EE 150L
Signals and Systems Lab

Lab4 Fourier Transform

Date Performed: 11·02

Class Id: 1A-105

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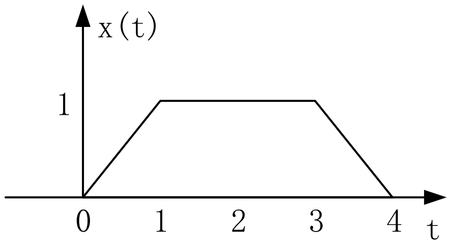
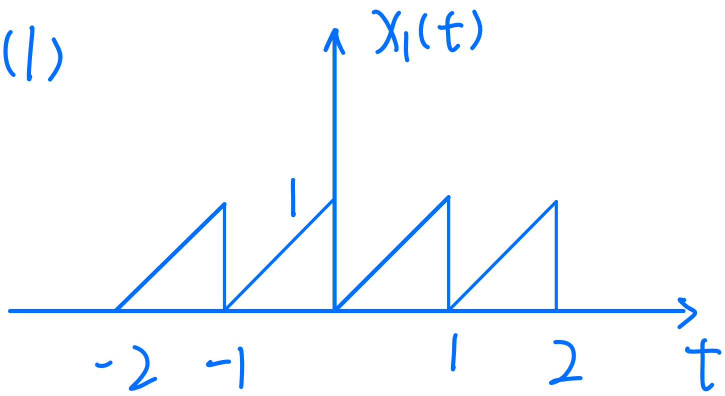
1. The following signals can be obtained by convolution or linear combination of two basic signals, which we mentioned in Lab1. Try to find out the basic signals for both method, then draw the basic signals.

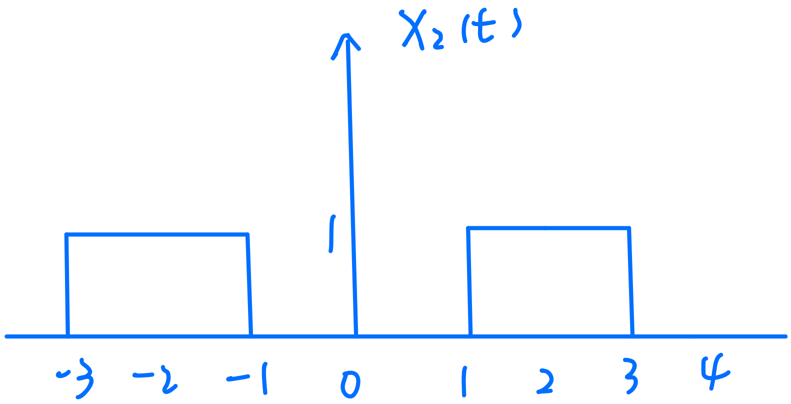


说明：以上信号可通过典型信号的卷积或线性组合获得。画出这两种方式下需要的典型信号。典型信号包含：三角信号、矩形窗、方波信号、三角形信号、锯齿波信号等。

linear combination

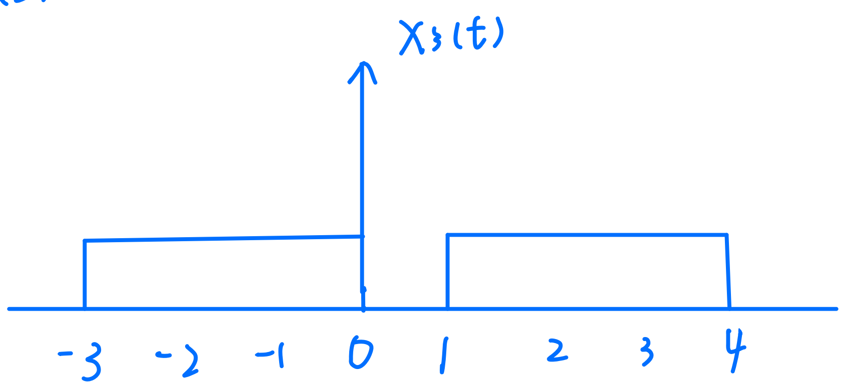
(1)

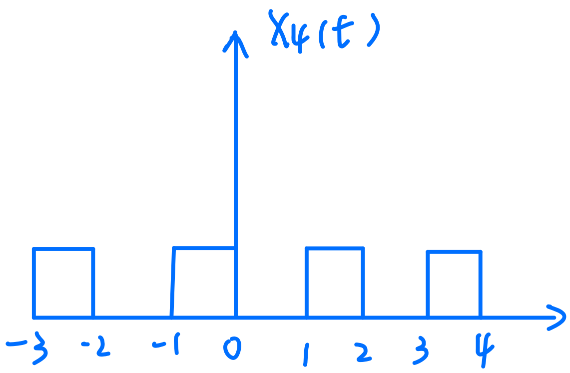




convolution

(2)





2. The formula for the Fourier transform of aperiodic signals is as follows, please try to decompose it into the form of matrix operations.

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

说明：将非周期信号的傅里叶公式转换成矩阵运算的模式。

$$F(j\omega) = \int_{-\infty}^{+\infty} f(t)\, e^{-j\omega t} dt = \lim_{\tau \to 0} \sum_{n=-\infty}^{\infty} f(n\tau)\, e^{-j\omega n\tau} \cdot \tau$$

Since the signal is time-limited, set N as the border of n

$$F(\omega_k) = \tau \sum_{n=-N}^{n=N} f(n\tau)\, e^{-j\omega_k n\tau}, \quad -N \le n \le N, \quad -M \le k \le M$$

$$F(\omega_k) = \begin{bmatrix} F(\omega_{-M}) \\ \vdots \\ F(\omega_0) \\ \vdots \\ F(\omega_M) \end{bmatrix}$$

$$= \tau * \begin{bmatrix} f(-N\tau)\cdot e^{-j\omega_{-M}(-N\tau)} + \cdots + f(0\cdot\tau)\cdot e^{j\omega_{-M}(0-\tau)} + \cdots + f(N\tau)\cdot e^{-j\omega_{-M}(N\tau)} \\ f(-N\tau)\cdot e^{-j\omega_0(-N\tau)} + \cdots + f(0\cdot\tau)\cdot e^{j\omega_0(0-\tau)} + \cdots + f(N\tau)\cdot e^{-j\omega_0(N\tau)} \\ f(-N\tau)\cdot e^{-j\omega_M(-N\tau)} + \cdots + f(0\cdot\tau)\cdot e^{j\omega_M(0-\tau)} + \cdots + f(N\tau)\cdot e^{-j\omega_M(N\tau)} \end{bmatrix}$$

$$= \tau * \begin{bmatrix} f(-N\tau) & \cdots & f(0\tau) & \cdots & f(N\tau) \end{bmatrix} \begin{bmatrix} e^{-j\omega_{-M}(-N\tau)} & \cdots & e^{-j\omega_0(-N\tau)} & \cdots & e^{-j\omega_M(-N\tau)} \\ \vdots & & \vdots & & \vdots \\ e^{-j\omega_{-M}(0\cdot\tau)} & \cdots & e^{-j\omega_0(0\cdot\tau)} & \cdots & e^{-j\omega_M(0\cdot\tau)} \\ \vdots & & \vdots & & \\ e^{-j\omega_{-M}(N\cdot\tau)} & \cdots & e^{-j\omega_0(N\cdot\tau)} & \cdots & e^{-j\omega_M(N\cdot\tau)} \end{bmatrix}$$

$$= \tau * \begin{bmatrix} f(-N\tau) & \cdots & f(0\tau) & \cdots & f(N\tau) \end{bmatrix} * e^{-j\cdot\begin{bmatrix} -N\tau \\ \vdots \\ 0\cdot\tau \\ \vdots \\ N\tau \end{bmatrix} * \begin{bmatrix} \omega_{-M} & \cdots & \omega_0 & \cdots & \omega_M \end{bmatrix}}$$