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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.)

- (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



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1,247 answers

SOLUTION

a)

Let

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

The Fourier transform of signal f(t)

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

i.e

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

$$F(\omega) = \int_{-\infty}^0 e^t e^{-j\omega t} dt + \int_0^{\infty} e^{-t} e^{-j\omega t} dt$$

$$F(\omega) = \int_{-\infty}^0 e^{t(1-j\omega)} dt + \int_0^{\infty} e^{-t(1+j\omega)} dt$$

$$F(\omega) = \left[ \frac{1}{(1-j\omega)} e^{t(1-j\omega)} \right]_{-\infty}^0 + \left[ \frac{1}{-(1+j\omega)} e^{-t(1+j\omega)} \right]_0^{\infty}$$

$$F(\omega) = \left[ \frac{1}{(1-j\omega)} e^{t(1-j\omega)} \right]_{-\infty}^0 - \left[ \frac{1}{(1+j\omega)} e^{-t(1+j\omega)} \right]_0^{\infty}$$

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

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

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

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

i.e

Fourier transform of

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

is

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

.....

b)

Fourier transform of

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

is

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Now

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,

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

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

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

i.e

The Fourier transform of

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

is

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

.....

c)

Let

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

Now,

The Fourier transform of

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

is

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

I.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

$$\text{If } x(t) \xleftrightarrow{\text{FT}} X(\omega) \text{ then,}$$

$$X(t) \xleftrightarrow{\text{FT}} 2\pi x(-\omega)$$

i.e

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

on simplifying,

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

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

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

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

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

Hence,

The Fourier transform of

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

is

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

.....

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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-|t|. (b) (5 pts) Determine 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](#)