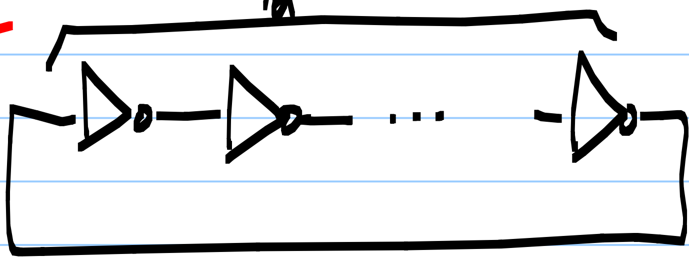
EE6322 — VCO phase noise — 16/2/2018

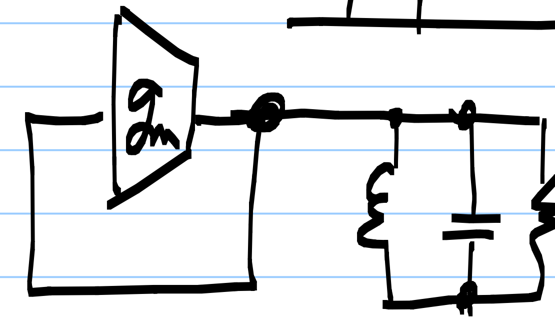


Ring oscillator

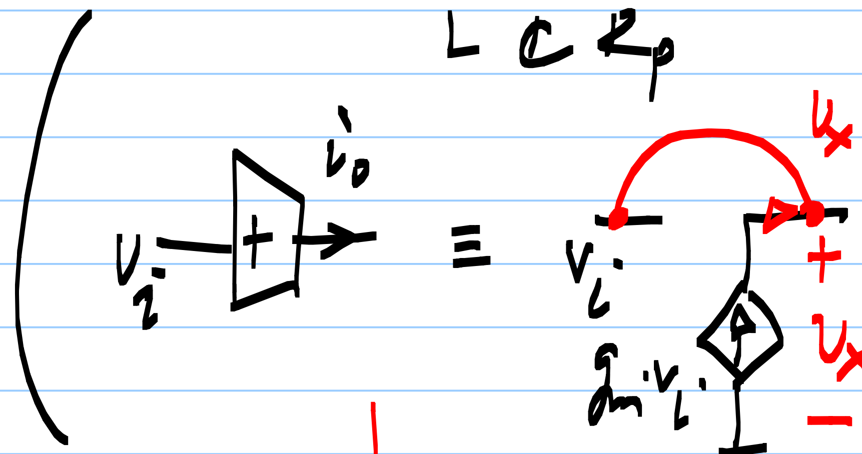
+ Compact
- Noisy
+ Widely tunable

period of osc. $= 2N \cdot T_d$

+ lower noise
- occupies a large area
- Narrow tuning range

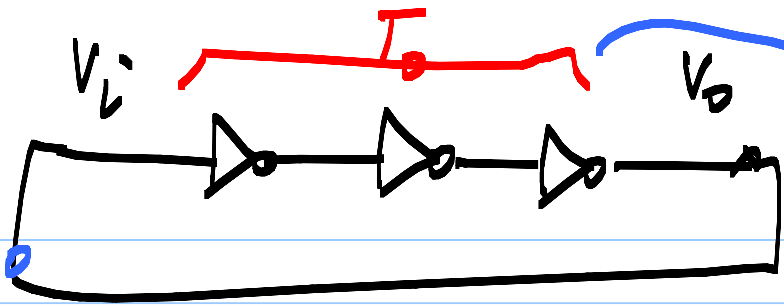


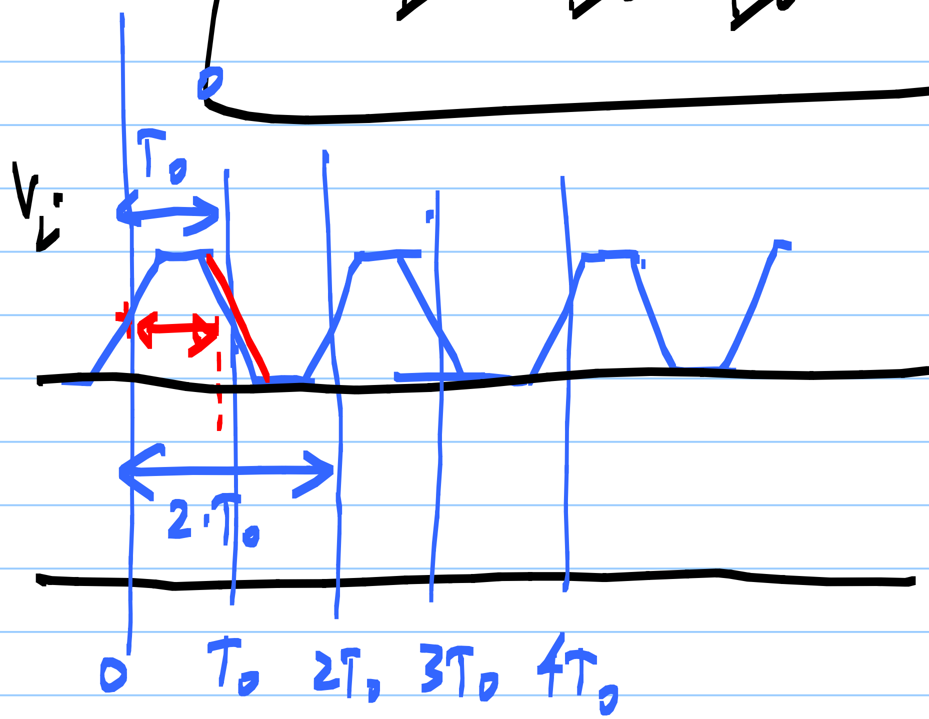
$g_m > \frac{1}{R_p}$

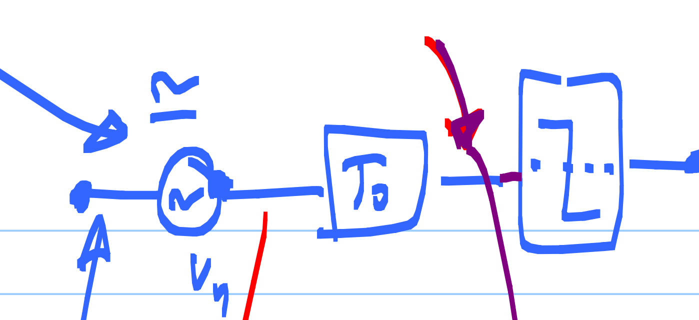


LC oscillator

$f_0 \sim \frac{1}{2\pi\sqrt{LC}}$

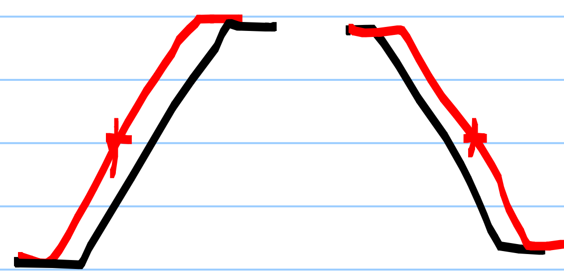


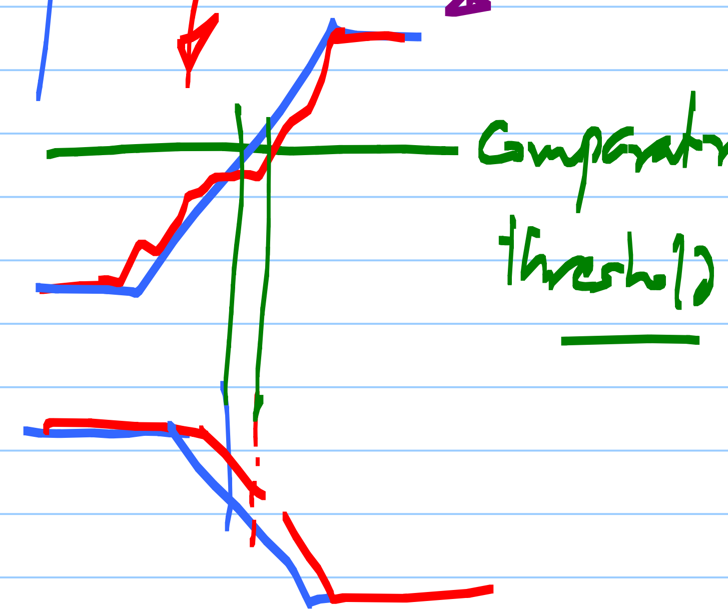




ideal: periodic with a
period $2 \cdot T_0$

$$\frac{v_n(T_0)}{S'}$$





First transition at $t=0$ (by defn.)

Second transition at $T_0 + \dfrac{v_n(T_0)}{s} \times \dfrac{2\pi}{2T_0}$

Third " " $2T_0 + \dfrac{v_n(T_0)}{s} - \dfrac{v_n(2T_0)}{s}$

4th " " $3T_0 + \dfrac{v_n(T_0)}{s} - \dfrac{v_n(2T_0)}{s} + \dfrac{v_n(3T_0)}{s}$

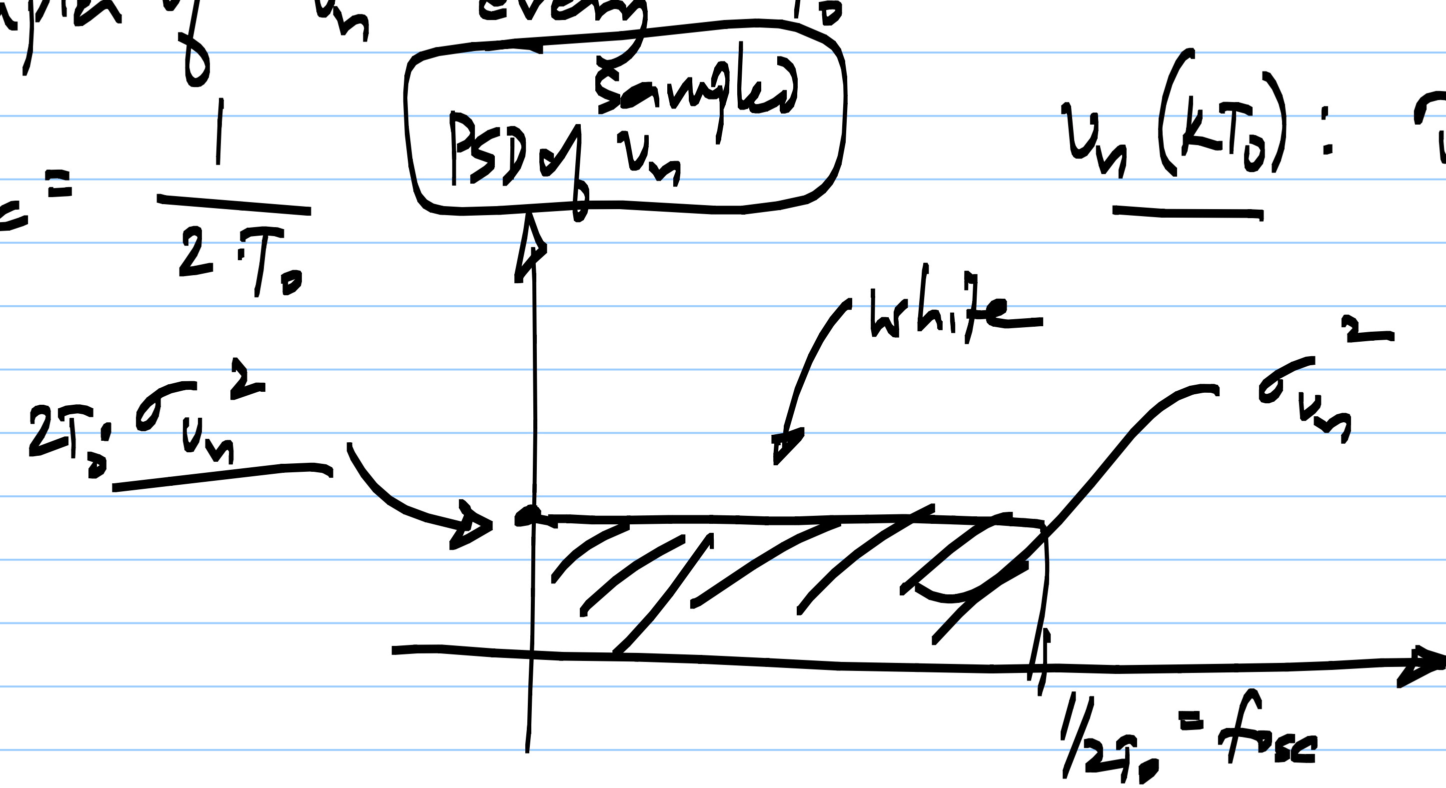
White noise; variance $\sigma_{v_n}^2$

v_n : Input ref. noise of amplifier/delay line/comparator

sample of v_n every T_0 $\quad \frac{1}{2T_0}$

$f_{osc} = \frac{1}{2 \cdot T_0}$

$v_n(kT_0) : \sigma_{v_n}^2$

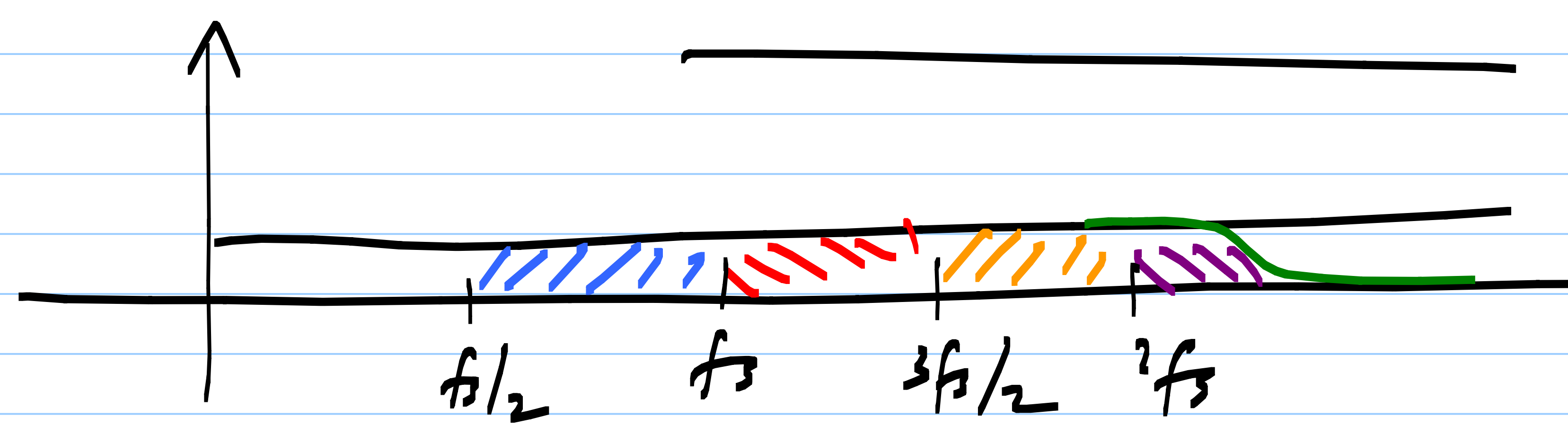


Cont. time noise

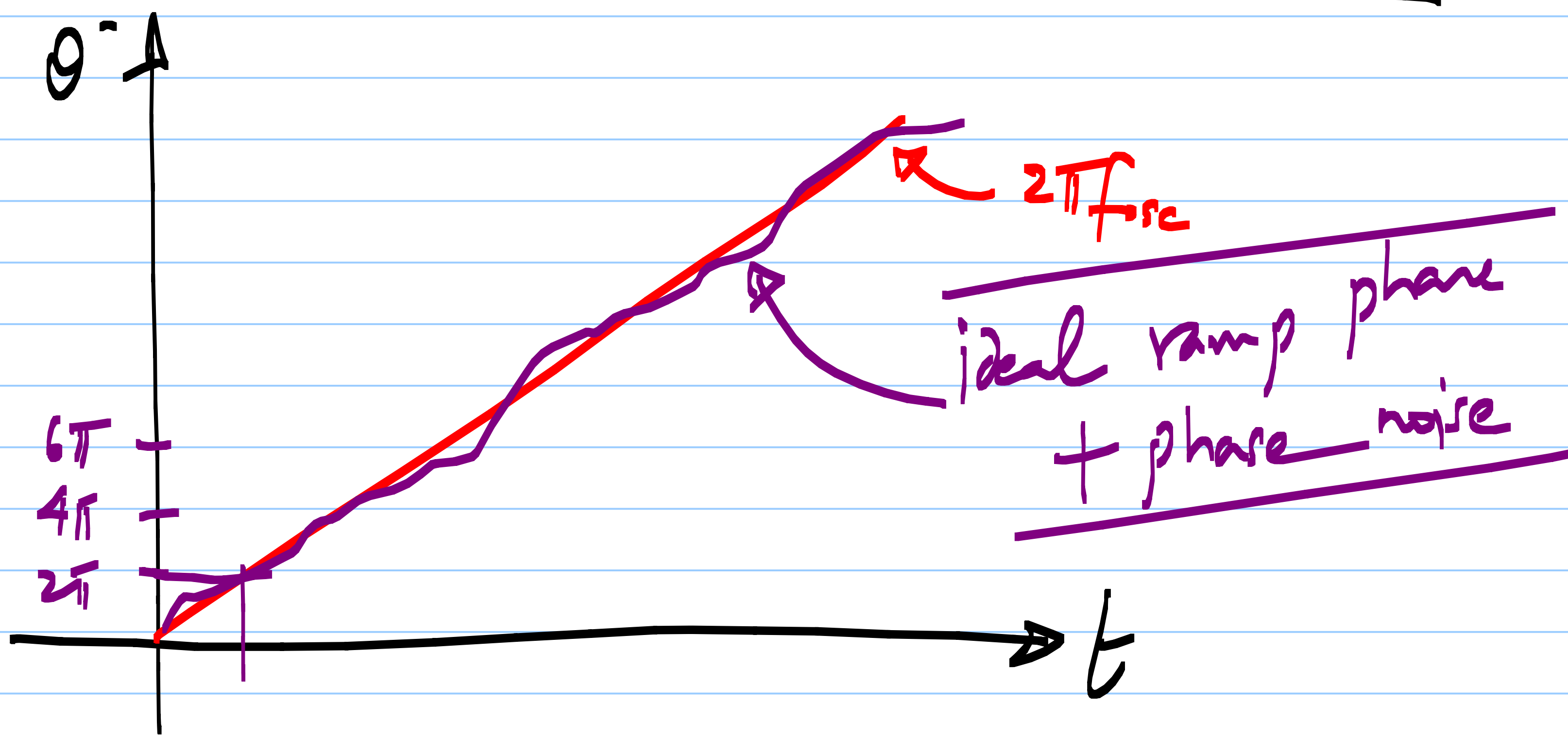
$$\underbrace{\int_0^\infty S_x(f)\,df}_{\text{one-sided spectral density}} = \sigma_x^2$$

Discrete-time noise
(Sampled @ f_s)

$$\int_0^{f_s/2} S_x(f)\,df = \sigma_x^2$$



Phase noise: shift in (zero-crossing) transition instants compared to an ideal periodic signal



1 period

Ideal zero-crossings	Actual	Deviation	(phase)
0	0	0	0
T_0	$T_0 + \tau_1$	τ_1	$\tau_1 \cdot \frac{2\pi}{2T_0}$
$2T_0$	$2T_0 + \tau_2$	τ_2	$\tau_2 \cdot \frac{2\pi}{2T_0}$
$3T_0$	$3T_0 + \tau_3$	τ_3	$\tau_3 \cdot \frac{2\pi}{2T_0}$
$4T_0$	$4T_0 + \tau_4$	τ_4	$\tau_4 \cdot \frac{2\pi}{2T_0}$
$\vdots$			

$$\tau_1 = \frac{v_n(T_0)}{s}$$

$$\tau_2 = \frac{v_n(T_0)}{s} - \frac{v_n(2T_0)}{s}$$

$$\tau_3 = \frac{v_n(T_1)}{s} - \frac{v_n(2T_0)}{s} + \frac{v_n(3T_0)}{s}$$

$$\vdots$$

$$\tau_k - \tau_{k-1} = \frac{v_n(kT_0)}{s}$$

$$\frac{v_n'(kT_0)}{s}$$

Same PSD as $v_n(kT_0)$

$$\tau_k - \tau_{k-1} = \frac{v_n'(kT_0)}{s} \qquad \tau(z)(1 - z^{-1}) = \frac{v_n'(z)}{s}$$

width of k^{th} half-period $= (kT_0 + \tau_k) - ((k-1)T_0 + \tau_{k-1})$

$$= T_0 + \tau_k - \tau_{k-1}$$

k^{th} half-period jitter : uncorrelated / white

$$\underbrace{\tau(z) = \frac{v_n'(z)}{s\,(1 - z^{-1})}}$$