BSM307
İşaretler ve Sistemler

Dr. Seçkin Arı

Sürekli Zaman Fourier Dönüşümü

İçerik

- Fourier Dönüşümü
- Ters Fourier Dönüşümü
- Fourier Dönüşüm Özellikleri
  - Doğrusallık
  - Zamanda
    - Öteleme
    - Ters çevirme
    - Türev ve İntegral
  - Zamanda ve Frekansta Ölçekleme
  - Frekansta Türev
  - Çift Taraflılık
  - Konvolüsyon
  - Çarpma

Fourier Dönüşümü

- Sürekli Zaman Periyodik Olmayan İşaretler
  - Frekans spektrumu

- $x(t)$ biliniyor $X(\omega)$ bulunuyor.

- $X(z) = \sum_{n=-\infty}^{\infty}$
- $X(\omega) =$

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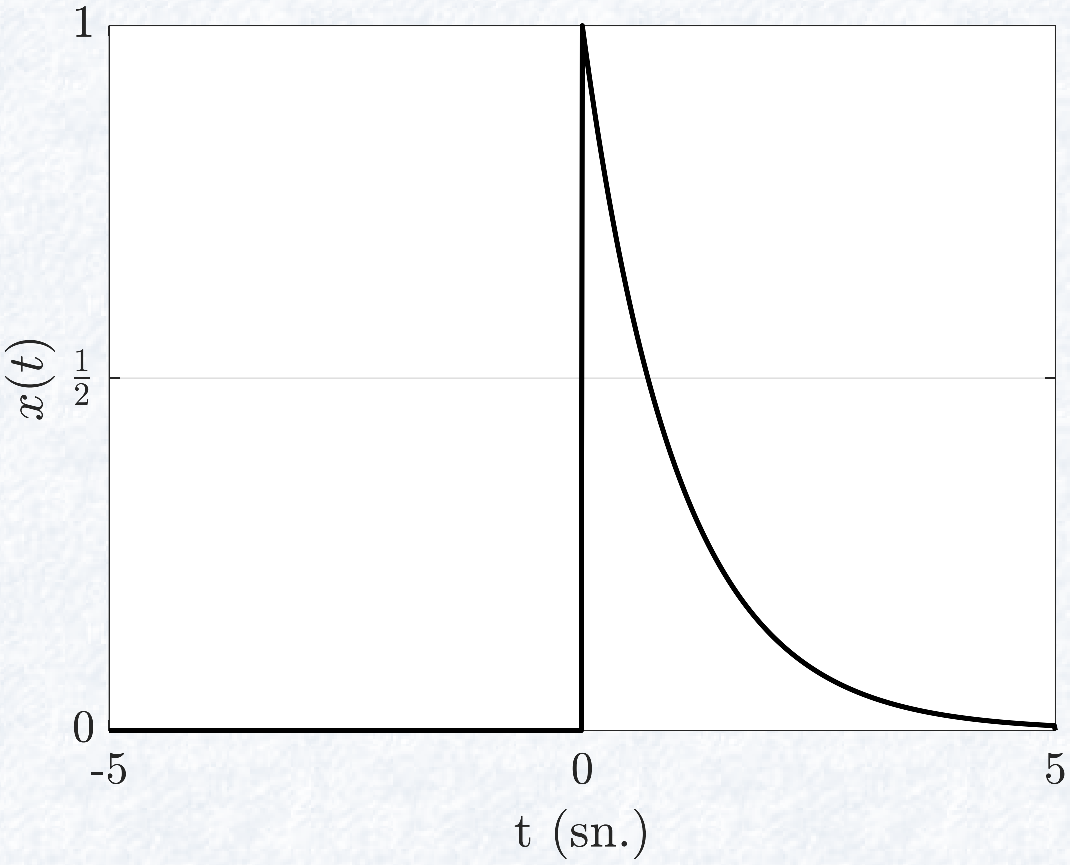
Örnek 1

- $x(t) = e^{-at}u(t)$ ise $X(\omega) = ?$



Örnek 1

- $x(t) = e^{-at}u(t)$ ise $X(\omega) =?$
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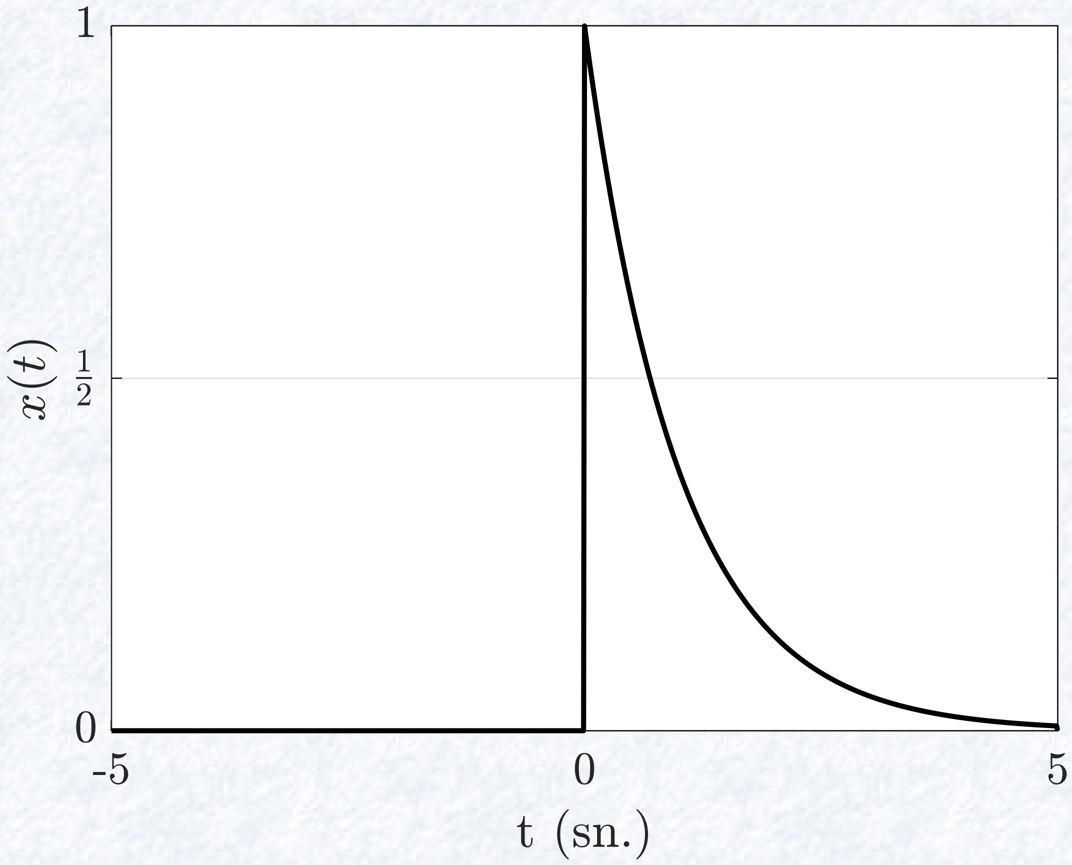

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- $X(\omega) = \int_0^\infty e^{-at}e^{-j\omega t}dt$
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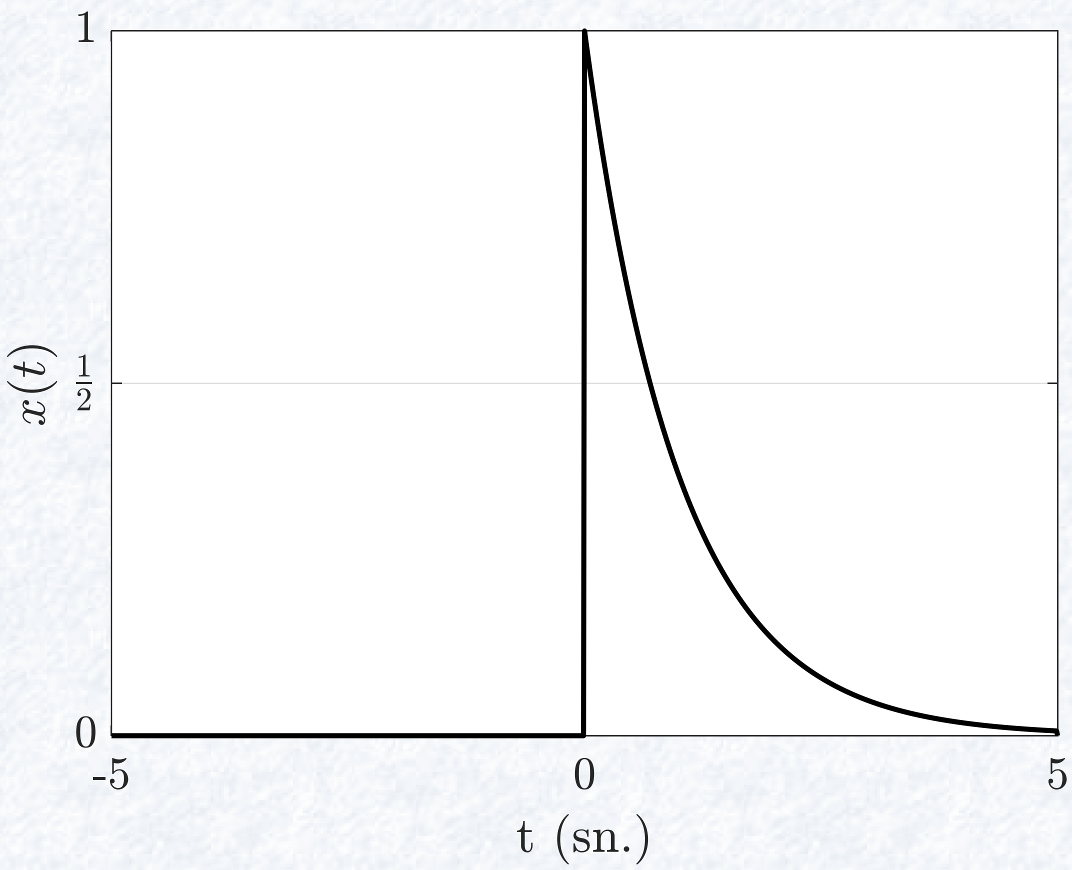

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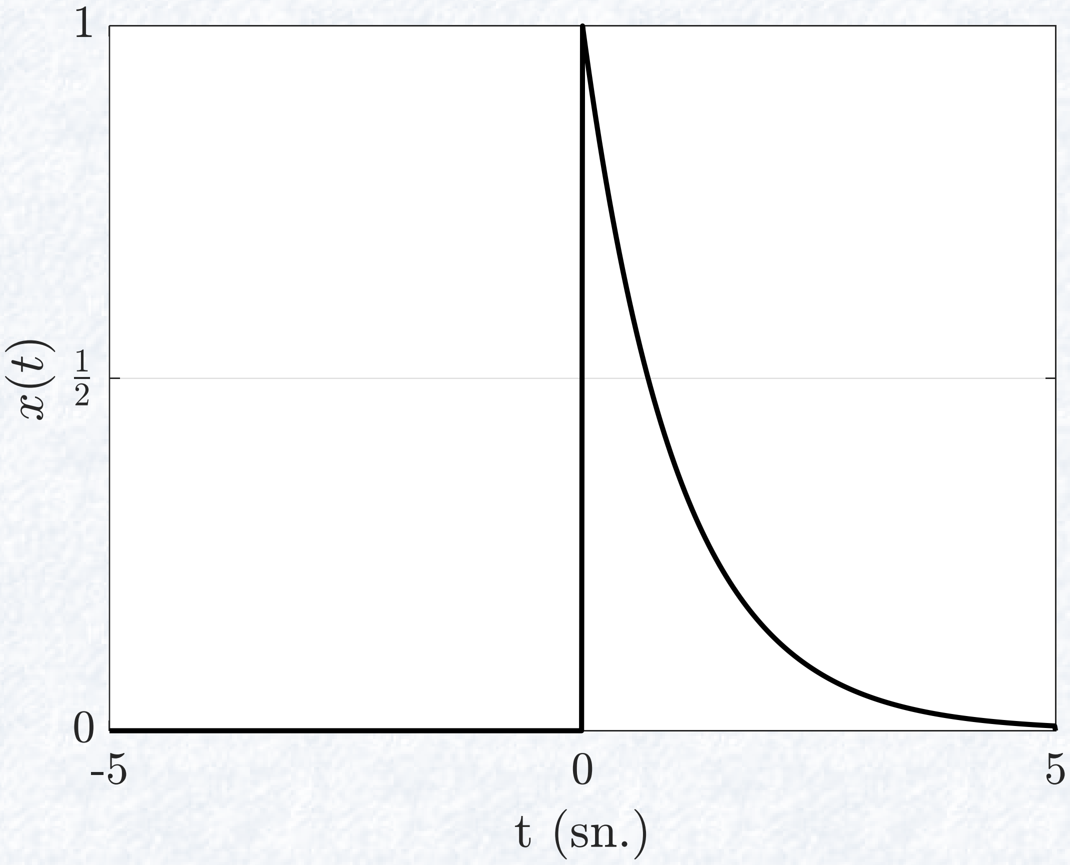

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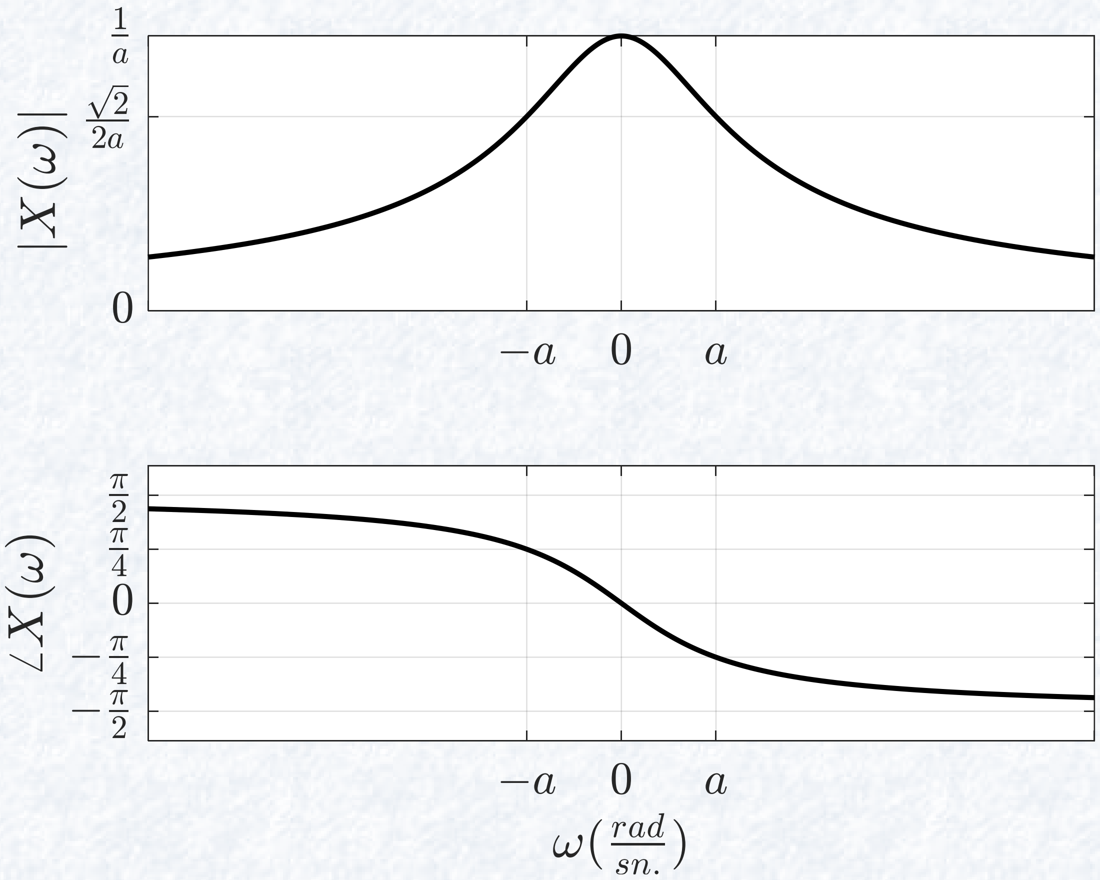
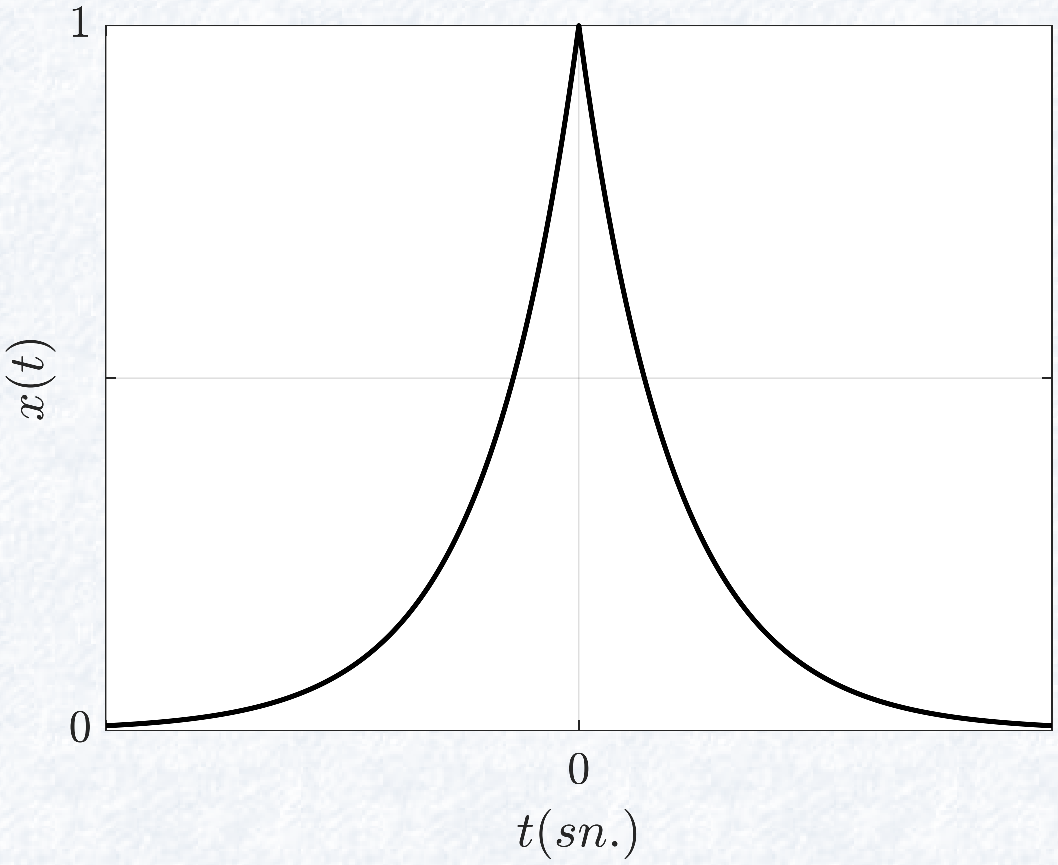
- $X(\omega) = -\frac{1}{a+j\omega}(0-1) = \frac{1}{a+j\omega}$



Örnek 2

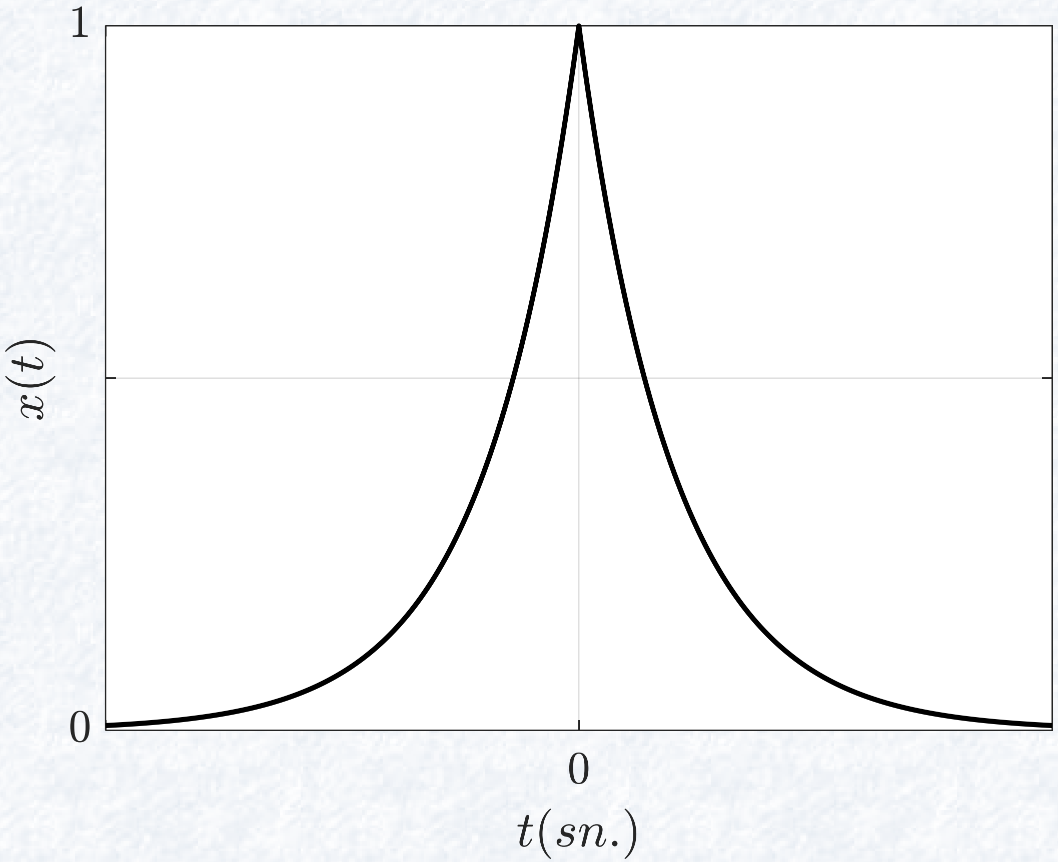
- $x(t) = e^{-a|t|}$ ise $X(\omega) = ?$



Örnek 2

- $x(t) = e^{-a|t|}$ ise $X(\omega) = ?$

- $x(t) = \begin{cases} \square, & t \geq 0 \\ \square, & t < 0 \end{cases}$



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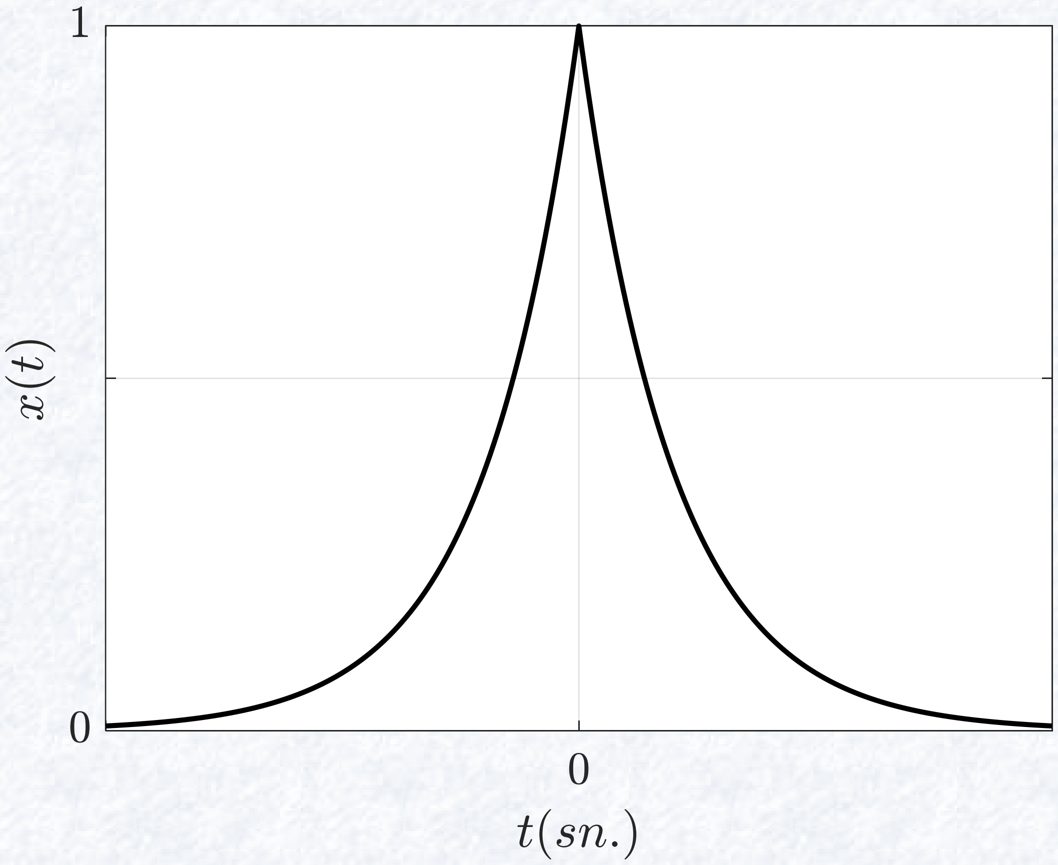

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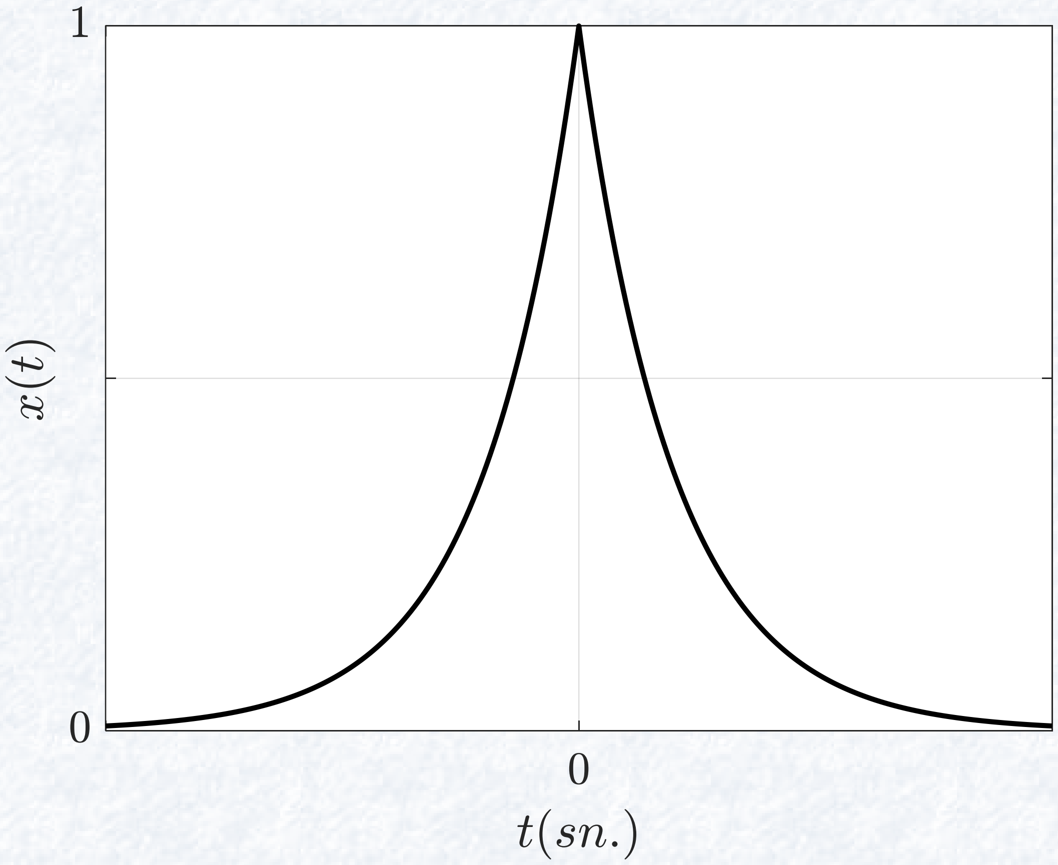
- $x(t) = e^{-a|t|}$ ise $X(\omega) = ?$
- $x(t) = \begin{cases} e^{-at}, & t \geq 0 \\ e^{at}, & t < 0 \end{cases}$
- $X(\omega) = \int_0^\infty e^{-at} e^{-j\omega t} dt +$



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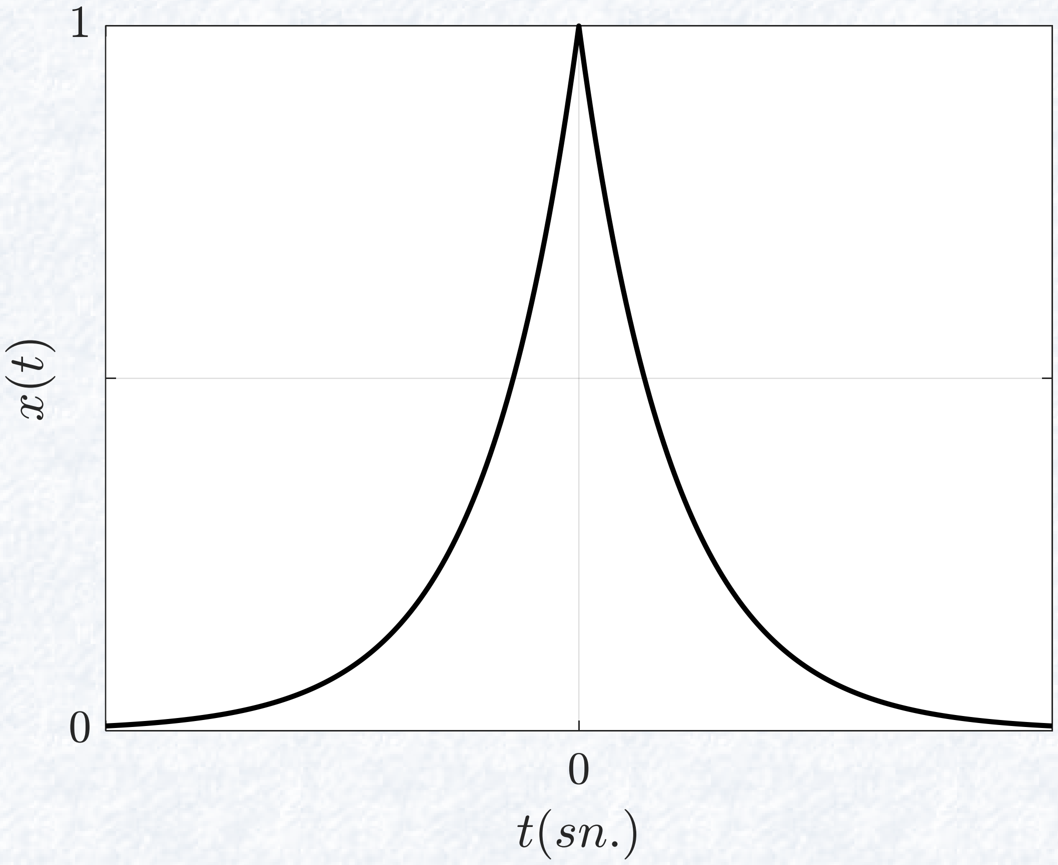
- $x(t) = \begin{cases} e^{-at}, & t \geq 0 \\ e^{at}, & t < 0 \end{cases}$
- $X(\omega) = \int_0^{\infty} e^{-at} e^{-j\omega t} dt + \int_{-\infty}^{0-} e^{at} e^{-j\omega t} dt$



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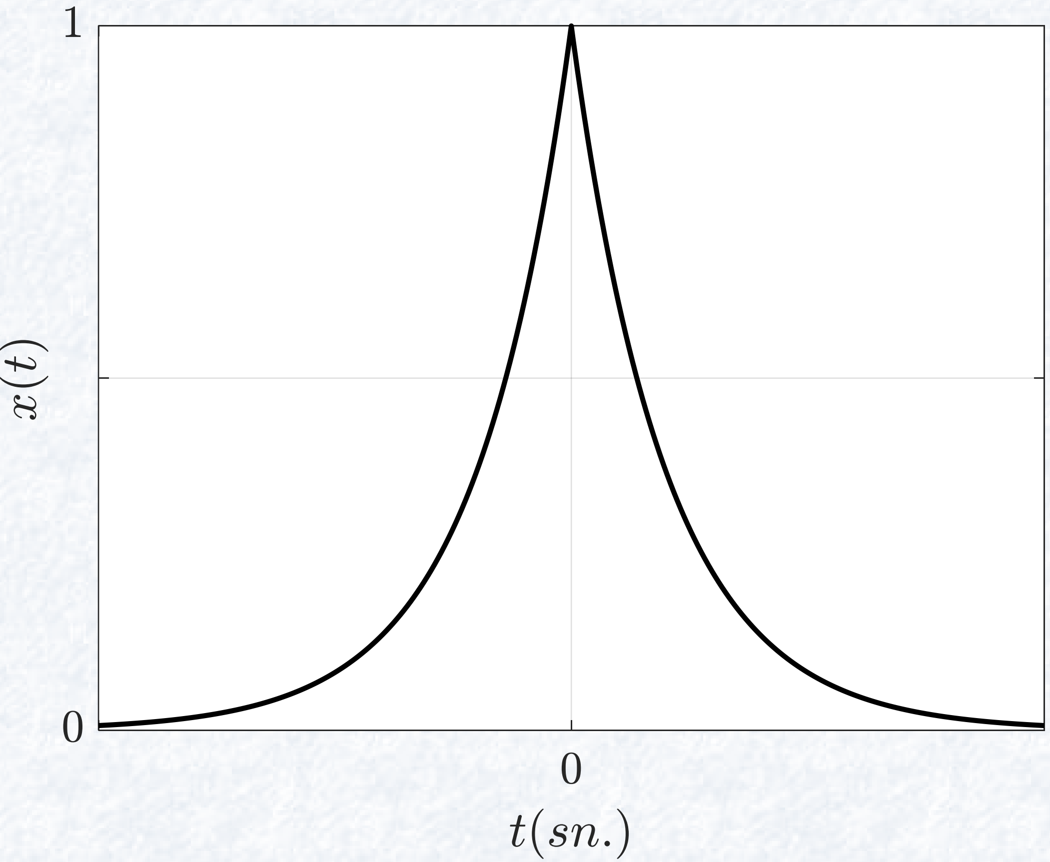
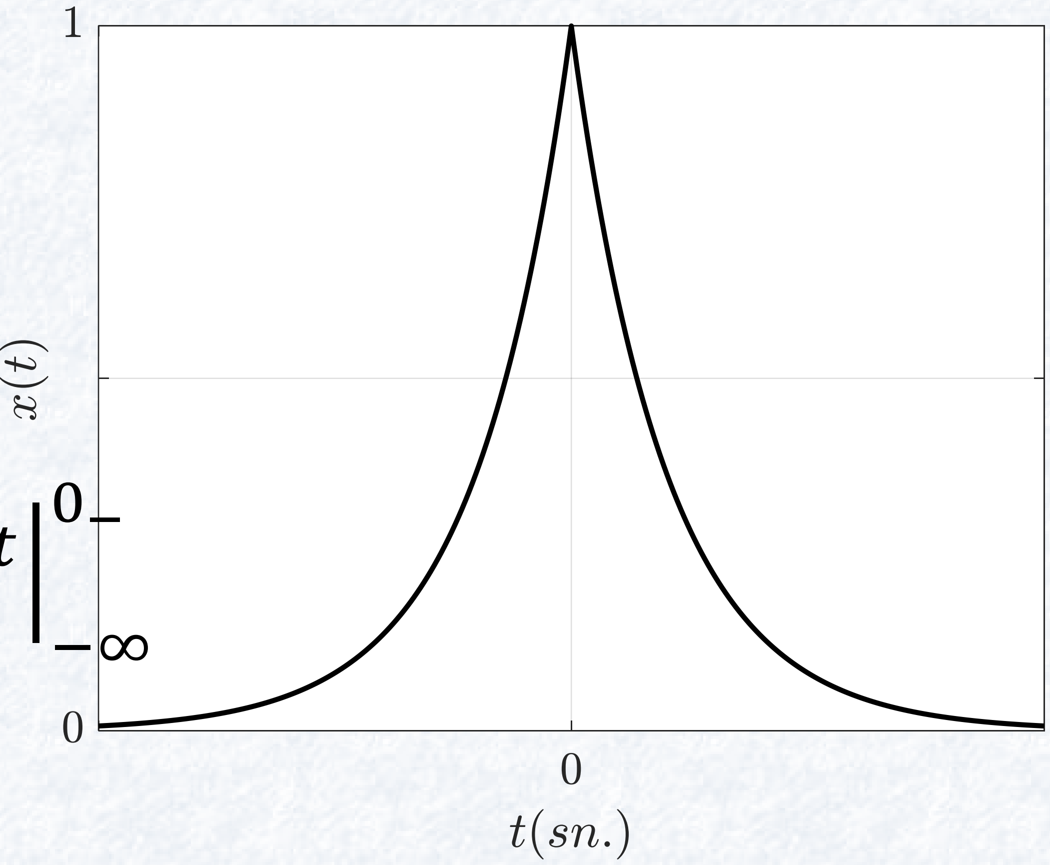
- $x(t) = e^{-a|t|}$ ise $X(\omega) = ?$
- $x(t) = \begin{cases} e^{-at}, & t \geq 0 \\ e^{at}, & t < 0 \end{cases}$
- $X(\omega) = \frac{1}{a+j\omega} + \int_{-\infty}^{-0} e^{at} e^{-j\omega t} dt$
- $\int_{-\infty}^{0-} e^{at} e^{-j\omega t} dt =$



Örnek 2

- $x(t) = e^{-a|t|}$ ise $X(\omega) =?$
- $x(t) = \begin{cases} e^{-at}, & t \geq 0 \\ e^{at}, & t < 0 \end{cases}$
- $X(\omega) = \frac{1}{a+j\omega} + \int_{-\infty}^{0_-} e^{at} e^{-j\omega t} dt$
- $\int_{-\infty}^{0_-} e^{at} e^{-j\omega t} dt = \frac{1}{a-j\omega} e^{(a-j\omega)t} \Big|_{-\infty}^{0_-}$

$=$



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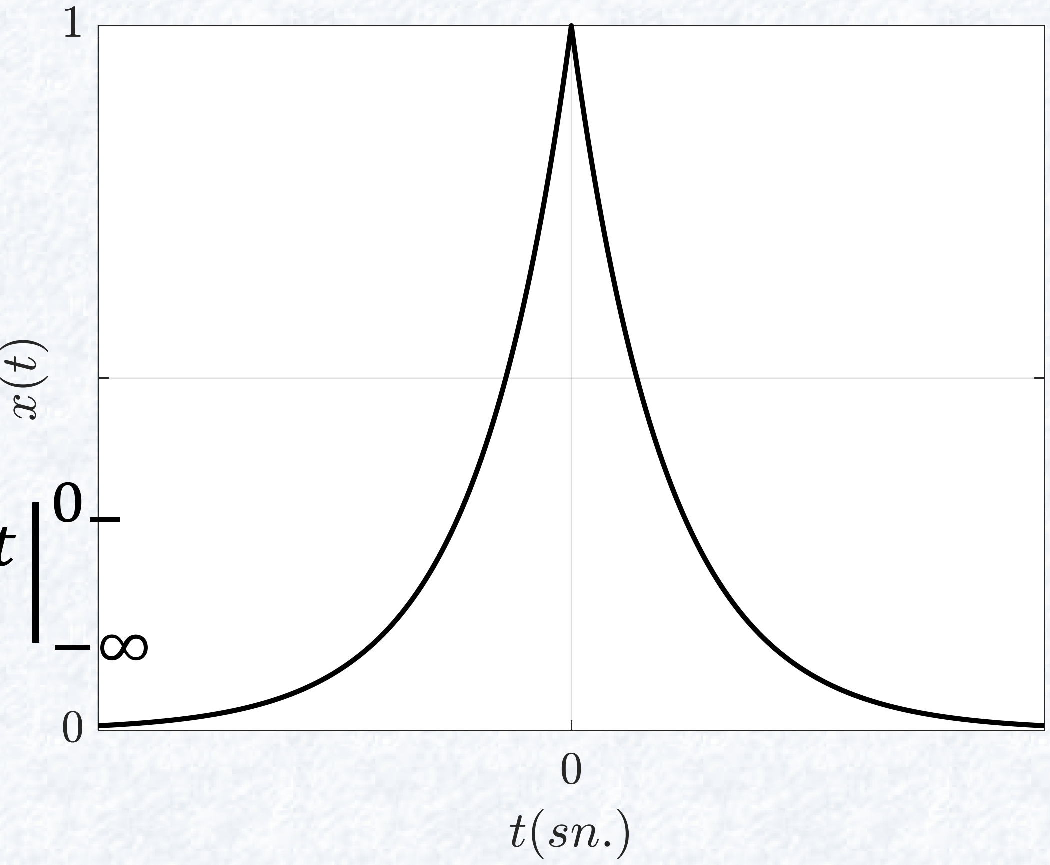
$= \frac{1}{a-j\omega}(1-0) = \frac{1}{a-j\omega}$



Örnek 2

- $x(t) = e^{-a|t|}$ ise $X(\omega) = ?$
- $x(t) = \begin{cases} e^{-at}, & t \geq 0 \\ e^{at}, & t < 0 \end{cases}$
- $\boxed{X(\omega) = \frac{1}{a+j\omega} + \frac{1}{a-j\omega}}$
- $\int_{-\infty}^{0-} e^{at} e^{-j\omega t} dt = \frac{1}{a-j\omega} e^{(a-j\omega)t} \Big|_{-\infty}^{0-}$

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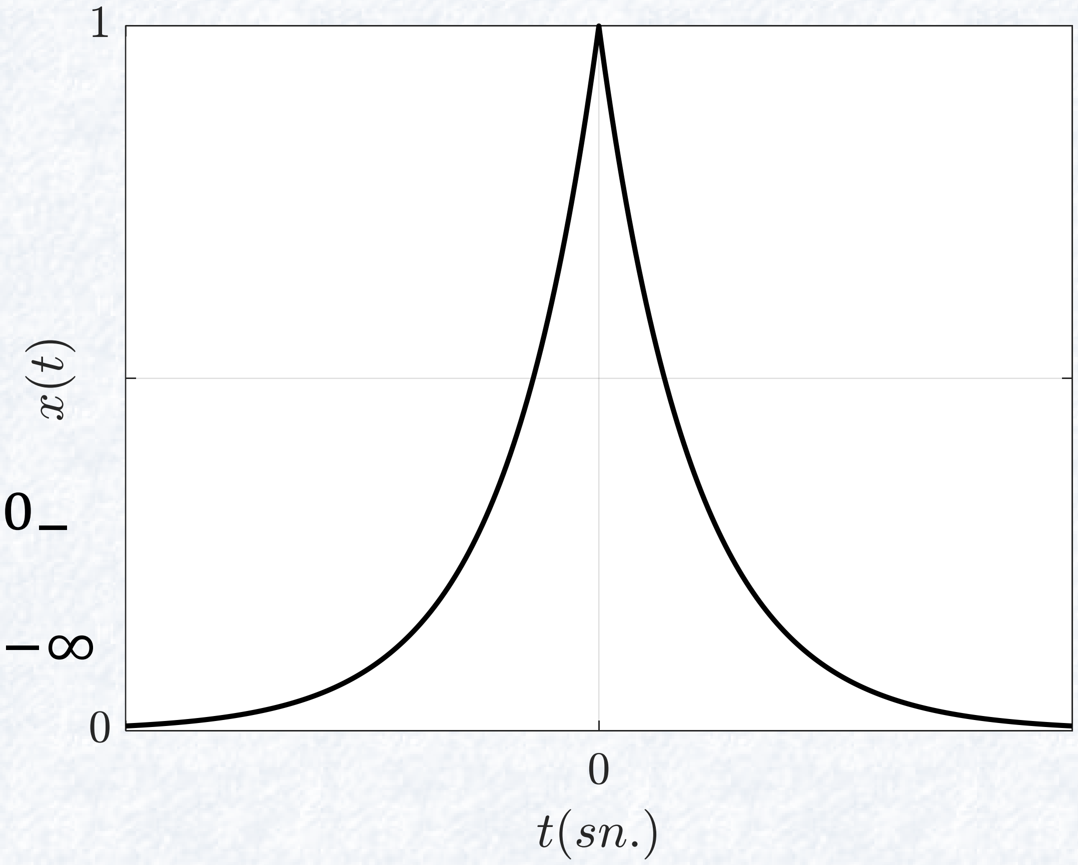

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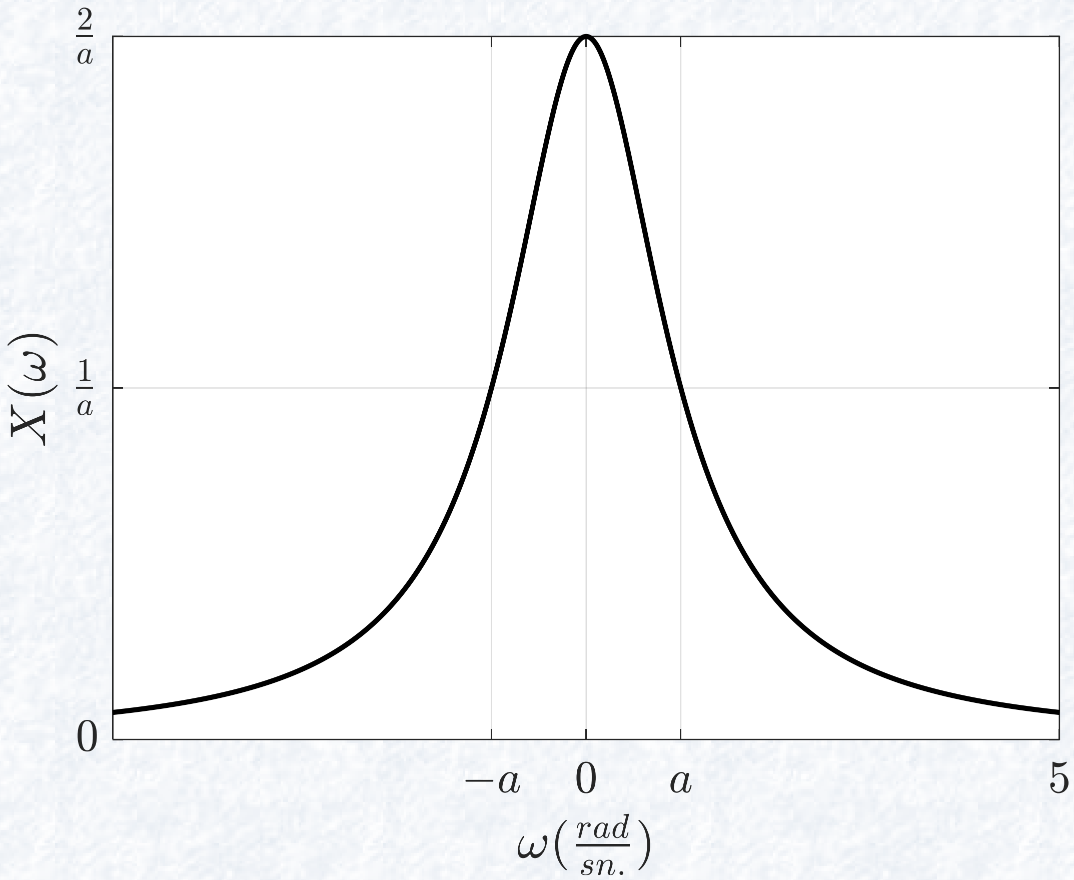
- $x(t) = e^{-a|t|}$ ise $X(\omega) =?$
- $x(t) = \begin{cases} e^{-at}, & t \geq 0 \\ e^{at}, & t < 0 \end{cases}$
- $X(\omega) = \frac{1}{a+j\omega} + \frac{1}{a-j\omega}$
- $X(\omega) = \frac{2a}{a^2+\omega^2}$



Örnek 3

- $x(t) = \delta(t)$ ise $X(\omega) =?$
- $X(\omega) = \int_{-\infty}^{\infty} \delta(t) e^{-j\omega t} dt =$

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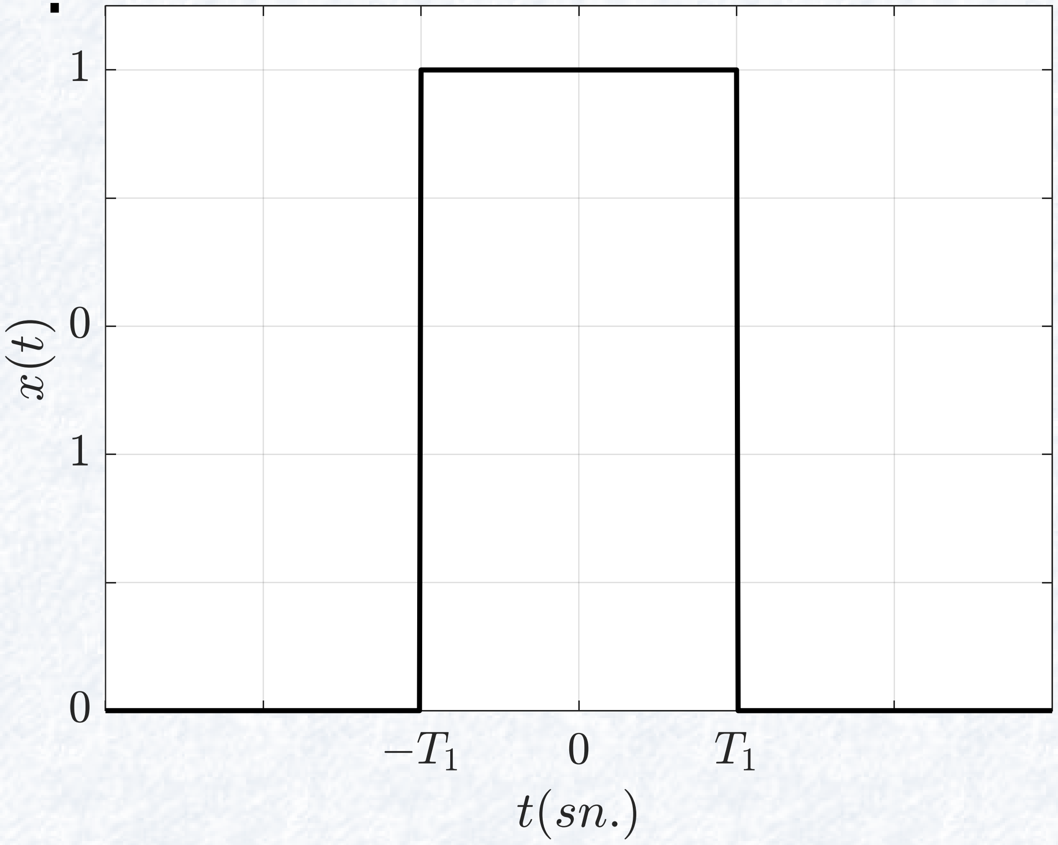
- $x(t) = \delta(t)$ ise $X(\omega) =?$
- $X(\omega) = \int_{-\infty}^{\infty} \delta(t) e^{-j\omega t} dt = 1$

Örnek 4

- $x(t) = \begin{cases} 1, & |t| \leq T_1 \\ 0, & |t| > T_1 \end{cases}$ ise $X(\omega) = ?$
- $X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$
- $X(\omega) =$



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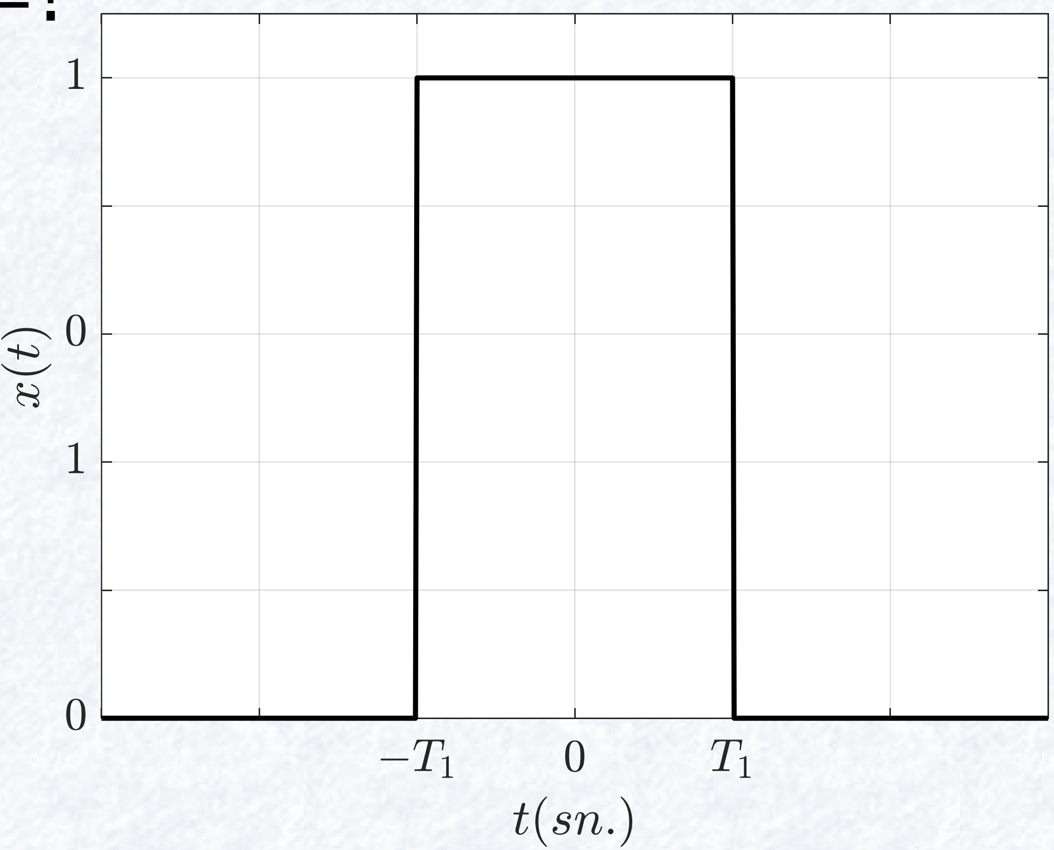
- $X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$
- $X(\omega) = \int_{-\infty}^{-T_1} + \int_{-T_1}^{T_1} + \int_{T_1}^{\infty}$
- $X(\omega) =$



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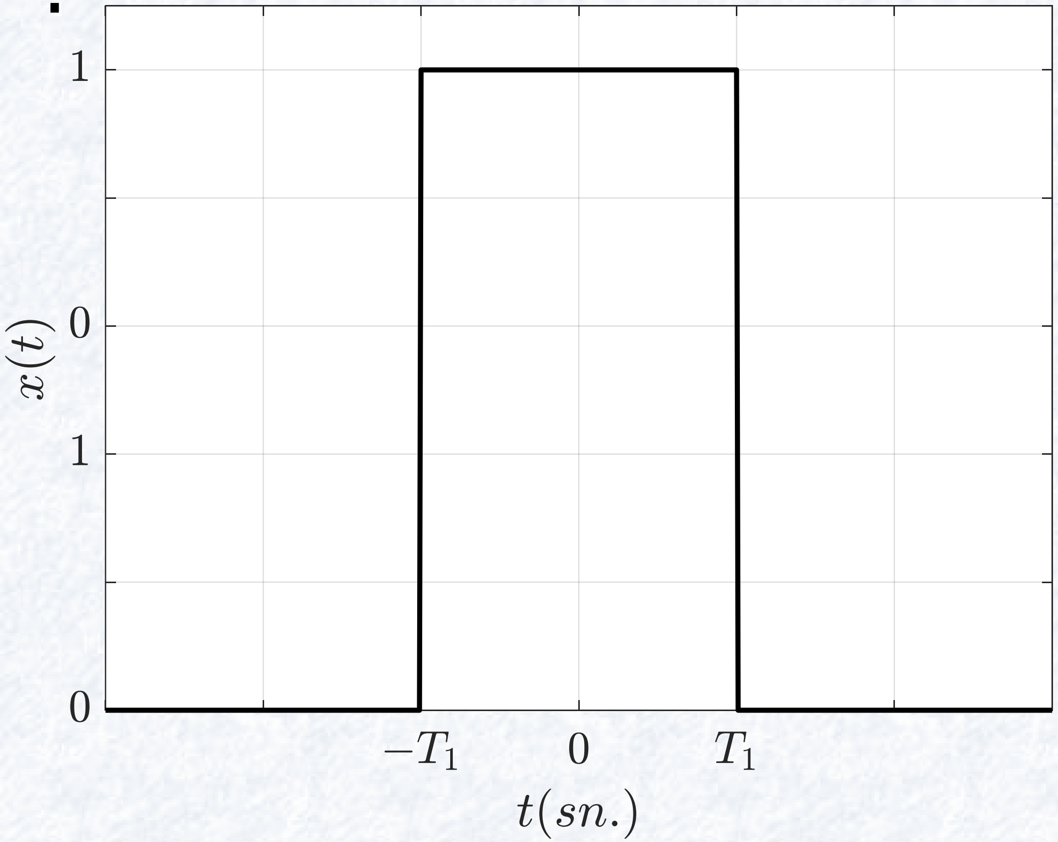
- $X(\omega) = \int_{-T_1}^{T_1} e^{-j\omega t} dt$



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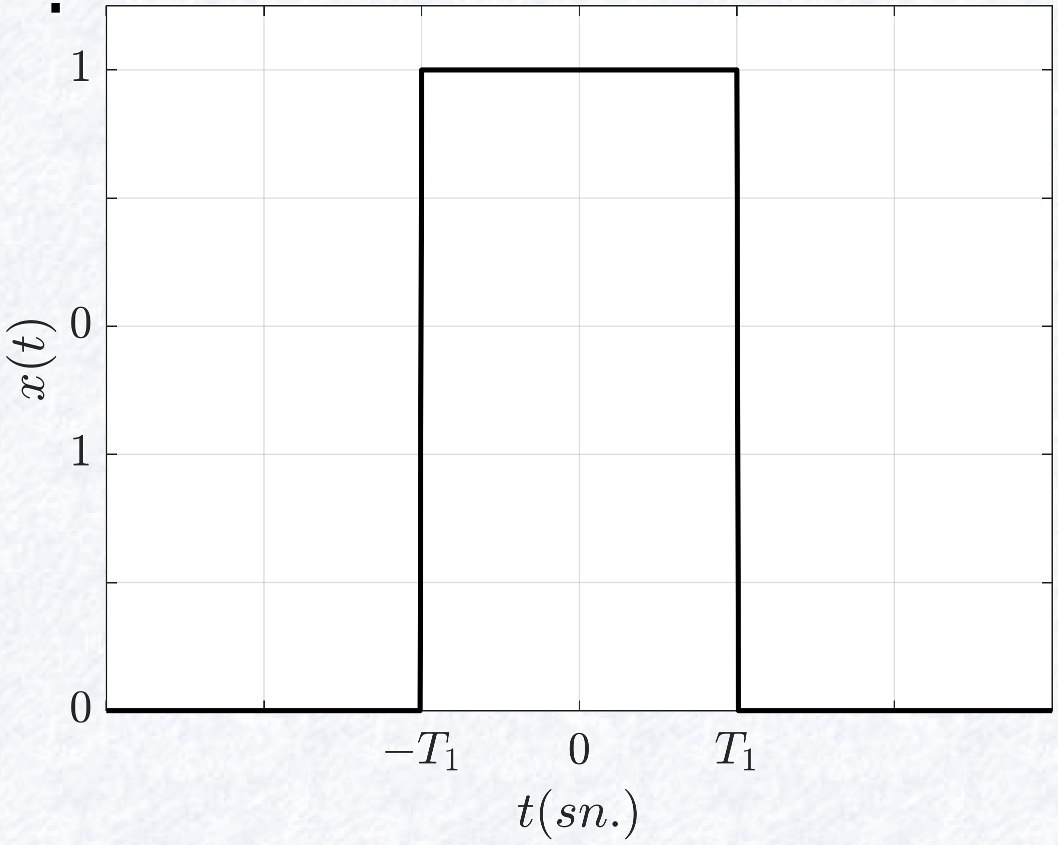
- $X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$
- $X(\omega) = \int_{-\infty}^{-T_1} + \int_{-T_1}^{T_1} + \int_{T_1}^{\infty}$
- $X(\omega) = \int_{-T_1}^{T_1} e^{-j\omega t} dt$
- $X(\omega) = -\frac{1}{j\omega} e^{-j\omega t} \Big|_{-T_1}^{T_1}$



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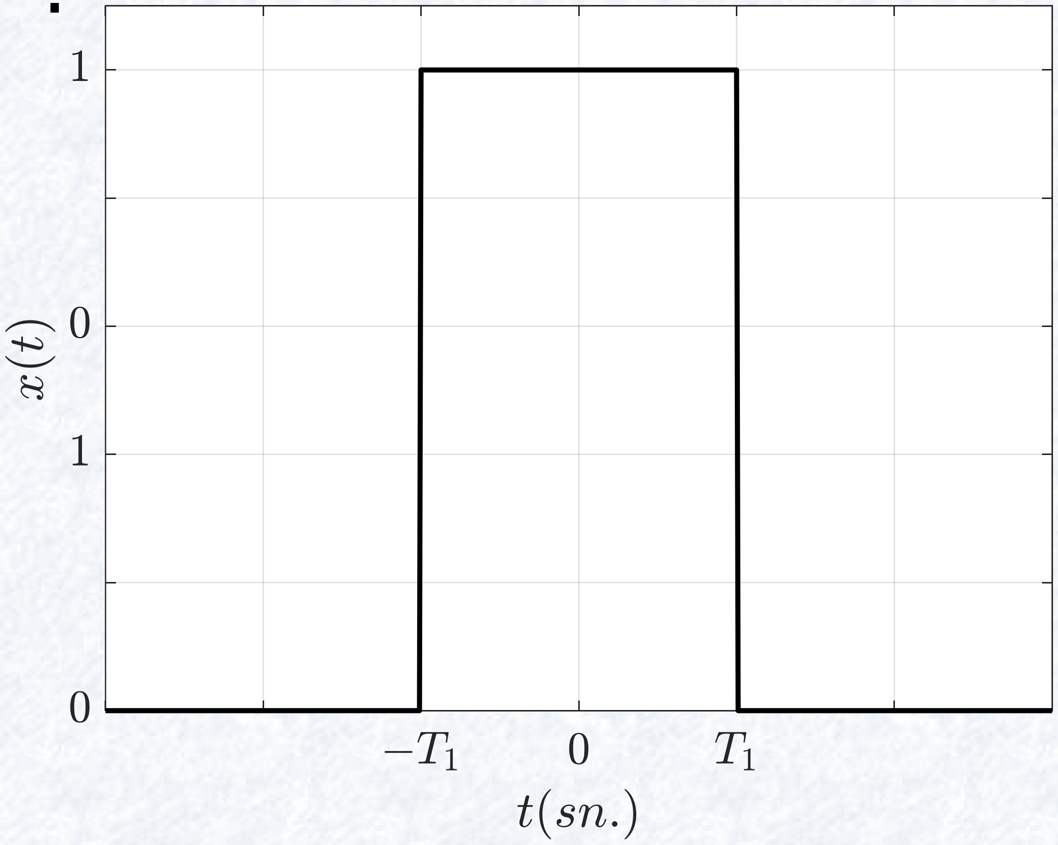

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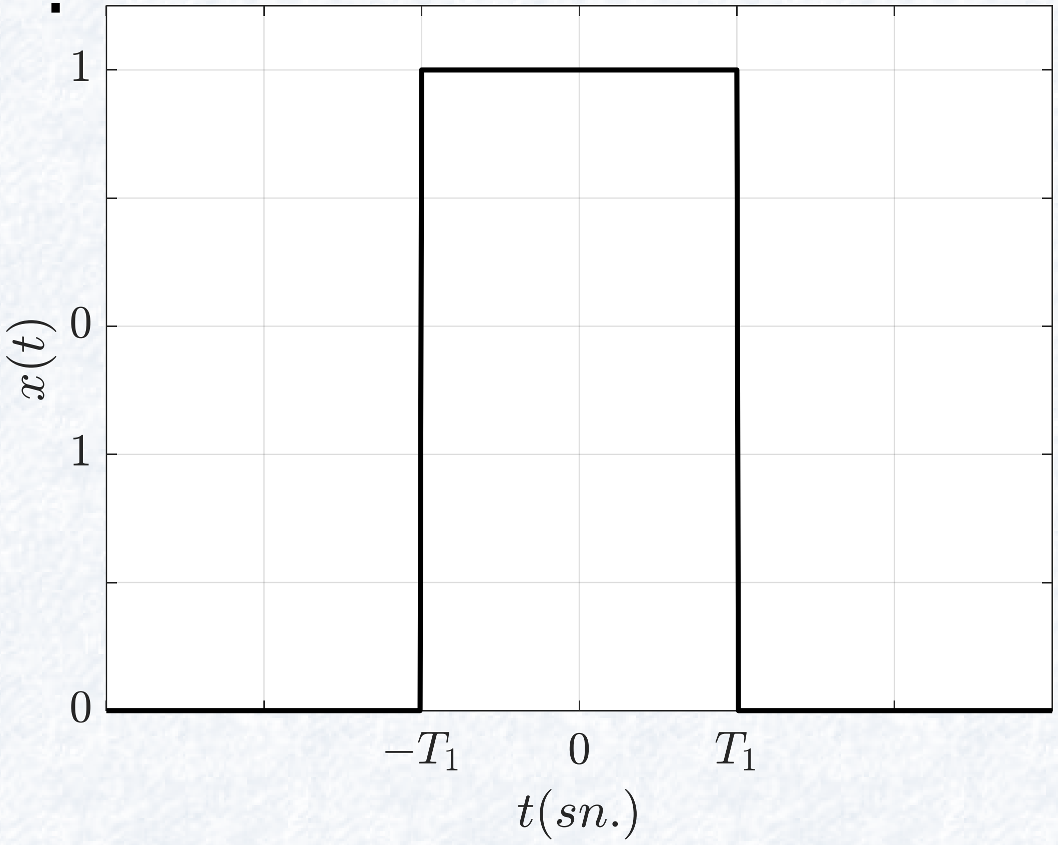
- $X(\omega) = -\frac{1}{j\omega} e^{-j\omega t} \Big|_{-T_1}^{T_1}$
- $X(\omega) = -\frac{1}{j\omega} \left(e^{-j\omega T_1} - e^{j\omega T_1} \right)$
- $X(\omega) = \frac{2}{2j\omega} \left(-e^{-j\omega T_1} + e^{j\omega T_1} \right)$



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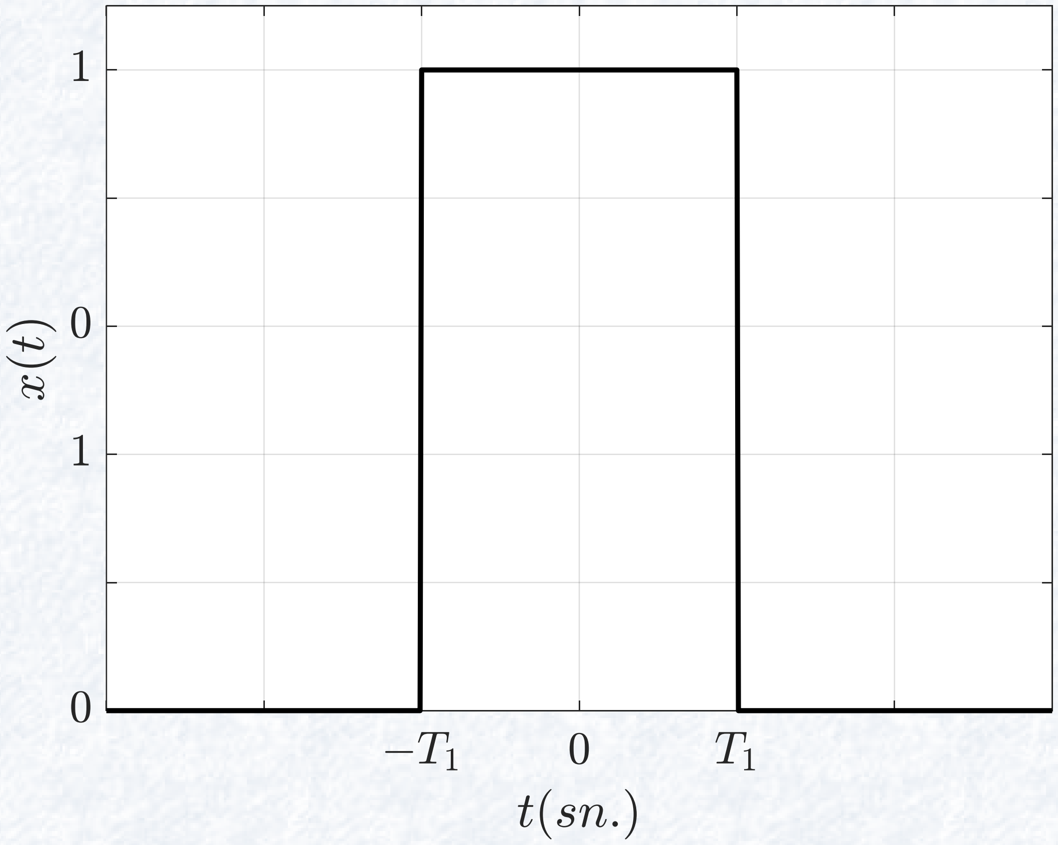
- $X(\omega) = \frac{2}{\omega} \frac{-e^{-j\omega T_1} + e^{j\omega T_1}}{2j} =$



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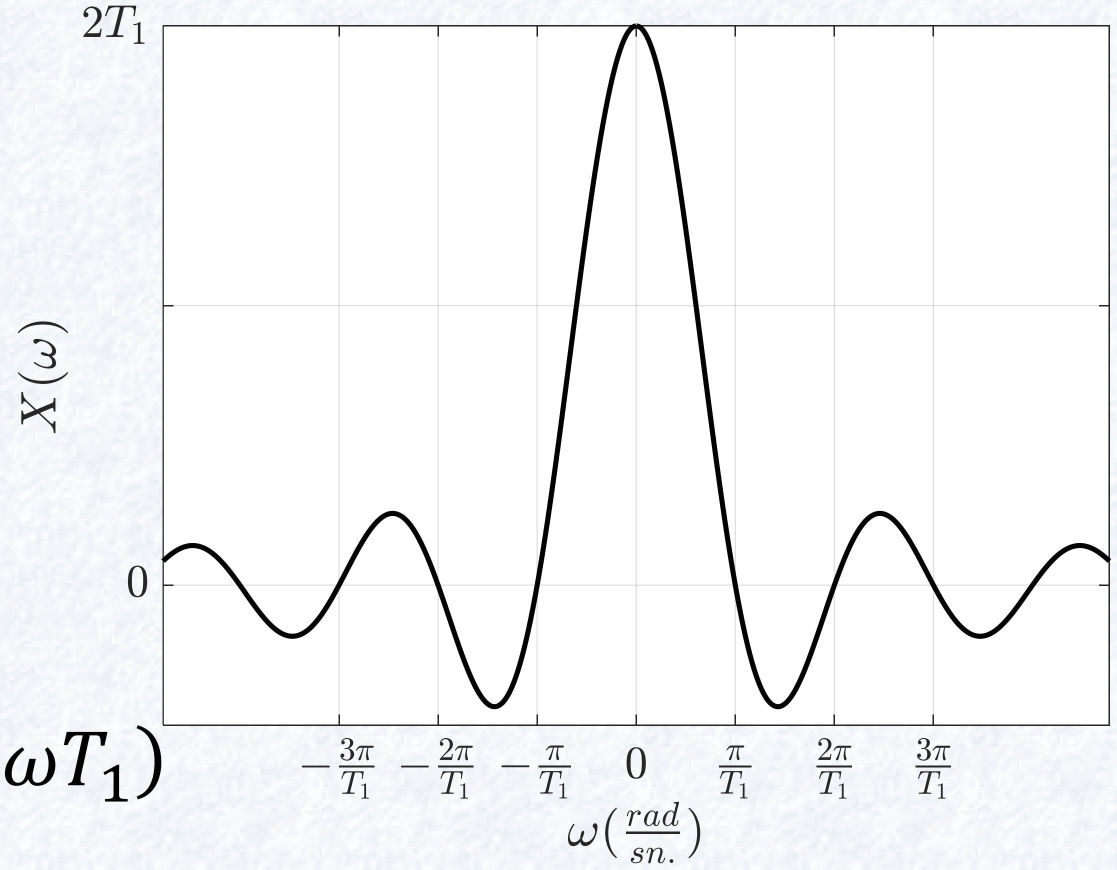

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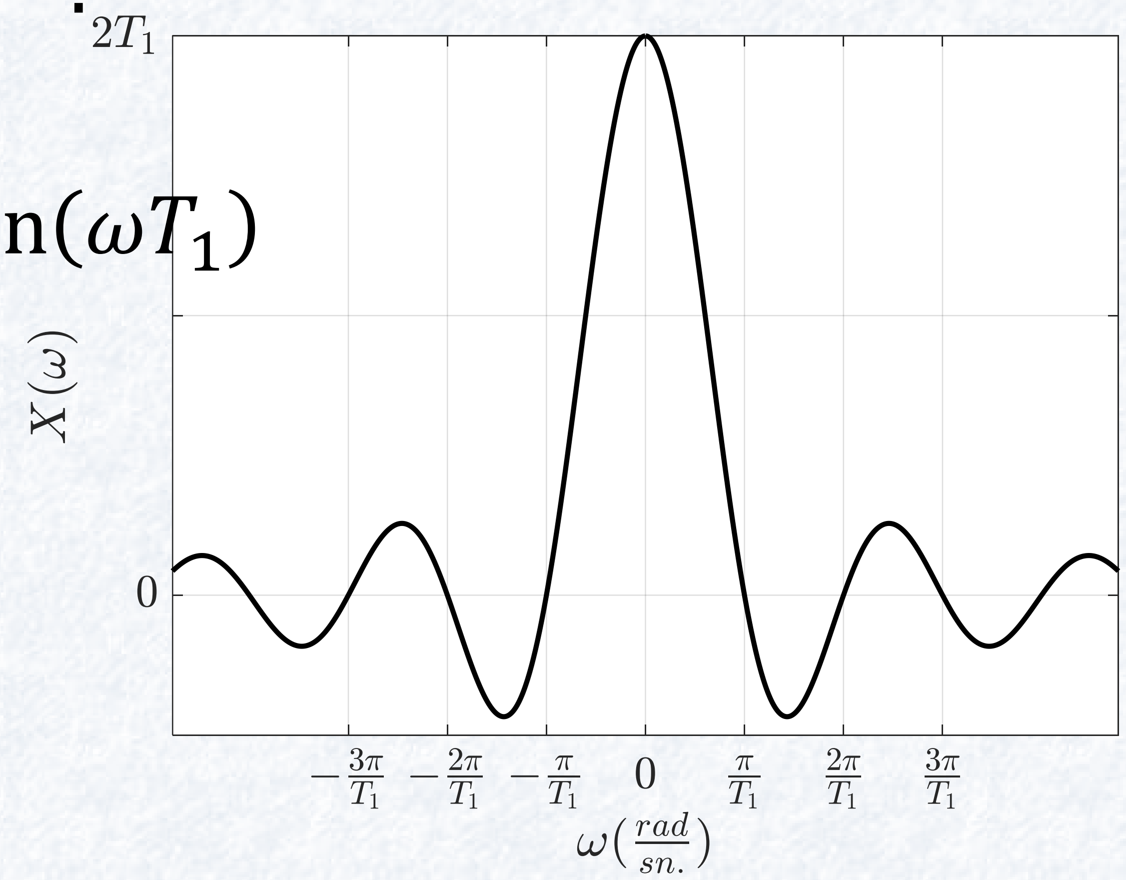
- Zamanda sınırlı
- Frekansta sınırsız
- Keskin geçişler
  - ♦ Yüksek frekans



Örnek 4

- Zamanda sınırlı
- Frekansta sınırsız
- Keskin geçişler
  - ♦ Yüksek frekans
- Görüntü de kenarlar
  - ♦ Yüksek frekanslı bileşenler

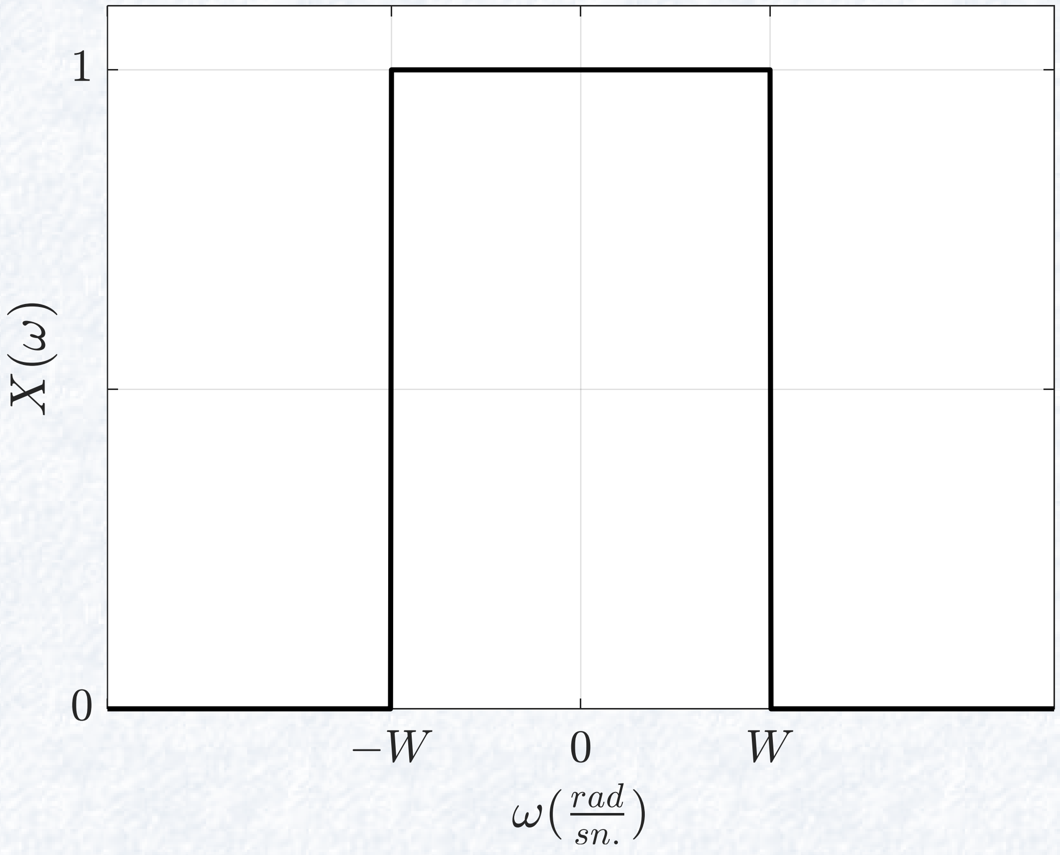
Ters Fourier Dönüşümü

- $X(\omega)$ biliniyor $x(t)$ bulunuyor.

- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$

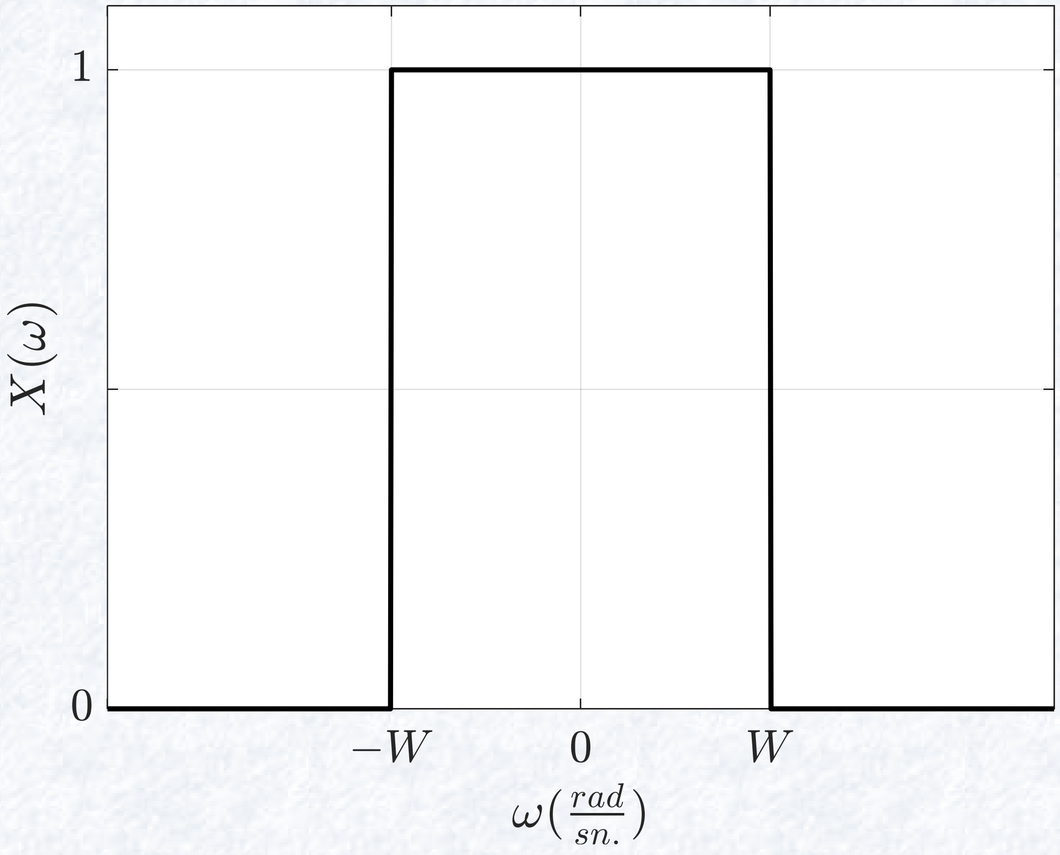
Örnek 5

- $X(\omega) = \begin{cases} 1, & |\omega| \leq W \\ 0, & |\omega| > W \end{cases}$ ise $x(t) = ?$
- $x(t) =$



Örnek 5

- $X(\omega) = \begin{cases} 1, & |\omega| \leq W \\ 0, & |\omega| > W \end{cases}$ ise $x(t)$ =?
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$
- $x(t) = \frac{1}{2\pi}(\quad)$



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- $X(\omega) = \begin{cases} 1, & |\omega| \leq W \\ 0, & |\omega| > W \end{cases}$ ise $x(t) =?$
- $x(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(\omega) e^{j\omega t} d\omega$
- $x(t) = \frac{1}{2\pi} \left(\int_{-\infty}^{-W} + \int_{-W}^{W} + \int_{W}^{\infty} \right)$
- $x(t) =$

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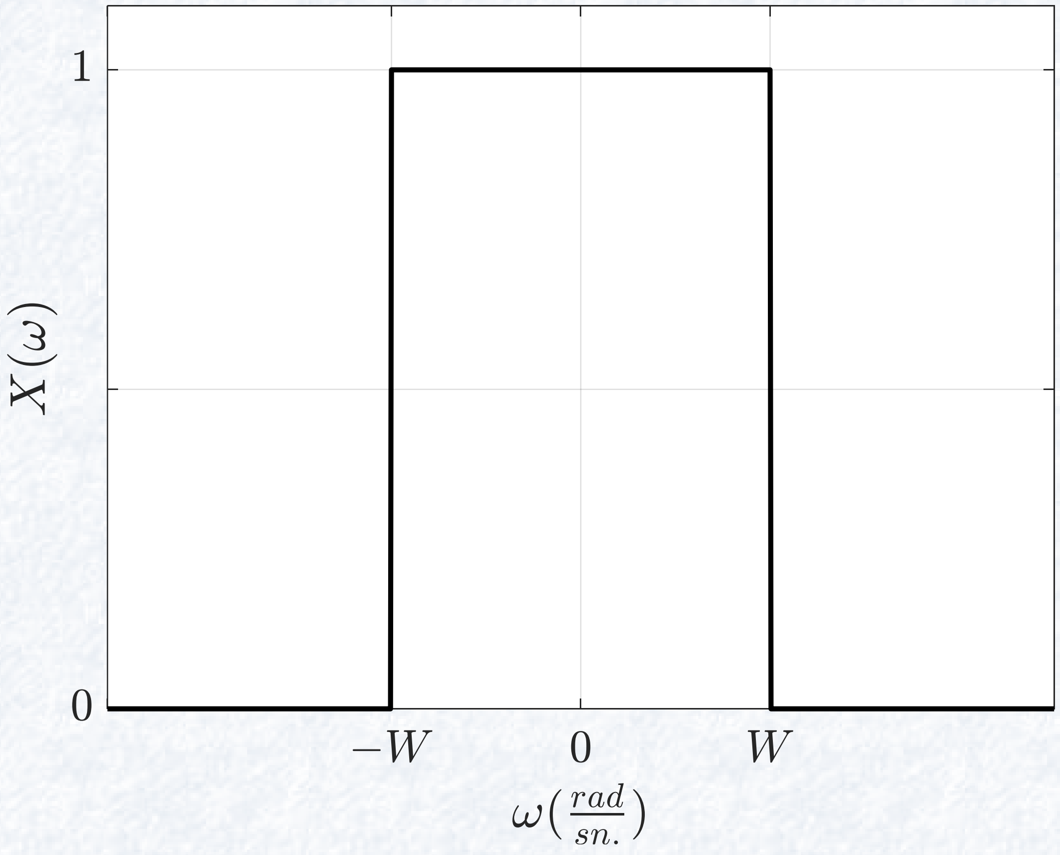
- $x(t) = \frac{1}{2\pi}\int_{-W}^{W} e^{j\omega t}d\omega$
- $x(t) = \frac{1}{2\pi}\frac{1}{jt}e^{j\omega t}\Big|_{-W}^{W}$
- $x(t) =$



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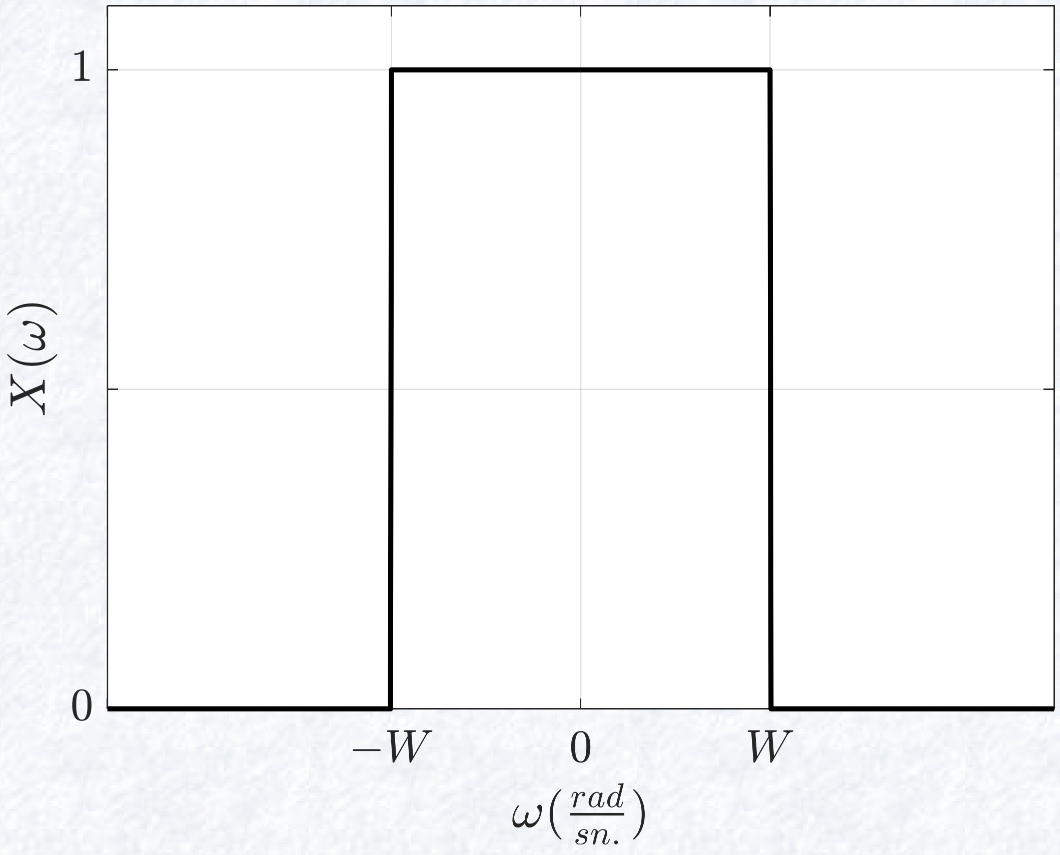
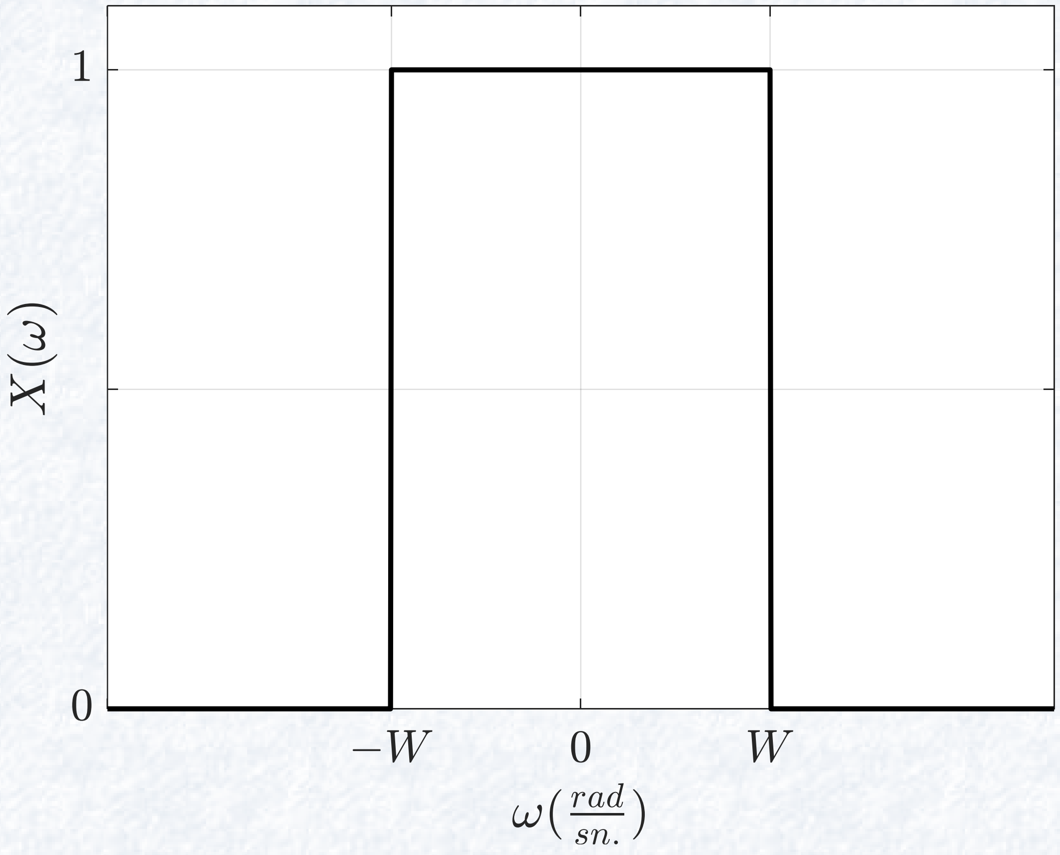
- $x(t) = \frac{1}{2\pi}\frac{1}{jt}\left(e^{jWt} - e^{-jWt}\right)$
- $x(t) =$



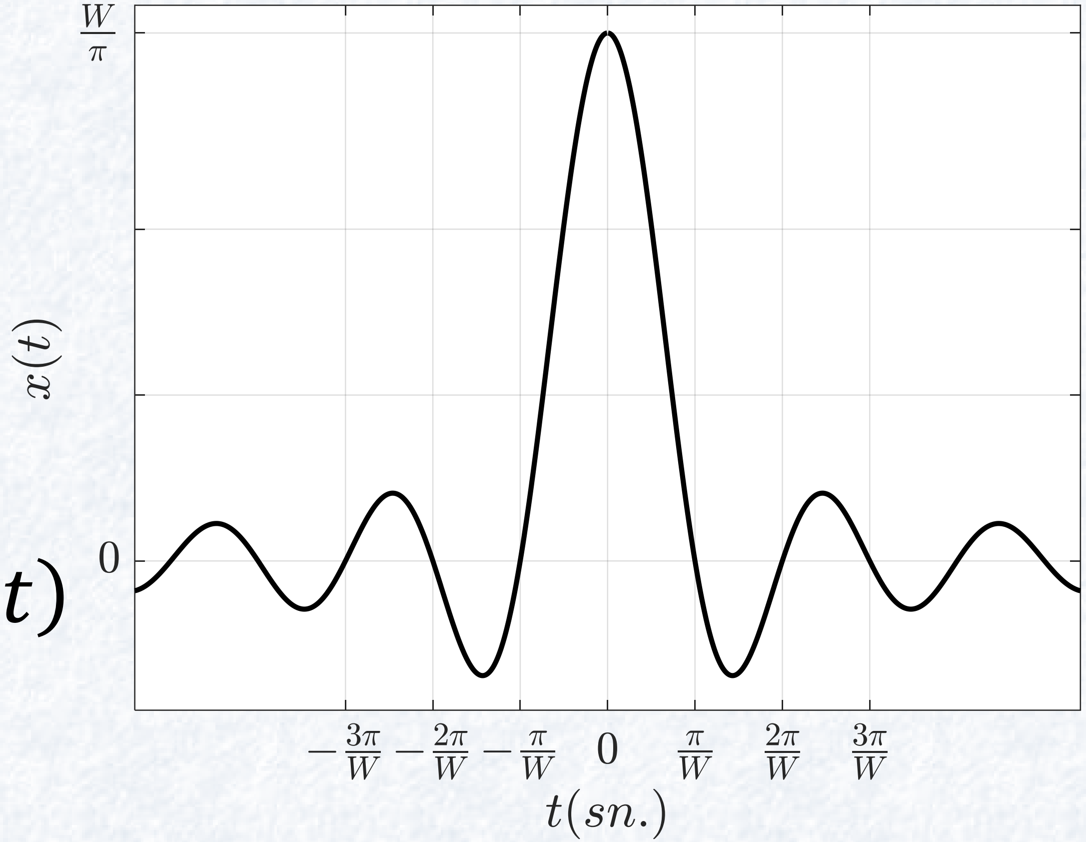
Örnek 5

- $X(\omega) = \begin{cases} 1, & |\omega| \leq W \\ 0, & |\omega| > W \end{cases}$ ise $x(t) = ?$
- $x(t) = \frac{1}{2\pi}\frac{1}{jt} e^{j\omega t}\Big|_{-W}^{W}$
- $x(t) = \frac{1}{2\pi}\frac{1}{jt}\left(e^{jWt} - e^{-jWt}\right)$
- $x(t) = \frac{1}{\pi t}\frac{e^{jWt} - e^{-jWt}}{2j} =$



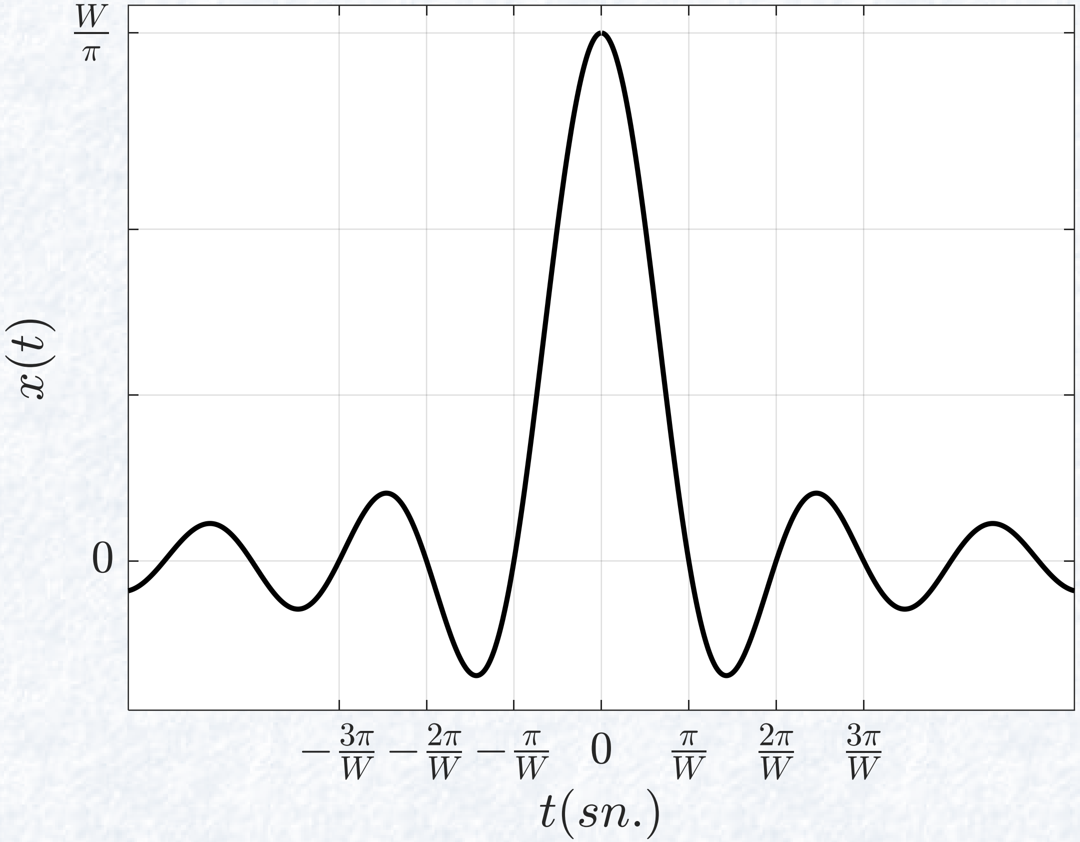
Örnek 5

- $X(\omega) = \begin{cases} 1, & |\omega| \leq W \\ 0, & |\omega| > W \end{cases}$ ise $x(t) =?$
- $x(t) = \frac{1}{2\pi}\frac{1}{jt}e^{j\omega t}\Big|_{-W}^{W}$
- $x(t) = \frac{1}{2\pi}\frac{1}{jt}\left(e^{jWt} - e^{-jWt}\right)$
- $x(t) = \frac{1}{\pi t}\frac{e^{jWt} - e^{-jWt}}{2j} = \frac{1}{\pi t}\sin(Wt)$

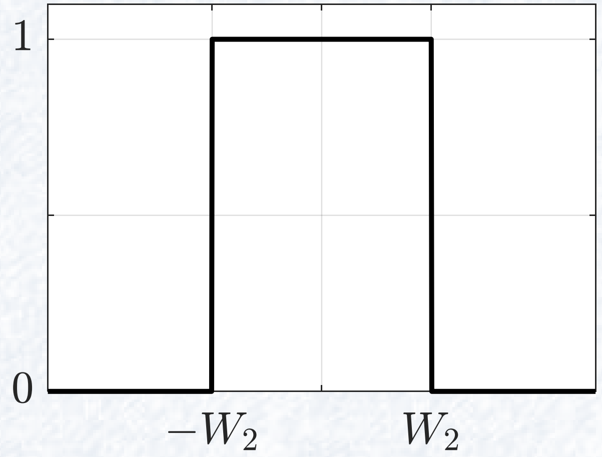


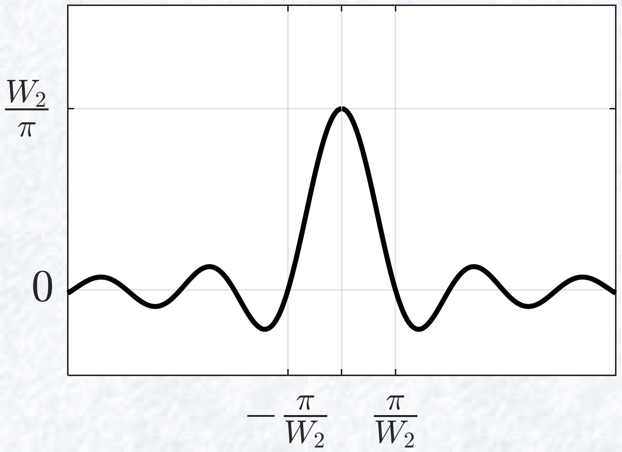
Örnek 5

- $X(\omega) = \begin{cases} 1, & |\omega| \leq W \\ 0, & |\omega| > W \end{cases}$ ise $x(t) =?$
- $x(t) = \dfrac{1}{\pi t}\sin(Wt)$
- Frekansta sınırlı
- Zamanda sınırsız

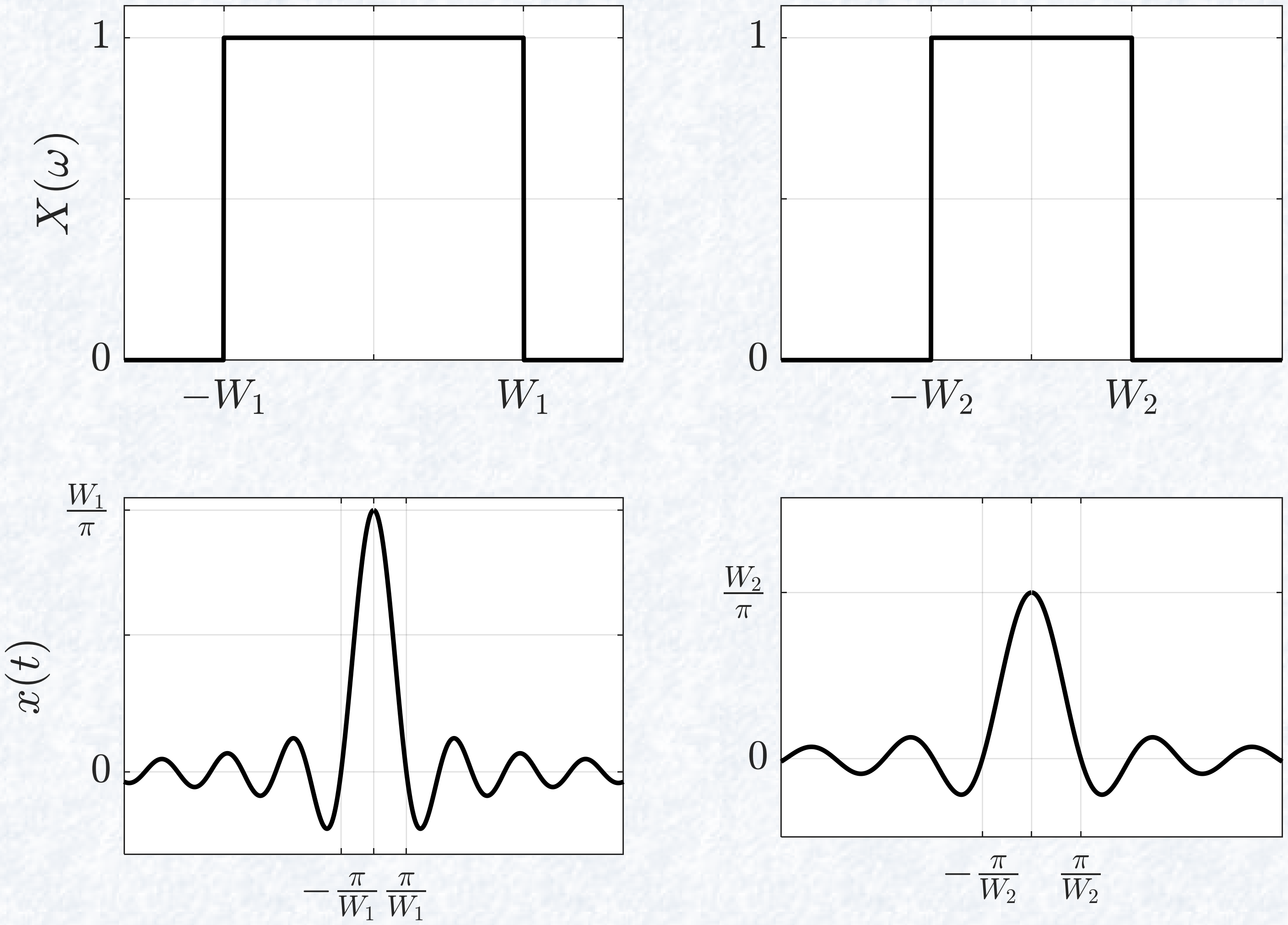


Örnek 5



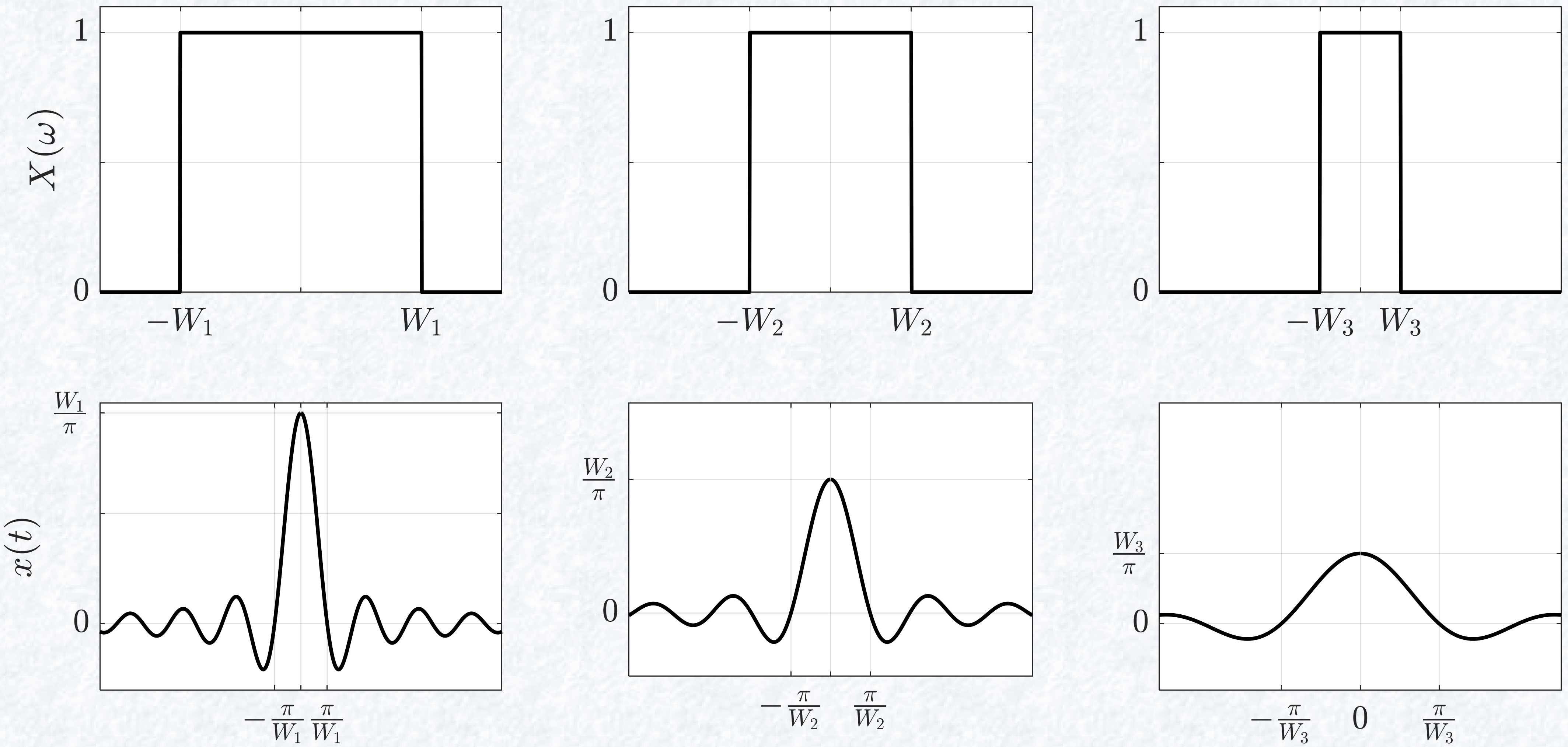


Örnek 5



1
0
$X(\omega)$
$-W_1$
W_1
1
0
$-W_2$
W_2
$\frac{W_1}{\pi}$
0
$x(t)$
$-\frac{\pi}{W_1}$ $\frac{\pi}{W_1}$
$\frac{W_2}{\pi}$
0
$-\frac{\pi}{W_2}$ $\frac{\pi}{W_2}$

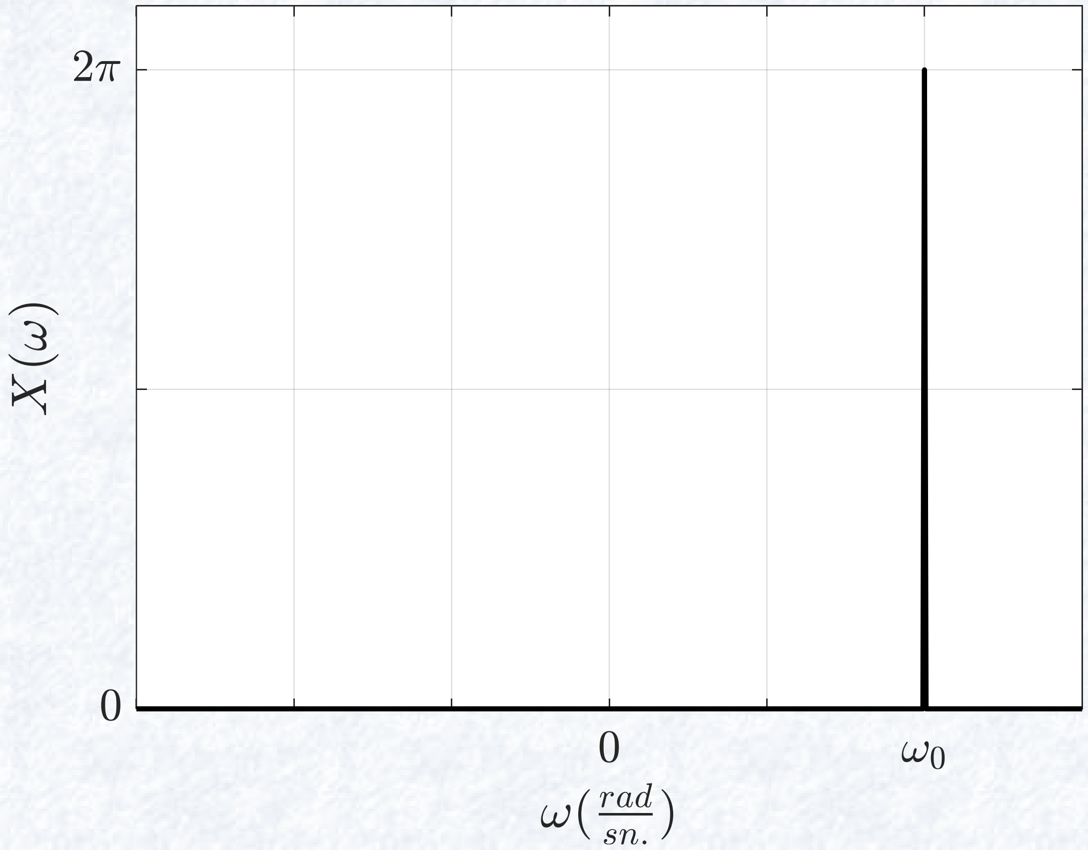
Örnek 5



$X(\omega)$
1
0
$-W_1$
W_1
1
0
$-W_2$
W_2
1
0
$-W_3$
W_3
$x(t)$
$\frac{W_1}{\pi}$
0
$-\frac{\pi}{W_1}$ $\frac{\pi}{W_1}$
$\frac{W_2}{\pi}$
0
$-\frac{\pi}{W_2}$ $\frac{\pi}{W_2}$
$\frac{W_3}{\pi}$
0
$-\frac{\pi}{W_3}$ 0 $\frac{\pi}{W_3}$

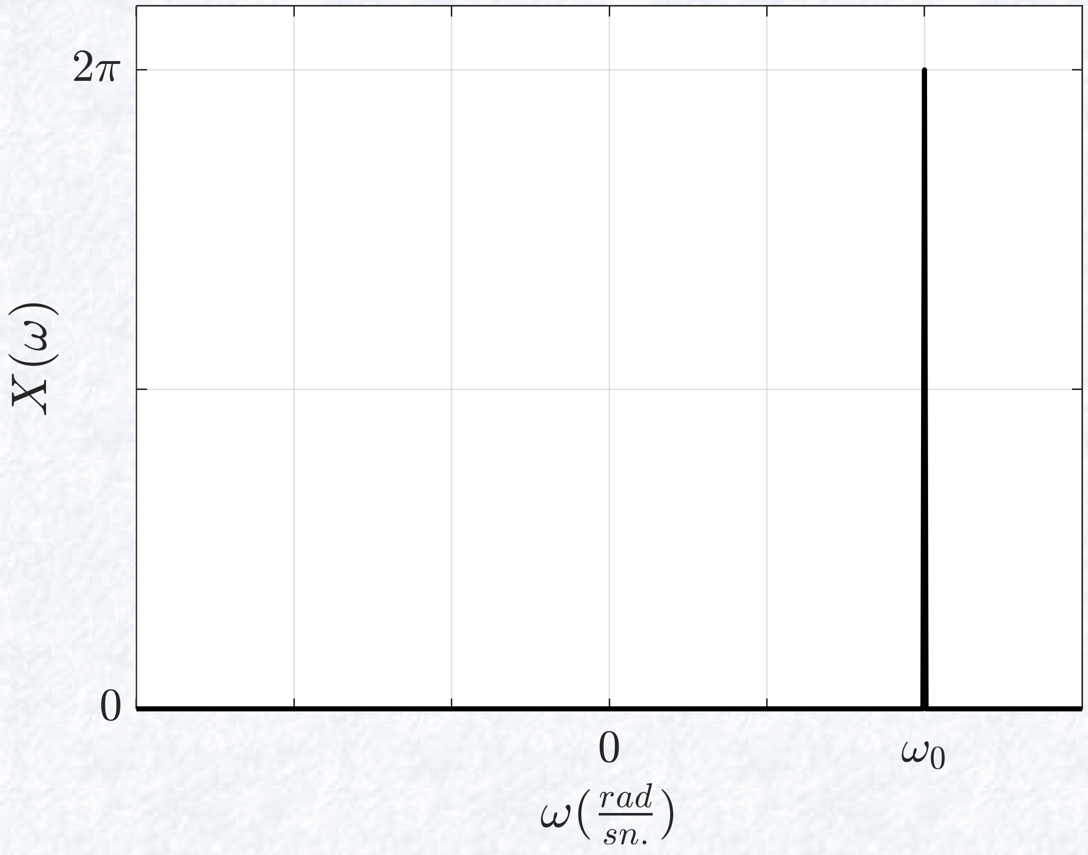
Örnek 6

- $X(\omega) = ?$



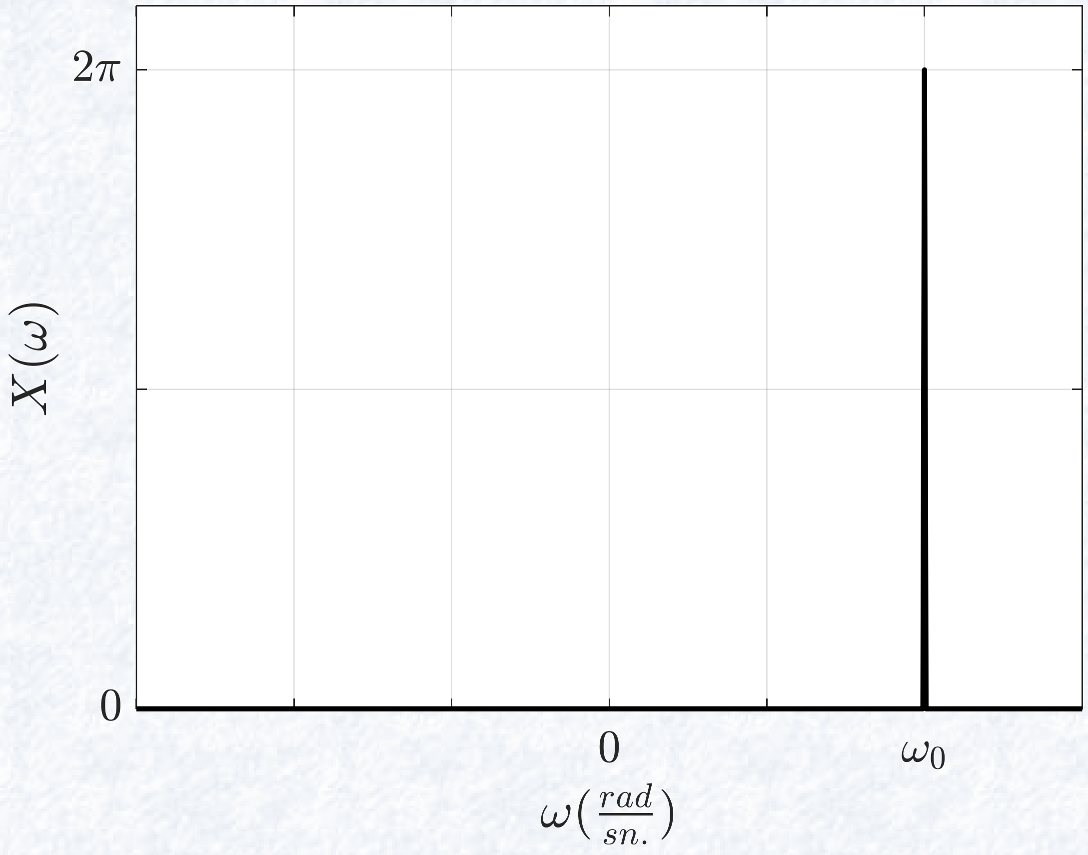
Örnek 6

- $X(\omega) = 2\pi\delta(\quad)$



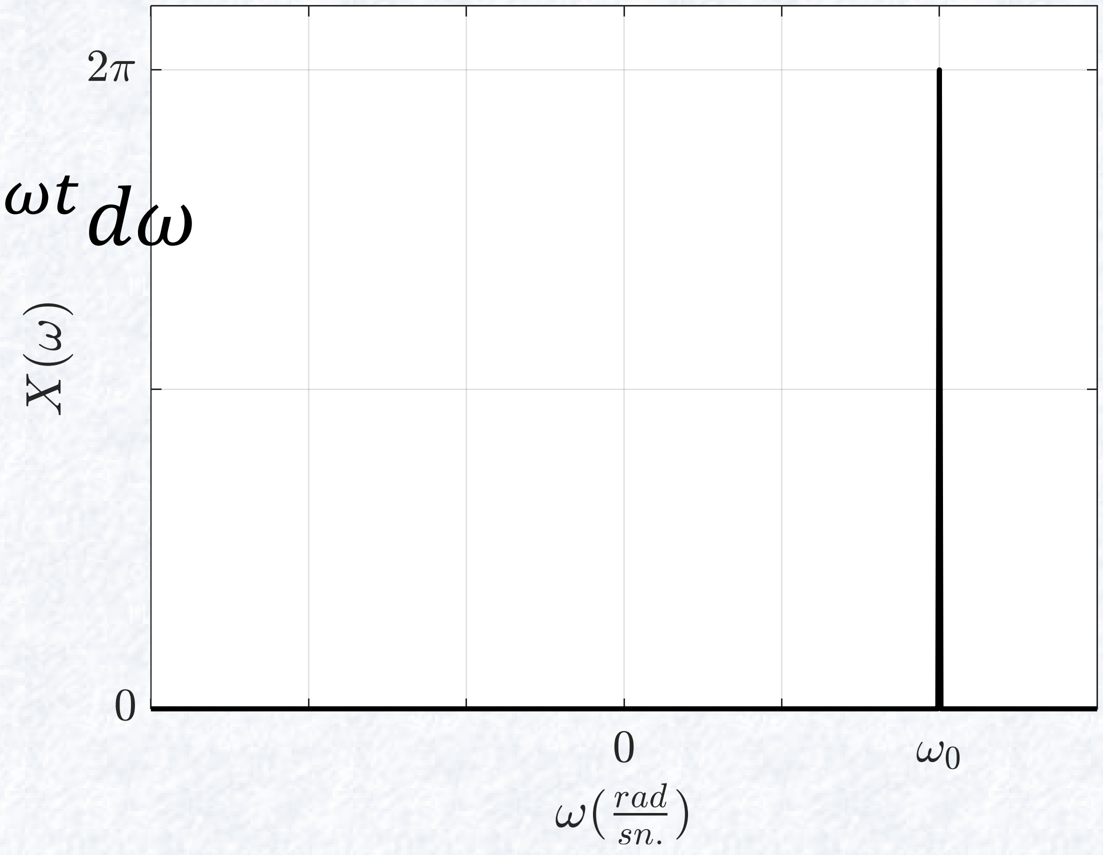
Örnek 6

- $X(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x(t) =$



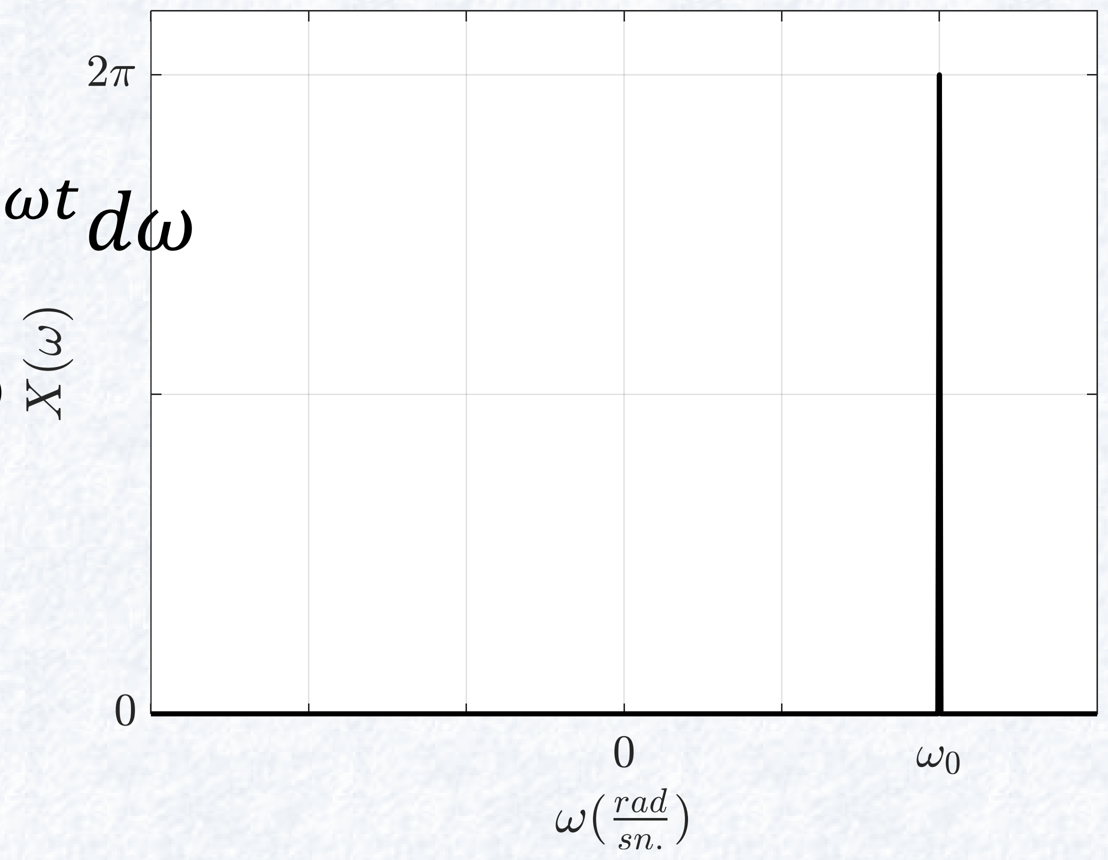
Örnek 6

- $X(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} 2\pi\delta(\omega - \omega_0)e^{j\omega t}d\omega$



Örnek 6

- $X(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} 2\pi\delta(\omega - \omega_0)e^{j\omega t}d\omega$
- $x(t) = \int_{-\infty}^{\infty} \delta(\omega - \omega_0)e^{j\omega t}d\omega$
- $x(t) =$



Örnek 6

- $X(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$
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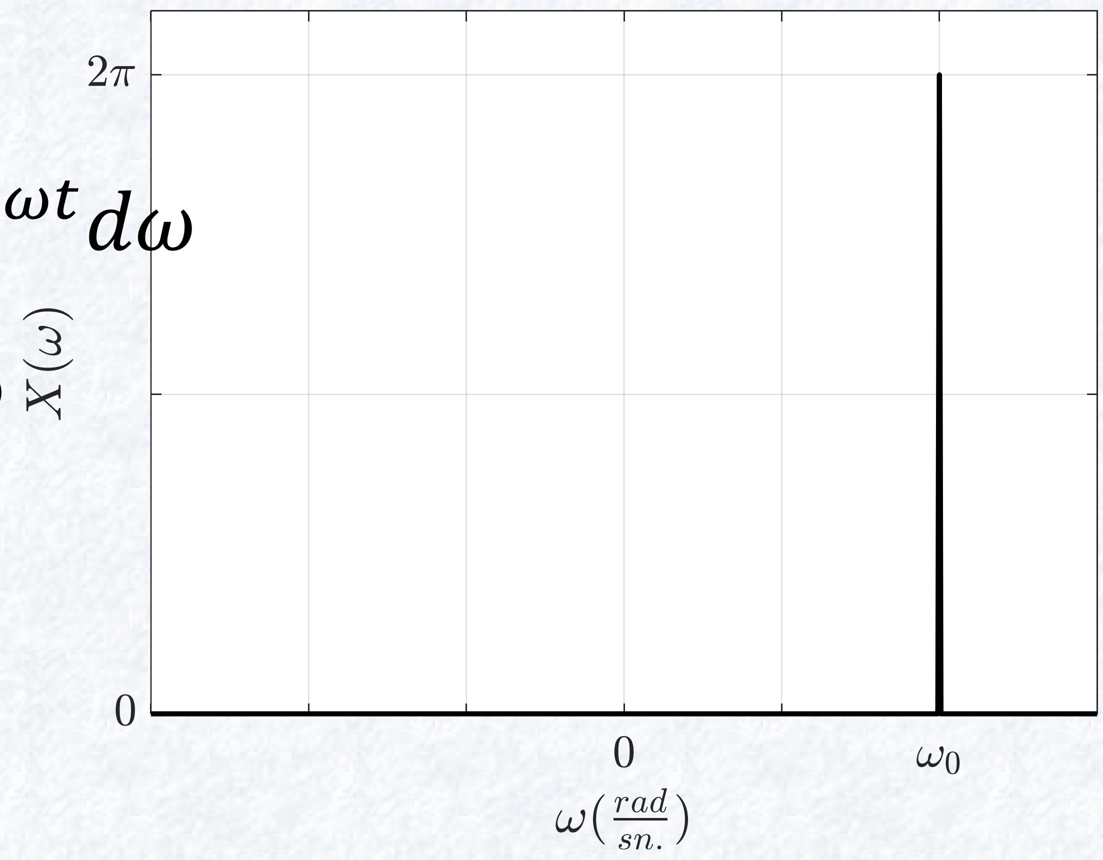
- $x(t) = \int_{-\infty}^{\infty} \delta(\omega - \omega_0)e^{j\omega t}d\omega$
- $x(t) = e^{j\omega_0 t}$



Örnek 6

- $X(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}d\omega$
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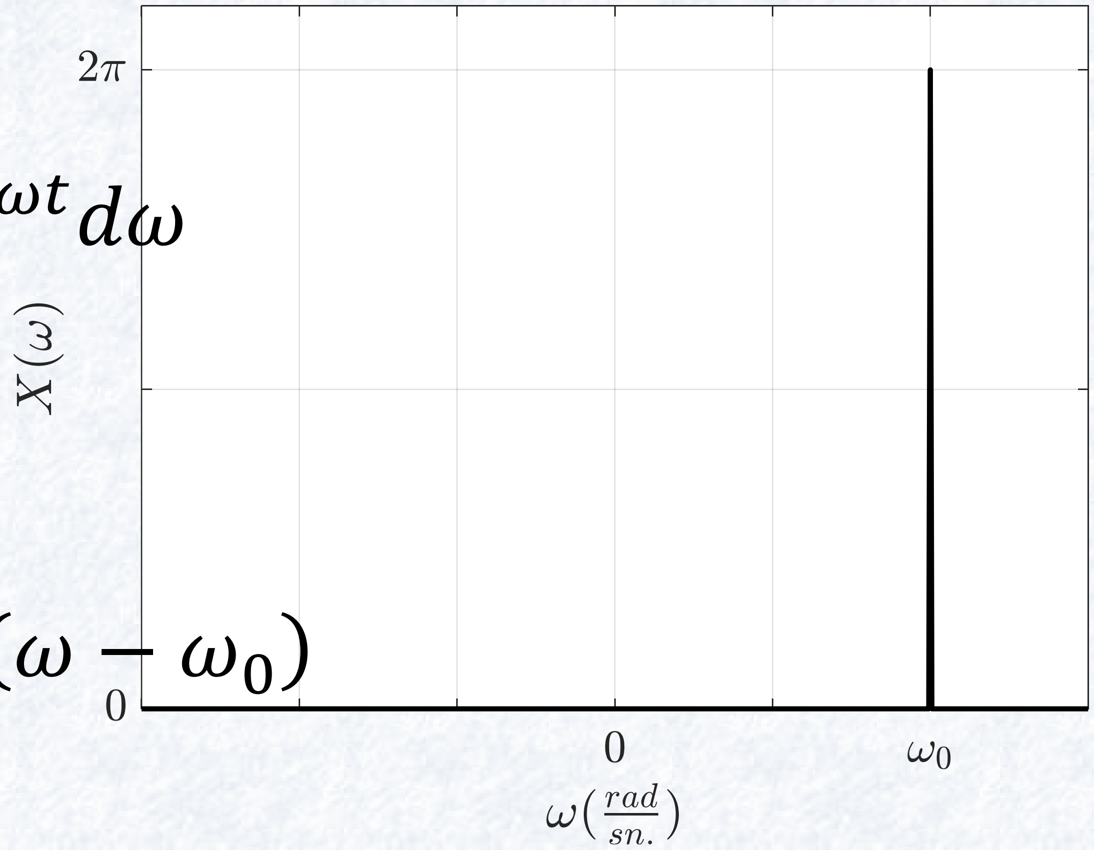
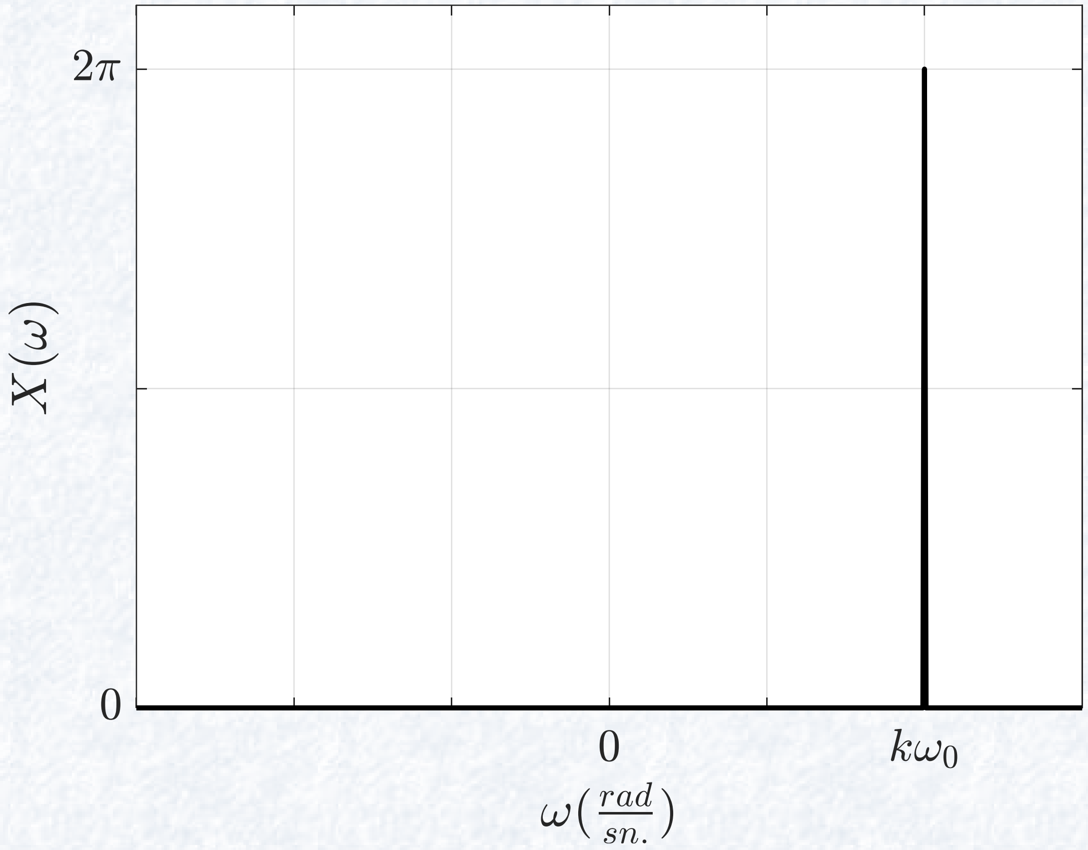
- $x(t) = \int_{-\infty}^{\infty} \delta(\omega - \omega_0)e^{j\omega t}d\omega$
- $x(t) = e^{j\omega_0 t}$
- $x(t) = e^{j\omega_0 t} \leftrightarrow X(\omega) = 2\pi\delta(\omega - \omega_0)$



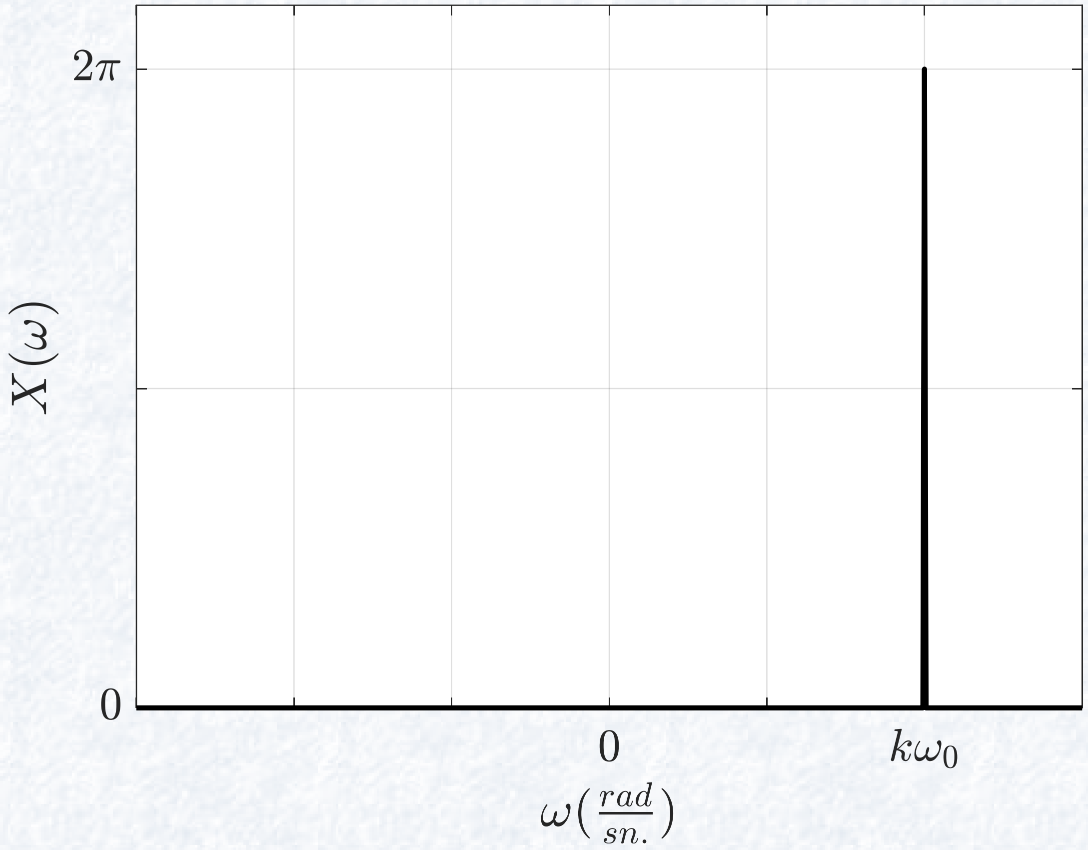
Örnek 7

- $X(\omega) =$



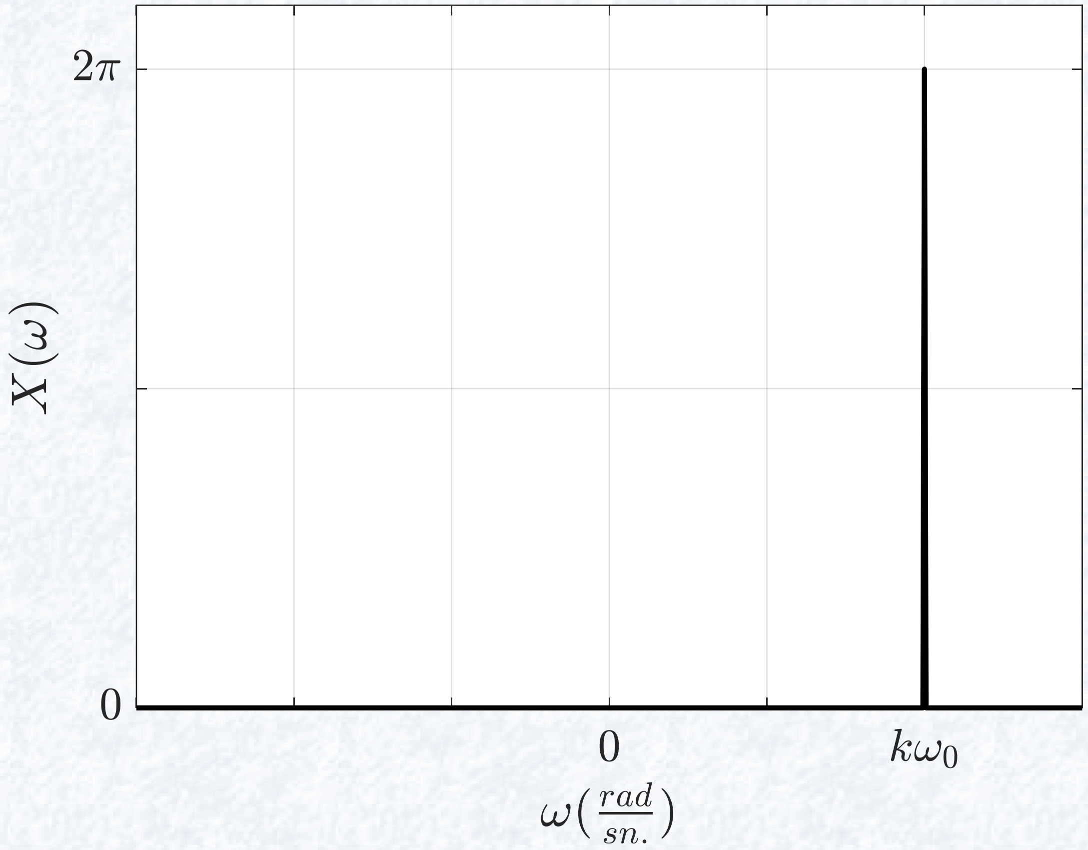
Örnek 7

- $X(\omega) = 2\pi\delta(\omega - k\omega_0) \leftrightarrow x(t) =$



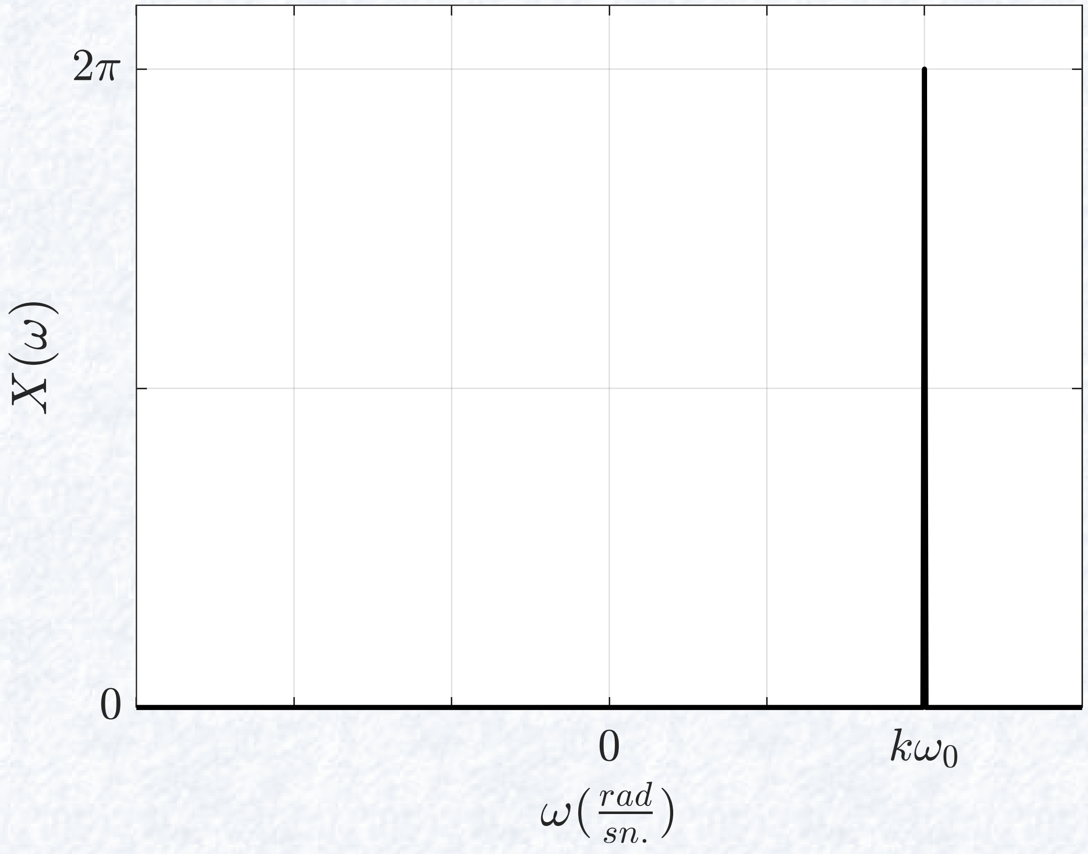
Örnek 7

- $X(\omega) = 2\pi\delta(\omega - k\omega_0) \leftrightarrow x(t) = e^{jk\omega_0 t}$



Örnek 7

- $X(\omega) = 2\pi\delta(\omega - k\omega_0) \leftrightarrow x(t) = e^{jk\omega_0 t}$
- Fourier Seri Açılımı



Fourier Seri Açılımı

- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$

Fourier Seri Açılımı

- $x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$
- $\mathcal{F}\{x(t)\} = \mathcal{F}\left\{\sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}\right\}$

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Fourier Seri Açılımı

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- $\mathcal{F}\{x(t)\} = \sum_{k=-\infty}^{\infty} a_k \mathcal{F}\left\{e^{jk\omega_0 t}\right\}$
- $\mathcal{F}\{x(t)\} = \sum_{k=-\infty}^{\infty} a_k 2\pi\delta(\omega - k\omega_0)$
- $X(\omega) = \sum_{k=-\infty}^{\infty} 2\pi a_k \delta(\omega - k\omega_0)$

Fourier Dönüşüm Özellikleri

- Doğrusallık
- $x(t) \leftrightarrow X(\omega)$ ve
- $y(t) \leftrightarrow Y(\omega)$ olduğu biliniyorsa

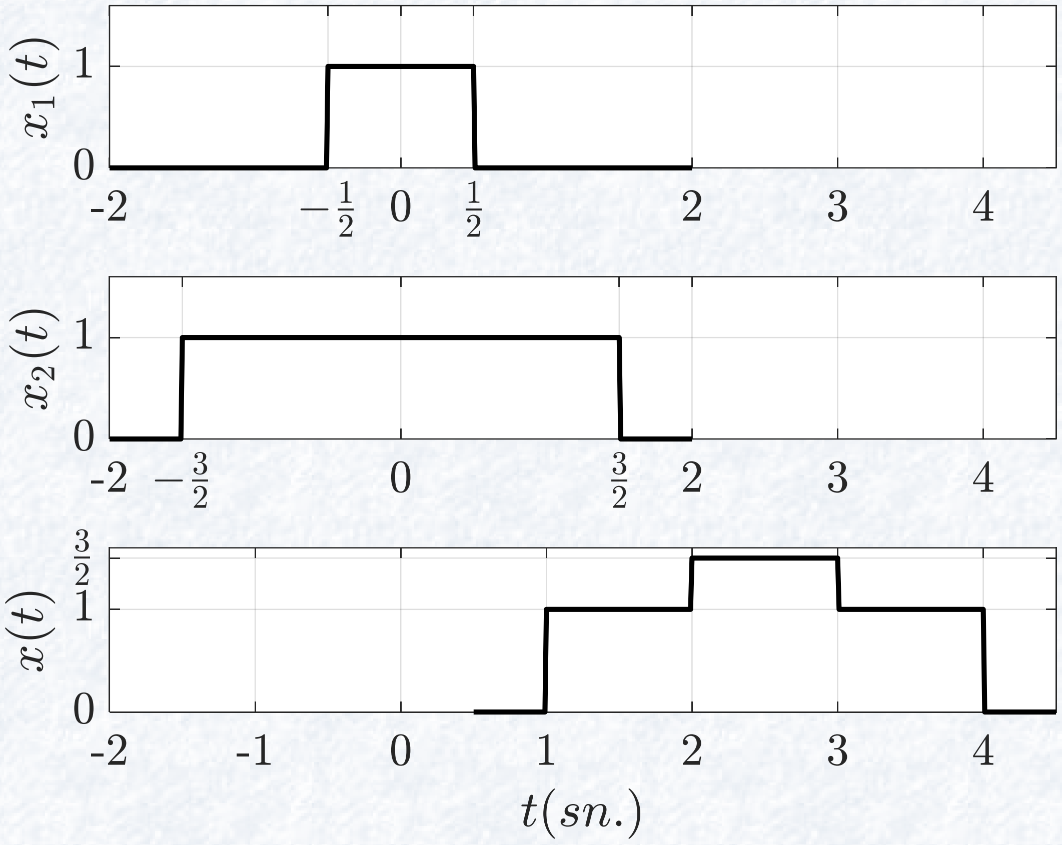
- $z(t) = ax(t) + by(t)$ ise
- $\mathcal{F}\{z(t)\} = a\mathcal{F}\{x(t)\} + b\mathcal{F}\{y(t)\}$
- $Z(\omega) = aX(\omega) + bY(\omega)$

Fourier Dönüşüm Özellikleri

- Zamanda Öteleme
- $x(t) \;\leftrightarrow X(\omega)$ olduğu biliniyorsa
- $\mathcal{F}\{x(t-t_0)\} = e^{-j\omega t_0}X(\omega)$

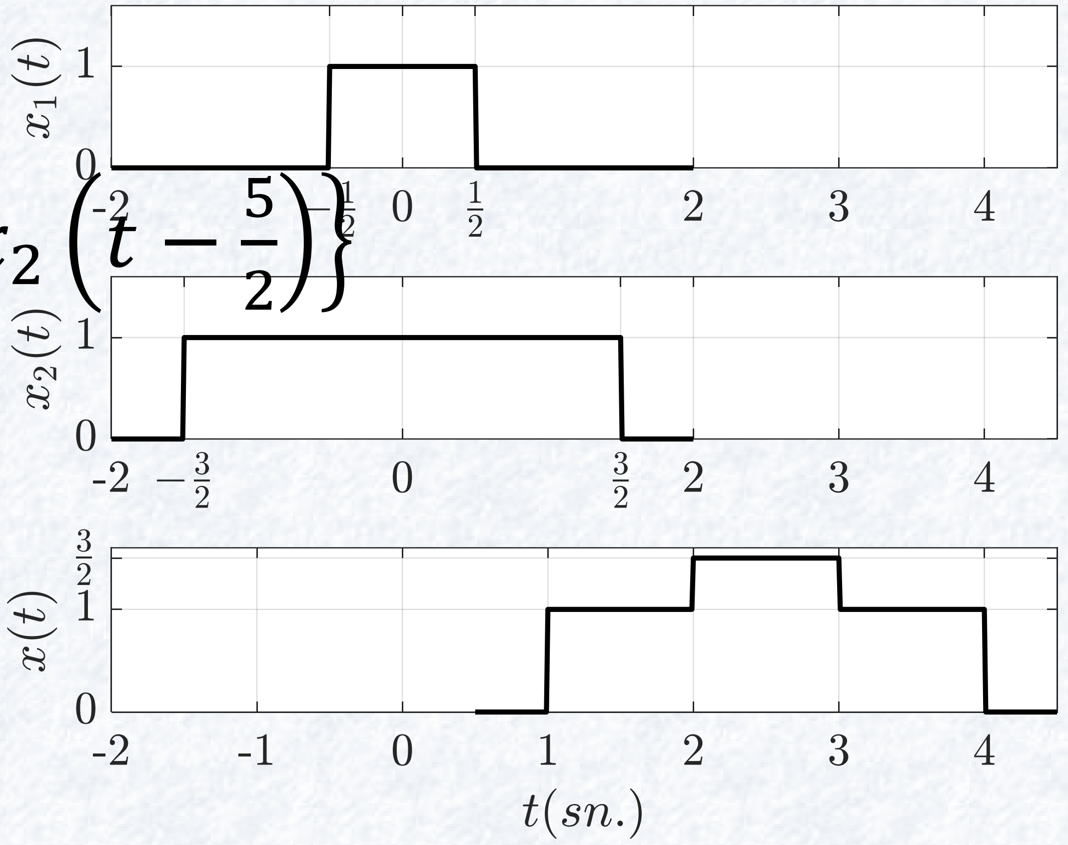
Örnek 8

- $x(t) = \frac{1}{2}x_1\left(t - \frac{5}{2}\right) + x_2\left(t - \frac{5}{2}\right)$
- $X(\omega) = ?$



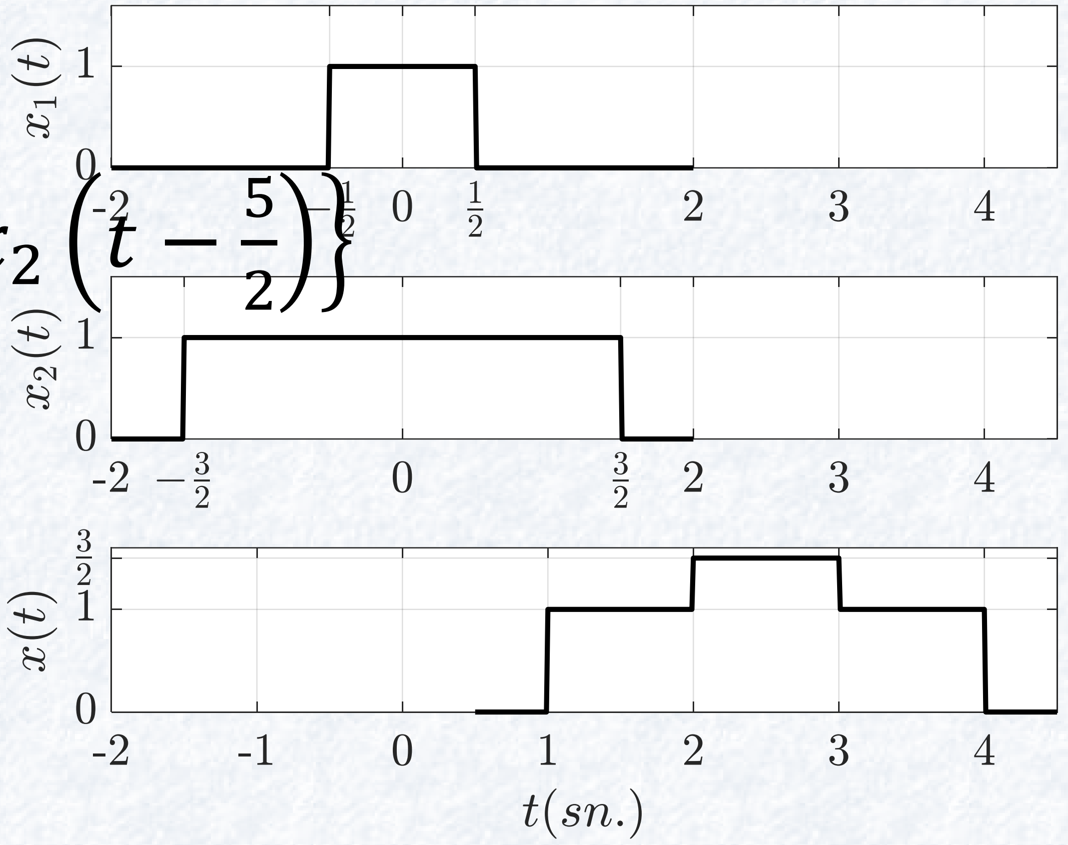
Örnek 8

- $x(t) = \frac{1}{2}x_1\left(t-\frac{5}{2}\right) + x_2\left(t-\frac{5}{2}\right)$
- $X(\omega) = ?$
- $X(\omega) = \frac{1}{2}\mathcal{F}\left\{x_1\left(t-\frac{5}{2}\right)\right\} + \mathcal{F}\left\{x_2\left(t-\frac{5}{2}\right)\right\}$
  - ♦ $\mathcal{F}\left\{x_1\left(t-\frac{5}{2}\right)\right\} =$



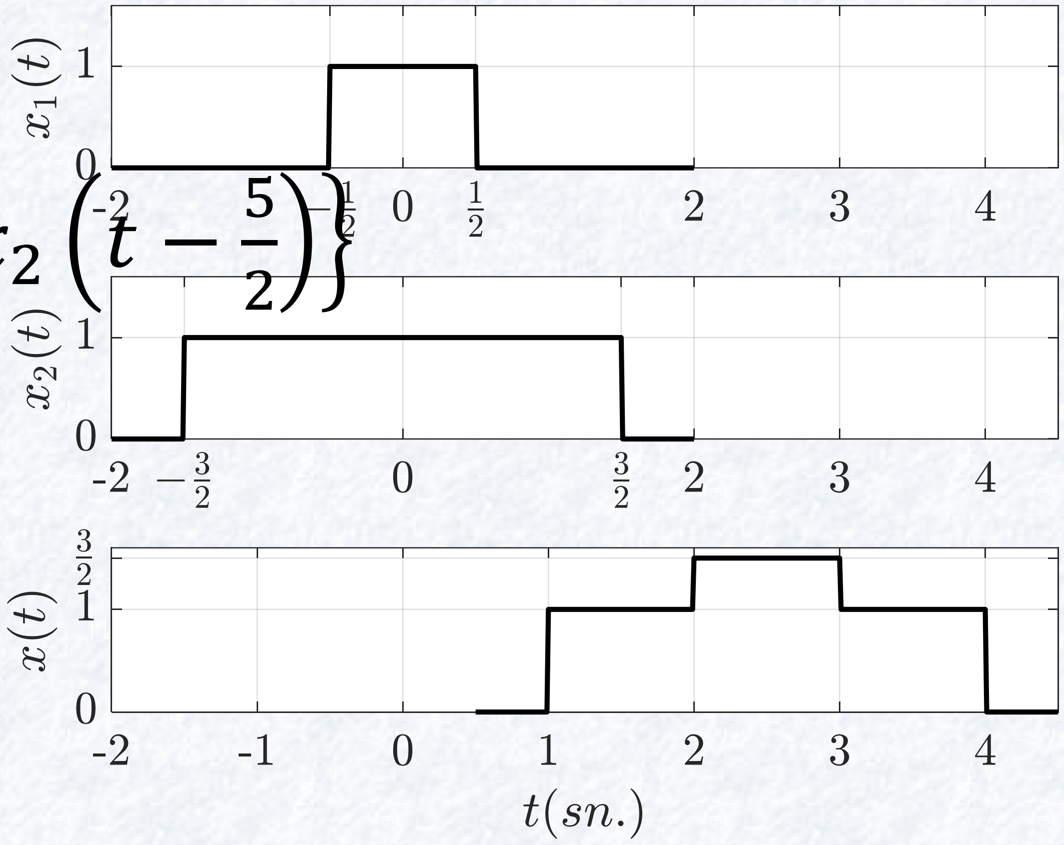
Örnek 8

- $x(t) = \frac{1}{2} x_1\left(t - \frac{5}{2}\right) + x_2\left(t - \frac{5}{2}\right)$
- $X(\omega) = ?$
- $X(\omega) = \frac{1}{2}\mathcal{F}\left\{x_1\left(t - \frac{5}{2}\right)\right\} + \mathcal{F}\left\{x_2\left(t - \frac{5}{2}\right)\right\}$
    - ♦ $\mathcal{F}\left\{x_1\left(t - \frac{5}{2}\right)\right\} = e^{-j\omega\frac{5}{2}} X_1(\omega)$
    - ♦ $\mathcal{F}\left\{x_2\left(t - \frac{5}{2}\right)\right\} =$



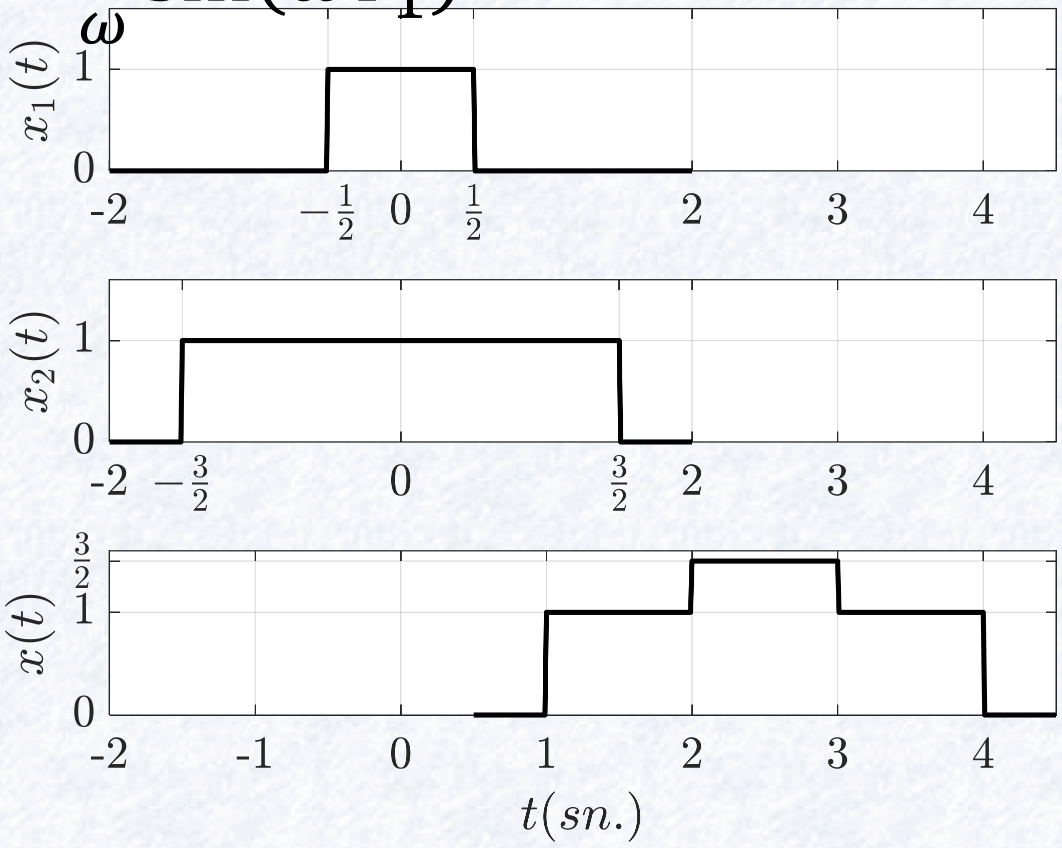
Örnek 8

- $x(t) = \frac{1}{2}x_1\left(t-\frac{5}{2}\right) + x_2\left(t-\frac{5}{2}\right)$
- $X(\omega) = ?$
- $X(\omega) = \frac{1}{2}\mathcal{F}\left\{x_1\left(t-\frac{5}{2}\right)\right\} + \mathcal{F}\left\{x_2\left(t-\frac{5}{2}\right)\right\}$
  - $\mathcal{F}\left\{x_1\left(t-\frac{5}{2}\right)\right\} = e^{-j\omega\frac{5}{2}}X_1(\omega)$
  - $\mathcal{F}\left\{x_2\left(t-\frac{5}{2}\right)\right\} = e^{-j\omega\frac{5}{2}}X_2(\omega)$



Örnek 8

- $x(t) = \begin{cases} 1, & |t| \leq T_1 \\ 0, & |t| > T_1 \end{cases} \leftrightarrow X(\omega) = \frac{2}{\omega}\sin(\omega T_1)$
- $X_1(\omega) = ?$



Örnek 8

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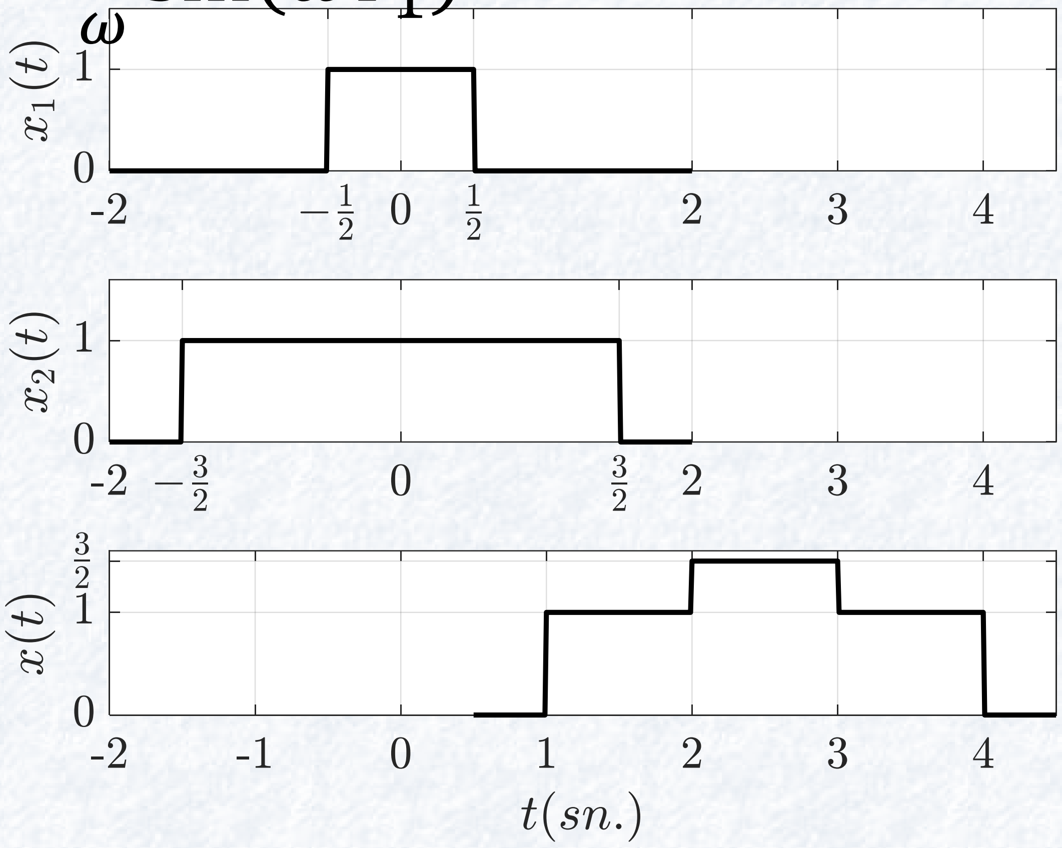
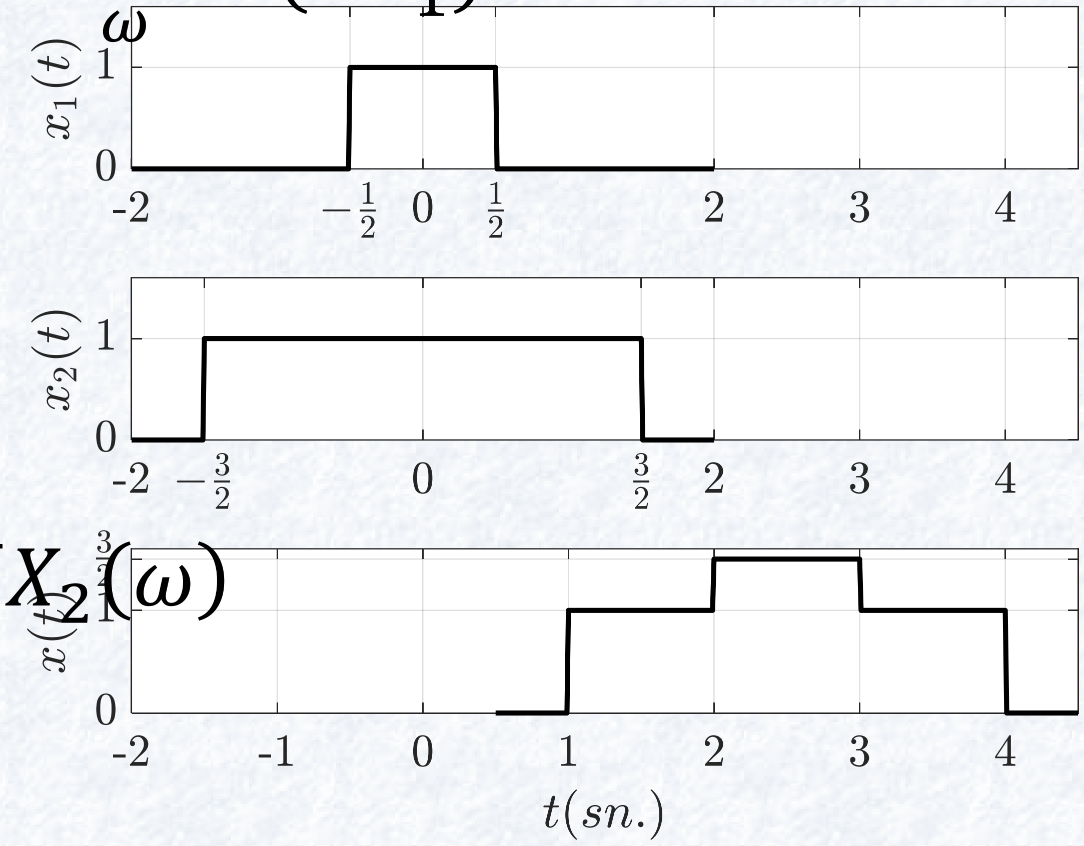
- $X_1(\omega) = \frac{2}{\omega}\sin\left(\omega\frac{1}{2}\right)$
- $X_2(\omega) =$



Örnek 8

- $x(t) = \begin{cases} 1, & |t| \leq T_1 \\ 0, & |t| > T_1 \end{cases} \leftrightarrow X(\omega) = \frac{2}{\omega}\sin(\omega T_1)$
- $X_1(\omega) = \frac{2}{\omega}\sin\left(\omega\frac{1}{2}\right)$
- $X_2(\omega) = \frac{2}{\omega}\sin\left(\omega\frac{3}{2}\right)$
- $X(\omega) = \frac{1}{2}e^{-j\omega\frac{5}{2}}X_1(\omega) + e^{-j\omega\frac{5}{2}}X_2(\omega)$
- $X(\omega) =$



Örnek 8

- $x(t) = \begin{cases} 1, & |t| \leq T_1 \\ 0, & |t| > T_1 \end{cases} \leftrightarrow X(\omega) = \frac{2}{\omega}\sin(\omega T_1)$
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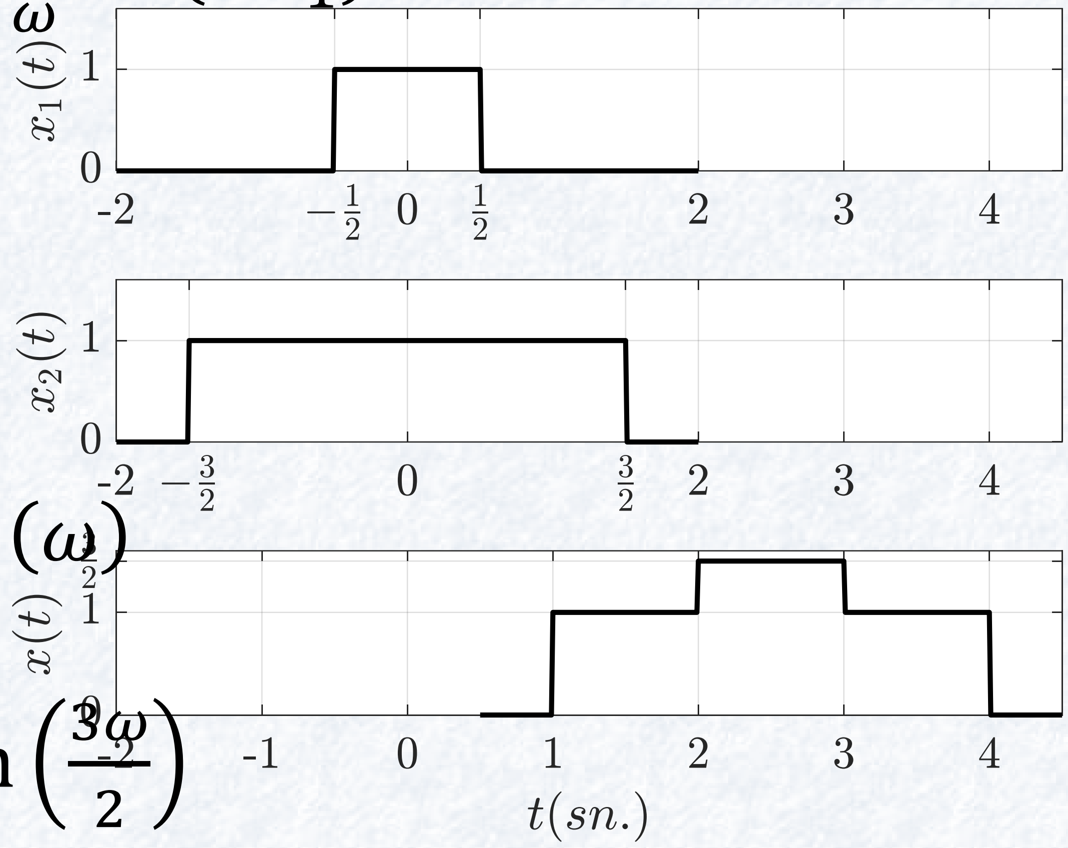
- $X_2(\omega) = \frac{2}{\omega}\sin\left(\omega\frac{3}{2}\right)$
- $X(\omega) = \frac{1}{2}e^{-j\omega\frac{5}{2}}X_1(\omega) + e^{-j\omega\frac{5}{2}}X_2(\omega)$
- $X(\omega) = \frac{e^{-j\omega\frac{5}{2}}}{\omega}\sin\left(\frac{\omega}{2}\right) + \frac{2e^{-j\omega\frac{5}{2}}}{\omega}\sin\left(\frac{3\omega}{2}\right)$



Fourier Dönüşüm Özellikleri

- Zamanda Ters Çevirme
- $x(t) \leftrightarrow X(\omega)$ olduğu biliniyorsa
- $\mathcal{F}\{x(-t)\} = X(-\omega)$

Örnek 9

- $x(t) = e^{at}u(-t)$ ise $X(\omega) =?$

Örnek 9

- $x(t) = e^{at}u(-t)$ ise $X(\omega) =?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) =$

Örnek 9

- $x(t) = e^{at}u(-t)$ ise $X(\omega) =?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(\quad)$

Örnek 9

- $x(t) = e^{at}u(-t)$ ise $X(\omega) =?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(-t)$
- $X(\omega) =$

Örnek 9

- $x(t) = e^{at}u(-t)$ ise $X(\omega) = ?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(-t)$
- $X(\omega) = X_1(-\omega) = \frac{1}{a-j\omega}$

Fourier Dönüşüm Özellikleri

- Zamanda Türev ve İntegral
- $x(t) \;\leftrightarrow X(\omega)$ olduğu biliniyorsa

- $\mathcal{F}\left\{\frac{\partial x(t)}{\partial t}\right\} = j\omega X(\omega)$

Fourier Dönüşüm Özellikleri

- Zamanda İntegral
- $x(t) \leftrightarrow X(\omega)$ olduğu biliniyorsa
- $\mathcal{F}\{\int x(t)dt\} = \frac{1}{j\omega}X(\omega) + \pi X(0)\delta(\omega)$

Fourier Dönüşüm Özellikleri

- Zamanda Ölçekleme
- $x(t) \leftrightarrow X(\omega)$ olduğu biliniyorsa
- $\mathcal{F}\{x(at)\} = \frac{1}{|a|} X\left(\frac{\omega}{a}\right)$

Örnek 10

- $x(t) = e^{-2at}u(t)$ ise $X(\omega) =?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(\quad)$

Örnek 10

- $x(t) = e^{-2at}u(t)$ ise $X(\omega) = ?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(2t)$
- $X(\omega) =$

Örnek 10

- $x(t) = e^{-2at}u(t)$ ise $X(\omega) = ?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(2t)$
- $X(\omega) = \frac{1}{2}X_1\left(\frac{\omega}{2}\right) = \frac{1}{2}\frac{1}{a+j\frac{\omega}{2}} = \frac{1}{2a+j\omega}$

Fourier Dönüşüm Özellikleri

- Frekansta Ölçekleme
- $x(t) \leftrightarrow X(\omega)$ olduğu biliniyorsa
- $\mathcal{F}\left\{\frac{1}{|a|}x\left(\frac{t}{a}\right)\right\} = X(a\omega)$

Fourier Dönüşüm Özellikleri

- Frekansta Türev
- $x(t) \leftrightarrow X(\omega)$ olduğu biliniyorsa
- $\mathcal{F}\{tx(t)\} = j\dfrac{\partial X(\omega)}{\partial \omega}$

Örnek 11

- $x(t) = te^{-at}u(t)$ ise $X(\omega) = ?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = x_1(\quad)$

Örnek 11

- $x(t) = te^{-at}u(t)$ ise $X(\omega) = ?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = tx_1(t)$
- $X(\omega) =$

Örnek 11

- $x(t) = te^{-at}u(t)$ ise $X(\omega) =?$
- $x_1(t) = e^{-at}u(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{1}{a+j\omega}$
- $x(t) = tx_1(t)$
- $X(\omega) = j\frac{\partial X_1(\omega)}{\partial \omega} = \frac{1}{(a+j\omega)^2}$

Fourier Dönüşüm Özellikleri

- Çift Taraflılık
- $x(t) \leftrightarrow X(\omega)$ olduğu biliniyorsa

- $\mathcal{F}\{X(t)\} = 2\pi x(-\omega)$

Örnek 12

- $x(t) = 1$ ise $X(\omega) =?$
- $x_1(t) = \delta(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 1$
- $x(t) = X_1(\quad)$

Örnek 12

- $x(t) = 1$ ise $X(\omega) =?$
- $x_1(t) = \delta(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 1$
- $x(t) = X_1(t) = 1$
- $X(\omega) =$

Örnek 12

- $x(t) = 1$ ise $X(\omega) =?$
- $x_1(t) = \delta(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 1$
- $x(t) = X_1(t) = 1$
- $X(\omega) = 2\pi x_1(-\omega) = 2\pi\delta(-\omega) = 2\pi\delta(\omega)$

Örnek 13

- $x(t) = \delta(t-a)$ ise $X(\omega) =?$
- 1. yol: zamanda öteleme
- $x_1(t) = \delta(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 1$
- $x(t) = x_1(\quad)$

Örnek 13

- $x(t) = \delta(t-a)$ ise $X(\omega) = ?$
- 1. yol: zamanda öteleme
- $x_1(t) = \delta(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 1$
- $x(t) = x_1(t-a) = \delta(t-a)$
- $X(\omega) =$

Örnek 13

- $x(t) = \delta(t-a)$ ise $X(\omega) = ?$
- 1. yol: zamanda öteleme
- $x_1(t) = \delta(t) \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 1$
- $x(t) = x_1(t-a) = \delta(t-a)$
- $X(\omega) = e^{-j\omega a} X_1(\omega) = e^{-j\omega a}$

Örnek 13

- $x(t) = \delta(t - a)$ ise $X(\omega) =?$
- 2. yol: çift taraflılık
- $x_1(t) = e^{j\omega_0 t} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x_2(t) = e^{jat} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) =$

Örnek 13

- $x(t) = \delta(t - a)$ ise $X(\omega) = ?$
- 2. yol: çift taraflılık
- $x_1(t) = e^{j\omega_0 t} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x_2(t) = e^{jat} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) = 2\pi\delta(\omega - a)$
- $x(t) = X_2(\quad)$

Örnek 13

- $x(t) = \delta(t-a)$ ise $X(\omega) = ?$
- 2. yol: çift taraflılık
- $x_1(t) = e^{j\omega_0 t} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x_2(t) = e^{jat} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) = 2\pi\delta(\omega - a)$
- $x(t) = \frac{1}{2\pi} X_2(t) = \delta(t-a)$
- $X(\omega) =$

Örnek 13

- $x(t) = \delta(t-a)$ ise $X(\omega) = ?$
- 2. yol: çift taraflılık
- $x_1(t) = e^{j\omega_0 t} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = 2\pi\delta(\omega - \omega_0)$
- $x_2(t) = e^{jat} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) = 2\pi\delta(\omega - a)$
- $x(t) = \frac{1}{2\pi} X_2(t) = \delta(t-a)$
- $X(\omega) = \frac{1}{2\pi} 2\pi x_2(-\omega) = e^{-ja\omega}$

Örnek 14

- $x(t) = \dfrac{\sin(at)}{\pi t}$ ise $X(\omega) = ?$
- $x_1(t) = \begin{cases} 1, & |t| \le T_1 \\ 0, & |t| > T_1 \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \dfrac{2}{\omega}\sin(\omega T_1)$
- $x_2(t) = \begin{cases} 1, & |t| \le a \\ 0, & |t| > a \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) =$

Örnek 14

- $x(t) = \dfrac{\sin(at)}{\pi t}$ ise $X(\omega) = ?$
- $x_1(t) = \begin{cases} 1, & |t| \le T_1 \\ 0, & |t| > T_1 \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{2}{\omega}\sin(\omega T_1)$
- $x_2(t) = \begin{cases} 1, & |t| \le a \\ 0, & |t| > a \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) = \frac{2}{\omega}\sin(a\omega)$
- $x(t) = X_2(\quad)$

Örnek 14

- $x(t) = \frac{\sin(at)}{\pi t}$ ise $X(\omega) = ?$
- $x_1(t) = \begin{cases} 1, & |t| \le T_1 \\ 0, & |t| > T_1 \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{2}{\omega}\sin(\omega T_1)$
- $x_2(t) = \begin{cases} 1, & |t| \le a \\ 0, & |t| > a \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) = \frac{2}{\omega}\sin(a\omega)$
- $x(t) = \frac{1}{2\pi} X_2(t) = \frac{1}{2\pi}\frac{2}{t}\sin(at)$
- $X(\omega) =$

Örnek 14

- $x(t) = \dfrac{\sin(at)}{\pi t}$ ise $X(\omega)$ =?
- $x_1(t) = \begin{cases} 1, & |t| \leq T_1 \\ 0, & |t| > T_1 \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \dfrac{2}{\omega}\sin(\omega T_1)$
- $x_2(t) = \begin{cases} 1, & |t| \leq a \\ 0, & |t| > a \end{cases} \overset{\mathcal{F}}{\leftrightarrow} X_2(\omega) = \dfrac{2}{\omega}\sin(a\omega)$
- $x(t) = \dfrac{1}{2\pi} X_2(t) = \dfrac{1}{2\pi}\dfrac{2}{t}\sin(at)$
- $X(\omega) = \dfrac{1}{2\pi} 2\pi x_2(-\omega) = x_2(-\omega) = \begin{cases} 1, & |-\omega| \leq a \\ 0, & |-\omega| > a \end{cases} = \begin{cases} 1, & |\omega| \leq a \\ 0, & |\omega| > a \end{cases}$

Örnek 15

- $x(t) = \frac{1}{a^2+t^2}$ ise $X(\omega) = ?$
- $x_1(t) = e^{-a|t|} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{2a}{a^2+\omega^2}$
- $x(t) = X_1(\quad)$

Örnek 15

- $x(t) = \frac{1}{a^2+t^2}$ ise $X(\omega) = ?$
- $x_1(t) = e^{-a|t|} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{2a}{a^2+\omega^2}$
- $x(t) = \frac{1}{2a} X_1(t) = \frac{1}{2a} \frac{2}{t} \frac{2a}{a^2+t^2} = \frac{1}{a^2+t^2}$
- $X(\omega) =$

Örnek 15

- $x(t) = \frac{1}{a^2+t^2}$ ise $X(\omega) = ?$
- $x_1(t) = e^{-a|t|} \overset{\mathcal{F}}{\leftrightarrow} X_1(\omega) = \frac{2a}{a^2+\omega^2}$
- $x(t) = \frac{1}{2a} X_1(t) = \frac{1}{2a}\frac{2}{t}\frac{2a}{a^2+t^2} = \frac{1}{a^2+t^2}$
- $X(\omega) = \frac{1}{2a} 2\pi x_1(-\omega) = \frac{\pi}{a} x_1(-\omega) = \frac{\pi}{a} e^{-a|-\omega|} = \frac{\pi}{a} e^{-a|\omega|}$

Fourier Dönüşüm Özellikleri

- Konvolüsyon
- $x(t) \leftrightarrow X(\omega)$ ve
- $h(t) \leftrightarrow H(\omega)$ olduğu biliniyorsa

- $y(t) =$

Fourier Dönüşüm Özellikleri

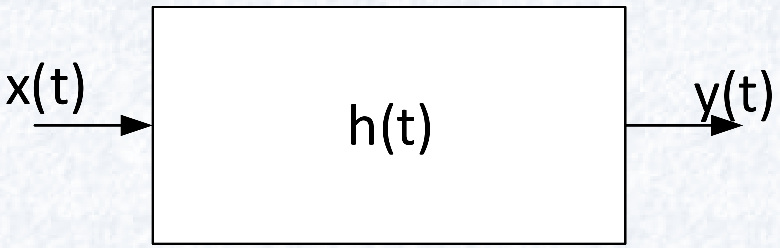
- Konvolüsyon
- $x(t) \leftrightarrow X(\omega)$ ve
- $h(t) \leftrightarrow H(\omega)$ olduğu biliniyorsa

- $y(t) = x(t) * h(t)$
- $\mathcal{F}\{y(t)\} = \mathcal{F}\{x(t) * h(t)\}$

- $Y(\omega) = X(\omega)H(\omega)$
- $H(\omega) = \frac{Y(\omega)}{X(\omega)}$ Sistemin frekans domeninde transfer fonksiyonu

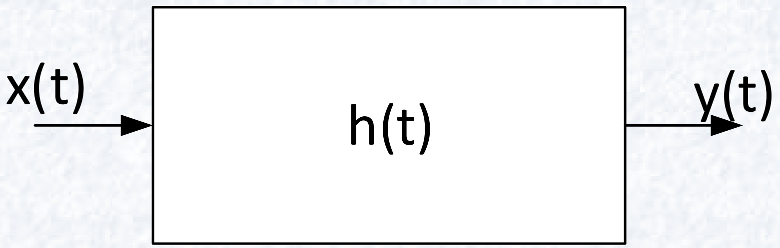
Örnek 16

- $h(t) = \delta(t - t_0)$ ise $y(t) = ?$



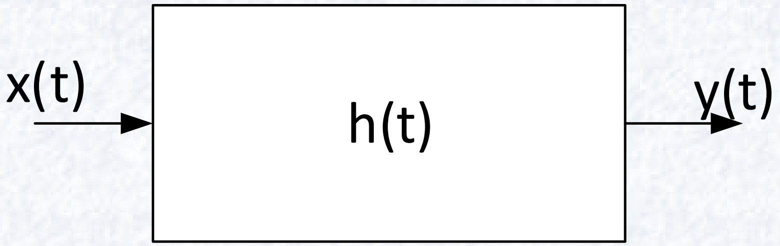
Örnek 16

- $h(t) = \delta(t - t_0)$ ise $y(t) = ?$
- $H(\omega) =$



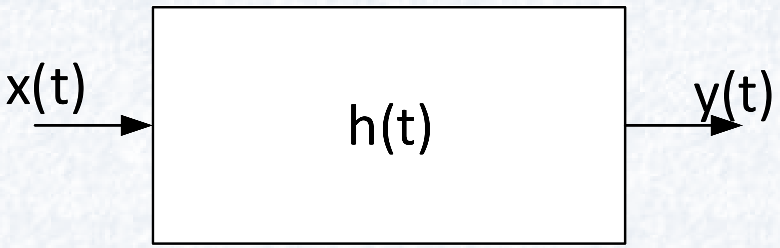
Örnek 16

- $h(t) = \delta(t - t_0)$ ise $y(t) = ?$
- $H(\omega) = e^{-j\omega t_0}$
- $Y(\omega) =$



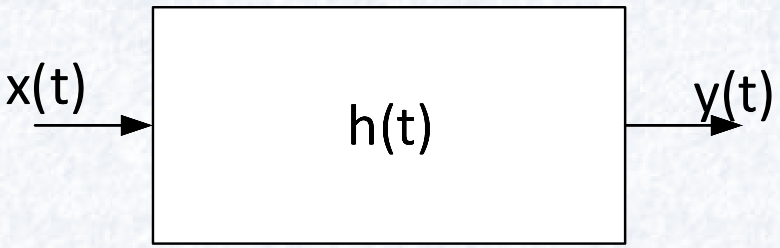
Örnek 16

- $h(t) = \delta(t - t_0)$ ise $y(t) =?$
- $H(\omega) = e^{-j\omega t_0}$
- $Y(\omega) = H(\omega)X(\omega)$



Örnek 16

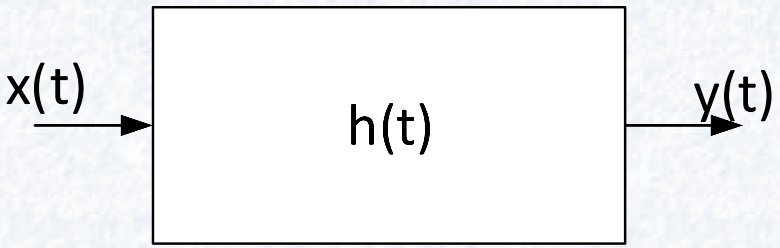
- $h(t) = \delta(t - t_0)$ ise $y(t) =?$
- $H(\omega) = e^{-j\omega t_0}$
- $Y(\omega) = H(\omega)X(\omega)$
- $Y(\omega) = e^{-j\omega t_0}X(\omega)$



- $y(t) =$

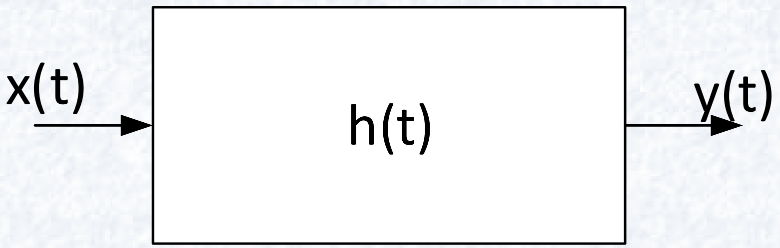
Örnek 16

- $h(t) = \delta(t - t_0)$ ise $y(t) = ?$
- $H(\omega) = e^{-j\omega t_0}$
- $Y(\omega) = H(\omega)X(\omega)$
- $Y(\omega) = e^{-j\omega t_0}X(\omega)$
  - *Zamanda öteleme*
- $y(t) =$



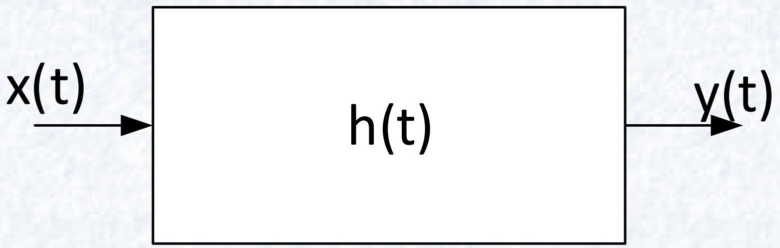
Örnek 16

- $h(t) = \delta(t - t_0)$ ise $y(t) = ?$
- $H(\omega) = e^{-j\omega t_0}$
- $Y(\omega) = H(\omega)X(\omega)$
- $Y(\omega) = e^{-j\omega t_0}X(\omega)$
  - *Zamanda öteleme*
- $y(t) = x(t - t_0)$



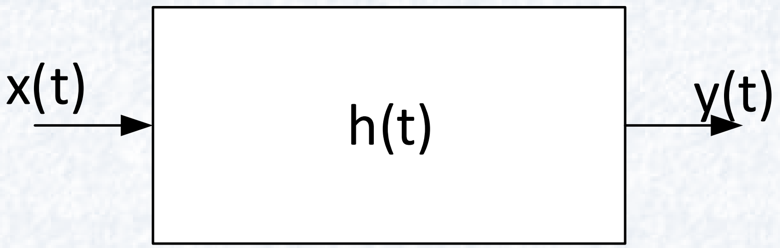
Örnek 17

- $h(t) = e^{-at}u(t)$ ve
- $x(t) = e^{-bt}u(t)$ ise $y(t) =?$
- $H(\omega) =$
- $X(\omega) =$



Örnek 17

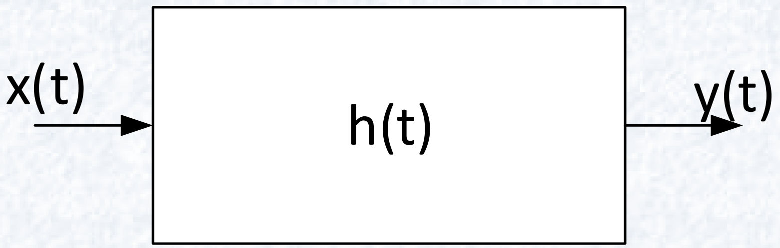
- $h(t) = e^{-at}u(t)$ ve
- $x(t) = e^{-bt}u(t)$ ise $y(t) = ?$



- $H(\omega) = \frac{1}{a+j\omega}$
- $X(\omega) = \frac{1}{b+j\omega}$
- $Y(\omega) = H(\omega)X(\omega) = \frac{1}{a+j\omega}\frac{1}{b+j\omega}$
- $Y(\omega) = \begin{cases} \frac{1}{b-a}\left(\frac{1}{a+j\omega} - \frac{1}{b+j\omega}\right), & a \neq b \\ \frac{1}{(a+j\omega)^2}, & a = b \end{cases} \leftrightarrow y(t) = \begin{cases} \boxed{\quad}, & a \neq b \\ \boxed{\quad}, & a = b \end{cases}$

Örnek 17

- $h(t) = e^{-at}u(t)$ ve
- $x(t) = e^{-bt}u(t)$ ise $y(t) = ?$
- $H(\omega) = \frac{1}{a+j\omega}$
- $X(\omega) = \frac{1}{b+j\omega}$
- $Y(\omega) = H(\omega)X(\omega) = \frac{1}{a+j\omega}\frac{1}{b+j\omega}$
- $Y(\omega) = \begin{cases} \frac{1}{b-a}\left(\frac{1}{a+j\omega} - \frac{1}{b+j\omega}\right), & a \neq b \\ \frac{1}{(a+j\omega)^2}, & a = b \end{cases} \leftrightarrow y(t) = \begin{cases} \frac{1}{b-a}\left(e^{-at}u(t) - e^{-bt}u(t)\right), & a \neq b \\ te^{-at}u(t), & a = b \end{cases}$



Fourier Dönüşüm Özellikleri

- Çarpma
- $p(t) \leftrightarrow P(\omega)$ ve
- $r(t) \leftrightarrow R(\omega)$ olduğu biliniyorsa

- $s(t) = p(t)r(t)$
- $\mathcal{F}\{s(t)\} = \mathcal{F}\{p(t)r(t)\}$

- $S(\omega) = \frac{1}{2\pi}\big(P(\omega) * R(\omega)\big) = \frac{1}{2\pi}\int_{-\infty}^{\infty} P(\theta)S(\omega - \theta)d\theta$

Örnek 18

- $x(t) = \cos\left(\frac{\pi}{4}t\right)\sin\left(\frac{2\pi}{3}t\right)$ ise $X(\omega) = ?$

Örnek 18

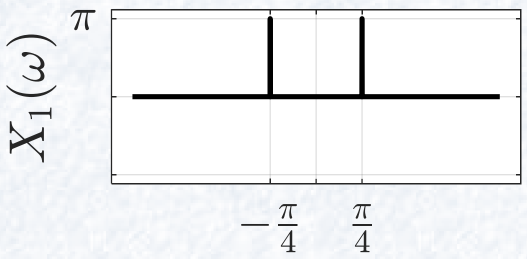
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
- $X(\omega) =$

Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) =$

Örnek 18

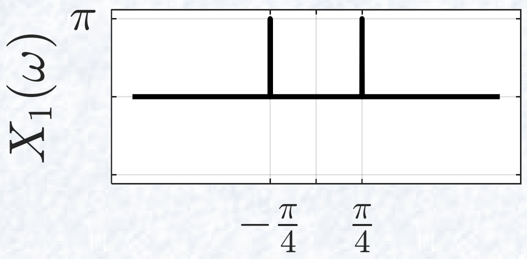
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega)$ =?

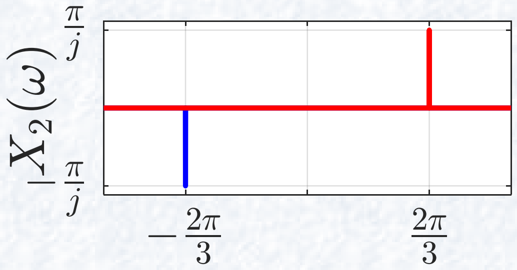


- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) =$
- $X(\omega) =$

Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$

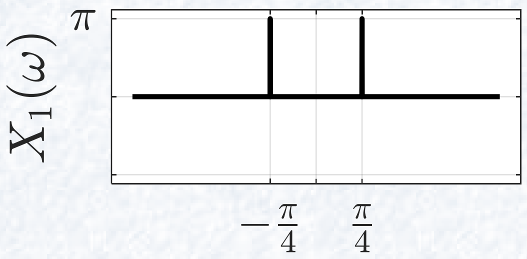


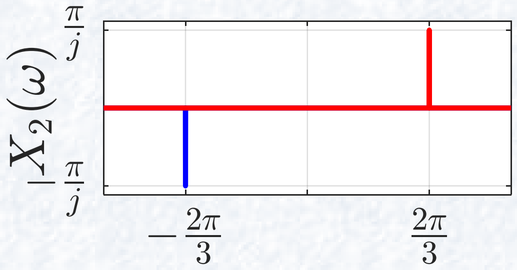


- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) =$

Örnek 18

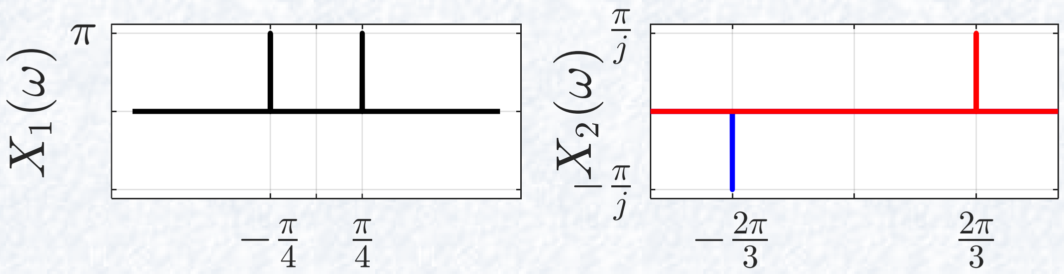
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)\right)$





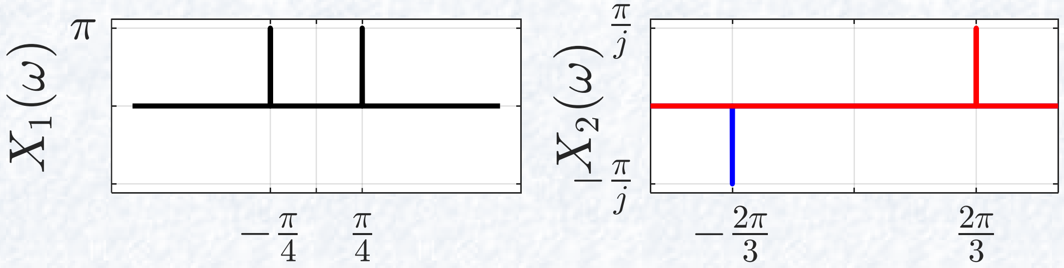
Örnek 18

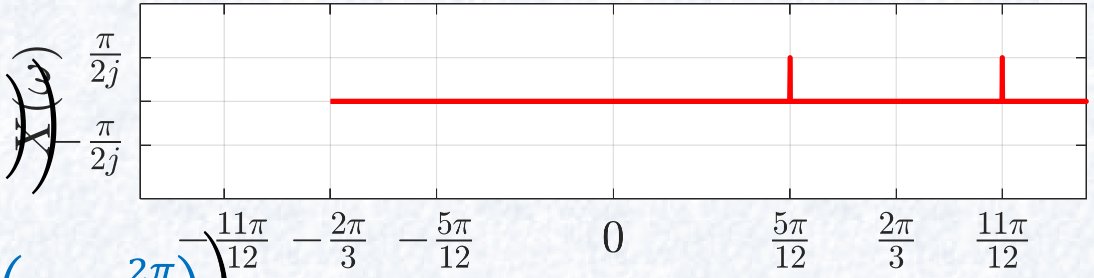
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{2\pi}{3}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) =$



Örnek 18

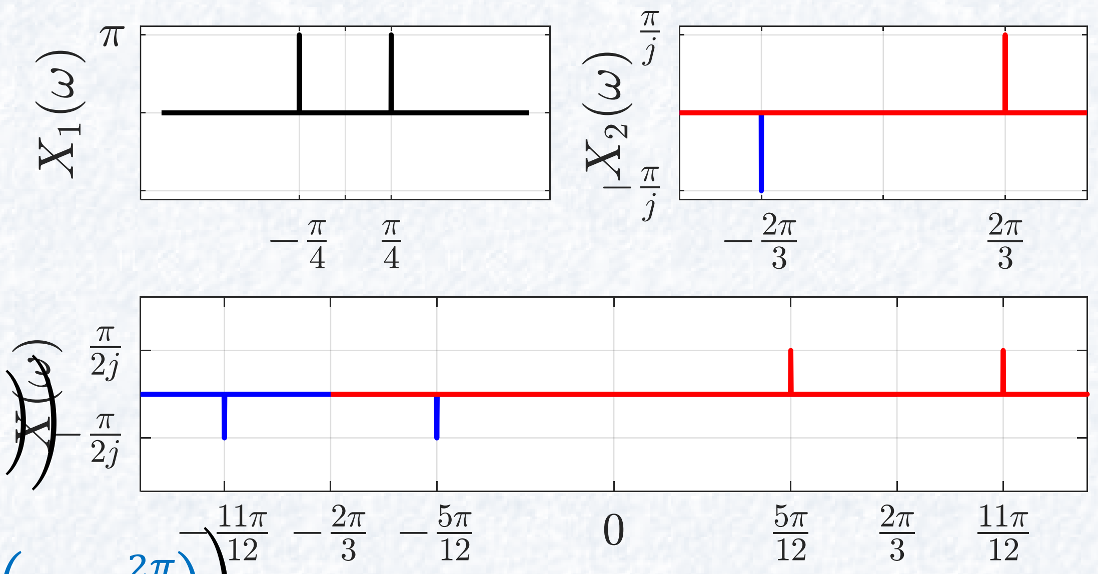
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{2\pi}{3}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2j}X_1\left(\omega - \frac{2\pi}{3}\right)$





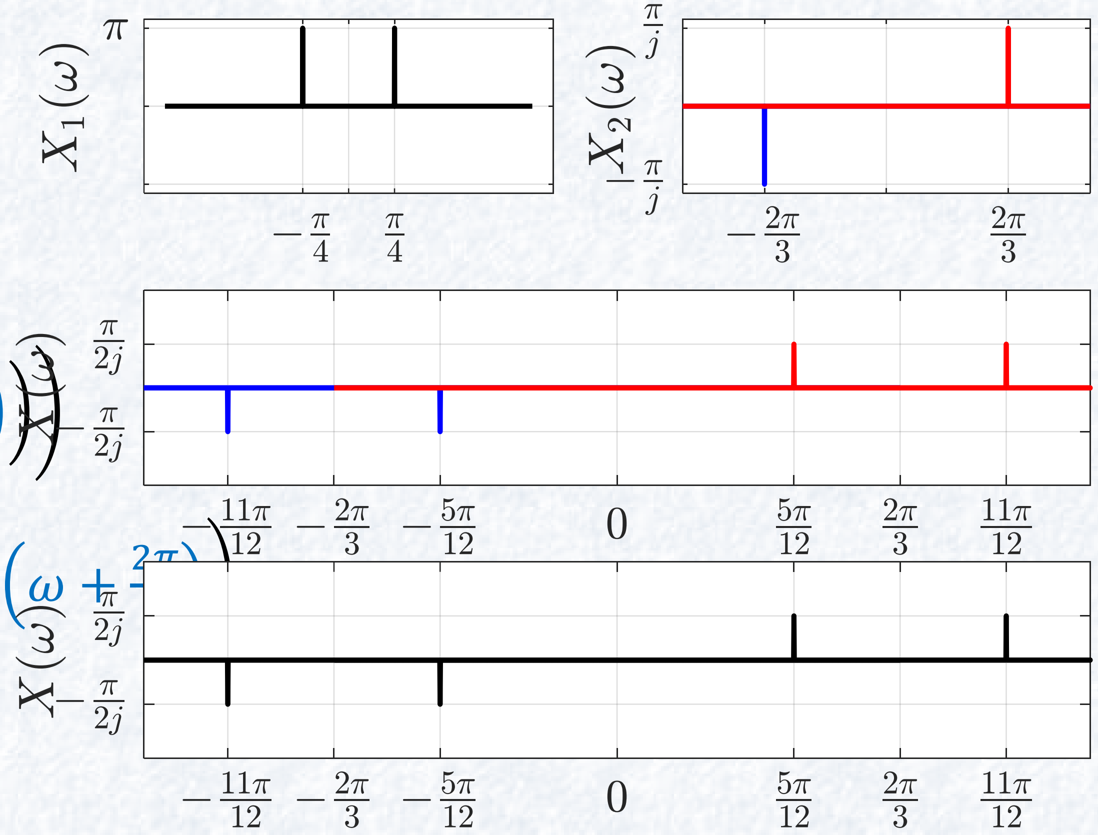
Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{2\pi}{3}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2j}X_1\left(\omega - \frac{2\pi}{3}\right) - \frac{1}{2j}X_1\left(\omega + \frac{2\pi}{3}\right)$



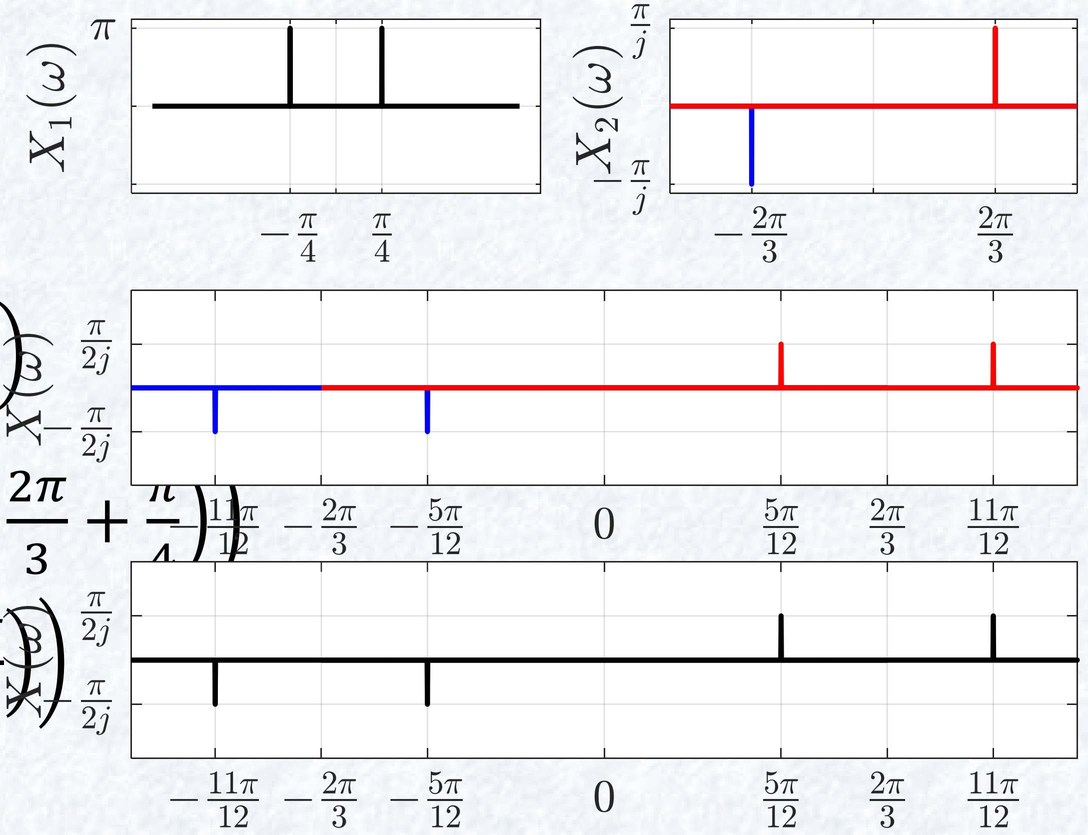
Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{2\pi}{3}\right) - \delta\left(\omega + \frac{2\pi}{3}\right)\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{2\pi}{3}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{2\pi}{3}\right)\right)$
- $X(\omega) = \frac{1}{2j}X_1\left(\omega - \frac{2\pi}{3}\right) - \frac{1}{2j}X_1\left(\omega + \frac{2\pi}{3}\right)$



Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega)$ =?
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X(\omega) = \frac{1}{2j}X_1\left(\omega - \frac{2\pi}{3}\right) - \frac{1}{2j}X_1\left(\omega + \frac{2\pi}{3}\right)$
- $X(\omega) = \frac{1}{2j}\pi\left(\delta\left(\omega - \frac{2\pi}{3} - \frac{\pi}{4}\right) + \delta\left(\omega - \frac{2\pi}{3} + \frac{\pi}{4}\right)\right)$
  $- \frac{1}{2j}\pi\left(\delta\left(\omega + \frac{2\pi}{3} - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{2\pi}{3} + \frac{\pi}{4}\right)\right)$

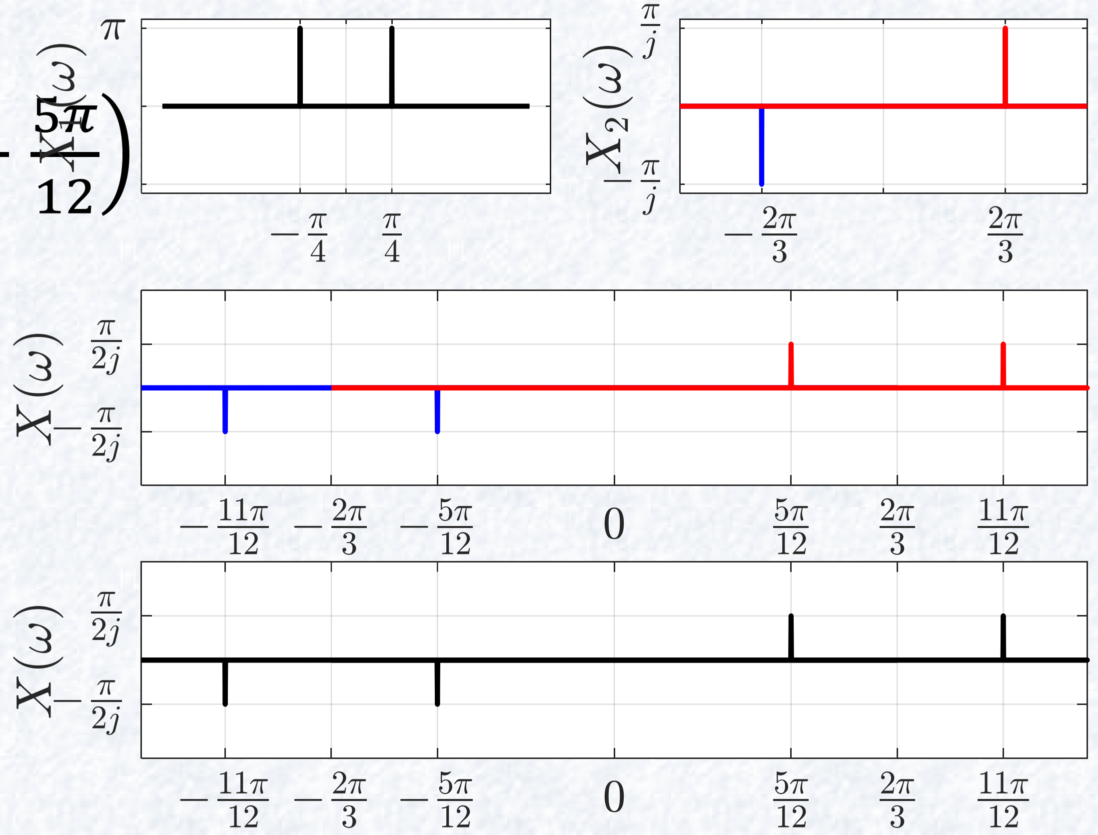


Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$

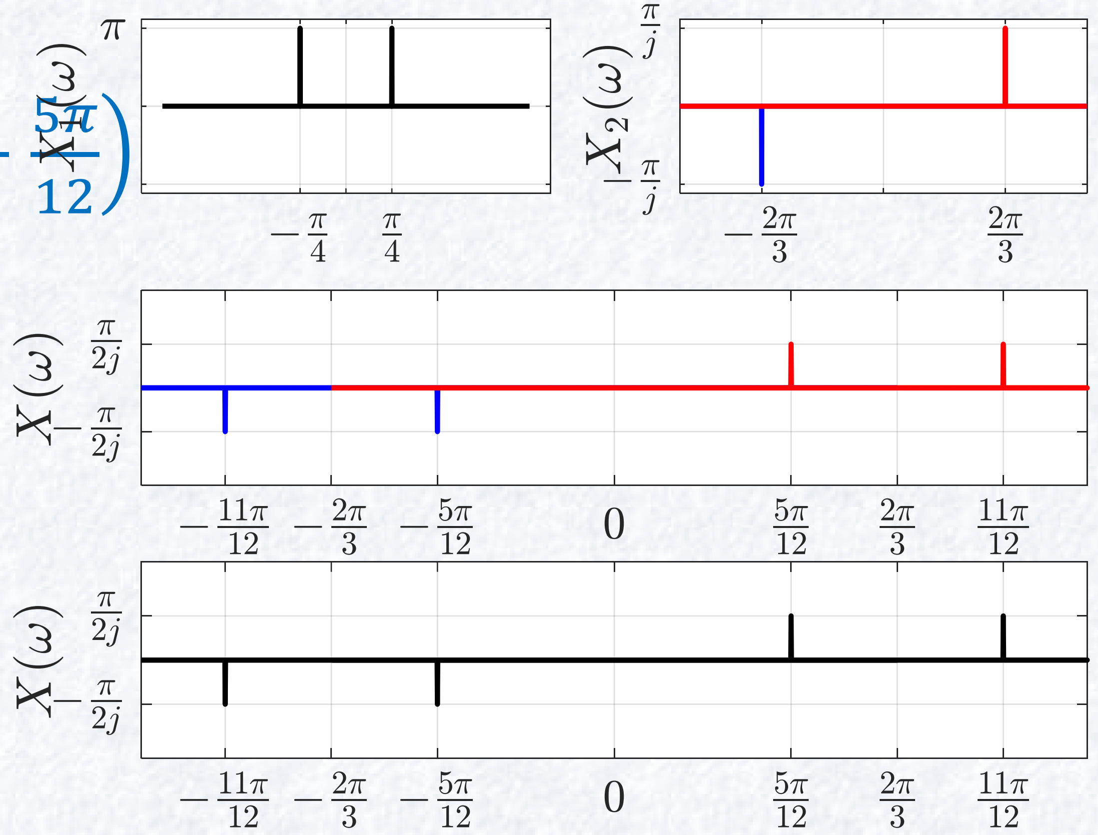
- $X(\omega) = \frac{\pi}{2j}\delta\left(\omega - \frac{11\pi}{12}\right) + \frac{\pi}{2j}\delta\left(\omega - \frac{5\pi}{12}\right)$
$- \frac{\pi}{2j}\delta\left(\omega + \frac{5\pi}{12}\right) - \frac{\pi}{2j}\delta\left(\omega + \frac{11\pi}{12}\right)$

- $x(t) =$



Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
- $X(\omega) = \frac{\pi}{2j}\delta\left(\omega - \frac{11\pi}{12}\right) + \frac{\pi}{2j}\delta\left(\omega - \frac{5\pi}{12}\right) - \frac{\pi}{2j}\delta\left(\omega + \frac{5\pi}{12}\right) - \frac{\pi}{2j}\delta\left(\omega + \frac{11\pi}{12}\right)$
- $x(t) = \frac{1}{2}\sin\left(\frac{11\pi}{12}t\right) +$

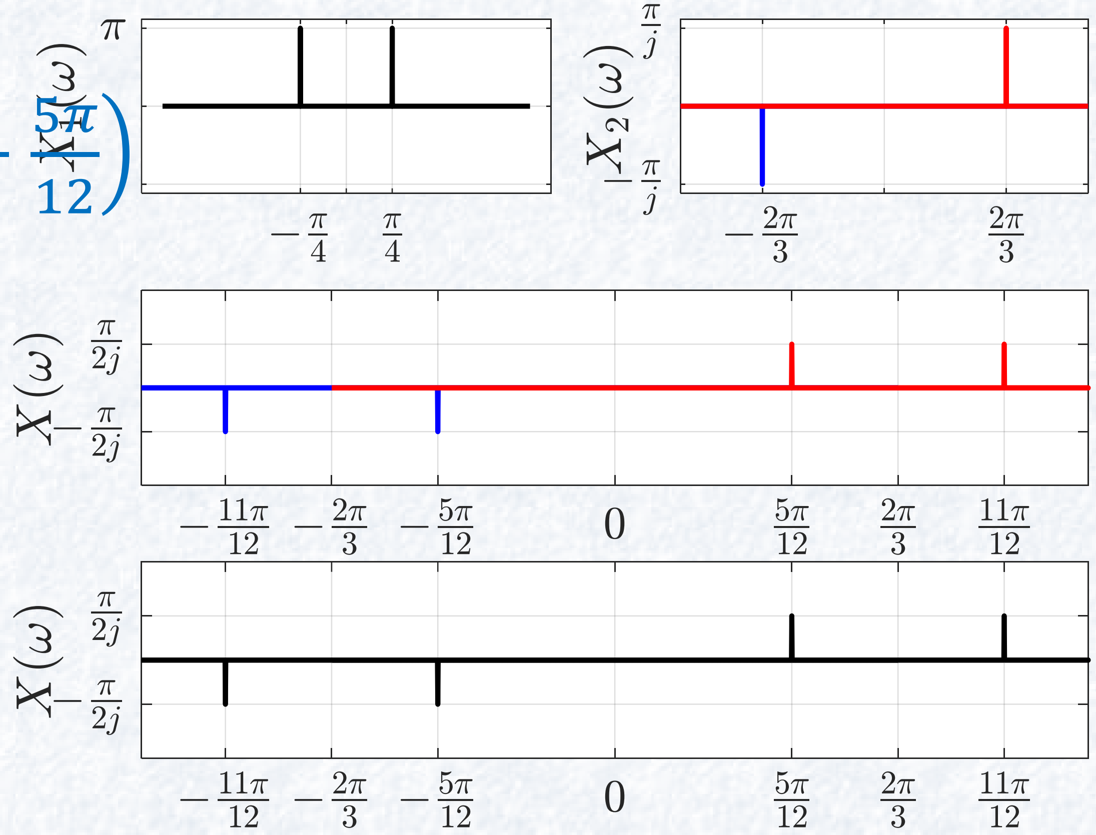


Örnek 18

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{2\pi}{3}t\right)}_{x_2(t)}$ ise $X(\omega) =?$

- $X(\omega) = \frac{\pi}{2j}\delta\left(\omega - \frac{11\pi}{12}\right) + \frac{\pi}{2j}\delta\left(\omega - \frac{5\pi}{12}\right)$
$- \frac{\pi}{2j}\delta\left(\omega + \frac{5\pi}{12}\right) - \frac{\pi}{2j}\delta\left(\omega + \frac{11\pi}{12}\right)$

- $x(t) = \frac{1}{2}\sin\left(\frac{11\pi}{12}t\right) + \frac{1}{2}\sin\left(\frac{5\pi}{12}t\right)$



Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$

Örnek 19

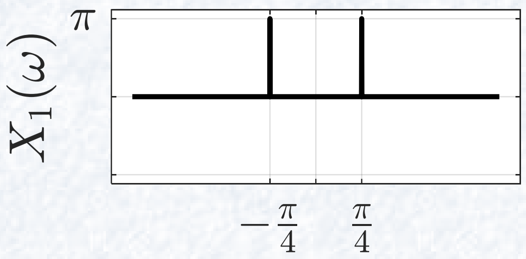
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
- $X(\omega) =$

Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) =$

Örnek 19

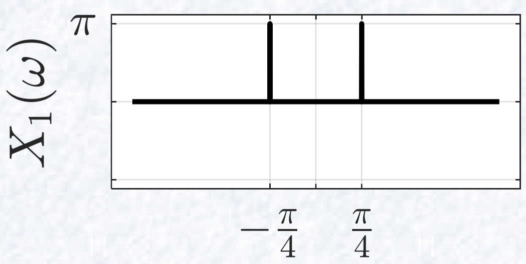
- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$

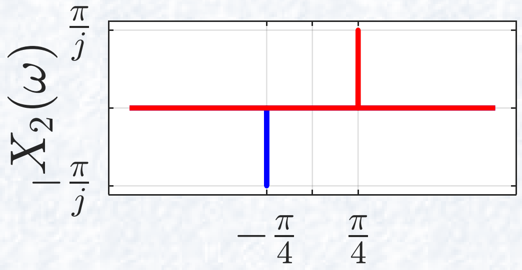


- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) =$

Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$





- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * X_2(\omega)\right)$
- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
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- $X(\omega) =$

Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
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- $X_1(\omega) = \pi\left(\delta\left(\omega - \frac{\pi}{4}\right) + \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{\pi}{4}\right) - \delta\left(\omega + \frac{\pi}{4}\right)\right)$
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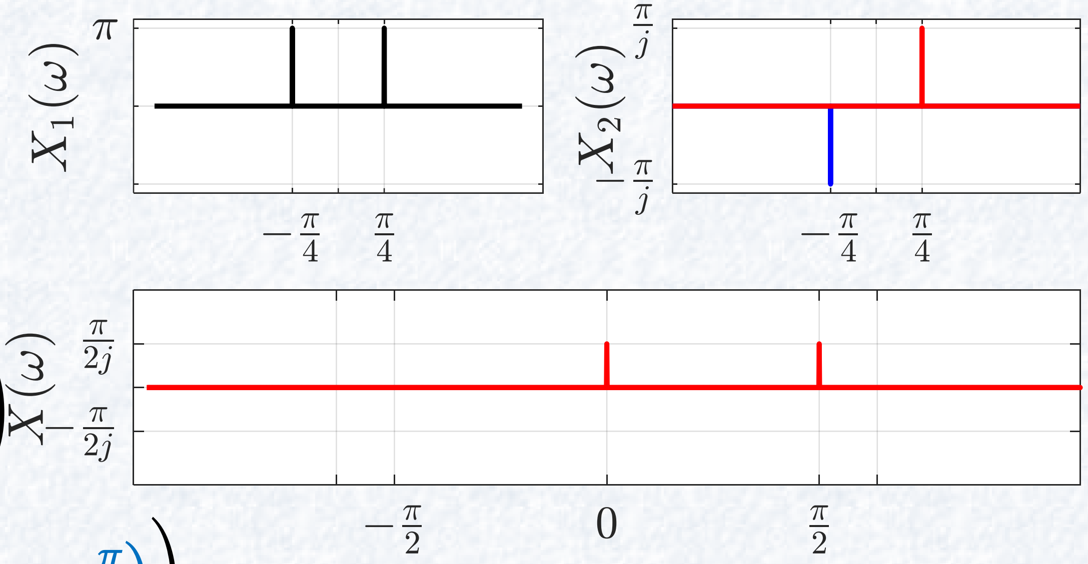
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{\pi}{4}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X(\omega) = \frac{1}{2j}X_1\left(\omega - \frac{\pi}{4}\right)$



Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) = ?$
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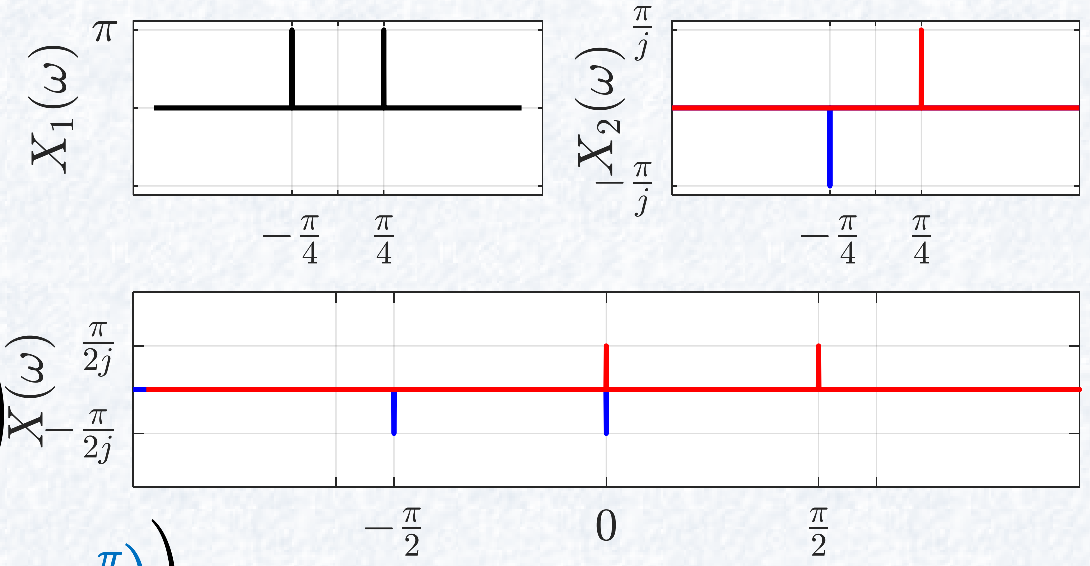
- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{\pi}{4}\right) - \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{\pi}{4}\right) - \delta\left(\omega + \frac{\pi}{4}\right)\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{\pi}{4}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X(\omega) = \frac{1}{2j}X_1\left(\omega - \frac{\pi}{4}\right) - \frac{1}{2j}X_1\left(\omega + \frac{\pi}{4}\right)$



Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)}\underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
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- $X_2(\omega) = \frac{\pi}{j}\left(\delta\left(\omega - \frac{\pi}{4}\right) - \delta\left(\omega + \frac{\pi}{4}\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\left(\delta\left(\omega - \frac{\pi}{4}\right) - \delta\left(\omega + \frac{\pi}{4}\right)\right)\right)$
- $X(\omega) = \frac{1}{2\pi}\left(X_1(\omega) * \frac{\pi}{j}\delta\left(\omega - \frac{\pi}{4}\right) - X_1(\omega) * \frac{\pi}{j}\delta\left(\omega + \frac{\pi}{4}\right)\right)$
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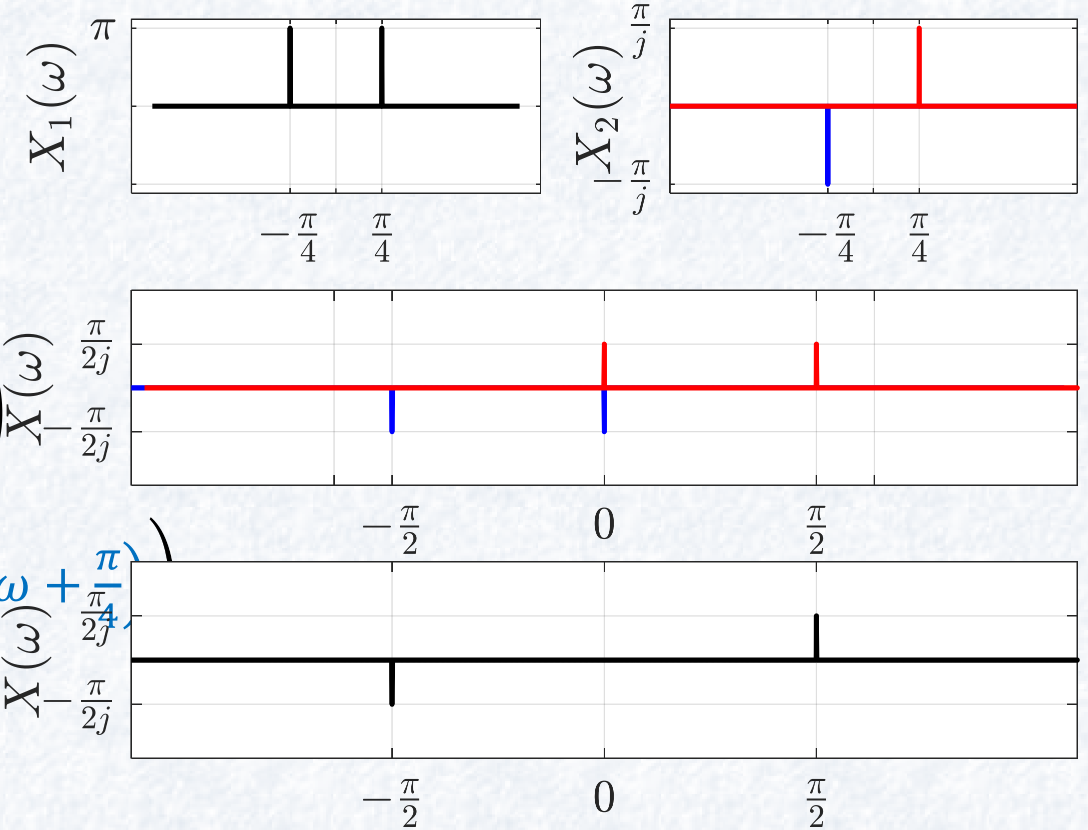

Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
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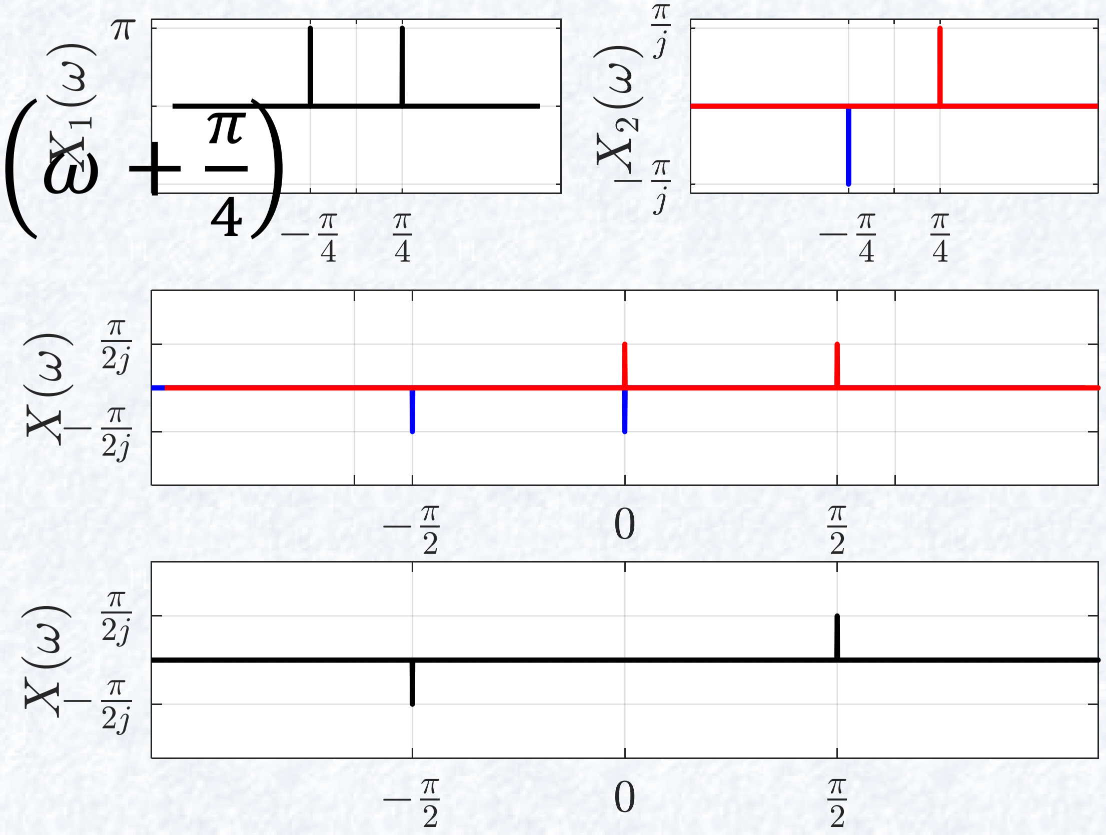
- $x(t) =$



Örnek 19

- $x(t) = \underbrace{\cos\left(\frac{\pi}{4}t\right)}_{x_1(t)} \underbrace{\sin\left(\frac{\pi}{4}t\right)}_{x_2(t)}$ ise $X(\omega) =?$
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- $x(t) = \frac{1}{2}\sin\left(\frac{\pi}{2}t\right)$