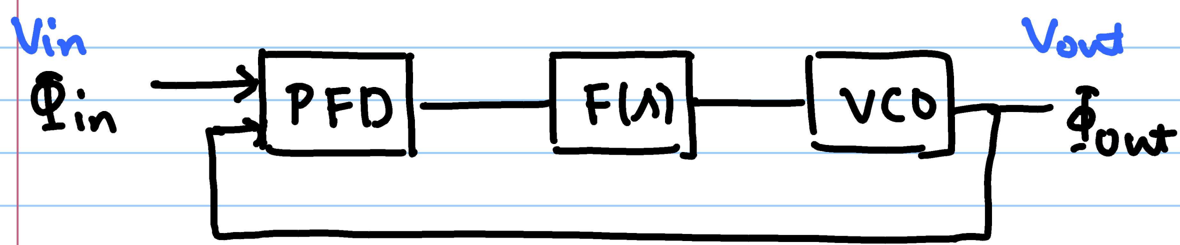
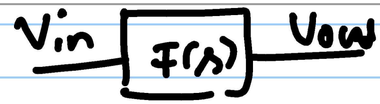
Lecture # 17

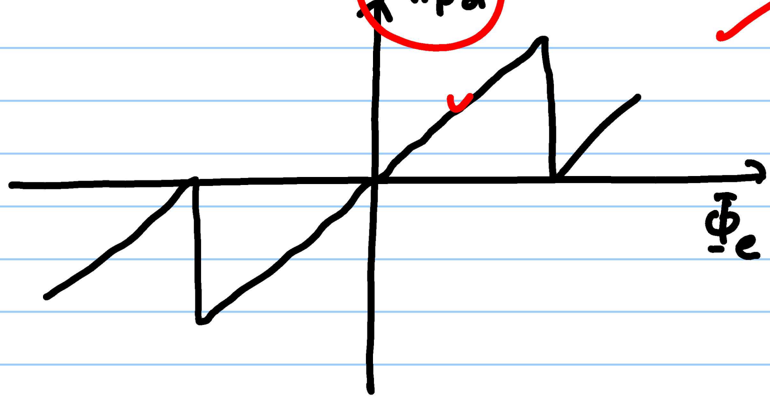
Note Title 29-08-2017

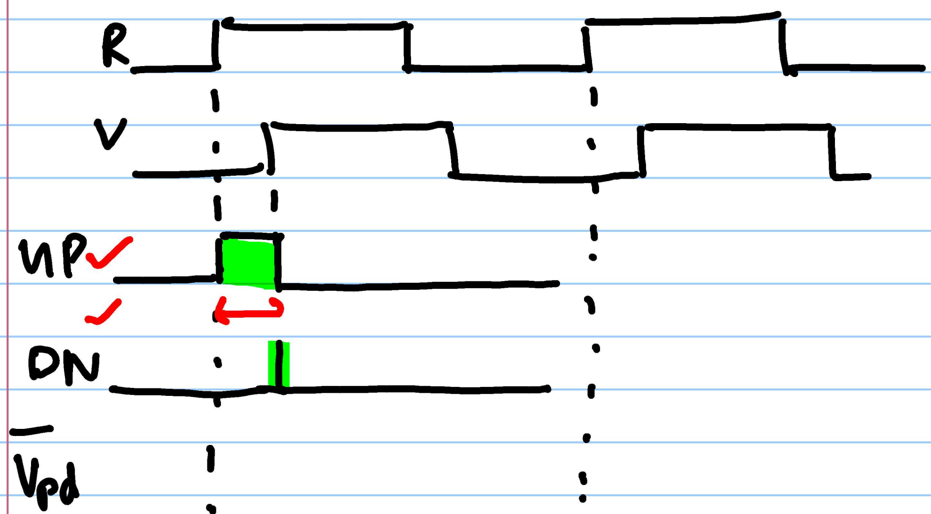




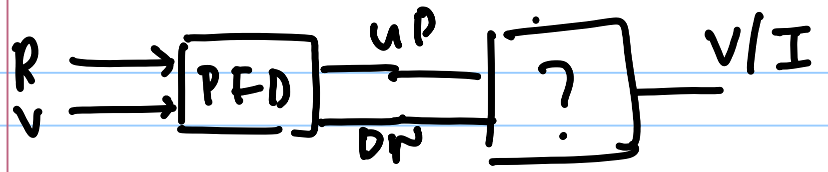
Phase Frequency Detector (PFD):

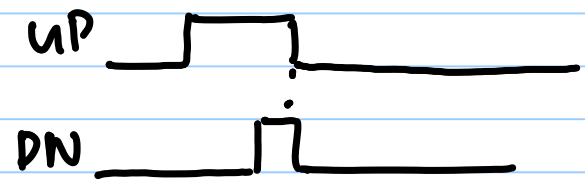
$\overline{V_{pd}} = \overline{UP - DN}$

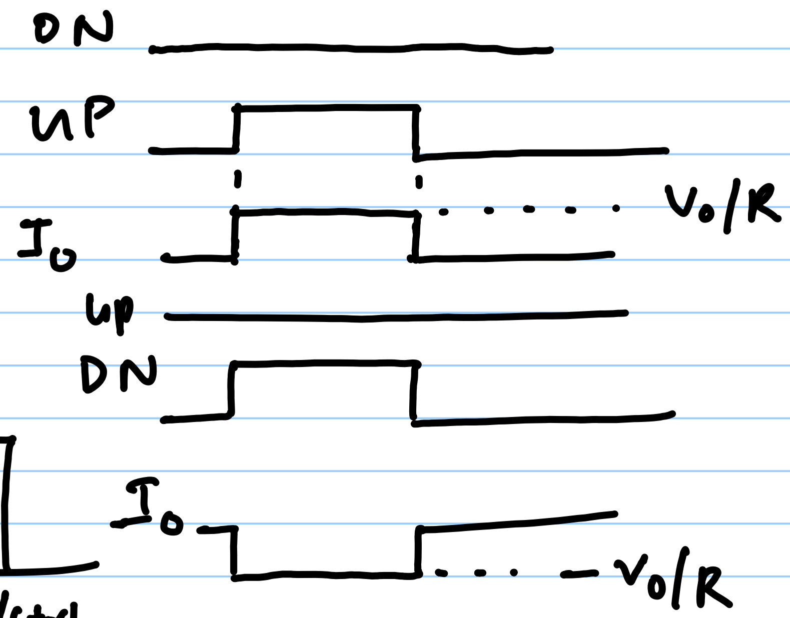


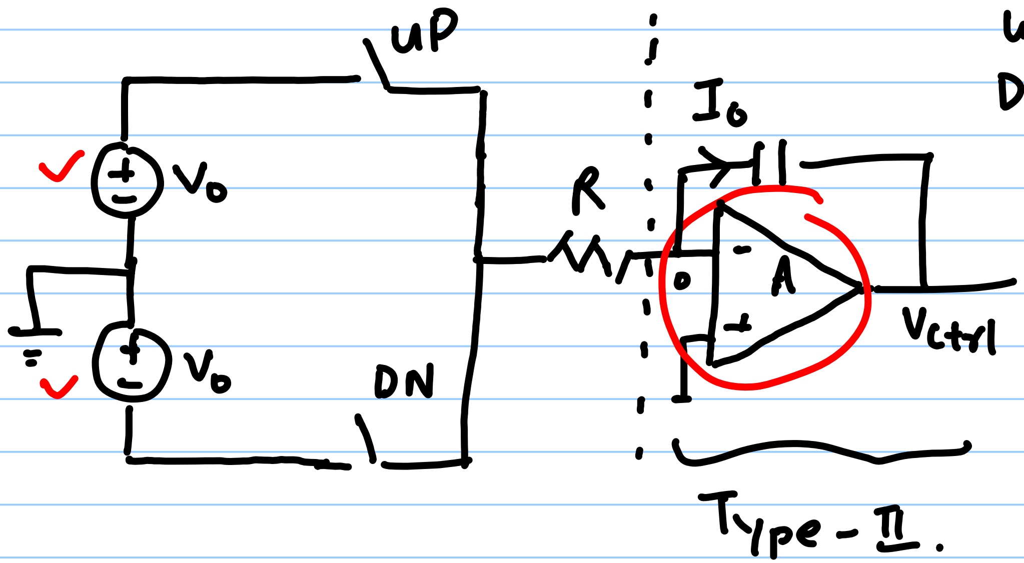


PFD o/p: Pulse width modulated waveform.

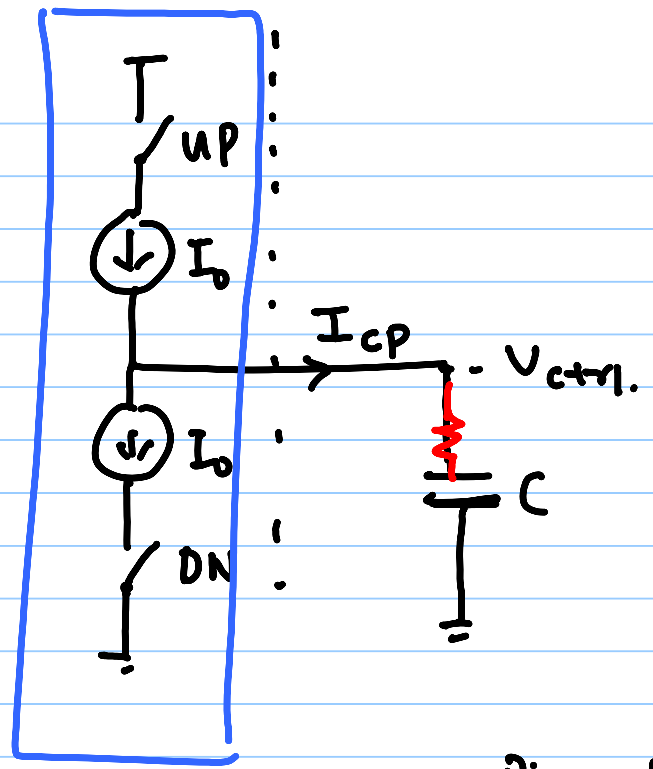




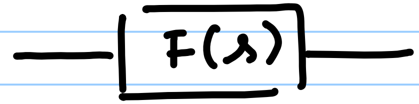




$$\frac{V_{ctrl}}{I_0} = \frac{1}{sC}$$



Charge-pump.

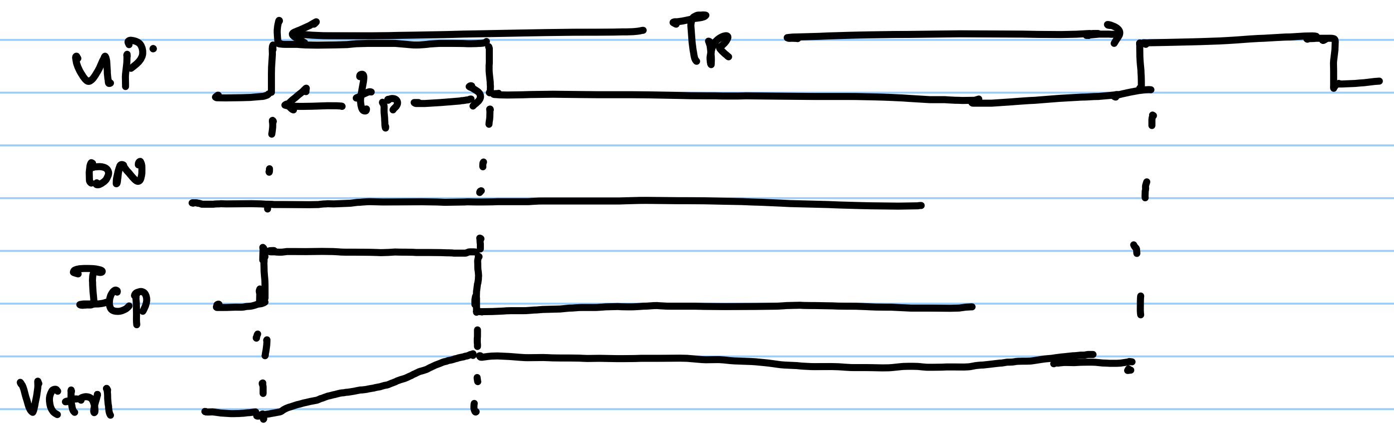


$$F(s) = \frac{\tau_p}{\tau_i} + \frac{1}{\tau_i s} = \frac{1 + s\tau_p}{s\tau_i}$$

$$V_{ctrl}(s) = I_{cp} \times \frac{1}{sC}$$

$$V_{ctrl}(s) = I_{cp} \times \left(\tau_p + \frac{1}{sC} \right)$$

$$V_{ctrl}(s) = I_{cp} \left(R + 1/sC \right)$$



$$\Delta V_{ctrl} = \frac{I_{cp} \cdot t_p}{C} = \frac{I_{cp}}{C} \cdot \frac{T_R}{2\pi} \underline{\Phi}_e \qquad \underline{\Phi}_e = 2\pi \cdot \frac{t_p}{T_R}$$

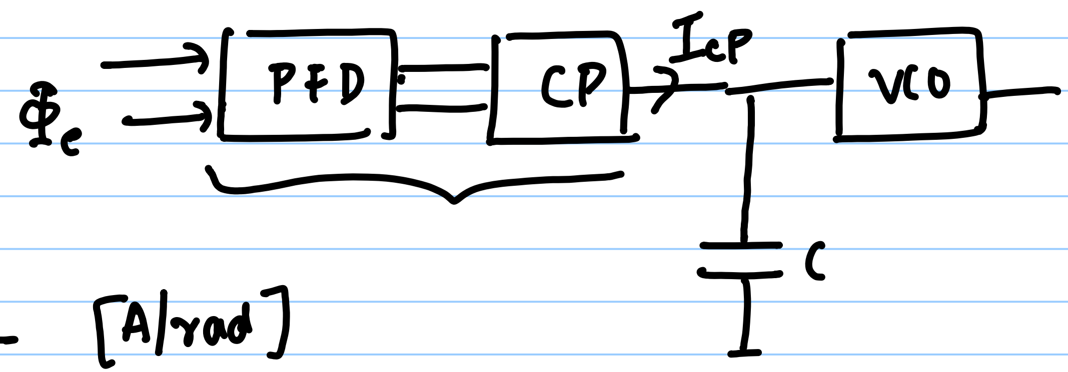
$$= \frac{I_{cp} \cdot T_R}{C} \cdot \underbrace{\frac{\underline{\Phi}_e}{2\pi}}$$

$$\Delta V_{ctrl}(nT_R) = \frac{I_{cp} \cdot T_R}{C} \times \frac{1}{2\pi} \sum_{k=0}^{n} \underline{\Phi}_e(kT_R)$$

$$V_{ctrl}(nT_R) = \frac{I_{cp}}{2\pi} \cdot \frac{T_R}{C} \sum_{k=0}^{n} \underline{\Phi}_e(kT_R) \quad ✓$$

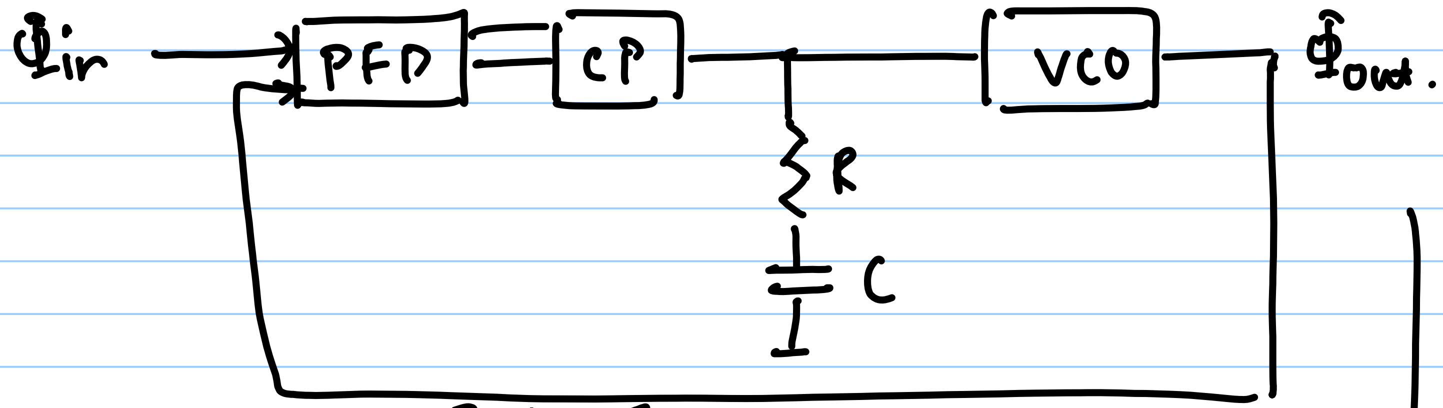
Time domain.

$$\boxed{\frac{V_{ctrl}(s)}{\underline{\Phi}_e(s)} = \frac{I_{cp}}{2\pi} \cdot \frac{1}{sC}}$$



$$\text{PFD+CP gain} = \frac{I_{cp}}{2\pi} \quad [A/rad]$$

charge-pump PLL (Type II, order 2).



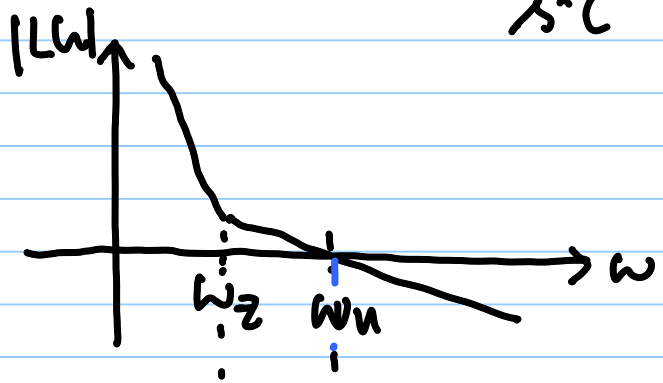
$[K_{vco}] = Hz/V$.
$= (rad/s)/V$.

$\left[\frac{2\pi K_{vco}}{s}\right] = \frac{(rad/s)/V}{(rad/s)}$

[A/rad] Ω

$$LG(s) = \left.\frac{\Phi_{out}}{\Phi_{in}}\right|_{\text{open loop}} = \frac{I_{cp}}{2\pi} \times \left(R + \frac{1}{sC}\right) \times \frac{2\pi K_{vco}}{s}$$ ✓

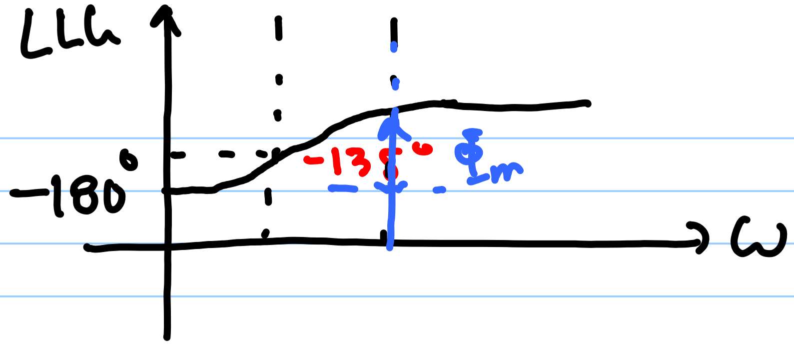
$$LG(s) = \frac{I_{cp} \cdot K_{vco}}{s^2 C} (1 + sRC)$$ ✓



$\omega_{p1} = \omega_{p2} = 0$

$\omega_z = 1/RC$

ω_u: unity gain frequency.



$$\angle LG = -180^\circ + \tan^{-1}\left(\frac{\omega}{\omega_z}\right)$$

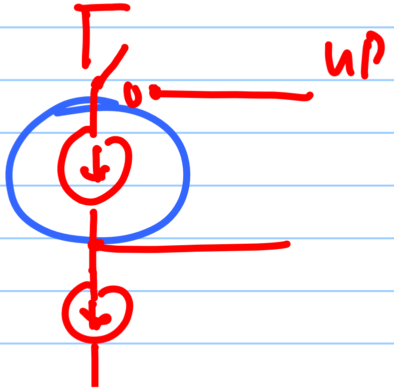
$$\Phi_m(\omega_u) = \angle LG(\omega_u) - (-180^\circ)$$

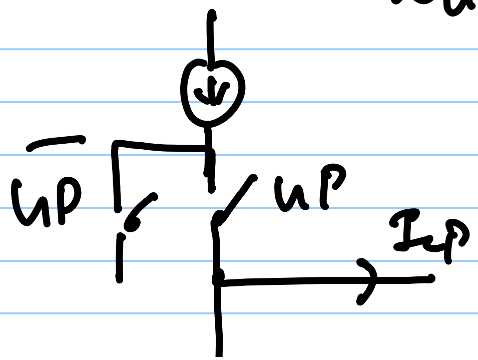
$$= \tan^{-1}\left(\frac{\omega_u}{\omega_z}\right)$$

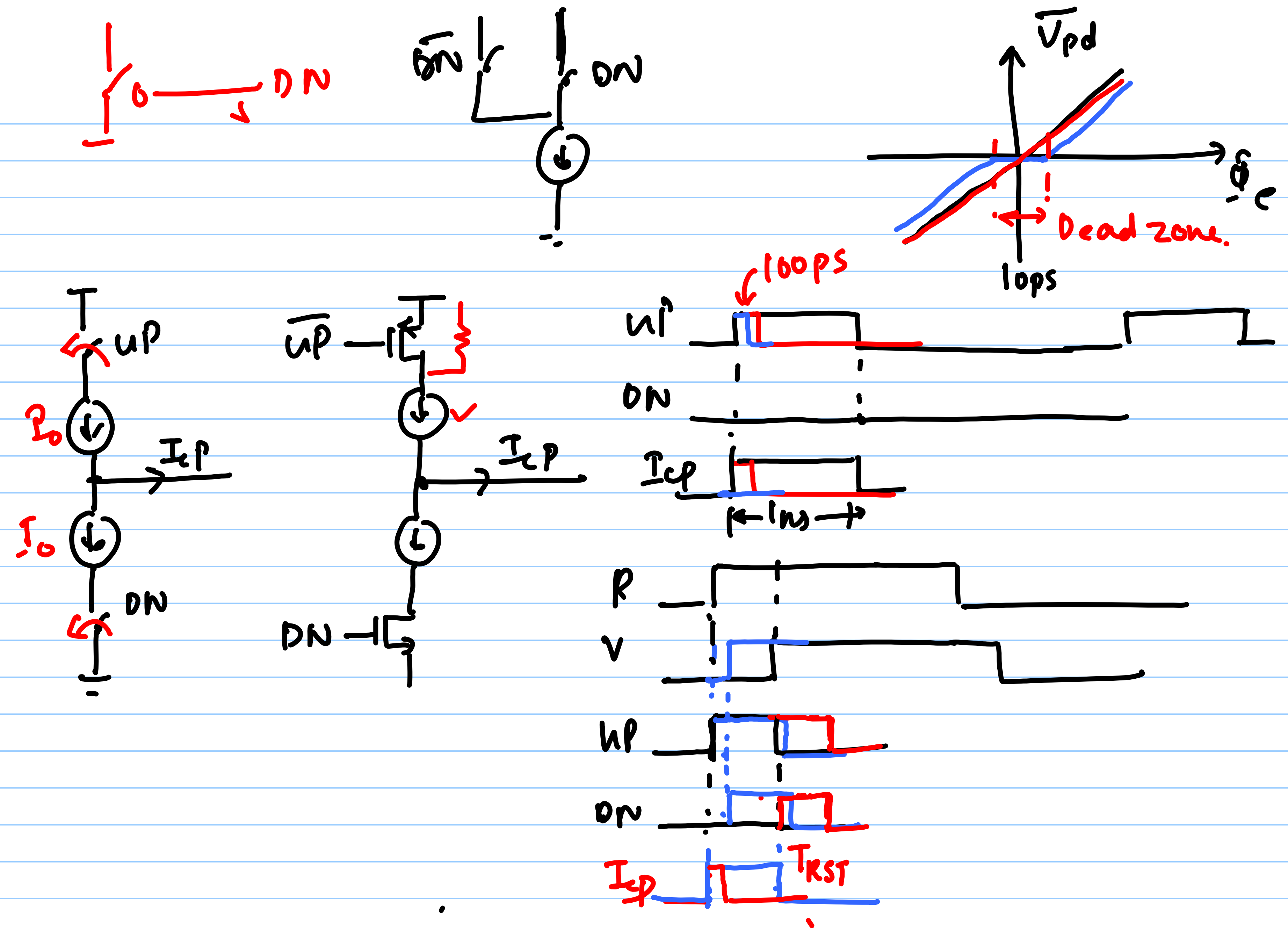
$\Phi_m, \omega_u \Rightarrow R, C, I_{cp},$

1.) $\Phi_m = \tan^{-1}\left(\frac{\omega_u}{\omega_z}\right)$

2.) $|LG(\omega_u)| = 1 \Rightarrow \frac{I_{cp} \cdot K_{vco}}{\omega_u^2 C}\sqrt{1 + \frac{\omega_u^2}{\omega_z^2}} = 1$






DN
DN
DN
$\bar{V}_{pd}$
ϕ_e
Dead zone.
10ps
UP
I_o
I_{cp}
I_o
DN
$\overline{UP}$
I_{cp}
DN
100ps
UP
DN
I_{cp}
1ns
R
V
UP
DN
I_{cp}
T_{RST}