Best optical filtering for duobinary transmission In ASE noise limited optical systems

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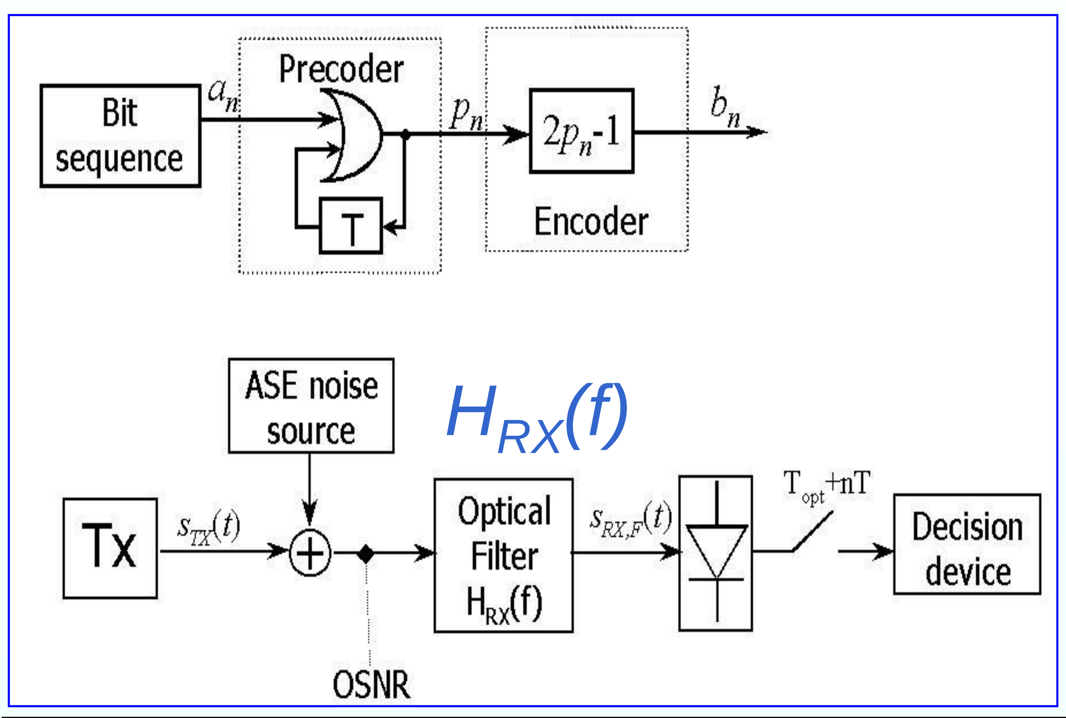
Abstract

In standard IMDD systems the optimum receiver is based on the optical filter matched to the pulse shape. We demonstrate that for duobinary transmission systems this is not valid in general.

Back-to-back performance in direct-detection

DUOBINARY SYSTEM SET-UP



$$s_{TX}(t)=\sqrt{\overline{P}_S}\left[\sum_n b_n u(t-nT)\right]e^{j2\pi f_0 t}\hat{v}_\parallel$$

$$s_{RX,F}(t_{opt})=\left\{\sqrt{\overline{P}_S}\,c_n x(0)+n_{\parallel F}(t)\right\}\hat{v}_\parallel+n_{\perp F}(t)\hat{v}_\perp$$

where $x(t)=u(t)*h_{RX}(t)$

$$BER=\frac{1}{2}\left\{e^{-\phi}(1+\phi)+1-Q_2\left(\sqrt{\frac{4\overline{P}_S x^2(0)}{\sigma^2}},\sqrt{2\phi}\right)\right\}$$

ϕ is a threshold to be optimized for each OSNR

Best optical filtering

Being $$\frac{4\overline{P}_S x^2(0)}{\sigma^2}=16\,\mathrm{OSNR}\,\frac{x^2(0)/T}{\int |H_{RX}(f)|^2 df}$$

we must optimize (maximize)

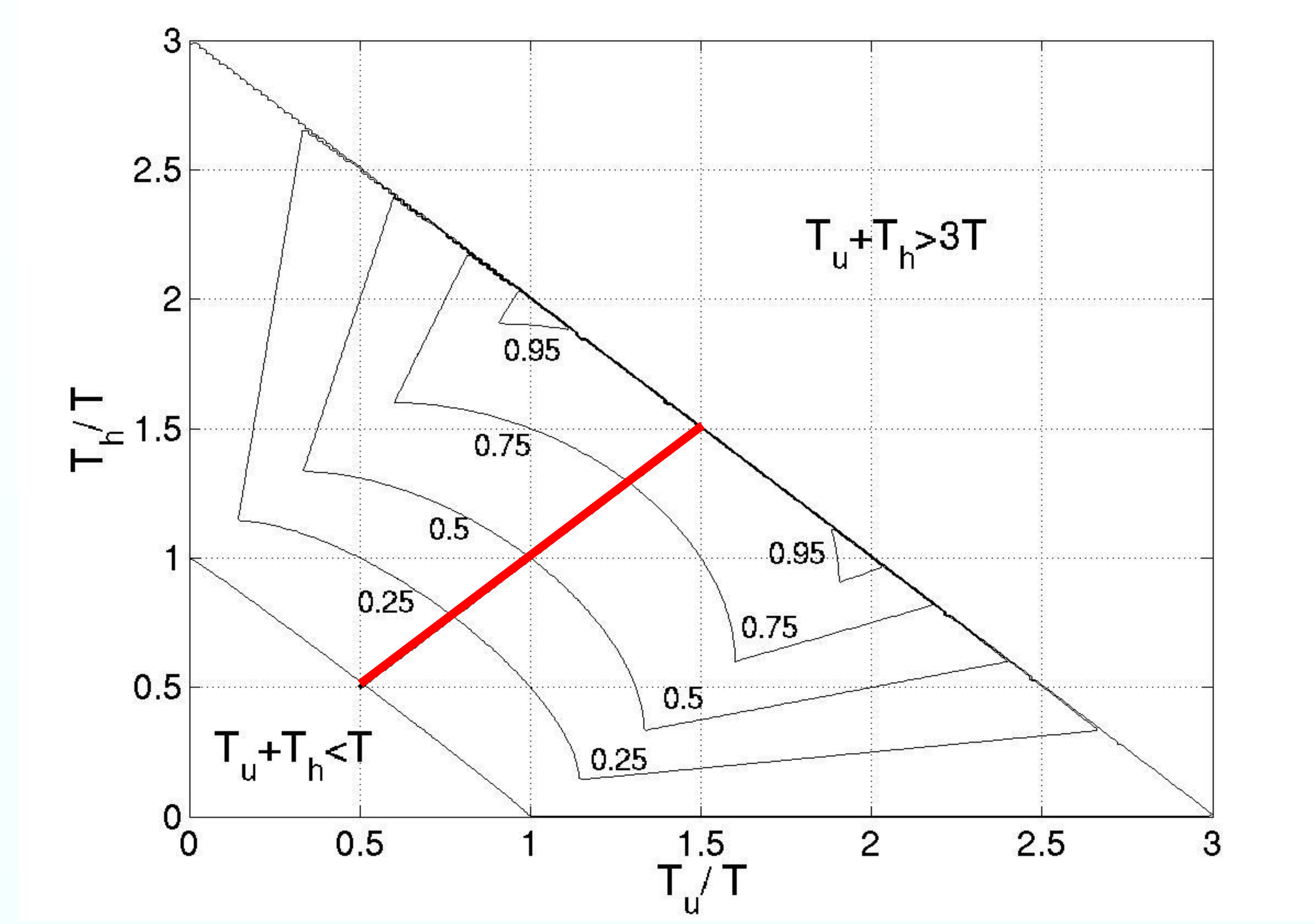
$$K=\frac{2\,x^2(0)/T}{\int |H_{RX}(f)|^2 df}=\frac{\frac{2}{T}\int u(t)h_{RX}(T/2-t)dt}{\int |h_{RX}(t)|^2 dt}$$

The optimum receiver for duobinary is based on pulse-filter pair that maximizes the parameter K.

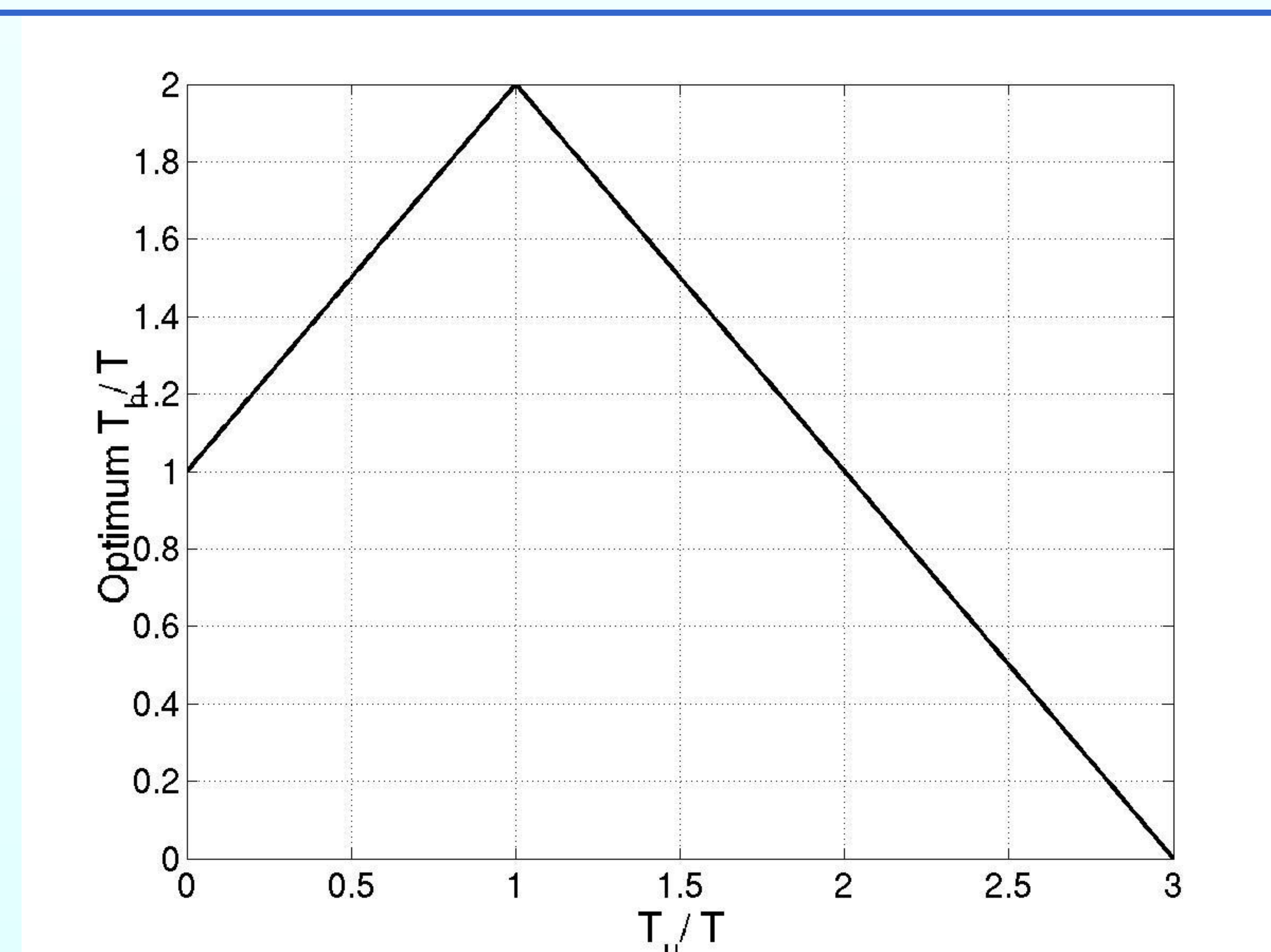
We assume that both the transmitted pulse and the receiver optical filter impulse response have a rectangular shape with duration respectively T_u and T_h.

We can evaluate K for each couple (T_u,T_h) finding the optimum filter for each pulse, showing that the best filter is not in general the matched filter (T_u=T_h).

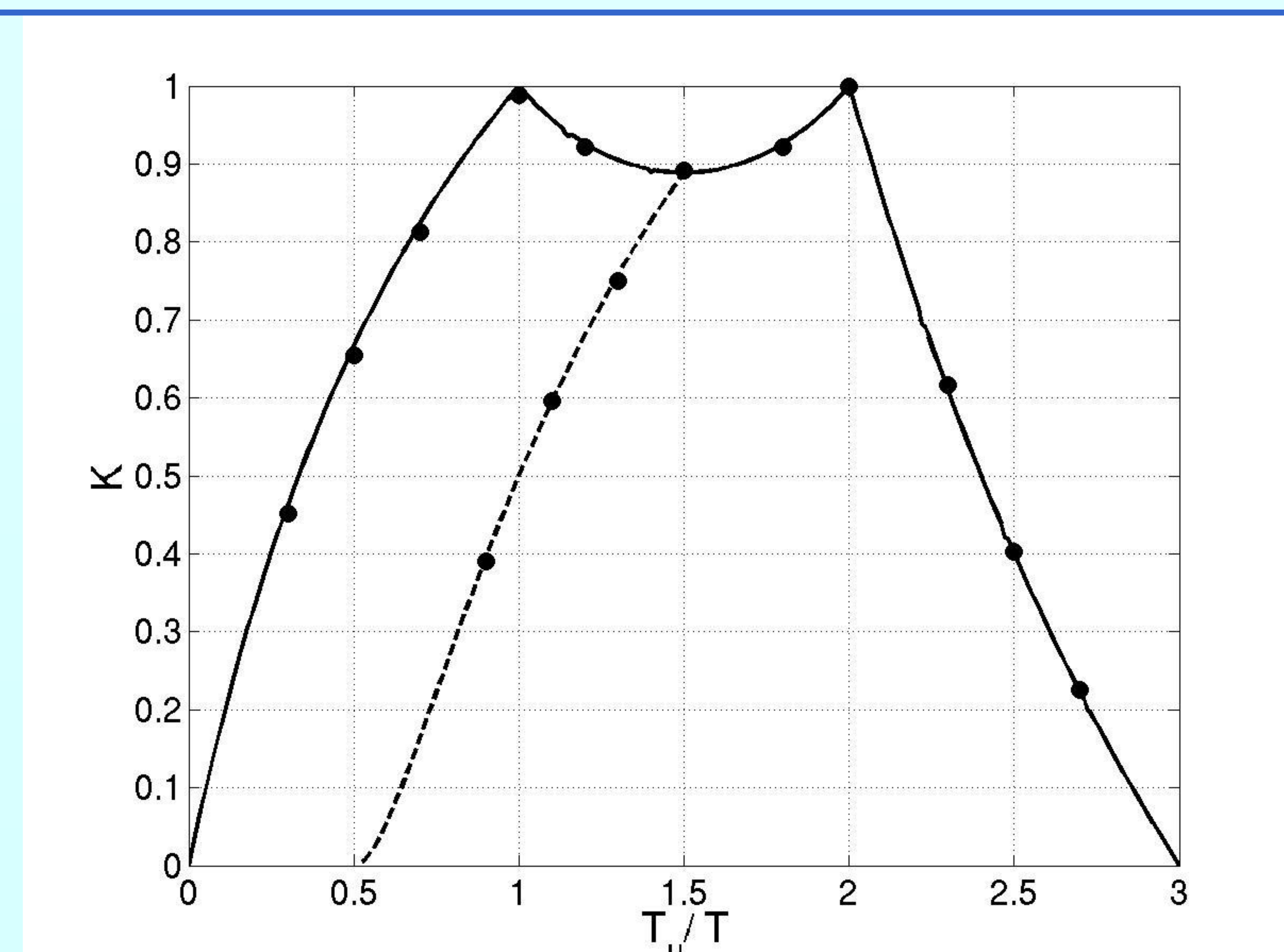
Results



Contour plot of the parameter K as a function of both the normalized duration of the transmitted pulse and of the receiver optical filter impulse response (T_u/T). The thick solid red line corresponds to the case of optical filter matched to the transmitted pulse



Plot of the normalized impulse response duration (T_h/T) of the optimum receiver optical filter as a function of the normalized duration of the transmitted pulse (T_u/T).



Plot of the optimum value of the parameter K as a function of T_u/T (solid line). Dashed line refers to the matched filter (sub-optimal) scenario. Black dots are obtained through numerical simulations based on error counting: a perfect agreement between theory and simulation can be observed.