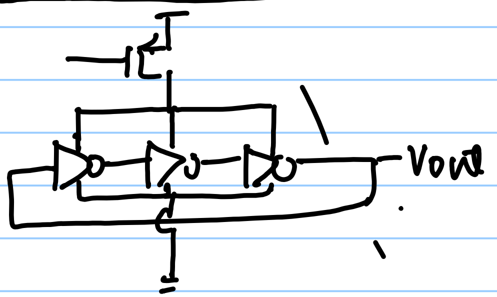
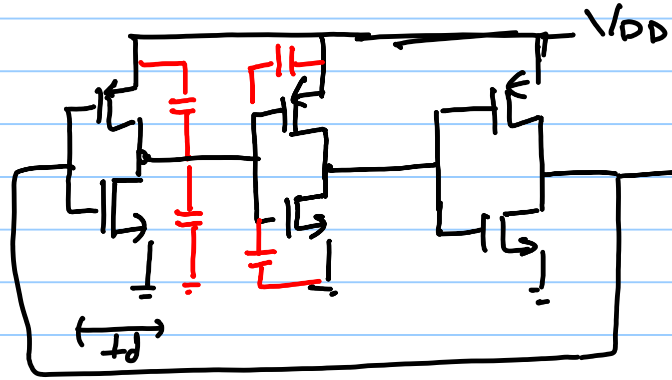
Note Title 08-10-2018

Lecture # 30

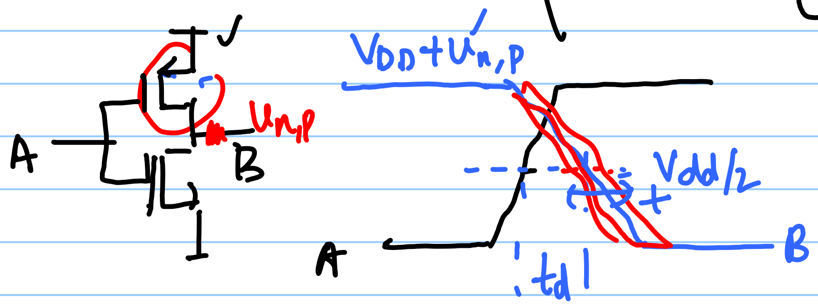
Phase noise & jitter in ring osc.

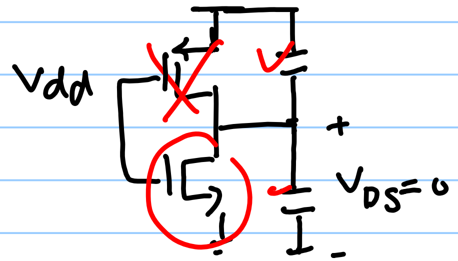




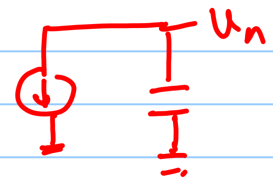
$$f_0 = \frac{1}{6t_d}$$

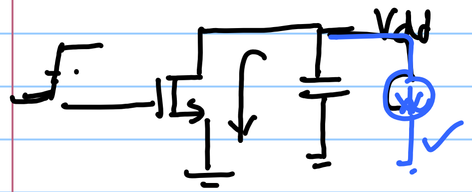
$$f = \frac{1}{2Mt_d}$$





$$I_0 = \frac{KW}{2L}(V_{GS} - V_t)^2$$

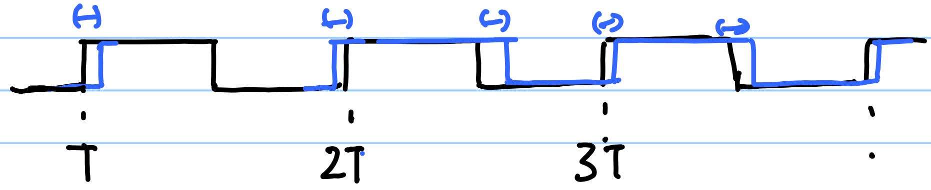




$$I_{tot} = I_0 + i_n = C\frac{dV_{out}}{dt}$$

Osc: f_0 o/p frequency
$(1/T)$

$$\Delta\Phi = 2\pi \cdot \frac{\Delta t}{T}$$



$$\tau(i) = \frac{1}{2\pi f_0}\left(\Phi(i+1) - \Phi(i)\right)$$

✓ $$\tau_i = \frac{1}{2\pi f_0}\left(\Phi_{i+1} - \Phi_i\right) = \frac{1}{2\pi f_0}\left(\Delta\Phi_i\right) \longrightarrow S_\tau(f) = S_\Phi(f)\,\frac{\sin^2(\pi f/f_0)}{(\pi f_0)^2}$$ ✓

✓ $$S_{\Delta\Phi}(f) = S_\Phi(f)\left|1 - e^{-j2\pi f/f_0}\right|^2$$

$$= 4 S_\Phi(f)\,\sin^2(\pi f/f_0)$$

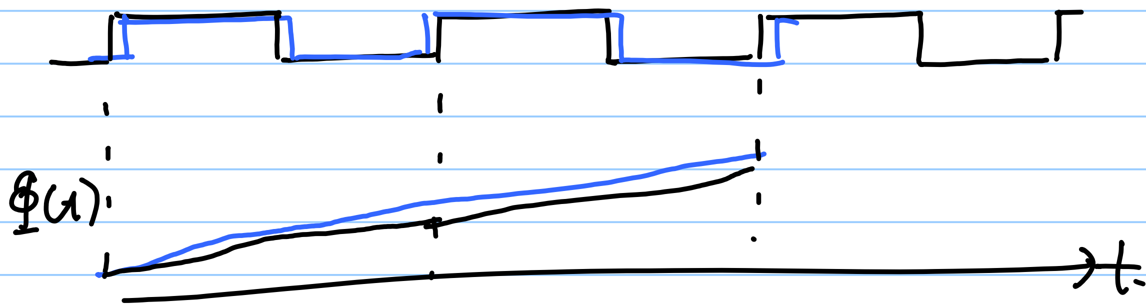
$\Delta\Phi \leftrightarrow \Phi$

$x(t) \longrightarrow X(f)$

$\frac{dx(t)}{dt} \longrightarrow s\,X(s)$

$x(n) \longrightarrow X(z)$

$x(n) - x(n-1) \longrightarrow$



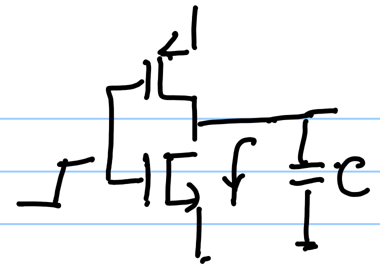
$$\sigma_\tau^2 = \int_0^\infty S_\tau(f)\,df = \int_0^\infty S_\Phi(f)\,\frac{\sin^2(\pi f/f_0)}{(\pi f_0)^2}\,df$$

Phase Noise PSD $\mathcal{L}(f) = \frac{S_\Phi(f)}{2} = \frac{S_W}{f^2} = \sigma_\tau^2 \frac{f_0^3}{f^2}$

$$\sigma_\tau^2 = \int_0^\infty \frac{2S_W}{f^2}\,\frac{\sin^2(\pi f/f_0)}{(\pi f_0)^2}\,df = \frac{S_W}{f_0^3}$$

$$S_\Phi(f) = 2\sigma_\tau^2 \frac{f_0^3}{f^2}$$

$$I_N = I_{DN,sat} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)(V_{DD}-V_{tn})^2$$

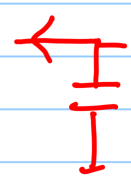


$$\frac{dV_{out}}{dt} = \frac{I_{DN,sat} + i_{nN}}{C}$$

$V_{out}: V_{DD} \to \frac{V_{DD}}{2}$

$K = \mu C_{ox}$

$$S_{i_{n,N}} = 4kT\gamma_N g_m = 8kT\gamma_N \frac{I_{DN,sat}}{V_{GS}-V_{tn}}$$



$V_{DD} \to \frac{V_{DD}}{2}$

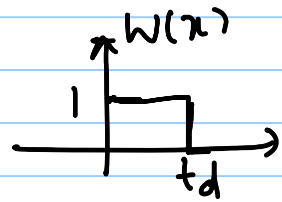
$$E\left[\int_0^{t_{dN}} \frac{I_N + i_{n,N}}{C}\cdot dt\right] = E\left[\frac{V_{DD}}{2}\right]$$

$$t_{dN} \equiv \langle t_{dN} \rangle = \frac{CV_{DD}}{2I_N}$$

$$\sigma_{t_{dN}}^2 = \frac{1}{I_N^2}\left\langle \left(\int_0^{t_{dN}} i_{nN}\, dt\right)^2 \right\rangle$$

$$v_n(t) = \frac{1}{C}\int_0^{t_d} i_n\, dt$$

$$v_n(t) = \frac{1}{C}\int_0^{\infty} i_n(x) \times w_{td}(t-x)\, dx$$



$$S_{t_{dN}} = \frac{t_{dN}^2}{I_N^2} \operatorname{sinc}^2 (f t_{dN}) \, S_{i_{nN}} \checkmark$$

$$\sigma_{t_{dN}}^2 = \int S_{t_{dN}} \cdot df$$

$$= \frac{4kT\gamma_N t_{dN}}{I_N (V_{DD} - V_{tn})} \checkmark$$

$$\langle v_n^2 \rangle = \underline{k}T/C \checkmark$$

$$i = C \frac{dv}{dt}$$

$$\sigma_{t_{dN}}^2 = \frac{4kT \gamma_N t_{dN}}{I_N (V_{DD} - V_{tn})} + \frac{kTC}{I_N^2} \checkmark$$

$$\sigma_{t_{dP}}^2 = \frac{4kT \gamma_p t_{dp}}{I_p (V_{DD} - |V_{tp}|)} + \frac{kTC}{I_p^2} \checkmark$$

$$S_{v_n}(f) = \frac{1}{C^2} |W_{td}(f)|^2 \, S_{i_n}(f)$$

$$W_{td}(s) = \frac{1 - e^{-st_d}}{s}$$

$$S_{v_n}(f) = \frac{1}{C^2} \left| \quad \right| S_{i_n}(f) \checkmark$$

$$\langle v_n^2 \rangle = \int S_{v_n}(f) \cdot df$$

$$f_0 = \frac{1}{M(t_{dN}+t_{dp})} = \frac{2}{MCV_{DD}\left(\frac{1}{I_N}+\frac{1}{I_p}\right)} \approx \frac{I/C}{MV_{DD}}$$

$$\sigma_\tau^2 = M\left(\sigma_{t_{dN}}^2 + \sigma_{t_{dp}}^2\right)$$

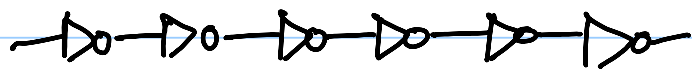
$$= \frac{kT}{I f_0}\left[\frac{2}{(V_{DD}-V_t)}(\gamma_N+\gamma_P) + \frac{2}{V_{DD}}\right]$$

$$T = t_{dN_1} + t_{dp_1} + t_{dN_2} + t$$

$$\sigma_T^2 = (\qquad)^2$$

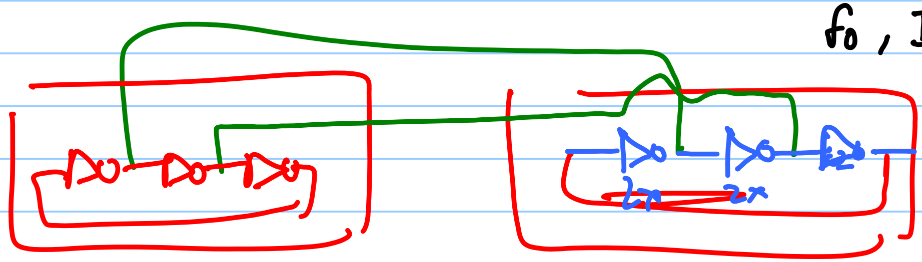
$$\mathcal{L}(f) = \frac{2kT}{I}\left[\frac{1}{V_{DD}-V_t}(\gamma_N+\gamma_P) + \frac{1}{V_{DD}}\right]\left(\frac{f_0}{f}\right)^2,$$

$$\mathcal{L}(f) \propto \frac{1}{f^2}$$



f_0, I, V_{DD} , $-x$ dBc/Hz

$f_0 \longrightarrow 2f_0$



$2f_0, \frac{I}{1}, V_{DD}$

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