PRIMER PROBLEMA

1 a)

AM con 100% de modulación.

La señal modulada es:

$$s(t) = A_c [1 + K_a m(t)] \cos(2\pi f_c t)$$

Para calcular A_c sabemos que la potencia media máxima es 18W

El valor máximo de $m(t)$ es 1, por lo tanto

$$s_{max}(t) = A_c [1 + K_a] \cos(2\pi f_c t)$$

Además como tenemos 100% de modulación $K_a = 1$,

ya que $\max\{|m(t)|\} = 1$. Entonces

$$s_{máx}(t) = 2A_c \cos(2\pi f_c t)$$

con potencia:

$$18 = (2A_c)^2 \cdot \frac{1}{2} = 4A_c^2 \frac{1}{2} = 2A_c^2$$

$$\boxed{A_c = 3}$$

La potencia transmitida:

$$P_S = \frac{A_c^2}{2} + \frac{A_c^2 K_a^2}{2} P_M = \frac{A_c^2}{2}(1 + K_a^2 P_M) = \frac{A_c^2}{2}(1 + P_M)$$

siendo P_M la potencia de la señal moduladora:

$$\boxed{P_M = \int_{-\infty}^{\infty} S_M(f)\,df = 8000\,Hz \cdot 0'02\,mW/Hz = 160\,mW = 0'16\,W}$$

Entonces:

$$\boxed{P_S = \frac{A_c^2}{2}(1+P_M) = \frac{3^2}{2}(1+0'16) = 4'5 \cdot 1'16 = 5'22\,W}$$

$$\boxed{P_C = \frac{A_c^2}{2} = \frac{3^2}{2} = 4'5\,W} \text{ de portadora}$$

$$\boxed{P_{USB} = P_{LSB} = \frac{A_c^2}{4}P_M = \frac{3^2}{4}0'16 = 0'36\,W}$$

DSB

La señal modulada

$$s(t) = A_c\, m(t) \cos(2\pi f_c t)$$

Para calcular A_c en este caso como $\max\{m(t)\} = 1$

$$s_{máx}(t) = A_c \cos(2\pi f_c t)$$

La potencia media máxima será

$$18 = A_c^2 \cdot \frac{1}{2} \qquad A_c^2 = 36 \qquad \boxed{A_c = 6}$$

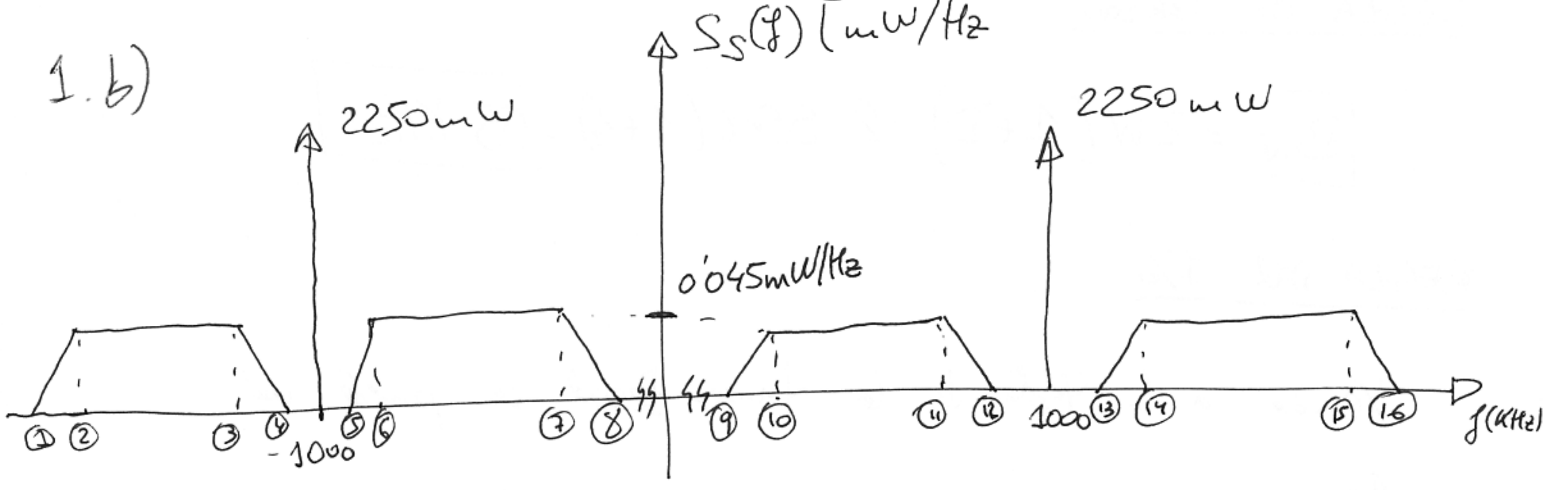
$$\boxed{P_S = \frac{A_c^2}{2}P_M = \frac{6^2}{2}0'16 = 2'88\,W}$$

$\boxed{P_C = 0\,W}$ de portadora (SIN PORTADORA)

$$\boxed{P_{USB} = P_{LSB} = \frac{A_c^2}{4}P_M = \frac{6^2}{4}0'16 = 1'44\,W}$$

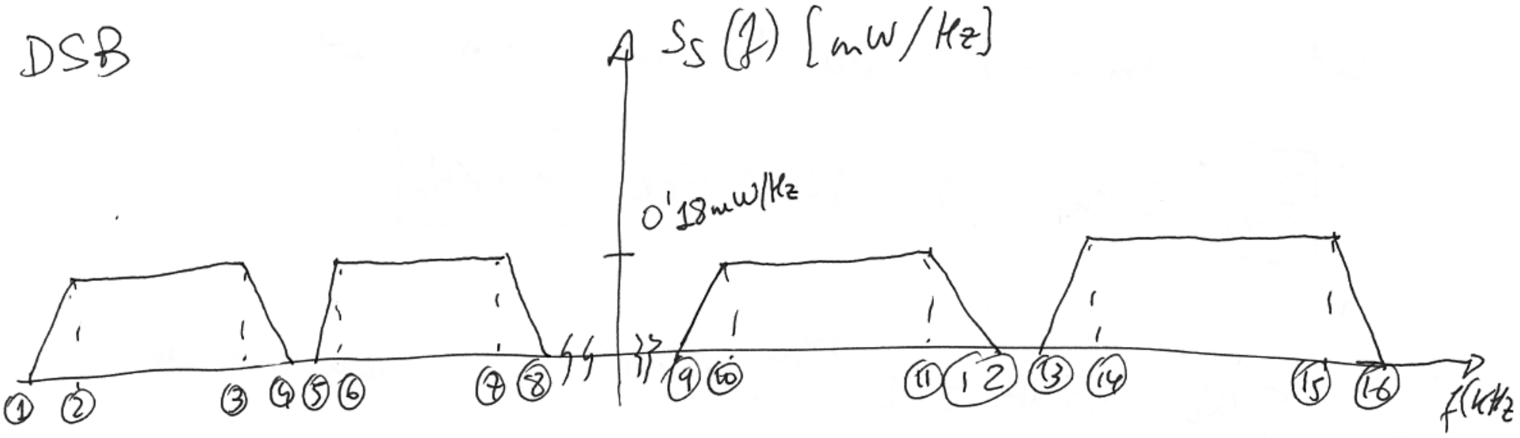
PROBLEMA 1 (continuación)

1.b)



1. -1005'5 kHz
2. -1004'5 kHz
3. -1001'5 kHz
4. -1000'5 kHz
5. -999'5 kHz
6. -998'5 kHz
7. -995'5 kHz
8. -994'5 kHz
9. 994'5 kHz
10. 995'5 kHz
11. 998'5 kHz
12. 999'5 kHz
13. 1000'5 kHz
14. 1001'5 kHz
15. 1004'5 kHz
16. 1005'5 kHz

DSB



2) Independientemente de m(t), ya que va a la fase de la señal,

$$\boxed{P_c = P_s = 18\,W}$$

Para los cálculos de ancho de banda necesitamos el ancho de banda W de m(t), que vale

$$\boxed{W = 5500\,Hz}$$

REGLA DE CARSON

$$\boxed{B_W = 2W(1+D) = 2 \cdot 5500(1+4) = 55\ KHz}$$

REGLA DEL 1%

Yendo a la tabla de la función Bessel se puede ver que $J_7(4) = 0'0152$ y $\begin{cases} J_8(4) = 0'0040 \\ J_9(4) = 0'0009 \\ J_{10}(4) = 0'0002 \end{cases}$

Entonces $n_{max} = 7$ por lo que $2n_{max} = 14$

$$\boxed{B_W = 2n_{max} \cdot W = 14 \cdot 5500 = 77\ KHz}$$

3) $SNR_0 = 35\,dB \equiv 10^{35/10} = 3162'3$ En unidades naturales

Para AM:

$$SNR_0^{AM} = \frac{A_c^2 K_a^2 P_M}{2W N_0} = \frac{A_c^2 P_M}{2W N_0}$$

Podemos despejar $\boxed{N_0 = \frac{A_c^2 P_M}{2W\, SNR_0^{AM}} = \frac{3^2 \cdot 0'16}{2 \cdot 5500 \cdot 3162'3} = 4'1397 \cdot 10^{-8}\ W/Hz}$

Para DSB:

$$SNR_0^{DSB} = \frac{A_c^2 P_M}{2W N_0} = \frac{6^2 \cdot 0'16}{2 \cdot 5500 \cdot 4'1397 \cdot 10^{-8}} = 12649'1$$

$$\boxed{SNR_0^{DSB} = 41'02\ dB}$$

PROBLEMA 1 (continuació)

Para FM:

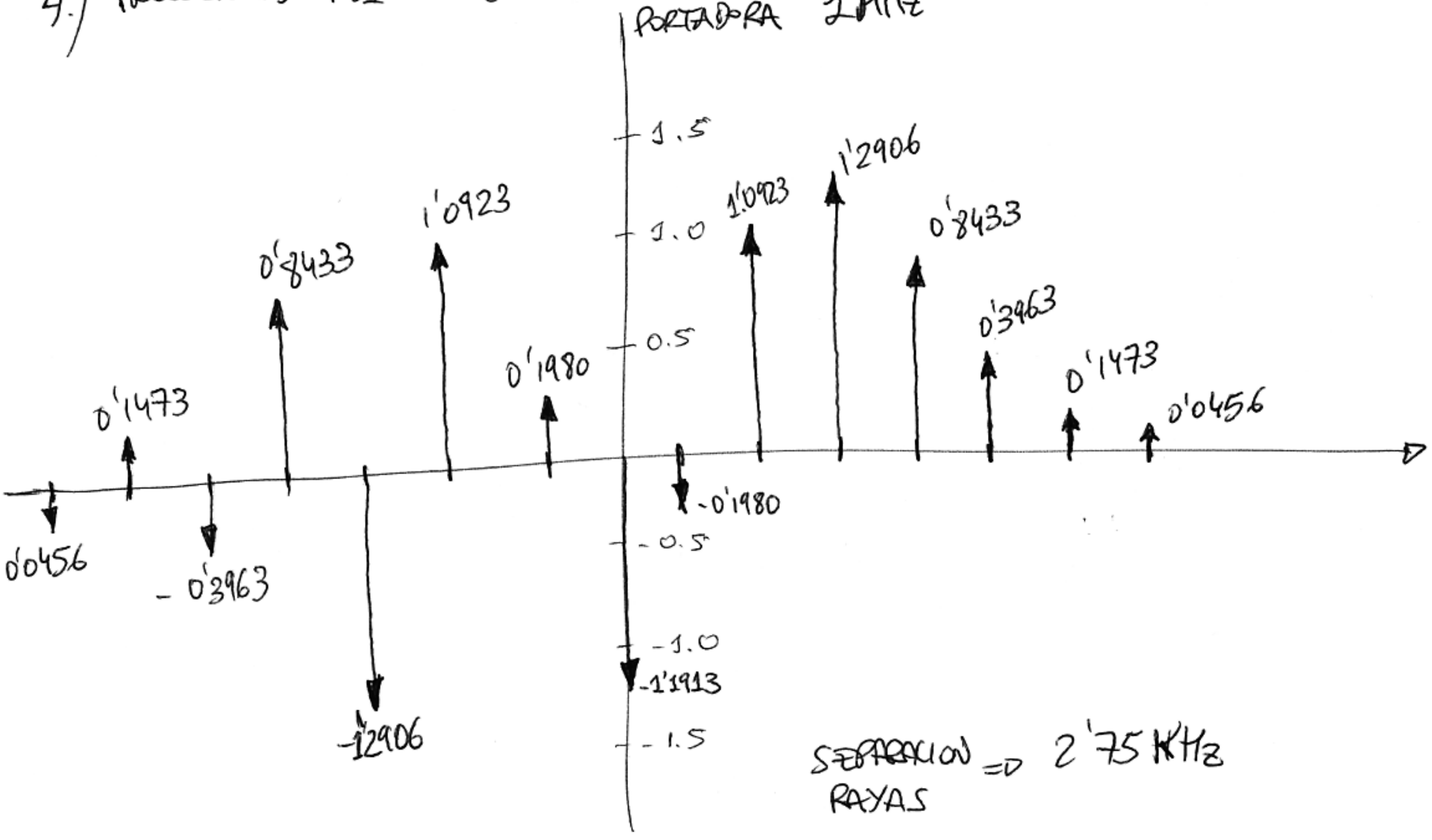
$$SNR_o^{FM} = \frac{3A_c^2 K_f^2 P_M}{2W^3 N_o} \qquad 18 = \frac{A_c^2}{2} \quad \boxed{A_c = 6}$$

Sabemos que $máx\{|m(t)|\} = 1 \Rightarrow \Delta f = K_f = D \cdot W = 4 \cdot 5500$

$$\boxed{K_f = 22 KHz/V}$$

$$\boxed{SNR_o^{FM} = \frac{3 \cdot 6^2 \cdot 22000^2 \cdot 0'16}{2 \cdot 5500^3 \cdot 4'1397 \cdot 10^{-8}} = 607.157'31 = 57'83 \text{ dB}}$$

4.) FRECUENCIAS POSITIVAS (IGUAL NEGATIVAS)



SEPARACION RAYAS $\Rightarrow$ 2'75 KHz

SE PODRIA COMPROBAR QUE LA SUMA DE LOS CUADRADOS ES $\frac{18W}{2}$
SI TENEMOS EN CUENTA RAYAS FREC NEGATIVAS, 18W

SEGUNDO PROBLEMA:

(1) PULSO CON ESPECTRO EN COSENO ALZADO:

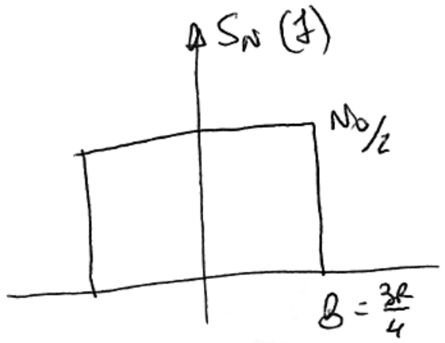
$$B = B_T(1+\rho)$$

CON B_T EL ANCHO DE BANDA MINIMO:

$$B_T = \frac{1}{2T} = \frac{R}{2}$$

ENTONCES: $$\boxed{B = \frac{R}{2}(1+\rho) = \frac{3R}{4}}$$

(2)

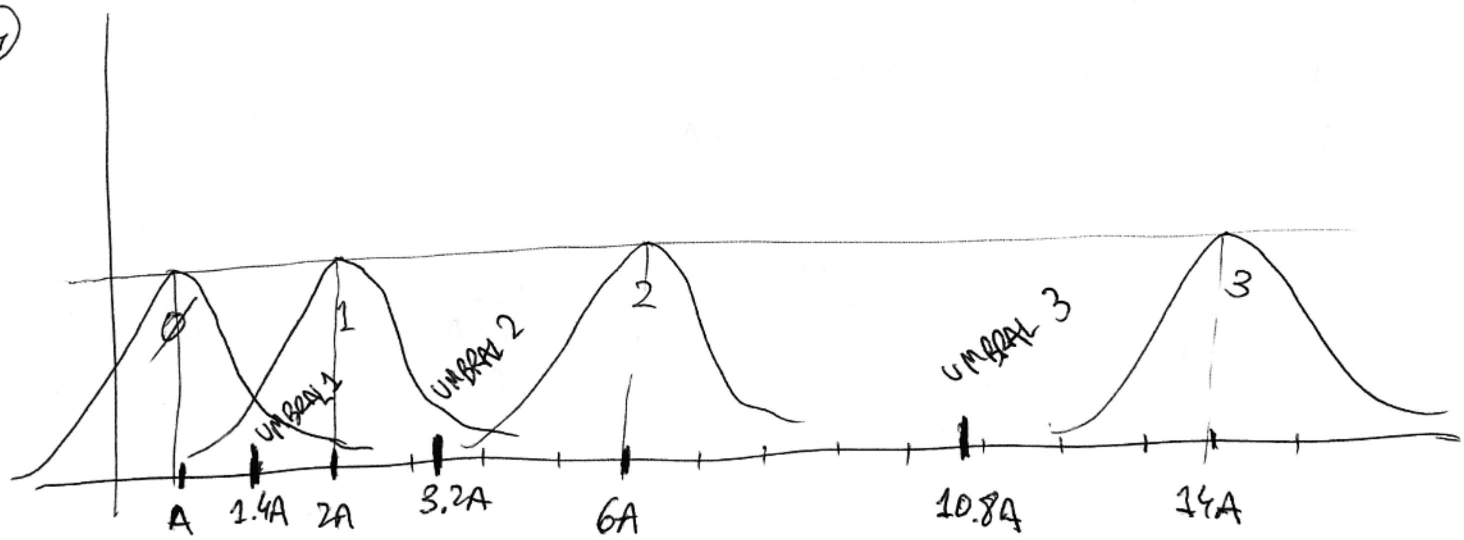


$$\boxed{\sigma_N^2 = \int_{-\infty}^{\infty} S_N(f)\,df = BN_0 = \frac{3RN_0}{4}}$$

(3) $$\boxed{\text{POT MED}} = \sum_{i=0}^{3} p(i)\cdot \text{POT}_i = \frac{1}{4}A^2 + \frac{1}{4}(2A)^2 + \frac{1}{4}(6A)^2 + \frac{1}{4}(14A)^2$$

$$= \frac{A^2 + 4A^2 + 36A^2 + 196A^2}{4} = \boxed{\frac{237}{4}A^2}$$

(4)



PARA APARTADOS 5 A 8:

$$\int_{\mu+\eta}^{\infty} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(-\frac{(x-\mu)^2}{2\sigma_N^2}\right) dx \quad \left| \begin{array}{l} z = \dfrac{x-\mu}{\sqrt{2}\,\sigma_N} \\ dz = \dfrac{dx}{\sqrt{2}\,\sigma_N} \end{array} \right| \quad \begin{array}{ll} x = \infty & z = \infty \\ x = \mu+\eta & z = \dfrac{\eta}{\sqrt{2}\,\sigma_N} \end{array}$$

$$= \frac{1}{\sqrt{\pi}} \int_{\frac{\eta}{\sqrt{2}\sigma_N}}^{\infty} \exp(-z^2)\, dz = \frac{1}{2} \operatorname{erfc}\left(\frac{\eta}{\sqrt{2}\,\sigma_N}\right)$$

PARA $\sigma_N^2 = \frac{3RN_0}{4} \Rightarrow \frac{1}{2} \operatorname{erfc}\left(\frac{2\eta}{\sqrt{6RN_0}}\right)$

SE PUEDE COMPROBAR QUE IGUALMENTE

$$\int_{-\infty}^{\mu-\eta} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(-\frac{(x-\mu)^2}{2\sigma_N^2}\right) dx = \frac{1}{2} \operatorname{erfc}\left(\frac{2\eta}{\sqrt{6RN_0}}\right)$$

5 $$\boxed{P_{e\phi}} = \int_{1.4A}^{\infty} f_{x/\phi}(x/\phi)\, dx = \int_{1.4A}^{\infty} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(-\frac{(x-A)^2}{2\sigma_N^2}\right) dx = \boxed{\frac{1}{2} \operatorname{erfc}\left(\frac{0.8A}{\sqrt{6RN_0}}\right)}$$

6 $$P_{e1} = \int_{-\infty}^{1.4A} f_{x/1}(x/1)\, dx + \int_{3.2A}^{\infty} f_{x/1}(x,1)\, dx =$$

$$= \int_{-\infty}^{1.4A} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(-\frac{(x-2A)^2}{2\sigma_N^2}\right) dx + \int_{3.2A}^{\infty} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(\frac{(x-2A)^2}{2\sigma_N^2}\right) dx$$

PROBLEMA 2 (CONTINUACION)

$$\boxed{P_{e1} = \frac{1}{2}\,\mathrm{erfc}\left(\frac{1.2A}{\sqrt{6RN_0}}\right) + \frac{1}{2}\,\mathrm{erfc}\left(\frac{2.4A}{\sqrt{6RN_0}}\right)}$$

7 $$P_{e2} = \int_{-\infty}^{3.2A} f_{x/2}(x/2)\,dx + \int_{10.8A}^{\infty} f_{x/2}(x/2)\,dx$$

$$= \int_{-\infty}^{3.2A} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(-\frac{(x-6A)^2}{2\sigma_N^2}\right) dx + \int_{10.8A}^{\infty} f_{x/2}(x/2)\,dx$$

$$\boxed{= \frac{1}{2}\,\mathrm{erfc}\left(\frac{5.6A}{\sqrt{6RN_0}}\right) + \frac{1}{2}\,\mathrm{erfc}\left(\frac{9.6A}{\sqrt{6RN_0}}\right)}$$

8 $$P_{e3} = \int_{-\infty}^{10.8A} f_{x/3}(x/3)\,dx = \int_{-\infty}^{10.8A} \frac{1}{\sqrt{2\pi}\,\sigma_N} \exp\left(-\frac{(x-14A)^2}{2\sigma_N^2}\right) dx$$

$$\boxed{= \frac{1}{2}\,\mathrm{erfc}\left(\frac{6.4A}{\sqrt{6RN_0}}\right)}$$

$$P_e = P_0 P_{e0} + P_1 P_{e1} + P_2 P_{e2} + P_3 P_{e3} = \frac{1}{4}\left(P_{e0} + P_{e1} + P_{e2} + P_{e3}\right) =$$

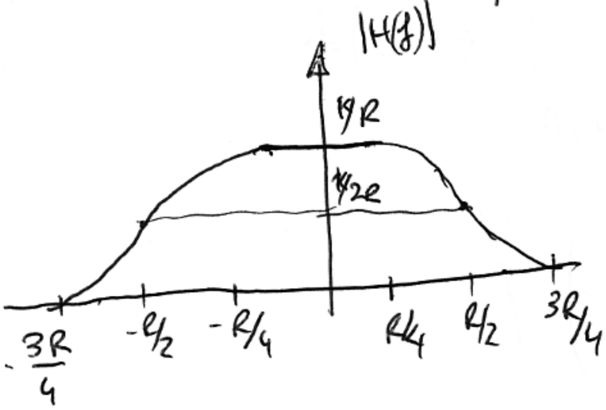
$$\boxed{= \frac{1}{8}\left[\mathrm{erfc}\left(\frac{0.8A}{\sqrt{6RN_0}}\right) + \mathrm{erfc}\left(\frac{1.2A}{\sqrt{6RN_0}}\right) + \mathrm{erfc}\left(\frac{2.4A}{\sqrt{6RN_0}}\right) + \mathrm{erfc}\left(\frac{5.6A}{\sqrt{6RN_0}}\right) + \mathrm{erfc}\left(\frac{6.4A}{\sqrt{6RN_0}}\right) + \mathrm{erfc}\left(\frac{9.6A}{\sqrt{6RN_0}}\right)\right]}$$

(9) PARA EL FILTRO ADAPTADO EN FRECUENCIA:

$$H(f) = K \cdot G^*(f) \exp(-j 2\pi f T)$$

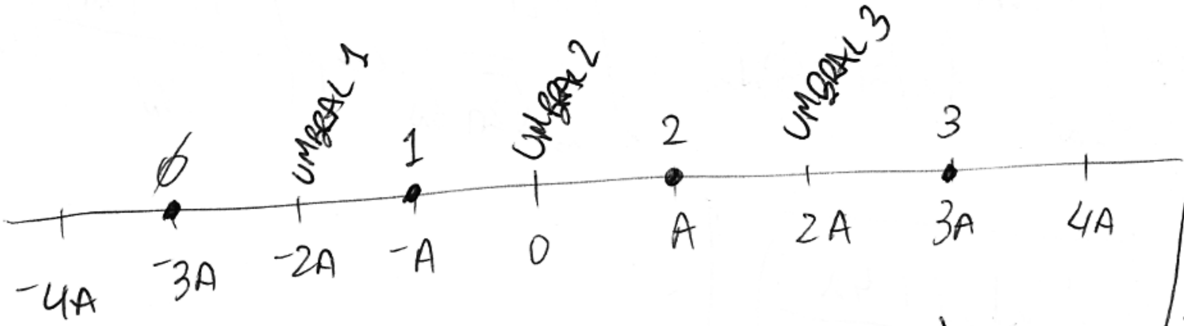
$G(f)$ PULSO EN COSENO ALZADO PARA $\rho = 0.5$, $B_T = \frac{R}{2}$, $f_1 = \frac{R}{4}$

$$H(f) = K \exp\left(-j \frac{2\pi f}{R}\right) \cdot \begin{cases} \frac{1}{R} & 0 \le |f| \le \frac{R}{4} \\ \frac{1}{2R} + \frac{1}{2R}\cos\left(\frac{2\pi |f|}{R} - \frac{1}{2}\right) & \frac{R}{4} \le |f| \le \frac{3R}{4} \\ 0 & \text{Resto} \end{cases}$$



EL PASO BAJO IDEAL NO ES ÓPTIMO.

(10) LA SITUACION NO ES ÓPTIMA EN ABSOLUTO:



SIMETRICA SIN COMPONENTE CONTINUA

$$Pe_{min} = \frac{1}{4} \cdot 6\, erfc\left(\frac{2A}{\sqrt{6N_0R}}\right) = \frac{3}{2}\, erfc\left(\frac{2A}{\sqrt{6N_0R}}\right)$$

$$P_{OT} = \frac{A^2 + A^2 + 3A^2 + 3A^2}{4} = \frac{83}{4} A^2$$