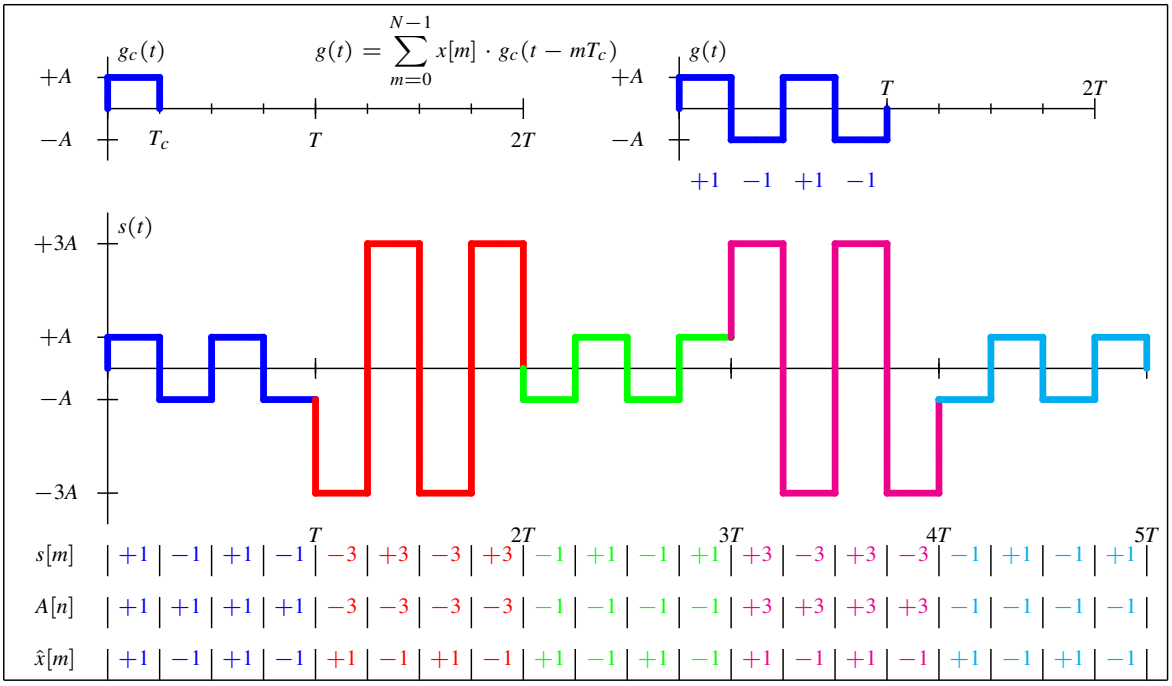
Generación de las señales $s(t)$ (Ejemplo $N = 4$)

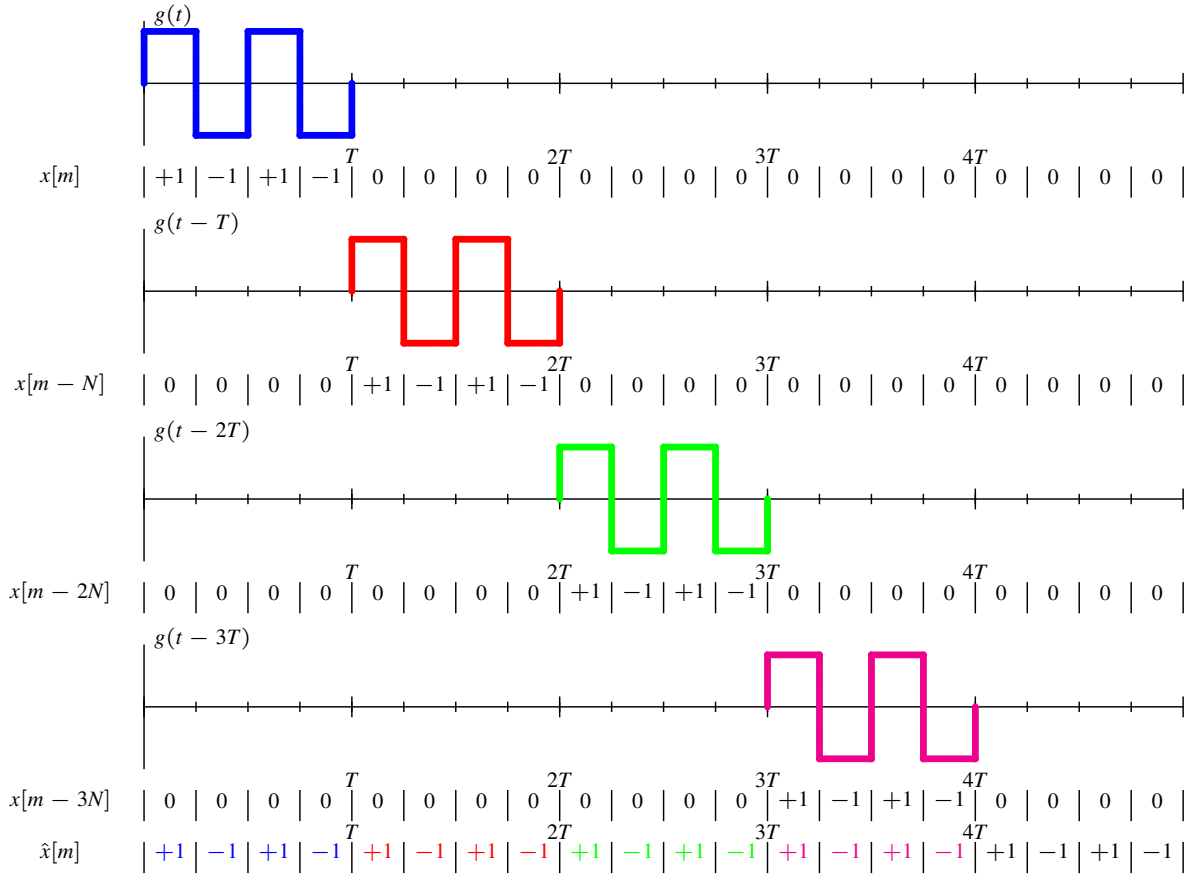
- Secuencia a transmitir:

n	0	1	2	3	4
$A[n]$	$+1$	-3	-1	$+3$	-1

- Secuencia de ensanchado ($N = 4$): $x[0] = +1,\ x[1] = -1,\ x[2] = +1,\ x[3] = -1$

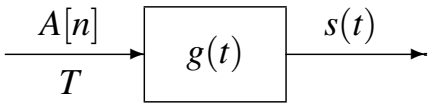


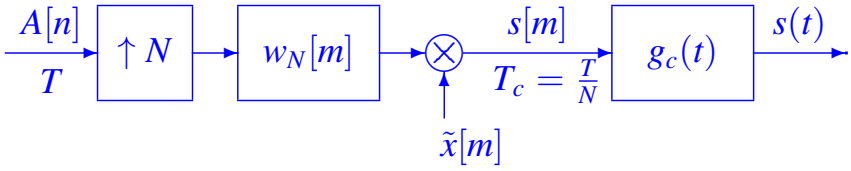
Expresiones para los pulsos retardados (Ejemplo $N = 4$)



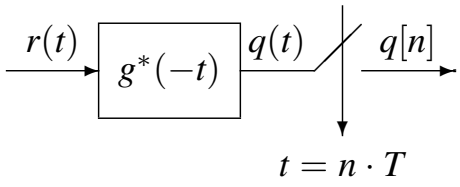
Modulación DSSS - Diagramas de bloques Tx y Rx

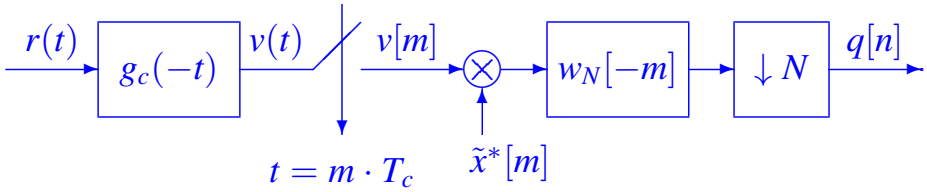
- Diagrama de bloques del transmisor



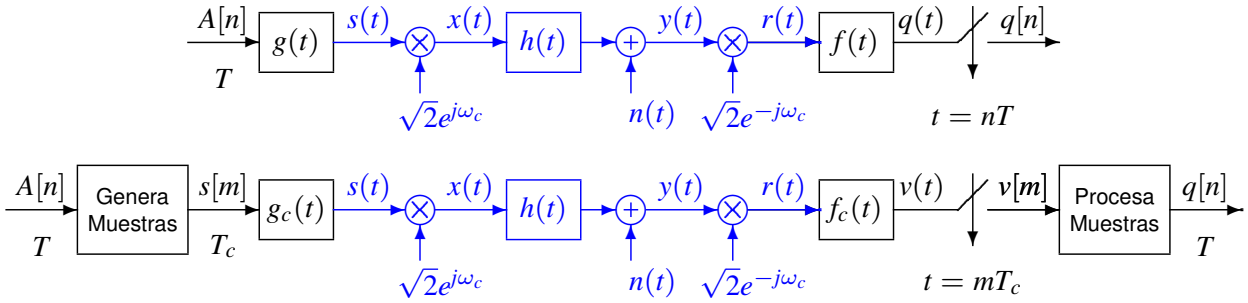


- Diagrama de bloques del receptor





Canales discretos equivalentes



- Filtros receptores - filtros adaptados: $f(t) = g^*(-t), \;\; f_c(t) = g_c(-t)$
- Respuestas conjuntas transmisor/receptor/canal
  - Transmisión de $A[n]$ a tiempo de símbolo: $p(t) = g(t) * h_{eq}(t) * f(t) = r_g(t) * h_{eq}(t)$
  - Transmisión de $s[m]$ a tiempo de chip: $d(t) = g_c(t) * h_{eq}(t) * f_c(t) = r_{g_c}(t) * h_{eq}(t)$
- Canales discretos equivalentes
  - A tiempo de símbolo

$$p[n] = p(t)\big|_{t=nT} = p(nT) \text{ relaciona } q[n] \text{ con } A[n]\text{: } q[n] = A[n] * p[n] + z[n]$$

  - A tiempo de chip

$$d[m] = d(t)\big|_{t=mT_c} = d(mT_c) \text{ relaciona } v[m] \text{ con } s[m]\text{: } v[m] = s[m] * d[m] + z_c[m]$$

Canal discreto equivalente - Ejemplo

- Canal discreto equivalente a tiempo de símbolo

$$p[n] = \sum_{m=0}^{N-1} \sum_{\ell=0}^{N-1} x[m] \cdot x^*[\ell] \cdot d[nN + \ell - m]$$

- Factor de ensanchado $N = 10$
  - Secuencia de ensanchado

$$x[0], x[1], x[2], x[3], x[4], x[5], x[6], x[7], x[8], x[9]$$

- Canal discreto equivalente a tiempo de chip

$$d[m] = a \cdot \delta[m] + b \cdot \delta[m-2] + c \cdot \delta[m-14]$$

  - Valores no nulos de $d[nN + \ell - m]$
    - $nN + \ell - m = 0$
    - $nN + \ell - m = 2$
    - $nN + \ell - m = 14$

Canal discreto equivalente - Ejemplo (II)

- Caso $nN + \ell - m = 0 \Rightarrow d[nN + \ell - m] = a$
  - $n = 0 \rightarrow \ell - m = 0 \rightarrow \ell = m$

$$\sum_{m=0}^{N-1} x[m] \cdot x^*[m] = \sum_{m=0}^{9} |x[m]|^2 = a_1$$

- Caso $nN + \ell - m = 2 \Rightarrow d[nN + \ell - m] = b$
  - $n = 0 \rightarrow \ell - m = 2 \rightarrow \ell = m + 2$

$$\sum_{m=0}^{N-1} x[m] \cdot x^*[m+2] = \sum_{m=0}^{7} x[m] \cdot x^*[m+2] = b_1$$

  - $n = 1 \rightarrow N + \ell - m = 2 \rightarrow \ell = m - 8$

$$\sum_{m=0}^{N-1} x[m] \cdot x^*[m-8] = \sum_{m=8}^{9} x[m] \cdot x^*[m-8] = b_2$$

Canal discreto equivalente - Ejemplo (III)

- Caso $nN + \ell - m = 14 \Rightarrow d[nN + \ell - m] = c$
  - $n = 1 \rightarrow N + \ell - m = 14 \rightarrow \ell = m + 4$

$$\sum_{m=0}^{N-1} x[m] \cdot x^*[m+4] = \sum_{m=0}^{5} x[m] \cdot x^*[m+4] = c_1$$

  - $n = 2 \rightarrow 2N + \ell - m = 14 \rightarrow \ell = m - 6$

$$\sum_{m=0}^{N-1} x[m] \cdot x^*[m-6] = \sum_{m=6}^{9} x[m] \cdot x^*[m-6] = c_2$$

- Canal discreto equivalente

$$\begin{aligned} p[n] = &(a \times a_1 + b \times b_1) \cdot \delta[n] \\ &+ (b \times b_2 + c \times c_1) \cdot \delta[n-1] \\ &+ (c \times c_2) \cdot \delta[n-2] \end{aligned}$$

Canal discreto equivalente - Ejemplo (IV)

- Secuencia de ensanchado

m	0	1	2	3	4	5	6	7	8	9
$x[m]$	$+1$	-1	$+1$	-1	-1	-1	$+1$	$+1$	-1	-1

- Valores relacionados con $p[n]$, para $a = 1$, $b = -\frac{1}{4}$, $c = \frac{1}{2}$

$$a_1 = 10,\ b_1 = -2,\ b_2 = 0,\ c_1 = +2,\ c_2 = 0$$

$$p[n] = \frac{21}{2}\delta[n] - \frac{1}{2}\delta[n-1]$$

  - Términos relacionados con la ISI

$$\sum_{m=0}^{N-1} x[m] \cdot x^*[m-k_a], \quad \sum_{m=0}^{N-1} x[m] \cdot x^*[m+k_b]$$