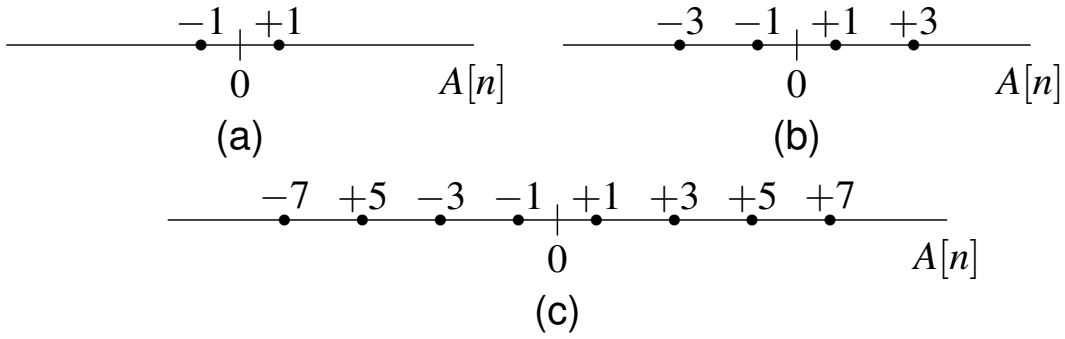
Modulación PAM en banda base

- Modulación unidimensional $N = 1$

$$s(t) = \sum_n A[n] \cdot g(t - nT)$$

  - PAM (*Pulse Amplitude Modulation*)
  - ASK (*Amplitude Shift Keying*)

- Constelaciones: 2-PAM (a), 4-PAM (b), 8-PAM (c)



Densidad espectral de potencia

$$S_s(j\omega) = \frac{1}{T} \cdot S_A(e^{j\omega T}) \cdot |G(j\omega)|^2$$

- Dos contribuciones:
  - Determinista: $|G(j\omega)|^2$
  - Estadística (estocástica): $S_A(e^{j\omega})$
- Para secuencias $A[n]$ blancas

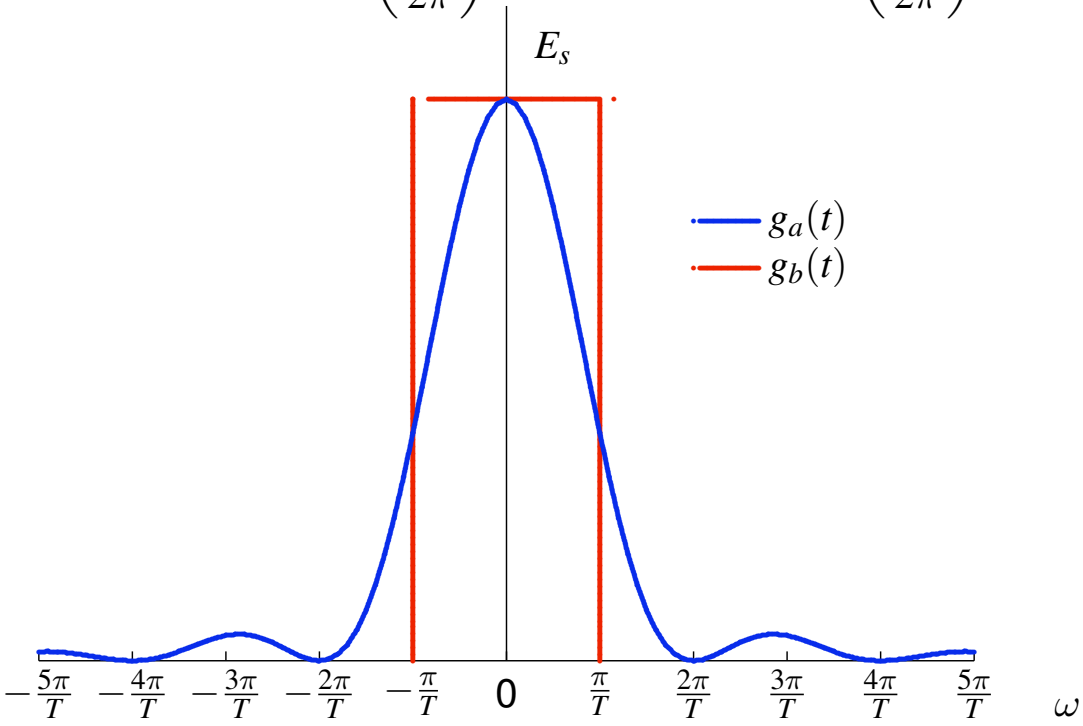
$$R_A[n] = E_s \cdot \delta[n], \qquad S_A(e^{j\omega}) = E_s = E\left\{|A[n]|^2\right\}$$

$$S_s(j\omega) = \frac{E_s}{T} \cdot |G(j\omega)|^2$$

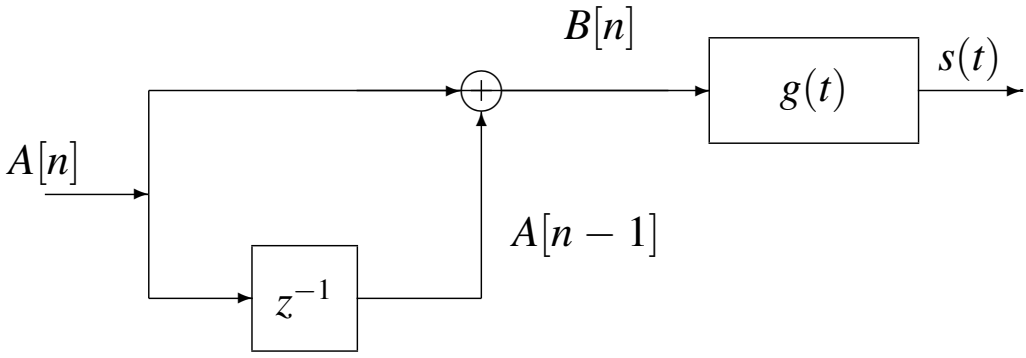
  - $g(t)$: Pulso conformador (filtro transmisor)

Espectro para secuencias blancas

$$G_a(j\omega) = \sqrt{T} \cdot \text{sinc}\left(\frac{\omega T}{2\pi}\right), \qquad G_b(j\omega) = \sqrt{T} \cdot \Pi\left(\frac{\omega T}{2\pi}\right)$$



Secuencia de datos coloreada



- Secuencia blanca $A[n]$: 2-PAM ($A[n] \in \{\pm 1\}$)
- Secuencia coloreada $B[n]$:

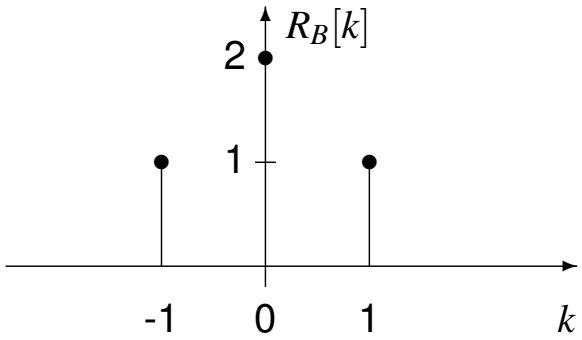
$$B[n] = A[n] + A[n-1],$$

$$s(t) = \sum_{n=-\infty}^{\infty} B[n] \cdot g(t - nT)$$

Función de autocorrelación de $B[n]$

- Autocorrelación de $A[n]$: $R_A[k] = E_s \cdot \delta[k] = \delta[k]$
- Autocorrelación de $B[n]$

$$\begin{aligned} R_B[k] =& E\{B[n]B^*[n+k]\} \\ =& E\{(A[n]+A[n-1]) \cdot (A[n+k]+A[n+k-1])\} \\ =& E\{A[n]A[n+k]\} + E\{A[n]A[n+k-1]\} \\ & + E\{A[n-1]A[n+k]\} + E\{A[n-1]A[n+k-1]\} \\ =& R_A[k] + R_A[k-1] + R_A[k+1] + R_A[k] \\ =& 2R_A[k] + R_A[k-1] + R_A[k+1] \end{aligned}$$



Power spectral density

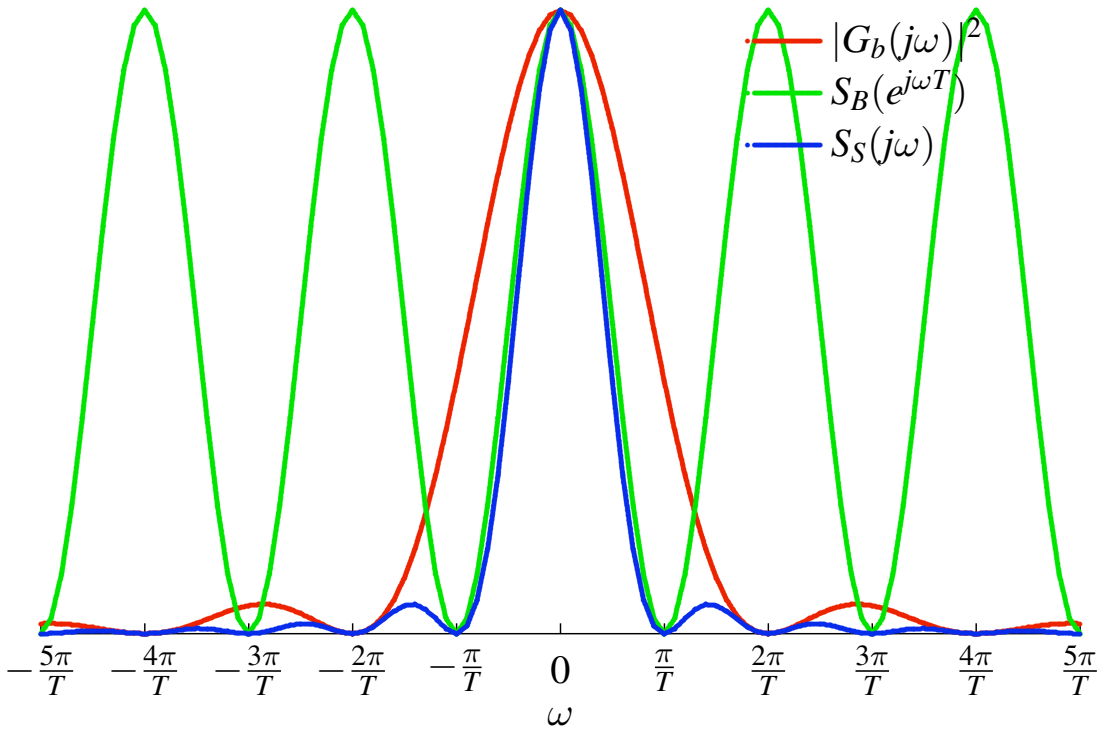
- Sequence $B[n]$

$$\begin{aligned} S_B\left(e^{j\omega}\right) =& \mathcal{TF}\{R_B[k]\} = \sum_k R_B[k] \cdot e^{-j\omega k} \\ =& 2 \cdot e^{j\omega \cdot 0} + e^{j\omega \cdot 1} + e^{-j\omega \cdot 1} \\ =& 2 \cdot \{1 + \cos(\omega)\} \end{aligned}$$

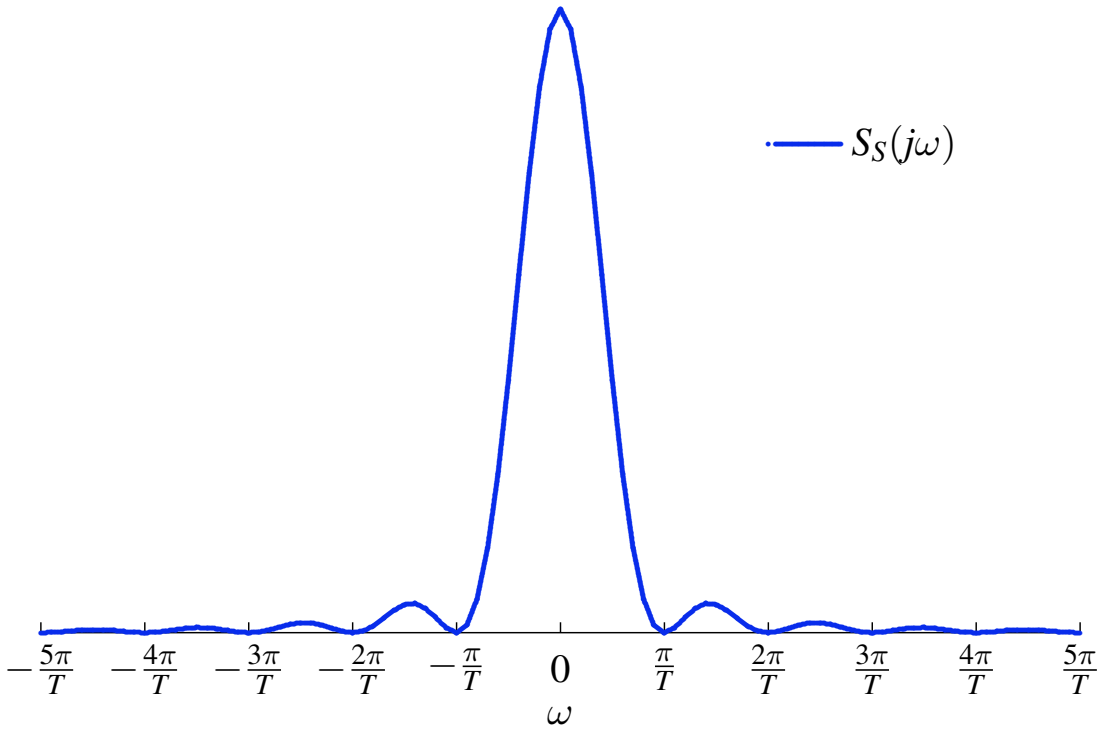
- Baseband PAM signal

$$S_s(j\omega) = \frac{2}{T}\left[1 + \cos(\omega T)\right] \cdot |G(j\omega)|^2$$

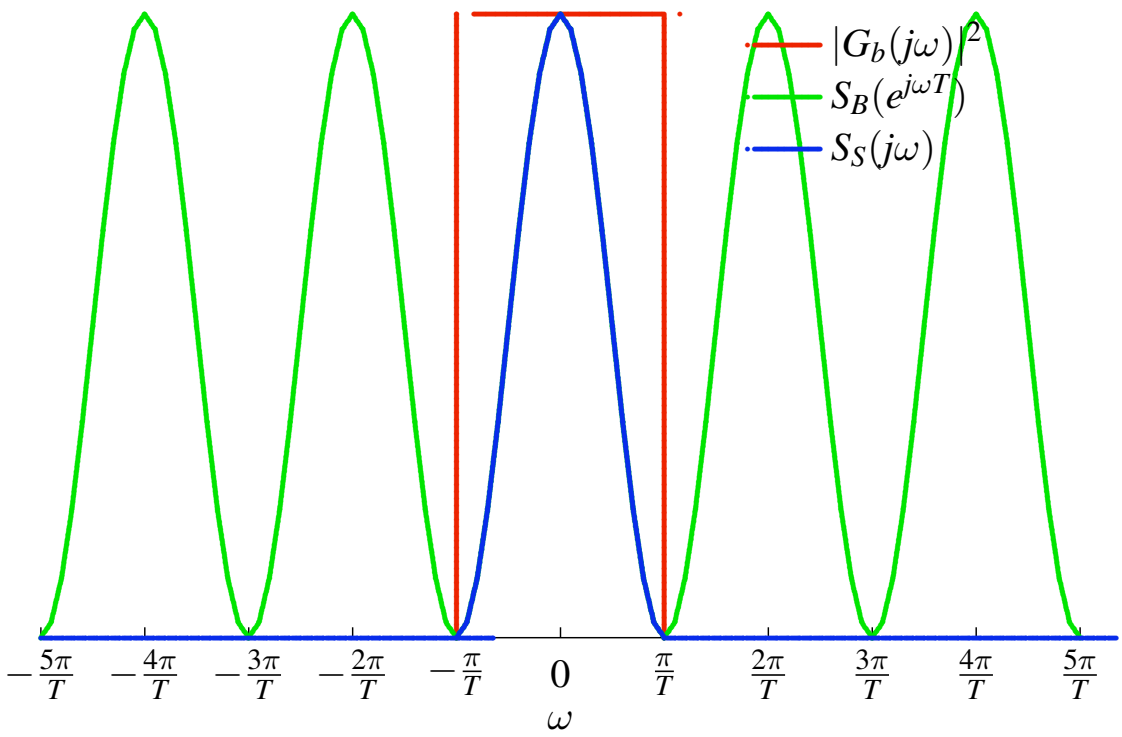
Power spectral density with $g_a(t)$



Power spectral density with $g_a(t)$



Power spectral density with $g_b(t)$



Power spectral density with $g_b(t)$