Programa de Pós-Graduação em Engenharia Eletrônica - UERJ

Disciplina: **Controle por Computador**

Aula: **Amostragem e Reconstrução de Sinais do Tempo Contínuo**

Professor: José Paulo Vilela Soares da Cunha

Turma 01 – 2024/2

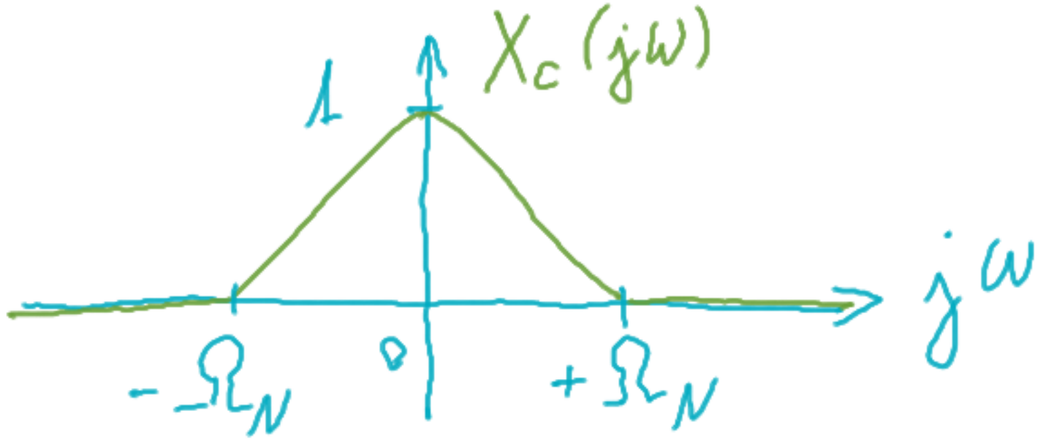
Rio de Janeiro, 03 de setembro de 2024.

Referências

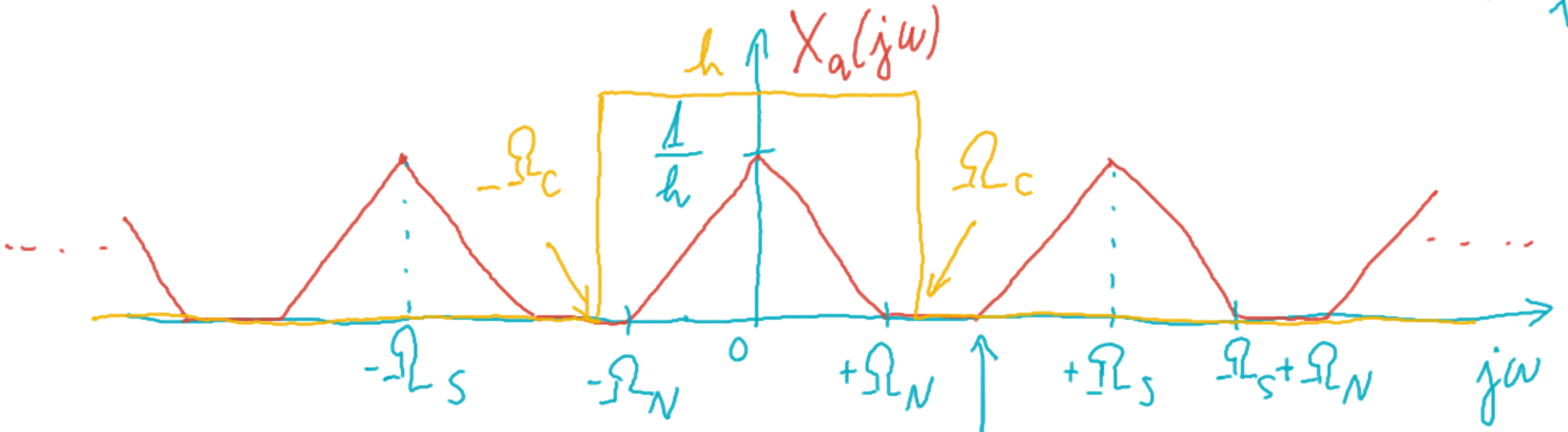
- Åström, K. J. & Wittenmark, B. (2011). Computer-Controlled Systems: Theory and Design, 3rd ed., Dover Publications, Seções 7.3 e 7.4.
- Oppenheim, A. V. & Schafer, R. W. (2013). Processamento em Tempo Discreto de Sinais, 3ª ed., Pearson Brasil.
- Oppenheim, A. V., Schafer, R. W. & Buck, J. R. (1999). Discrete-Time Signal Processing, 2nd ed., Prentice-Hall. (*)

(*) Organizado para as Seções 4.0 a 4.3 da 2ª Edição.

EXEMPLO 1:



$$\Omega_s = 2\pi f_s = \frac{2\pi}{h}$$



$$\Omega_N < \Omega_c < \Omega_s - \Omega_N$$

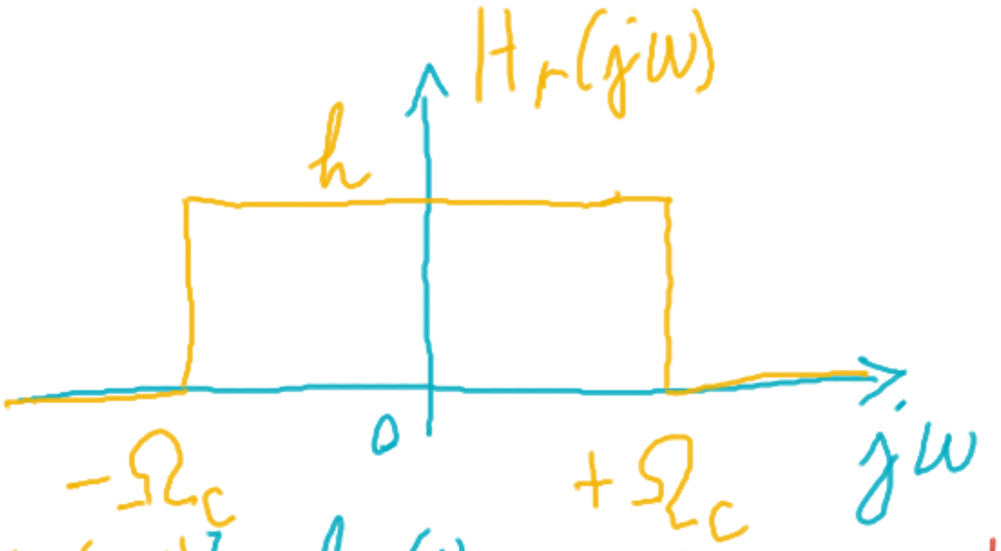
. SUPERPOSIÇÃO ESPECTRAL ("ALIASING") SERÁ EVITADA SE $\Omega_N < \Omega_S - \Omega_N$

$$\Rightarrow \boxed{2\Omega_N < \Omega_S}.$$

. TEOREMA DE NYQUIST-SHANNON.

• FILTRO RECONSTRUTOR:

$$x_r(t) = x_c(t)$$

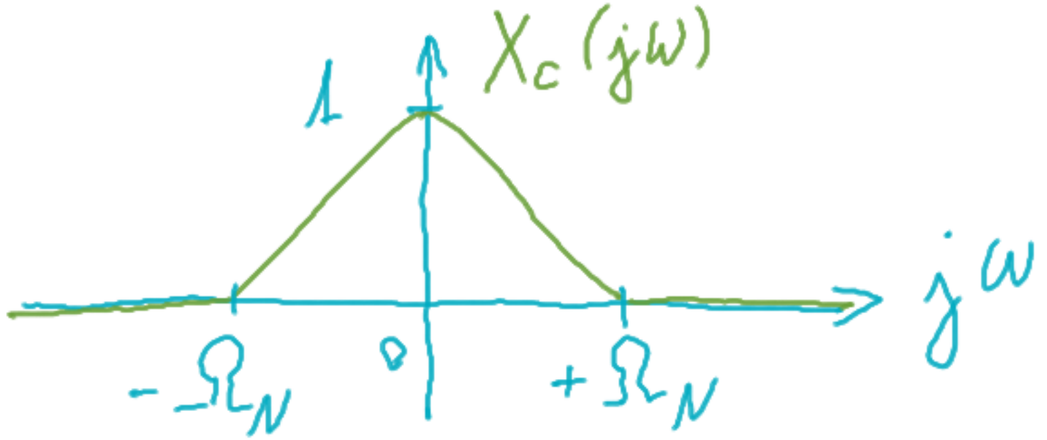


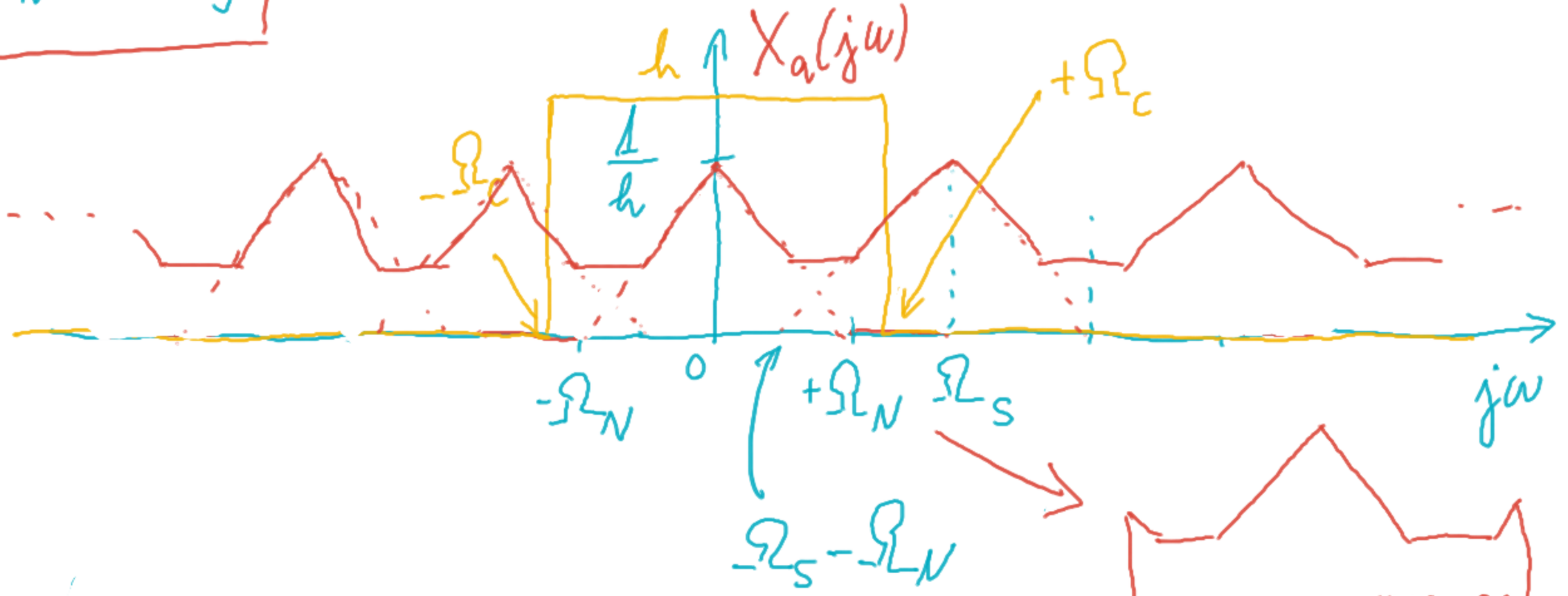
$\mathcal{F}^{-1}\{H_r(jw)\} = h_r(t) \rightarrow$ NÃO CAUSAL!

ALIASING

EXEMPLO 2:

$$2\Omega_N > \Omega_S$$

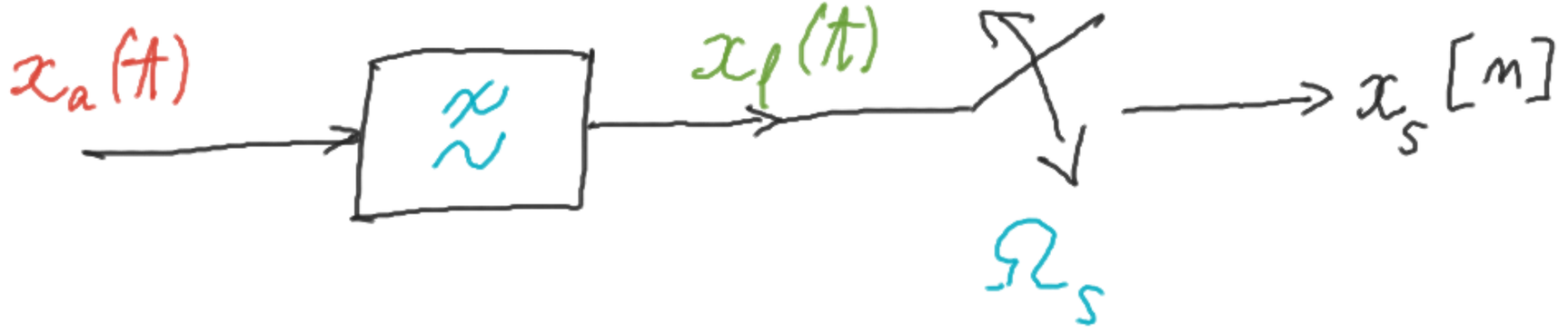


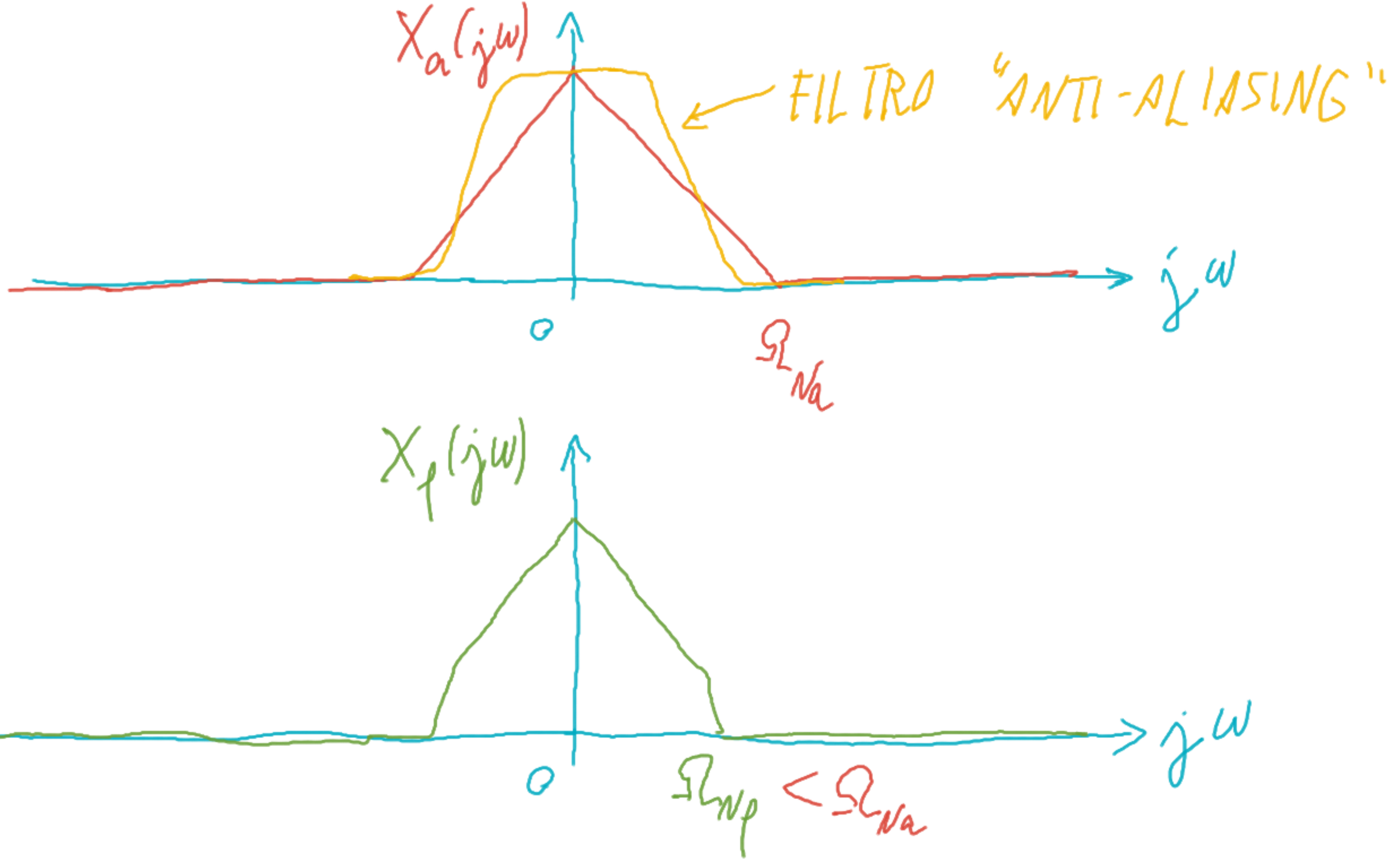


REMÉDIOS PARA O "ALIASING"

- ESCOLHER $\Omega_s > 2\Omega_N$

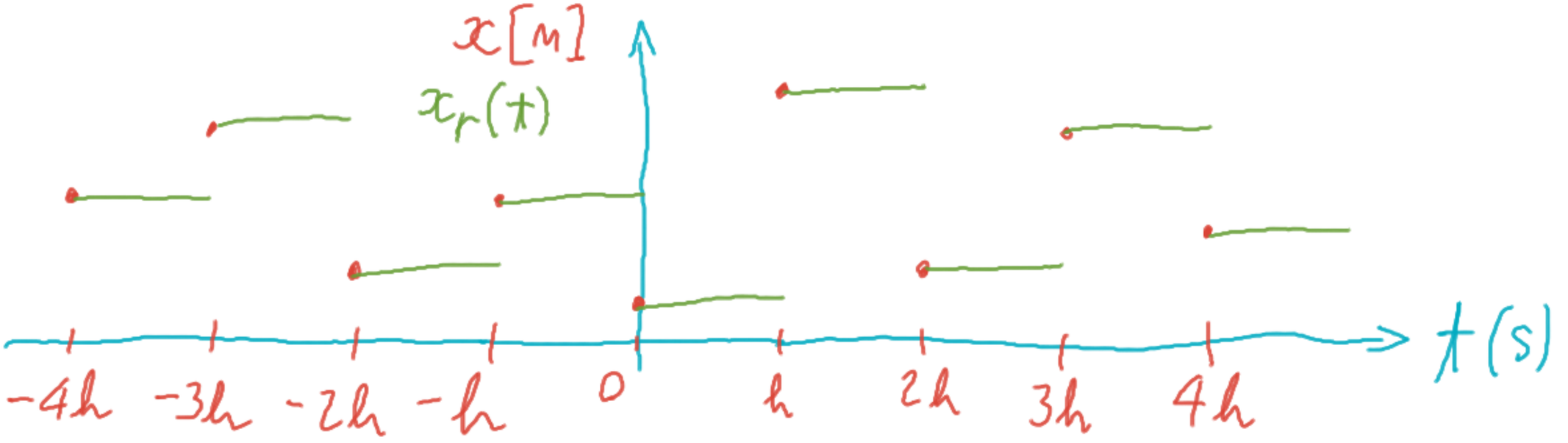
- USO DE FILTRO "ANTI-ALIASING"




$X_a(jw)$
FILTRO "ANTI-ALIASING"
jw
0
Ω_{Na}
$X_p(jw)$
jw
0
$\Omega_{Np} < \Omega_{Na}$

"ZERO-ORDER-HOLD" (ZOH)

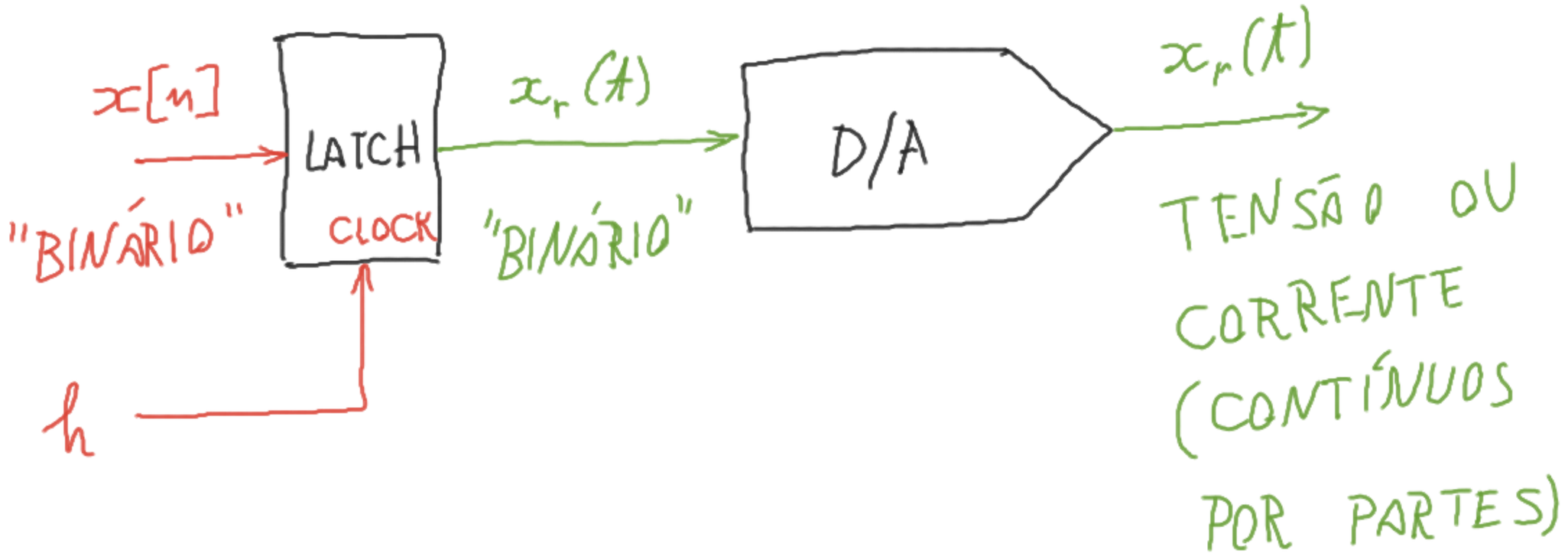
"SEGURADOR DE ORDEM ZERO" → CAUSAL



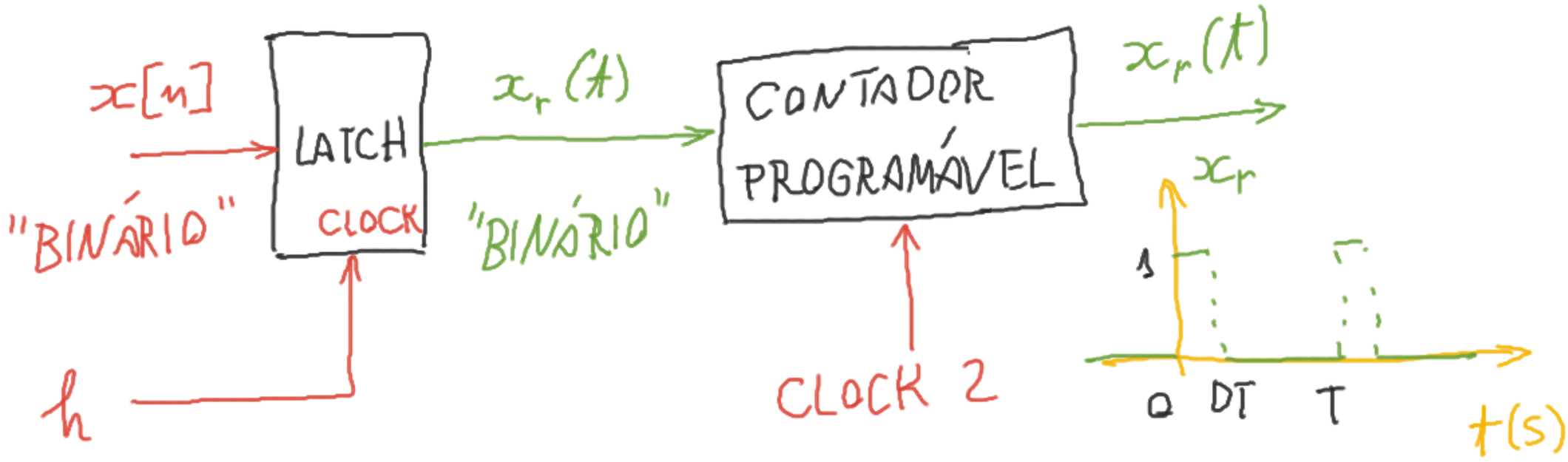
$$x_r(t) = x[n], \quad nh \leq t < nh + h$$

$x_r(t) = C_0[n]$ → POLINÔMIO DE ORDEM 0

- MODELO PARA D/A TÍPICO:



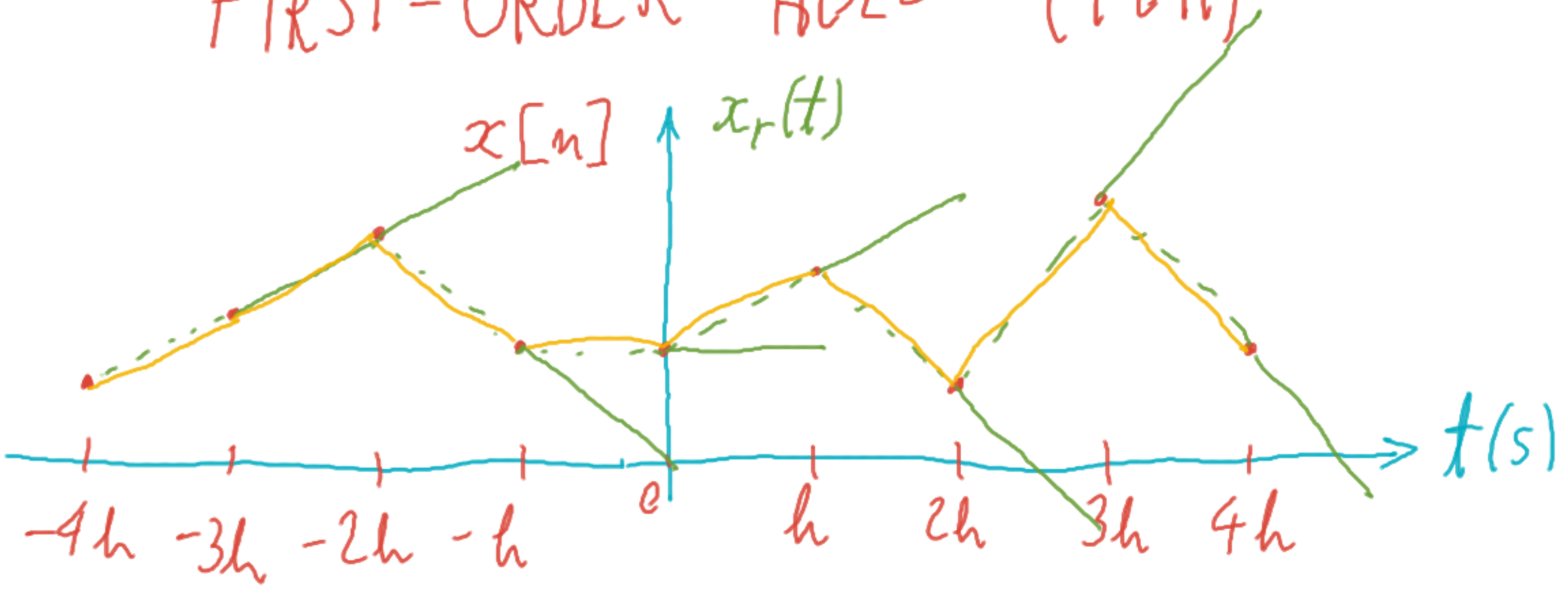
• MODULADOR PWM ("PULSE WIDTH MODULATION"):



$0 \leq D \leq 1 \rightarrow$ "DUTY CYCLE"

ou $0 \leq D \leq 100\%$ (CICLO DE CONDUÇÃO)

"FIRST-ORDER-HOLD" (FOH)



FOH → EXTRAPOLAÇÃO → CAUSAL

FOH → INTERPOLAÇÃO → NÃO CAUSAL

$x_r(t) = c_0[n] + c_1[n]\,t$ → POLINÔMIO DE ORDEM 1