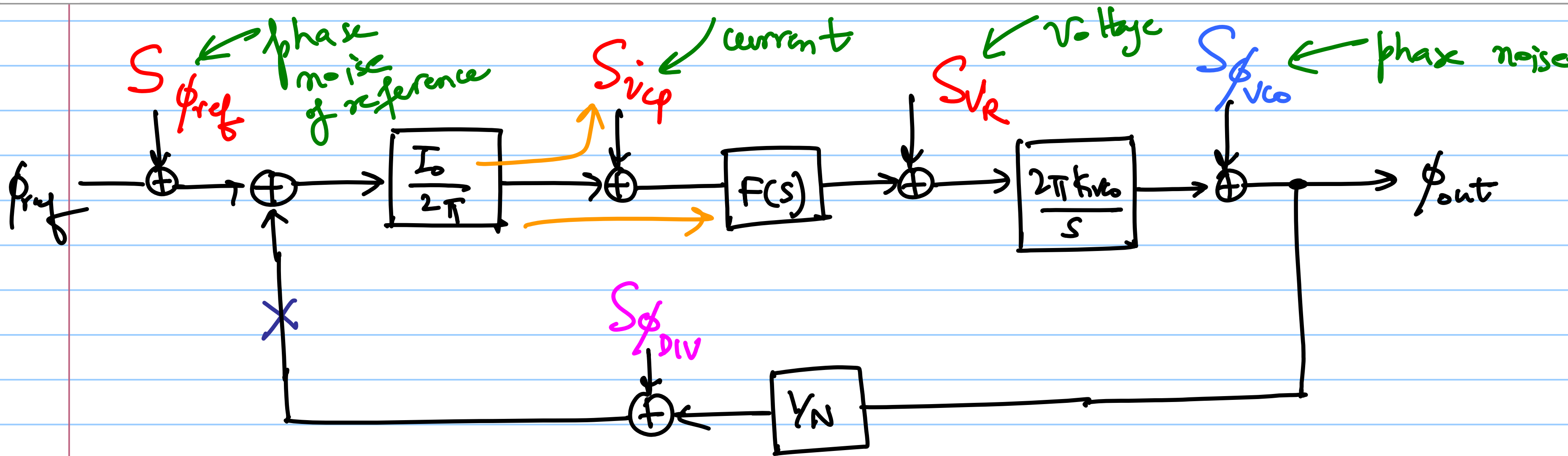
ECE 504 - Lecture 21

Note Title 11/7/2016



loop gain $L(s) = \frac{I_o K_{VCO}}{N} \cdot \frac{F(s)}{s}$

Noise Transfer Function

$$NTF_{ref}(s) = \frac{\phi_{out}(s)}{\phi_{ref}(s)} = \frac{N \cdot L(s)}{1 + L(s)}$$

low-pass response

$$NTF_{DIV}(s) = NTF_{ref}(s)$$

$I_{cp} = I_o$

$$NTF_{cp}(s) = \frac{\phi_{out}(s)}{i_{cp}(s)} = \frac{NTF_{ref}(s)}{I_{cp}/2\pi} = \frac{2\pi}{I_{cp}} \cdot NTF_{ref}(s)$$

low-pass

NTF_{ref} divided by CP gain

$$NTF_R(s) = \frac{\phi_{out}(s)}{v_R(s)} = \frac{\frac{2\pi K_{vco}}{s}}{1 + L(s)}$$

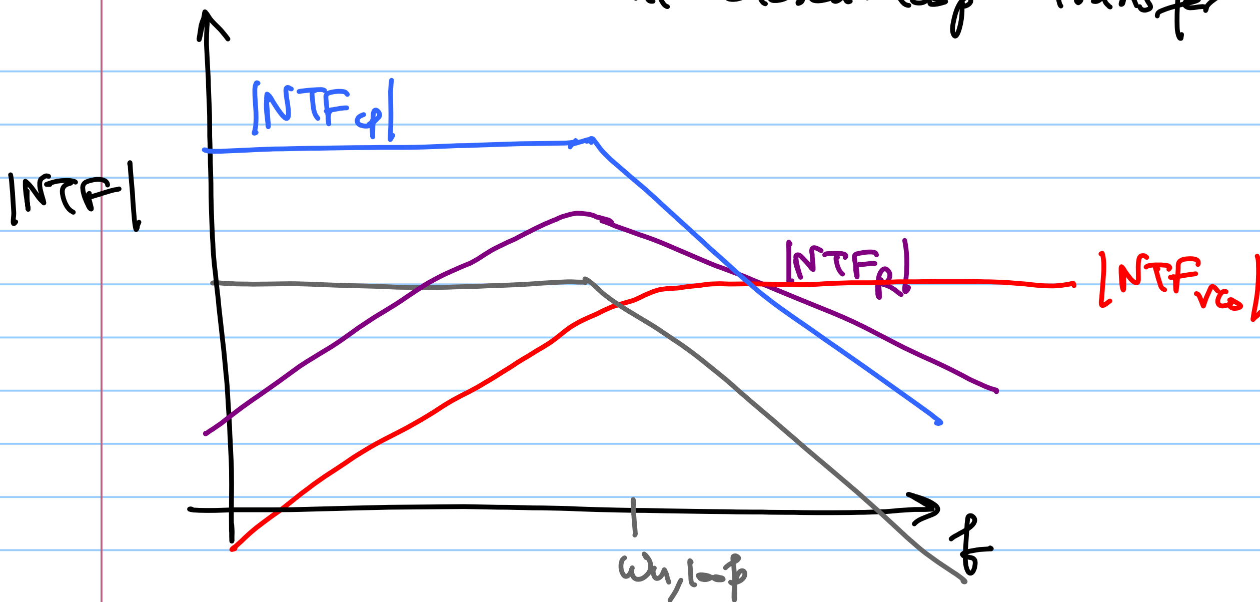
Same ∂^r as NTF_{ref}

Band pass Response

$$NTF_{VCO}(s) = \frac{\phi_{out}(s)}{\phi_{VCO}(s)} = \frac{1}{1+L(s)}$$

High-pass Response

All closed-loop Transfer functions

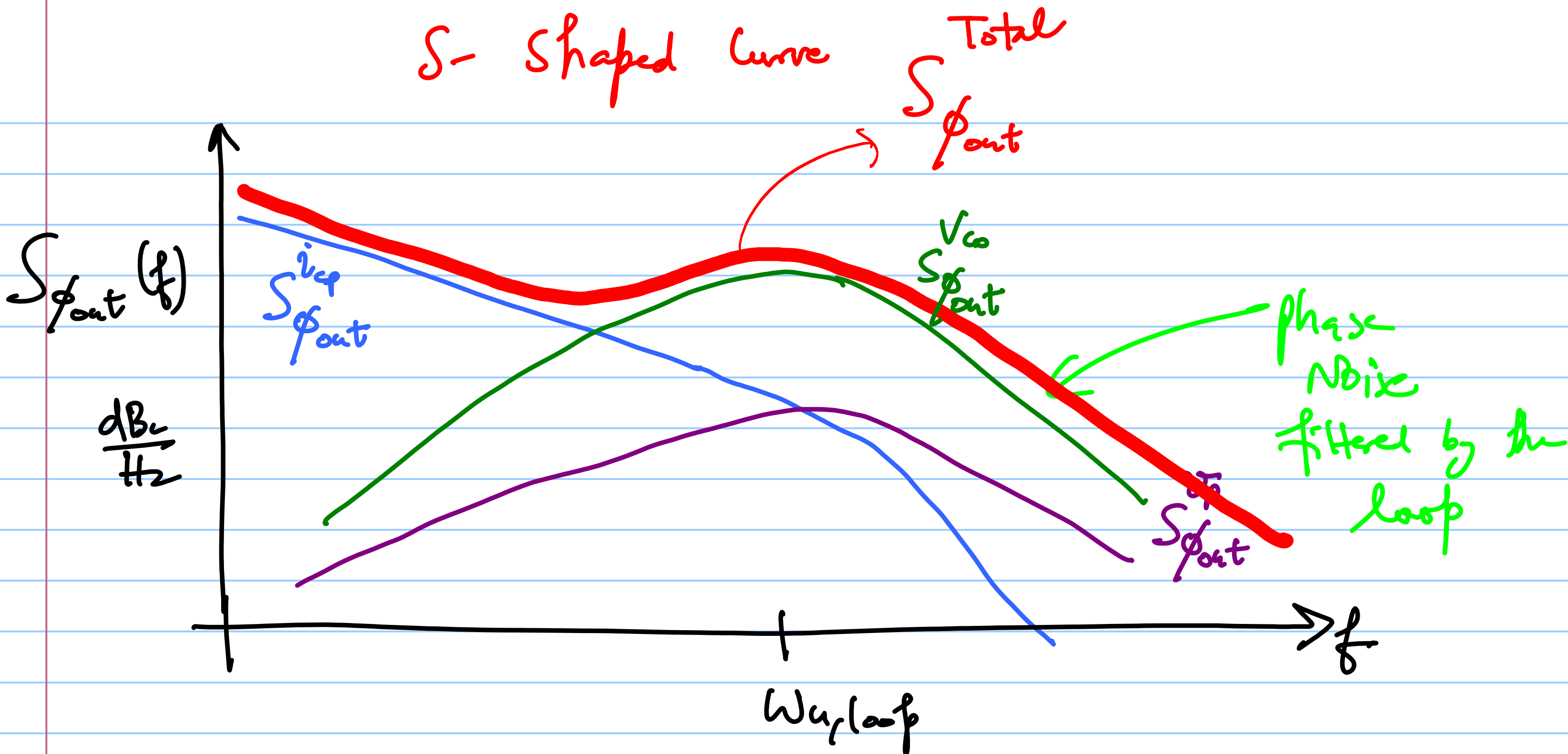


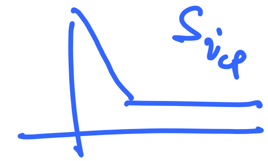
Output Phase Noise Contribution

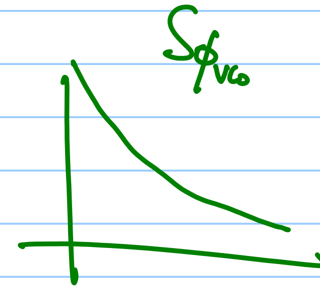
$$S_{\phi_{out}}^{\phi_{ref}} = S_{\phi_{ref}} \left| NTF_{ref}(j\omega) \right|^2$$

$$S_{\phi_{out}}^{Total} = S_{\phi_{out}}^{\phi_{ref}} + S_{\phi_{out}}^{i_{cp}} + S_{\phi_{out}}^{V_R} + S_{\phi_{out}}^{\phi_{vco}} + S_{\phi_{out}}^{DIV}$$

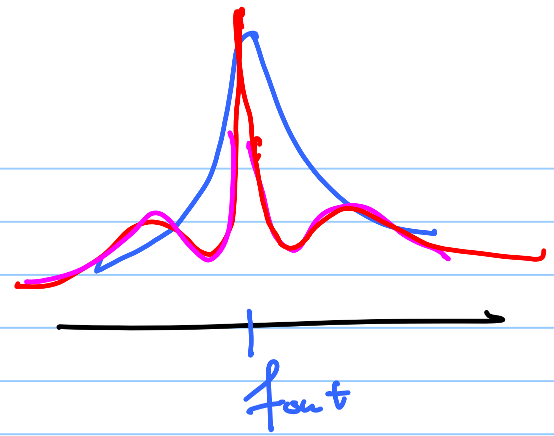
S- Shaped Curve







Total
ϕ_{out}
0
f



f_{out}

Calculating Jitter from Phase Noise

$$\text{Total phase Noise} = \sigma_{\Delta\phi}^2 = \int_0^{\infty} S_{\phi_{out}}^{Total}(f)\cdot df$$

Variance of phase Noise (also the phase noise power)

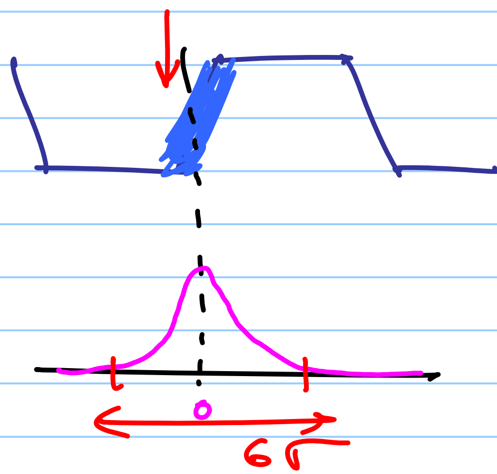
↳ (in radians)

Jitter : Standard deviation

$$\sigma_{\Delta T} = \sqrt{\int_0^{\infty} S_{out}^{Total}(f)\,df} \times \frac{T_{VCO}}{2\pi}, \text{ (sec)}$$

* In MATLAB trapz function for discrete integration

Jitter is usually represented as ps rms



Jitter → random jitter → total phase noise

Jitter → deterministic jitter → spurs

deterministic jitter → power supply induced jitter

PLL Noise Optimization

① Start with $\omega_{u,loop} < \frac{\omega_{ref}}{10}$

② Find loop parameters (K_{VCO}, I_{cp}, R, C_1 & C_2)

③ Estimate the PSD of all noise sources ($\overline{S^{i}_{\phi out}}$)

④ Find total output phase noise $S^{Total}_{\phi out} \longrightarrow \sigma_{jitter}$

⑤ If total phase noise doesn't meet the spec

↳ adjust BW and/or lower noise

⑥ If the spec is met, reduce power

$$S_{v_R} \propto K_{v_{co}}^2 \cdot R$$