Class Work Forecast

Class B.tech 2nd yr (E.C.E)

Sub: Signal & System

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Topic: Property of fourier ~~Transf~~ Series / Transform

1. Linearity:

If $x_1(t) \xleftrightarrow{F} X_1(f)$

and $x_2(t) \xleftrightarrow{F} X_2(f)$

then

$$a_1x_1(t) + a_2x_2(t) \xleftrightarrow{F} a_1X(f) + a_2X(f)$$

This follows directly from the definition of the fourier transform (as the integral operator is linear). It is easily extended to a linear combination of an arbitrary number of signals.

② **Time scaling** :-

* Let $x(t)$ and $X(f)$ be fourier Transform pairs and let "α" be a constant. Then time scaling property states that:

$$x(\alpha t) \overset{F}{\longleftrightarrow} \frac{1}{|\alpha|} X\left(\frac{f}{\alpha}\right)$$

$X(\alpha t)$ represents a time scaled signal and $X\left(\frac{f}{\alpha}\right)$ represents frequency scaled signal.

* For $\alpha < 1$, $X(\alpha t)$ represents compressed signal but $X\left(\frac{f}{\alpha}\right)$ represents expanded version of $X(f)$.

* For $\alpha > 1$, $X(\alpha t)$ will be expanded signal in the time domain. But its fourier transform $X(f/\alpha)$ respresents versions of $X(f)$.

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Time shifting

* The time shifting property states that if $x(t)$ and $X(f)$ from a fourier transform pair then

$$x(t-t_d) \xleftrightarrow{F} e^{-j2\pi f t_d} \cdot X(f)$$

* It is the same signal $x(t)$ only shifted in time

here the signal $x(t-t_d)$ is time shifted signal

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4. Duality or Symmetry:

* This property states that:

if $x(t) \xleftrightarrow{F} X(-f)$

then

$X(t) \xleftrightarrow{F} x(-f)$

* The duality theorem tells us that the shape of the segnal in the time domain and the shape of the spectrum can be interchanged.

Area under $x(t)$

* This property states that the area under the curve $x(t)$ equals the values of its Fourier transform at $F = 0$.

i.e. if $x(t) \xleftrightarrow{F} X(f)$.

then $x(t) = X(0)$

Area under $X(f)$.

* This property states that the area under the curve $X(f)$ equals the values of signal $x(t)$ at $t = 0$

if

$$x(t) \xleftrightarrow{F} X(f)$$

then $x(0) = X(f)$

Frequency shifting

* The frequency shifting characteristics states that if $x(t)$ and $X(f)$ form a fourier transform pair then

$$e^{j2\pi f_c t} x(t) \xleftrightarrow{F} X(f - f_c)$$

* F_c is a real constant

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Differentiation In Time Domain

* This property is applicable if and only if the derivative of $x(t)$ is fourier transformable

$$\frac{d}{dt} x(t) \xleftrightarrow{F} j2\pi f\, X(f)$$

Integration in Time Domain

* Integration in time Domain is equivalent to dividing the fourier the fourier transform by $(j2\pi f)$

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* If $x(t) \xleftrightarrow{F} X(f)$ and provided that $X(0) = 0$

$$\int_{-\infty}^{t} x(\lambda)\,d\lambda \xleftrightarrow{F} \frac{1}{j2\pi f} X(f)$$

Multiplication in Time domain :

* The multiplication theorem states that:

If $x_1(t) \xleftrightarrow{F} X_1(f)$ and

$x_2(t) \xleftrightarrow{F} X_1(f)$ are

the two fourier transform pair then:

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$$x_1(t) \cdot x_2(t) \xleftrightarrow{F} \int_{-\infty}^{\infty} X_1(\tau) \cdot X_2(f-\tau)\, d\tau$$

This means that multiplication of two signals in time domain gets transformed into convolution of the fourier transform

$$x_1(t) \cdot x_2(t) \xleftrightarrow{F} X_1(f) \times X_2(f)$$

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Convolution in Time Domain

This property states that the convolutions of signals in the time domain will be transformed into the multiplications of their fourier transform in the frequency domain

i.e.

$$x_1(t) * x_2(t) \xleftrightarrow{F} X_1(f) \cdot X_2(f)$$