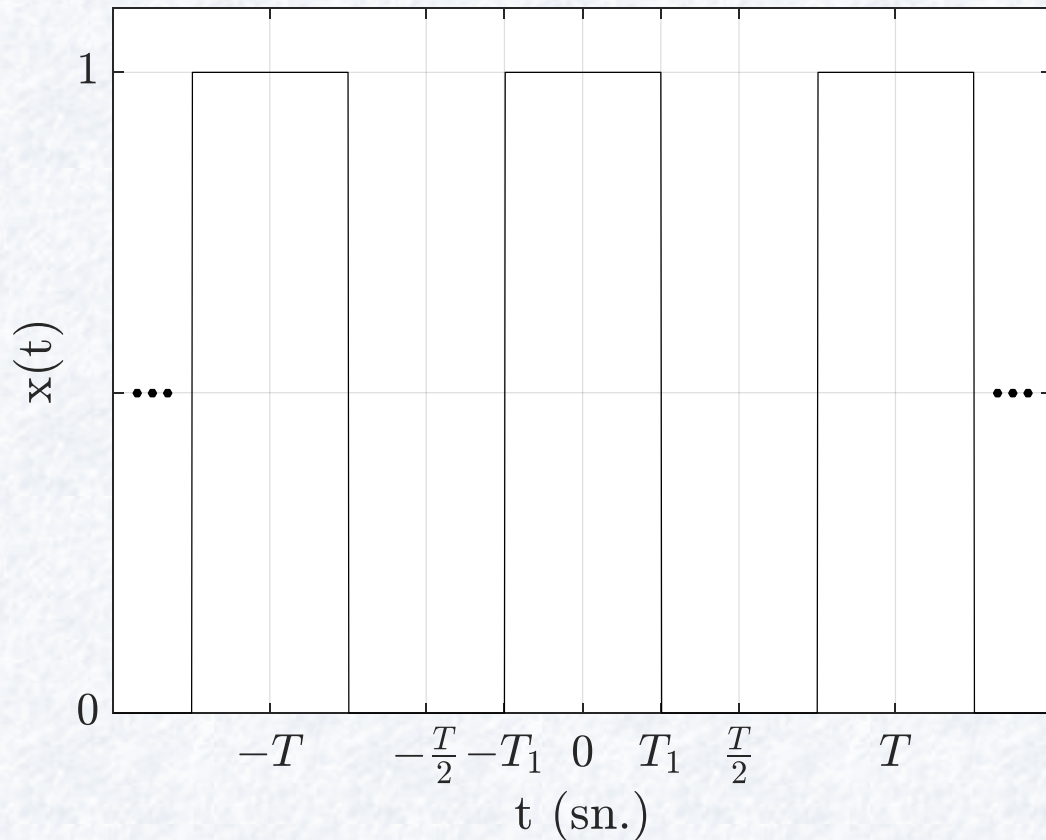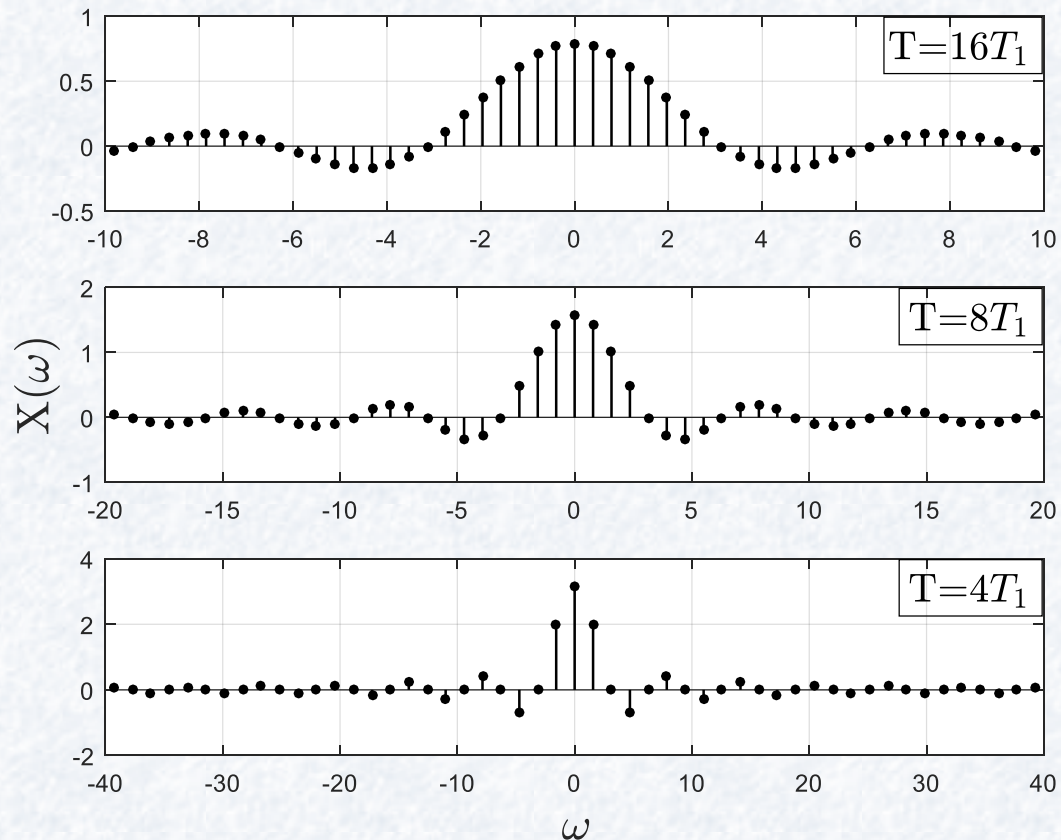
- $a_0 =$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{\sin\left(k\dfrac{2\pi T_1}{T}\right)}{\pi k}$

- $a_0 = \dfrac{\dfrac{2\pi T_1}{T}\cos\left(k\dfrac{2\pi T_1}{T}\right)}{\pi}\Bigg|_{k=0} = \dfrac{2T_1}{T}$

Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

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- $a_0 = \dfrac{1}{T}\int_{-T_1}^{T_1} 1 e^{-j0\frac{2\pi}{T}t}\,dt$

Örnek 8
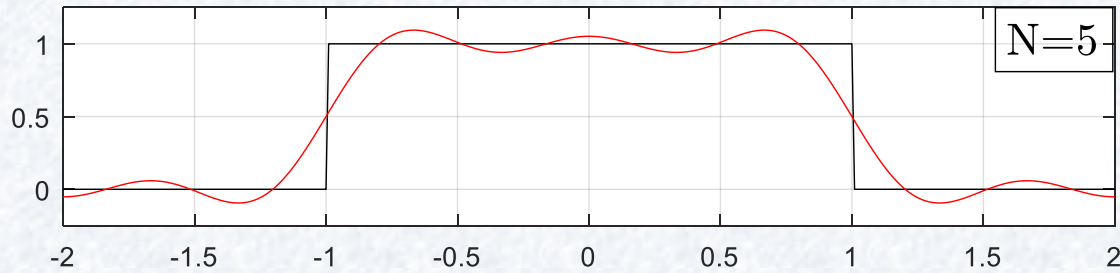
- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{\sin\left(k\dfrac{2\pi T_1}{T}\right)}{\pi k}$

- $a_0 = \dfrac{\dfrac{2\pi T_1}{T}\cos\left(k\dfrac{2\pi T_1}{T}\right)}{\pi}\Bigg|_{k=0} = \dfrac{2T_1}{T}$

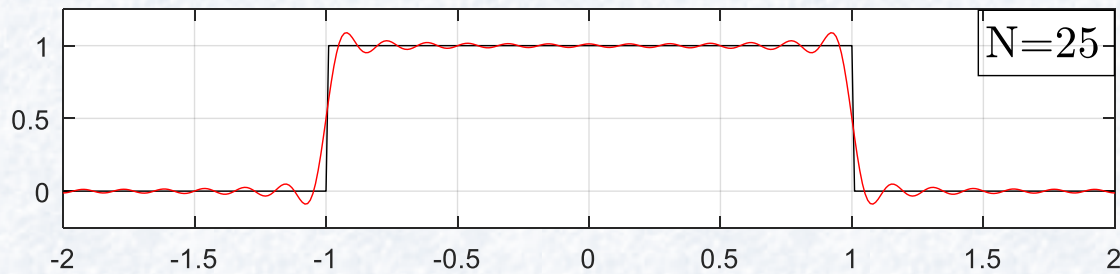- $a_0 = \dfrac{1}{T}\int_{-T_1}^{T_1} dt = \dfrac{1}{T}t\Big|_{-T_1}^{T_1} = \dfrac{2T_1}{T}$

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{\sin\left(k\dfrac{2\pi T_1}{T}\right)}{\pi k}$

- $a_0 = \dfrac{\dfrac{2\pi T_1}{T}\cos\left(k\dfrac{2\pi T_1}{T}\right)}{\pi}\Bigg|_{k=0} = \dfrac{2T_1}{T}$

- $a_0 = \dfrac{1}{T}\int_{-T_1}^{T_1} dt = \dfrac{1}{T}t\Big|_{-T_1}^{T_1} = \dfrac{2T_1}{T}$
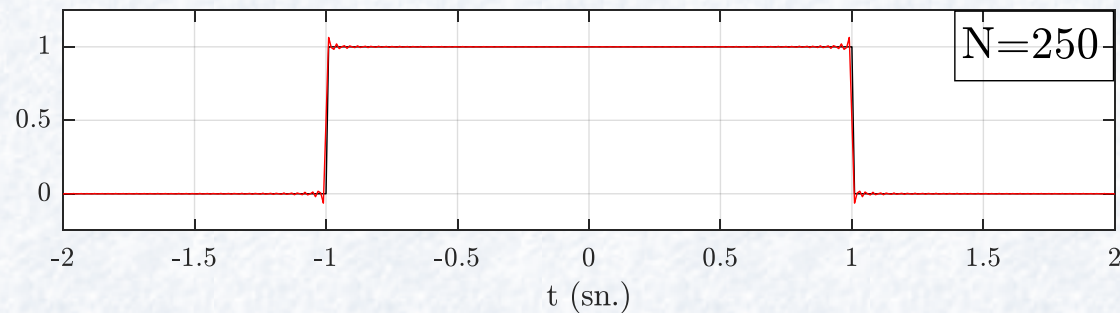
Örnek 8

- Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{\sin\left(k\dfrac{2\pi T_1}{T}\right)}{\pi k}$

- $a_0 = \dfrac{\dfrac{2\pi T_1}{T}\cos\left(k\dfrac{2\pi T_1}{T}\right)}{\pi}\Bigg|_{k=0} = \dfrac{2T_1}{T}$

- $a_0 = \dfrac{1}{T}\displaystyle\int_{-T_1}^{T_1} dt = \dfrac{1}{T}t\Big|_{-T_1}^{T_1} = \dfrac{2T_1}{T}$

Örnek 8

- ## Fourier seri açılımı?

- $x(t) = \sum_{k=-5}^{5} a_k e^{jk\frac{2\pi}{T}t}$
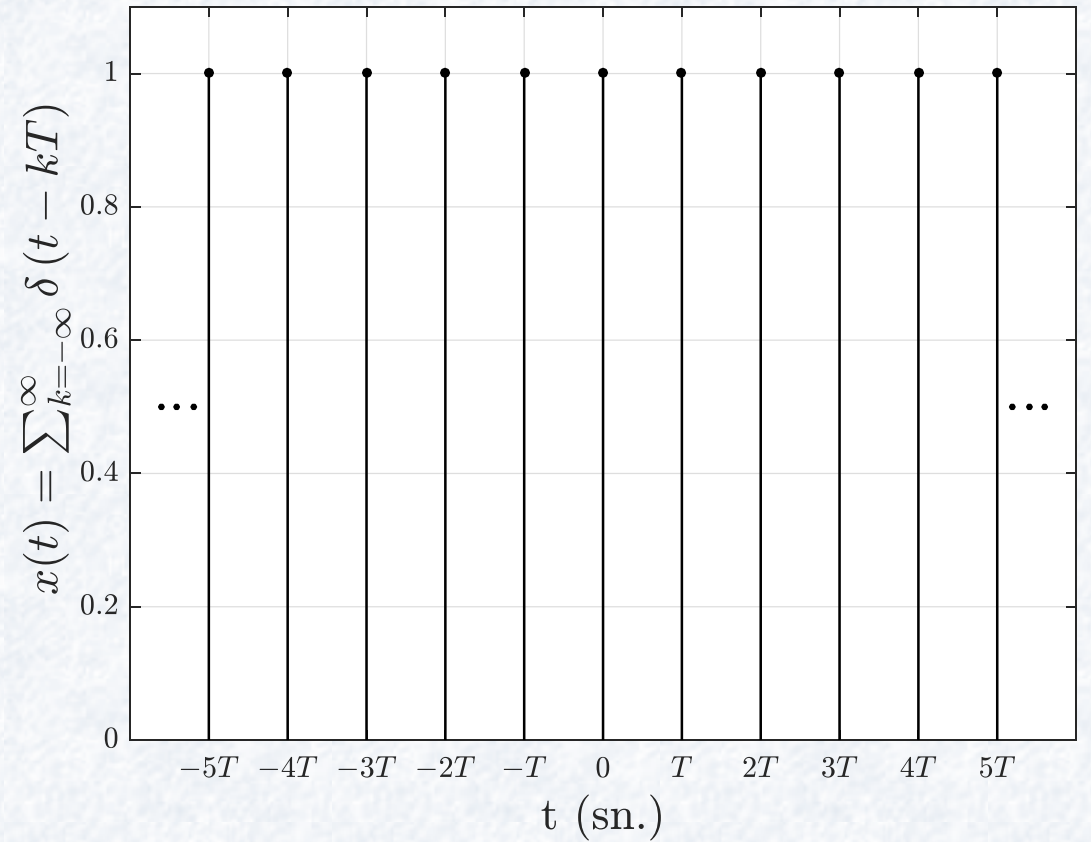
- $x(t) = \sum_{k=-25}^{25} a_k e^{jk\frac{2\pi}{T}t}$

- $x(t) = \sum_{k=-250}^{250} a_k e^{jk\frac{2\pi}{T}t}$

Örnek 9

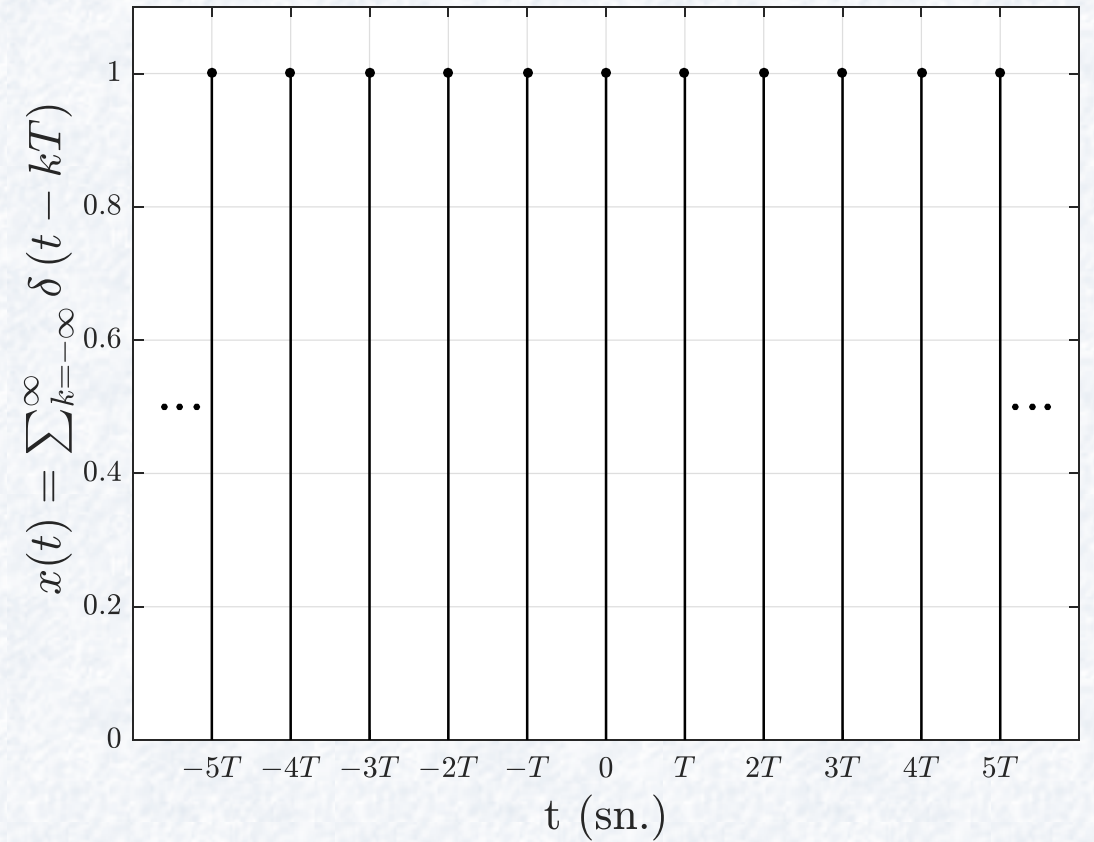- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?
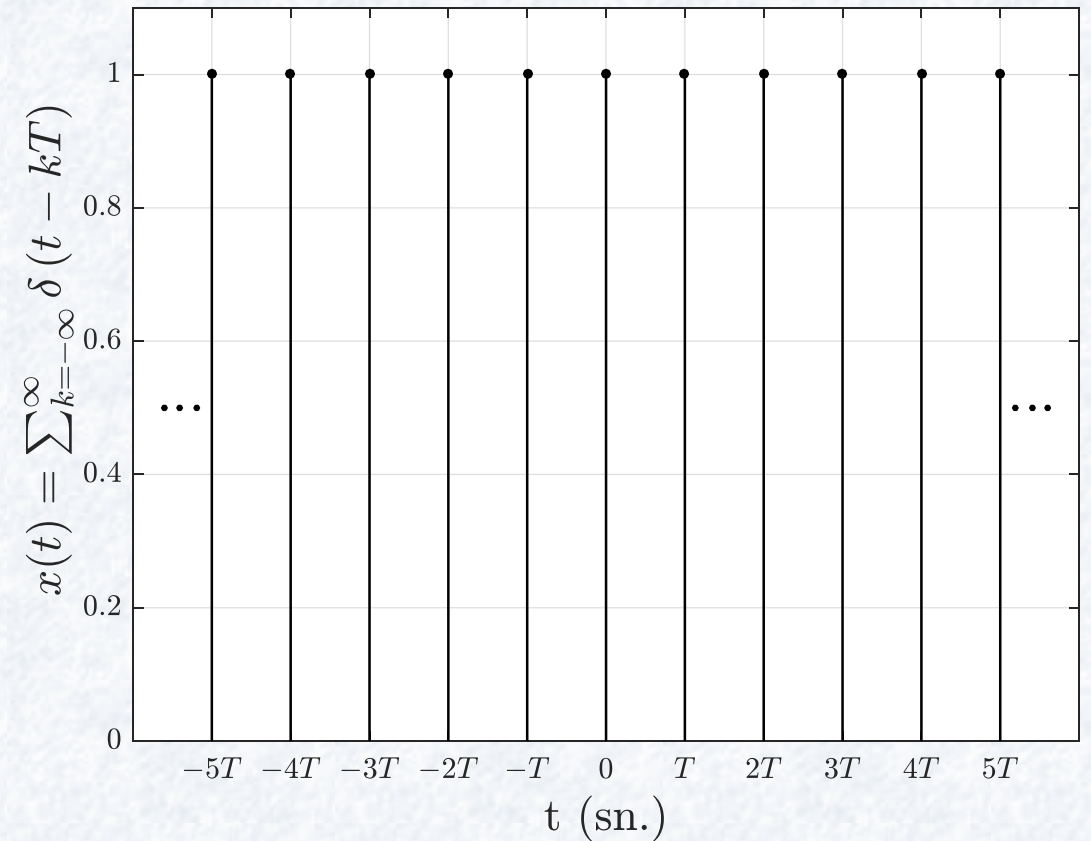- $\omega_0 =$

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

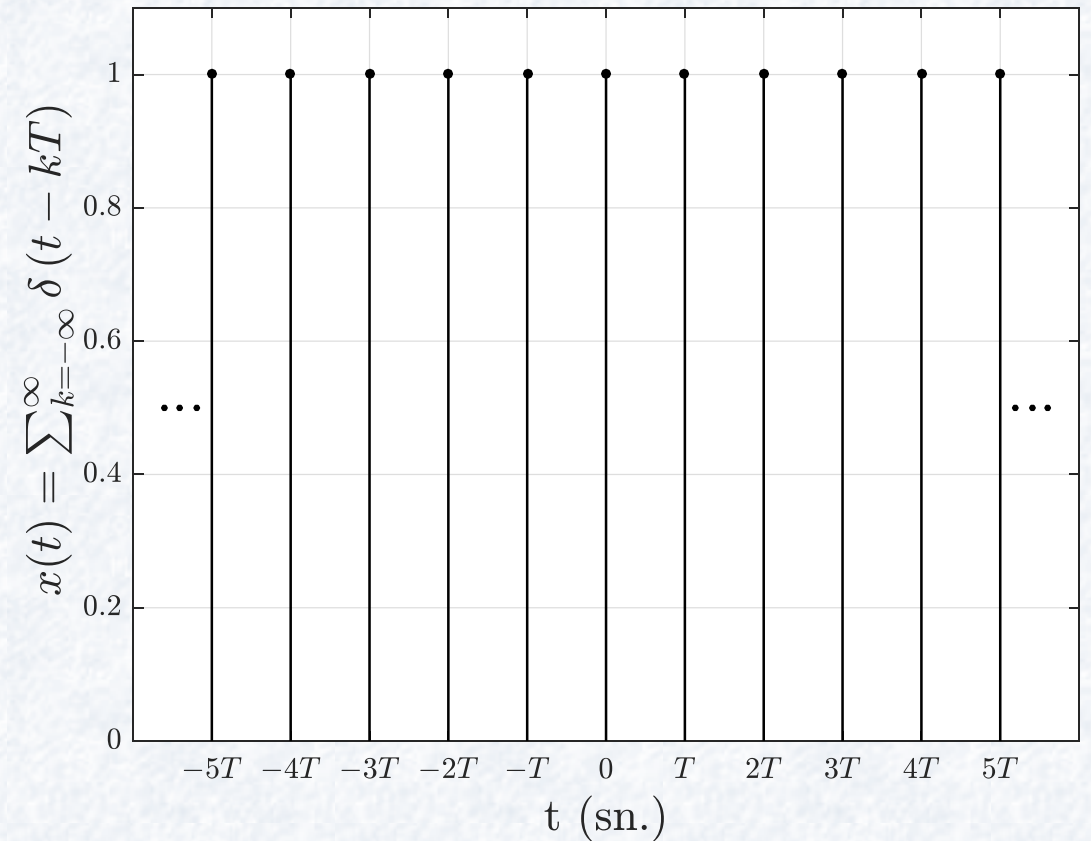- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k =$

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \int_{-T/2}^{T/2} \textcolor{red}{x(t)} e^{-jk\omega_0 t} dt$

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \underbrace{\int_{-T/2}^{T/2} \delta(t) e^{-jk\omega_0 t} dt}_{?}$
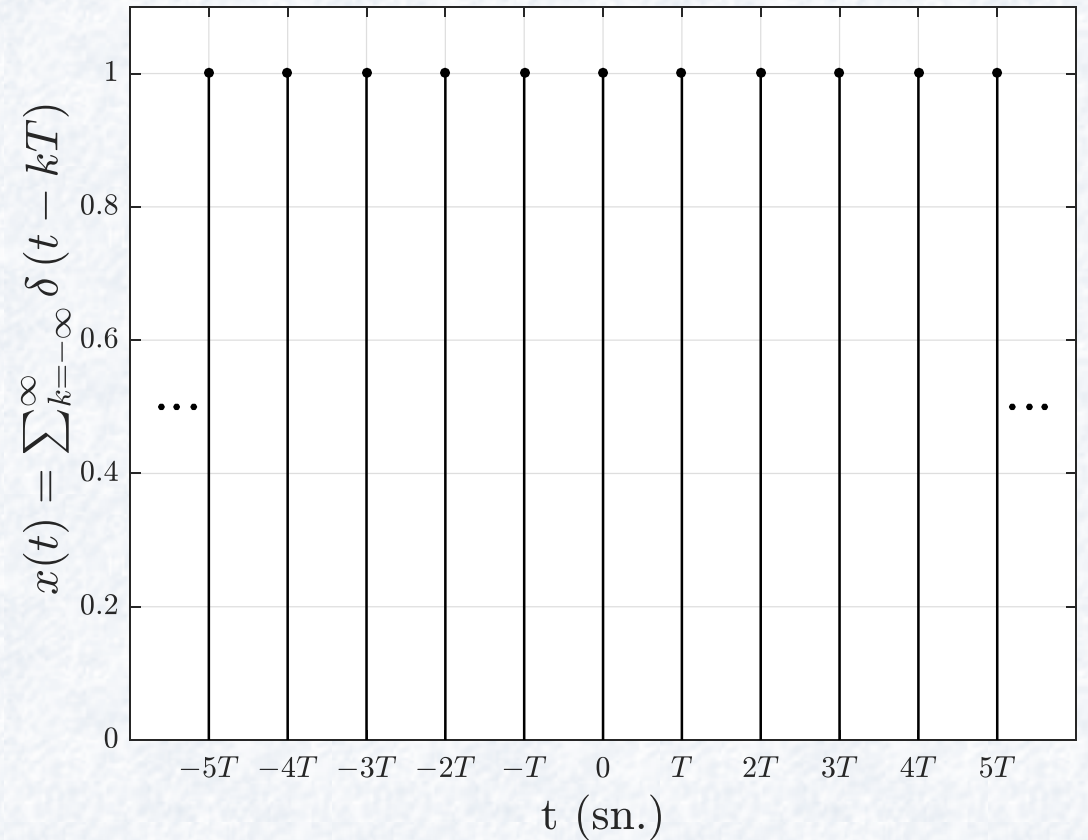
- $a_k = \dfrac{1}{T} \square$

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \underbrace{\int_{-T/2}^{T/2} \delta(t) e^{-jk\omega_0 t} dt}_{e^{-jk\omega_0 0}}$

- $a_k = \dfrac{1}{T} 1 = \dfrac{1}{T}$

- $a_0 =$

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \underbrace{\int_{-T/2}^{T/2} \delta(t) e^{-jk\omega_0 t} dt}_{e^{-jk\omega_0 0}}$
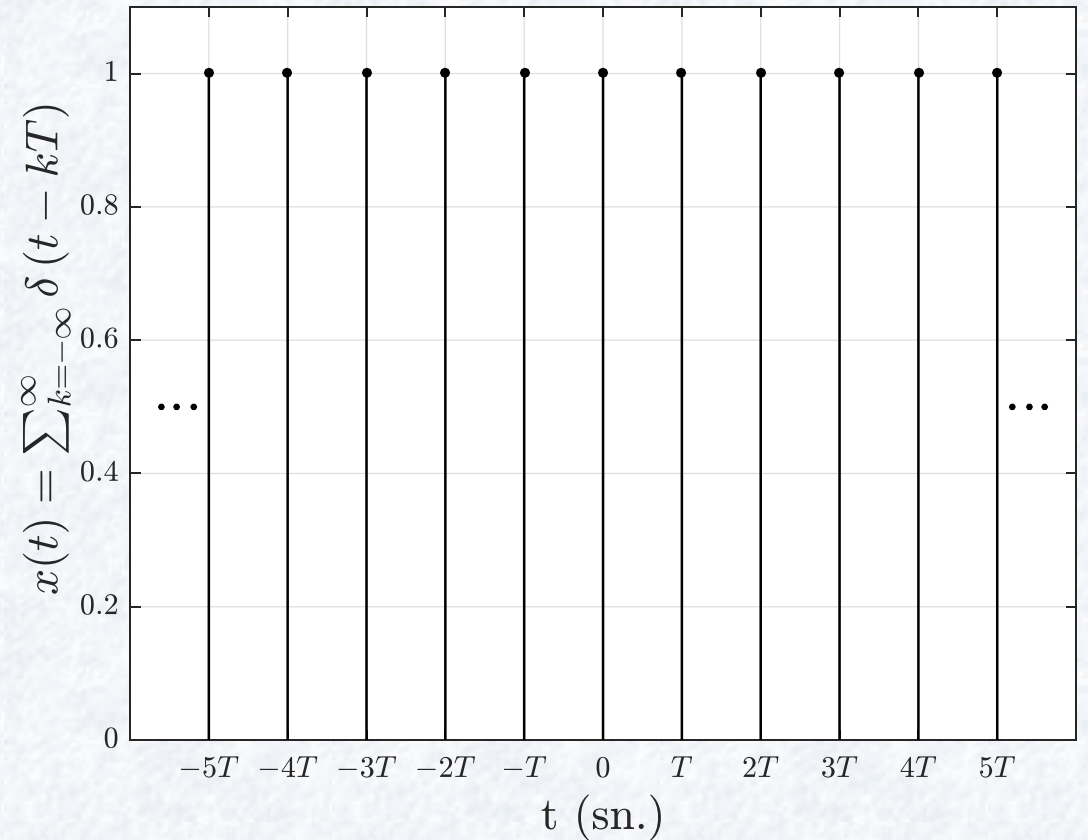
- $a_k = \dfrac{1}{T} 1 = \dfrac{1}{T}$

- $a_0 = \dfrac{1}{T}$

- $x(t) = \sum_{k=-\infty}^{\infty} \dfrac{1}{T} e^{jk\frac{2\pi}{T}t}$

Örnek 9

- $x(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT)$ ise Fourier seri açılımı?

- $\omega_0 = \dfrac{2\pi}{T}$

- $a_k = \dfrac{1}{T} \underbrace{\int_{-T/2}^{T/2} \delta(t) e^{-jk\omega_0 t} dt}_{e^{-jk\omega_0 0}}$

- $a_k = \dfrac{1}{T} 1 = \dfrac{1}{T}$

- $a_0 = \dfrac{1}{T}$

- $x(t) = \sum_{k=-\infty}^{\infty} \dfrac{1}{T} e^{jk\frac{2\pi}{T}t}$