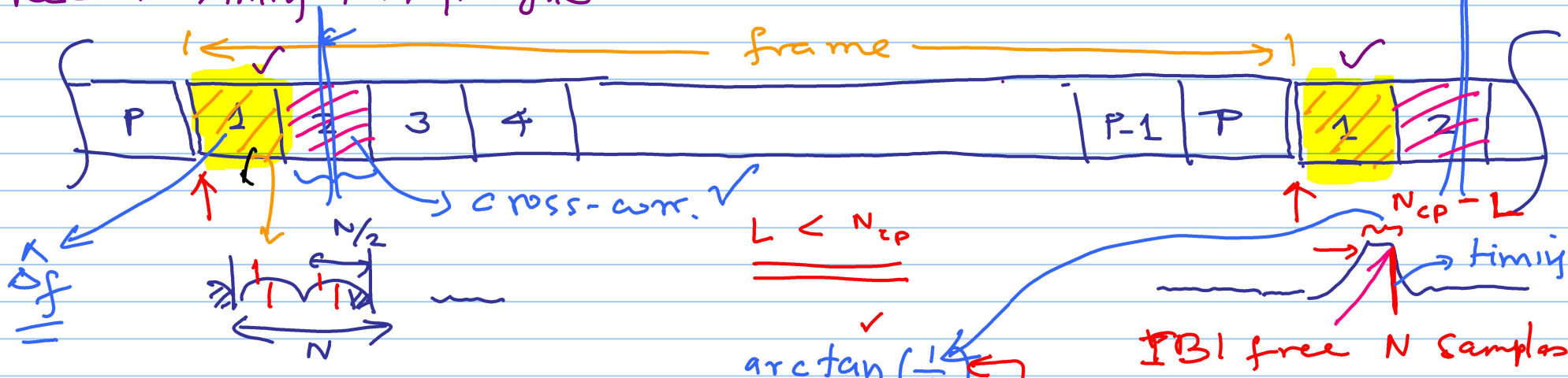
Class #7

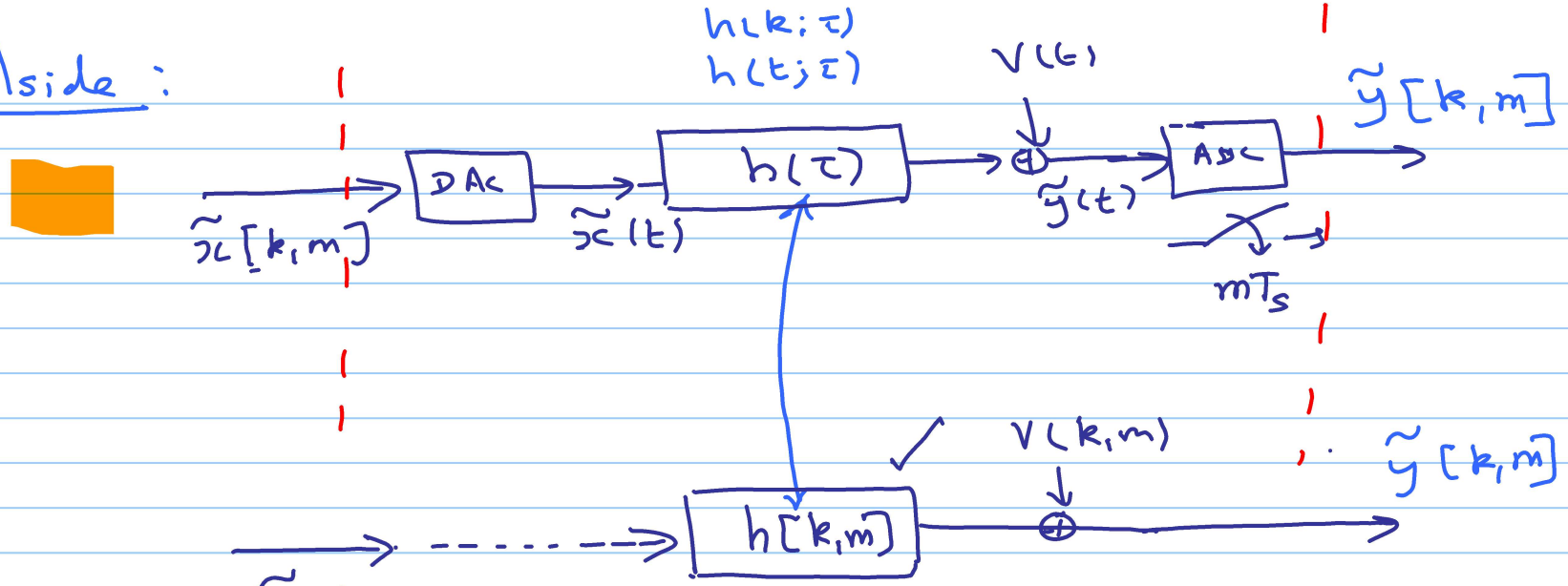
Note Title 4/28/2020

Apr. 28

(X) Recall Timing + Freq. Sync



Aside :

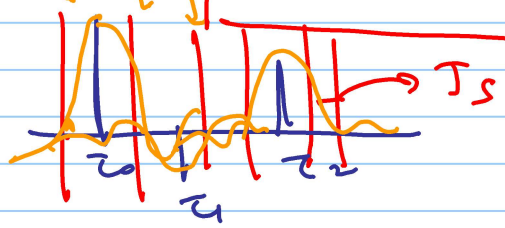


Given $h(\hat{\tau};k) = \sum_{l=0}^{L-1} \alpha_l^k \, \delta(\tau - \tau_l^k)$ → multipath model

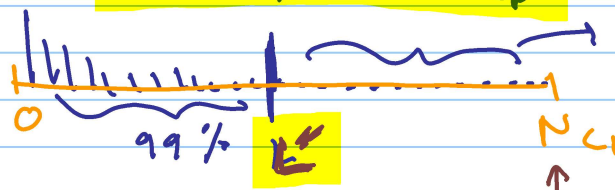
it can be shown that the "sample-spaced" channel model $h[m]$

multi-tap

$$h[m] \approx \sum_{l=0}^{L-1} \alpha_l \, e^{-j\frac{\pi}{N}\left(\frac{\tau_l}{T_s}-m\right)} \cdot \mathrm{sinc}\left(\pi\left(\frac{\tau_l}{T_s}-m\right)\right)$$

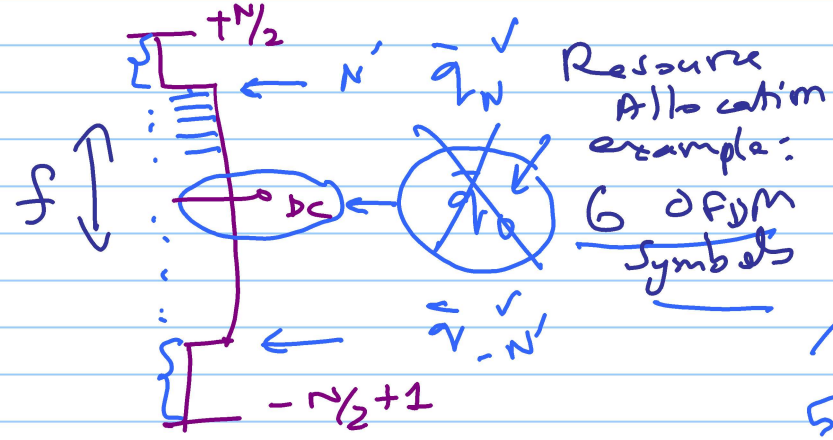


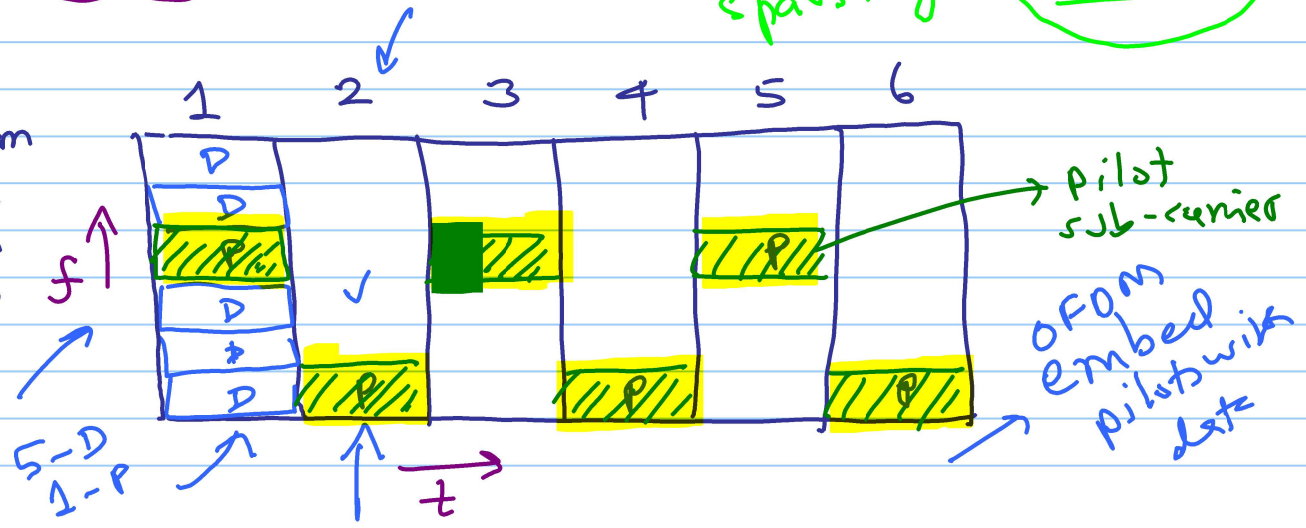
$$\sum_{m=0}^{L_{CP}} |h[m]|^2 \quad \text{for} \quad m = 0, 1, \ldots N_{cp}$$

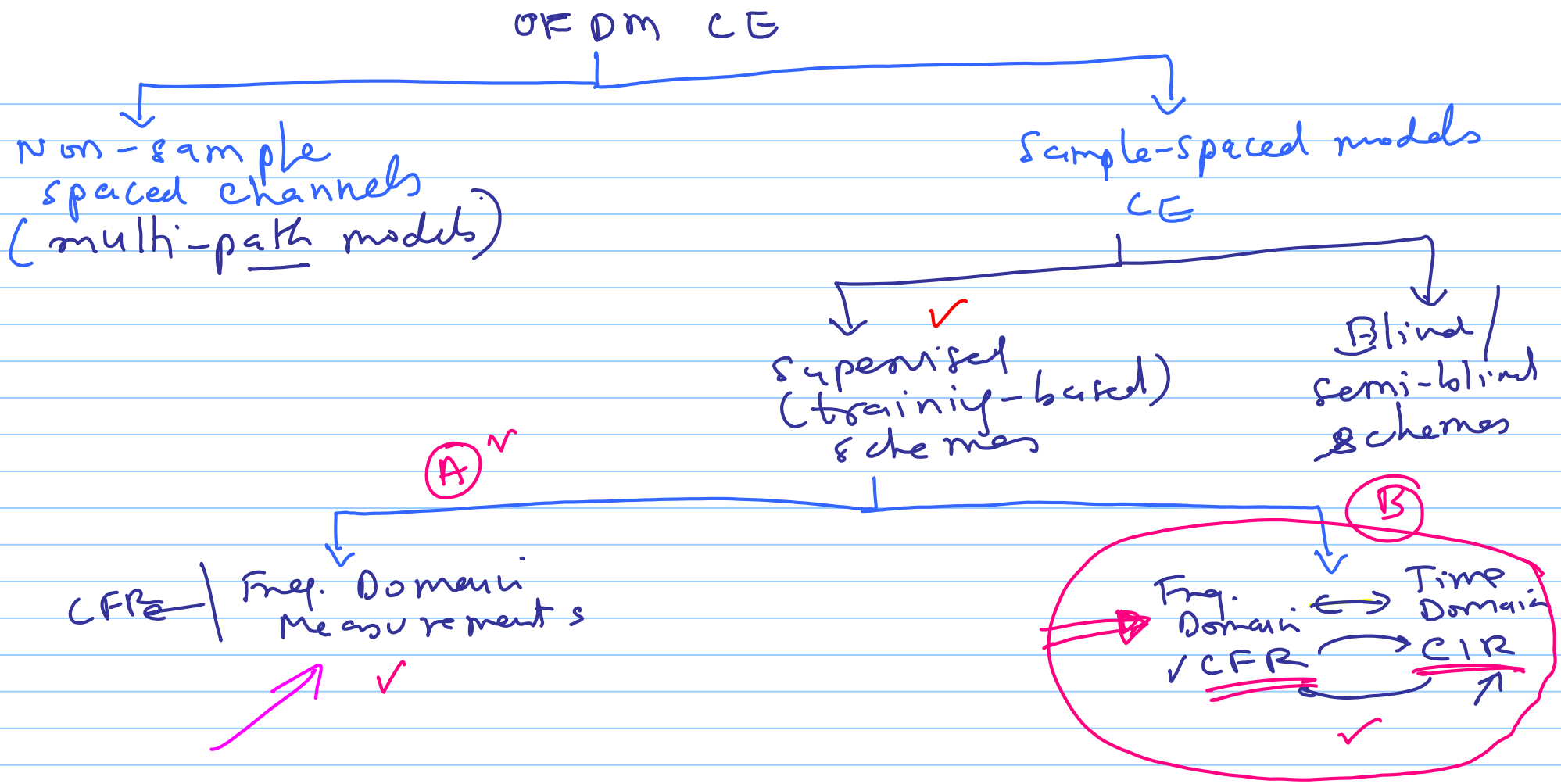


loss of sparsity → $L' > L$

OFDM Channel Estimation :

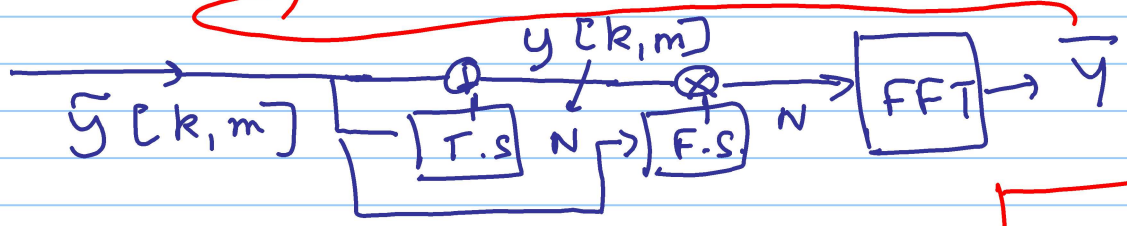





OFDM CE
Non-sample spaced channels (multi-path models)
Sample-spaced models CE
Supervised (training-based) schemes
Blind / semi-blind schemes
A
B
CFR
Freq. Domain Measurements
Freq. Domain
Time Domain
CFR
CIR

(A) CE based on Freq. Domain information alone

$$Y[k,n] = H[k,n]\, d_p[k,n] + V[k,m]$$



(i) ML $\max_{H} p(Y|H)$ $\longrightarrow$ $\hat{H}_{ML} = \dfrac{Y}{d_p}$; $\hat{H} \rightarrow$ ZF

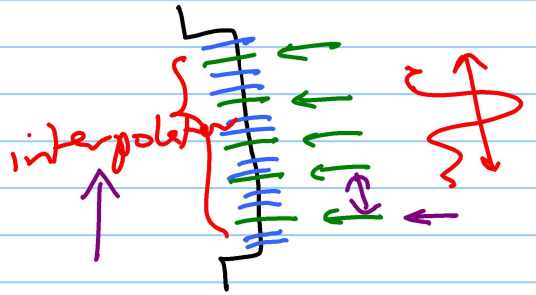
(ii) LS $\min_{\hat{H}} (Y - \hat{Y})^2$ where $\hat{Y} = \hat{H}_{LS} d_p$ $\Rightarrow$ $\hat{H}_{LS}$

(iii) L- MMSE

$$\min_{W} \; E\left[(H - \hat{H})^2 \right] \quad \text{where } \hat{H} = W Y$$

filter

$$W = \frac{\alpha_p E[H^2]}{\left(\sigma_a^2 E[H^2] + \sigma_v^2 \right)} \; ; \quad \hat{H}_{LMMSE} = W Y \rightarrow \hat{H}_{ZF}$$



Σ

MSE $\rightarrow E\left[\left| H(n) - \hat{H}(n) \right|^2 \right]$

ML / ZF / L-MMSE

CE Based on CIR description CFR $\leftrightarrow$ CIR

$\Rightarrow$ (a) 2D-MMSE / suboptimal

(b) FFT-based Interpolation CE ← ✓

→ (c) Modified LS Technique ✓ (mLS) ← ✓

(d) Modified L-MMSE CE (?) ✗