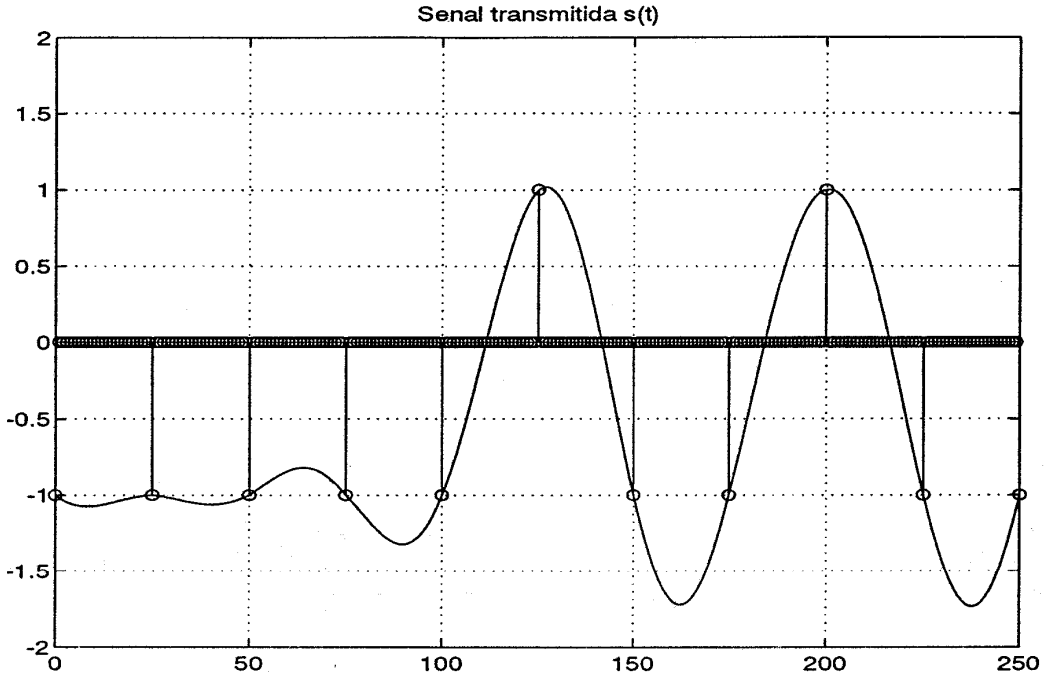
Ingeniería Informática

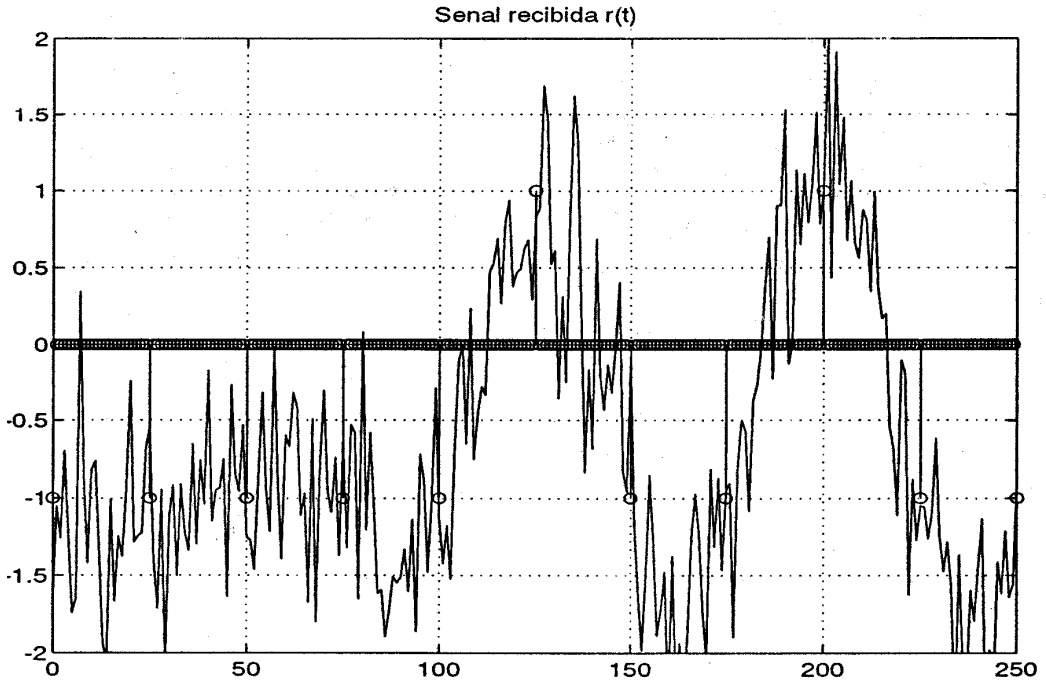
Medios de Transmisión (MT)

Tema 8
Transmisión digital por canales con ruido

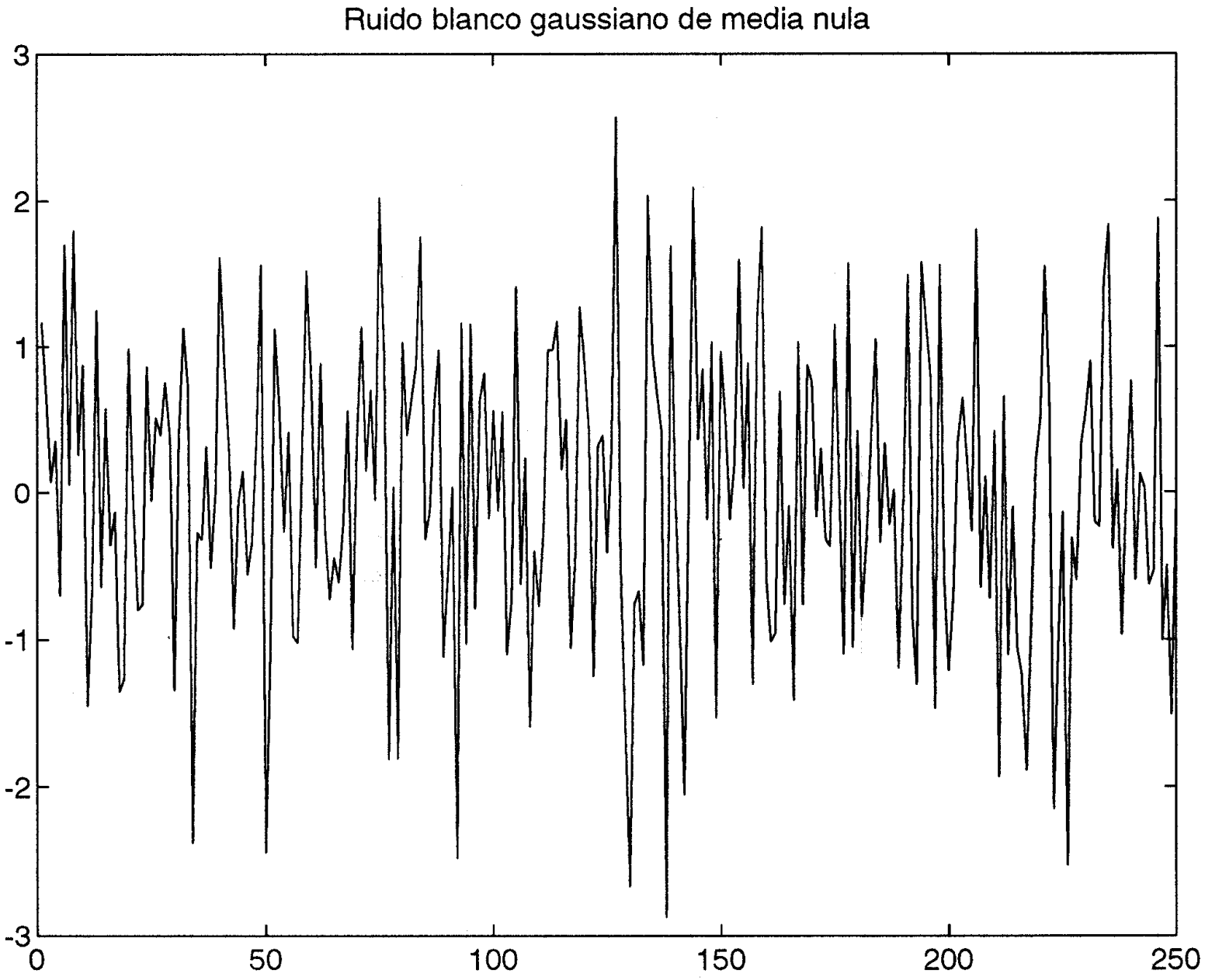
Curso 2008-09

Ejemplo de distorsión de una señal PAM por un canal con ruido

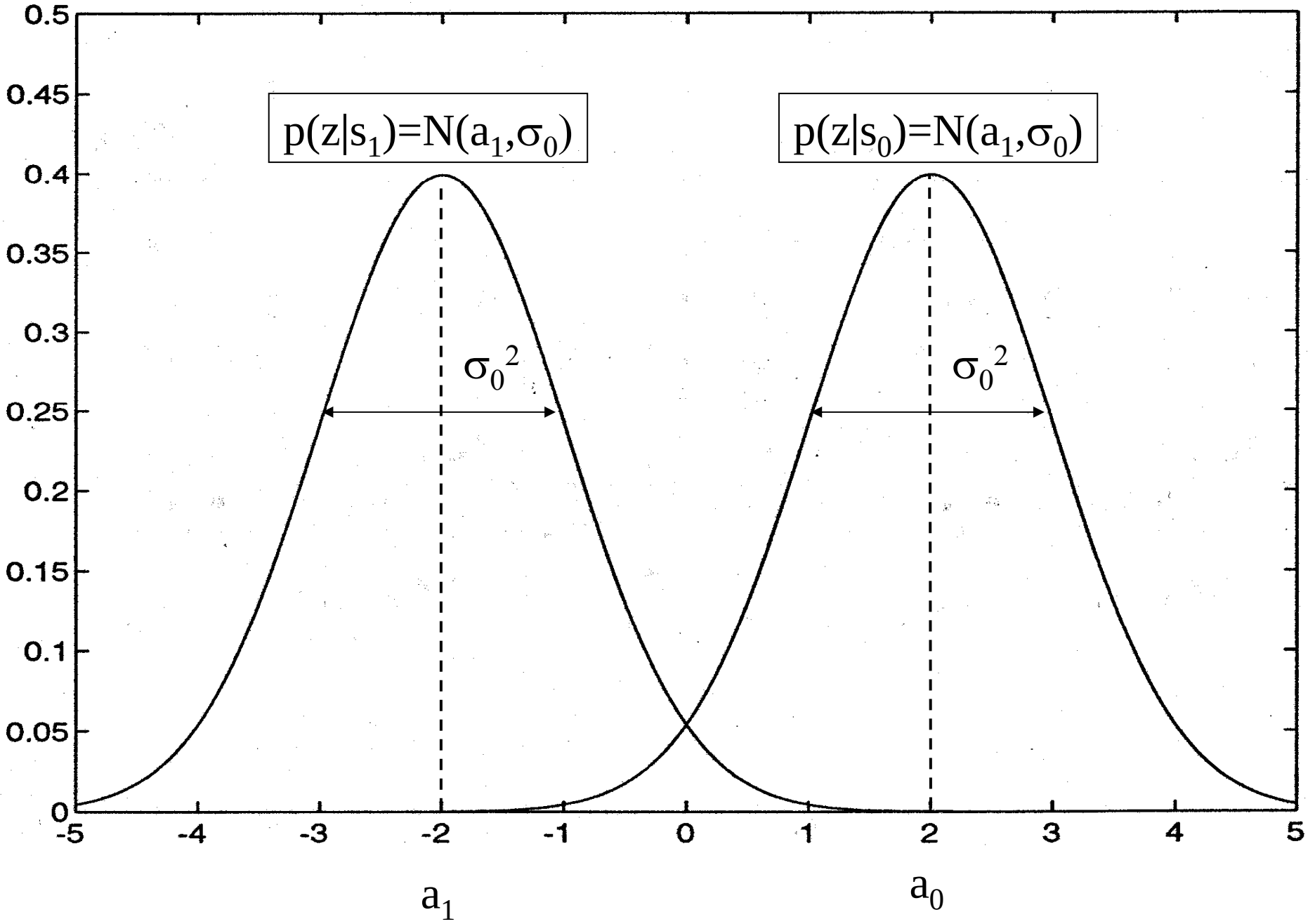




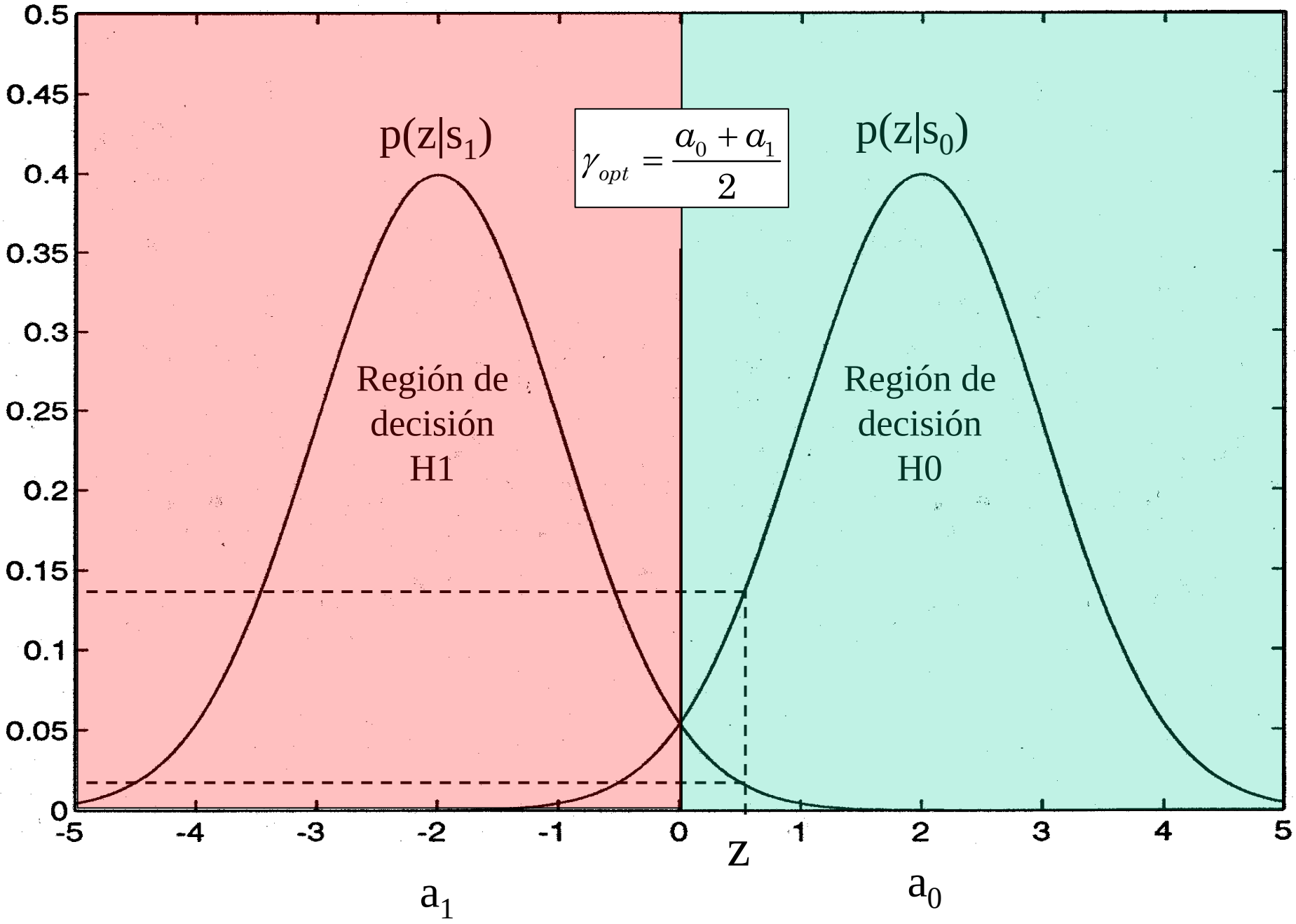
Ruido blanco gaussiano de media cero



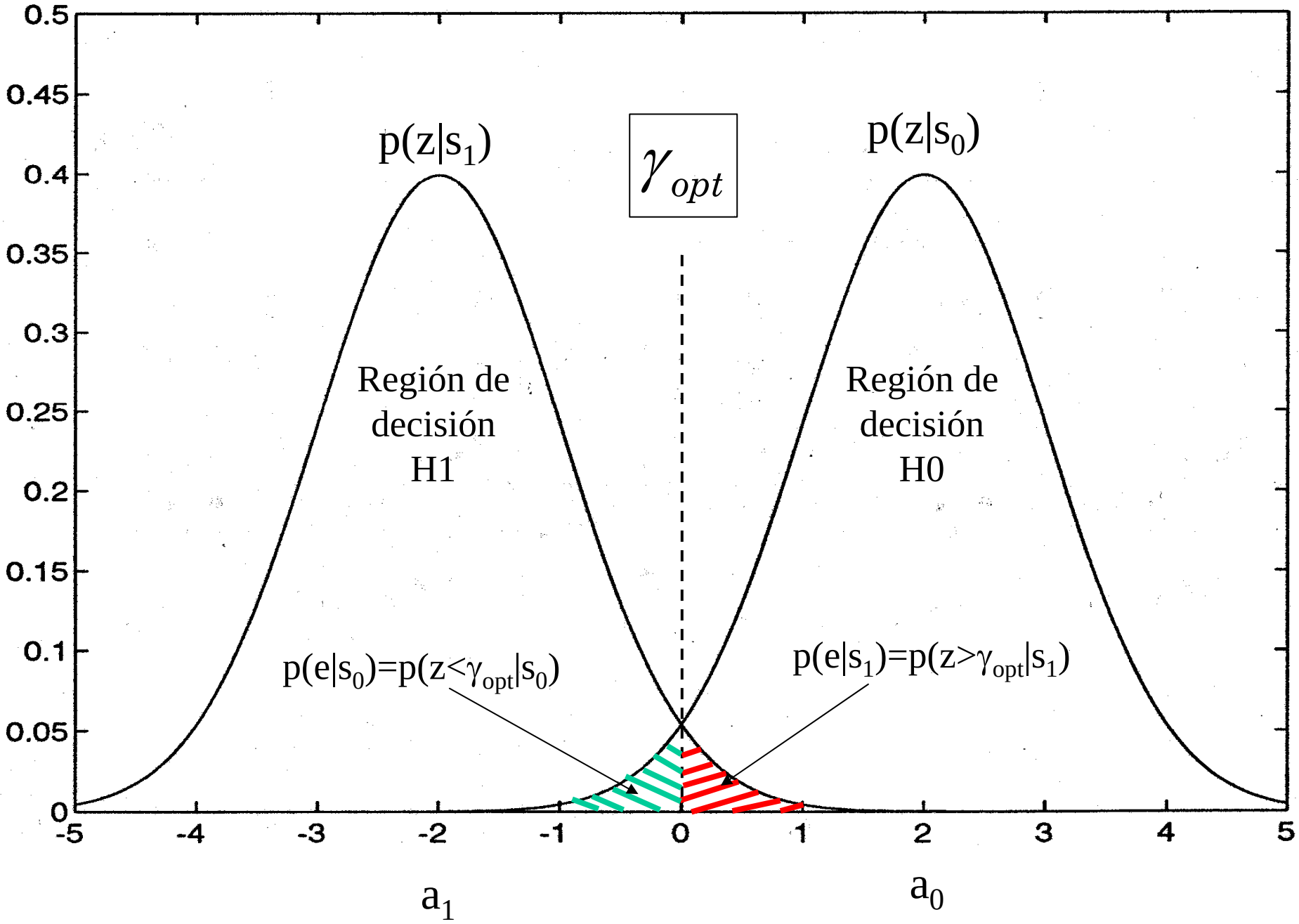
Verosimilitudes: $p(z|s_0)$ y $p(z|s_1)$

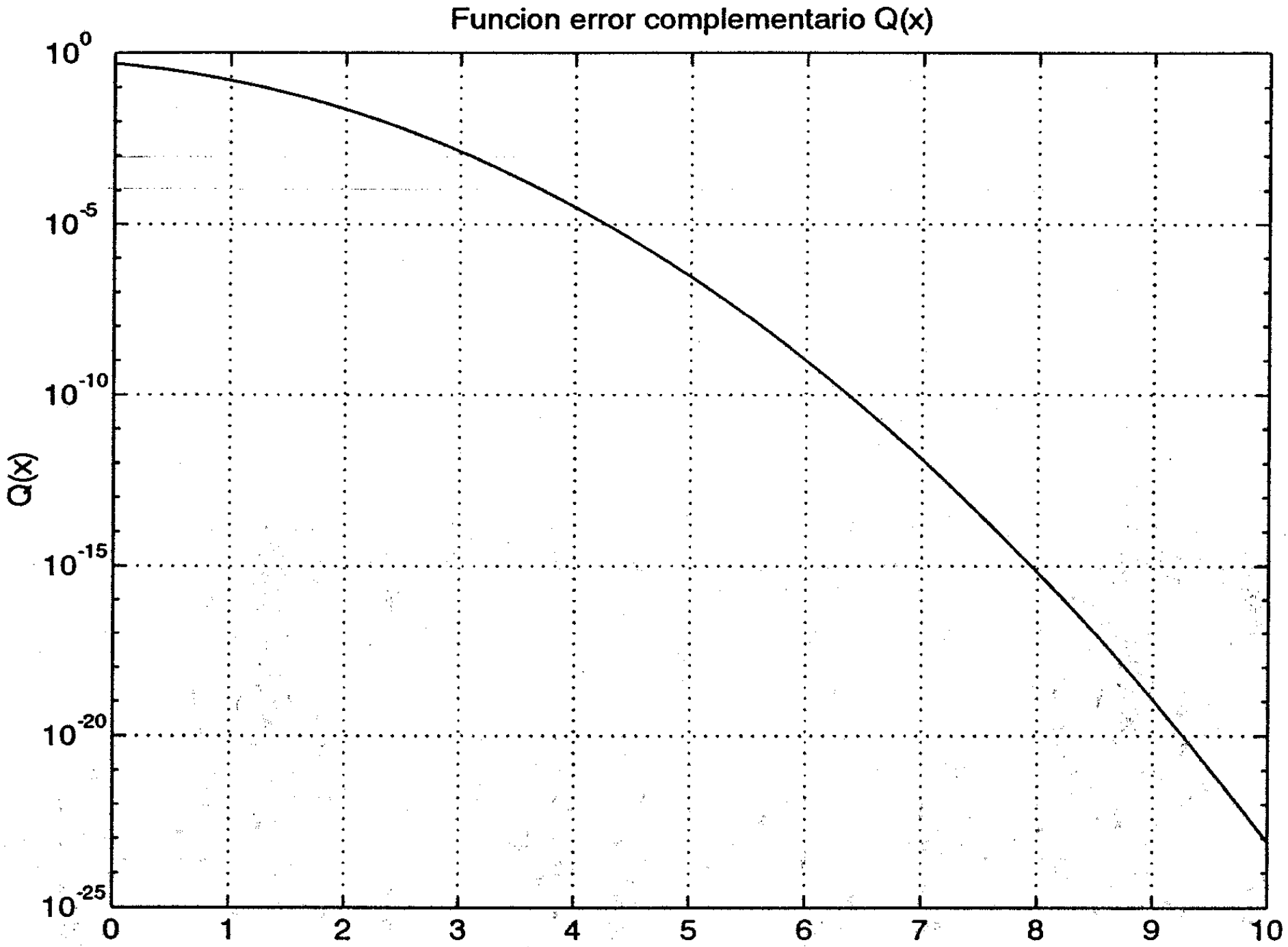


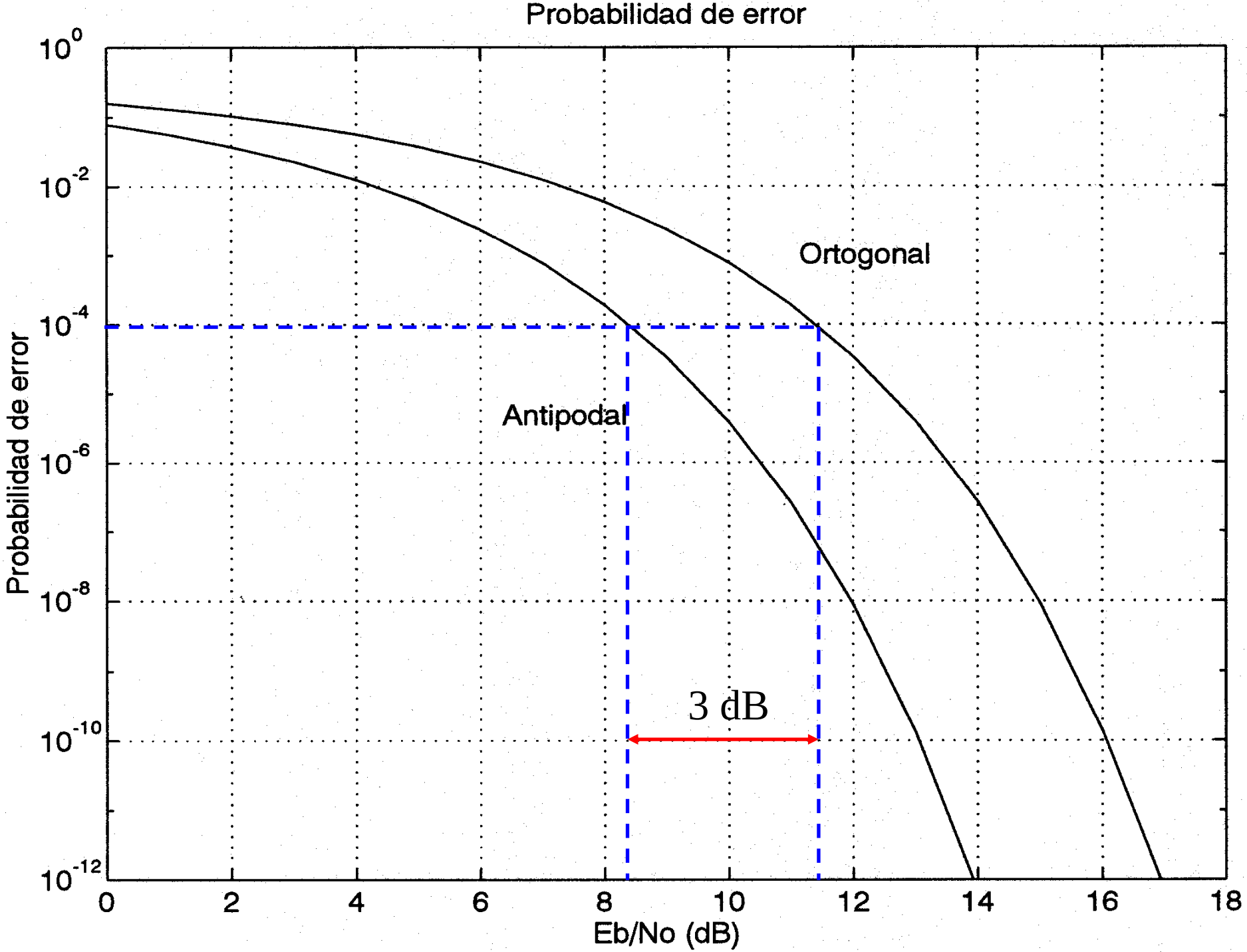
Regla de decisión ML



Probabilidad de error




Funcion error complementario Q(x)
Q(x)
10^0
10^-5
10^-10
10^-15
10^-20
10^-25
0
1
2
3
4
5
6
7
8
9
10


Probabilidad de error
Probabilidad de error
Eb/No (dB)
Ortogonal
Antipodal
3 dB
10^0
10^-2
10^-4
10^-6
10^-8
10^-10
10^-12
0
2
4
6
8
10
12
14
16
18

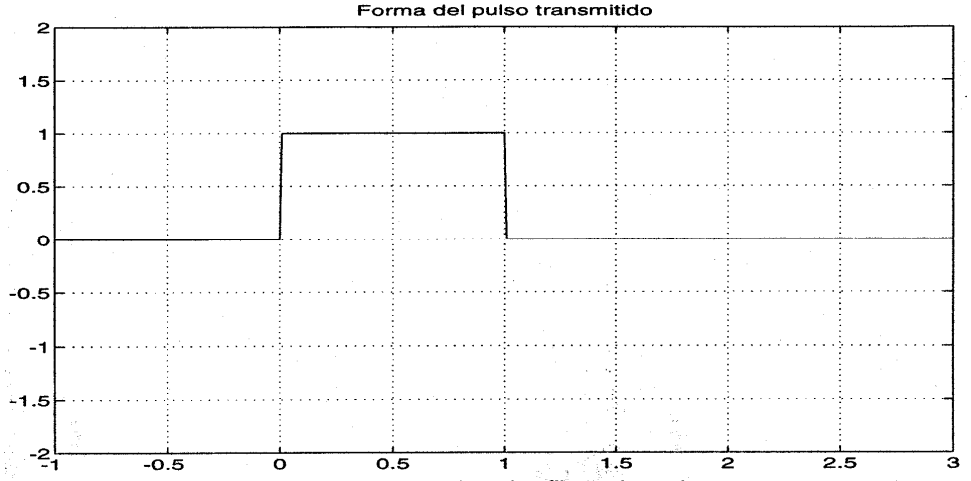
Señalización ortogonal y anitpodal

- Señalización ortogonal $\Rightarrow$ $p(e)=Q\left(\sqrt{\frac{E_b}{N_0}}\right)$
- Señalización antipodal $\Rightarrow$ $p(e)=Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$
- Para conseguir la misma p(e) se necesita dos veces (i.e., 3 dB) más E_b/N_0 con señalización ortogonal que con antipodal

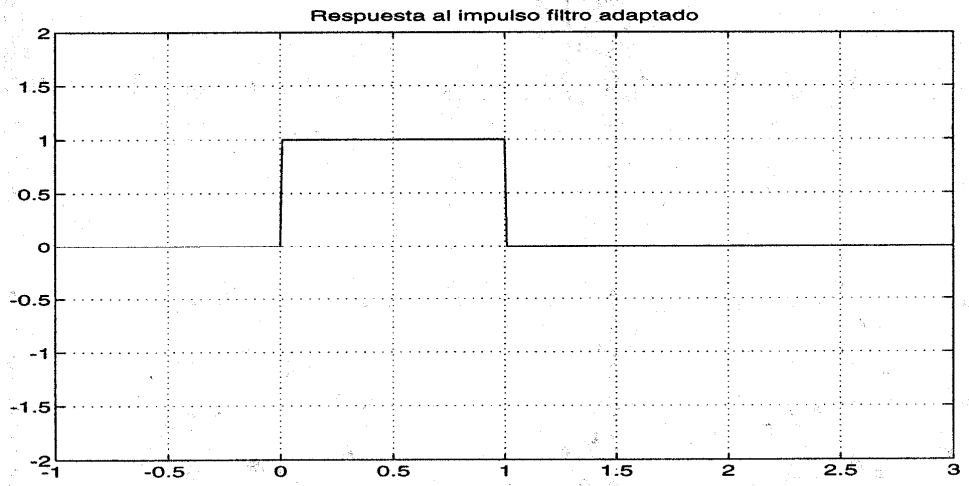
$$\left.\frac{E_b}{N_0}\right|_{ort} = 2\left.\frac{E_b}{N_0}\right|_{ant} \Rightarrow 10\log_{10}\left(\left.\frac{E_b}{N_0}\right|_{ort}\right) = 10\log_{10}\left(2\left.\frac{E_b}{N_0}\right|_{ant}\right) \Rightarrow \left.\frac{E_b}{N_0}\right|_{ort} dB = 10\log_{10}(2) + \left.\frac{E_b}{N_0}\right|_{ant} dB$$

$$\boxed{\left.\frac{E_b}{N_0}\right|_{ort} dB = \left.\frac{E_b}{N_0}\right|_{ant} dB + 3\ dB}$$

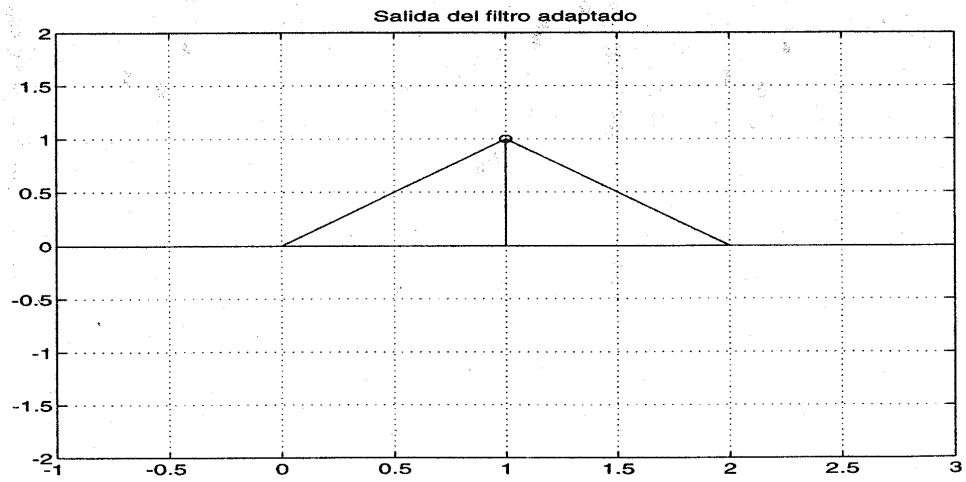
Pulso recibido sin ruido



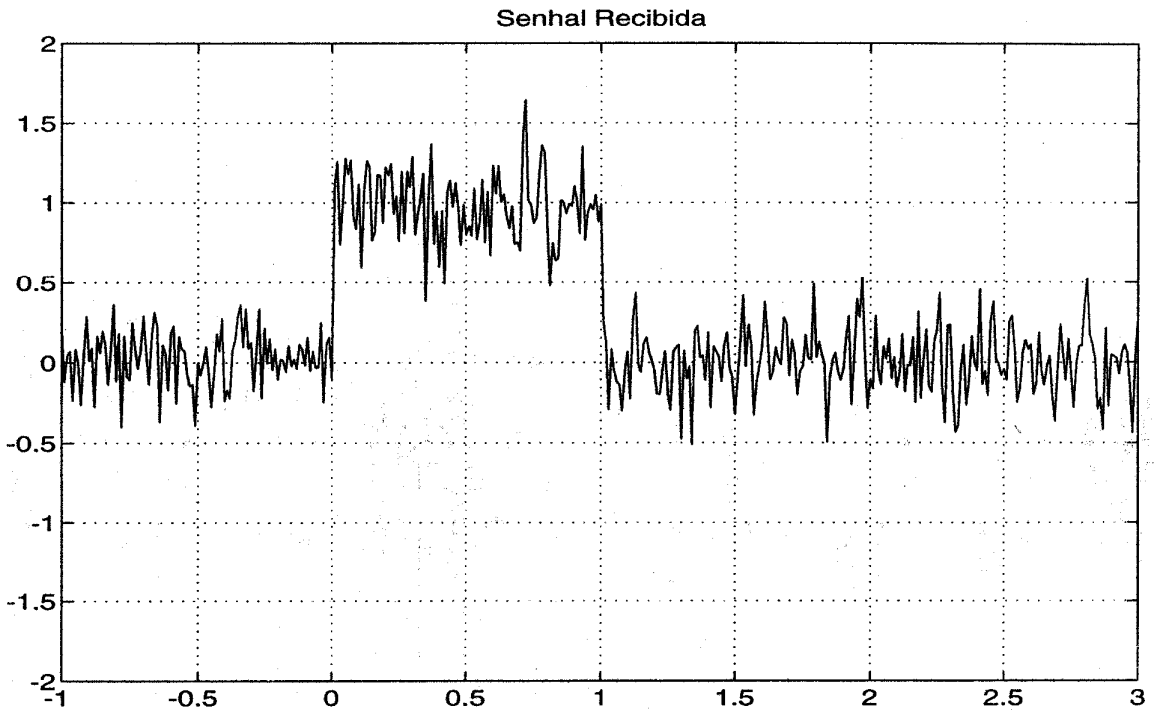
Respuesta al impulso del filtro adaptado



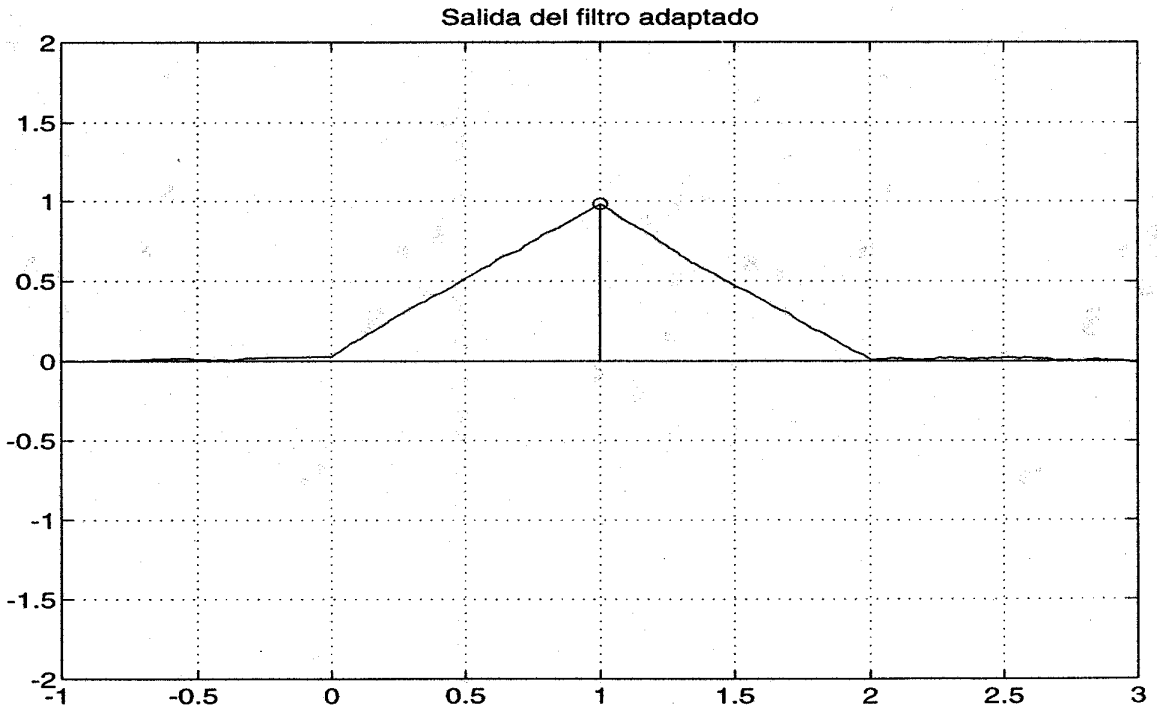
Salida del filtro adaptado



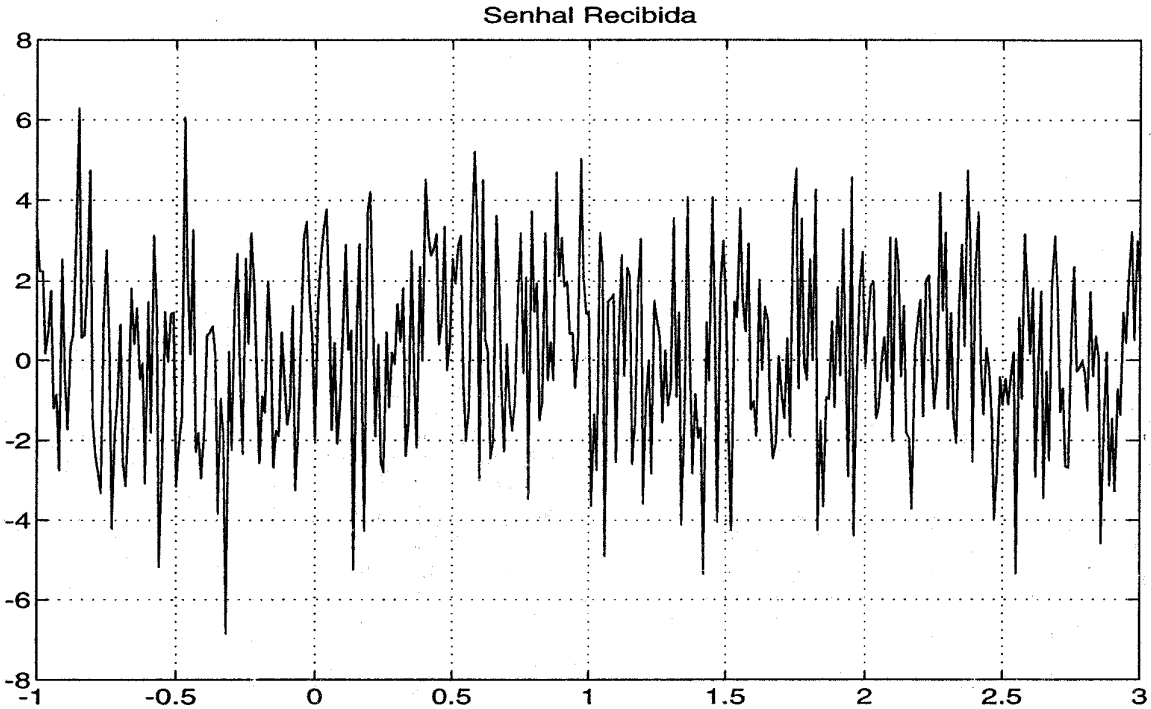
Pulso recibido
$E_b/N_0 = 30$ dB



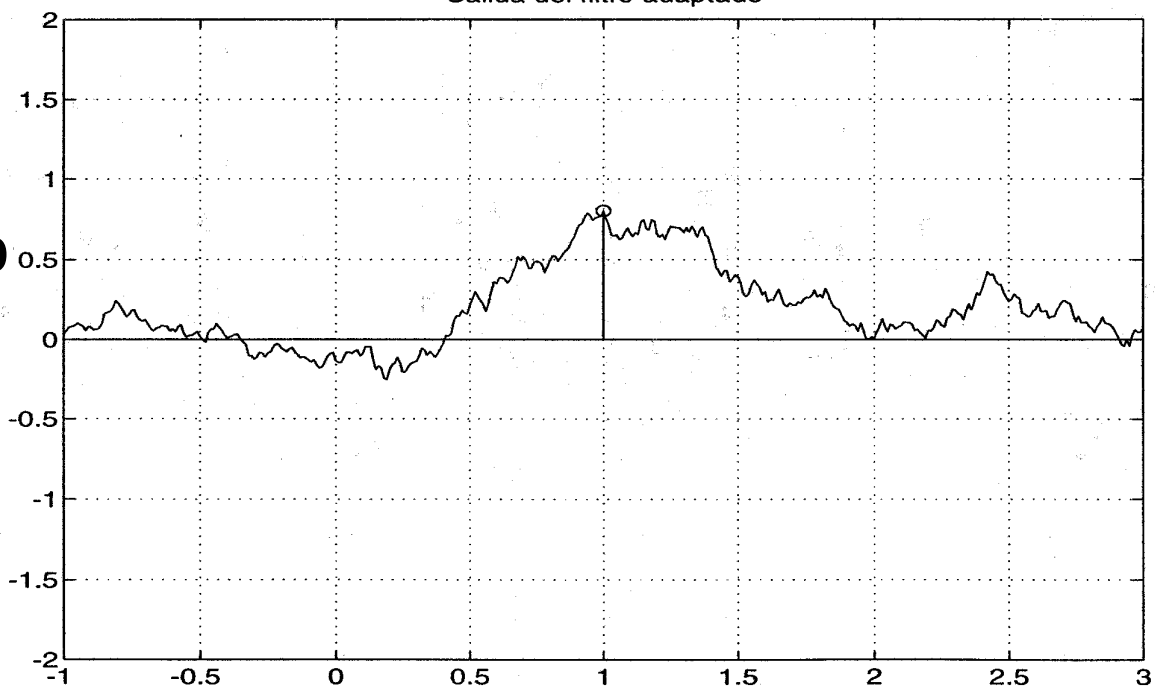
Salida del filtro adaptado



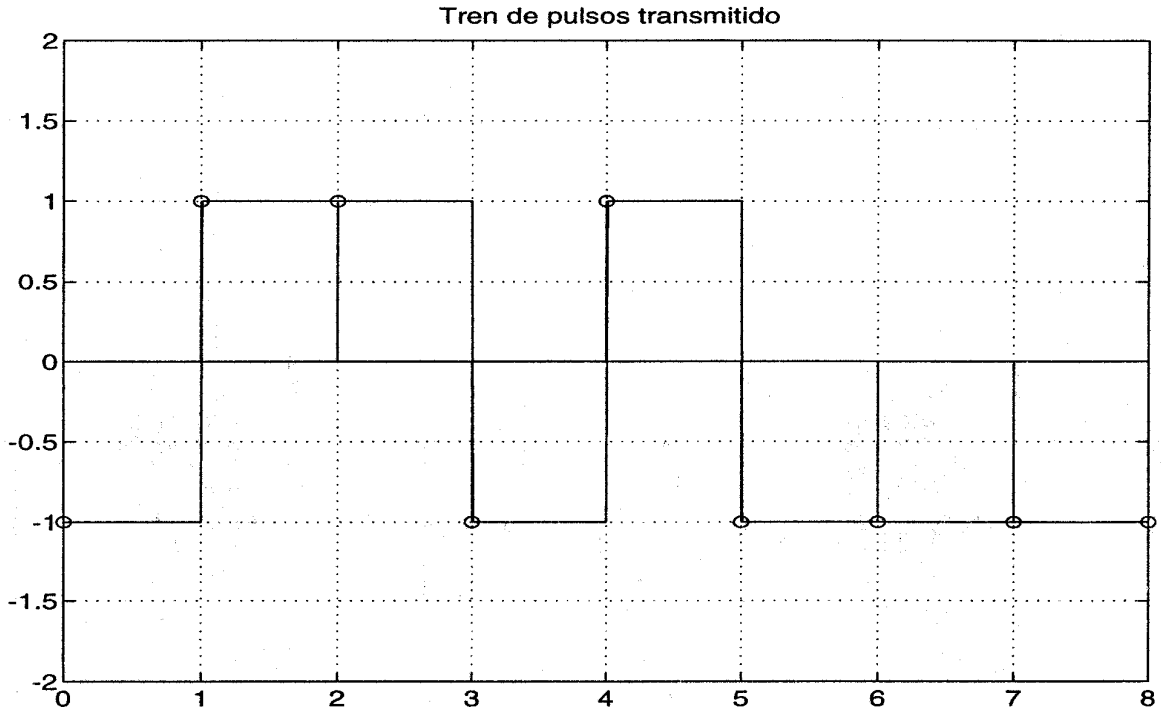
Pulso recibido
$E_b/N_0 = 10$ dB



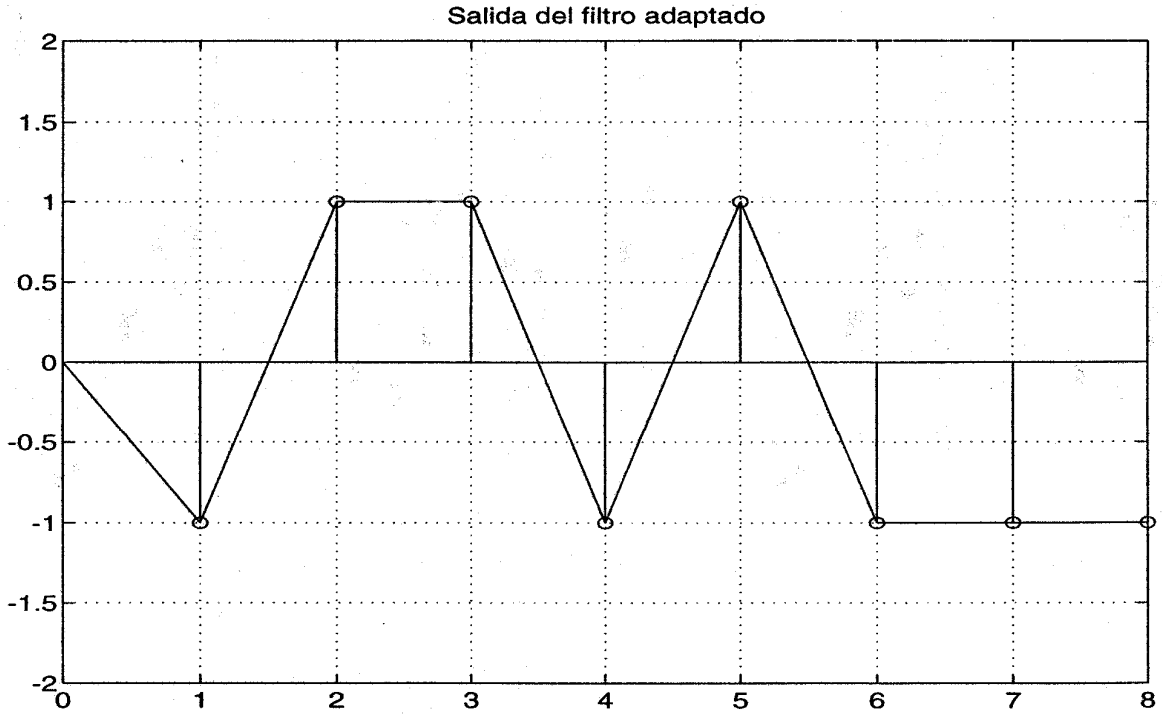
Salida del filtro adaptado



Señal PAM recibida sin ruido



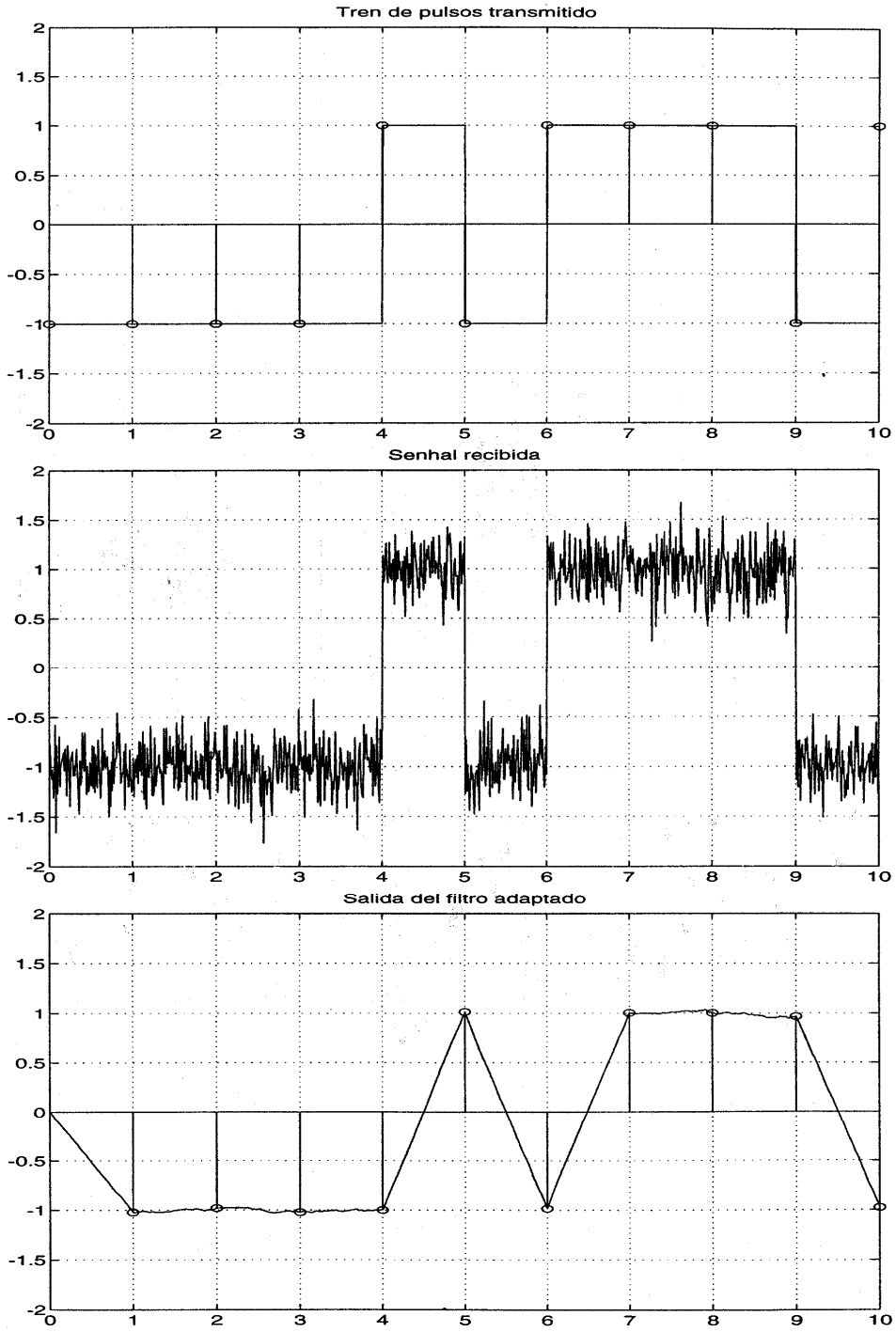
Salida del filtro adaptado



Señal PAM transmitida

Señal PAM recibida
$E_b/N_0 = 30$ dB

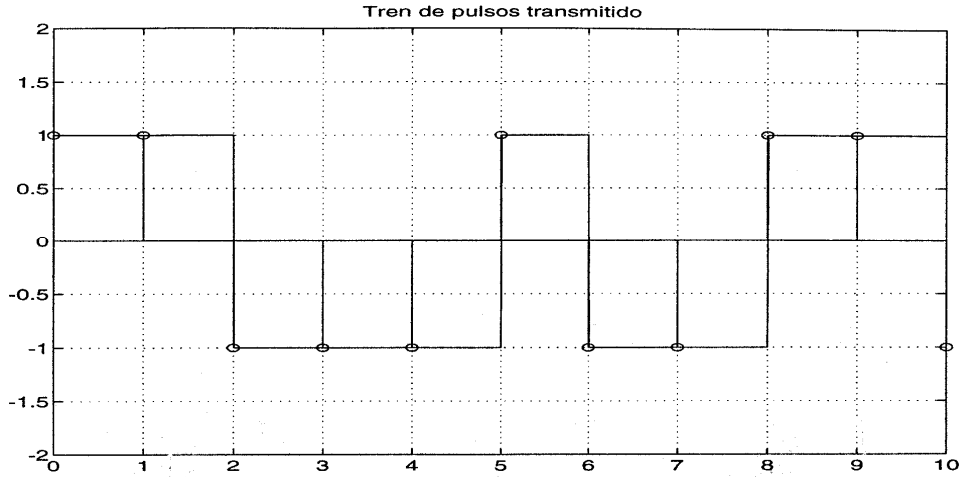
Salida del filtro adaptado

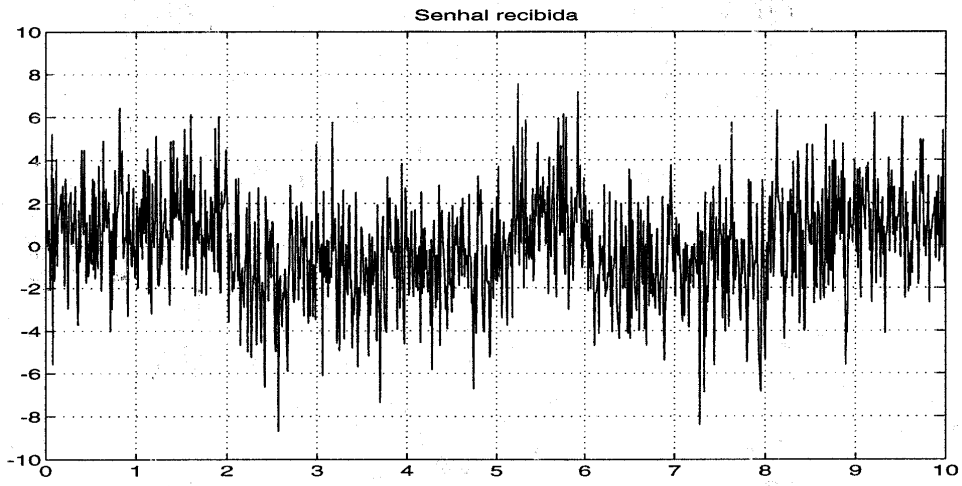


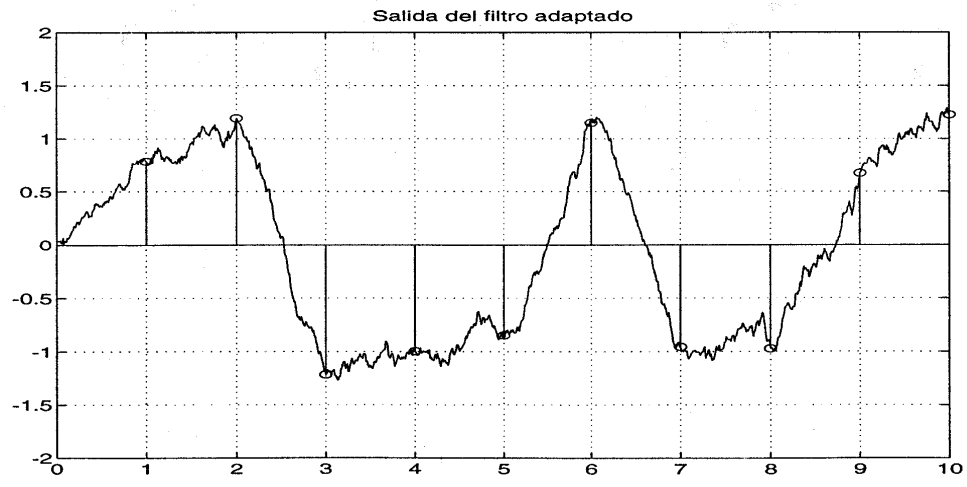
Señal PAM transmitida

Señal PAM recibida
$E_b/N_0 = 10$ dB

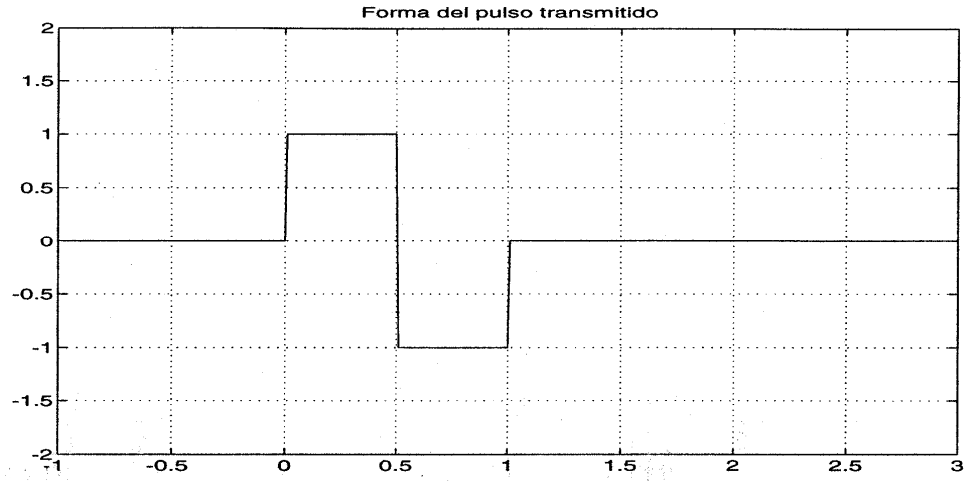
Salida del filtro adaptado



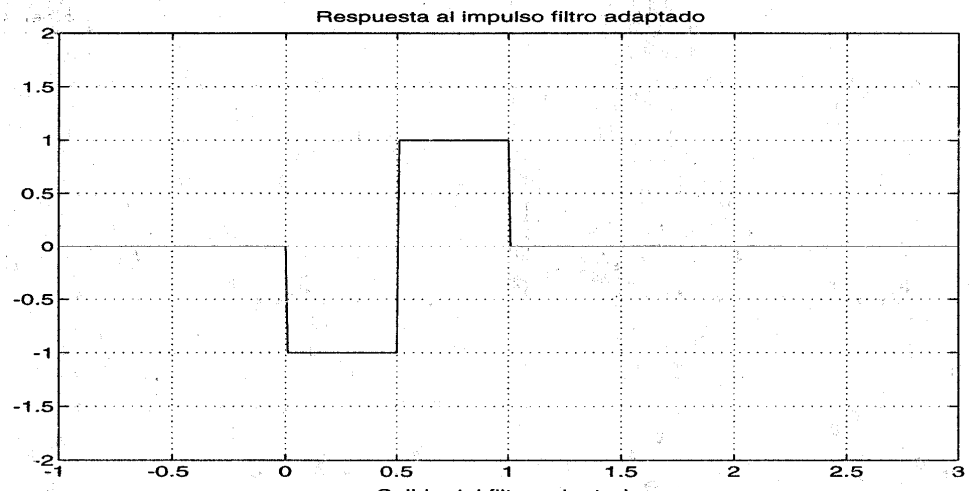




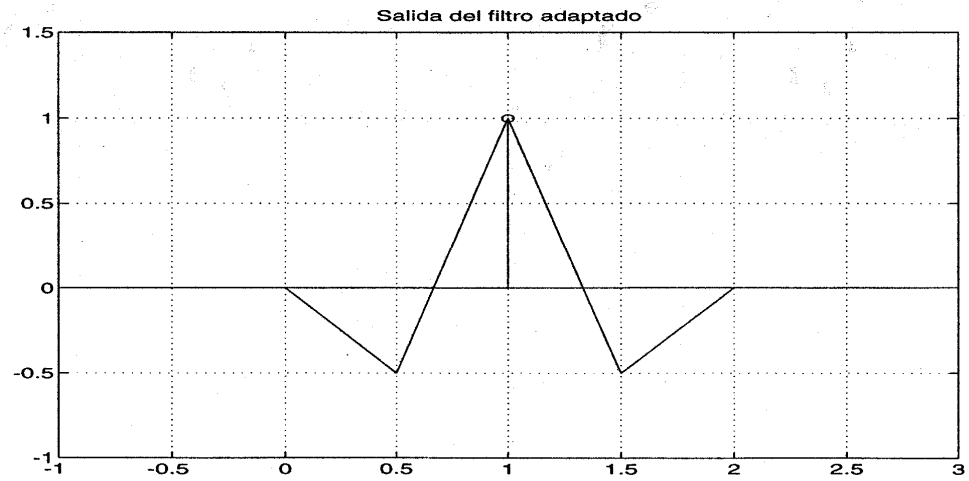
Pulso bifase recibido sin ruido



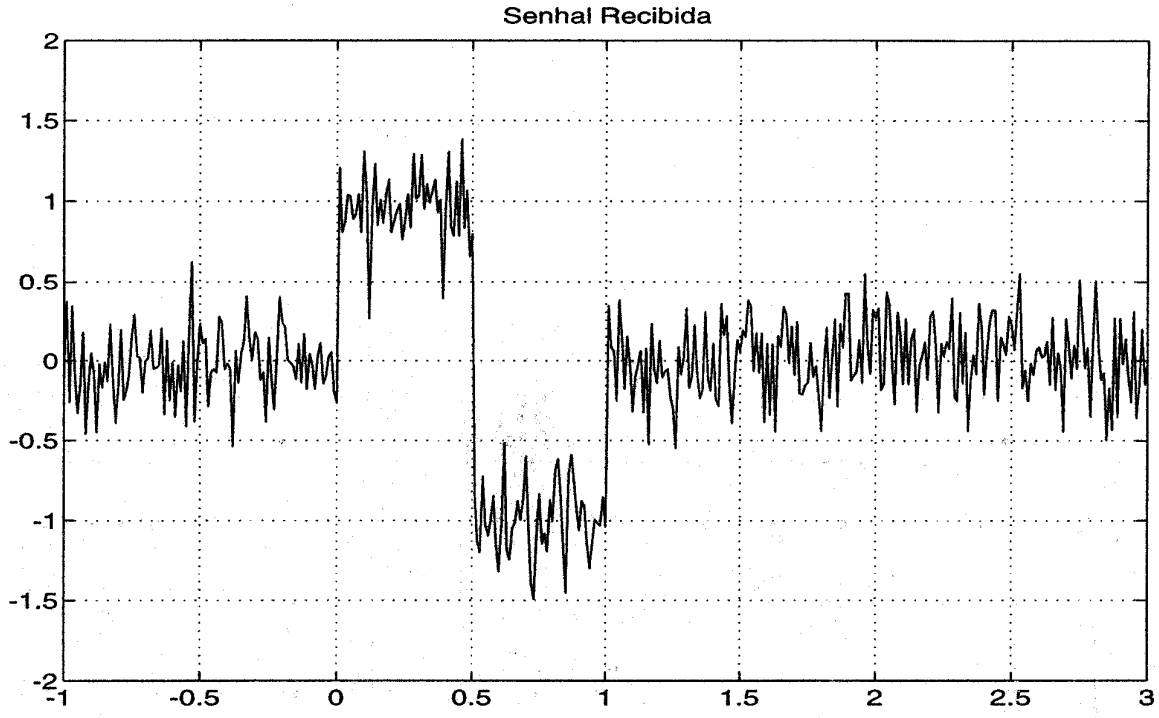
Respuesta al impulso del filtro adaptado



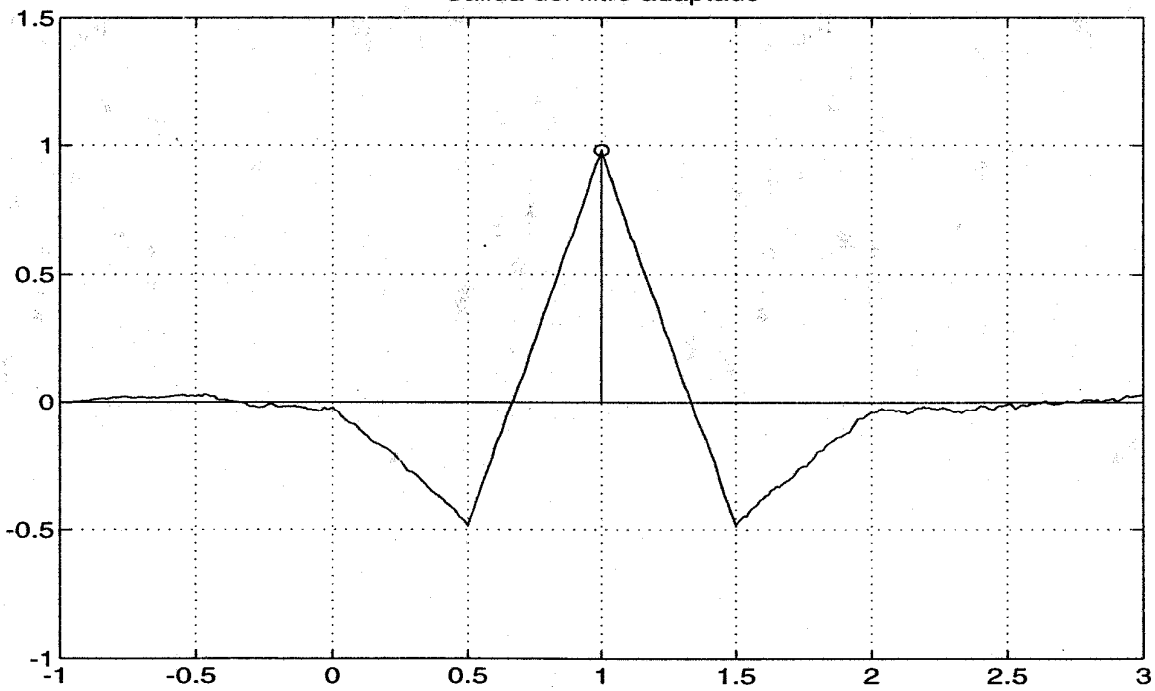
Salida del filtro adaptado



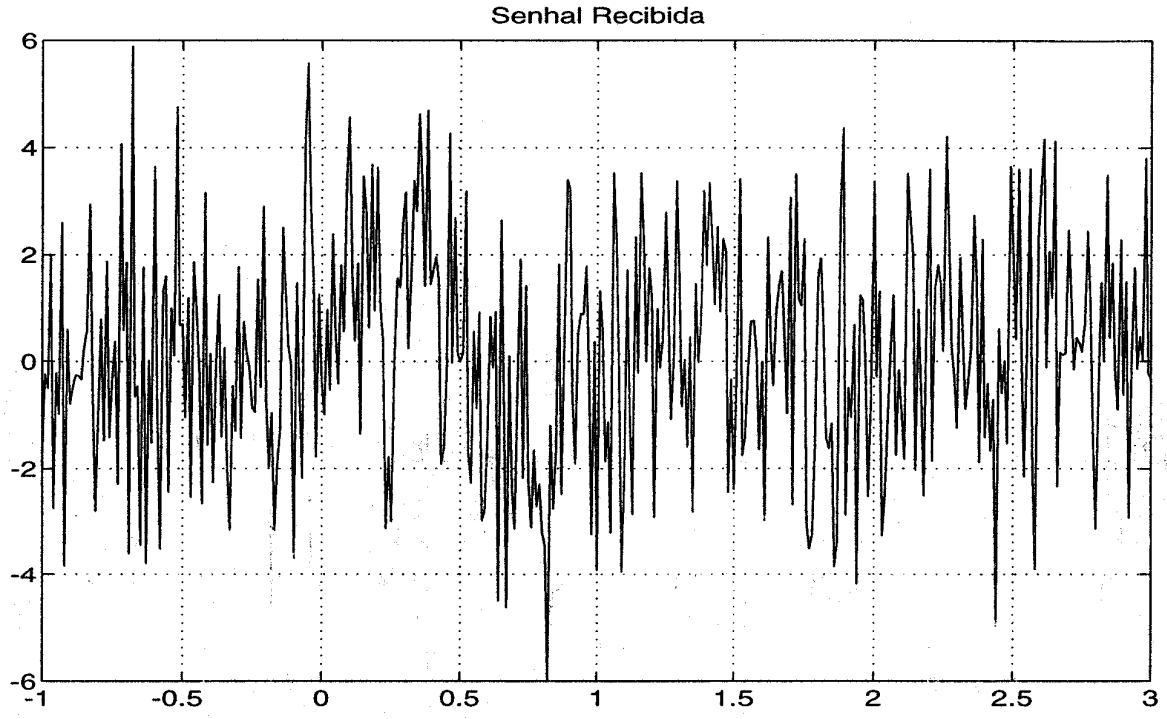
Pulso bifase recibido
$E_b/N_0 = 30$ dB



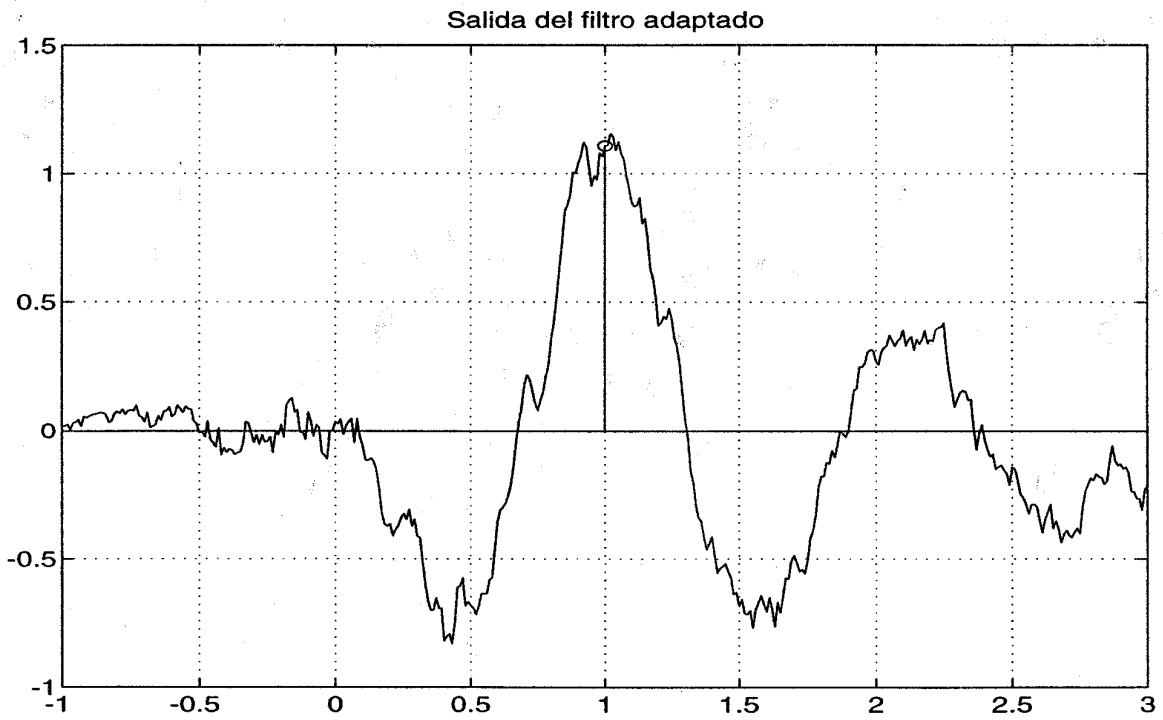
Salida del filtro adaptado



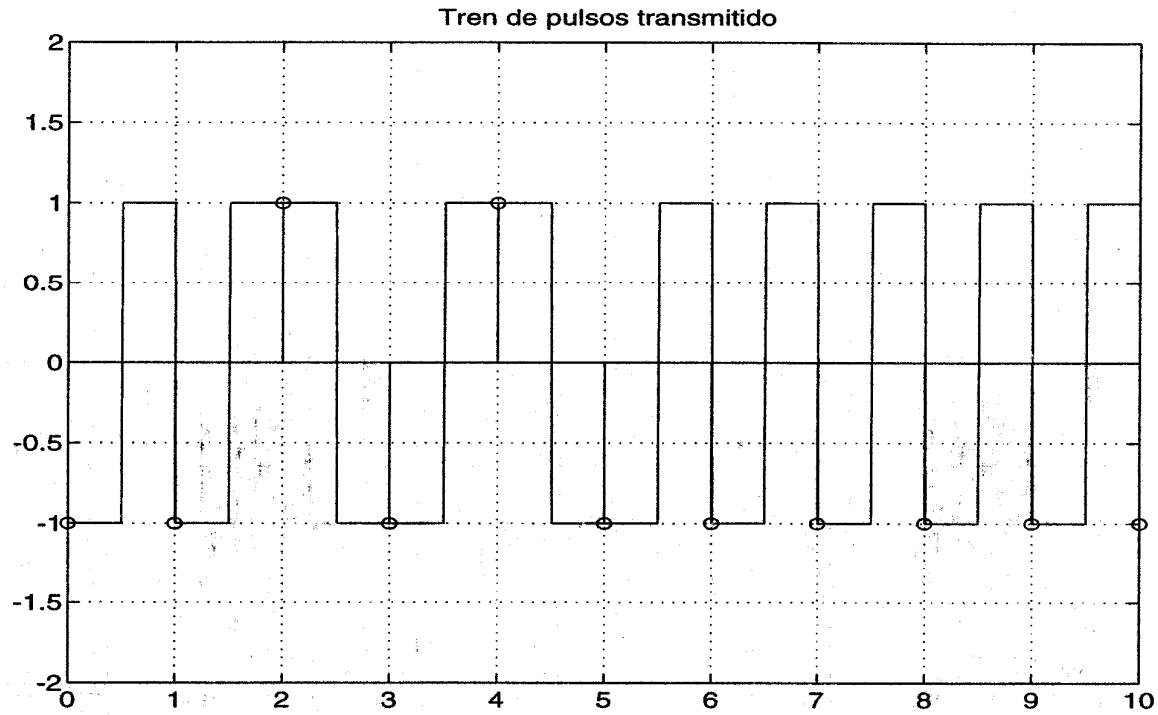
Pulso bifase recibido
$E_b/N_0 = 10$ dB



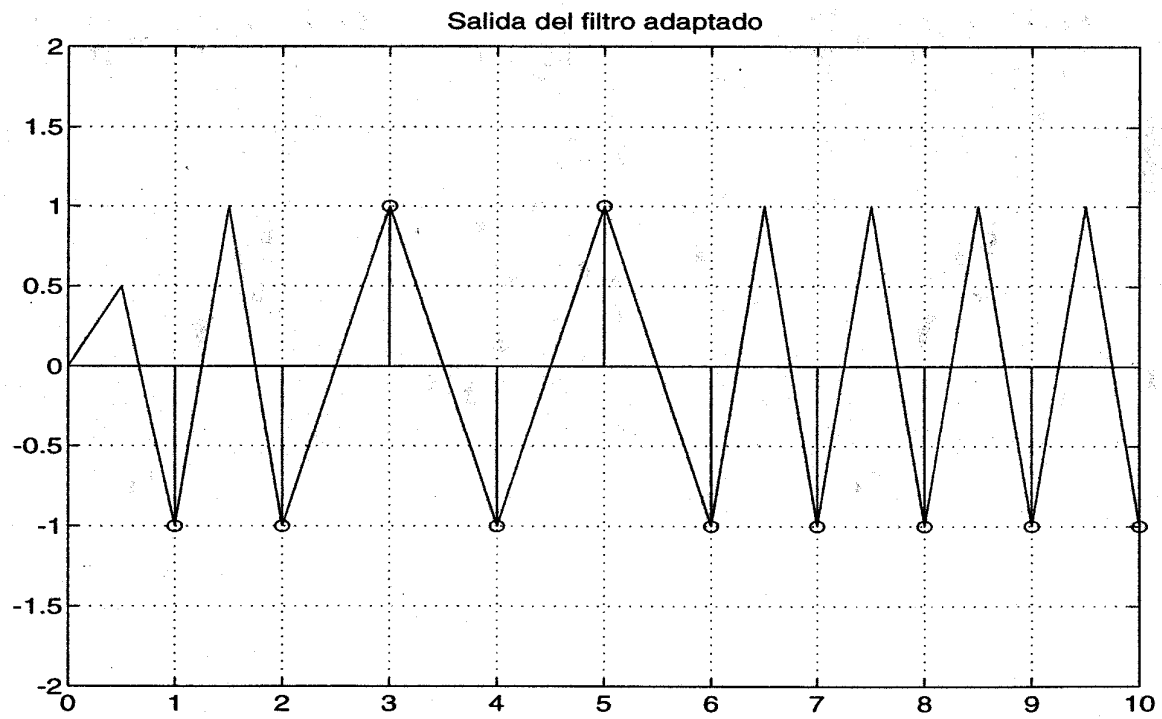
Salida del filtro adaptado



Señal PAM con pulsos bifase sin ruido



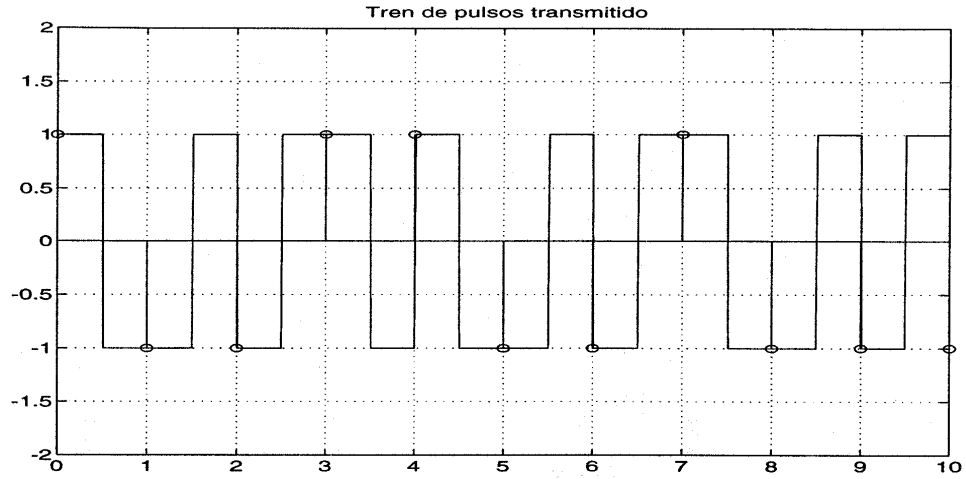
Salida del filtro adaptado

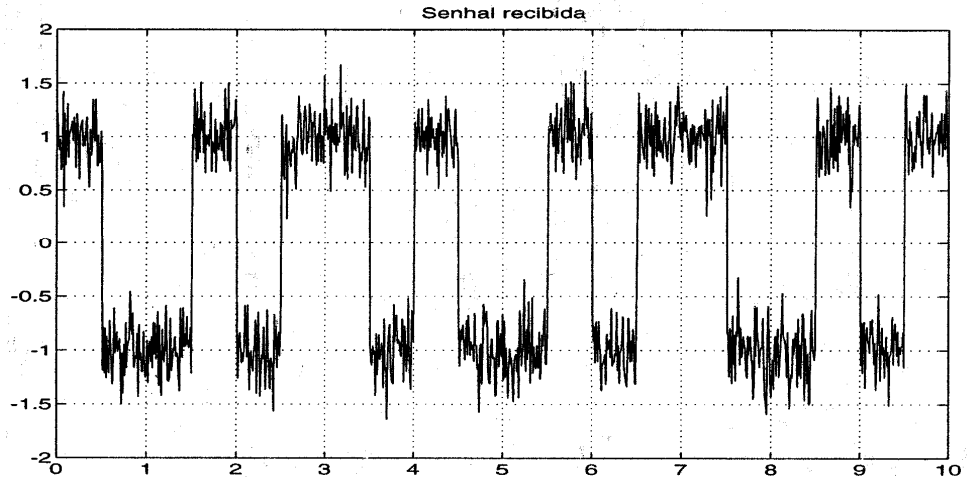


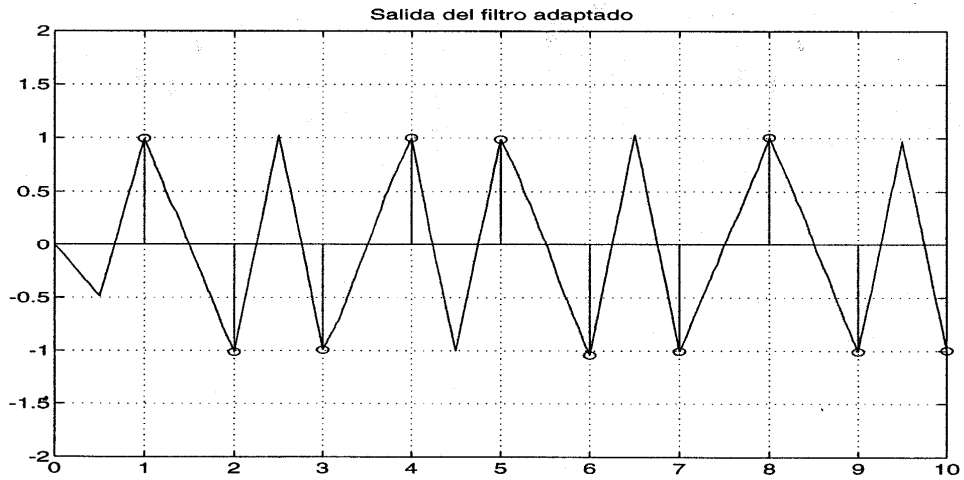
Señal PAM transmitida

Señal PAM recibida
$E_b/N_0 = 30$ dB

Salida del filtro adaptado



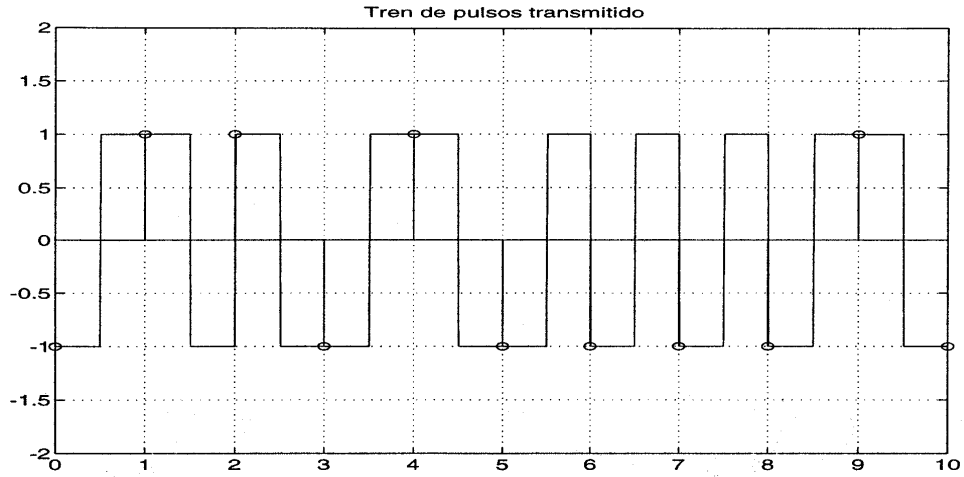


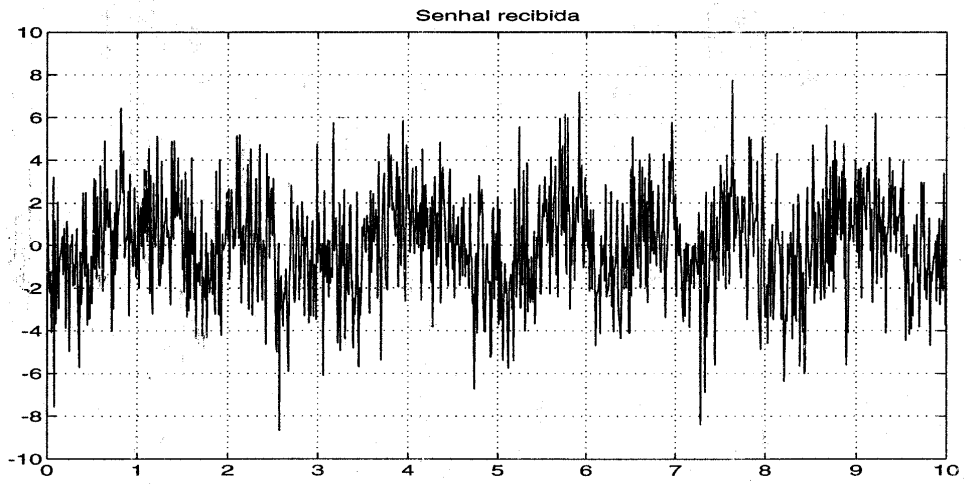


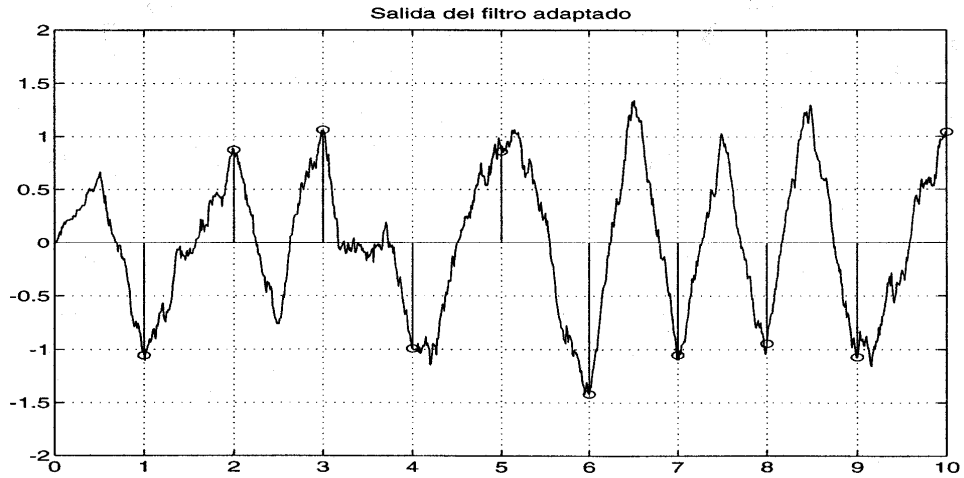
Señal PAM transmitida

Señal PAM recibida
$E_b/N_0 = 10$ dB

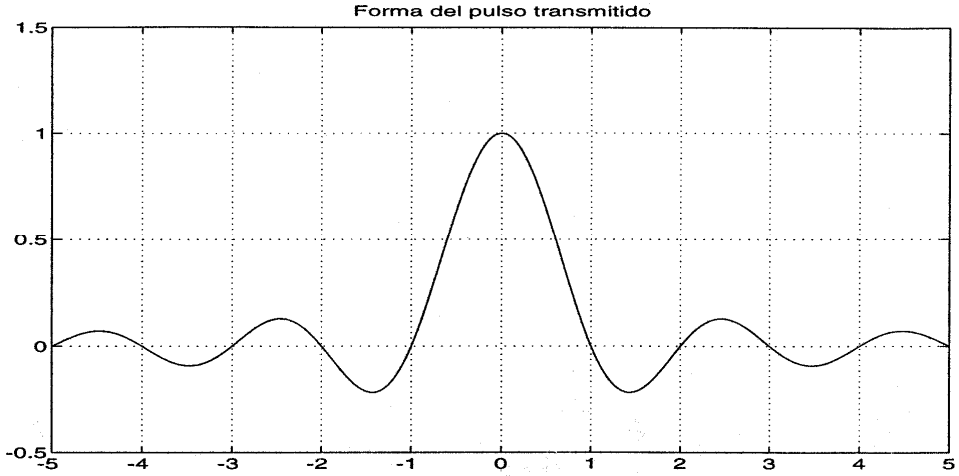
Salida del filtro adaptado



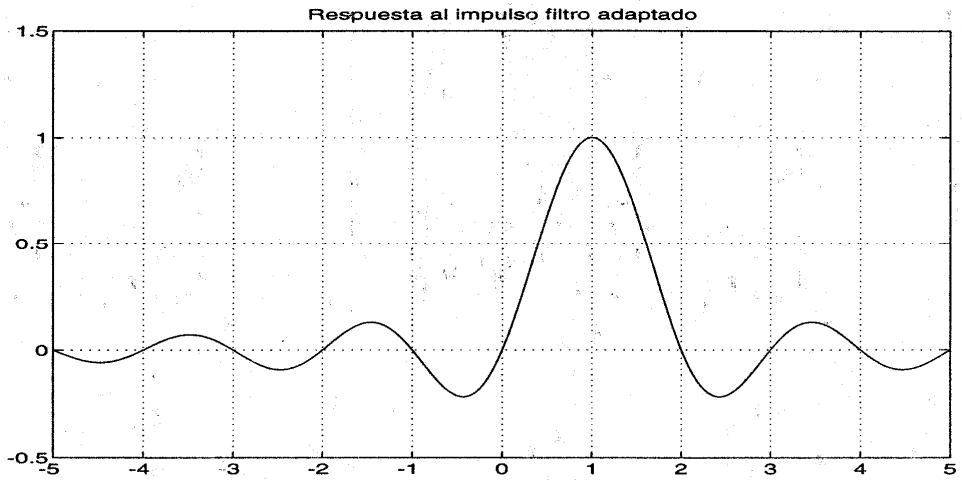




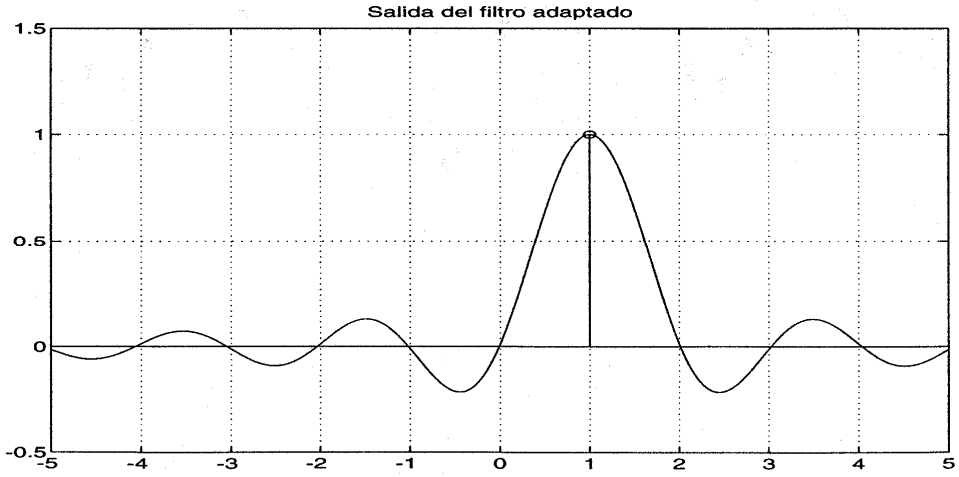
Pulso de Nyquist recibido sin ruido



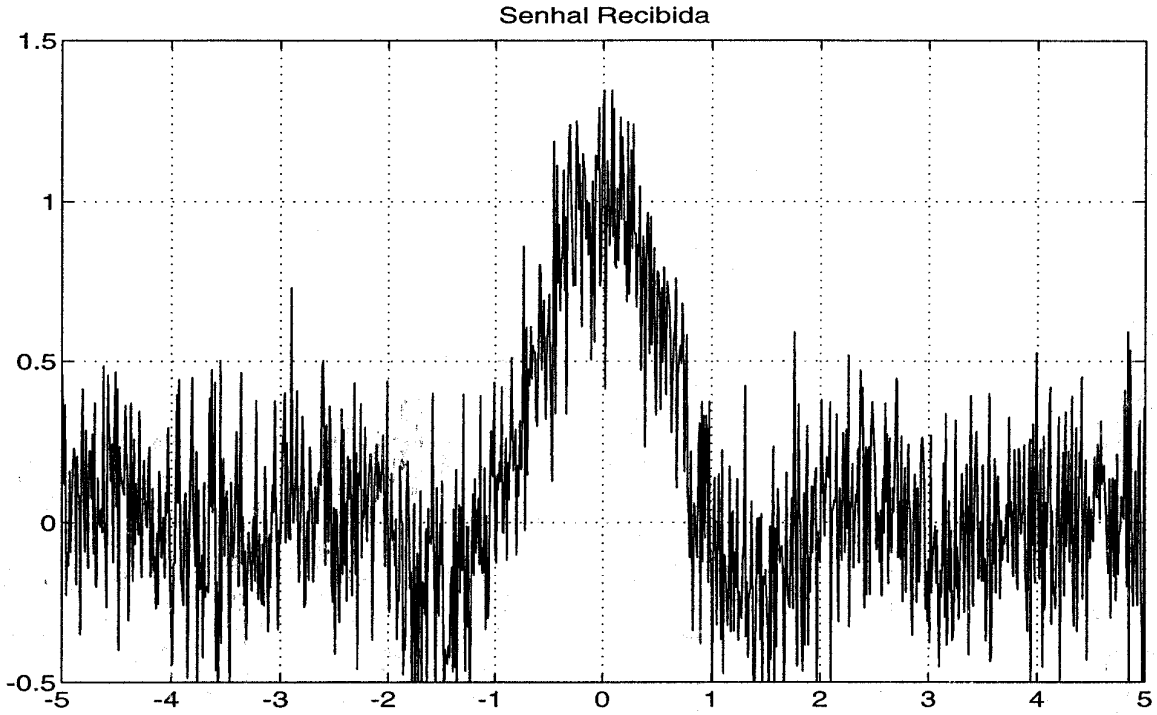
Respuesta al impulso del filtro adaptado



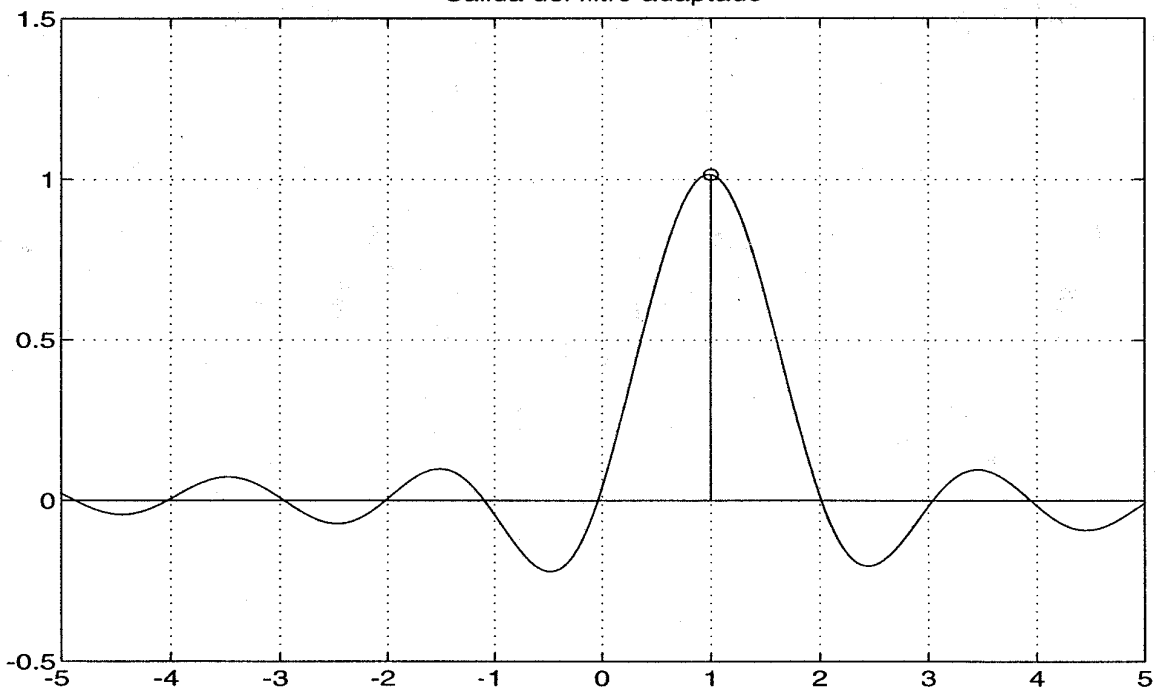
Salida del filtro adaptado



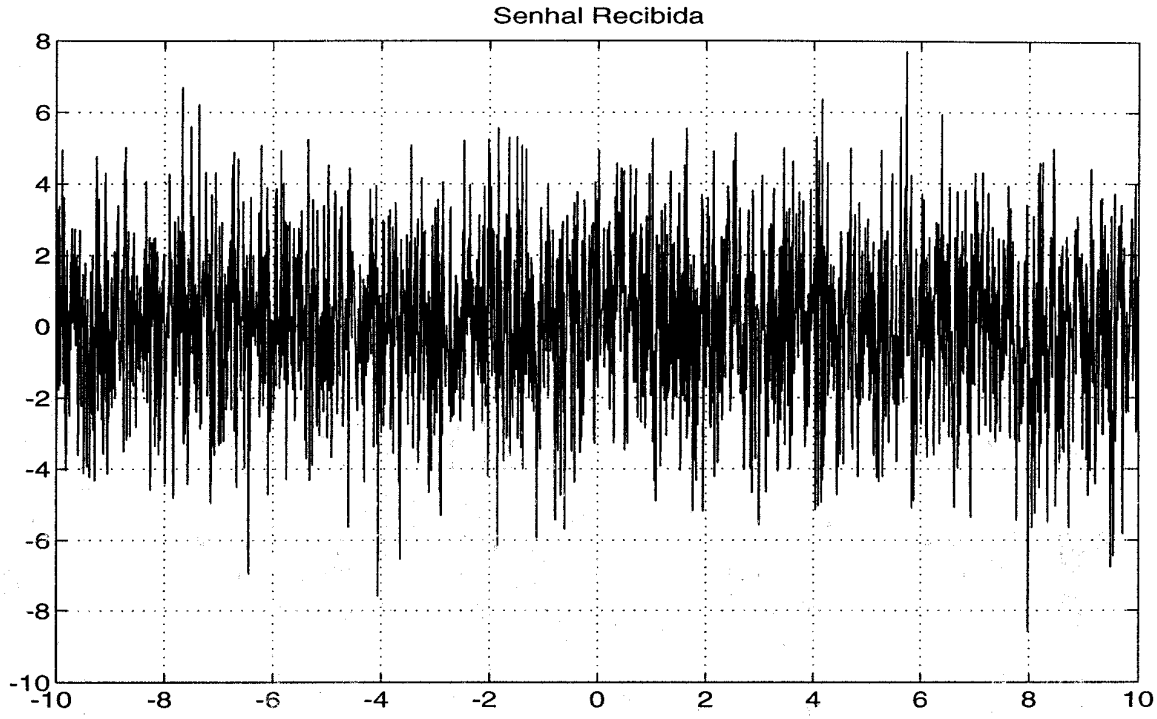
Pulso de Nyquist recibido
$E_b/N_0 = 30$ dB



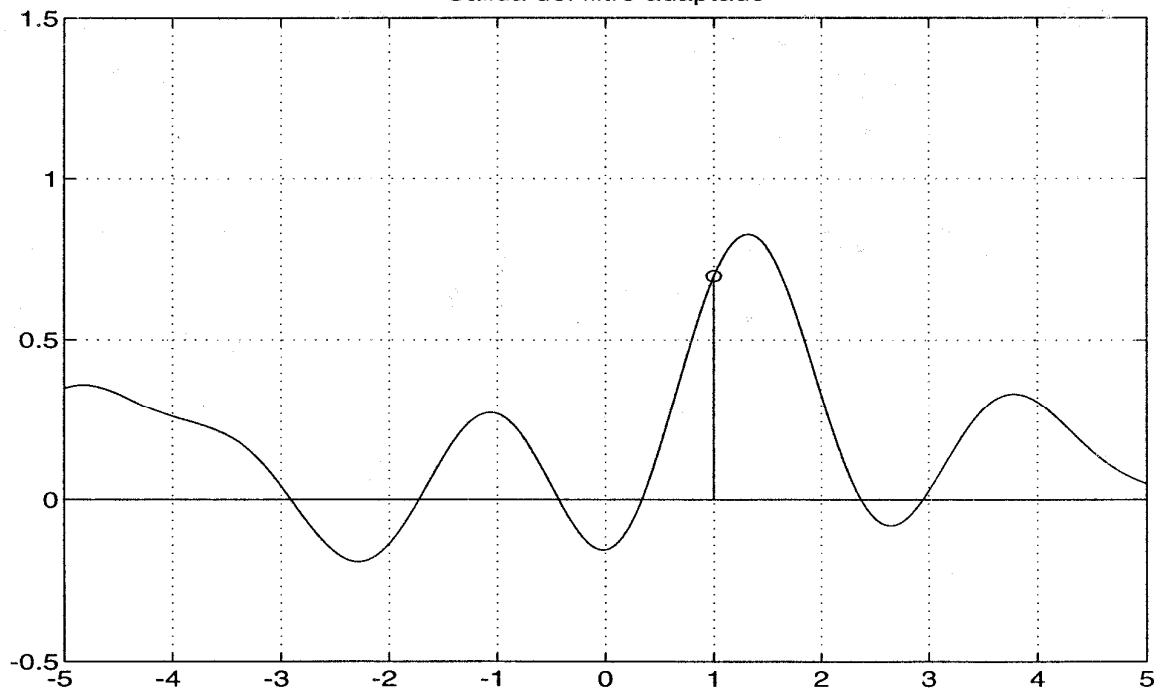
Salida del filtro adaptado



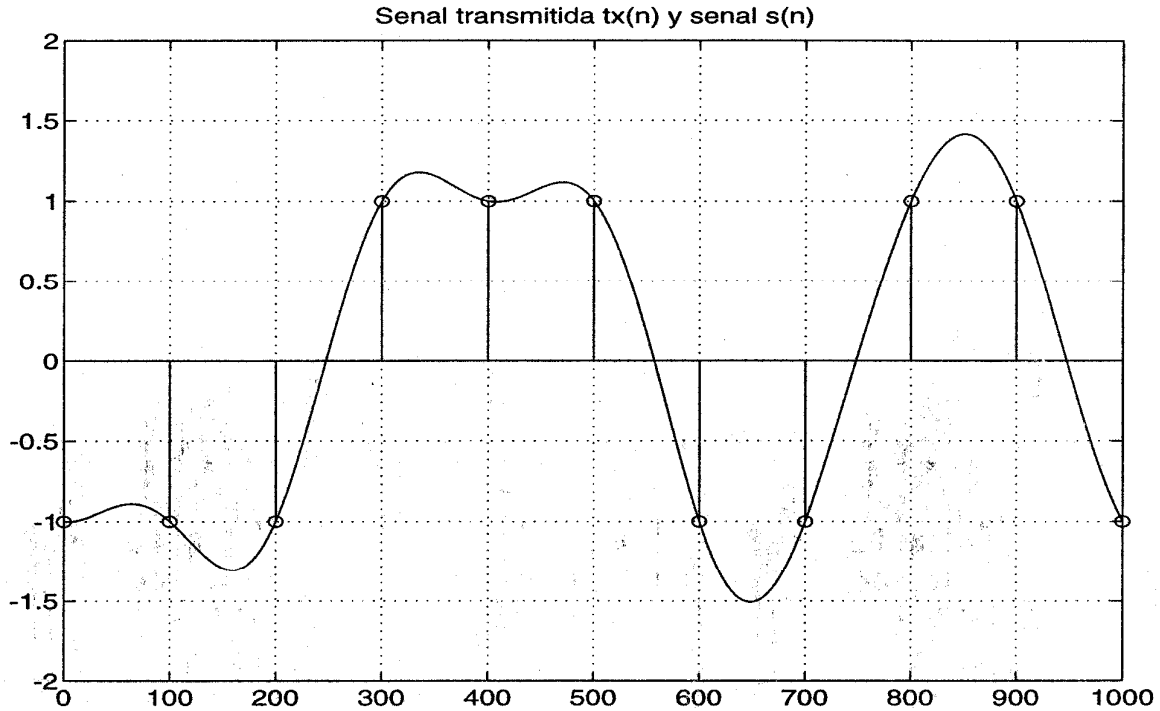
Pulso de Nyquist recibido
$E_b/N_0 = 10$ dB



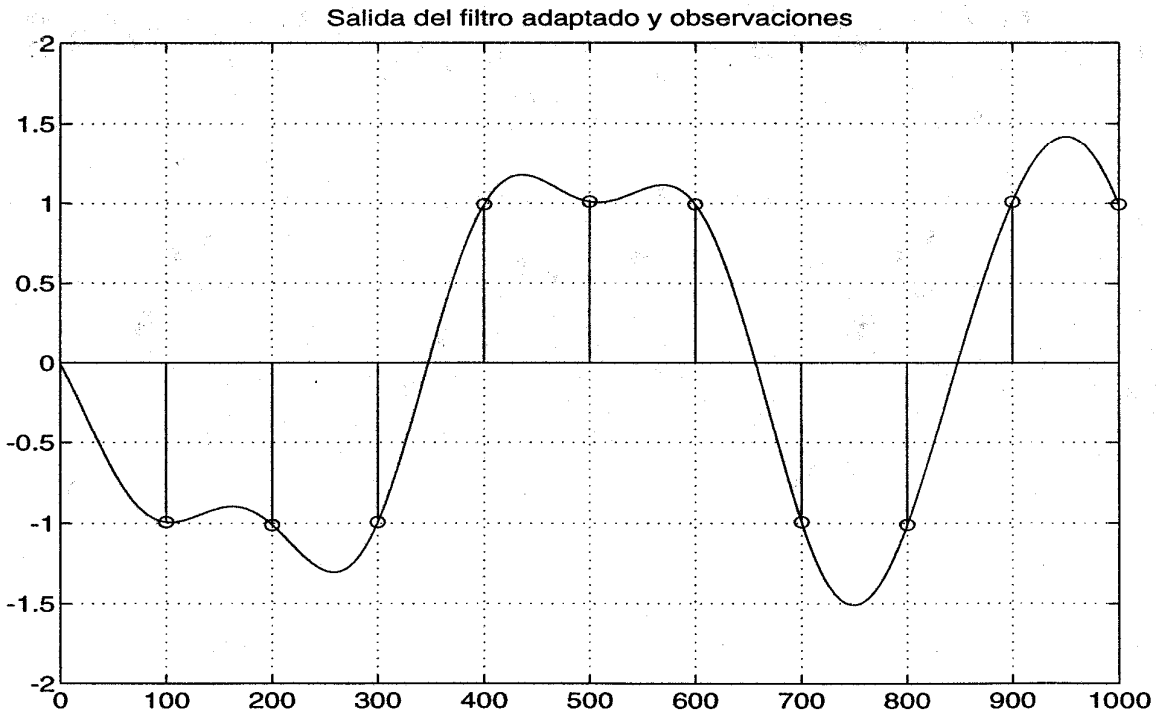
Salida del filtro adaptado



Señal PAM con pulsos de Nyquist sin ruido



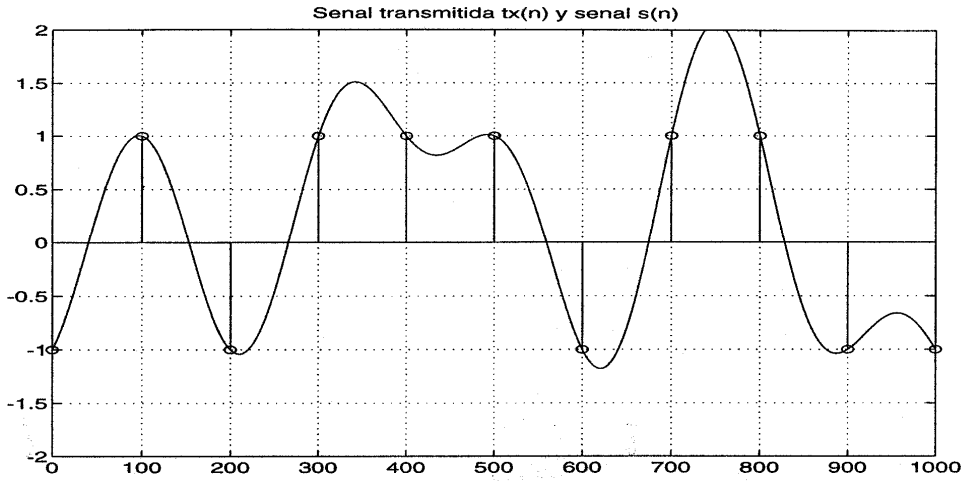
Salida del filtro adaptado

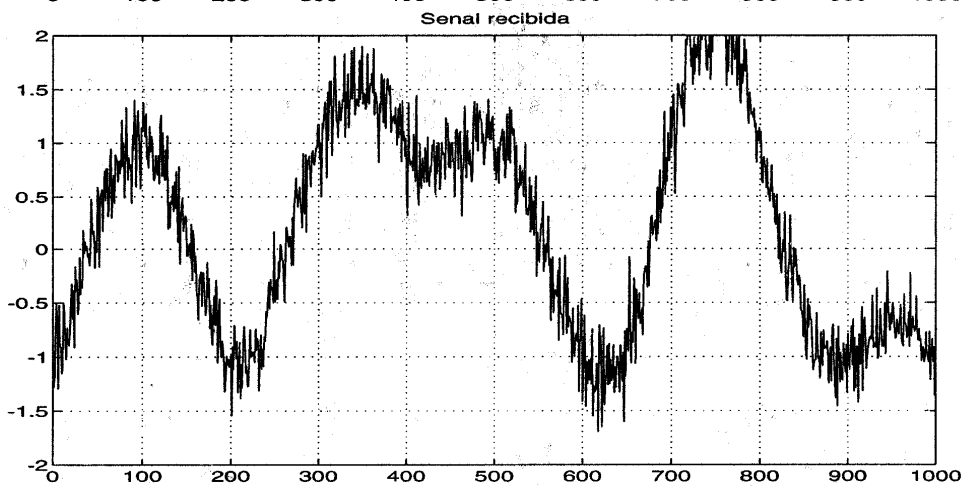


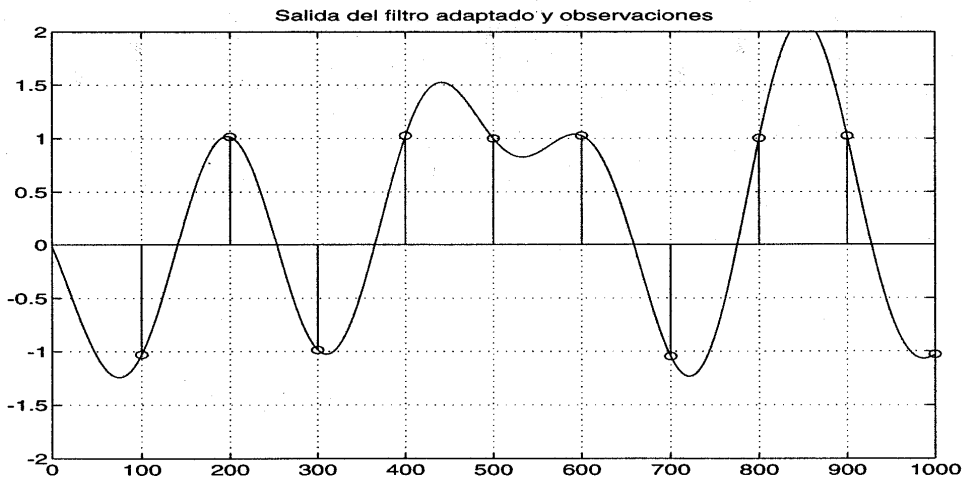
Señal PAM transmitida

Señal PAM recibida
$E_b/N_0 = 30$ dB

Salida del filtro adaptado



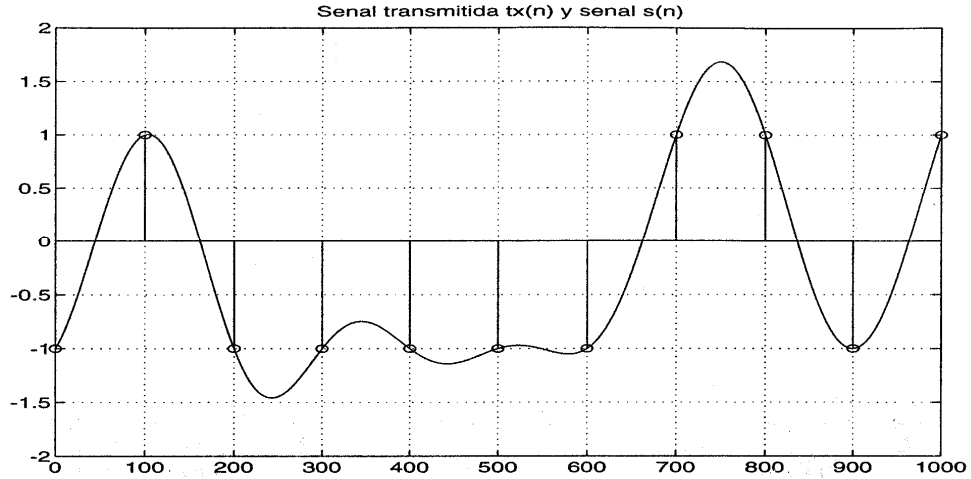


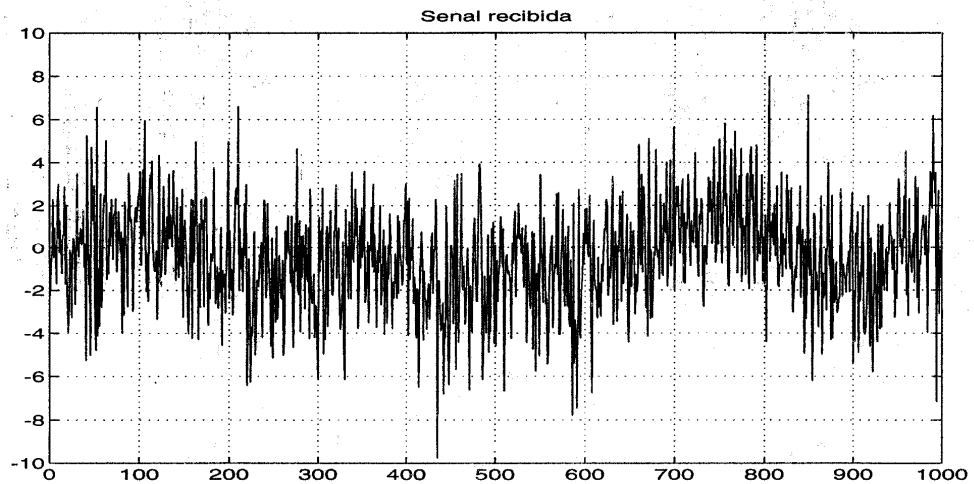


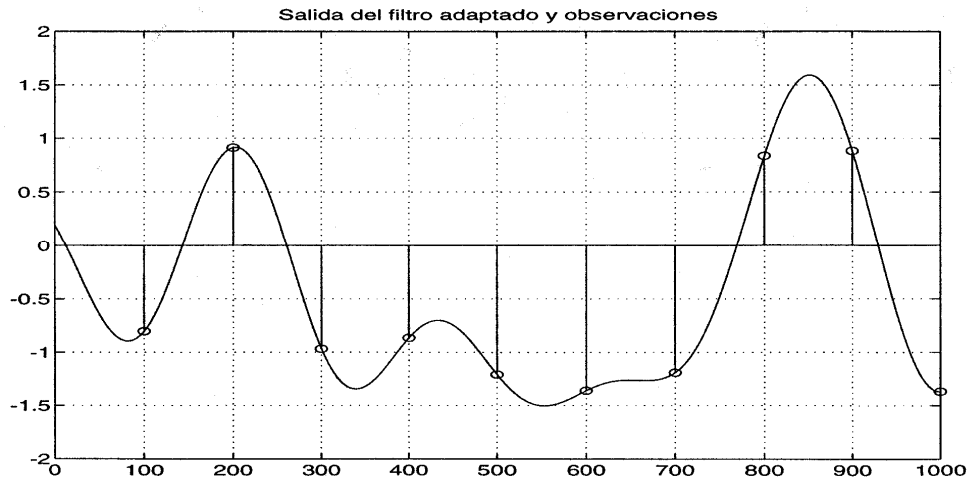
Señal PAM transmitida

Señal PAM recibida
$E_b/N_0 = 10$ dB

Salida del filtro adaptado







Probabilidad de error de un sistema M-PAM

$$p(e) = \frac{2(M-1)}{M} Q\left(\sqrt{\frac{6\log_2 M}{M^2-1}\frac{E_b}{N_0}}\right)$$