

## TECM: RESUMEN. DIGITAL

$$V_T = \frac{\text{bits}}{\text{tiempo}} = \frac{K}{T} \quad \text{VELOCIDAD DE TRANSMISIÓN}$$

$$V_S = \frac{\text{símbolos}}{\text{tiempo}} = \frac{1}{T} \quad \text{VELOCIDAD DE SÍMBOLO}$$

$$V_T = K V_S$$

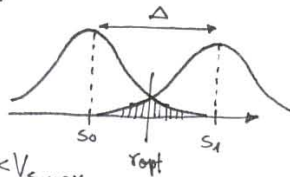
### TEOREMA DEL MUESTREO

$$f_s > 2W$$

CUANTIFICACIÓN  $V_T = n f_s$

CODIFICACIÓN  $L = 2^n$

RX POR MUESTREO  $\Rightarrow$  IES = 0



BINARIO  $B_{\min} = \frac{V_T}{2}$

$V_{T\max} = K V_{S\max}$

NO BINARIO  $B_{\min} = \frac{V_S}{2}$

PROBAB. A PRIORI:

FALSA ALARMA

PÉRDIDA

$$P(H_0) = p_0$$

$$P(H_1) = p_1$$

$$P_{FA} = P(D_1 | H_0)$$

$$P_M = P(D_0 | H_1)$$

$$P_M = \frac{1}{2} \text{erfc} \left( \frac{s_1(t) - \gamma}{\sigma \sqrt{2}} \right)$$

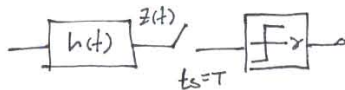
$$P_{FA} = \frac{1}{2} \text{erfc} \left( \frac{\gamma - s_0(t)}{\sqrt{2} \sigma} \right)$$

$$\text{BER} = P_{FA} \cdot p_0 + P_M \cdot p_1$$

$$P_0 = p_1 \quad \text{BER} = \frac{P_{FA} + P_M}{2}$$

$$\text{BER} = \frac{1}{2} \text{erfc} \left( \frac{\Delta}{2\sqrt{2} \cdot \sigma} \right)$$

RX ÓPTIMO:



FILTRO ADAPTADO:  $h(t) = s(T-t)$

$$\text{SNR}_{\max} = \frac{2E}{\eta}$$

Si  $s_0(t) = K s_1(t)$

$$h(t) = s_1(T-t)$$

Si  $s_0(t), s_1(t)$  no proporcionales

$$h(t) = s_d(T-t) = s_1(T-t) - s_0(T-t)$$

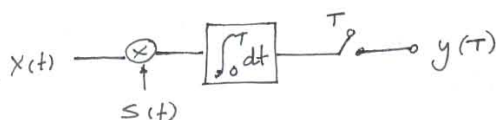
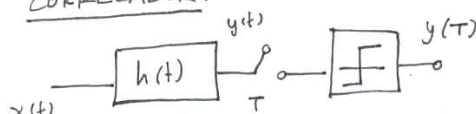
$$\text{BER} = \frac{1}{2} \text{erfc} \left( \frac{1}{2} \sqrt{\frac{E_d}{\eta}} \right)$$

$$E_d = E_1 + E_0 - 2\rho \sqrt{E_0 E_1}$$

FÓRMULA ÚTIL:

$$V_T E_b = P_R$$

CORRELADOR:



COEF. DE CORRELACIÓN:

$$R_{ik} = \int_0^T s_i(t) s_k(t) dt$$

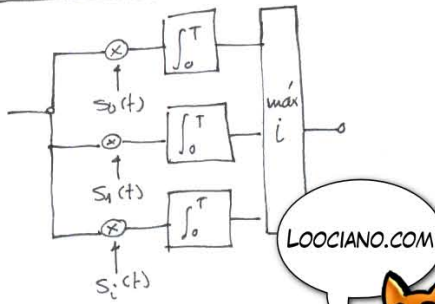
$$\rho = \begin{cases} \frac{1}{\sqrt{E_0 E_1}} \int_0^T s_0(t) s_1(t) dt & E_i \neq 0 \\ 0 & E_i = 0 \end{cases}$$

$\rho = 1$  PROPORC.

$\rho = 0$  ORTOGON.

$\rho = -1$  ANTIPORC.

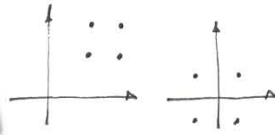
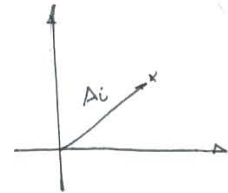
RX OPTIMO:



POTENCIA DE CONSTELACIÓN:

$$P_i = \frac{1}{2} A_i^2 = \frac{1}{2} (I_i^2 + Q_i^2)$$

$$P_m = \frac{1}{2M} \sum (I_i^2 + Q_i^2)$$



Misma BER, pero distintos potencias



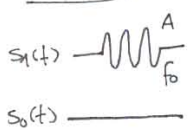
Envolvente constante

EFICIENCIA ESPECTRAL

$$\eta_f = \frac{V_T}{BW_T}$$

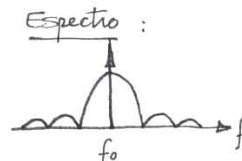
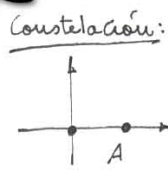
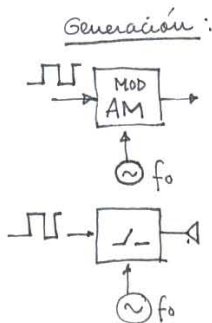
**VENTAJA: SENCILLEZ**

• ASK:



$$P=0$$

$$BER_{ASK/FSK} = \frac{1}{2} \text{erfc} \left( \frac{1}{\sqrt{2}} \sqrt{\frac{E_b}{N_0}} \right)$$



$$\begin{aligned} \langle x_n^2 \rangle &= 1 \\ m &= 1 \\ E_p &= 50\% \\ \eta_f &= \frac{V_T}{B_{min}} = 1 \end{aligned}$$

Demodulación:



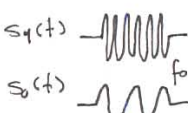
**INCOHERENTE**

$$B_{Tmin} = \frac{1}{T} \text{ modulac.}$$



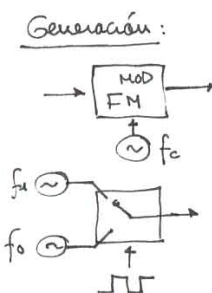
**COHERENTE**

• FSK:

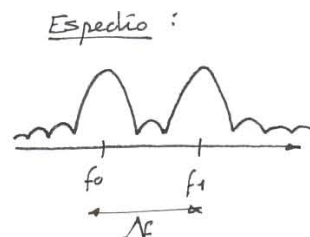


$$P=0$$

$$BER_{ASK/FSK} = \frac{1}{2} \text{erfc} \left( \frac{1}{\sqrt{2}} \sqrt{\frac{E_b}{N_0}} \right)$$



NO SE PUEDE DIBUJAR



$$\Delta f_{min} = \frac{1}{2T}$$

Si  $\Delta f_{min}$ : **MSK**

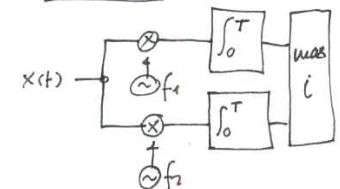
$\eta_f$  NO ENTRA

Especio:

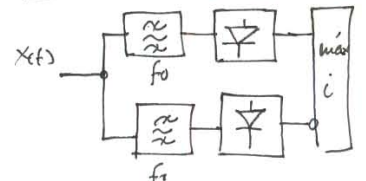
**NO**

Demodulación:

**RX OPTIMO COHERENTE**

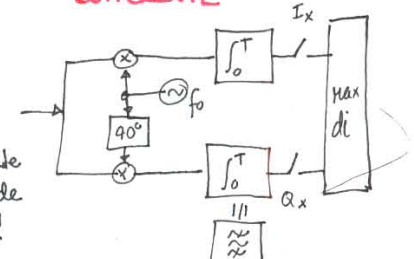


**RX SUBOPTIMO: INCOHERENTE**



Demodulación:

**COHERENTE**



Tambien vale Recuperador de portadora!

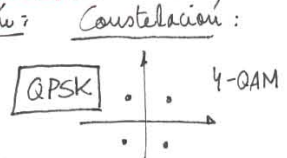
$$V_T = \eta_f B$$

**VENTAJA: EFICIENCIA**  
**DESVENTAJA: NO ENCTE, A MÁS M+ RUIDO**

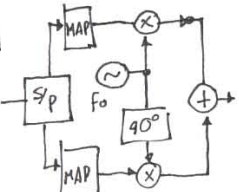
• QAM:

$$s_i(t) = I_i \cos \omega_c t - Q_i \sin \omega_c t$$

( $I_i, Q_i$ )



4-QAM	$\eta_f = K$	M
16-QAM	2	
64-QAM	4	
256-QAM	6	
1024-QAM	8	
	10	



$$BER \approx \frac{2}{K} \left( 1 - \frac{1}{\sqrt{M}} \right) \text{erfc} \left[ \sqrt{\frac{3KE_b}{2(M-1)N_0}} \right]$$

