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Chapter 2

2.1-1 Let us denote the signal in question by $x(t)$ and its energy by E_x . For parts (a) and (b)

$$E_x = \int_{-\infty}^{\infty} \cos^2 t \, dt = \frac{1}{2} \int_{-\infty}^{\infty} (1 + \cos 2t) \, dt = \frac{1}{2} \int_{-\infty}^{\infty} 1 \, dt + \frac{1}{2} \int_{-\infty}^{\infty} \cos 2t \, dt = \infty + 0 = \infty$$

(a) $E_x = \int_{-\infty}^{\infty} \sin^2 t \, dt = \frac{1}{2} \int_{-\infty}^{\infty} (1 - \cos 2t) \, dt = \frac{1}{2} \int_{-\infty}^{\infty} 1 \, dt - \frac{1}{2} \int_{-\infty}^{\infty} \cos 2t \, dt = \infty - 0 = \infty$

(b) $E_x = \int_{-\infty}^{\infty} (2 \cos t)^2 \, dt = 4 \int_{-\infty}^{\infty} \cos^2 t \, dt = 4 \int_{-\infty}^{\infty} \frac{1 + \cos 2t}{2} \, dt = 2 \int_{-\infty}^{\infty} (1 + \cos 2t) \, dt = 2(\infty + 0) = \infty$

Thus, change and time does not alter the signal energy. Doubling the signal quadruples its energy. In the case $\omega = \pi$ we can show that the energy of $2x(t)$ is $4E_x$.

2.1-2 (a) $E_x = \int_{-\infty}^{\infty} (1/t)^2 \, dt = \infty$. $E_y = \int_{-\infty}^{\infty} (1/t^2)^2 \, dt = \int_{-\infty}^{\infty} 1/t^4 \, dt = \infty$

Therefore $E_{2x} = E_x = E_y$.

(b) If $x = \int_{-\infty}^{\infty} (1/t)^2 \, dt = \int_{-\infty}^{\infty} (-1)^2 \, dt = 2\pi$. $E_x = \int_{-\infty}^{\infty} (1/t)^2 \, dt = \int_{-\infty}^{\infty} (-1)^2 \, dt = \int_{-\infty}^{\infty} 1 \, dt = 2\pi$

$$E_{2x} = \int_{-\infty}^{\infty} (2/t)^2 \, dt = 4 \int_{-\infty}^{\infty} (1/t)^2 \, dt = 4 \times 2\pi = 8\pi$$

Similarly, we can show that $E_{x/2} = E_x/4 = \pi$. Therefore $E_{2x} = 4E_x$. We are tempted to conclude that $E_{2x} = 4E_x$ in general. Let us see:

(c) $E_x = \int_{-\infty}^{\infty} (1/t^2)^2 \, dt = \int_{-\infty}^{\infty} 1/t^4 \, dt = \infty$. $E_y = \int_{-\infty}^{\infty} (1/t^2)^2 \, dt = \infty$

$$E_{2x} = \int_{-\infty}^{\infty} (2/t^2)^2 \, dt = 4 \int_{-\infty}^{\infty} (1/t^2)^2 \, dt = 4 \times \infty = \infty$$

Therefore, in general, $E_{2x} \neq E_x = E_y$.

2.1-3

$$f_1 = \frac{1}{2\pi} \int_{-\infty}^{\infty} \cos^2(\omega t) \, dt = \frac{1}{2\pi} \int_{-\infty}^{\infty} (1 + \cos(2\omega t)) \, dt$$
$$= \frac{1}{2\pi} \left[\int_{-\infty}^{\infty} 1 \, dt + \int_{-\infty}^{\infty} \cos(2\omega t) \, dt \right] = \frac{1}{2\pi} (\infty + 0) = \frac{\infty}{2}$$

2.1-4 This problem is identical to Example 2.2b, except that $\omega_1 \neq \omega_2$. In this case the third integral in f_3 (see p. 15) is not zero. This integral is given by

$$f_3 = \frac{1}{2\pi} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \cos(\omega_1 t) \cos(\omega_2 t) \, dt$$
$$= \frac{1}{2\pi} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \frac{1}{2} [\cos(\omega_1 t + \omega_2 t) + \cos(\omega_1 t - \omega_2 t)] \, dt$$
$$= \frac{1}{4\pi} \left[\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \cos(\omega_1 t + \omega_2 t) \, dt + \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \cos(\omega_1 t - \omega_2 t) \, dt \right]$$
$$= \frac{1}{4\pi} \left[\frac{2\pi}{\omega_1 + \omega_2} \cos(\omega_1 + \omega_2) + \frac{2\pi}{\omega_1 - \omega_2} \cos(\omega_1 - \omega_2) \right]$$

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