BSM307
İşaretler ve Sistemler

Dr. Seçkin Arı

Fourier Seri Açılım Özellikleri

İçerik

- Doğrusallık
- Zamanda Öteleme
- Zamanda
  - Ters Çevirme
  - Ölçekleme
  - Çarpma
  - Türev
  - İntegral

Doğrusallık

- $\mathcal{FS}\{x(t)\} \ \rightarrow \ a_k$ ve $\mathcal{FS}\{y(t)\} \ \rightarrow \ b_k$ biliniyorsa
  - Aynı T periyodu

Doğrusallık

- $\mathcal{FS}\{x(t)\} \ \rightarrow \ a_k$ ve $\mathcal{FS}\{y(t)\} \ \rightarrow \ b_k$ biliniyorsa
  - ♦ Aynı T periyodu
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $y(t) = \sum_{k=-\infty}^{\infty} b_k e^{jk\frac{2\pi}{T}t}$
- $z(t) = Ax(t) + By(t)$ ise
- $\mathcal{FS}\{z(t)\} \ \rightarrow$

Doğrusallık

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- $z(t) = Ax(t) + By(t)$ ise
- $\mathcal{FS}\{z(t)\} \rightarrow Aa_k + Bb_k$ olur.

Doğrusallık

- $\mathcal{FS}\{x(t)\} \ \rightarrow \ a_k$ ve $\mathcal{FS}\{y(t)\} \ \rightarrow \ b_k$ biliniyorsa
  - ♦ Aynı T periyodu
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
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- $z(t) = Ax(t) + By(t)$ ise
- $\mathcal{FS}\{z(t)\} \ \rightarrow c_k = Aa_k + Bb_k$ olur.
- $z(t) = \sum_{k=-\infty}^{\infty} c_k e^{jk\frac{2\pi}{T}t}$

Örnek 1

- $\mathcal{FS}\{x(t)\} \rightarrow c_k = ?$
  - ♦ $x(t) = 2\cos(2t) - \sin(2t)$

Örnek 1

- $\mathcal{FS}\{x(t)\} \rightarrow c_k = ?$
  - ♦ $x(t) = 2\underbrace{\cos(2t)}_{a_k=?} - \underbrace{\sin(2t)}_{b_k=?}$
  - ♦ $\omega_0 =$

Örnek 1

- $\mathcal{FS}\{x(t)\} \rightarrow c_k =?$
  - $x(t) = 2\underbrace{\cos(2t)}_{a_{\pm 1}=\frac{1}{2}} - \underbrace{\sin(2t)}_{\substack{b_1=\frac{1}{2j} \\ b_{-1}=-\frac{1}{2j}}}$
  - $\omega_0 = 2$ rad/sn

Örnek 1

- $\mathcal{FS}\{x(t)\} \rightarrow c_k = ?$
  - $x(t) = 2\underbrace{\cos(2t)}_{a_{\pm 1}=\frac{1}{2}} - \underbrace{\sin(2t)}_{\substack{b_1=\frac{1}{2j} \\ b_{-1}=-\frac{1}{2j}}}$
  - $\omega_0 = 2$ rad/sn
- $c_k =$

Örnek 1

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  - $x(t) = 2\underbrace{\cos(2t)}_{a_{\pm 1}=\frac{1}{2}} - \underbrace{\sin(2t)}_{\substack{b_1=\frac{1}{2j} \\ b_{-1}=-\frac{1}{2j}}}$
  - $\omega_0 = 2$ rad/sn
- $c_k = 2a_k - b_k$
  - $c_1 =$

Örnek 1

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  - $x(t) = 2\underbrace{\cos(2t)}_{a_{\pm 1}=\frac{1}{2}} - \underbrace{\sin(2t)}_{\substack{b_1=\frac{1}{2j} \\ b_{-1}=-\frac{1}{2j}}}$
  - $\omega_0 = 2$ rad/sn
- $c_k = 2a_k - b_k$
  - $c_1 = 2a_1 - b_1 = 1 - \frac{1}{2j}$
  - $c_{-1} =$

Örnek 1

- $\mathcal{FS}\{x(t)\} \rightarrow c_k = ?$
  - $x(t) = 2\underbrace{\cos(2t)}_{a_{\pm 1}=\frac{1}{2}} - \underbrace{\sin(2t)}_{b_1=\frac{1}{2j}}$

    $b_{-1} = -\frac{1}{2j}$
  - $\omega_0 = 2$ rad/sn
- $c_k = 2a_k - b_k$
  - $c_1 = 2a_1 - b_1 = 1 - \frac{1}{2j}$
  - $c_{-1} = 2a_{-1} - b_{-1} = 1 + \frac{1}{2j}$
  - $k \neq \pm 1$ iken $c_k = 0$

Zamanda Öteleme

- $\mathcal{FS}\{x(t)\} \rightarrow a_k$ biliniyorsa
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $\mathcal{FS}\{x(t-t_0)\} \rightarrow b_k = e^{-jk\frac{2\pi}{T}t_0} a_k$ olur.
- $x(t-t_0) = \sum_{k=-\infty}^{\infty} b_k e^{jk\frac{2\pi}{T}t}$

Örnek 2

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$
- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$ ise $b_k = ?$

Örnek 2

- $x(t) = \cos(2t)$
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- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$ ise $b_k = ?$
- $x_1(t) = x(\quad)$

Örnek 2

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$

- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$ ise $b_k =?$
- $x_1(t) = x\left(t - \frac{\pi}{8}\right)$
  - $b_k =$

Örnek 2

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  - $a_{\pm 1} = \frac{1}{2}$
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- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$ ise $b_k = ?$
- $x_1(t) = x\left(t - \frac{\pi}{8}\right)$
  - $b_k = e^{-jk2\frac{\pi}{8}} a_k$
  - $b_1 =$

Örnek 2

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$

- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$ ise $b_k = ?$
- $x_1(t) = x\left(t - \frac{\pi}{8}\right)$
  - $b_k = e^{-jk2\frac{\pi}{8}} a_k$
  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
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Örnek 2

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
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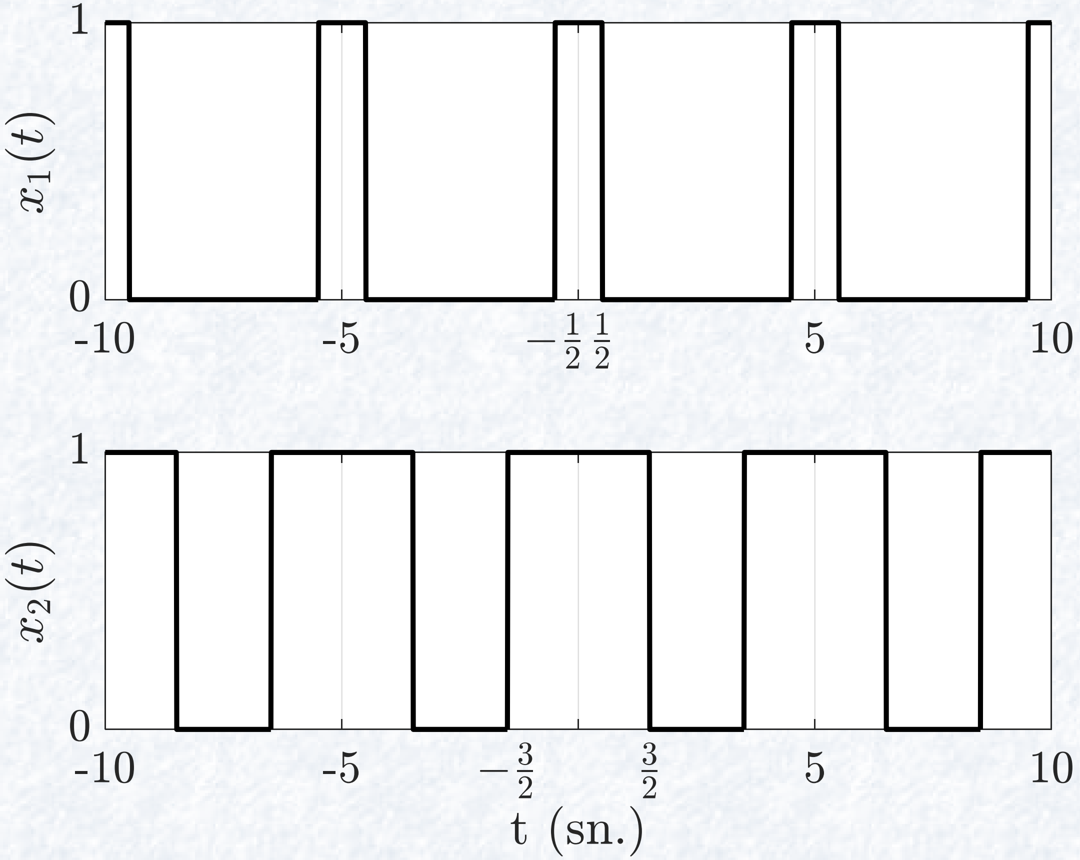
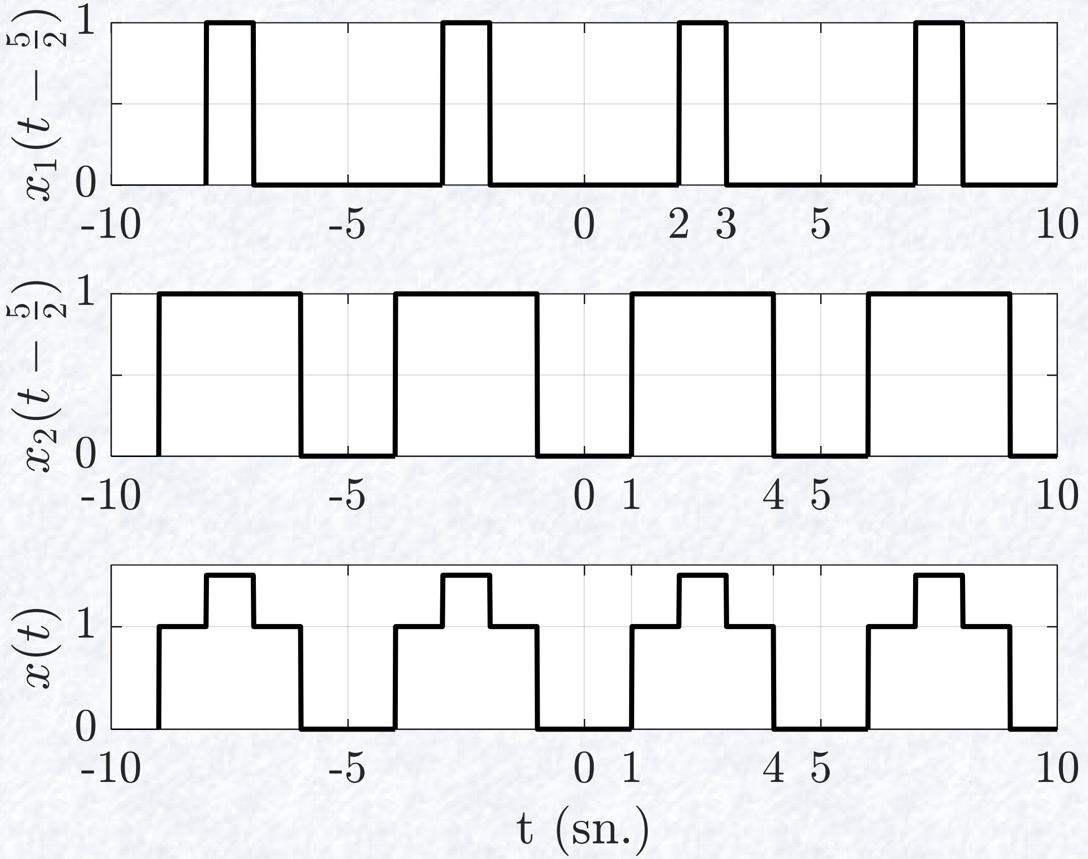
- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$ ise $b_k =$?
- $x_1(t) = x\left(t - \frac{\pi}{8}\right)$
  - $b_k = e^{-jk2\frac{\pi}{8}} a_k$
  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $b_{-1} = e^{j\frac{\pi}{4}} a_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $b_k = 0$

Örnek 3

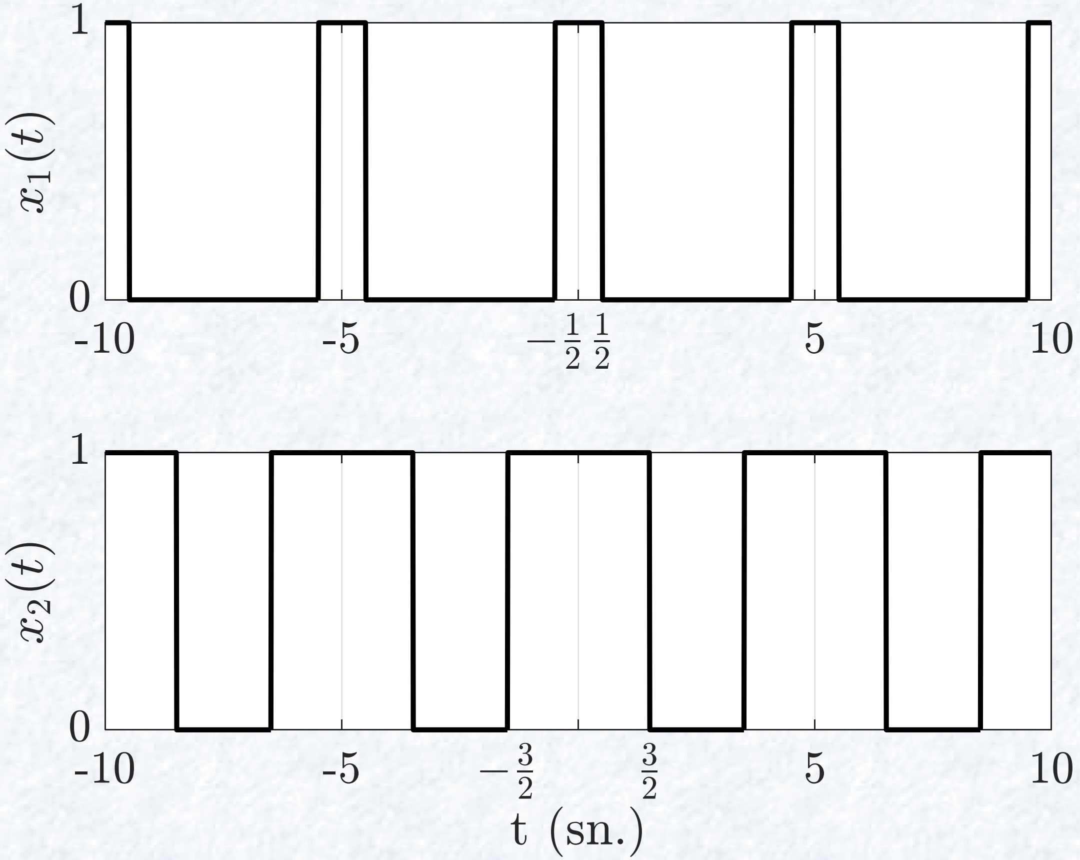
- $\mathcal{FS}\{x(t)\} \rightarrow e_k = ?$

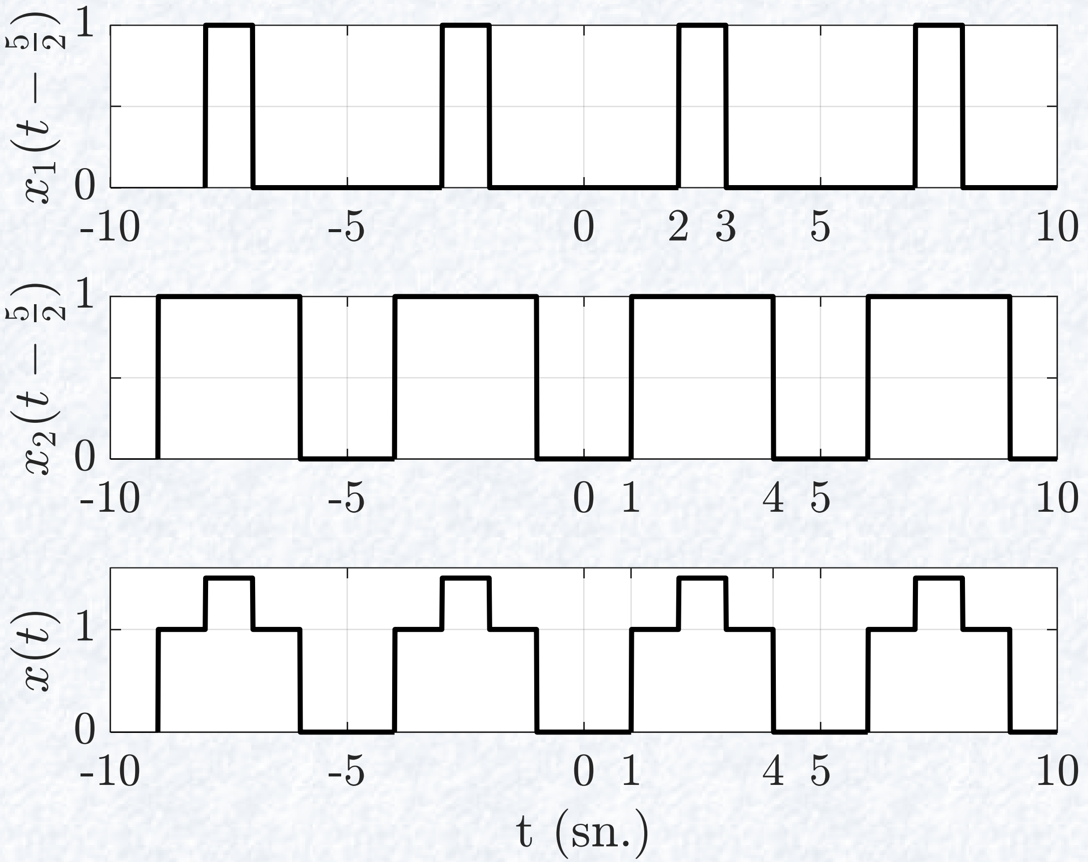




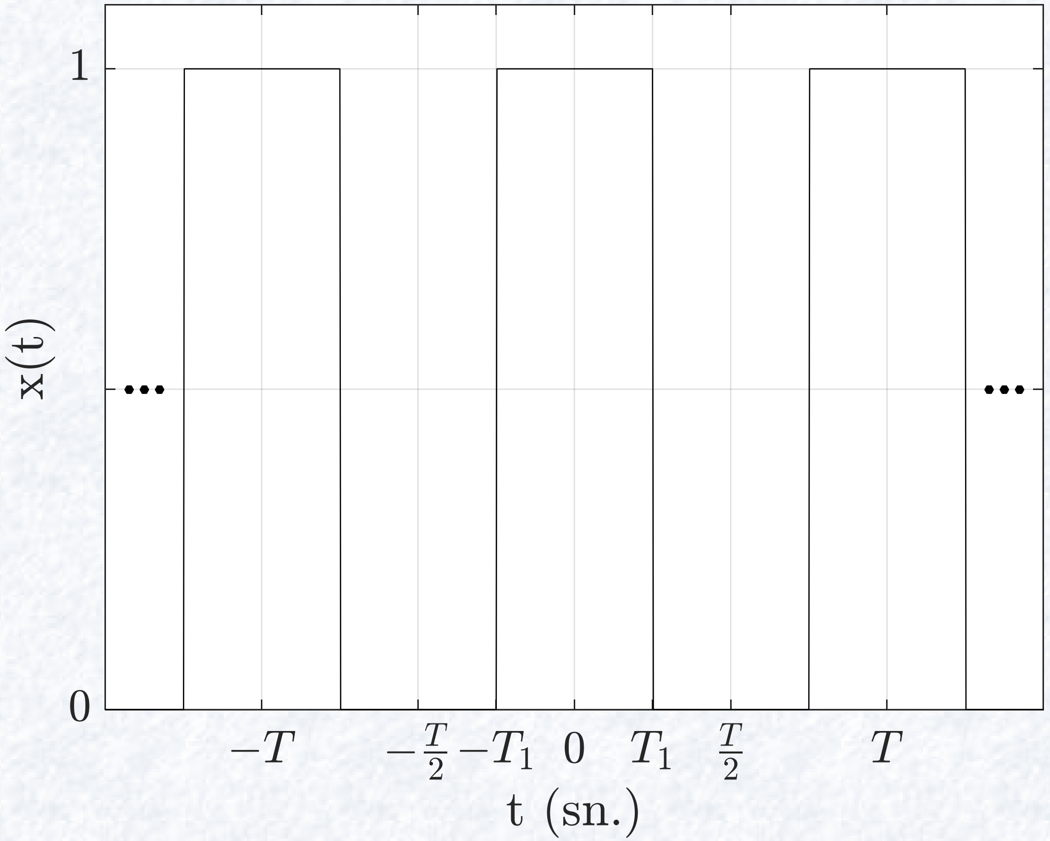
Örnek 3

- $\mathcal{FS}\{x(t)\} \rightarrow e_k = ? \quad x(t) = \frac{1}{2}x_1\left(t-\frac{5}{2}\right) + x_2\left(t-\frac{5}{2}\right)$





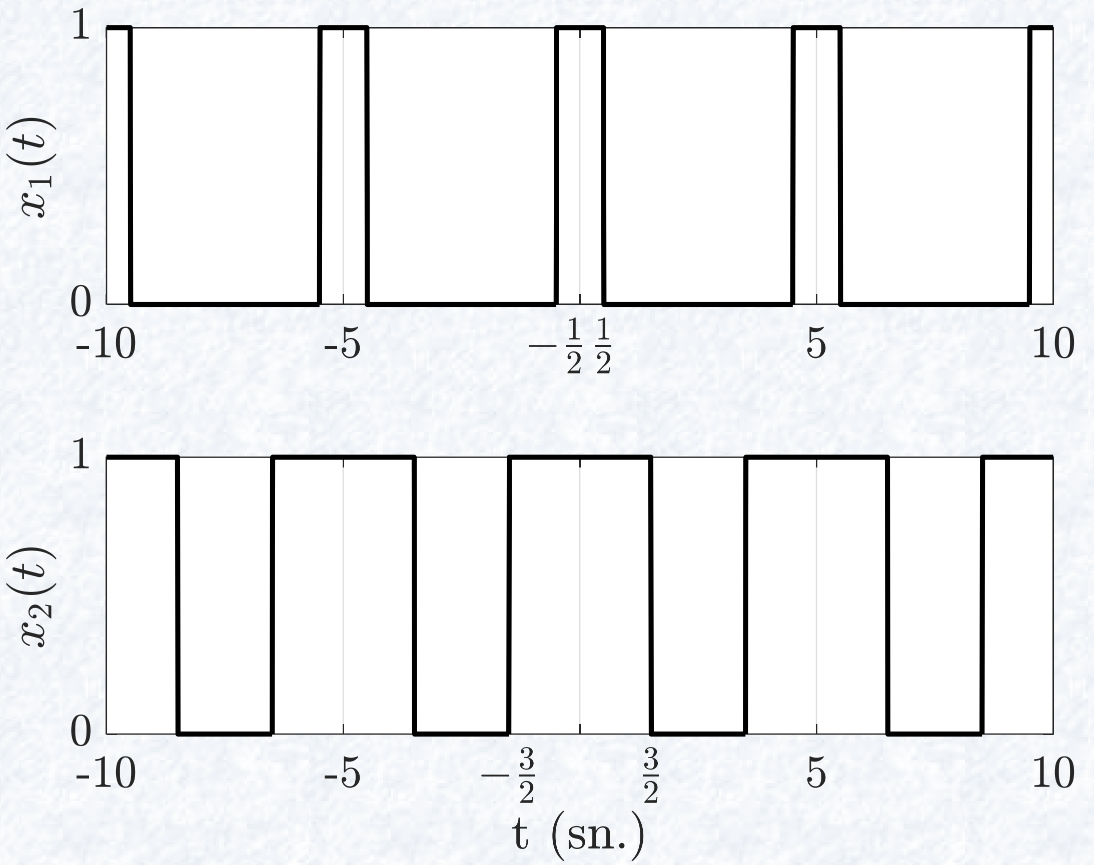
Örnek 3



- $\omega_0 = \frac{2\pi}{T}$ rad/sn
- $a_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$
- $a_0 = \frac{1}{T}\int_{-T_1}^{T_1} dt = \frac{1}{T} t\Big|_{-T_1}^{T_1} = \frac{2T_1}{T}$

Örnek 3

- $\mathcal{FS}\{x_1(t)\} \rightarrow a_k = ?$
- $\mathcal{FS}\{x_2(t)\} \rightarrow b_k = ?$



Örnek 3

- $\mathcal{FS}\{x_1(t)\} \rightarrow a_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$

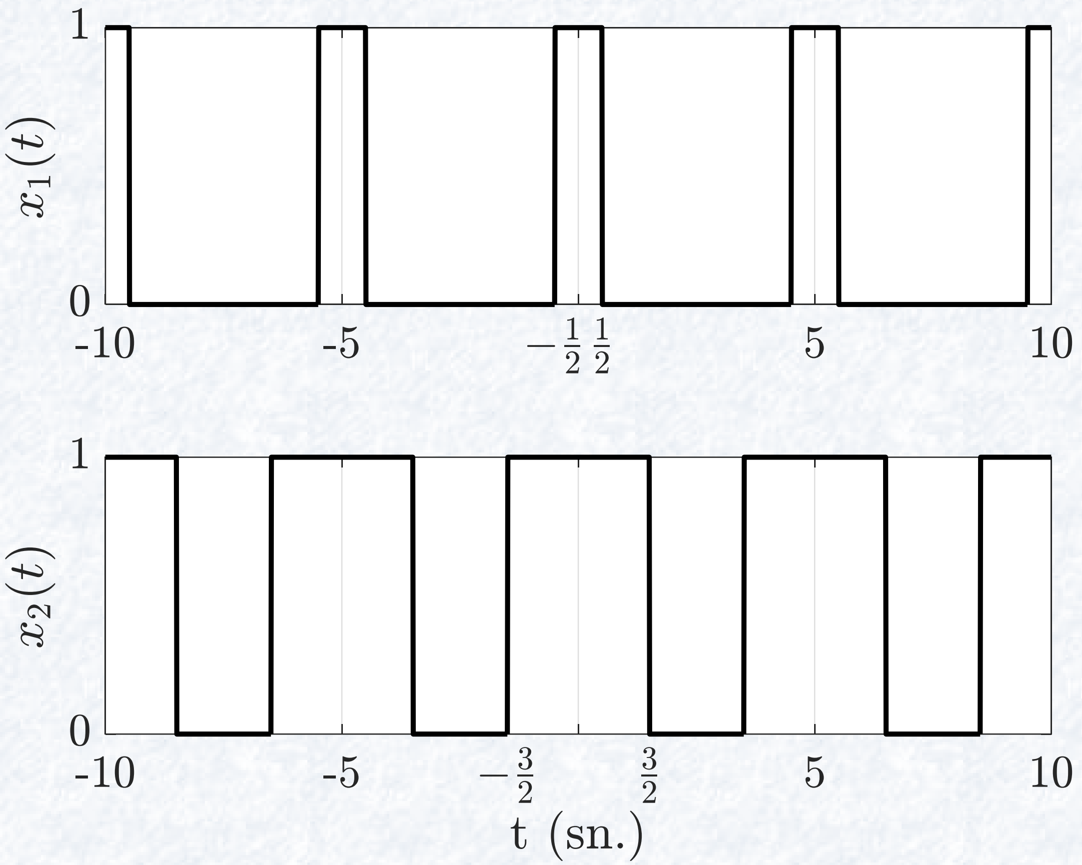
  $a_0 = \dfrac{2T_1}{T}$

  - $T = \boxed{}, T_1 = \boxed{}$

- $\mathcal{FS}\{x_2(t)\} \rightarrow b_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$

  $b_0 = \dfrac{2T_1}{T}$

  - $T = \boxed{}, T_1 = \boxed{}$



Örnek 3

- $\mathcal{FS}\{x_1(t)\} \rightarrow \; a_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$

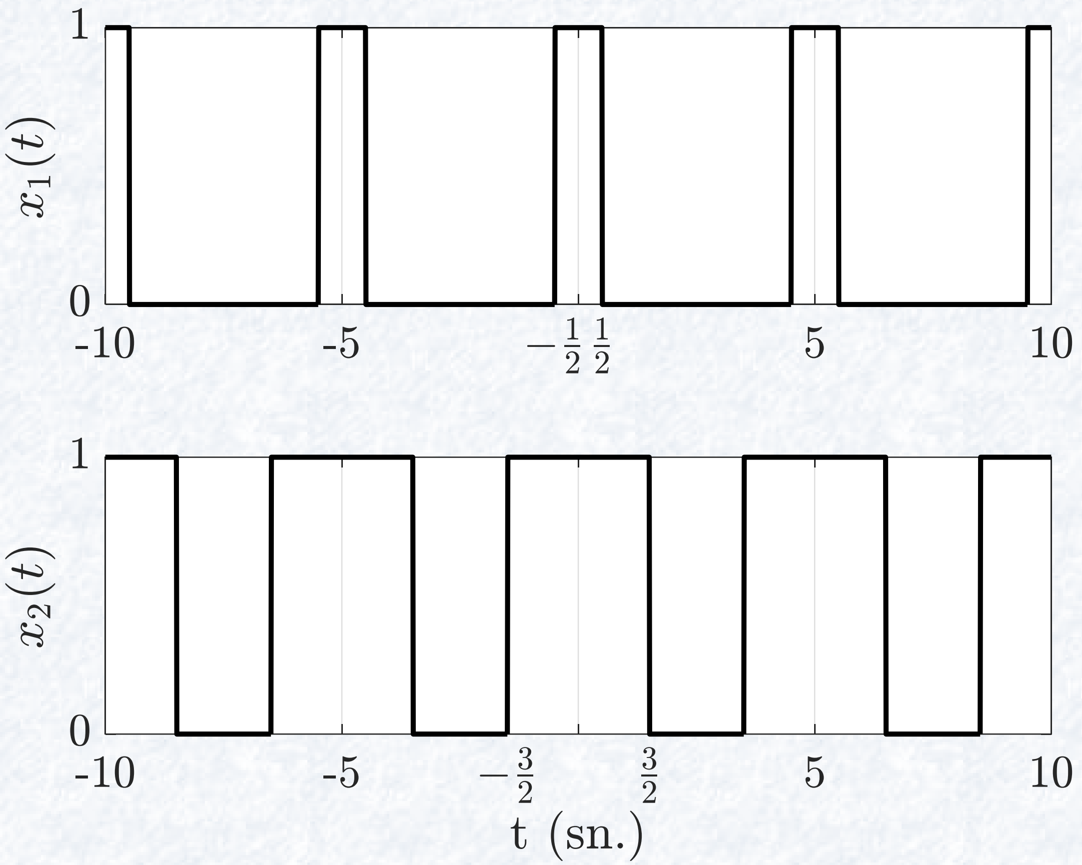
$$a_0 = \frac{2T_1}{T}$$

  - ♦ $T = 5, T_1 = \frac{1}{2}$

- $\mathcal{FS}\{x_2(t)\} \rightarrow \; b_k = \dfrac{\sin\left(k\frac{2\pi T_1}{T}\right)}{\pi k}$

$$b_0 = \frac{2T_1}{T}$$

  - ♦ $T = 5, T_1 = \frac{3}{2}$



Örnek 3

- $\mathcal{FS}\{x_1(t)\} \rightarrow \; a_k = \dfrac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}$

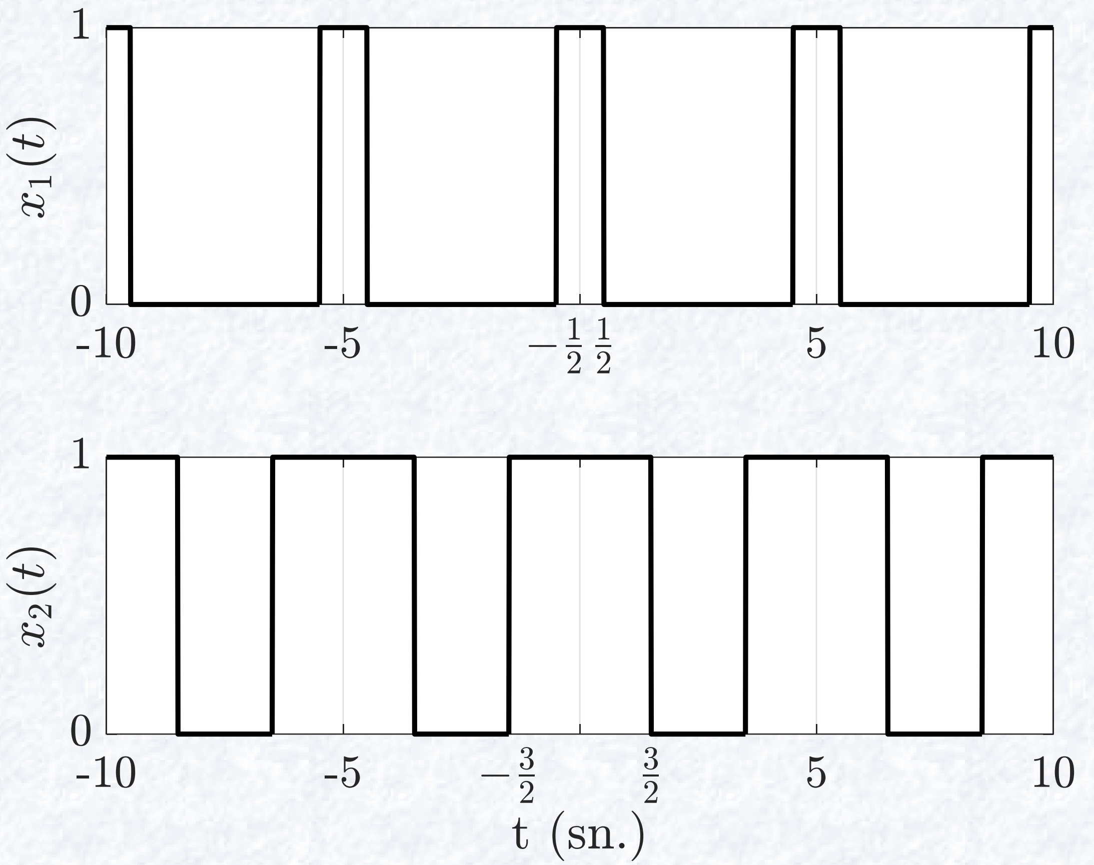
$$a_0 = \frac{1}{5}$$

  - ♦ $T = 5, T_1 = \frac{1}{2}$

- $\mathcal{FS}\{x_2(t)\} \rightarrow \; b_k = \dfrac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}$

$$b_0 = \frac{3}{5}$$

  - ♦ $T = 5, T_1 = \frac{3}{2}$



Örnek 3

- $\mathcal{FS}\{x_1(t)\} \rightarrow a_k = \frac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}$

$$a_0 = \frac{1}{5}$$

- $\mathcal{FS}\left\{x_1\left(t-\frac{5}{2}\right)\right\} \rightarrow c_k = e^{-jk\pi}a_k$

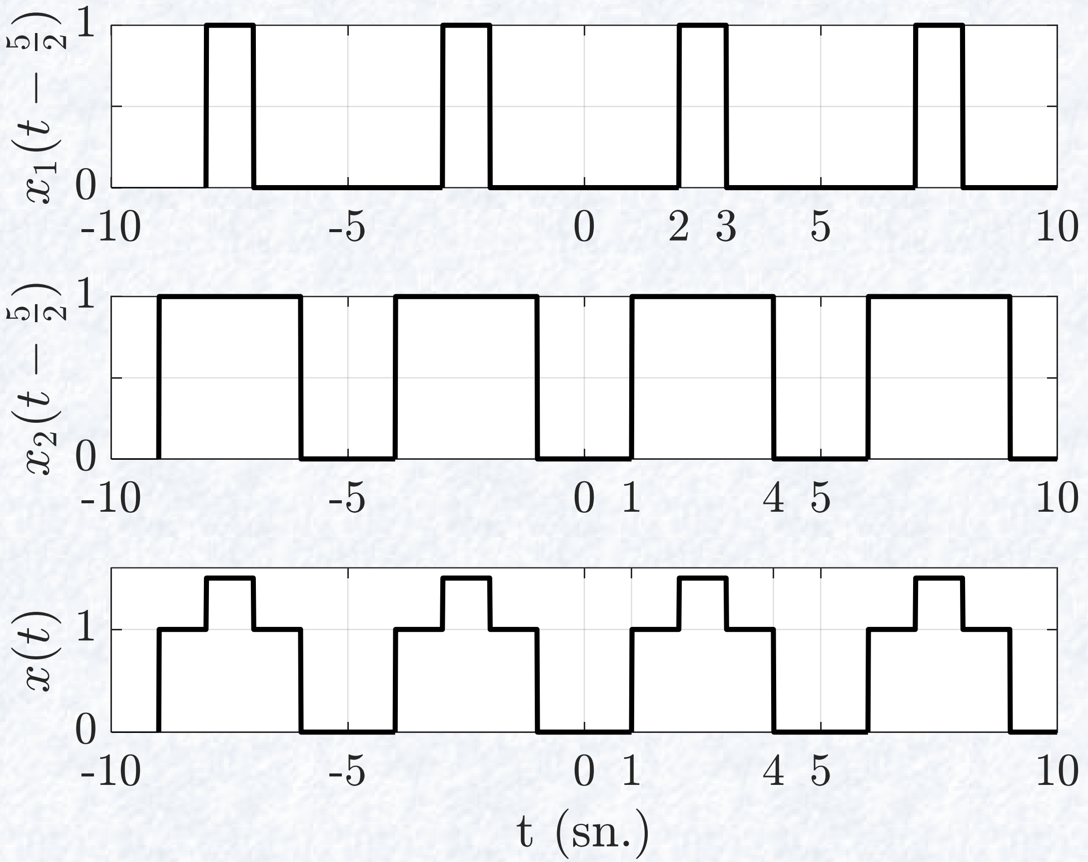
$$c_0 = a_0$$

- $\mathcal{FS}\{x_2(t)\} \rightarrow b_k = \frac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}$

$$b_0 = \frac{3}{5}$$

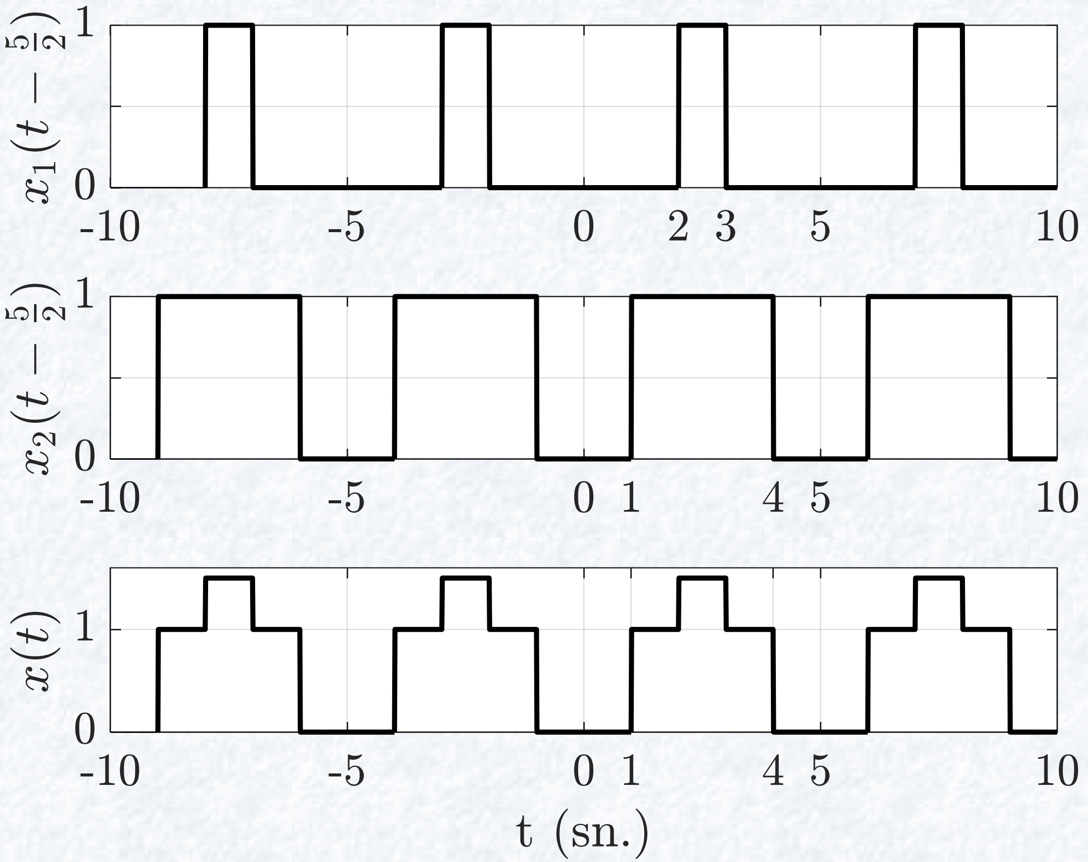
- $\mathcal{FS}\left\{x_2\left(t-\frac{5}{2}\right)\right\} \rightarrow d_k = e^{-jk\pi}b_k$

$$d_0 = b_0$$



Örnek 3

- $\mathcal{FS}\{x_1(t)\} \rightarrow a_k = \dfrac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}$
$$a_0 = \frac{1}{5}$$
- $\mathcal{FS}\left\{x_1\left(t-\frac{5}{2}\right)\right\} \rightarrow c_k = (-1)^k a_k$
$$c_0 = a_0$$
- $\mathcal{FS}\{x_2(t)\} \rightarrow b_k = \dfrac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}$
$$b_0 = \frac{3}{5}$$
- $\mathcal{FS}\left\{x_2\left(t-\frac{5}{2}\right)\right\} \rightarrow d_k = (-1)^k b_k$
$$d_0 = b_0$$



Örnek 3

- $\mathcal{FS}\left\{x_1\left(t-\frac{5}{2}\right)\right\}$
  - $c_k=(-1)^k\frac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}$
  - $c_0=\frac{1}{5}$
- $\mathcal{FS}\left\{x_2\left(t-\frac{5}{2}\right)\right\}$
  - $d_k=(-1)^k\frac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}$
  - $d_0=\frac{3}{5}$

- $x(t)=\frac{1}{2}x_1\left(t-\frac{5}{2}\right)+x_2\left(t-\frac{5}{2}\right)$
- $e_k=$
- $e_0=$

Örnek 3

- $\mathcal{FS}\left\{x_1\left(t-\frac{5}{2}\right)\right\}$
  - $c_k=(-1)^k\frac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}$
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- $\mathcal{FS}\left\{x_2\left(t-\frac{5}{2}\right)\right\}$
  - $d_k=(-1)^k\frac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}$
  - $d_0=\frac{3}{5}$
- $x(t)=\frac{1}{2}x_1\left(t-\frac{5}{2}\right)+x_2\left(t-\frac{5}{2}\right)$
- $e_k=\frac{1}{2}c_k+d_k$
- $e_0=\frac{1}{2}c_0+d_0$

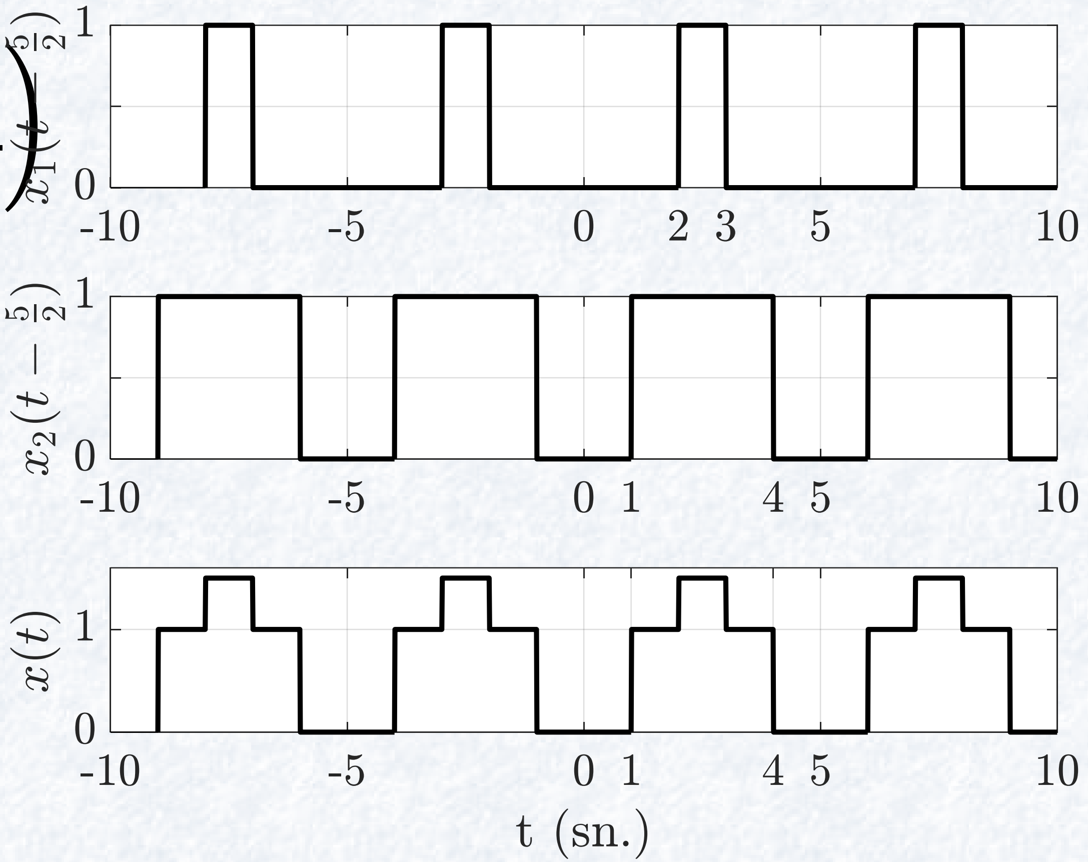
Örnek 3

- $\mathcal{FS}\left\{x_1\left(t-\frac{5}{2}\right)\right\}$
  - $c_k=(-1)^k\frac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}$
  - $c_0=\frac{1}{5}$
- $\mathcal{FS}\left\{x_2\left(t-\frac{5}{2}\right)\right\}$
  - $d_k=(-1)^k\frac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}$
  - $d_0=\frac{3}{5}$

- $x(t)=\frac{1}{2}x_1\left(t-\frac{5}{2}\right)+x_2\left(t-\frac{5}{2}\right)$
- $e_k=\frac{1}{2}c_k+d_k$
- $e_k=(-1)^k\left(\frac{1}{2}\frac{\sin\left(k\frac{\pi}{5}\right)}{\pi k}+\frac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}\right)$
- $e_0=\frac{1}{2}c_0+d_0$
- $e_0=\frac{1}{2}\frac{1}{5}+\frac{3}{5}=\frac{7}{10}$

Örnek 3

- $x(t) = \frac{1}{2}x_1\left(t-\frac{5}{2}\right) + x_2\left(t-\frac{5}{2}\right)$
- $e_k = (-1)^k\left(\frac{1}{2}\frac{\sin\left(k\frac{\pi}{5}\right)}{\pi k} + \frac{\sin\left(k\frac{3\pi}{5}\right)}{\pi k}\right)$
- $e_0 = \frac{7}{10}$
- $x(t) = \sum_{k=-\infty}^{\infty} e_k e^{jk\frac{2\pi}{5}t}$



Zamanda Ters Çevirme

- $\mathcal{FS}\{x(t)\} \rightarrow a_k$ biliniyorsa
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $\mathcal{FS}\{x(-t)\} \rightarrow b_k = a_{-k}$ olur.
- $x(-t) = \sum_{k=-\infty}^{\infty} b_k e^{jk\frac{2\pi}{T}t}$

Örnek 4

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$
- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$
  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $b_{-1} = e^{j\frac{\pi}{4}} a_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $b_k = 0$
- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$ ise $c_k = ?$

Örnek 4

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$
- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$
  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $b_{-1} = e^{j\frac{\pi}{4}} a_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $b_k = 0$

- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$ ise $c_k = ?$
- $x_2(t) = x_1(-t)$
  - $c_k =$

Örnek 4

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
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  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $b_{-1} = e^{j\frac{\pi}{4}} a_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $b_k = 0$

- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$ ise $c_k =?$
- $x_2(t) = x_1(-t)$
  - $c_k = b_{-k}$
  - $c_1 =$

Örnek 4

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$
- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$
  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $b_{-1} = e^{j\frac{\pi}{4}} a_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $b_k = 0$
- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$ ise $c_k =?$
- $x_2(t) = x_1(-t)$
  - $c_k = b_{-k}$
  - $c_1 = b_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $c_{-1} =$

Örnek 4

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
  - $k \neq \pm 1$ iken $a_k = 0$
- $x_1(t) = \cos\left(2t - \frac{\pi}{4}\right)$
  - $b_1 = e^{-j\frac{\pi}{4}} a_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $b_{-1} = e^{j\frac{\pi}{4}} a_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $b_k = 0$
- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$ ise $c_k =?$
- $x_2(t) = x_1(-t)$
  - $c_k = b_{-k}$
  - $c_1 = b_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $c_{-1} = b_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $c_k = 0$

Zamanda Ölçekleme

- $\mathcal{FS}\{x(t)\} \ \rightarrow \ a_k$ biliniyorsa
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $\mathcal{FS}\{x(\beta t)\} \ \rightarrow b_k = a_k$ olur.
  - $T_{yeni} = \frac{T}{\beta}$
  - $\omega_{0_{yeni}} = \beta\omega_0$
- $x(\beta t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\beta\frac{2\pi}{T}t}$

Örnek 5

- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$
  - ♦ $c_1 = b_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - ♦ $c_{-1} = b_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - ♦ $k \neq \pm 1$ iken $c_k = 0$
- $x_3(t) = \cos\left(-t - \frac{\pi}{4}\right)$ ise

  $d_k = ?$

Örnek 5

- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$
  - ♦ $c_1 = b_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - ♦ $c_{-1} = b_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - ♦ $k \neq \pm 1$ iken $c_k = 0$
- $x_3(t) = \cos\left(-t - \frac{\pi}{4}\right)$ ise $d_k = ?$
- $x_3(t) = x_2(\quad)$

Örnek 5

- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$
  - ♦ $c_1 = b_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - ♦ $c_{-1} = b_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - ♦ $k \neq \pm 1$ iken $c_k = 0$

- $x_3(t) = \cos\left(-t - \frac{\pi}{4}\right)$ ise $d_k = ?$
- $x_3(t) = x_2\left(\frac{t}{2}\right)$
  - ♦ $d_k = c_k$
  - ♦ $T_3 =$

Örnek 5

- $x_2(t) = \cos\left(-2t - \frac{\pi}{4}\right)$
  - $c_1 = b_{-1} = \frac{e^{j\frac{\pi}{4}}}{2}$
  - $c_{-1} = b_1 = \frac{e^{-j\frac{\pi}{4}}}{2}$
  - $k \neq \pm 1$ iken $c_k = 0$

- $x_3(t) = \cos\left(-t - \frac{\pi}{4}\right)$ ise $d_k = ?$
- $x_3(t) = x_2\left(\frac{t}{2}\right)$
  - $d_k = c_k$
  - $T_3 = 2T = 2\pi$ sn
  - $\omega_{0_3} = 1$ rad/sn

Zamanda Çarpma

- $\mathcal{FS}\{x(t)\} \rightarrow a_k$ ve $\mathcal{FS}\{y(t)\} \rightarrow b_k$ biliniyorsa
  - Aynı T periyodu
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $y(t) = \sum_{k=-\infty}^{\infty} b_k e^{jk\frac{2\pi}{T}t}$
- $z(t) = x(t)y(t)$ ise
- $\mathcal{FS}\{z(t)\} \rightarrow c_k = \sum_{l=-\infty}^{\infty} a_l b_{k-l}$ olur.
- $z(t) = \sum_{k=-\infty}^{\infty} c_k e^{jk\frac{2\pi}{T}t}$

Örnek 6

- $x(t) = \cos(2t)$
  - ♦ $a_{\pm 1} = \frac{1}{2}$
- $y(t) = \sin(2t)$
  - ♦ $b_{\pm 1} = \pm \frac{1}{2j}$
- $\mathcal{FS}\{z(t) = x(t)y(t)\} \rightarrow c_k = ?$

Örnek 6

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $y(t) = \sin(2t)$
  - $b_{\pm 1} = \pm \frac{1}{2j}$
- $\mathcal{FS}\{z(t) = x(t)y(t)\} \rightarrow c_k = \sum_{l=-\infty}^{\infty} a_l b_{k-l}$

Örnek 6

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $y(t) = \sin(2t)$
  - $b_{\pm 1} = \pm \frac{1}{2j}$
- $\mathcal{FS}\{z(t) = x(t)y(t)\} \rightarrow c_k = \sum_{l=-\infty}^{\infty} a_l b_{k-l}$
  - $c_{-2} =$

Örnek 6

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $y(t) = \sin(2t)$
  - $b_{\pm 1} = \pm \frac{1}{2j}$
- $\mathcal{FS}\{z(t) = x(t)y(t)\} \rightarrow c_k = \sum_{l=-\infty}^{\infty} a_l b_{k-l}$
  - $c_{-2} = a_{-1}b_{-1} + a_1 b_{-3} = -\frac{1}{4j}$
  - $c_0 =$

Örnek 6

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $y(t) = \sin(2t)$
  - $b_{\pm 1} = \pm\frac{1}{2j}$
- $\mathcal{FS}\{z(t) = x(t)y(t)\} \rightarrow c_k = \sum_{l=-\infty}^{\infty} a_l b_{k-l}$
  - $c_{-2} = a_{-1}b_{-1} + a_1 b_{-3} = -\frac{1}{4j}$
  - $c_0 = a_{-1}b_1 + a_1 b_{-1} = 0$
  - $c_2 =$

Örnek 6

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $y(t) = \sin(2t)$
  - $b_{\pm 1} = \pm\frac{1}{2j}$
- $\mathcal{FS}\{z(t) = x(t)y(t)\} \rightarrow c_k = \sum_{l=-\infty}^{\infty} a_l b_{k-l}$
  - $c_{-2} = a_{-1}b_{-1} + a_1 b_{-3} = -\frac{1}{4j}$
  - $c_0 = a_{-1}b_1 + a_1 b_{-1} = 0$
  - $c_2 = a_{-1}b_3 + a_1 b_1 = \frac{1}{4j}$

Zamanda Türev

- $\mathcal{FS}\{x(t)\} \rightarrow a_k$ biliniyorsa
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t}\right\} \rightarrow b_k = jk\omega_0 a_k$ olur.
- $\frac{\partial x(t)}{\partial t} = \sum_{k=-\infty}^{\infty} b_k e^{jk\frac{2\pi}{T}t}$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t} = -2\sin(2t)\right\} \rightarrow$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t} = -2\sin(2t)\right\} \rightarrow jk2a_k$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t} = -2\sin(2t)\right\} \rightarrow jk2a_k$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{-2\partial t} = \sin(2t)\right\} \rightarrow f_k =$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t} = -2\sin(2t)\right\} \rightarrow jk2a_k$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{-2\partial t} = \sin(2t)\right\} \rightarrow f_k = \frac{jk2a_k}{-2}$
  - $f_1 =$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t} = -2\sin(2t)\right\} \rightarrow jk2a_k$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{-2\partial t} = \sin(2t)\right\} \rightarrow f_k = \frac{jk2a_k}{-2}$
  - $f_1 = -ja_1 = -\frac{j}{2}$
  - $f_{-1} =$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_4(t) = \sin(2t)\} \rightarrow f_k =$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{\partial t} = -2\sin(2t)\right\} \rightarrow jk2a_k$
- $\mathcal{FS}\left\{\frac{\partial x(t)}{-2\partial t} = \sin(2t)\right\} \rightarrow f_k = \frac{jk2a_k}{-2}$
  - $f_1 = -ja_1 = -\frac{j}{2}$
  - $f_{-1} = ja_{-1} = \frac{j}{2}$

Zamanda İntegral

- $\mathcal{FS}\{x(t)\} \;\rightarrow\; a_k$ biliniyorsa
- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\frac{2\pi}{T}t}$
- $\mathcal{FS}\{\int x(t)\} \rightarrow b_k = \frac{a_k}{jk\omega_0}$ olur.
- $\int x(t) = \sum_{k=-\infty}^{\infty} b_k e^{jk\frac{2\pi}{T}t}$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_5(t) = \sin(2t)\} \rightarrow g_k =$
- $\mathcal{FS}\left\{\int x(t) = \frac{\sin(2t)}{2}\right\} \rightarrow$

Örnek 7

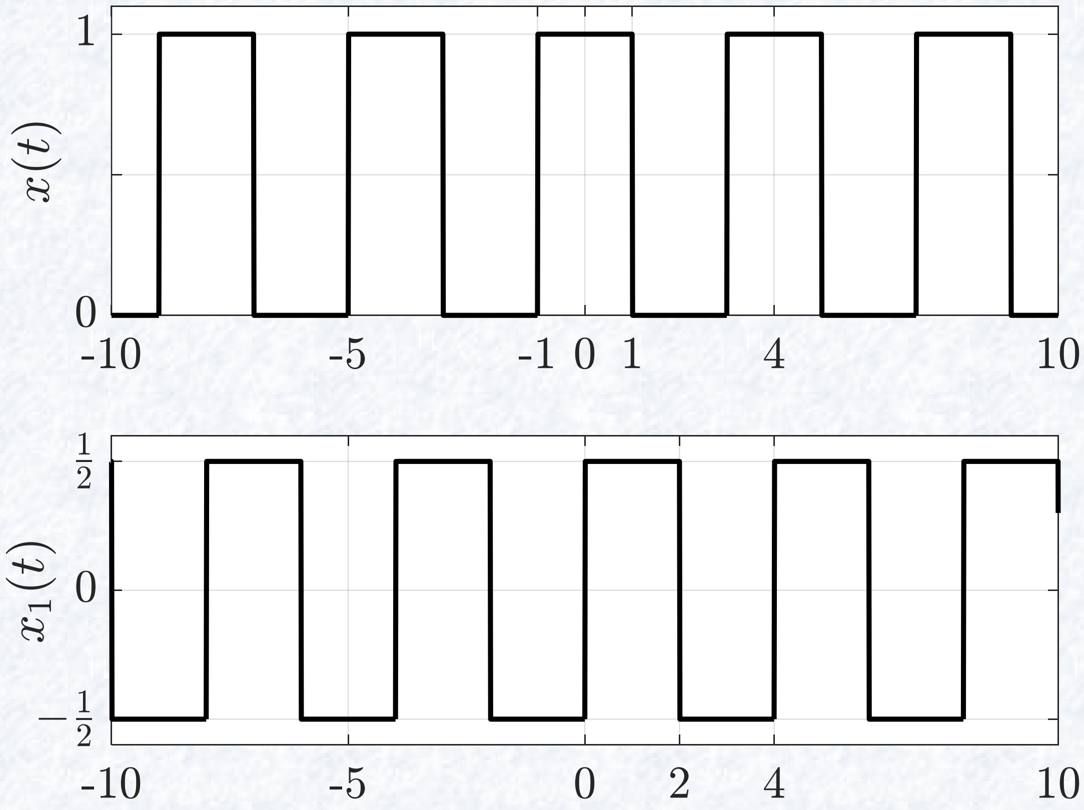
- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_5(t) = \sin(2t)\} \rightarrow g_k =$
- $\mathcal{FS}\left\{\int x(t) = \frac{\sin(2t)}{2}\right\} \rightarrow \frac{a_k}{jk2}$
- $\mathcal{FS}\{2\int x(t) = \sin(2t)\} \rightarrow g_k =$

Örnek 7

- $x(t) = \cos(2t)$
  - $a_{\pm 1} = \frac{1}{2}$
- $\mathcal{FS}\{x_5(t) = \sin(2t)\} \rightarrow g_k =$
- $\mathcal{FS}\left\{\int x(t) = \frac{\sin(2t)}{2}\right\} \rightarrow \frac{a_k}{jk2}$
- $\mathcal{FS}\left\{2\int x(t) = \sin(2t)\right\} \rightarrow g_k = \frac{a_k}{jk}$
  - $g_1 = \frac{a_1}{j} = \frac{1}{2j}$
  - $g_{-1} = \frac{a_{-1}}{-j} = -\frac{1}{2j}$

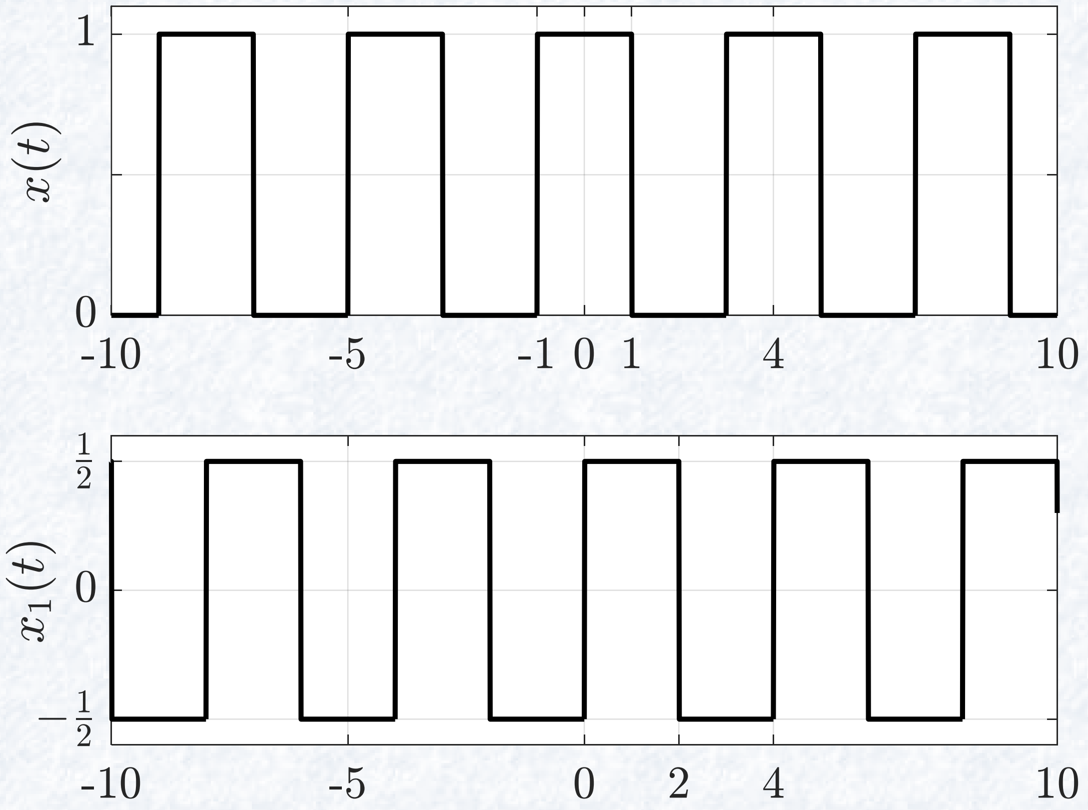
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \rightarrow \ c_k = ?$



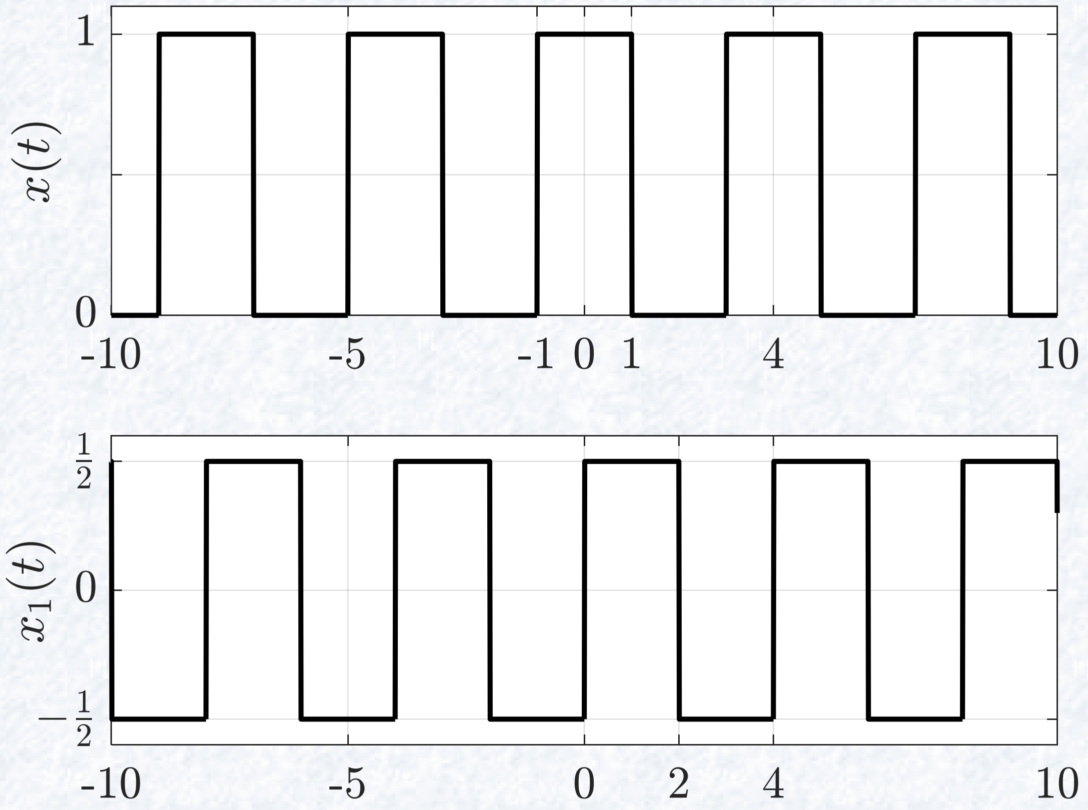
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \;\rightarrow\; c_k = ?$
- $\mathcal{FS}\{x(t)\}$
  - $a_k = \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $a_0 = \dfrac{1}{2}$
- $x_1(t) = x(\quad)$



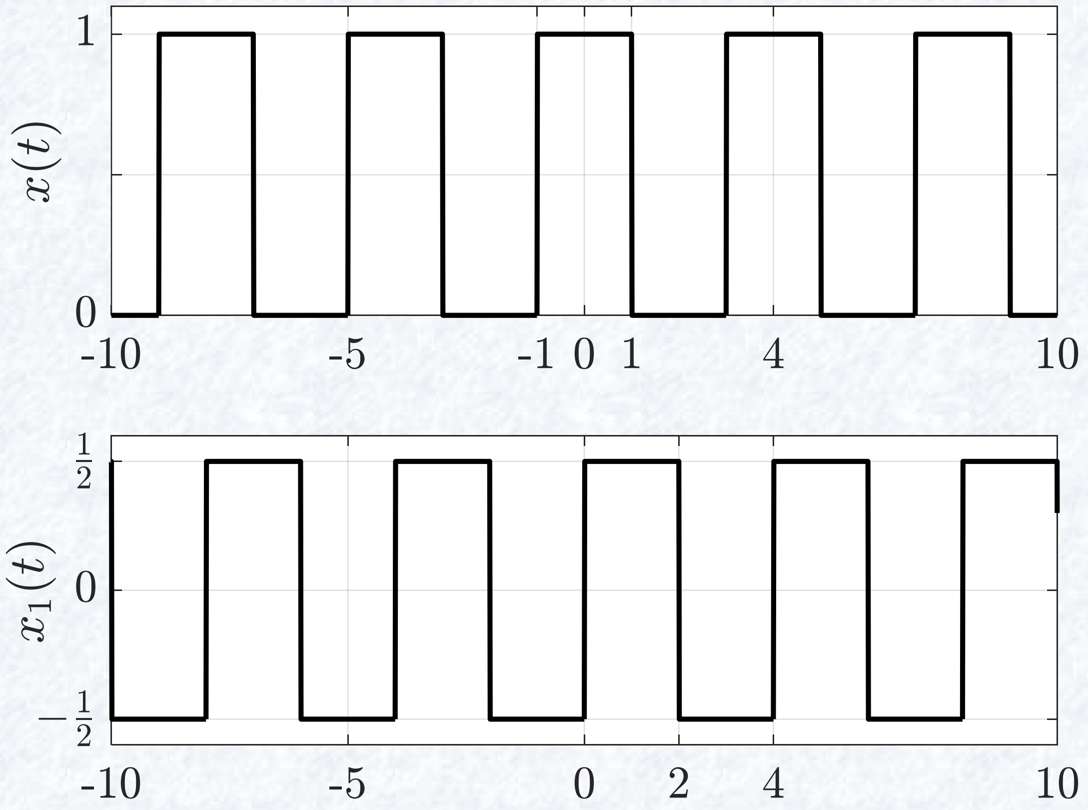
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \rightarrow c_k = ?$
- $\mathcal{FS}\{x(t)\}$
  - $a_k = \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $a_0 = \dfrac{1}{2}$
- $x_1(t) = x(t-1) - \dfrac{1}{2}$



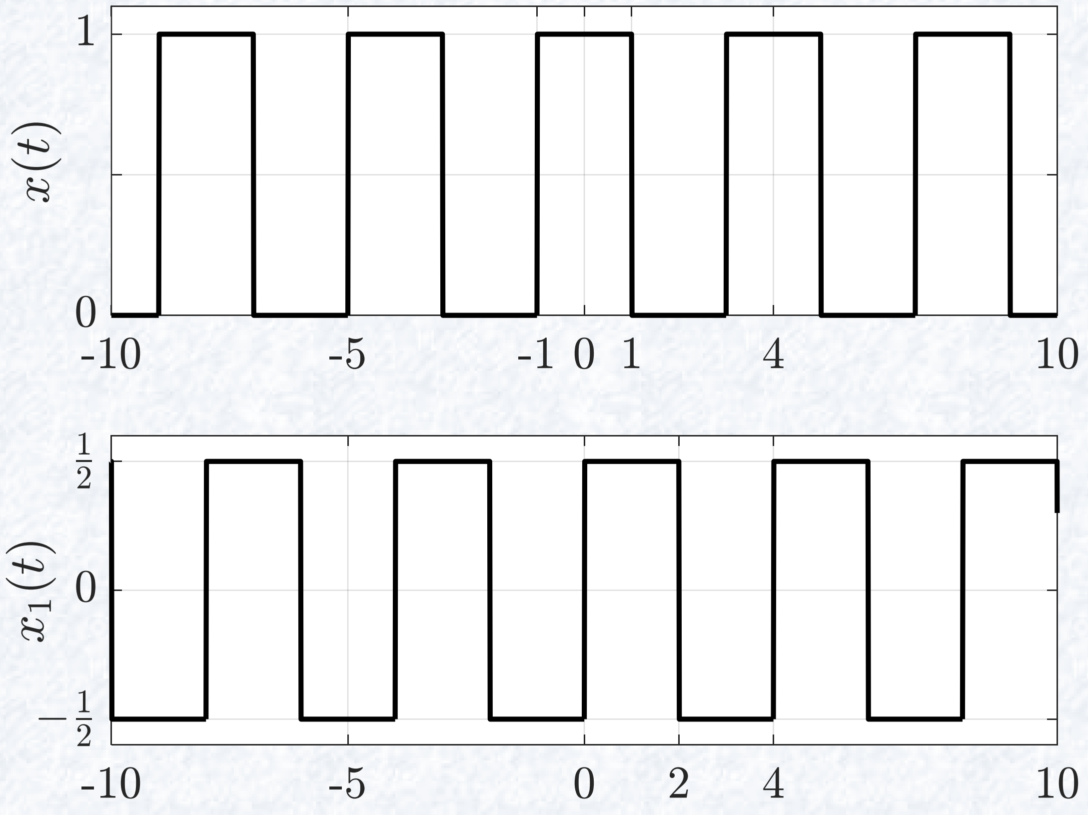
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \rightarrow c_k =?$
- $\mathcal{FS}\{x(t)\}$
  - $a_k = \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $a_0 = \dfrac{1}{2}$
- $x_1(t) = x(t-1) - \dfrac{1}{2}$
- $\mathcal{FS}\{x(t-1)\}$
  - $b_k =$



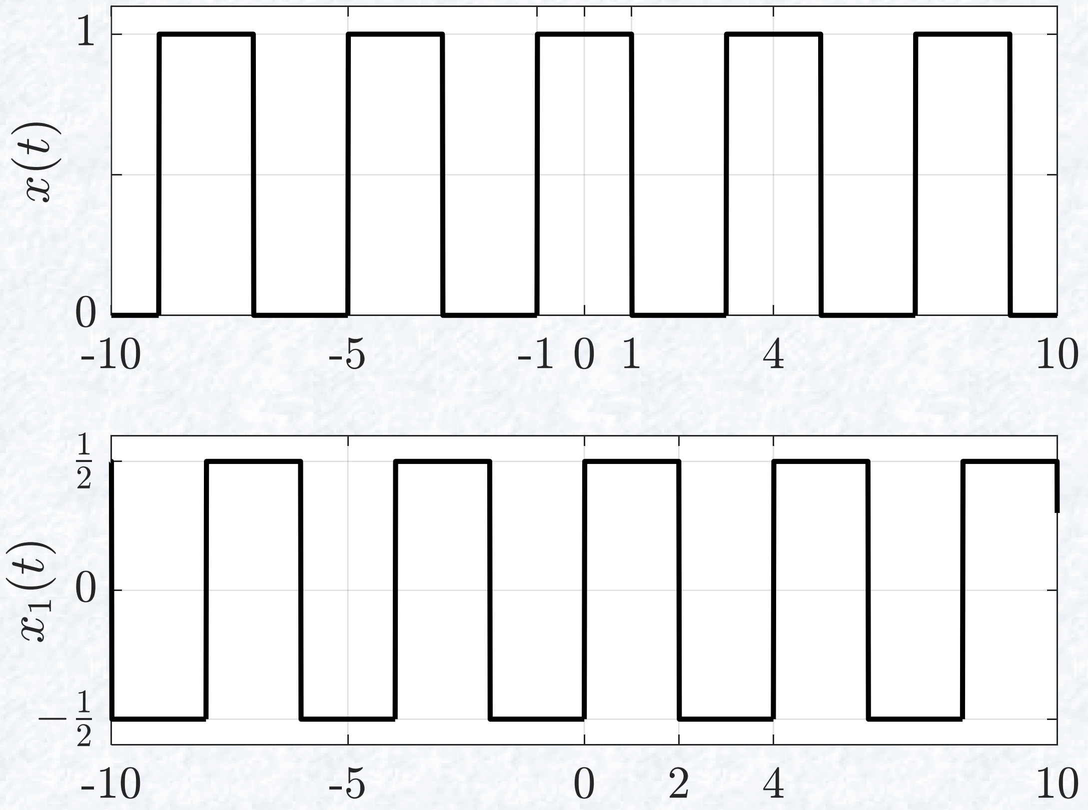
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \;\rightarrow\; c_k = ?$
- $\mathcal{FS}\{x(t)\}$
    - $a_k = \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
    - $a_0 = \dfrac{1}{2}$
- $x_1(t) = x(t-1) - \dfrac{1}{2}$
- $\mathcal{FS}\{x(t-1)\}$
    - $b_k = e^{-jk\frac{\pi}{2}} a_k = e^{-jk\frac{\pi}{2}} \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
    - $b_0 =$



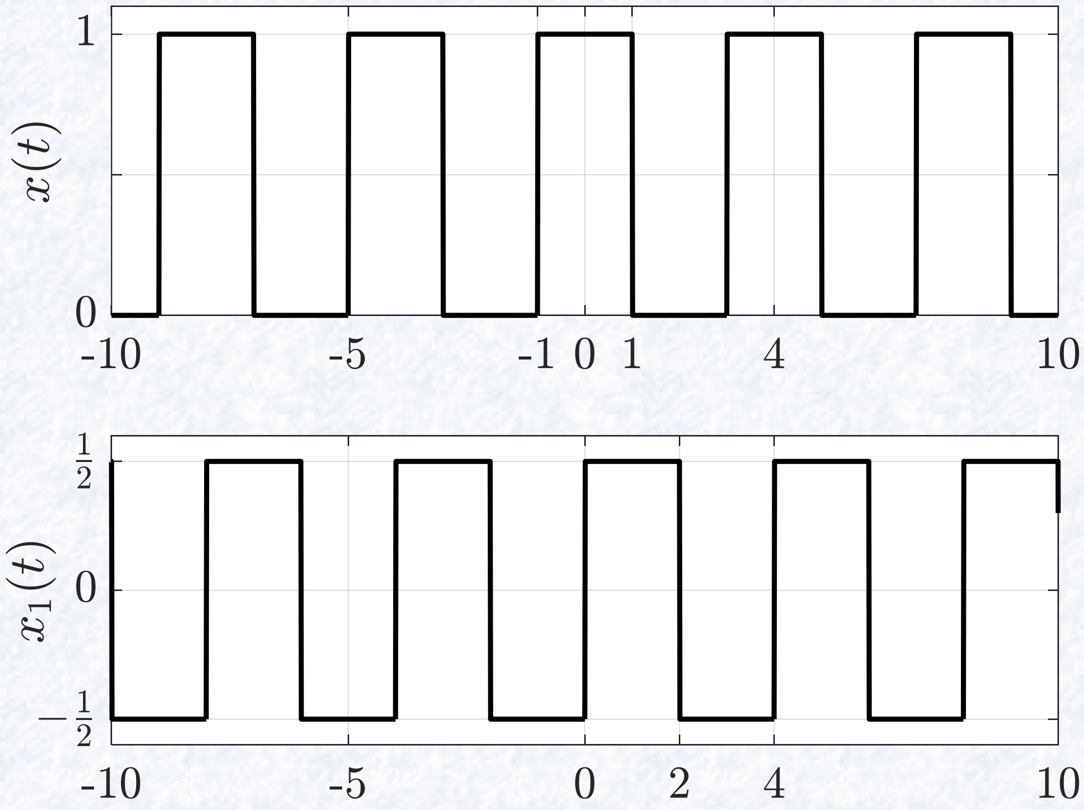
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \rightarrow c_k = ?$
- $\mathcal{FS}\{x(t)\}$
  - ♦ $a_k = \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - ♦ $a_0 = \dfrac{1}{2}$
- $x_1(t) = x(t-1) - \dfrac{1}{2}$
- $\mathcal{FS}\{x(t-1)\}$
  - ♦ $b_k = e^{-jk\frac{\pi}{2}} a_k = e^{-jk\frac{\pi}{2}} \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - ♦ $b_0 = a_0 = \dfrac{1}{2}$



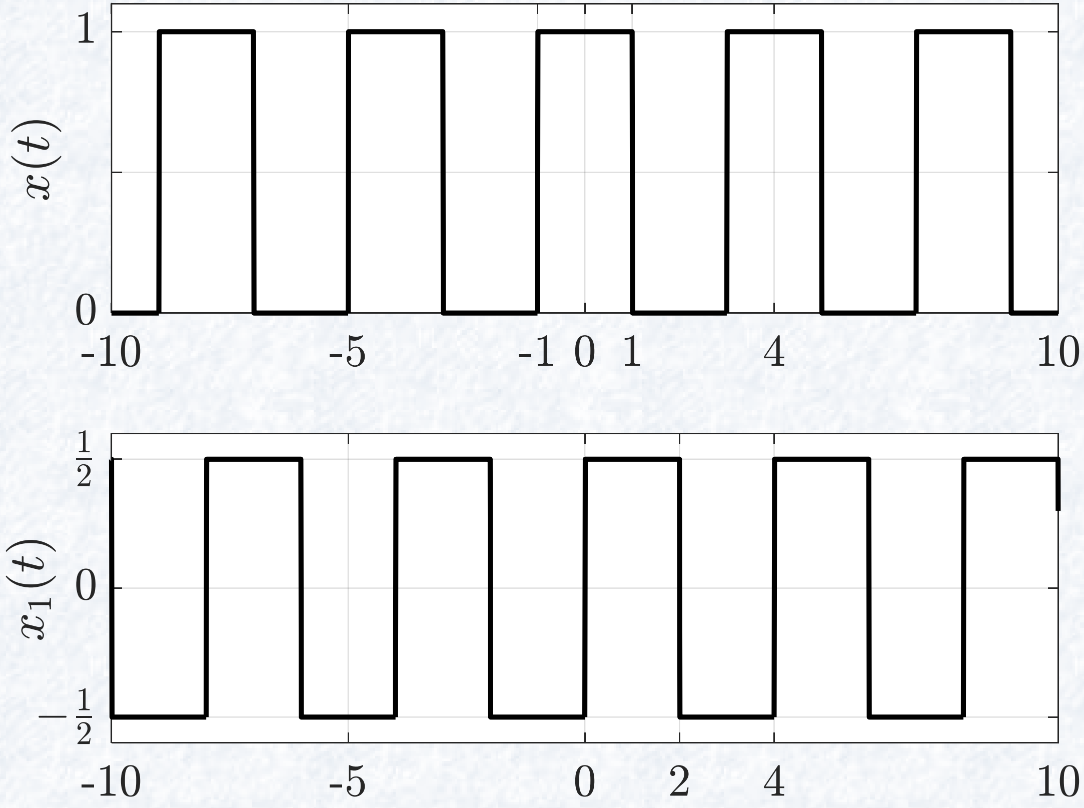
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \rightarrow c_k = ?$
- $x_1(t) = x(t-1) - \frac{1}{2}$
- $\mathcal{FS}\{x(t-1)\}$
  - $b_k = e^{-jk\frac{\pi}{2}} a_k = e^{-jk\frac{\pi}{2}} \frac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $b_0 = a_0 = \frac{1}{2}$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k =$



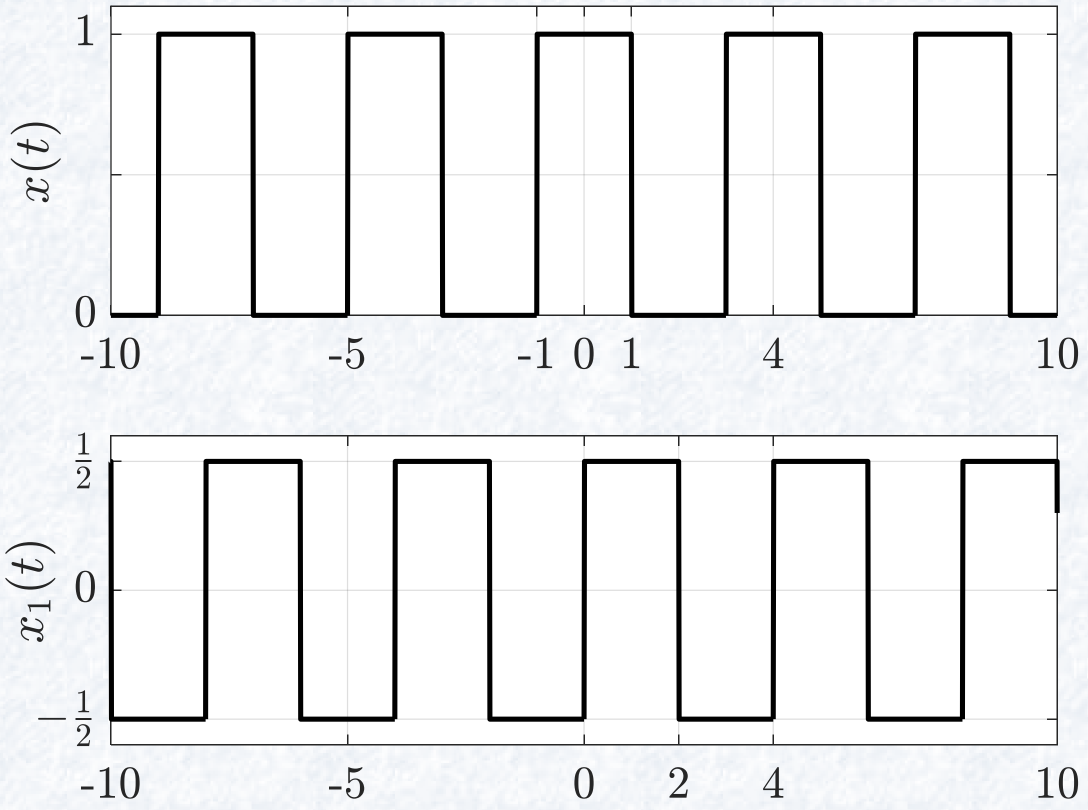
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \rightarrow c_k =?$
- $x_1(t) = x(t-1) - \frac{1}{2}$
- $\mathcal{FS}\{x(t-1)\}$
  - $b_k = e^{-jk\frac{\pi}{2}} a_k = e^{-jk\frac{\pi}{2}} \frac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $b_0 = a_0 = \frac{1}{2}$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k = b_k$
  - $c_0 =$



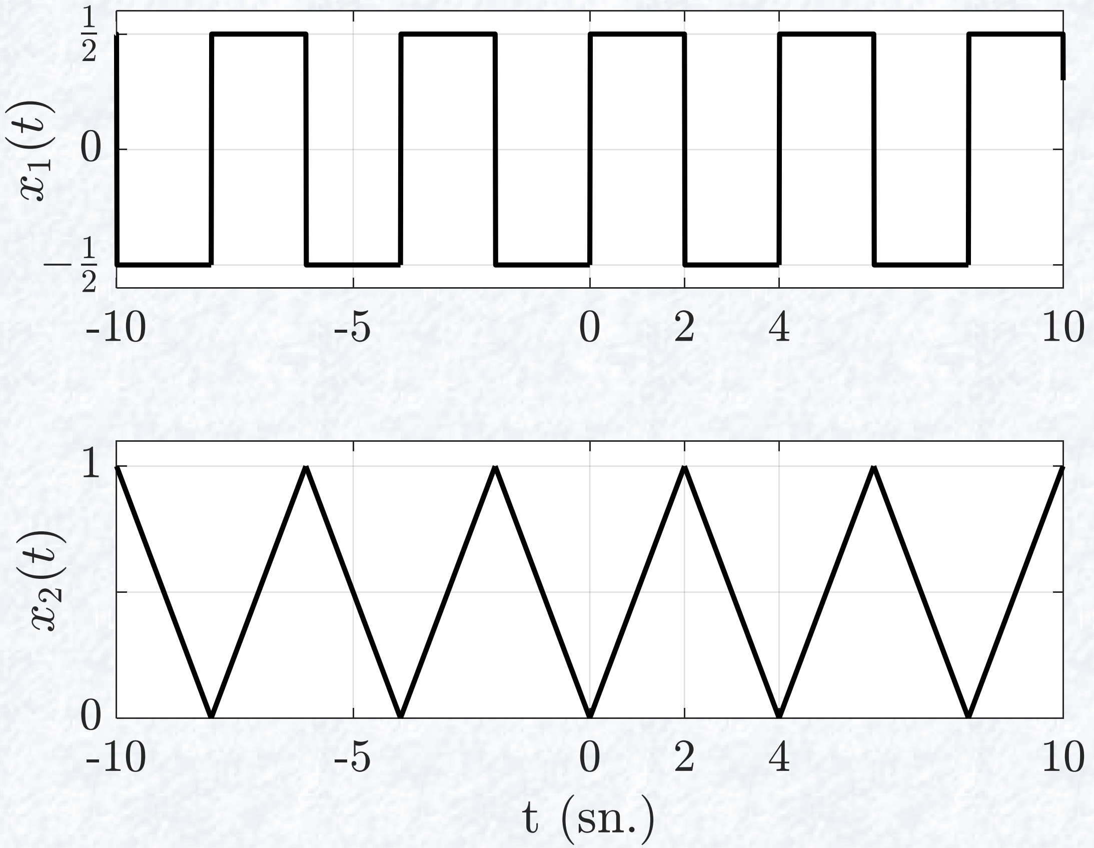
Örnek 8

- $\mathcal{FS}\{x_1(t)\} \;\rightarrow\; c_k = ?$
- $x_1(t) = x(t-1) - \frac{1}{2}$
- $\mathcal{FS}\{x(t-1)\}$
  - $b_k = e^{-jk\frac{\pi}{2}} a_k = e^{-jk\frac{\pi}{2}} \frac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $b_0 = a_0 = \frac{1}{2}$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k = b_k$
  - $c_0 = b_0 - \frac{1}{2} = 0$



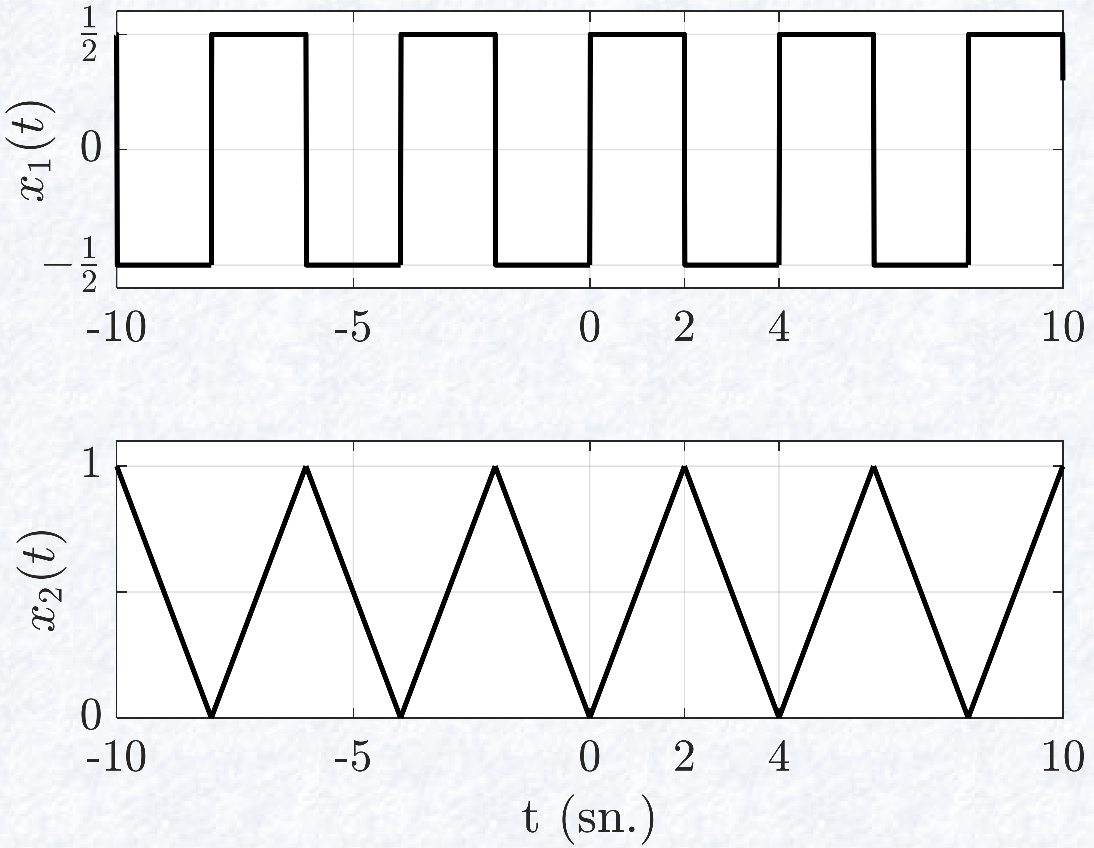
Örnek 8

- $\mathcal{FS}\{x_2(t)\} \;\rightarrow\; d_k = ?$
- $\mathcal{FS}\{x_1(t)\}$
  - ♦ $c_k = b_k = e^{-jk\frac{\pi}{2}} \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - ♦ $c_0 = b_0 - \dfrac{1}{2} = 0$



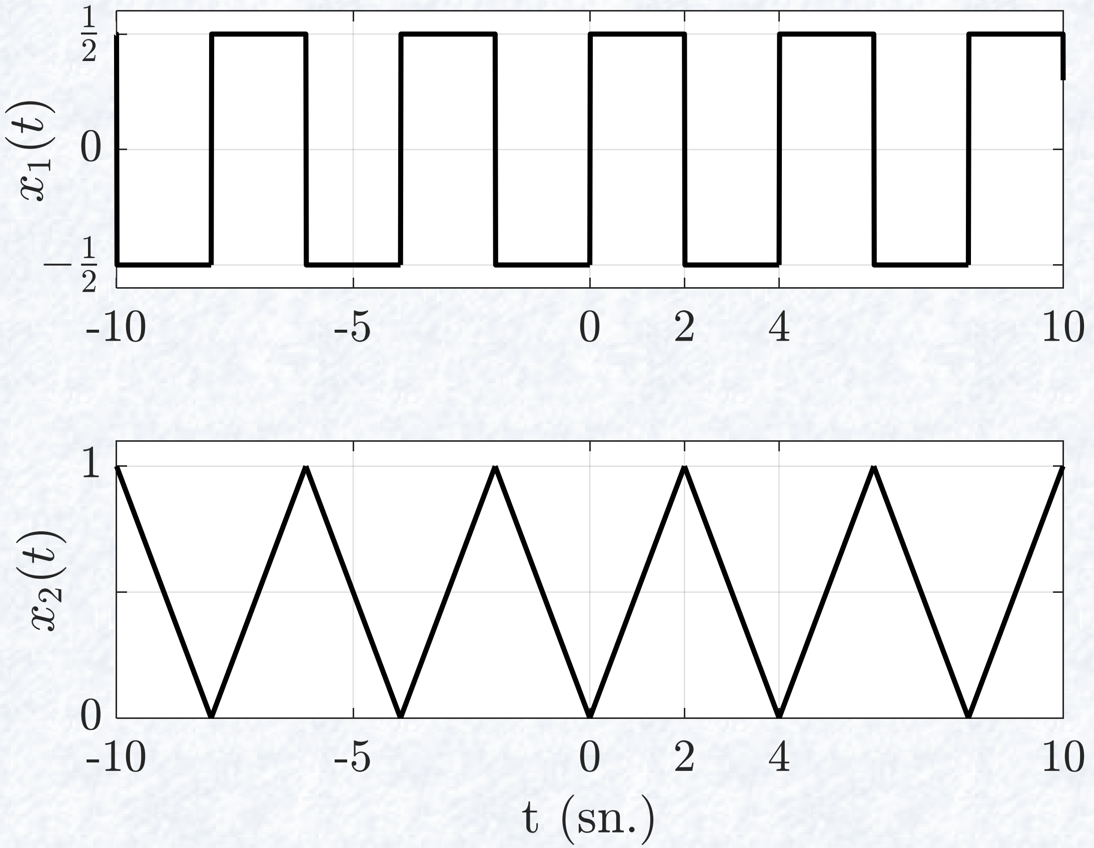
Örnek 8

- $\mathcal{FS}\{x_2(t)\} \rightarrow \; d_k =?$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k = b_k = e^{-jk\frac{\pi}{2}} \frac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $c_0 = b_0 - \frac{1}{2} = 0$
- $x_2(t) = x_1(\quad)$



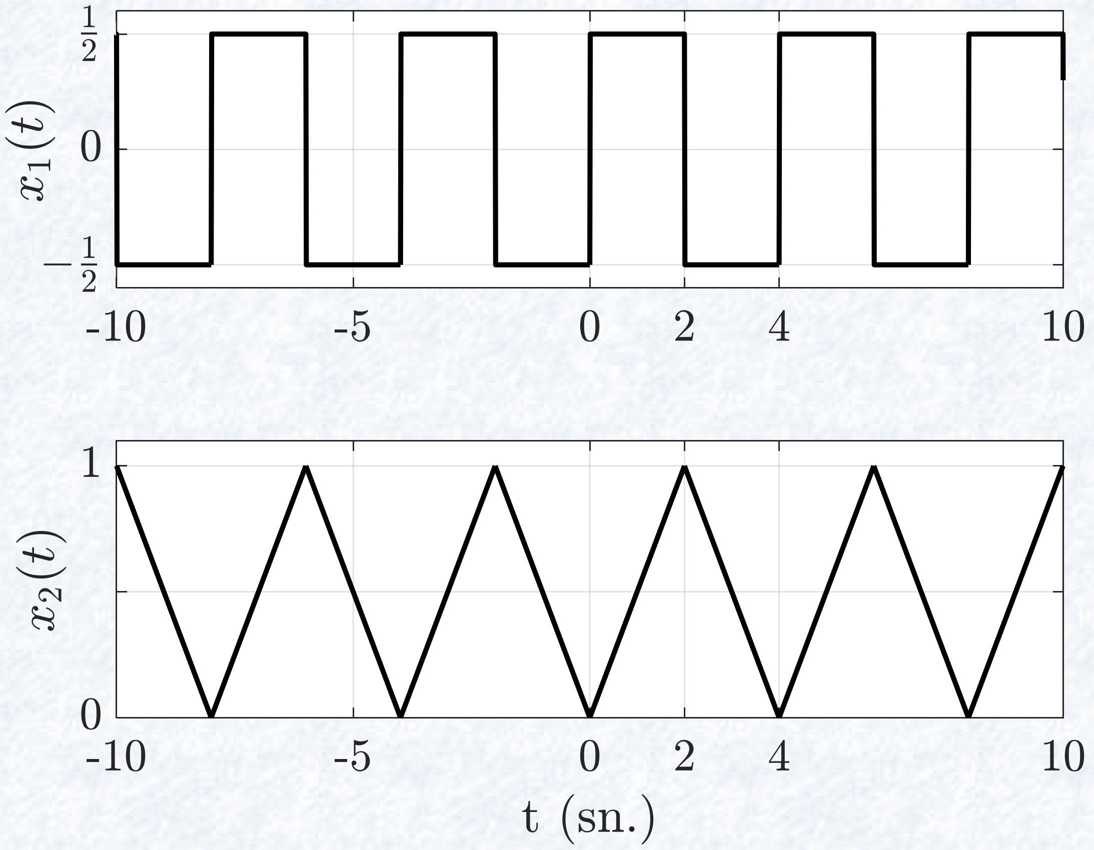
Örnek 8

- $\mathcal{FS}\{x_2(t)\} \rightarrow d_k = ?$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k = b_k = e^{-jk\frac{\pi}{2}} \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $c_0 = b_0 - \dfrac{1}{2} = 0$
- $\dfrac{\partial x_2(t)}{\partial t} = x_1(t)$



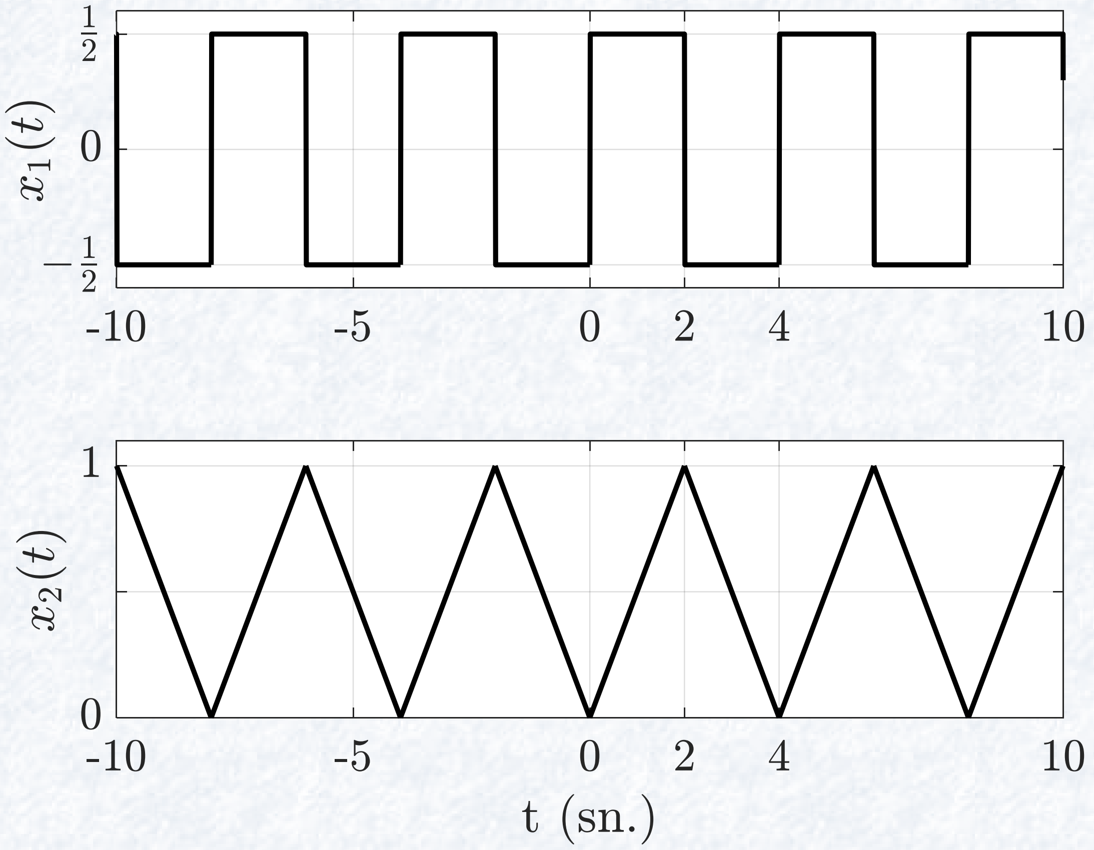
Örnek 8

- $\mathcal{FS}\{x_2(t)\} \rightarrow \ d_k = ?$
- $\mathcal{FS}\{x_1(t)\}$
  - ♦ $c_k = b_k = e^{-jk\frac{\pi}{2}} \frac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - ♦ $c_0 = b_0 - \frac{1}{2} = 0$
- $\frac{\partial x_2(t)}{\partial t} = x_1(t)$
- $jk\frac{\pi}{2} d_k = c_k$



Örnek 8

- $\mathcal{FS}\{x_2(t)\} \;\rightarrow\; d_k = ?$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k = b_k = e^{-jk\frac{\pi}{2}} \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $c_0 = b_0 - \dfrac{1}{2} = 0$
- $\dfrac{\partial x_2(t)}{\partial t} = x_1(t)$
- $jk\dfrac{\pi}{2} d_k = c_k$
- $d_k = \dfrac{1}{jk\frac{\pi}{2}} e^{-jk\frac{\pi}{2}} \dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
- $d_0 =$



Örnek 8

- $\mathcal{FS}\{x_2(t)\} \;\rightarrow\; d_k = ?$
- $\mathcal{FS}\{x_1(t)\}$
  - $c_k = b_k = e^{-jk\frac{\pi}{2}}\dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
  - $c_0 = b_0 - \frac{1}{2} = 0$
- $\dfrac{\partial x_2(t)}{\partial t} = x_1(t)$
- $jk\dfrac{\pi}{2} d_k = c_k$
- $d_k = \dfrac{1}{jk\frac{\pi}{2}} e^{-jk\frac{\pi}{2}}\dfrac{\sin\left(k\frac{\pi}{2}\right)}{\pi k}$
- $d_0 = \frac{1}{4}\left(\int_0^2 \frac{t}{2}\,dt + \int_2^4 \left(2 - \frac{t}{2}\right) dt\right) = \frac{1}{2}$