# ECE 310: Lecture 29: Oversampled D/A and A/D Converters

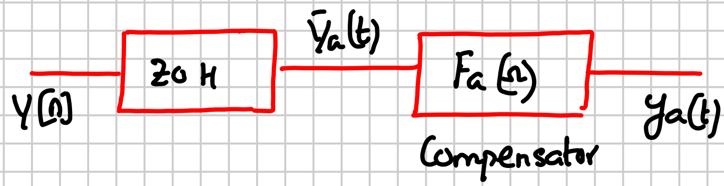
Consider the D/A Converter :


① Ideal D/A Converter :

$$y_a(t) = \sum_{n=0}^{\infty} y[n]\, g_a(t - nT)$$

$$\boxed{g_a(t) = \text{Sinc}\ \frac{\pi t}{T}}$$ → Pulse in frequency domain

② Zero-order Hold (ZOH) :

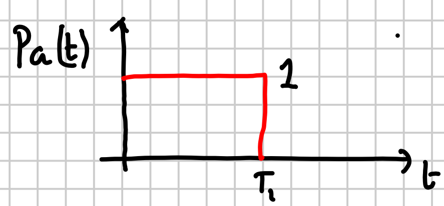



$\bar{y}_a(t)$ = Step approximation for $y_a(t)$

Compensator $F_a(\Omega)$ takes $\bar{y}_a(t)$ and gives $y_a(t)$

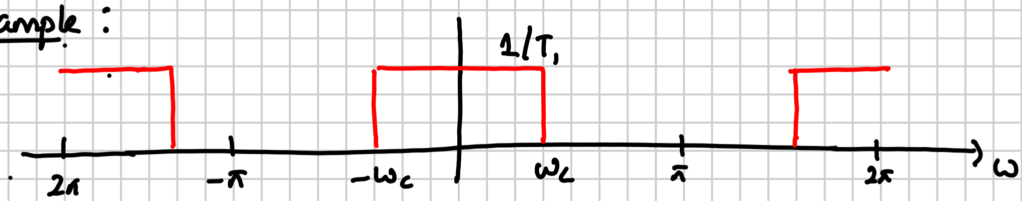
ZOH : D/A Converter using rectangular pulses

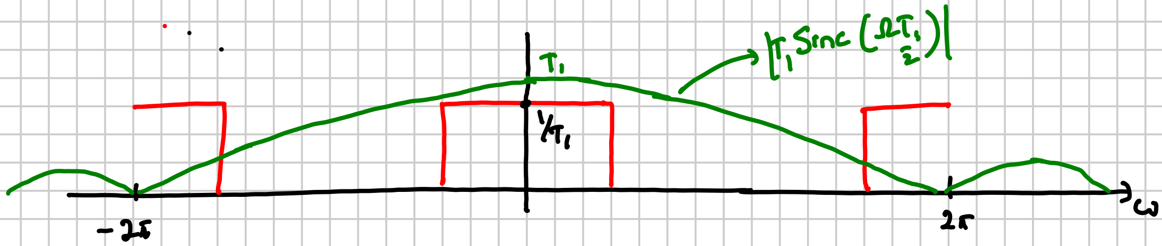
$$\Rightarrow \quad \bar{y}_a(t) = \sum_{n=-\infty}^{\infty} y[n]\, p_a(t - nT_1)$$

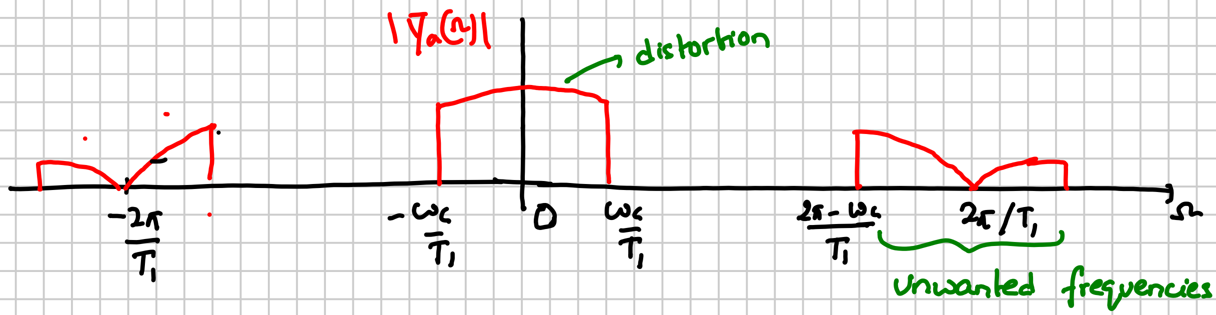



$$\boxed{\bar{Y}_a(\Omega) = T_1\, e^{-j\Omega T_1/2}\, \text{Sinc}\left(\frac{\Omega T_1}{2}\right) Y_d(\Omega T)}$$

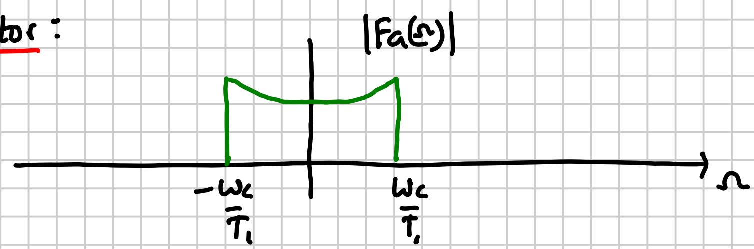
Example :



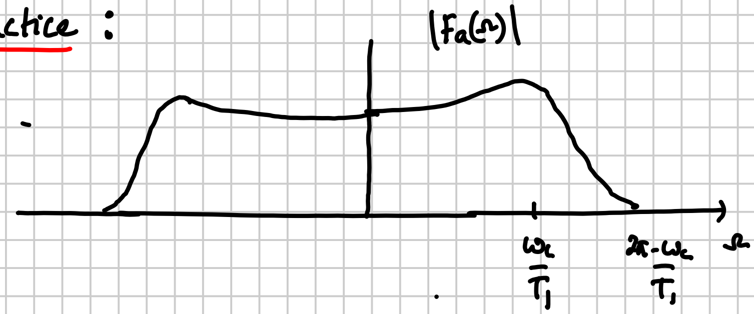




Compensator :




Ideal $|F_a(\Omega)|$ : LPF with $\dfrac{1}{\operatorname{Sinc}\frac{\Omega T}{2}}$ shape.

In practice :

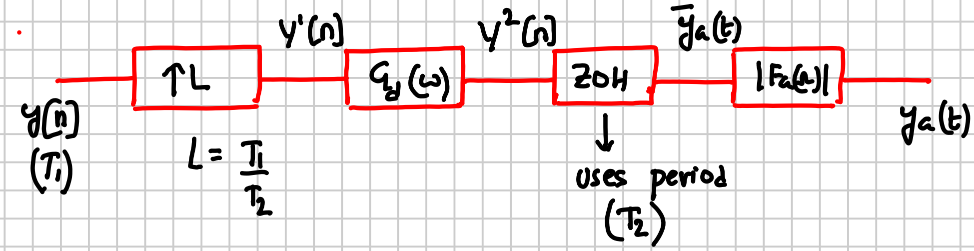



Permitted Trancition bandwidth

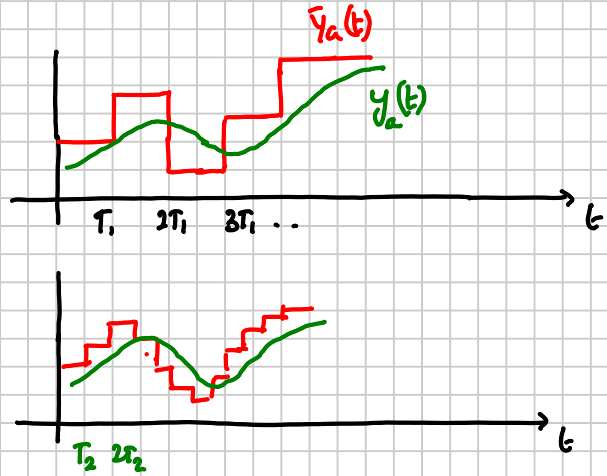
$$B = \frac{2\pi - \omega_c}{T_1} - \frac{\omega_c}{T_1}$$

$$\Rightarrow \boxed{B = \frac{2(\pi - \omega_c)}{T_1}}$$

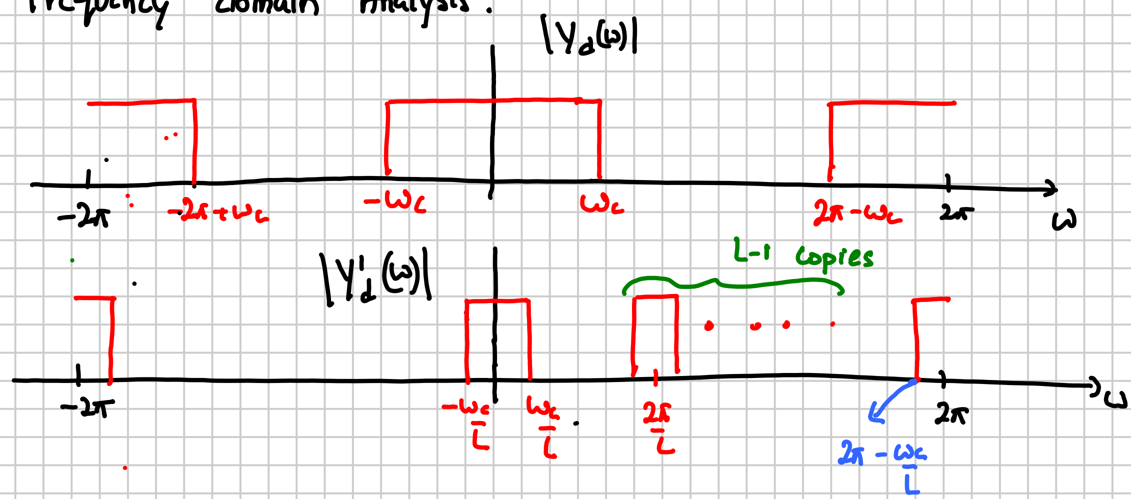
## Oversampled D/A:

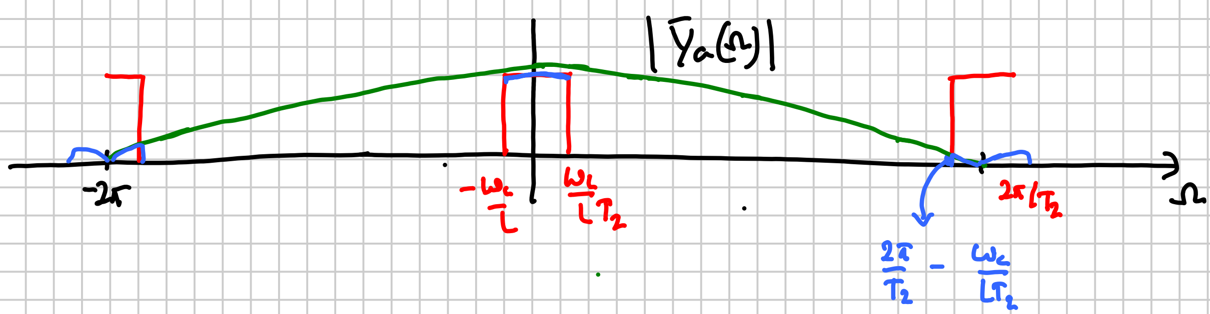



Due to interpolation, the above ZOH puts out finer staircase approximation.




## Frequency domain Analysis:




Transition bandwidth of the compensation filter:

$$B = \frac{2\pi}{T_2} - \frac{\omega_c}{LT_2} - \frac{\omega_c}{LT_2}$$

$$\Rightarrow \quad B = \frac{2\pi L}{T_1} - \frac{\omega_c}{T_1} - \frac{\omega_c}{T_1}$$

$$\Rightarrow \quad \boxed{B = \frac{2(\pi L - \omega_c)}{T_1}}$$

Note: $\boxed{\frac{2(\pi L - \omega_c)}{T_1} \gg \frac{2\pi(\omega - \omega_c)}{T_1}}$

Also Note: ① Center pulse being smaller is almost flat.

② Artifact centered at $\frac{2\pi}{T_2}$ is nearly zero, so even a fairly crude $F_a(\Omega)$ will work