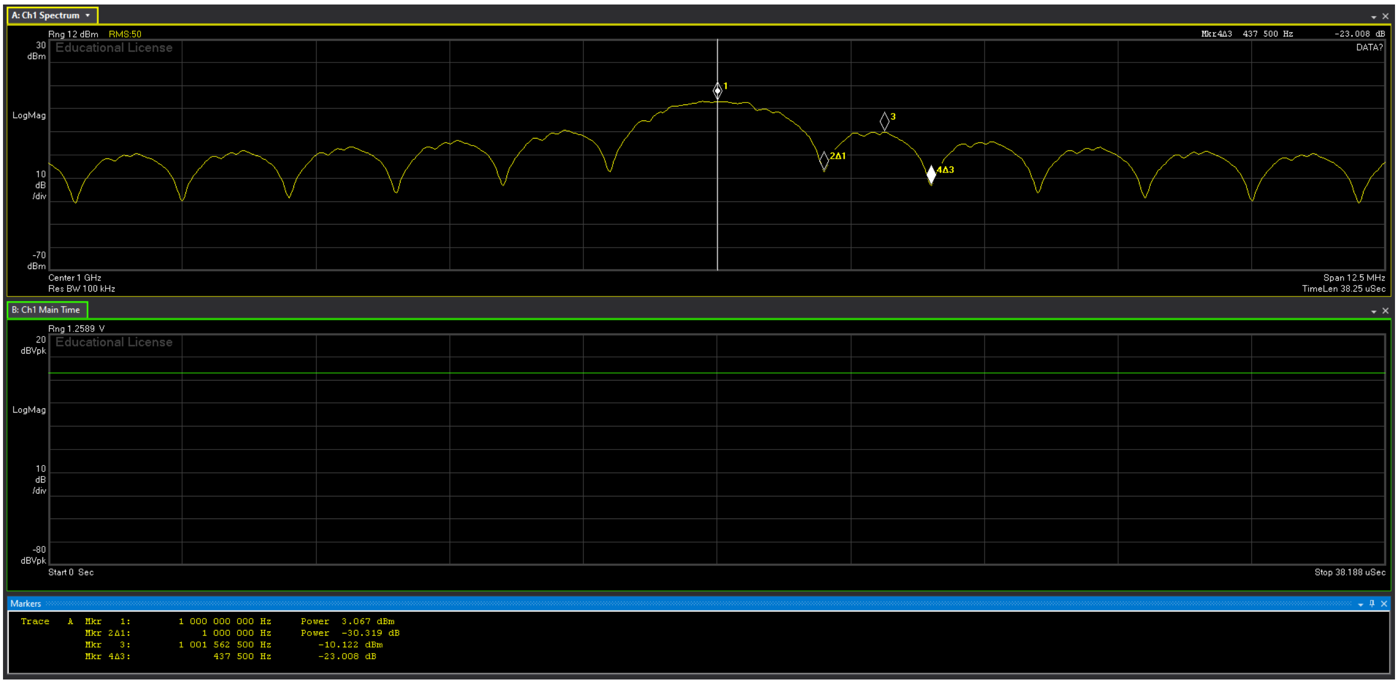
Aitor Pitarch
Pere Sanchez

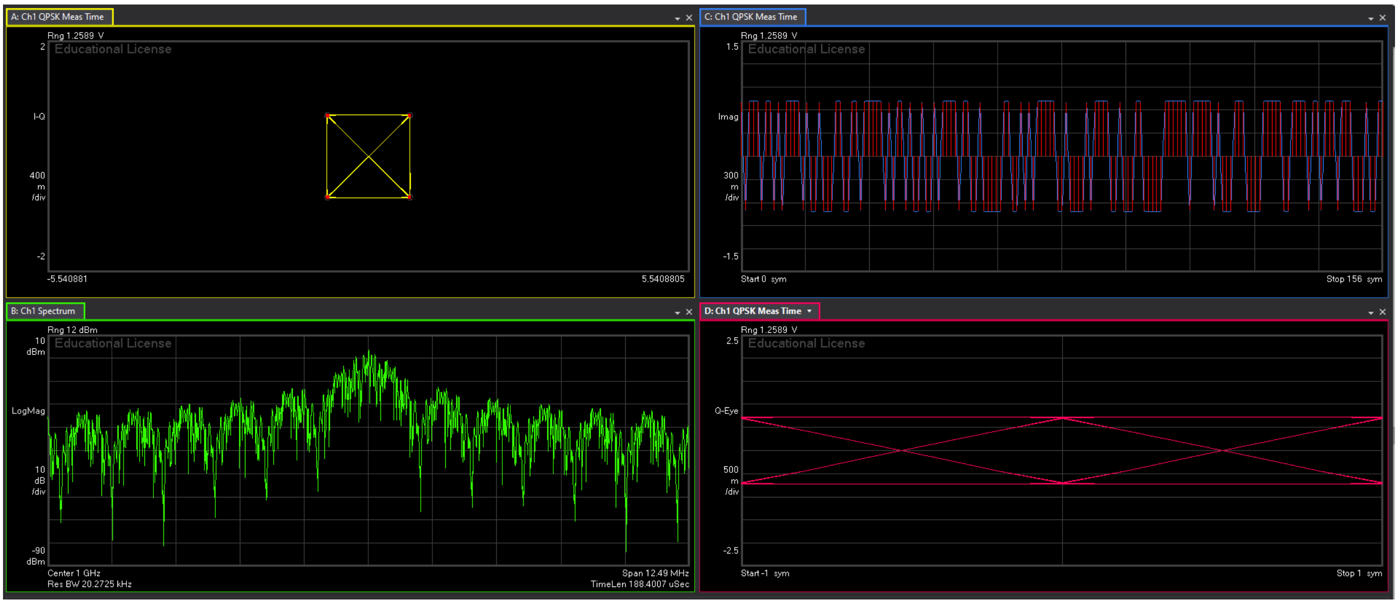
5.1 Visualization of the transmitted QPSK spectrum



BW del lòbul principal: 2MHz
Rs = Rb / b = 2MHz / 2 = 1MBaud

Diferència entre lòbul principal i secundari: 13,189 dB.

5.2 Demodulation of the transmitted QPSK



La principal diferència que podem observar és que, al utilitzar un pols rectangular en comptes d'un SRRC, les transicions son rectes.

On no hi ha diferència és en la falta de distorsió, això es deu a que la demodulació feta es ideal.

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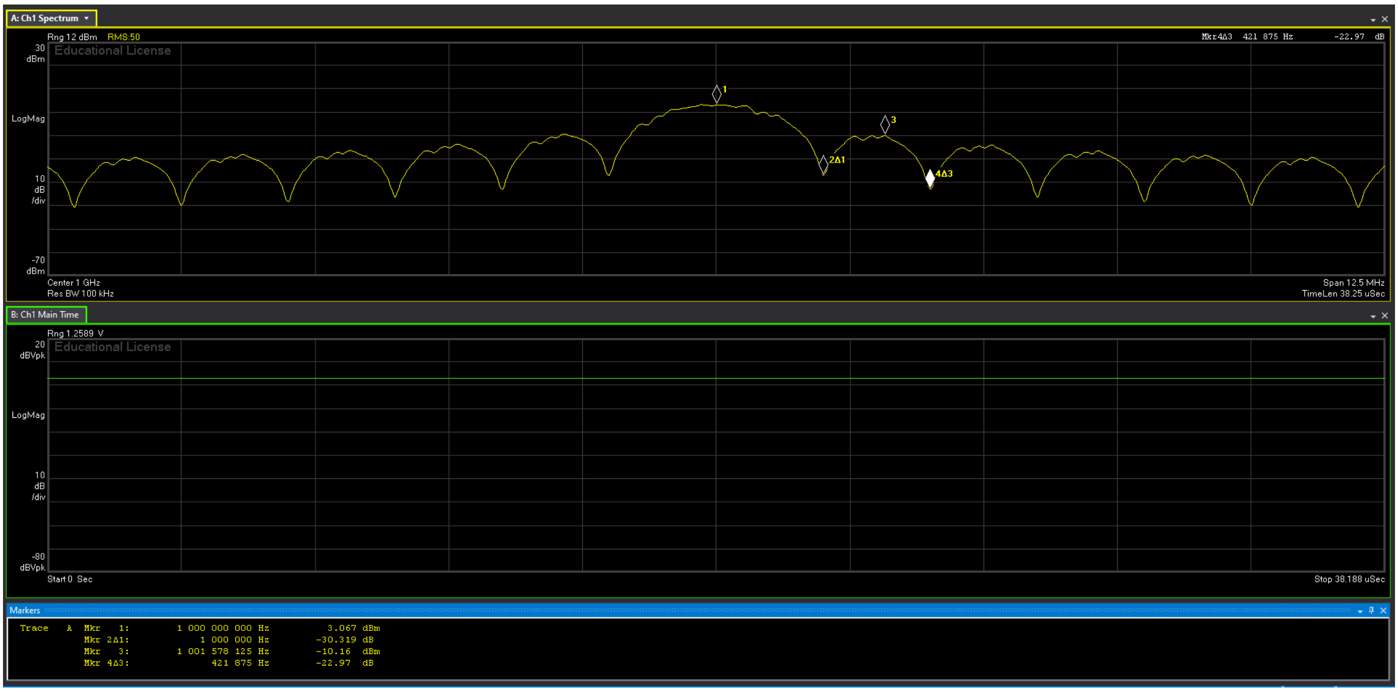
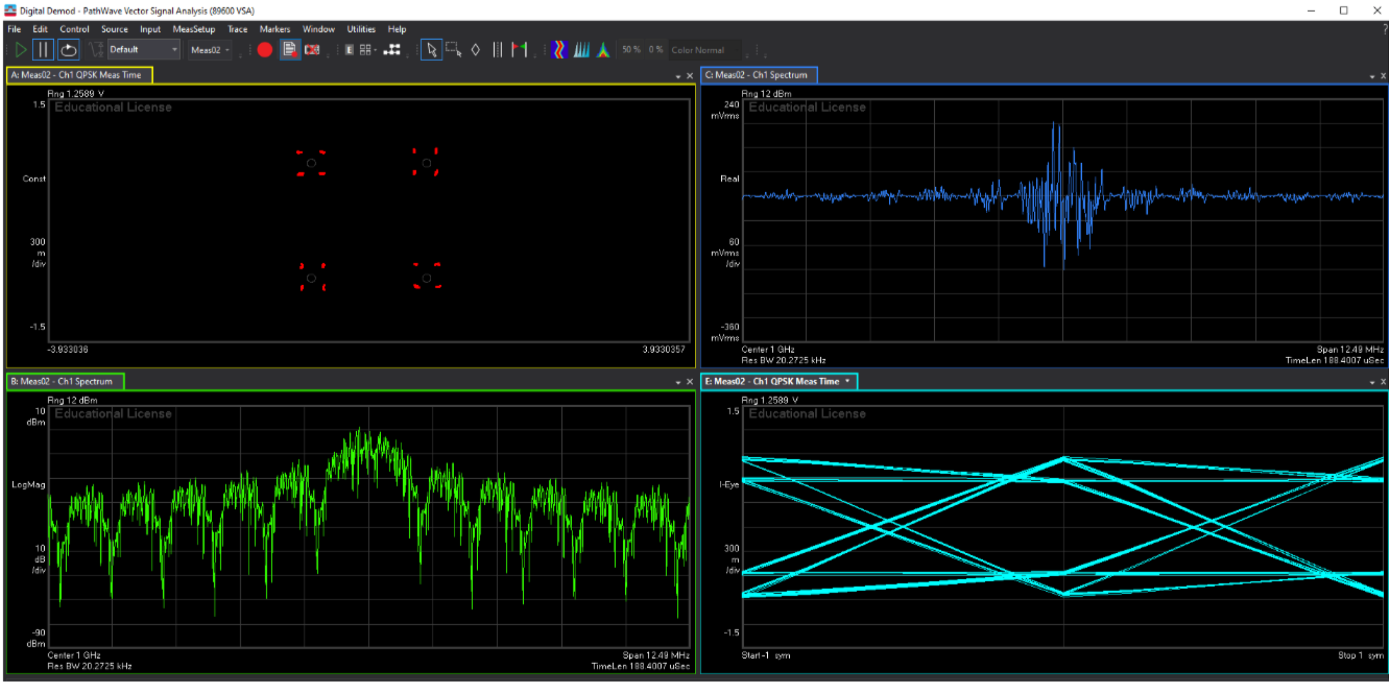
5.3 Visualization of the received QPSK spectrum without noise



BW del lòbul principal: 2MHz
Rs = Rb / b = 2MHz / 2 = 1MBaud
Aquest valor es manté després de passar pel canal

Ara la diferència entre el lòbul principal i el secundari és -13.227dB.

5.4 Demodulation of the received QPSK without noise

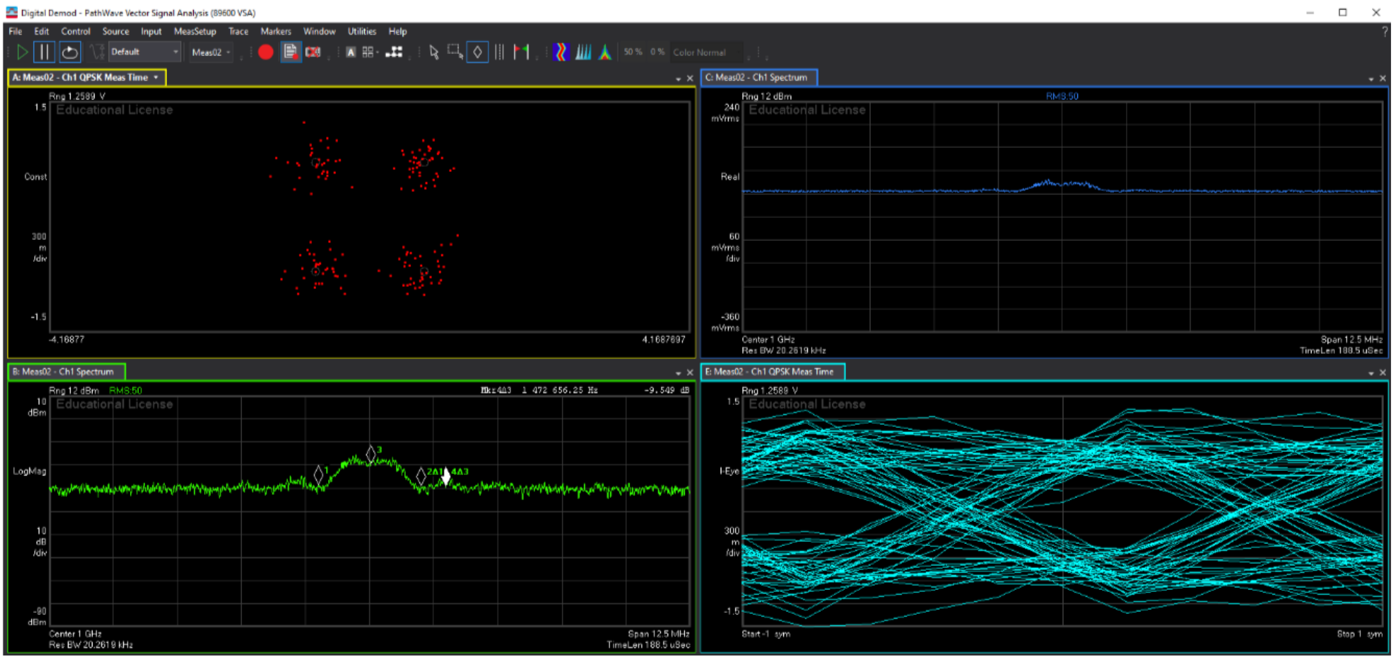


Al comparar els dos gràfics podem observar com en aquests si que hi ha dispersió, és a dir,

$$\frac{d}{D} < 100\%$$

Això també es fàcilment observable al gràfic de la constel·lació, on veiem com els punts no estan centrats.

5.5 Demodulation of the received QPSK signal with noise



En aquest cas el soroll ha resultat en una major dispersió del senyal.

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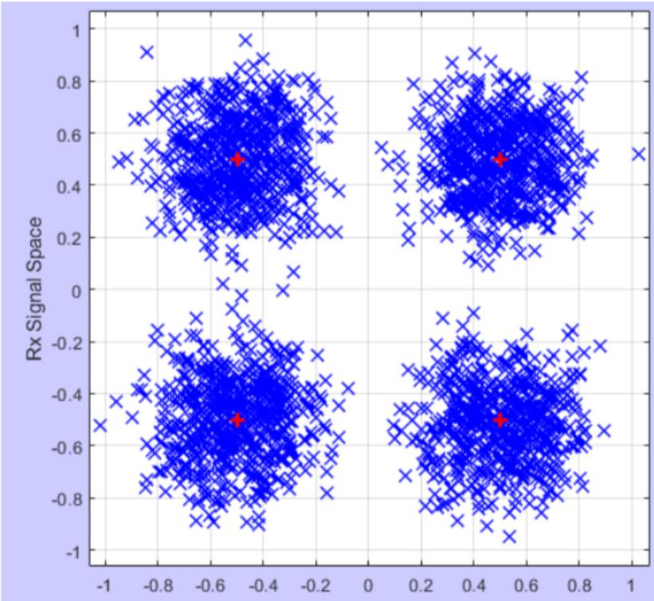
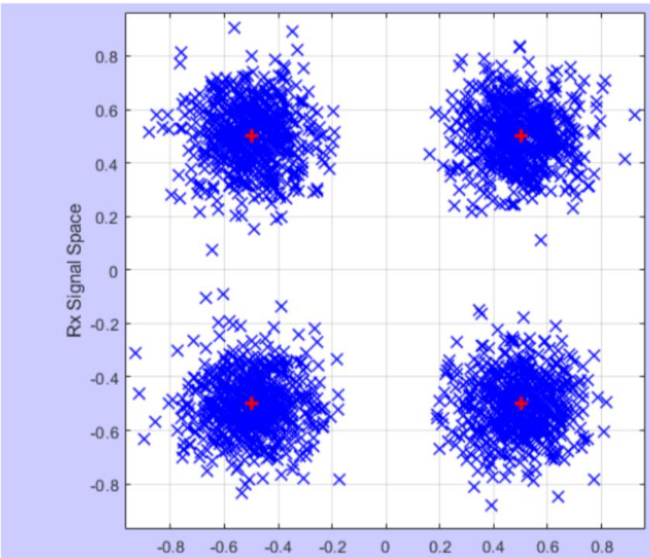
5.6 Design of the equalizer

Primer estudiem el senyal amb soroll:

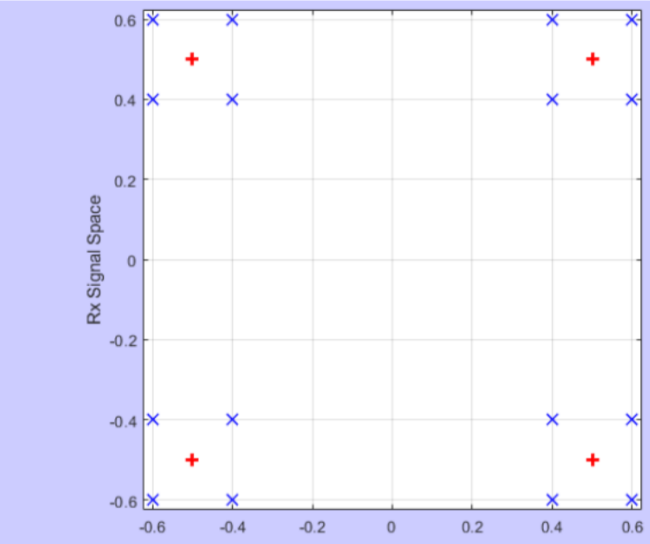


Step 6: Hi ha massa dispersió.

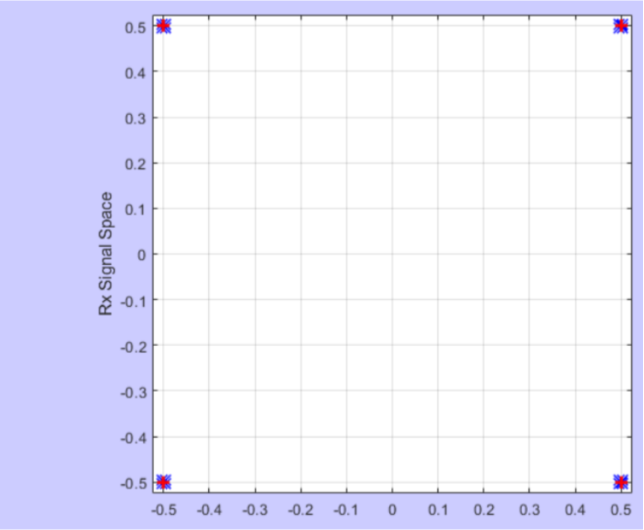


Step 7: Al equalitzar, segueix havent-hi dispersió, tot i que, ara els punts estan més concentrats als seus respectius centres.

Seguidament l'estudiem sense:



Step 6: Veiem com, degut a la falta de soroll, la dispersió es òbviament menor.



Step 7: Un cop equalizada, veiem com la dispersió gairebé desapareix completament.

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Estudi previ 5

	a_i	a_q
00	A	A
01	-A	A
10	A	-A
11	-A	-A

Q1) 20 Mbps $p_0 = p_1$ QPSK $a[k] = a_i[k] + j\,a_q[k]$

$$s(t) = \sum_{m=-\infty}^{\infty} a_i[m]\,p(t-mT)\cos(2\pi f_c t) - \sum_{m=-\infty}^{\infty} a_q[m]\,p(t-mT)\sin(2\pi f_c t)$$

$\circ\ h_c(t) + n(t) \longrightarrow S_w(f) = \frac{N_0}{2}$ $\circledast\ h_{FA}(t) = p(-t)$

a) $\boxed{r = \frac{1}{T}}$ $r = \frac{r_b}{b} = \frac{\cancel{2}\cdot 10^6\ b/s}{\cancel{2}\ \cancel{b}} = \boxed{10^6\ \text{Mbaud}}$

b) $A = 1\,mV,\ N_0 = 5\cdot 10^{-8}\ W/Hz$ E_b/N_0 ratio en dB

$$E_b = \frac{1}{2}\cdot\frac{\cancel{E_p}\cdot P_a}{b} = \frac{P_b}{4} = \frac{P_i + P_q}{4} = \frac{\cancel{2}A^2}{\cancel{4}} = \frac{(1mV)^2}{2} = \boxed{0{,}5\cdot 10^{-6}\ V}$$

$$P_i = P_q = \frac{1}{4}(A^2 + A^2 + A^2 + A^2) = A^2 = P_a$$

$$\frac{E_b}{N_0} = \frac{\cancel{0{,}5}\cdot 10^{-6}}{\cancel{0{,}5}\cdot 10^{-7}} = \boxed{10\,dB}$$

c) $h_c(t) = \delta(t)$ $BER = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \rightarrow Q_x = \frac{1}{\sqrt{2\pi}}\int_x^{+\infty} e^{(-\lambda/2)^2}\,d\lambda$

$y(t) = \sum_n a[n]\,P_R(t-nT) + n(t) \rightarrow [P_R(t) = p(t) * h_{FA} = p(t) * p^*(-t) = R_p$

$$y(t_k) = y[k] = \sum_n a[n]\,R_p(kT-nT) + n(kT)$$

$t_k = t_0 + kT \longrightarrow \boxed{t_0 = \emptyset}$

$$P_e = \frac{1}{4}(P_e/B_1 + P_e/B_2 + P_e/B_3 + P_e/B_4)$$

$\hookrightarrow P_e = P_e/B_1 = 1 - P(y[k] \in R_1/B_2) =$

$= 1 - \iint f_y(y/B_1) - 1 - \int_0^{\infty} f_{Ni}(y_i - A)\,dy_i \int_0^{\infty} f_{Nq}(y_q - A)\,dy_q =$

$$= \boxed{2Q\left(\frac{A}{\sigma}\right) - Q^2\frac{A}{\sigma}}$$

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$\hookrightarrow E_b = \frac{A^2}{2} \Rightarrow A = \sqrt{2E_b} \; ; \; \frac{A}{\sigma} = \sqrt{\frac{2E_b}{N_o}}$

$\boxed{P_e = 2Q\sqrt{\frac{2E_b}{N_o}}} \cancel{- Q^2\sqrt{\frac{2E_b}{N_o}}}$ despreciable

$BER \simeq \frac{P_e}{b} = Q\sqrt{\frac{2E_b}{N_o}} = Q\,2\sqrt{5}$

$b_{hc}(t) = 2\delta(t) - 0{,}4\,\delta(t-T)$

d) $\boxed{S_{ybs}}$

$TF\{R_{ybs}(\tau)\} = S_{bs}(f)\,|B_{hc}(f)|^2 = (\cdots) =$

$\boxed{= (8{,}32 - 3{,}2\cos(2\pi f T))A^2 \operatorname{sinc}^2(f/r) + N_o/2}$

$\circ\, |B_{HC}(f)|^2 = B_{hc}(f)\,B_{hc}^*(f) = (2 - 0{,}4e^{-j2\pi fT})(2 - 0{,}4e^{j2\pi fT}) =$

$= 4 - 0{,}8e^{-j2\pi fT} - 0{,}8e^{-j2\pi fT} + 0{,}16 =$

$= \boxed{4{,}16 - 1{,}6\cos(2\pi f t)}$

$\longrightarrow S_{bs}(f) = S_{is}(f) + S_{qs}(f) + j(\cancel{S_{qs}(f)} - S_{iq}(f)) =$

$= \boxed{2S_{is}(f)}$ $m = 0$ independent

$\longrightarrow S_{is}(f) = \sigma_a^2\, r\, S_p(f) + |m_a|^2 r^2 \sum_k S_p(kr)\,\delta(f - kr)$

$\boxed{\sigma_a^2 = P_a = A^2}$

$S_p(f) = |P(f)|^2 = T\operatorname{sinc}^2(Tf) = \frac{1}{r}\operatorname{sinc}^2(f/r)$

$S_{bs}(f) = 2A^2\operatorname{sinc}^2(f/r)$

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e) $\boxed{y(t) \longrightarrow h_{FA}(t)}$

$$y(t) = b_s(t) * h_c(t) * h_{FA}(t) + n(t) =$$

$$= \left[\sum_n Z_a[n] R_p(t-nT) - 0{,}4 \sum_n a[n] p(t-nT) * p(t)\right] + n(t) =$$

$$\boxed{\sum_n Z_a[n] R_p(t-nT) - 0{,}4 \sum_n a[n] R_p(t-nT-T) + n(t)}$$

f) $\boxed{y[k] = y_i[k] + j y_q[k]}$

$$= \boxed{2a[k] - a[k-1] + n[k]}$$

5.2

stage 1 QPSK, 2bits/simbol, 1mV

stage 2 Pols rectangular, $\alpha = 0$, duració = 1, 16 samples/simbol

stage 3 Bit rate = 2Mbps, Carrier freq = $\emptyset$

stage 4 Channel impulse response = $\delta(t) - 0{,}2\delta(t-T)$

stage 5 $E_b N_o$ = 10dB

stage 6 default.

stage 7 Eq. type : 2F, Number of taps : 3