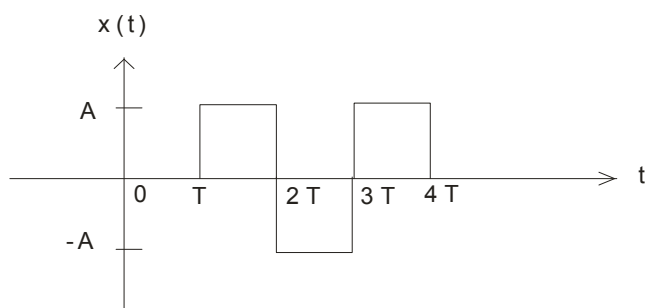


Signali in informacije - izpit 24. januar 2011

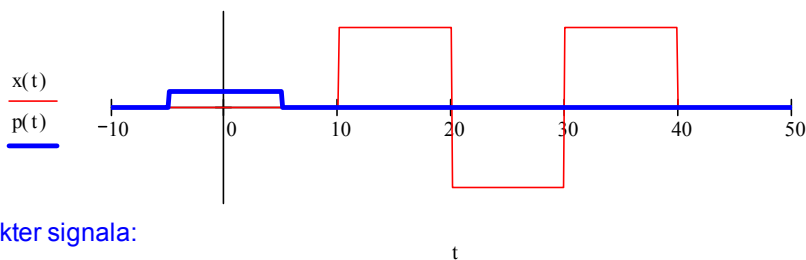
1. Izračunajte spekter signala na sliki, podatki $A=10$, $T=5$.
Koliko je energija signala?

$A := 5$

$T := 10$



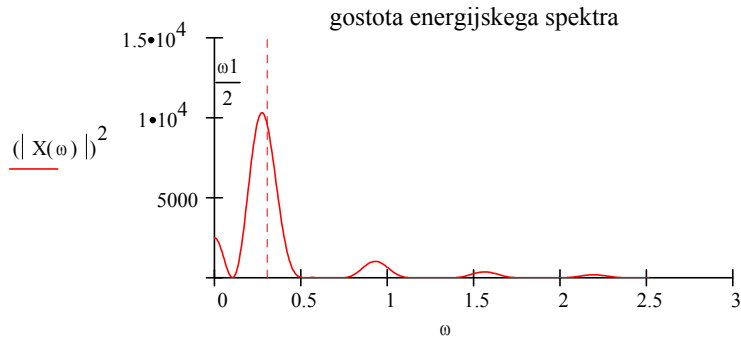
$$p(t) := |t| < \frac{T}{2} \quad x(t) := A \cdot p\left(t - 3 \cdot \frac{T}{2}\right) - A \cdot p\left(t - 5 \cdot \frac{T}{2}\right) + A \cdot p\left(t - 7 \cdot \frac{T}{2}\right) \quad t := -T, -0.99 \cdot T, \dots, 5 \cdot T$$



spekter signala:

$$S_x(x) := \text{if}\left(x \neq 0, \frac{\sin(x)}{x}, 1\right) \quad P(\omega) := T \cdot S_x\left(\omega \cdot \frac{T}{2}\right) \quad \omega_1 := \frac{2 \cdot \pi}{T} \quad \omega := 0, \frac{\omega_1}{100}, \dots, 4 \cdot \omega_1$$

$$X(\omega) := A \cdot P(\omega) \cdot \begin{pmatrix} e^{-j \cdot \omega \cdot \frac{3}{2} \cdot T} & -e^{-j \cdot \omega \cdot \frac{5}{2} \cdot T} & -e^{-j \cdot \omega \cdot \frac{7}{2} \cdot T} \\ & & + e^{-j \cdot \omega \cdot \frac{7}{2} \cdot T} \end{pmatrix}$$



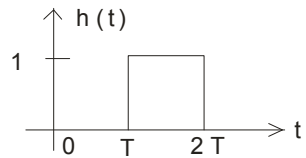
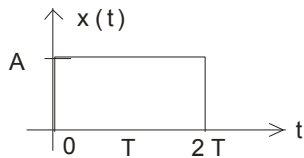
Energija signala:

$$\frac{1}{\pi} \int_0^{3 \cdot \omega_1} |X(\omega)|^2 d\omega = 708.109 \quad E := A^2 \cdot 3 \cdot T \quad E = 750$$

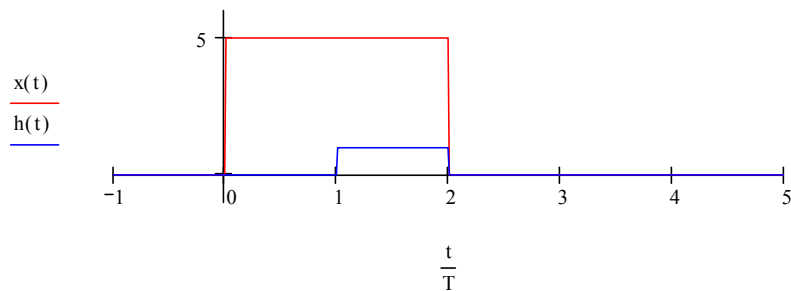
2. Signal ima omejen spekter, $f_{zg}=10000$. Izračunajte minimalno vzorčevalno frekvenco !

$$f_{zg} := 10000 \quad \text{Odgovor : } f_{vz} > 2 f_{zg} \quad f_{vz} := 2 \cdot f_{zg} \quad f_{vz} = 2 \cdot 10^4$$

3. Podana sta signal na vhodu sira $x(t)$ in sistemska funkcija $h(t)$. Podatki: $A=4$, $T=5$. Izračunajte in skicirajte signal na izhodu sira $y(t)$!



$$x(t) := A \cdot (t \geq 0) \cdot (t < 2 \cdot T) \quad h(t) := 1 \cdot (t \geq T) \cdot (t < 2 \cdot T) \quad t := -T, -0.99 \cdot T, \dots, 5 \cdot T$$



Signal na izhodu sira računamo s konvolucijo : $y(t)=x(t)*h(t)$ ali $y(t)=h(t)*x(t)$:

$$y_a(t) := \int_0^{2 \cdot T} x(t_1) \cdot h(t - t_1) dt_1$$

$$y_b(t) := \int_T^{2 \cdot T} h(t_1) \cdot x(t - t_1) dt_1$$

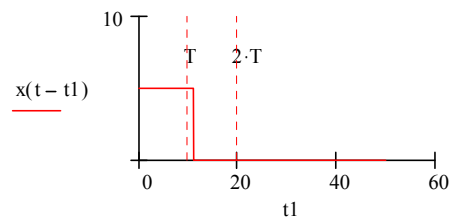
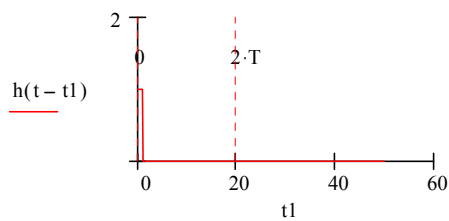
ali

$$y_a(t) := A \cdot \int_0^{2 \cdot T} h(t - t_1) dt_1$$

$$y_b(t) := 1 \cdot \int_T^{2 \cdot T} x(t - t_1) dt_1$$

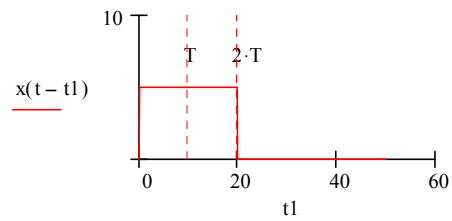
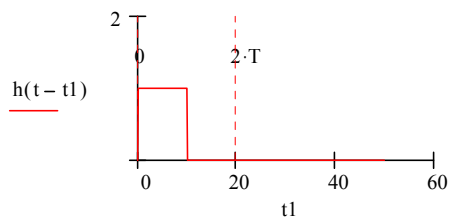
$$t_1 := 0, \frac{T}{100} \dots 5 \cdot T \quad t := T \cdot 1.1$$

$$t_1 := 0, \frac{T}{100} \dots 5 \cdot T \quad t := 1.1 \cdot T$$



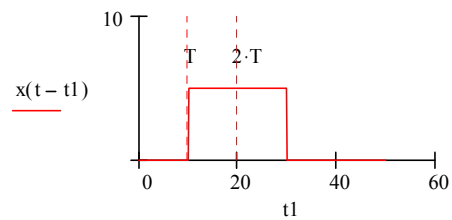
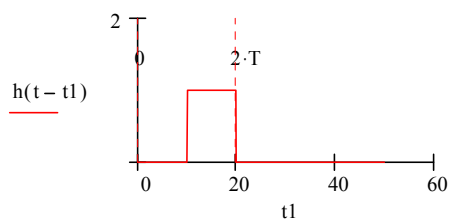
$$t_1 := 0, \frac{T}{100} \dots 5 \cdot T \quad t := 2 \cdot T$$

$$t_1 := 0, \frac{T}{100} \dots 5 \cdot T \quad t := 2 \cdot T$$

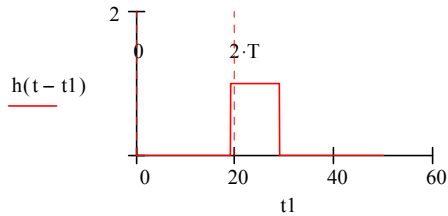


$$t_1 := 0, \frac{T}{100} \dots 5 \cdot T \quad t := 3 \cdot T$$

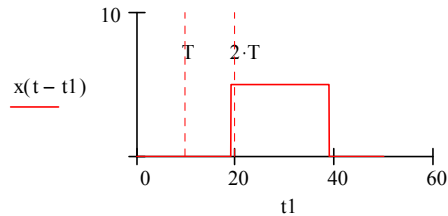
$$t_1 := 0, \frac{T}{100} \dots 5 \cdot T \quad t := 3 \cdot T$$



$$t_1 := 0, \frac{T}{100} .. 5 \cdot T \quad t := 3.9 \cdot T$$



$$t_1 := 0, \frac{T}{100} .. 5 \cdot T \quad t := 3.9 \cdot T$$



Potek $y(t)$ ima pet segmentov:

$$t < T \quad y(t) = 0$$

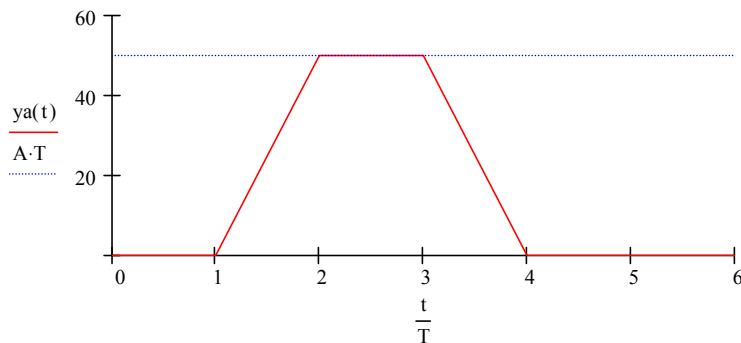
$$2T > t > T \quad y(t) \text{ rampa } k \cdot t$$

$$3T > t > 2T \quad y(t) = A \cdot T$$

$$4T > t > 3T \quad \text{padajoč potek}$$

$$y_a(1) = 0 \quad y_a(T \cdot 1.5) = 25.007 \quad y_a(2 \cdot T) = 50 \quad A \cdot T = 50$$

$$t := 0, \frac{T}{2} .. 6 \cdot T$$



4. Informacijski izvor naključno generira naključna zaporedja osmih različnih znakov. Podane so verjetnosti nastopanja znakov.

a) Izračunajte entropijo izvora!

b) Generirajte Huffmanovo kodo in izračunajte povprečno dolžino kode!

$$p := (0.1 \ 0.2 \ 0.05 \ 0.05 \ 0.02 \ 0.15 \ 0.12 \ 0.13)$$

$$M := 8 \quad m := 0 .. M - 1$$

$$ps := p^T$$

$$\sum_{m=0}^{M-1} ps_m = 1 \quad \log_2(x) := \frac{\log(x)}{\log(2)}$$

Entropija izvora:

$$H := \sum_{m=0}^{M-1} ps_m \cdot \log_2 \left(\frac{1}{ps_m} \right)$$

$$H = 2.853$$

Generirane kode:

$$\text{Huff} := \begin{bmatrix} 1111 \\ 01 \\ 11101 \\ 11100 \\ 00 \\ 110 \\ 100 \\ 101 \end{bmatrix}$$

Dolžine Huffmanovih kod :

$$\text{LH} := \begin{bmatrix} 4 \\ 2 \\ 5 \\ 5 \\ 2 \\ 3 \\ 3 \\ 3 \end{bmatrix} \quad \text{ps} = \begin{bmatrix} 0.1 \\ 0.2 \\ 0.05 \\ 0.05 \\ 0.2 \\ 0.15 \\ 0.12 \\ 0.13 \end{bmatrix}$$

povprečna dolžina Huffmanove kode

$$L_p := \sum_m L_{H_m} \cdot p_{s_m} \quad L_p = 2.9$$

5. Na frekvenčno omejenem kanalu je podan potek razmerja gostot močnostnega spektra signala in šuma. Kanal je razdeljen na šest enako širokih frekvenčnih pasov, $B_i=100\text{kHz}$. Izračunajte kapaciteto kanala !

$$B_0 := 100000 \quad P_{s_Pn} := \begin{bmatrix} 3 \\ 7 \\ 15 \\ 15 \\ 31 \\ 63 \end{bmatrix} \quad i := 0.. 5$$

$$r_i := B_0 \cdot \log_2(1 + P_{s_Pn_i}) \quad r = \begin{bmatrix} 2 \cdot 10^5 \\ 3 \cdot 10^5 \\ 4 \cdot 10^5 \\ 4 \cdot 10^5 \\ 5 \cdot 10^5 \\ 6 \cdot 10^5 \end{bmatrix}$$

$$r_{\max} := \sum_i r_i \quad r_{\max} = 2.4 \cdot 10^6$$

Odg : Po kanalu lahko prenašamo največ 2.4Mbit/s.