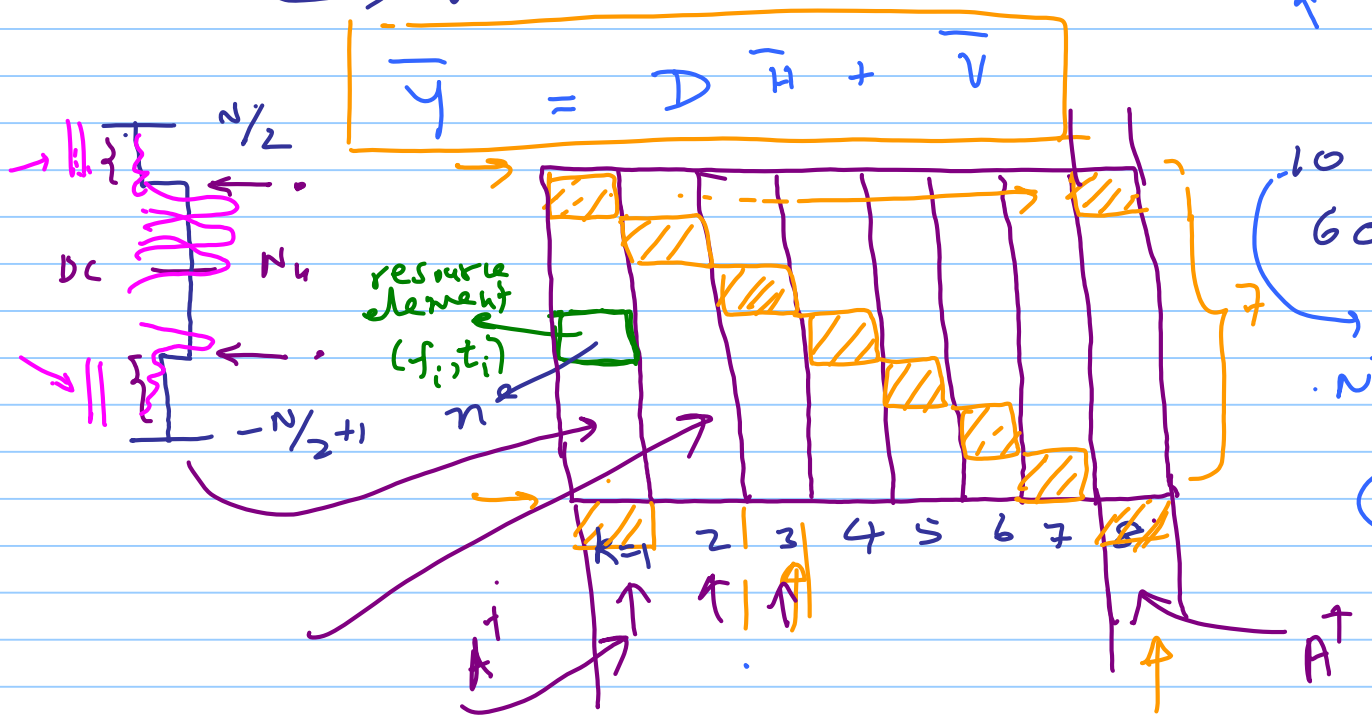
OFDM Channel Estimation

Note Title 5/2/2020

Recall → Scalar Measurement Model: $y = Hd + v$ ← LS/ML/ZF $\hat{H} = \frac{y}{d}$, L-MMSE

→ Vector Measurement Model: $y[k,n] = H[k,n]\,d[k,n] + v[k,n]$

$$\bar{y} = D\,\bar{H} + \bar{v}$$



10 MHz ; Δf_{sub} = 15 kHz ✓

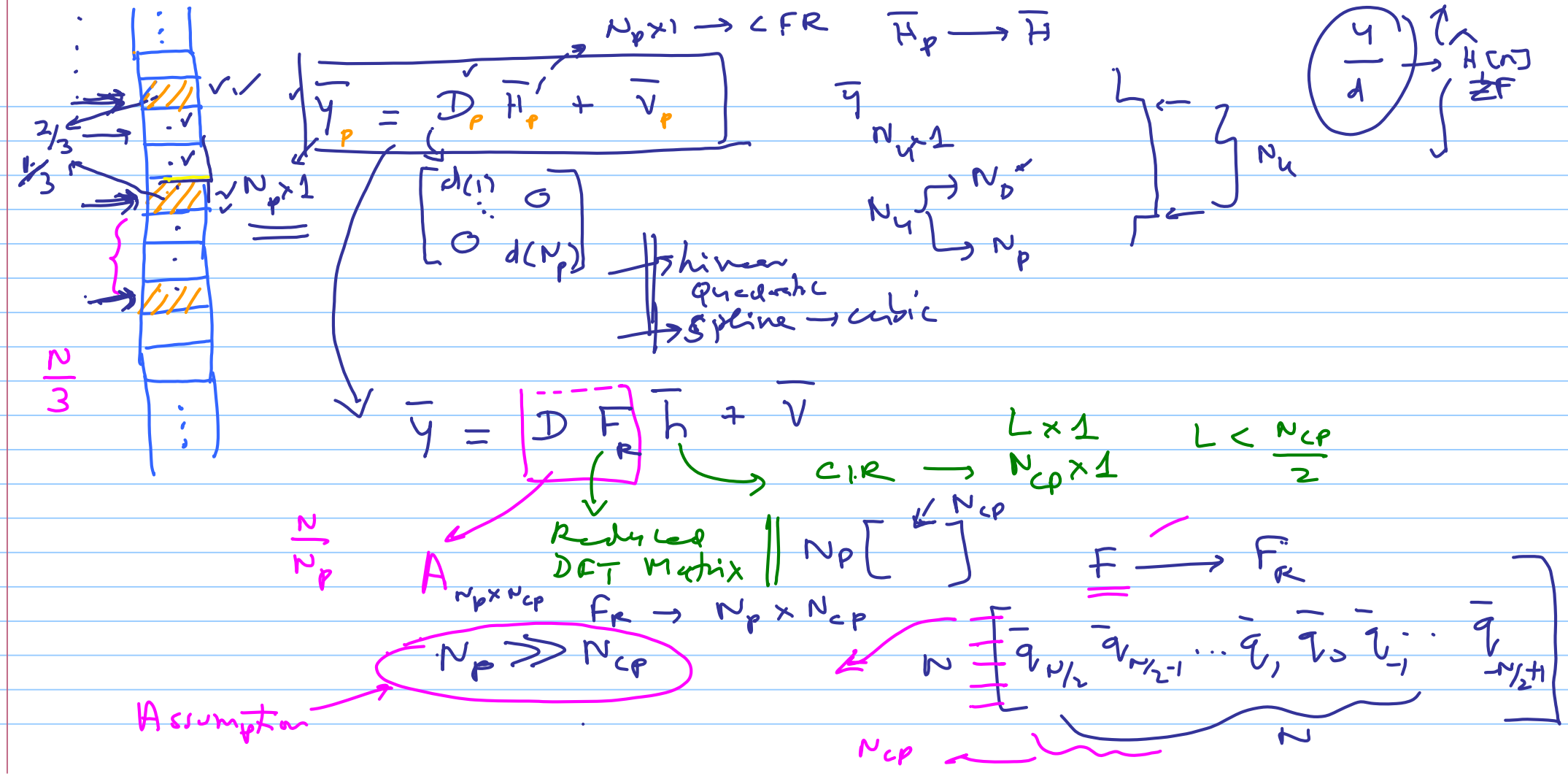
600 ← N 600 × 15 = 9 MHz

15.36 MHz ← f_s

N = 1024

15 ← OSF → 15.36 / 9

15360 → + 61.44 → 122.88


$N_p \times 1 \rightarrow$ CFR
$\bar{H}_p \rightarrow \bar{H}$
$\bar{y}_p = D_p \bar{H}_p' + \bar{v}_p$
$N_p \times 1$
$\bar{y}$
$N_H \times 1$
$N_H \rightarrow N_D$
$N_H \rightarrow N_p$
N_H
$\frac{y}{d} \rightarrow H[n] \overset{ZF}{\rightarrow}$
$\begin{bmatrix} d(1) & & 0 \\ & \ddots & \\ 0 & & d(N_p) \end{bmatrix}$
linear
quadratic
spline → cubic
$\frac{N}{3}$
$\frac{2}{3}$
$\frac{1}{3}$
$\bar{y} = D F_R \bar{h} + \bar{v}$
$L \times 1$
$N_{cp} \times 1$
$L < \frac{N_{cp}}{2}$
CIR →
$\frac{N}{N_p}$
$A_{N_p \times N_{cp}}$
Reduced DFT Matrix
$N_p \left[\begin{matrix} \\ \\ \\ \end{matrix} \right]^{N_{cp}}$
$F \rightarrow F_R$
$F_R \rightarrow N_p \times N_{cp}$
$N_p \gg N_{cp}$
Assumption
N
$\bar{q}_{N/2} \; \bar{q}_{N/2-1} \cdots \bar{q}_1 \; \bar{q}_0 \; \bar{q}_{-1} \cdots \bar{q}_{-N/2+1}$
N_{cp}
N

$\bar{y} = A\bar{h} + \bar{v}$ $\quad A \to$ known

$\bar{y} = N_p [\;]_{N_{cp}} [\bar{h}] + \bar{v} \longrightarrow F\bar{h}_{mLS} = F A^{+} \cdot \bar{y}$ (mLS) $\to \hat{H}_{mLS}$

pre-compute

$A^{+} = (AA^T)^{-1} A^T$ $\quad N_{cp} \times N_{cp}$ $\to$ condition #

✓ $N_p \to$ eqns.

$\to N_{cp} \to$ unknowns

L

modified LS

$L_1 << L$

pdp $\leftarrow$ "sparsity"

N_{cp}

$\hat{h}_{mLS} \xrightarrow{F} \hat{H}_{mLS}$

$\xleftarrow{F^H}$

$F \to$ FFT

$F^H \to$ IFFT

$0 \quad \cdots \quad N-1$

F

$\to A = D F_R$

$N_p \times N_p \quad N_p \times N_{cp}$

$\left[AA^T + \sigma^2 I \right]^{-1}$

? Tchikonoff

$N_p >> N_{cp}$

$N_p \simeq 1.5 N_{cp}$

1.2

$\to$ Regularization

$\dfrac{\lambda_{max}}{\lambda_{min}} > 10{,}000$

< 1.5

100

(2) → Modified L-MMSE ⟷ 2D-MMSE

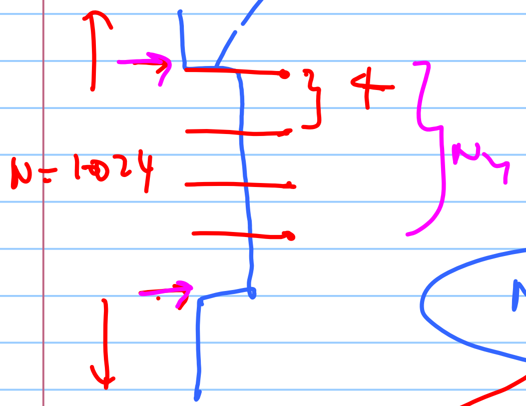
Parametric approaches

2nd order statistics

Freq. Corr. → Delay spread (pdp)

Time-Corr → Doppler

(3) FFT-based CE



N: 1024 → N_u: 800

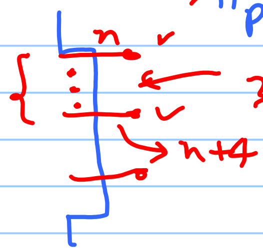
$N_p = \frac{800}{4} = 200$

$N_{cp} = 64$

$L < 64$

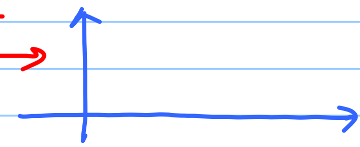
$Y = Hd + v$

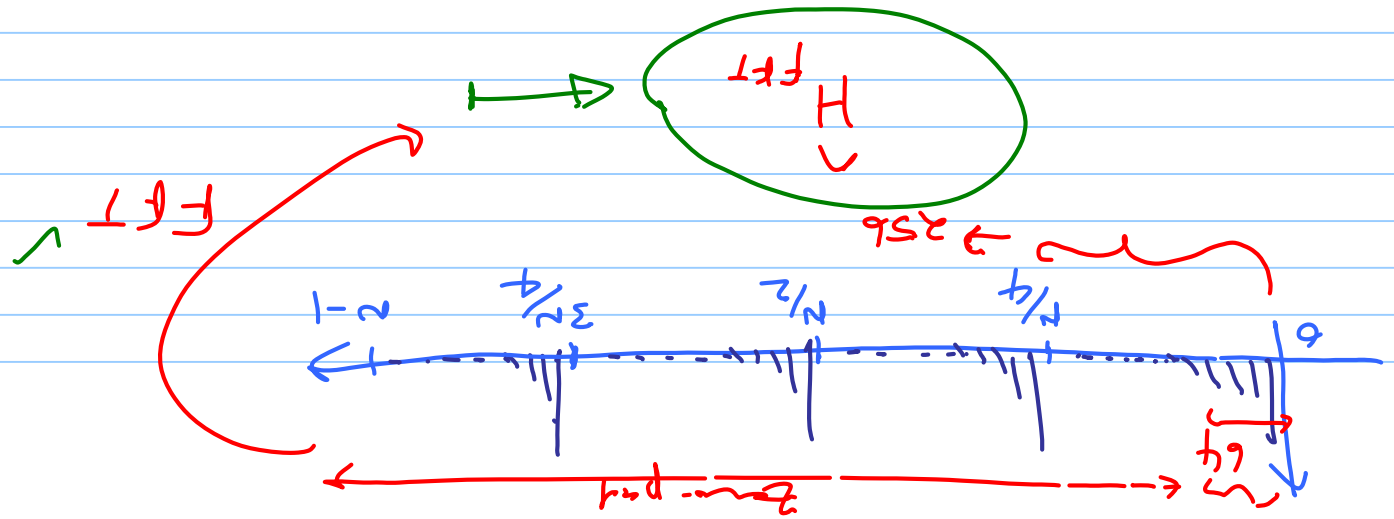
$\hat{H}_p = \frac{y}{d}$



$\hat{\bar{H}}_{N\times 1}$ → IFFT (F^H)

noisy




H
0
N/4
N/2
3N/4
N-1