$$x_s(t) = \sum_{n=-\infty}^{+\infty} x(nT_s)\delta(t - nT_s)$$

normalization of time

$$n = \frac{nT_s}{T_s}$$

$$f_{norm} = \frac{f}{F_s}$$

$$\omega_{norm} = \frac{\omega}{F_s}$$

convol in freq and in time.

$$X_s(j\omega) = X(j\omega) \star S(j\omega) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} X(\alpha)S(\omega - \alpha)d\alpha$$

$$y(t) = x(t) \star h(t) = \int_{-\infty}^{+\infty} x(\tau)h(t - \tau)d\tau$$

four series

$$c_k = \frac{D\vartheta}{T_s}\text{sinc}\left(\frac{\vartheta}{2}k\Omega_s\right)$$

$$c_k = \lim_{\vartheta \to 0} \frac{\frac{1}{\vartheta}\vartheta}{T_s}\text{sinc}\left(\frac{\vartheta}{2}k\Omega_s\right) = \frac{1}{T_s}\text{sinc}(0) = \frac{1}{T_s}$$

$$S(j\omega) = \sum_{k=-\infty}^{+\infty} 2\pi c_k \delta(\omega - k\Omega_s) = \sum_{k=-\infty}^{+\infty} \frac{2\pi}{T_s}\delta(\omega - k\Omega_s)$$

convolutions again

$$X_s(j\omega) = X(\omega) \star \frac{2\pi}{T_s}\delta(\omega) = F_s X(\omega)$$

$$X_s(j\omega) = X(\omega) \star \frac{2\pi}{T_s}\delta(\omega - \Omega_s) = F_s X(\omega - \Omega_s)$$

$$X_s(j\omega) = X(\omega) \star \frac{2\pi}{T_s}[\delta(\omega) + \delta(\omega - \Omega_s)] = F_s[X(\omega) + X(\omega - \Omega_s)]$$

$$X_s(j\omega) = X(\omega) \star \frac{2\pi}{T_s} \sum_{k=-\infty}^{+\infty} \delta(\omega - k\Omega_s) = F_s \sum_{k=-\infty}^{+\infty} X(\omega - k\Omega_s)$$

reco in frquency

$$H_r(j\omega) = \begin{cases} T_s & \text{for } -\Omega_s/2 < \omega < \Omega_s/2 \\ 0 & \text{elsewhere} \end{cases}$$

reco time

$$h_r(t) = \frac{T_s}{2\pi}\Omega_s \text{sinc}\left(\frac{\Omega_s}{2}t\right) = \text{sinc}\left(\frac{\Omega_s}{2}t\right)$$

$$\frac{\Omega_s}{2}t_x = \pi, \quad \text{therefore} \quad t_x = \frac{2\pi}{\Omega_s} = \frac{2\pi T_s}{2\pi} = T_s.$$

$$x(0)\delta(t) \longrightarrow x(0)\text{sinc}\left(\frac{\Omega_s}{2}t\right),$$

$$x(nT_s)\delta(t - nT_s) \longrightarrow x(nT_s)\text{sinc}\left(\frac{\Omega_s}{2}(t - nT_s)\right),$$

$$x_r(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\text{sinc}\left(\frac{\Omega_s}{2}(t - nT_s)\right).$$

——————— FR pomoci DFT ———————

$$c_k = \frac{1}{T_1} \int_{T_1} x(t)e^{-jk\omega_1 t}dt,$$

$$c_k \approx \frac{1}{NT_s} \sum_{n=0}^{N-1} x(nT_s)e^{-jk\frac{2\pi}{NT_s}nT_s}T_s = \frac{T_s}{NT_s} \sum_{n=0}^{N-1} x(nT_s)e^{-jk\frac{2\pi}{N}n} = \frac{1}{N} \sum_{n=0}^{N-1} x[n]e^{-jkn\frac{2\pi}{N}}.$$

$$c_k = \frac{X[k]}{N}.$$

$$k_{max} < \frac{N}{2},$$

$$\omega_{max} < \frac{\Omega_s}{2}.$$

$$c_k = \frac{X[mk]}{N},$$

——————— FT pomoci DFT ——————

$$X(j\omega) = \int_{-\infty}^{+\infty} x(t)e^{-j\omega t}dt$$

$$\Omega_s = \frac{2\pi}{T_s}$$

$$k\frac{\Omega_s}{N}$$

.

$$X(jk\frac{\Omega_s}{N}) \approx \sum_{n=0}^{N-1} x(nT_s)e^{-jk\frac{\Omega_s}{N}nT_s}T_s = T_s\sum_{n=0}^{N-1} x(nT_s)e^{-jk\frac{2\pi/T_s}{N}nT_s} = T_s\sum_{n=0}^{N-1} x[n]e^{-jkn\frac{2\pi}{N}}.$$

$$k\frac{\Omega_s}{N}$$

$$X(jk\frac{\Omega_s}{N}) = T_sX[k]$$

$$k < \frac{N}{2}$$

$$\omega_{max} < \frac{\Omega_s}{2}$$

$$X(jk\frac{\Omega_s}{N}) \longrightarrow X(jk\frac{\Omega_s}{N})e^{-jk\frac{\Omega_s}{N}t_{start}}$$