Università di Pavia
Corso: Costruzioni Optoelettroniche
Docente: Guido Giuliani
Lezioni del 29-30/11/2004
Argomento: Progetto - Telemetro Sinusoidale

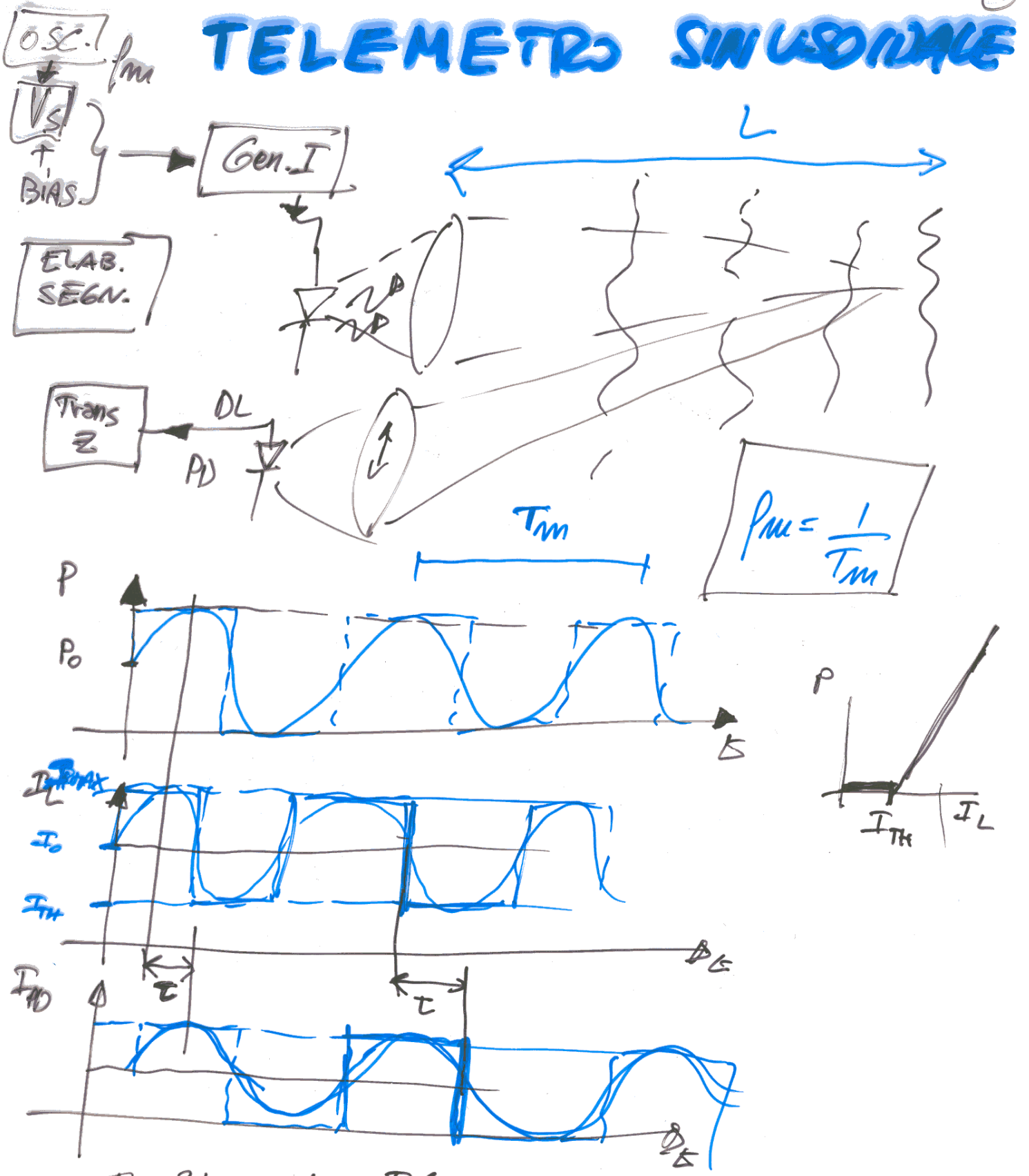
T. Sinus.

- Progetto ottico
  - Sperim. accopp. verso PD
- Scelta fm ↔ componenti elettronici
- Alim. Laser – Gen corrente modulabile (100MHz)
- oscillatore (Onda Quadra → Noi)
- Verifica legge $\tau = \frac{2L}{c}$ (oscilloscopio)
- Amp. Trans-Z

↑ Dimostraz. Principio ↑
↓ Sviluppo strumentale ↓

- Tecniche di misura τ (conversione $\tau \rightarrow V_{OUT}$)
- Rumore (accuratezza)
- ? Sfasamenti indesiderati ? (compensarli)
- x Mod. sinus: PLL (= Filtro a banda stretta...)

TELEMETRO SINUSOIDALE



$\tau = \frac{2L}{c} \Rightarrow L = \frac{\tau c}{2}$

$0 < \tau < T_m$

$f_m \leq \frac{c}{2L_{MAX}}$

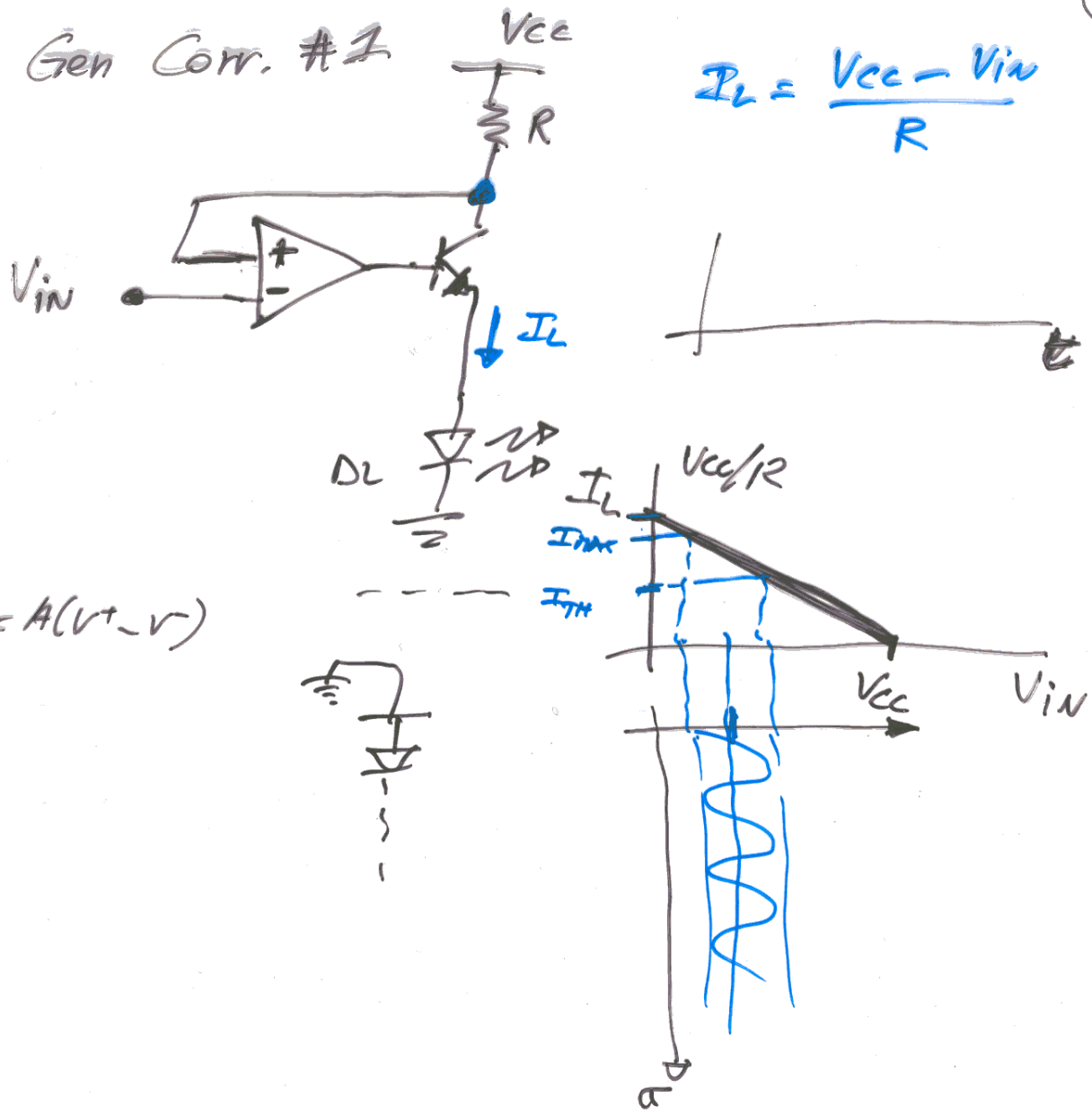
per $L_{MAX} = 15\,m$ → $f_m \leq 10\,MHz$

? $V_{OUT} \propto L$

$$V_{OUT} = K \cdot L$$

$[V] \quad \left[\frac{V}{m}\right] \quad [m]$

☐ Gen Corr. #1

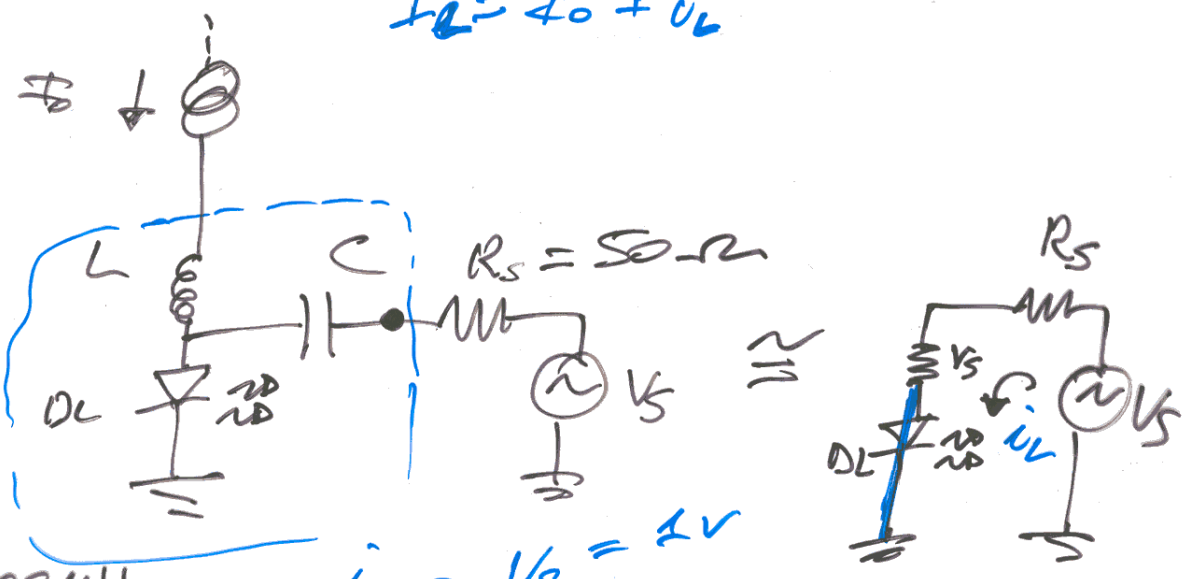


$I_L = \frac{V_{cc} - V_{in}}{R}$

$V_o = A(V^+ - V^-)$

☐ Gen Corr #2

$I_L = I_o + i_L$



$L = 1, 10, 100, 1000\ \mu H$

$i_L = \frac{V_S}{R_S + V_S \to 0\Omega} = \frac{1V}{\quad}$

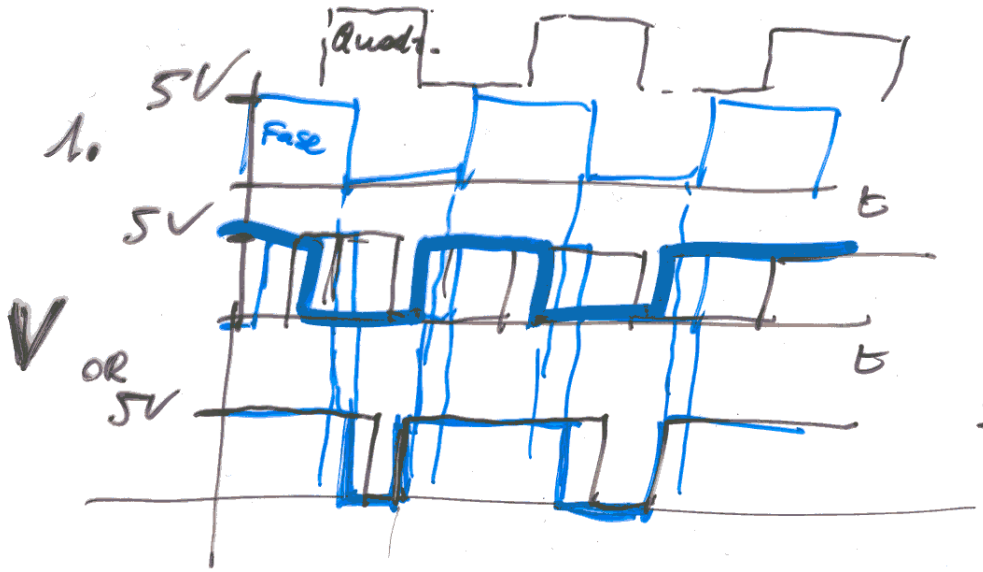
$i_L \simeq 15\ mA$

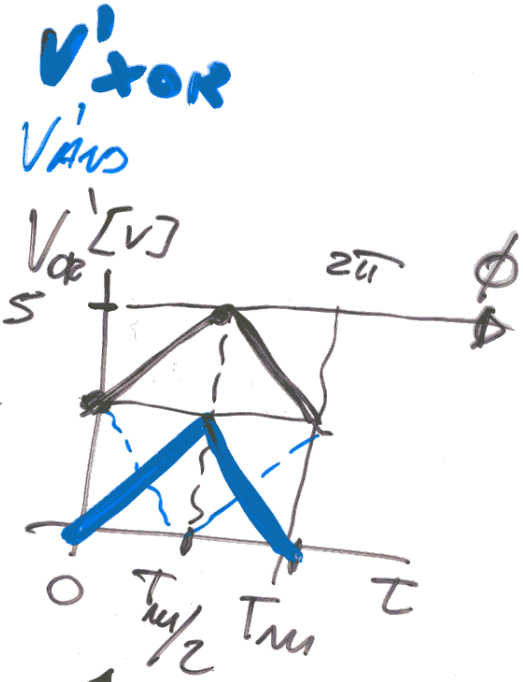
Circ. misura τ

1. OR/AND/XOR tra onde quadre
2. sottraz. finale

$$V_{OUT} = K \cdot L$$

$$V_{OUT} = K' \cdot \tau$$





V_{OR} → [L.P.] → V_{OR}'

→ $f_c \ll f_m$

1.1 OK ERO XOR ($L_{MAX}/2$)

mi limita a $L_{MAX}/2$

1.2 ~~Stop~~ 2 segnali di riferim. (fase e Quadr.)

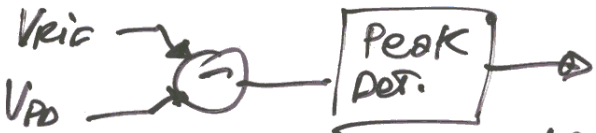
2.1 sottraz. sinus. (stessa ampl.)

$V_{RIF} = V_0 \sin(\omega_m t)$; $V_{PD} = V_1 \sin(\omega_m t - \phi)$

$\phi = \frac{\tau}{T_m} \cdot 2\pi$

$V_{TOT} = V_{RIF} - V_{PD} = V_0 \left[2 \cos\left(\omega_m t - \frac{\phi}{2}\right) \cdot \sin\frac{\phi}{2}\right]$

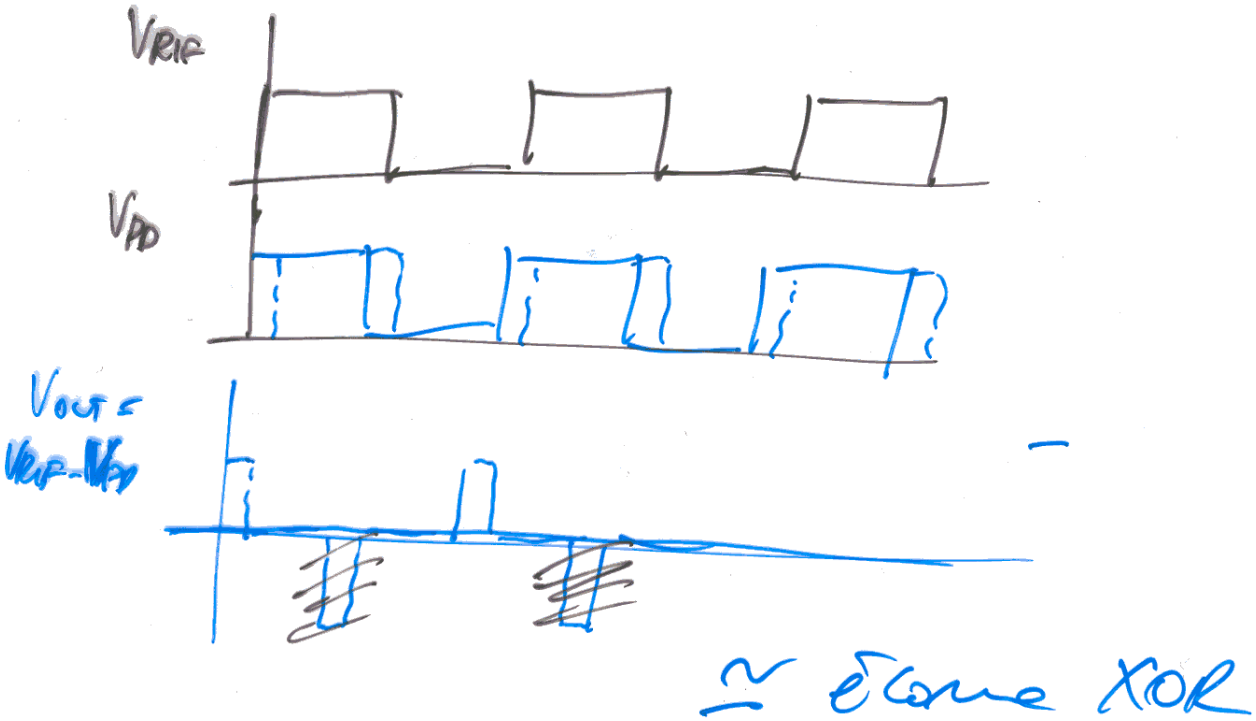
($V_0 = V_1$)



$V_{OUT} \propto \sin\frac{\phi}{2} \propto \sin\frac{\tau \cdot \pi}{T_m}$

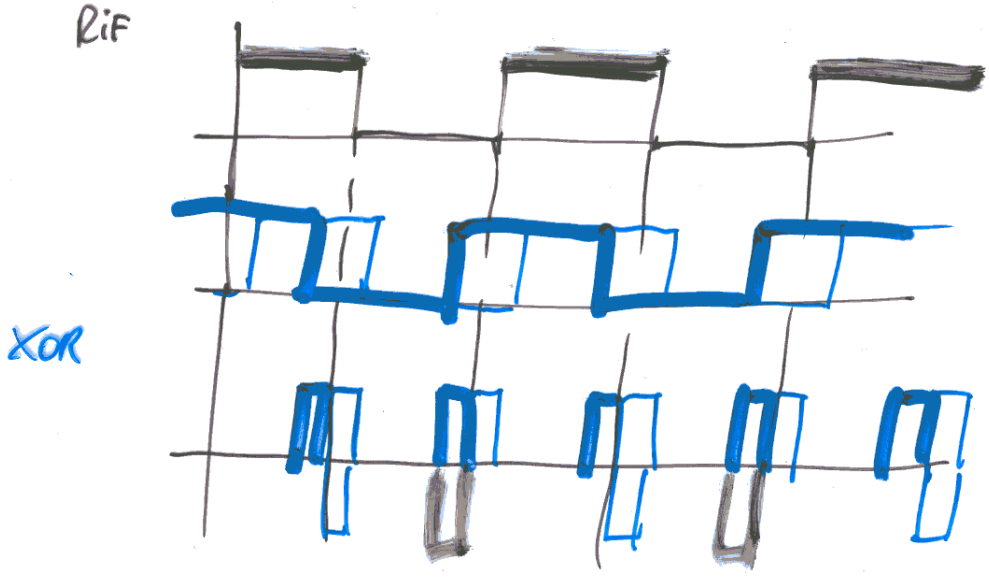
NON LINEARE

2.2 Sottraz. Tra segn. Onda quadra



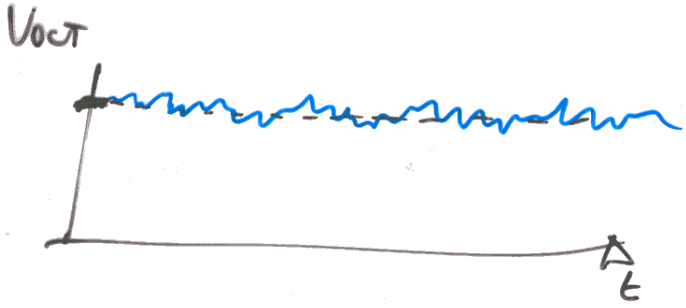
≃ come XOR

1. XOR



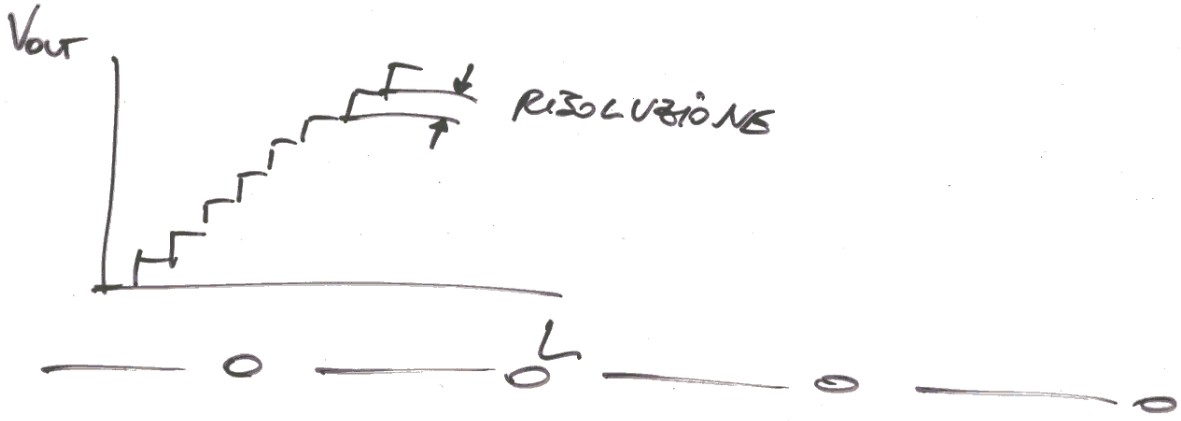
Il RUMORE

$V_{OUT} = K \cdot L$ $\quad V_{OUT} = \overline{V_{OUT}} + \Delta V_{OUT}(t)$



& uscita puramente Analogica

Nel caso di ~~misura~~ di lettura digitale + conv. D/A, se rumore $\leq$ LSB



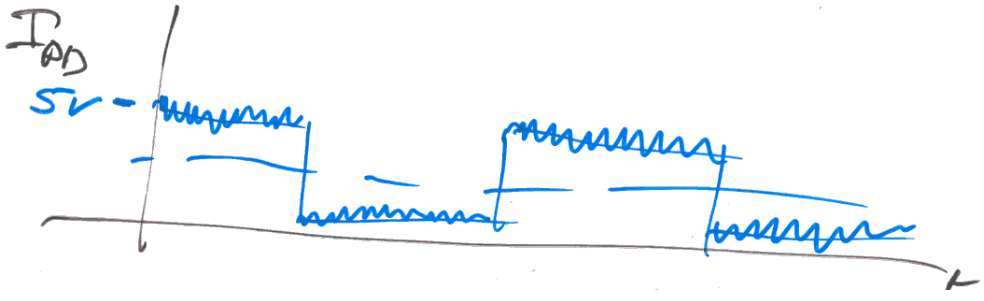
1. Speckle
2. Rumore di Fotorivelaz.

Regime Quantico $\quad S = I_S \quad N = 2qI_S'B$

$$\frac{S}{N} = \frac{I_S^2}{2qI_S'B} = \frac{\overline{I_S}}{2qB}$$

$$I_S' = \sigma (P_{SCAT,TARG} + P_{FONDO})$$

$P_{SCAT,TARG}$ ↓ AC, P_{FONDO} ↓ DC → Fluttuaz.

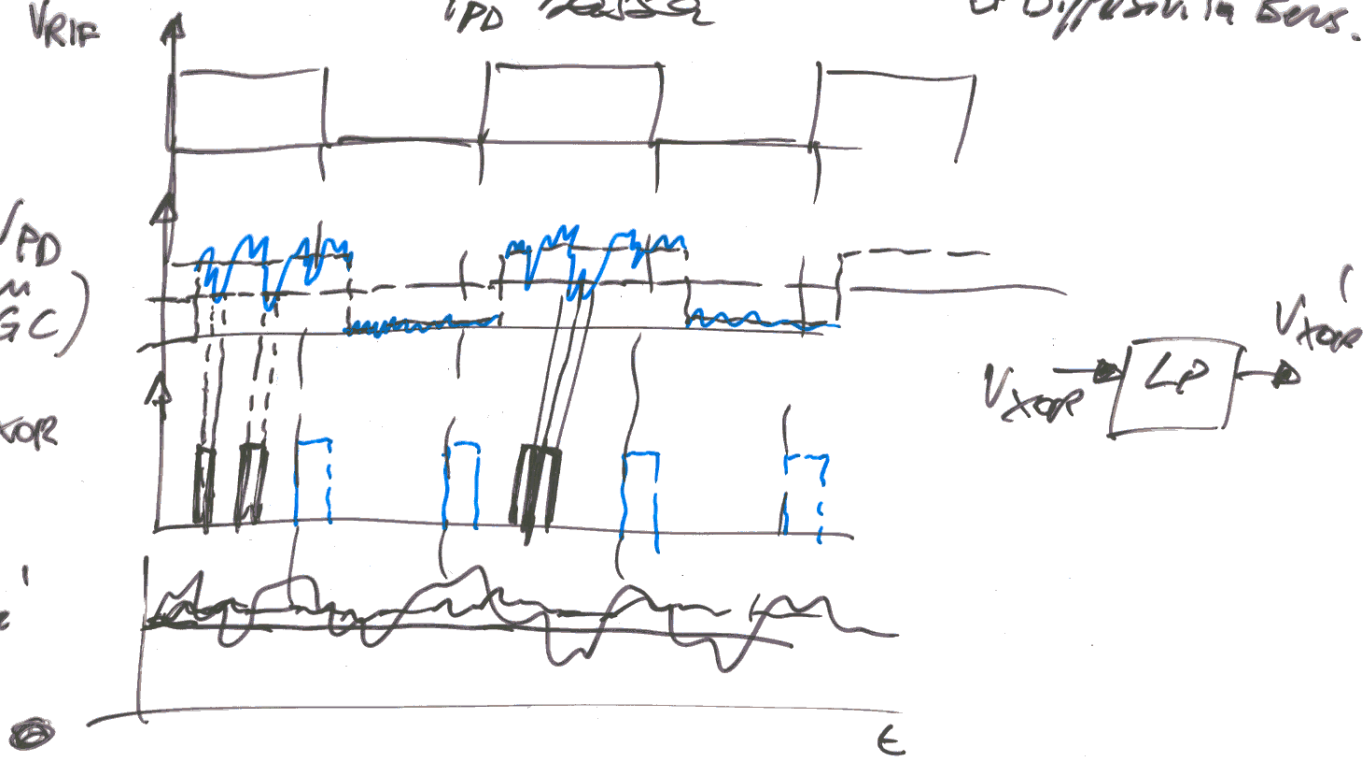


- $S/N \gg 1$ — Errore di misura → discriminazione di fase
  - jitter onda quadra (sum. di fase dell'oscillatore)

$\frac{\Delta L}{L}$ indip. da L $\quad T_1 \neq T_2 \neq T_3$

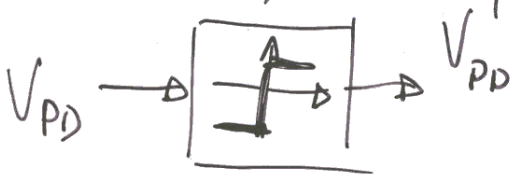
$\tau_1 \neq \tau_2 \neq \tau_3 \dots \neq \tau$

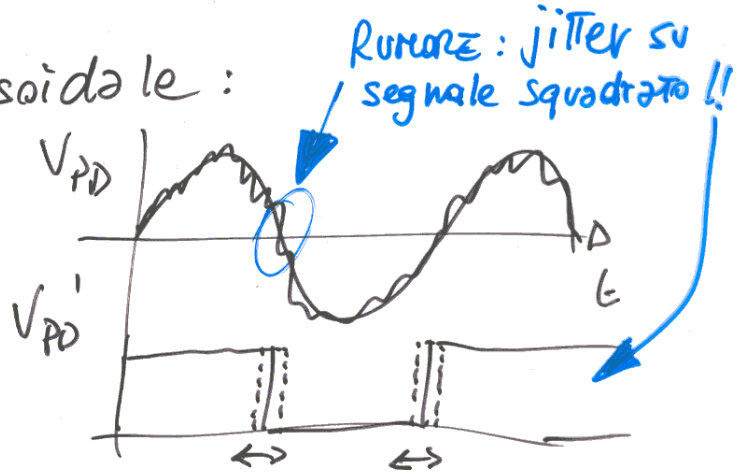
- $S/N \gtrsim 1$ (L grandi) P_{PD} bassa → Dip. anche da:
  - L
  - Diffusività Bers.



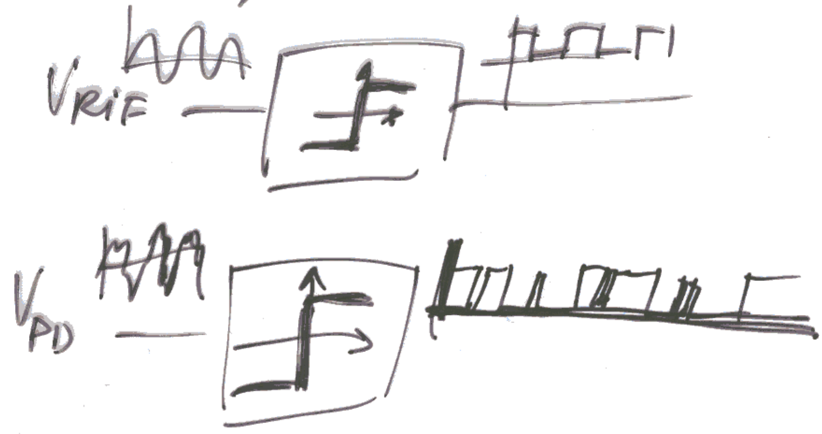
- ERRORE di MISURA

- $S/N \gg 1$, mod. sinusoidale:





☐ Con segnali sinusoidali

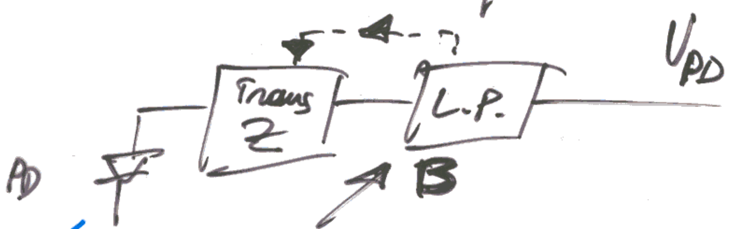


☐ in Rivelaz. ho banda B

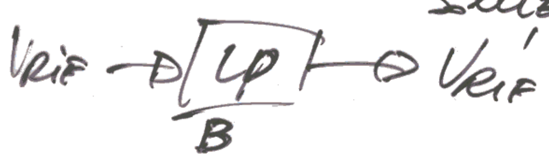
$$I_n^2 = 2 q I_s B$$

☐ SFASAMENTO

$$B \gtrsim 2 f_m$$



ATTENZIONE: allo sfasamento (≠0 per L=0)



Soluz.:

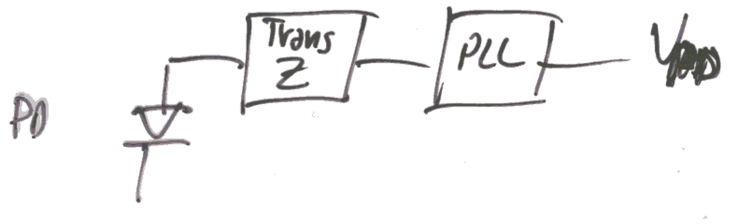
① In uscita sottraggo/aggiungo un vol. continua a VOUT
SVANT: dip-da f_m

② Filtro anche VRIF

③ ? sfasam. introdotto dal laser (dal circuito di modulazione ??)

Meglio: utilizzo un PLL

PLL ≃ filtro Passa-Banda a banda stretta
e sintonizzabile



? sfasamento ?