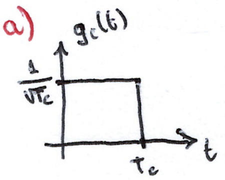
5.10.

DS-SS w/ $N=10$; 2-PAM , $A[n] \in \{\pm 1\}$; AWGN $S_N = \frac{N_0}{2}$

$d[m] = \delta[m] - 0.5\,\delta[m-4]$

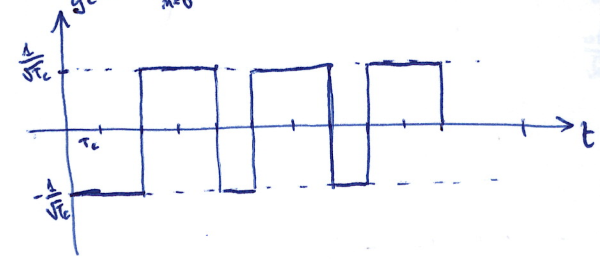
$x[m] = \{\underset{[0]}{-1}, -1, +1, +1, -1, \underset{[5]}{+1}, +1, -1, +1, \underset{[9]}{+1}\}$

a)



$\rightarrow$

$g_c(t) = \sum_{m=0}^{N-1} x[m]\, g_c(t - mT_c)$



b) get $p[n]$, $\exists$? ISI, & P_e w/ SBSD

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

$$(x*d)[m] = \{\underset{[0]}{-1}, -1, +1, +1, -0.5, \underset{[5]}{+1.5}, +0.5, -1.5, +1.5, +0.5, \underset{[10]}{-0.5}, +0.5, -0.5, \underset{[13]}{-0.5}\}$$

$p[0] = 1+1+1+1+0.5+1.5+0.5+1.5+1.5+0.5 = 10$

$p[1] = +0.5 -0.5 -0.5 -0.5 = -1$

~~$p[2]=0$, $p[3]=0$ ... $p[n]=0\ \forall n \geq 2$~~

$p[n] \neq 0 \iff \exists\, l \in [0, N-1] : x[l] \neq 0$ and $(x*d)[nN+l] \neq 0$

- $x[l] \neq 0\ \forall\, l \in [0, N-1]$
- $(x*d)[nN+l] \neq 0 \iff 0 \leq nN+l \leq 13 \iff l \leq 13-nN$ and $l \geq -nN \iff$ $0 \leq l \leq N-1$

proof of

$$\iff \begin{cases} 0 \leq 13-nN \\ \text{and} \\ N-1 \geq -nN \end{cases} \iff \begin{cases} n \leq \frac{13}{N} = 1.3 \\ \text{and} \\ n \geq \frac{1-N}{N} = \frac{-9}{10} = -0.9 \end{cases}$$

$p[n] \neq 0$, $n \in [0,1]$

$p[n] = 0\ \forall\, n \notin [0,1]$

$\boxed{p[n] = 10\,\delta[n] - \delta[n-1]}$

(not proportional)

$\boxed{\text{There is ISI because } p[n] \not\propto \delta[n]}$

...b)

We can find ~~this~~ P_e by using the following formula (taken from a different chapter, but equally applicable)

$$P_e \approx Q\left(\frac{|p[0]|\, d_{min}^{A[n]}}{2\sigma_{err}}\right) = Q\left(\frac{10 \cdot 2}{2\sqrt{\sigma_{ISI}^2 + \sigma_Z^2}}\right) = Q\left(\frac{10}{\sqrt{\frac{N_0}{2}+1}}\right)$$

$$\left.\begin{aligned}\sigma_{ISI}^2 &= \sum_{n\neq 0} |p[n]|^2 E_s = 1 \\ \sigma_Z^2 &= \frac{N_0}{2}\end{aligned}\right\}$$