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Question: (15 pts) Solve the following questions using the appropriate pr...

(15 pts) Solve the following questions using the appropriate properties of the Fourier Transform. (In part a give the derivation and in parts b, c use the properties.)

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- (a) (5 pts) Derive the Fourier transform of the signal $e^{-|t|}$.
- (b) (5 pts) Find the Fourier transform of $te^{-|t|}$.
- (c) (5 pts) Using the result of part b find the Fourier transform of $\frac{4t}{(1+t^2)^2}$

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Expert Answer (1)



RAVI SHANKAR KUMAR & 1,247 answers

SOLUTION

a)

Let

$$f(t) = e^{-|t|}$$

The Fourier transform of signal f(t)

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-jwt} dt$$

$$F(\omega) = \int_{-\infty}^{\infty} e^{-|t|} e^{-jwt} dt$$

$$F(\omega) = \int_{-\infty}^{0} e^{t} e^{-jwt} dt + \int_{0}^{\infty} e^{-t} e^{-jwt} dt$$

$$F(\omega) = \int_{-\infty}^{0} e^{t(1-jw)} dt + \int_{0}^{\infty} e^{-t(1+jw)} dt$$

$$F(\omega) = \left[\frac{1}{(1 - jw)} e^{t(1 - jw)} \right]_{-\infty}^{0} + \left[\frac{1}{-(1 + jw)} e^{-t(1 + jw)} \right]_{0}^{\infty}$$

$$F(\omega) = \left[\frac{1}{(1 - jw)} e^{t(1 - jw)} \right]_{-\infty}^{0} - \left[\frac{1}{(1 + jw)} e^{-t(1 + jw)} \right]_{0}^{\infty}$$

$$F(\omega) = \left[\frac{1}{(1-jw)} - 0\right] - \left[0 - \frac{1}{(1+jw)}\right]$$

$$F(\omega) = \left[\frac{1}{(1-jw)} \right] - \left[-\frac{1}{(1+jw)} \right]$$

$$F(\omega) = \left[\frac{1}{(1-jw)}\right] + \left[\frac{1}{(1+jw)}\right]$$

$$F(\omega) = \frac{2}{1 + w^2}$$

i.e

Fourier transform of

$$f(t) = e^{-|t|}$$

$$F(\omega) = \frac{2}{1 + w^2}$$

b)

Fourier transform of

$$f(t) = e^{-|t|}$$

■ 0

■ 0

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Fourier transform of

$$x(t) = t \, e^{-|t|}$$

$$x(t) = t f(t)$$

is

$$X(\omega) = j \frac{dF(\omega)}{d\omega}$$

[using multiplication of t with f(t) properties]

i e

Now,

$$X(\omega) = j \frac{dF(\omega)}{d\omega}$$

$$X(\omega) = j \left[-\frac{4\omega}{\left(1 + \omega^2\right)^2} \right]$$

$$X(\omega) = -j \left[\frac{4\omega}{\left(1 + \omega^2\right)^2} \right]$$

i.e

The Fourier transform of

$$x(t) = t e^{-|t|}$$

:-

$$X(\omega) = -j \left[\frac{4\omega}{\left(1 + \omega^2\right)^2} \right]$$

c)

Let

$$g(t) = \frac{4t}{(1+t^2)^2}$$

Now,

The Fourier transform of

$$x(t) = t \, e^{-|t|}$$

is

$$X(\omega) = -j \left[\frac{4\omega}{\left(1 + \omega^2\right)^2} \right]$$

l.e

$$x(t) \leftrightarrow X(\omega)$$

$$t e^{-|t|} \leftrightarrow -j \left[\frac{4\omega}{(1+\omega^2)^2} \right]$$

Now

Using the duality property of Fourier transform

If
$$x(t) \leftarrow FT \rightarrow X(\omega)$$
 then,

$$X$$
 (t) \leftarrow FT \rightarrow 2π $x(-\omega)$

i.e

$$-j\left[\frac{4t}{\left(1+t^2\right)^2}\right] \leftrightarrow 2\pi(-\omega) \; e^{-|(-\omega)|}$$

on simplifying,

$$-j\left[\frac{4t}{\left(1+t^2\right)^2}\right] \leftrightarrow -2\pi\omega\;e^{-|\omega|}$$

$$j\left[\frac{4t}{\left(1+t^2\right)^2}\right] \leftrightarrow 2\pi\omega \; e^{-|\omega|}$$



$$\lfloor (1+t^2)^2 \rfloor$$
 j

$$\frac{4t}{\left(1+t^2\right)^2} \leftrightarrow \frac{1}{j} \cdot 2\pi\omega \; e^{-|\omega|}$$

$$\frac{4t}{\left(1+t^2\right)^2} \leftrightarrow -j \cdot 2\pi\omega \; e^{-|\omega|}$$

Hence,

The Fourier transform of

$$g(t) = \frac{4t}{\left(1 + t^2\right)^2}$$

$$G(\omega) = -j \cdot 2\pi\omega \; e^{-|\omega|}$$

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Q: (15 pts) Using Fourier Transform properties, please solve them (a) (5 pts) Firstly derive a Fourier transform of the signal e-It|. (b) (5 pts) Deterimine the Fourier transform of te-1t|. (C) (5 pts) Using the result of part b find the Fourier transform of (1442)2 ·

A: See answer

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