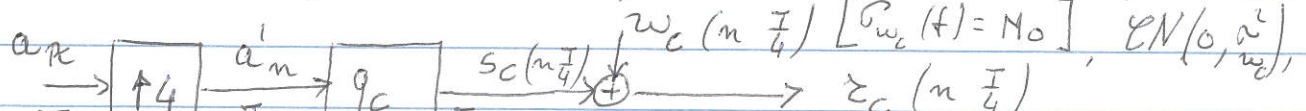
DIGITAL COMMUNICATIONS — MAY 3, 2018

HW3 — DUE MAY 21, 2018

Consider the system model, known at the receiver,



$$\Gamma = \frac{M_{s_c}}{N_0 \frac{1}{T}} = \frac{\hat{a}^2 E_{q_c}}{\hat{\sigma}^2_{w_c}} \quad ; \quad E_{q_c} = \sum_m |q_c(m\tfrac{T}{4})|^2$$

Assume $T = 1$ and $a_R \in \{\pm 1 \pm j\}$, a QPSK constellation.

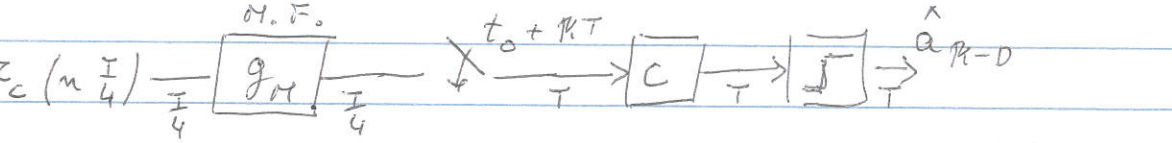
$$a'_m = \begin{cases} a_R, & n = 4R \\ 0, & \text{otherwise} \end{cases} \quad \text{(upsampler)}$$

$$s_c(n\tfrac{T}{4}) = \alpha\, s_c((n-1)\tfrac{T}{4}) + \beta\, a'_{n-5}, \quad \alpha = 0.67, \quad \beta = 0.7424$$

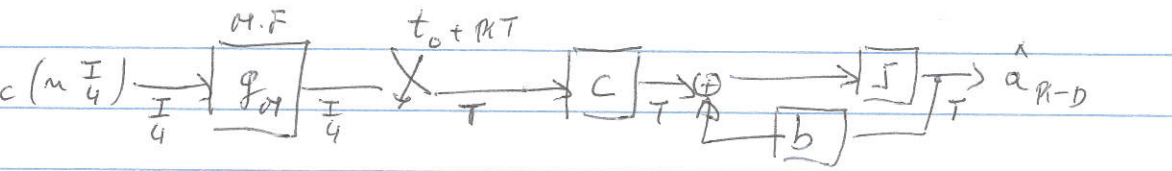
Plot $|q_c|$ vs $n\frac{T}{4}$. Plot $|G_c(f)|$, in dB, for $f \in (0, \frac{2}{T})$.

let $t_0 = \bar{t}_0 \cdot \frac{T}{4}$, $\bar{t}_0$ an integer

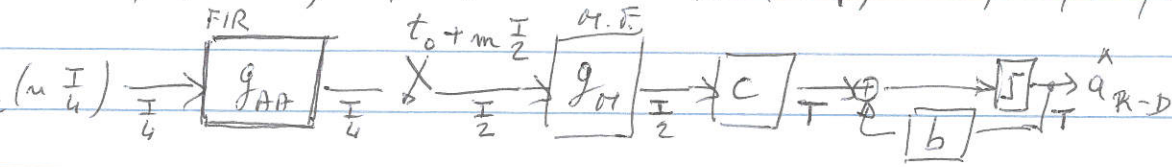
Consider the following receiver schemes

a) (10p) 

For $\Gamma = 10$ dB, give $\bar{t}_0$, M_1, D. Plot $|g_M|$ @ $\frac{T}{4}$, $|C|$, [illegible] $|\Psi|$.

(b) (10p) 

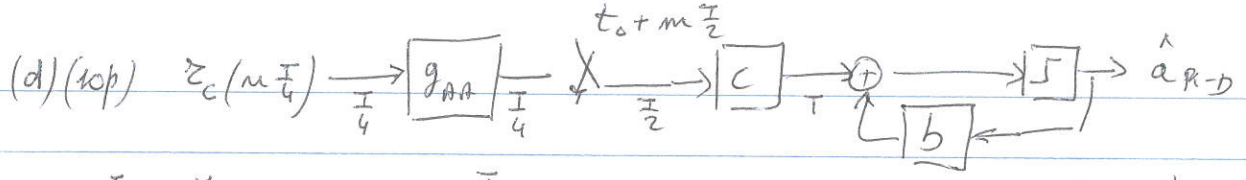
For $\Gamma = 10$ dB, give $\bar{t}_0$, M_1, M_2, D. Plot $|g_M|$ @ $\frac{T}{4}$, $|c|$, $|b|$, $|\Psi|$.

(c) (10p) 

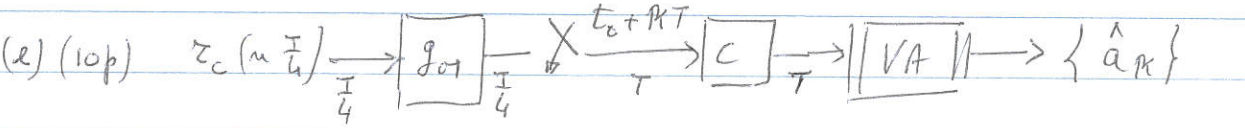
Plot $|G_{AA}(f)|$, in dB, $f \in (0, \frac{2}{T})$. Plot $|G_M(f)|$, in dB, $f \in (0, \frac{2}{T})$.

For $\Gamma = 10$ dB, give $\bar{t}_0$, M_1, M_2, D. Plot $|g_M|$ @ $\frac{T}{2}$, $|c|$ @ $\frac{T}{2}$, $|b|$, $|\Psi|$ @ $\frac{T}{2}$.

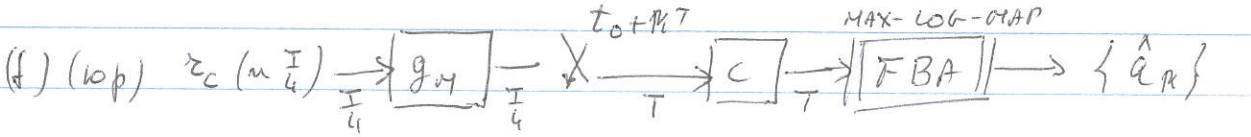
Please, note that g_M in this problem is not the same of Problems a) and b).

(d) (10p) 

For $\Gamma = 10$ dB, give t_0, M_1, M_2, D. Plot $|c|@\frac{T}{2}$, $|b|$, $|4|@\frac{T}{2}$.

(e) (10p) 

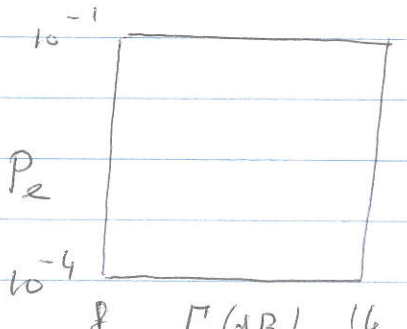
The VA is using the 'channel' as given by $\gamma_D, \gamma_{D+1}, \dots, \gamma_{D+M_2}$ in 'Receiver b)'. Give the state definition

(f) (10p) 

The FBA is using the 'channel' as at point (e).

For each scheme, determine the probability of symbol error, $P_e = P[\hat{a}_M \neq a_k]$, by simulation, for various values of Γ. Let $8 \le (\Gamma)_{dB} \le 14$ and $10^{-4} \le P_e \le 10^{-1}$. For each value of Γ design the various filters but do not report their values. Plot also P_e vs. Γ given by the 'matched filter bound', as from theory and simulation, where $\gamma_k = a_k + w_k$, with $\Gamma = \tilde{a}^2 / \tilde{\sigma}_w^2$, and $w_k \in \mathcal{N}(0, \tilde{\sigma}_w^2)$ IID

In conclusion there are eight curves



MF + LE @ T	'blue dashed'
MF + DFE @ T	'blue solid'
AAF + MF + DFE @ $\frac{T}{2}$	'black dashed'
AAF + DFE @ $\frac{T}{2}$	'black solid'
VA	'red dashed'
FBA (max-log-MAP)	'red solid'
MF bound - Sim	'green dashed'
MF bound - Theory	'green solid'

Please, use this legend (bold part), in this order and with the given corresponding colors.