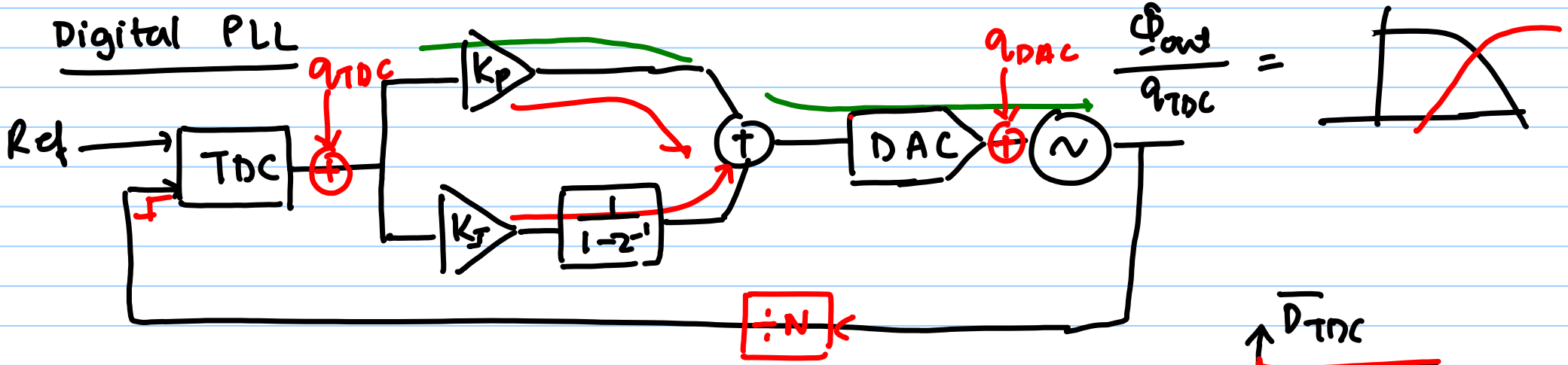
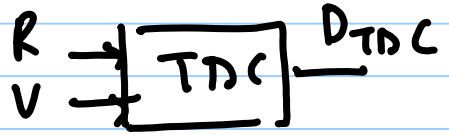
Lecture # 45

Note Title 26-10-2017

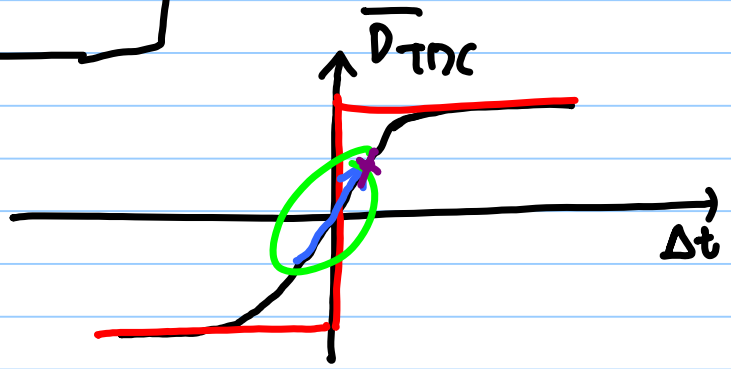
Digital PLL

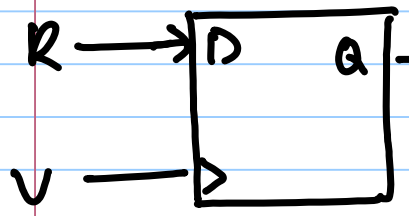




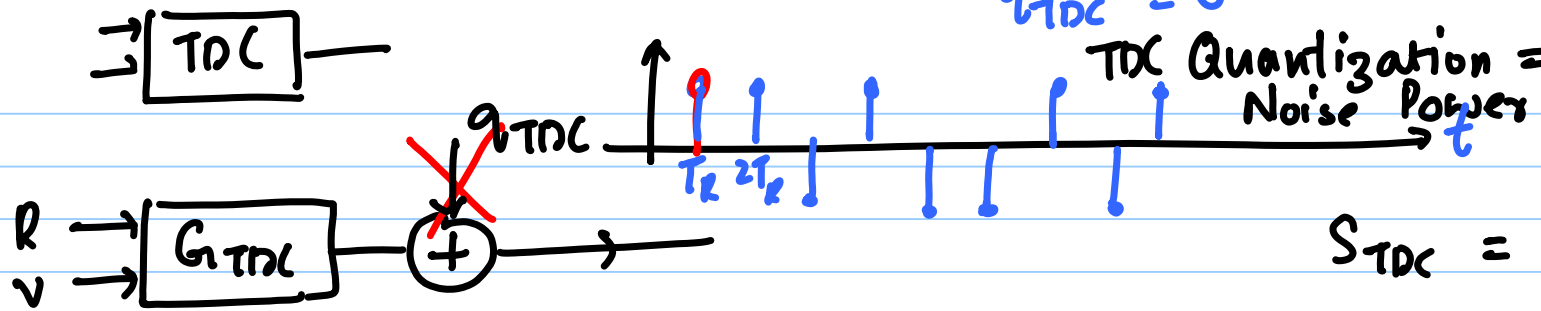
$$TDC_{LSB} = \frac{T_{ref}}{N}$$

$$D_{TDC} = \pm TDC_{LSB}$$





$$\overline{D_{TDC}} = P(D_{TDC} = +TDC_{LSB}) \times TDC_{LSB} + P(D_{TDC} = -TDC_{LSB}) - TDC_{LSB}$$

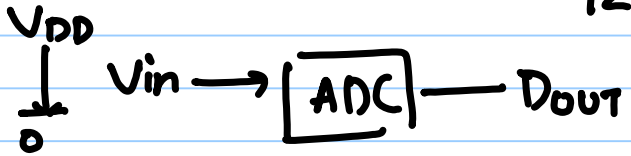


$\overline{q_{TDC}} = 0$

TDC Quantization Noise Power $= \frac{(TDC_{LSB})^2}{12}$

$S_{TDC} = \frac{(TDC_{LSB})^2}{12} \times \frac{1}{freq}$

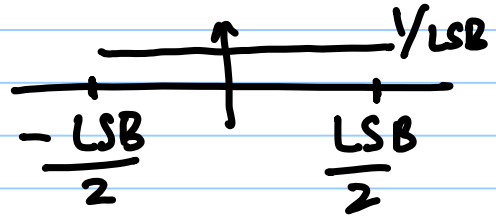
- q_{TDC} is low pass filtered
- $q_{TDC} \propto \frac{1}{\#\text{ delay elements in TDC}}$



$LSB = \frac{VDD}{2^N - 1}$

- Quantization Noise $\leq \pm \frac{LSB}{2}$
- $\overline{q_{ADC}} = 0$

$E[q_{ADC}^2] = \int x^2 f(x)\, dx$



Large cap. area in integral path ⟶ Digital Loop filter

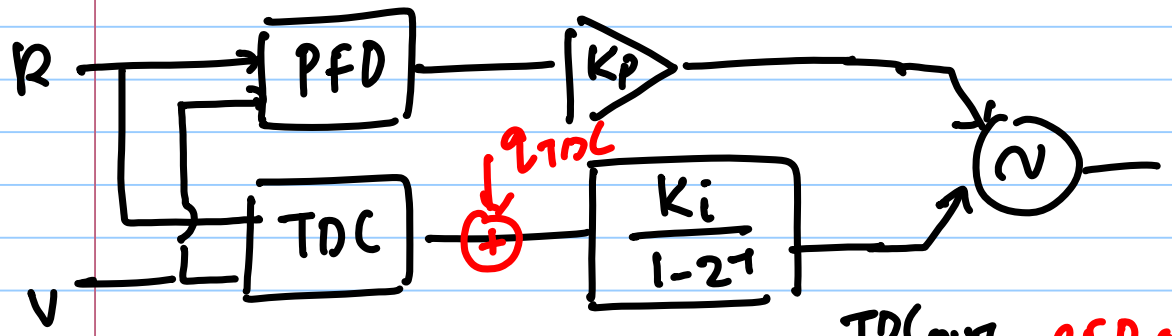
(Prop. + Integral)

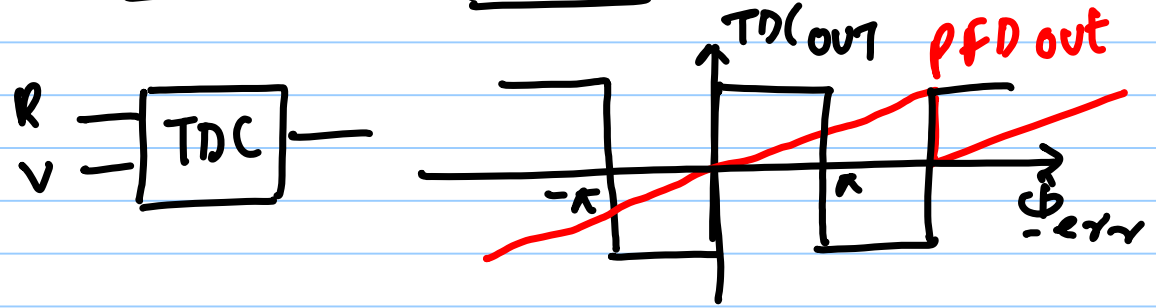
↓ q_{TDC}

Large q_{TDC} through prop. path

$$NTF_q = \frac{\left(K_p + \frac{K_{ifreq}}{s}\right)\frac{2\pi K_{vco}}{s}}{1 + LG}$$

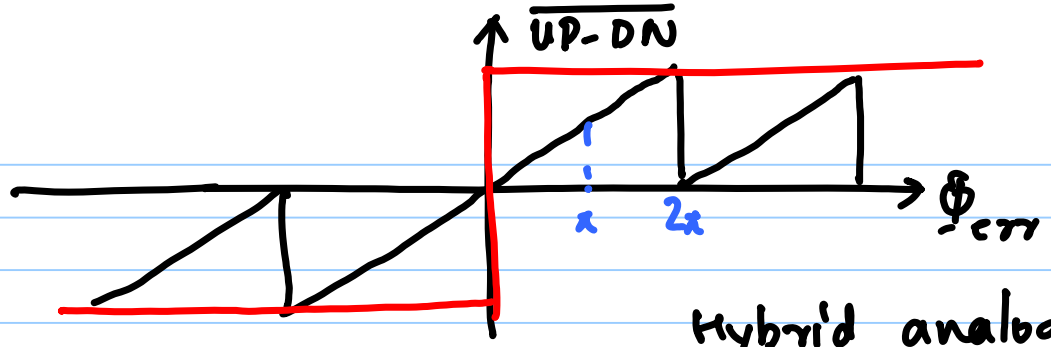
$$\frac{\alpha}{\beta} = \frac{f_{req}}{\omega_n}\tan(\phi_m) = \frac{1}{2}$$

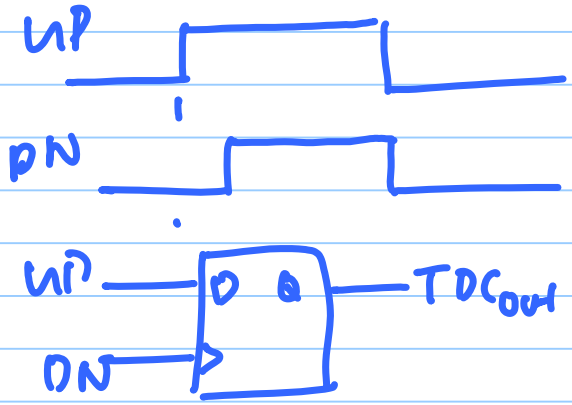




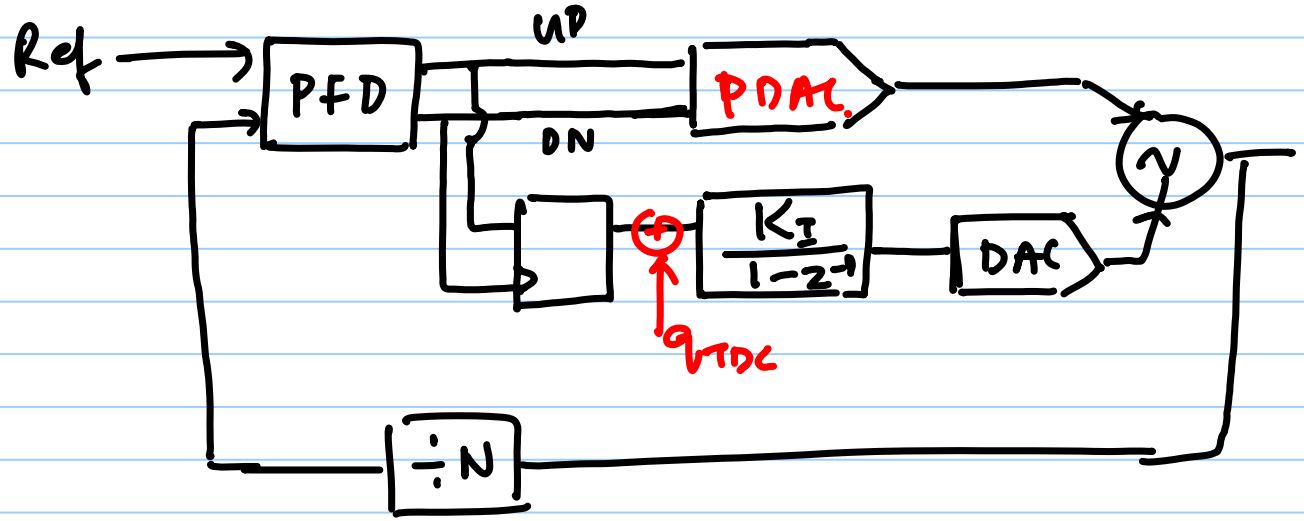
NTF_{prop}

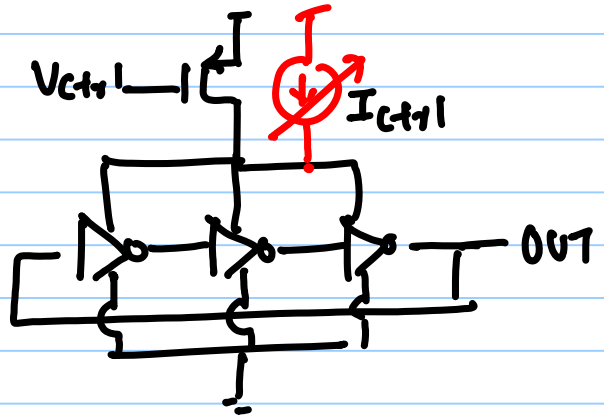
$$NTF_{int} = \frac{K_{ifreq}}{s \cdot K_p} NTF_{prop}$$





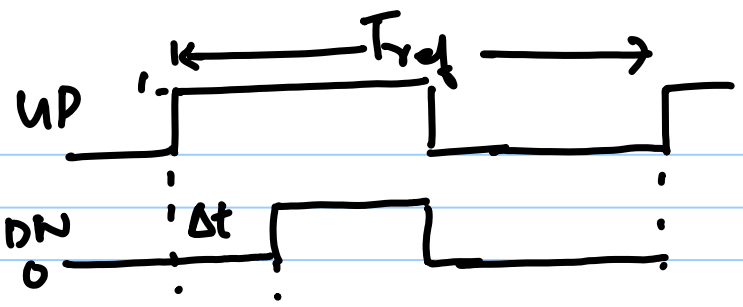
Hybrid analog/digital PLL

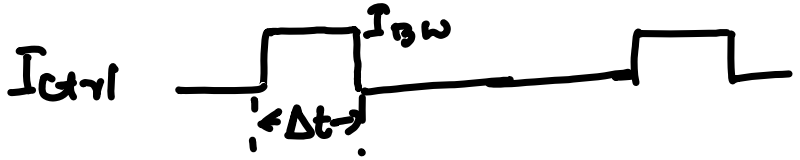




$V_{ctrl} \xrightarrow{K_{VCO}}$ OUT freq

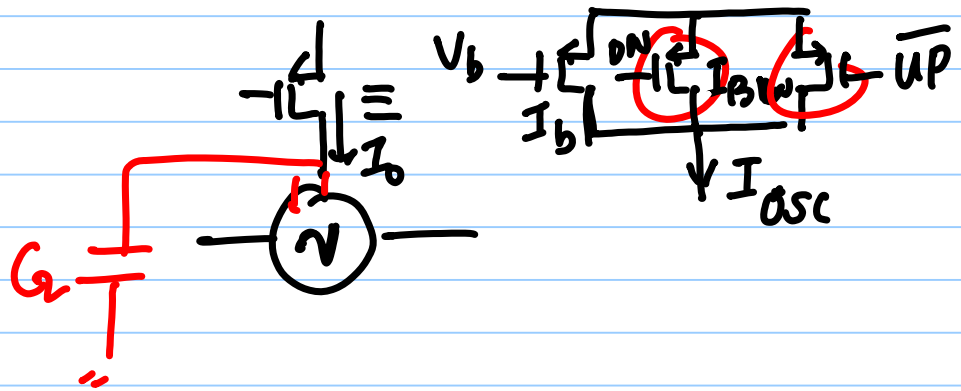
$I_{ctrl} \xrightarrow{K_{CCO}}$ OUT freq





$f_{out} = K_{CCO} \times I_{BW}$

$$\overline{UP - DN} = \frac{\Delta\theta}{T_{ref}} \qquad f_{out} = K_{VCO} \times \overline{UP - DN}$$



UP	DN	I_{OSC}	
0	0	$I_b + I_{BW}$	$-I_{BW}$
0	1	I_b	
1	0	$I_b + 2I_{BW}$	$+I_{BW}$
1	1	$I_B + I_{BW}$	