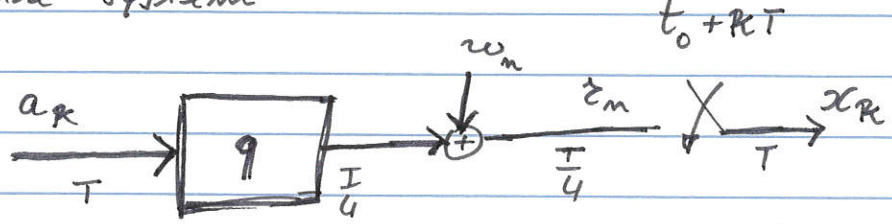
DIGITAL TRANSMISSION — MAY 11, 2015

HW3 — DUE MAY 26, 2015

PROBLEM 1 (10 p)

Given the system



$$\Gamma = \frac{\sigma_a^2 E_q}{4\sigma_w^2}, \quad w_n \sim \mathcal{CN}(0, \sigma_w^2) \text{ i.i.d.}$$

with

$$\left\{q(m\tfrac{T}{4}),\ m=0,1,\dots\right\} = \{0,0,0,0,0,0,0,0,\ 0.19e^{-j2.21},\ 0.09e^{j1.64},\ 0.7e^{-j2.57},$$
$$0.45e^{j0},\ 0.6e^{-j2.26},\ 0.35e^{j3.15},\ 0.24e^{j1.34},$$
$$0.37e^{j2.60},\ 0.34e^{-j1.17},\ 0.0e^{j3.00},\ 0.15e^{-j2.66},$$
$$0.15e^{j3.27},\ 0.17e^{j2.13},\ 0.40e^{j2.06},\ 0.58e^{-j1.51},$$
$$0.03e^{j2.15},\ 0.18e^{j3.60},\ 0.29e^{j3.17},\ 0.40e^{-j1.63},$$
$$0.07e^{-j3.16}\},$$

$a_k \in \{\pm 1 \pm j\}$, i.e. modulation is QPSK with $\sigma_a^2 = 2$. Note that a_k may assume binary values, e.g. $+(1+j)$ and $-(1+j)$, but not $+1$ and -1.

The tx sends ONCE a M-L sequence of length L, partially repeated, for a total length $L_{TS} = L+N$. Here $N=10$ fixed. After the training sequence (binary) the QPSK data follows.
For $L=15$, estimates t_0 (as multiple of $\frac{T}{4}$) and the corresponding ch. impulse response at T, $\{\hat{h}_i\}$, $i=-N_1,\dots,N_2$: Assume $\Gamma = 20$ dB and the LS method for the ch. estimate. Please, note that the choice of N does not dictate the length of $\{\hat{h}_i\}$, and $N > N_1 + N_2 + 1$.

Report equation to determine t_0

" " " " $\{\hat{h}_i\}$

" values of $\{\hat{h}_i\}$, magnitude and phase, in a table.

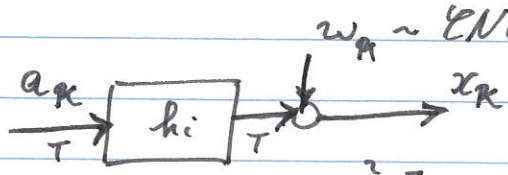
Plot $\{|\hat{h}_i|\}$ vs i., $i = -N_1, \ldots, 0, \ldots, N_2$.

Determine estimate of noise variance $\hat{\sigma}^2_w$ (in dB) and compare it with σ^2_w (in dB).

Compare the estimate $\hat{\Lambda}_m = \dfrac{\hat{\sigma}^2_w}{Ma\, \|\underline{\Delta h}\|^2}$ with the 'true value' Λ_m, in dB.

PROBLEM 2 (30p)

For the system at T:



$$\Gamma = \frac{\sigma^2_a E_h}{\sigma^2_w}, \quad h_i = q(t_0 + iT)$$

where at receiver we only know $\hat{\sigma}^2_w$ and $\{\hat{h}_i\}$, simulate the BER for different receivers at various values of Γ.

LE + threshold detector (TD): parameters M_1 and D,

DFE + " " " M_1, M_2, and D

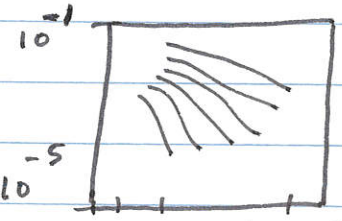
VA : give state definition

FBA (Max-log-MAP)

For $\Gamma = 10$ dB in LE and DFE, plot $\{|\hat{h}_{i,l}|\}$, $\{|c_{i,l}|\}$, $\{|b_{i,l}|\}$, $\{|f_{i,l}|\}$.

Obviously the design must be repeated for each value of Γ.

Plots:



LE
DFE
VA
FBA (Max-log-MAP)
MF bound (formula)
MF " {simulation $x_k = a_k + w_k$}

Give number of bits in simulations.

Repeat simulations if $\hat{\sigma}^2_w = \sigma^2_w$ and $\hat{h}_i = h_i$. Assume above values of filter parameters and just redo plots.