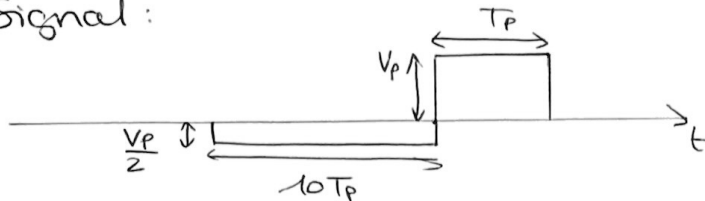


14.4.2024

1

Signal:



$$T_P = 200 \text{ ns}$$

Preamplifier

$$\sqrt{S_V} = 5 \text{ nV}/\sqrt{\text{Hz}}$$

$$\frac{1}{f^2}, f_c = 10 \text{ MHz}$$

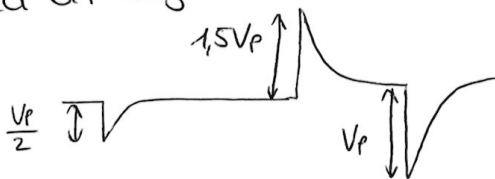
$$f_{FA} = 500 \text{ MHz}$$

a) optimum filter: whitening filter + matched filter

• whitening filter: CR HPF $f_W = f_c$

$$T_W = \frac{1}{2\pi \cdot 10^7 \text{ Hz}} = 0,16 \cdot 10^{-7} = 16 \text{ ns} \ll T_P$$

effect on signal of HPF:

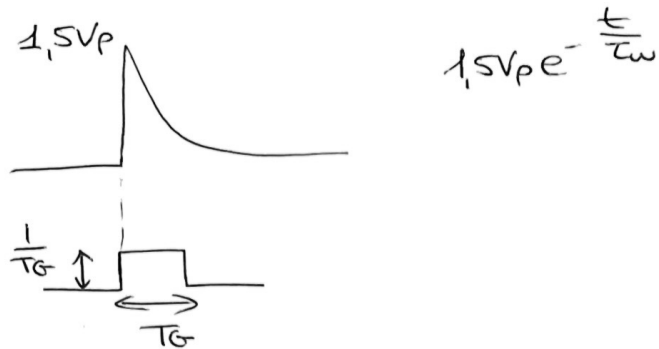


• Matched filter: same shape of signal

$$b(t) = \begin{cases} -\frac{1}{2} e^{-\frac{t}{T_W}} & 0 \leq t < 10T_P \\ 1,5 e^{-\frac{t-10T_P}{T_W}} & 10T_P \leq t < 11T_P \\ -1 e^{-\frac{t-11T_P}{T_W}} & t \geq 11T_P \end{cases}$$

$$\left(\frac{S}{N}\right)_{\text{OPT}} = \frac{V_P}{\sqrt{\frac{S_V}{2}}} \cdot \sqrt{k_{bb}(\omega)}$$

Practical filter: CR-HPF + $16I$.
 • GI applied after the whitening filter on the highest peak



$$S = 1.5V_p \cdot \frac{1}{T_G} T_w (1 - e^{-\frac{T_G}{T_w}})$$

$$N = \sqrt{S_v \cdot \frac{1}{2T_G}}$$

$$\frac{S}{N} = \frac{1.5V_p \frac{T_w}{T_G} (1 - e^{-\frac{T_G}{T_w}})}{\sqrt{S_v \cdot \frac{1}{2T_G}}}$$

$$T_G = 1.25 T_w$$

$$\frac{S}{N} = \frac{1.5V_p \cdot 0.8 \cdot 0.71}{\sqrt{S_v \frac{1}{2.5 T_w}}}$$

$$V_{pmin} = \sqrt{S_v} \sqrt{\frac{1}{40ns}} \frac{1}{1.5 \cdot 0.8 \cdot 0.71} = 5nV \frac{1}{2} \cdot 10^4 \cdot 1.17$$

$$\approx 29.2 \mu V$$

b) keeping the whitening filter makes $\frac{B}{f^3}$ component to become $\propto \frac{1}{f} \rightarrow$ ideally infinite noise with CR-HPF + 6I
 However we can expect a zero setting when system is reset

$$\Delta T_{\text{meas, max}} = 12 \text{ hours} = 43200 \text{ s}$$

$$f_{\text{ieq}} \approx \frac{1}{2\pi \Delta T_{\text{meas, max}}} \approx 3.7 \mu\text{Hz}$$

same white noise of point a)

$$G_w = \sqrt{S_v \cdot \frac{1}{2.5 T_w}} = \frac{5 \text{ nV}}{\sqrt{\text{Hz}}} \sqrt{\frac{1}{40 \text{ ns}}} = 25 \mu\text{V}$$

$$G_{\frac{1}{f}} \approx \sqrt{S_v f_c \ln\left(\frac{1}{\frac{40 \text{ ns}}{3.7 \mu\text{Hz}}}\right)} = 5 \text{ nV} \cdot 10^3 \cdot \sqrt{10 \ln\left(\frac{10^{15}}{148}\right)} \approx 86 \mu\text{V}$$

$$G_{\text{TOT}} \approx 90 \mu\text{V}$$

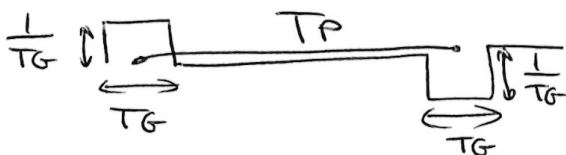
same signal of point a)

$$S = 0.852 V_p$$

$$V_{\text{PMIN}} = \frac{90 \mu\text{V}}{0.852} \approx 106 \mu\text{V}$$

dominated by $\frac{1}{f}$ noise

- CDF on two highest signal peaks
 two identical integration windows for the sake of simplicity



$$\frac{1}{2\pi T_P} = 0.8 \text{ mHz}$$

$$\frac{1}{2T_G} = 25 \text{ mHz}$$

$$S = 1,5V_p \cdot \frac{\tau_w}{\tau_g} (1 - e^{-\frac{\tau_g}{\tau_w}}) + V_p \frac{\tau_w}{\tau_g} (1 - e^{-\frac{\tau_g}{\tau_w}}) =$$

$$= 2,5V_p \cdot 0,8 \cdot 0,71 = 1,42V_p$$

$$G_w \approx \sqrt{2} \quad G_{w_{GI}} \approx 35 \mu V$$

(fast computation)
 $\frac{1}{2\tau_g} \gg \frac{1}{2\pi f_i}$

$$G_{1/2} = \sqrt{2Sf_c \ln\left(\frac{25}{0,8}\right)} = 41 \mu V$$

$$G_{TOT} = 53,9 \mu V$$

$$V_{PMIN} = \frac{53,9 \mu V}{1,42} \approx 38 \mu V$$

c) see theory