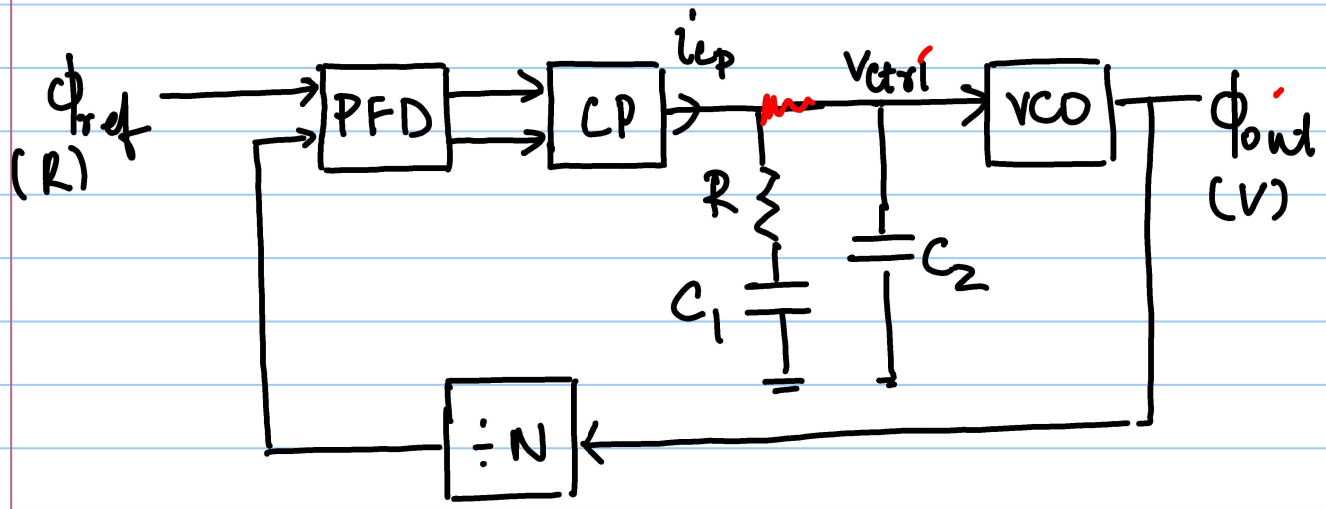
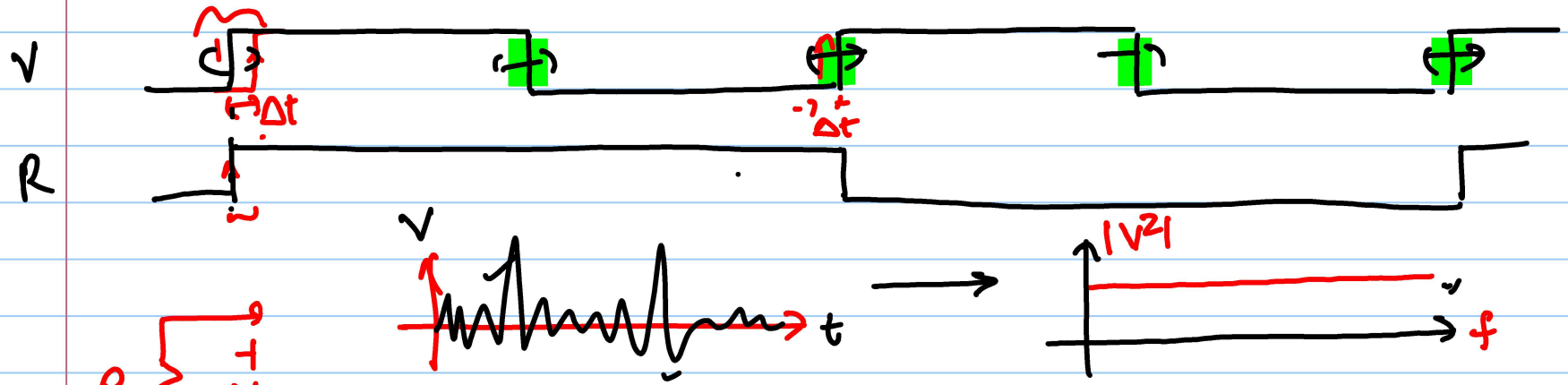
Lecture # 21

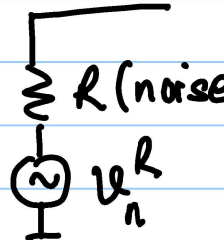
Note Title 19-10-2020



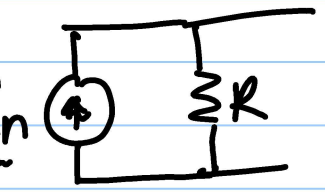
- $f_{out} = N f_{ref}$ ✓
- $\frac{d(\phi_{err})}{dt} = 0$ ✓



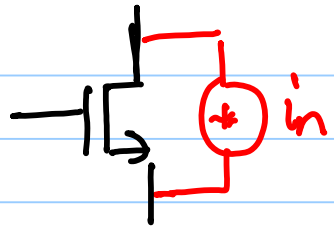
$$S_n^R(f) = \frac{\overline{V^2}}{\Delta f} = 4kTR \quad \text{(Power Spectral Density)}$$



$$S_n^R(f) = \frac{\overline{V_n^2}}{\Delta f} = 4kTR \quad \frac{V^2}{Hz}$$

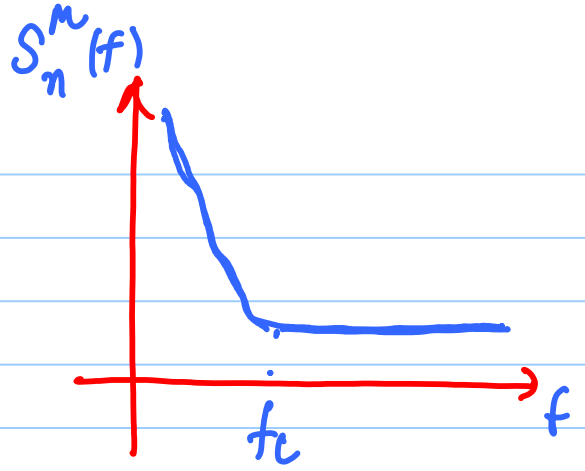


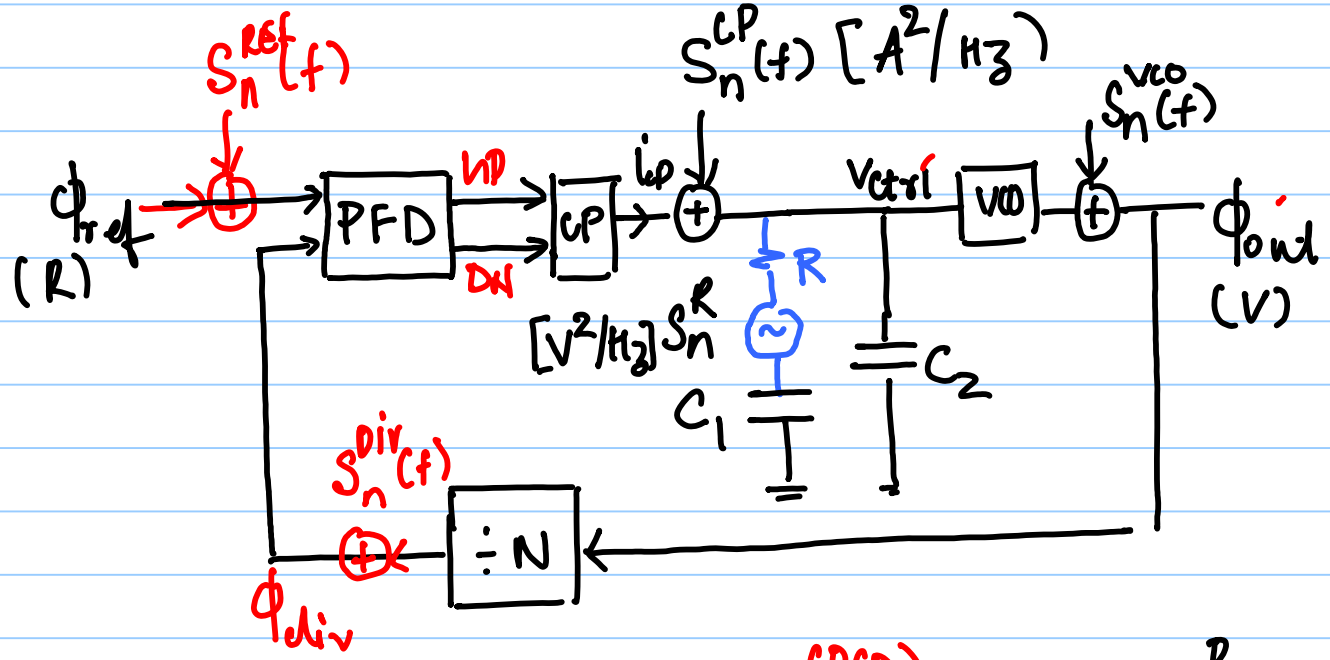
$$\frac{\overline{i_n^2}}{\Delta f} = \frac{4kT}{R}$$

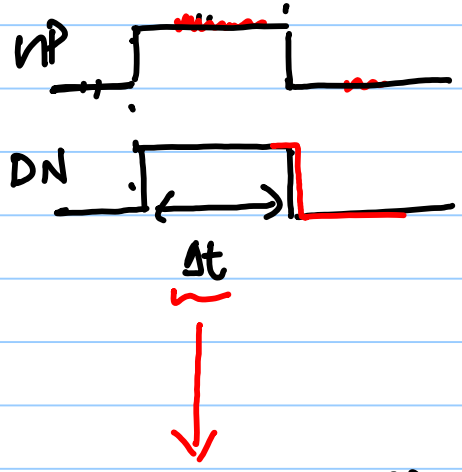


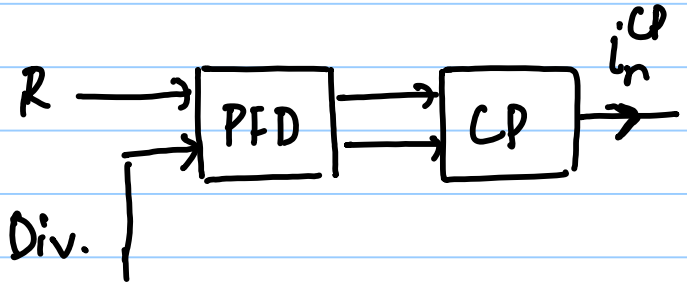
$$\frac{\overline{i_n^2}}{\Delta f} = 4kT\gamma g_m \quad \text{(Thermal Noise)}$$

$$\frac{2}{3} \leq \gamma \leq 2$$



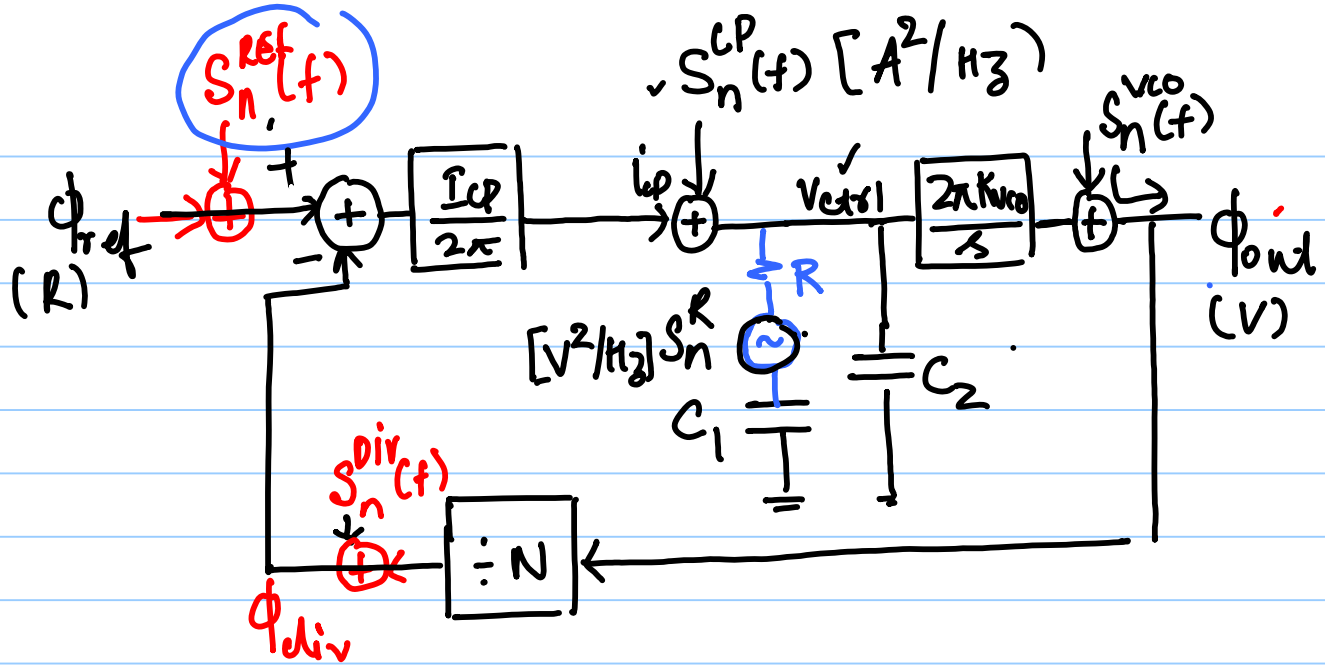






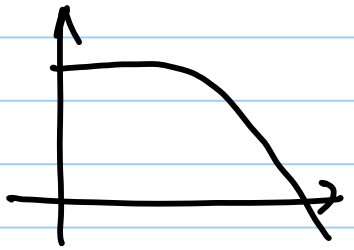
$S_n^{REF}(f)$: Power Spectral Density (PSD) of ref. phase noise.

$S_n^{div}(f)$, $S_n^{VCO}(f)$: PSD



$$L_G(s) = \frac{I_{CP}.K_{VCO}}{s^2(C_1+C_2)N} \frac{(1+sRC_1)}{\left(1+\frac{sRC_1C_2}{C_1+C_2}\right)}$$

$$\frac{\phi_{out}}{\phi_{ref}} = \frac{N \times L_G}{1+L_G} = \text{Noise Transfer function} \quad (NTF_{Ref})$$



$$\phi_{n,Ref}^{out} = \phi_n^{Ref} \times NTF_{Ref}$$

$$\left|\phi_{n,Ref}^{out}\right|^2 = \left|\phi_n^{Ref}\right|^2 \times \left|NTF_{Ref}\right|^2 = S_n^{Ref} \times \left|NTF_{Ref}\right|^2. \quad \text{(lowpass)}$$

$$NTF_{CP} = \frac{2\pi}{I_{CP}} \frac{N \times L_h}{1 + L_h} = \frac{2\pi}{I_{CP}} NTR_{Ref} \checkmark$$ (Low Pass)

$$NTF_R = \frac{\phi_{out}}{V_R} = \frac{2\pi K_{VCO}/s}{1 + L_h} \times \frac{1/sC_2}{\frac{1}{sC_2} + R + \frac{1}{sC_1}}$$ (band pass)

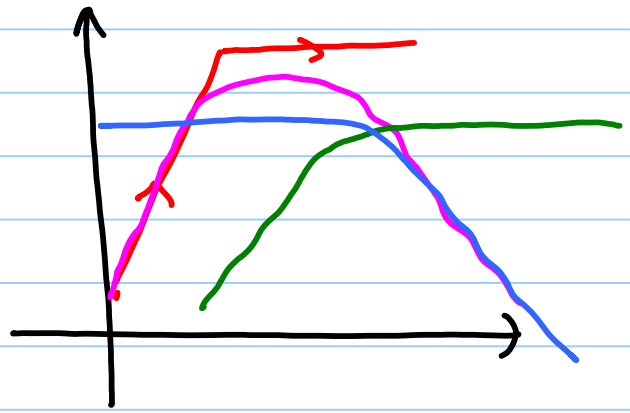
$$= \frac{2\pi K_{VCO}}{s} \frac{1/sC_2}{\frac{sRC_1C_2 + C_1 + C_2}{sC_1C_2}} \times \frac{1}{1 + L_h}$$

$$= \frac{C_1}{C_1 + C_2} \frac{2\pi K_{VCO}}{s} \times \frac{1}{1 + \frac{sRC_1C_2}{C_1 + C_2}} \times \frac{1}{1 + L_h}$$

$$= \frac{2\pi s}{I_{CP}(1 + sRC_1)} \frac{N \times L_h}{1 + L_h}$$

$$NTF_{VCO} = \frac{1}{1 + L_h} \checkmark$$ (high pass)

$$= \frac{N \times L_h}{1 + L_h} \frac{1}{N \times L_h}$$



$$S_{n,total}^{\phi_{out}} = S_{n,ref}^{\phi_{out}} + S_{n,CP}^{\phi_{out}} + S_{n,R}^{\phi_{out}} + S_{n,VCO}^{\phi_{out}} + S_{n,div}^{\phi_{out}}$$

$$= S_n^{ref} |NTF_{ref}|^2 + S_n^{CP} \times |NTF_{CP}|^2 + S_n^{R} |NTF_R|^2$$

$$+ S_n^{VCO} |NTF_{VCO}|^2 + S_n^{div} |NTF_{div}|^2$$

$$\int S_{n,total}^{\phi_{out}} \cdot df = \left(\phi_n^{out}\right)^2 \qquad \phi = 2\pi \frac{\Delta t}{T}$$

$$\sigma_{\Delta t}^2 = \left(\frac{T}{2\pi}\right)^2 \int S_{n,total}^{\phi_{out}} \cdot df$$

$$\sigma_{\Delta t} = \frac{T}{2\pi} \sqrt{\int S_{n,total}^{\phi_{out}} \cdot df}$$

(R.M.S Jitter)