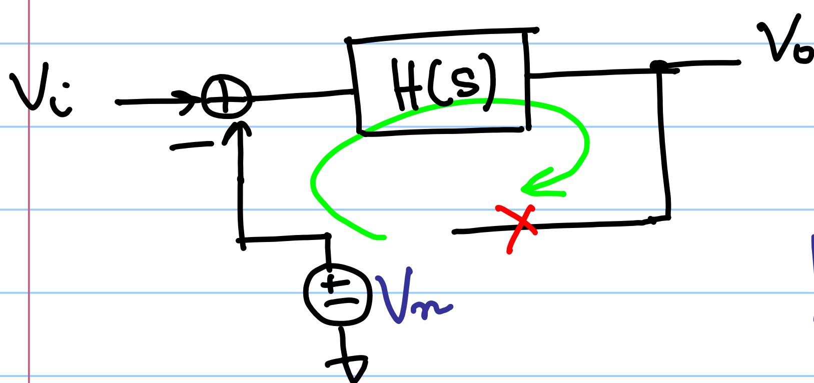
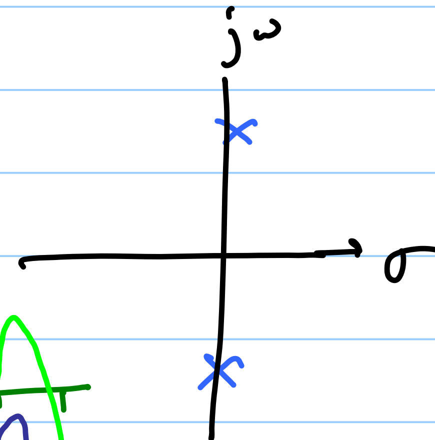
ECE 518 – Lecture 19

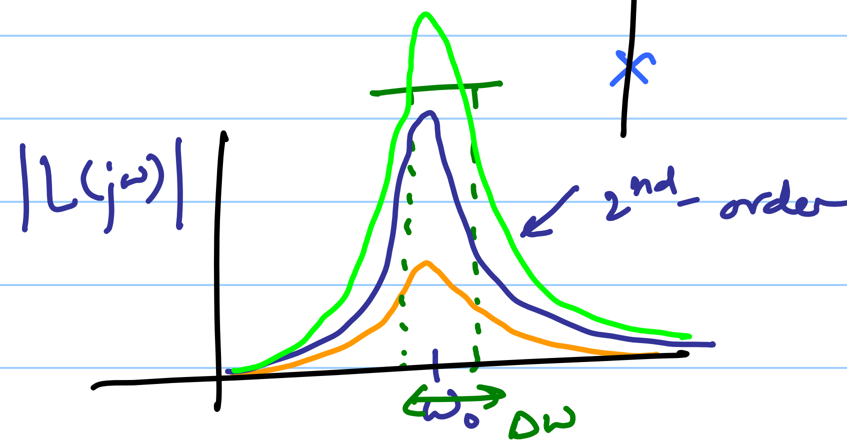
Note Title 3/19/2015

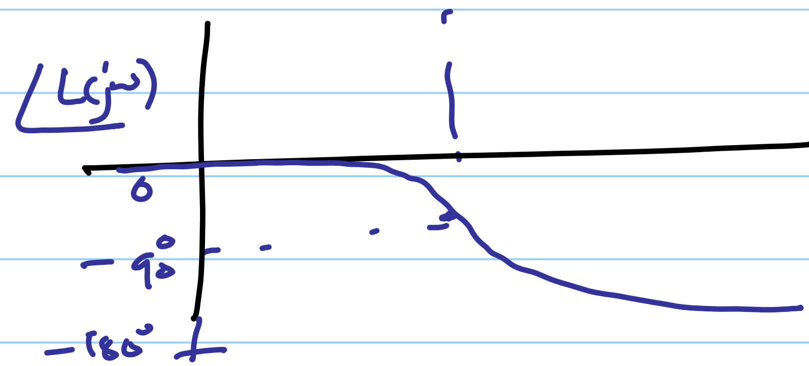
Phase Noise Overview:

Oscillator

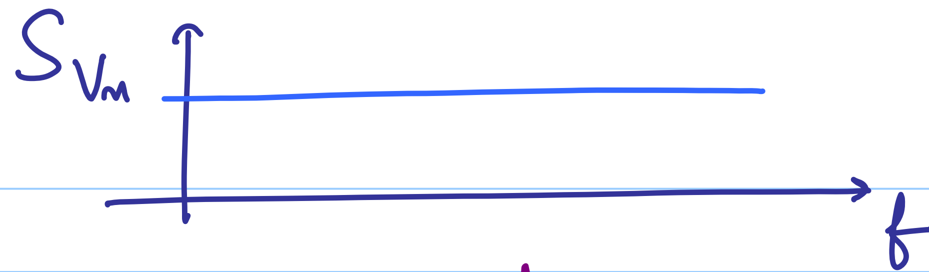




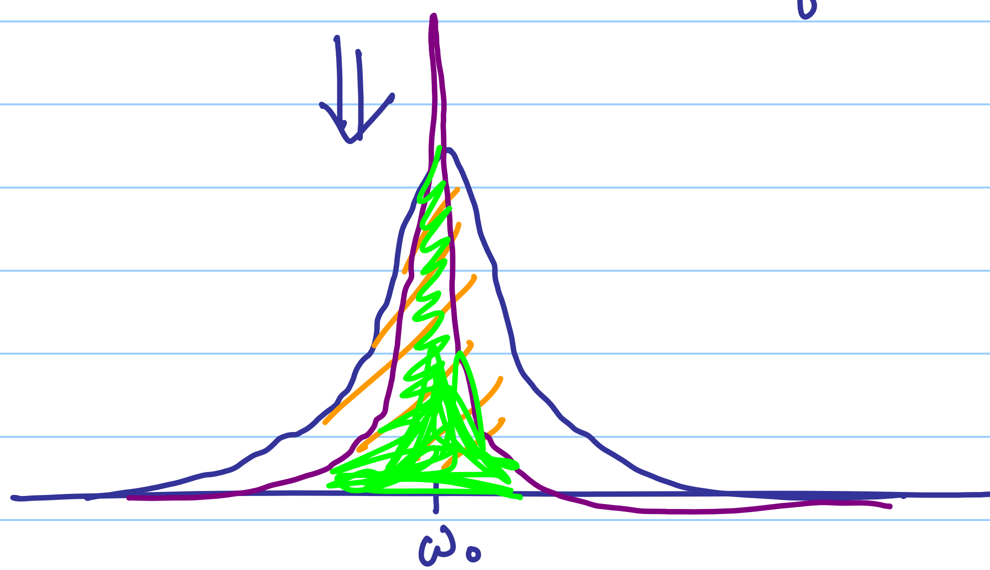


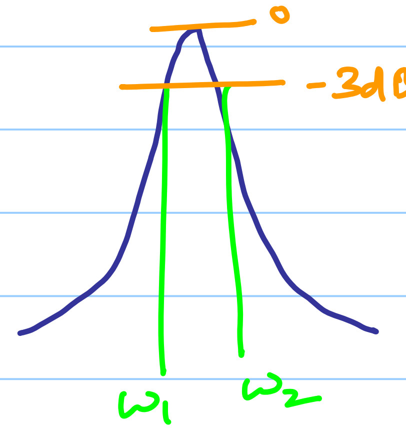


$$Q \propto \frac{\omega_0}{\Delta\omega}$$



white noise





$$\Delta\omega = |\omega_2 - \omega_1|$$

$$\omega_0 = \sqrt{\omega_1 \omega_2}$$

Noise Sources

Deterministic

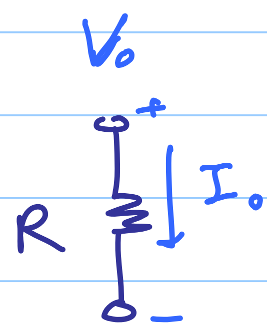
- Supply noise
- Coupling
- Substrate noise

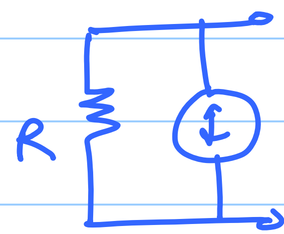
PLL → reference feedthrough

Random (CMOS)

- Thermal
- Flicker

Thermal Noise

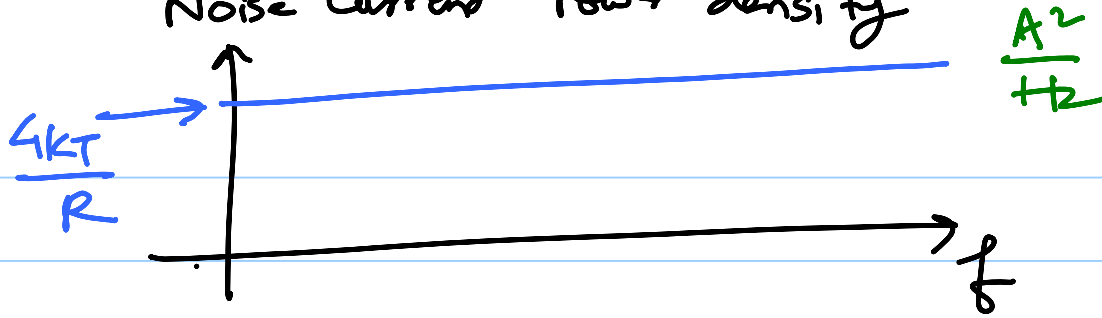




$$\overline{I_n^2} = \frac{4kT}{R}$$

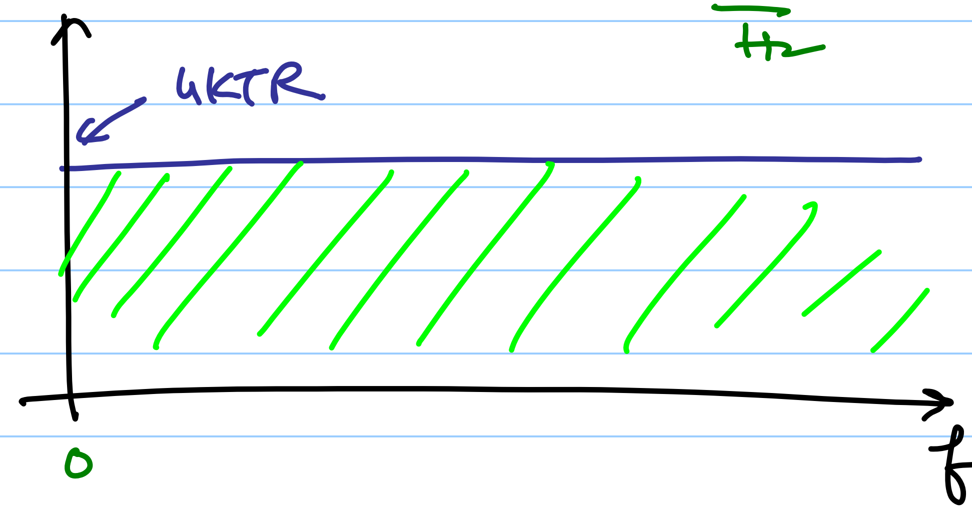
power in 1 Hz BW

Noise Current Power density



Noise Power density

$\overline{V_n^2} = 4kTR$

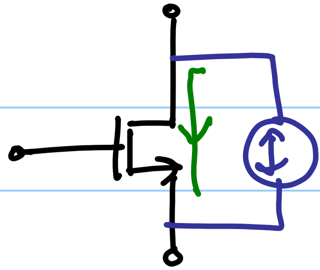


$\overline{V_n^2} \propto R$

$\propto T$

Thermal Noise in MOSFET

SAT

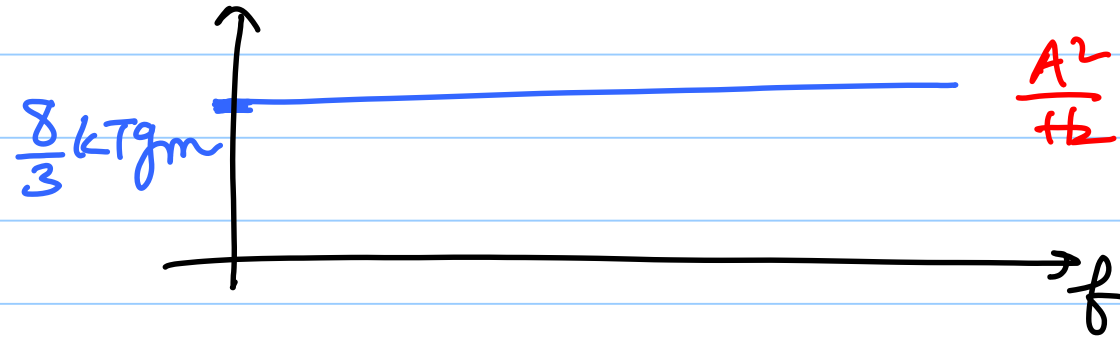


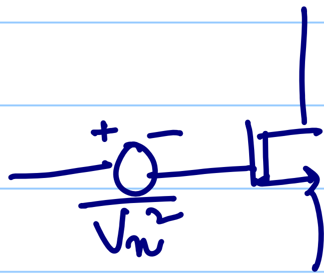
$$\overline{I_n^2} = 4kT\gamma g_m$$

Tech dependent

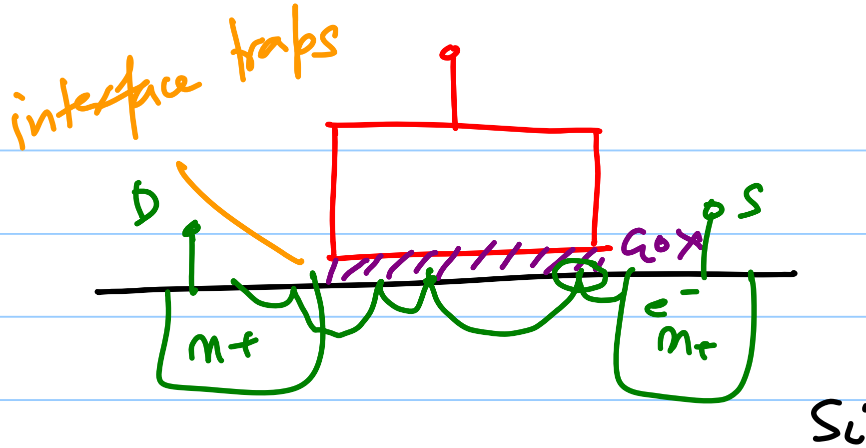
Long-channel $\Rightarrow \frac{2}{3}$

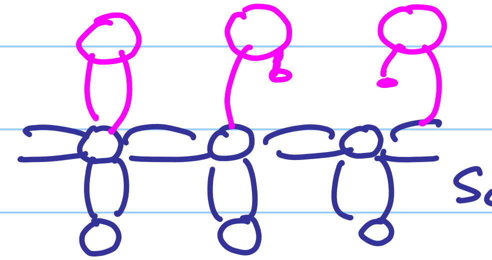
charge flows thru resistive channel

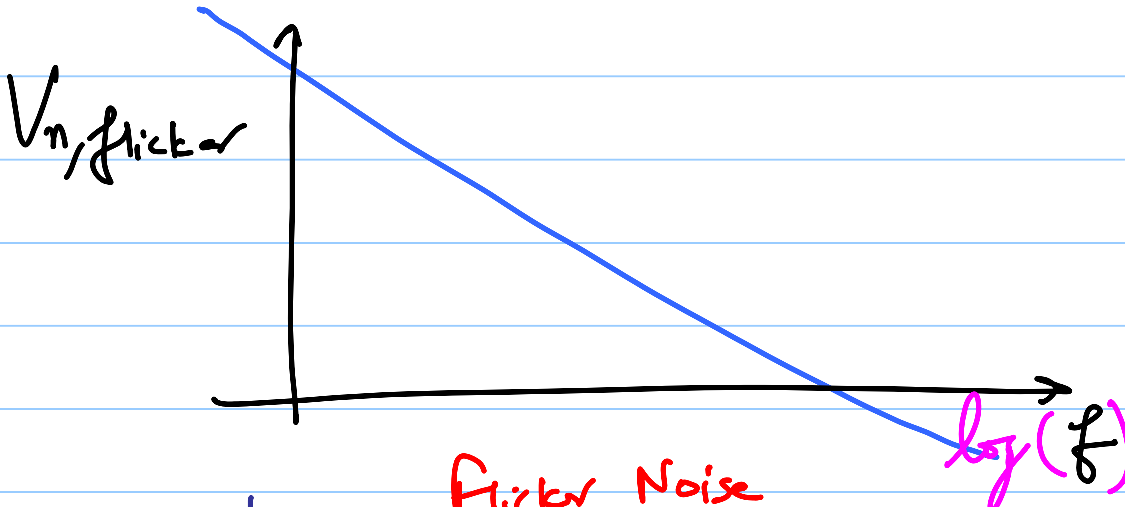




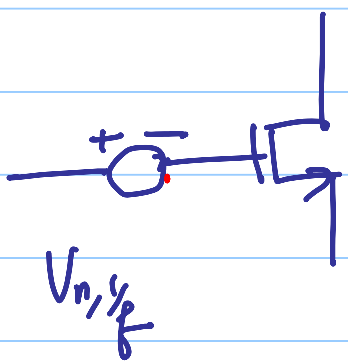
$$\overline{V_n^2} = \frac{\overline{I_n^2}}{g_m^2} = \frac{4kT\gamma}{g_m}$$



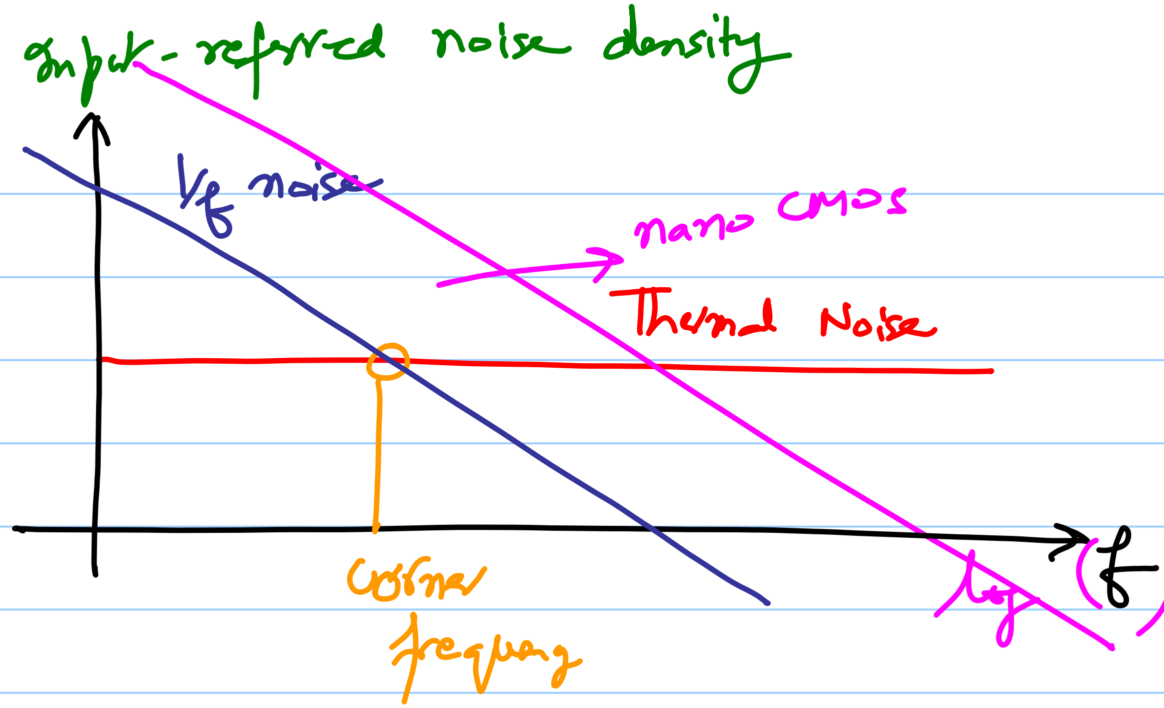




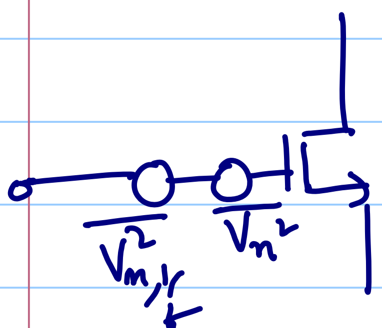
Flicker Noise



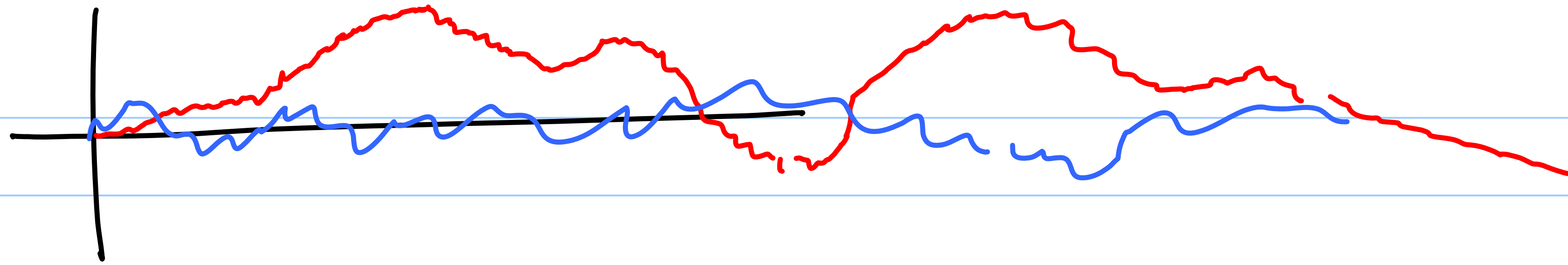
$$V_{n,1/f} \propto \frac{1}{f} = \frac{K}{C_{ox}WL}\cdot\frac{1}{f}$$

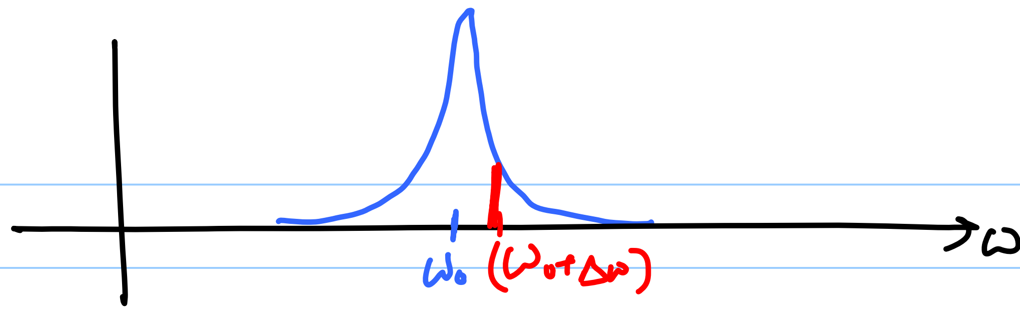


input-referred noise density
1/f noise
nano CMOS
Thermal Noise
corner frequency
log (f)



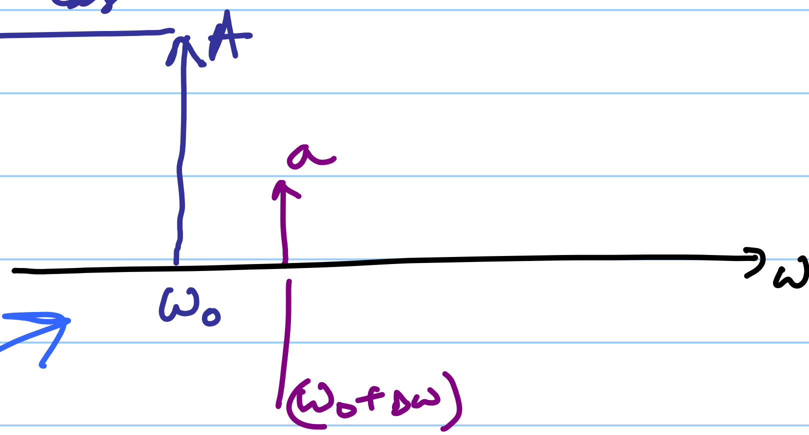
$\overline{V_{n,1/f}^2}$
$\overline{V_n^2}$





Simple case

$A\cos\omega_0 t$



$a << A$

Lets say the carrier is at ω_0 & there is an additive noise in a 1 Hz Bandwidth centered at $\omega_0 + \Delta\omega$.

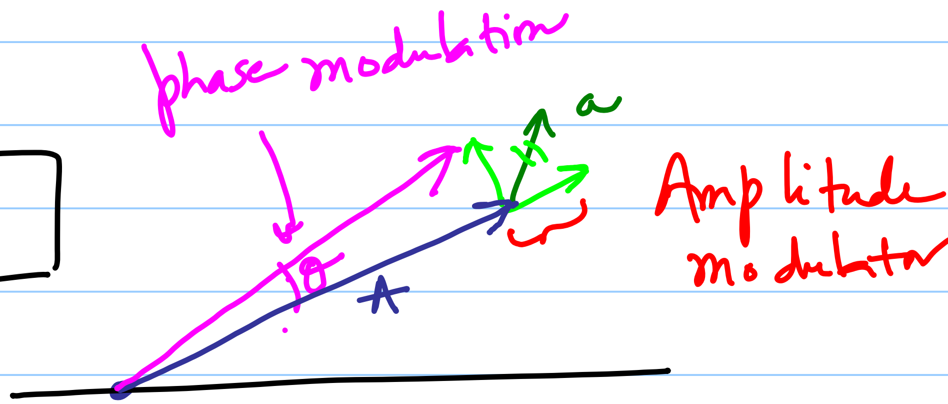
$$x(t) = \underbrace{A\cos\omega_0 t}_{\text{carrier}} + \underbrace{\boxed{a\cos(\omega_0+\Delta\omega)t}}_{\text{noise component.}}$$

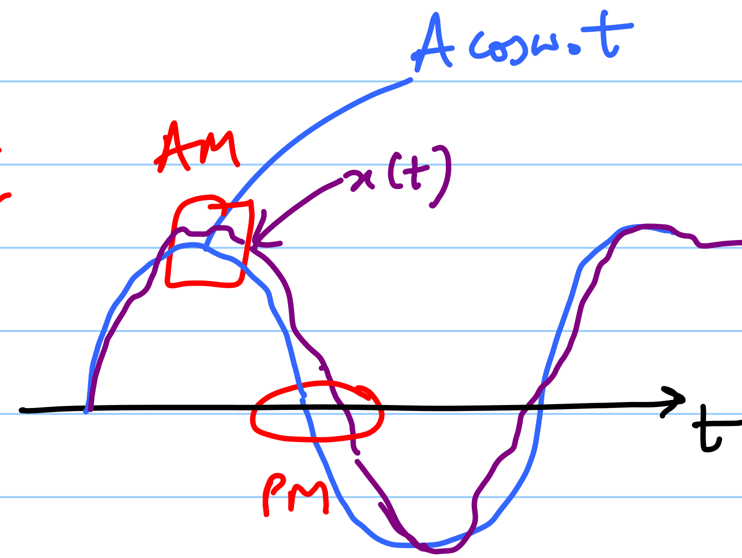
overall waveform:

↳ we expect the additive component to produce both amplitude & phase modulation of the carrier

↳ let's express $x(t)$ in polar form (phasor)

$\boxed{\text{phasor}}$



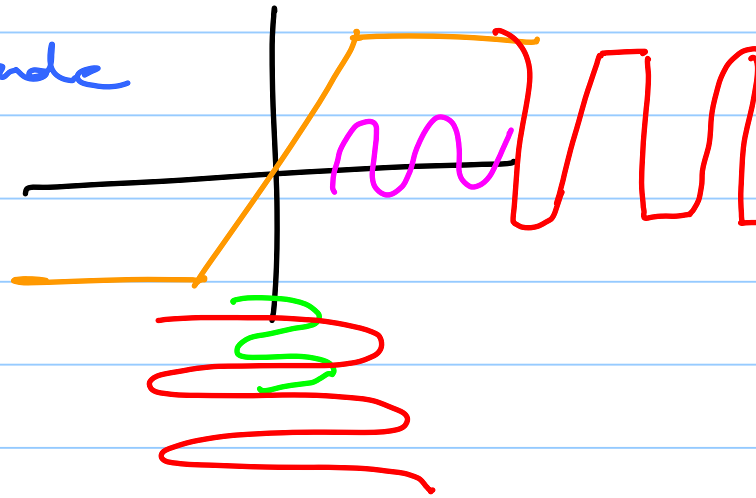


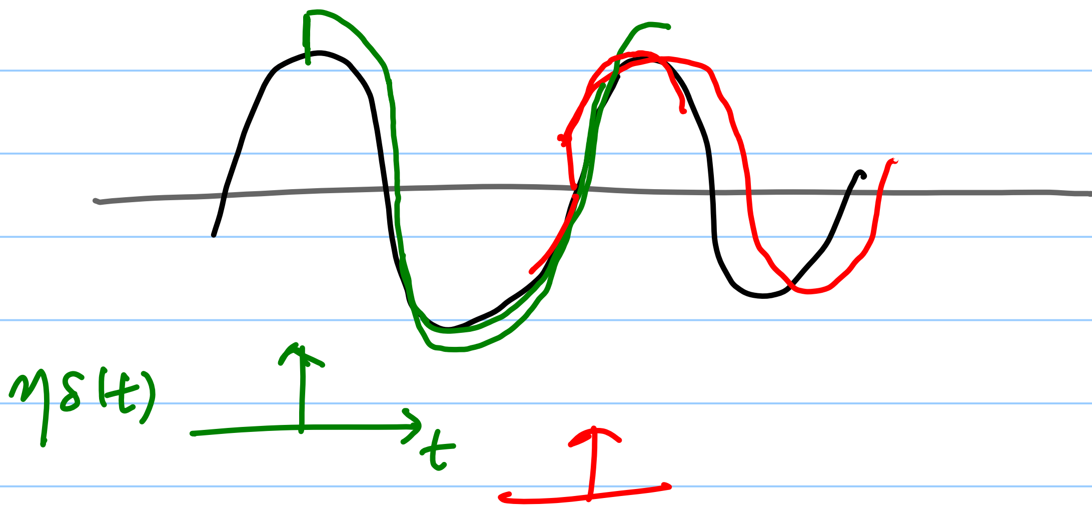
* Both AM & PM

* The composite signal is applied to a hard limiter

↳ the circuit clips the magnitude & hence removes the AM

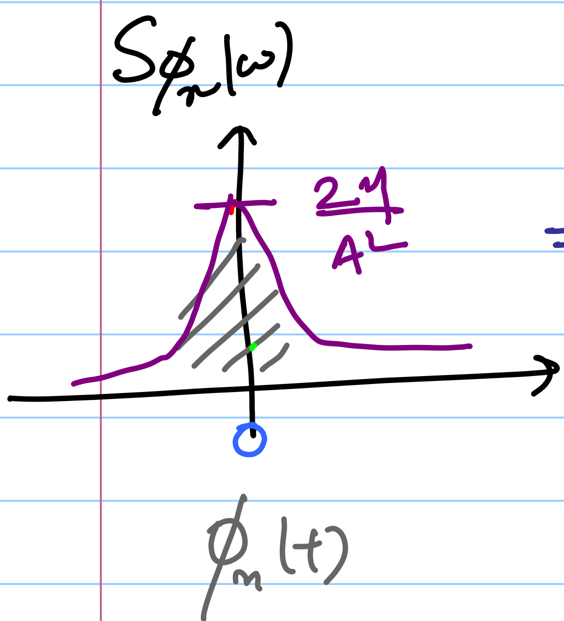
↳ only phase modulation remains



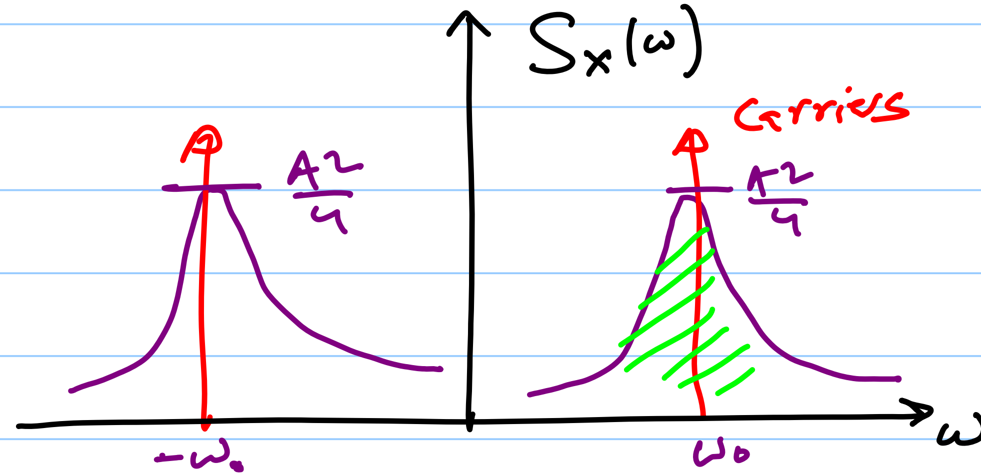


$$x_{lim}(t) \simeq \frac{A}{2}\cos\Big(\omega_0 t - \underbrace{\frac{2a}{A}\sin\Delta\omega t}_{\text{phase noise}}\Big)$$

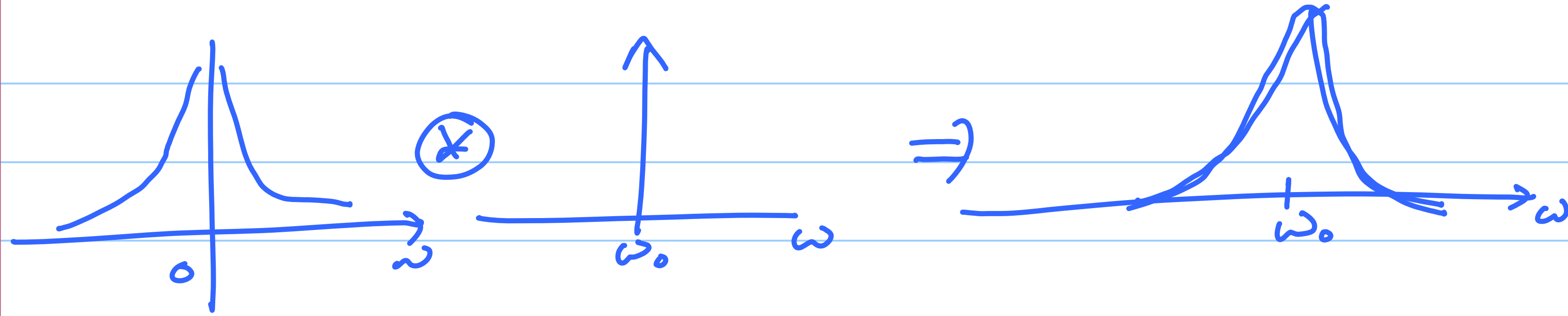
+ original additive component at $(\omega_0+\Delta\omega)$ is translated down to ω_0, shifted by $90°$ & normalized by $\frac{A}{2}$

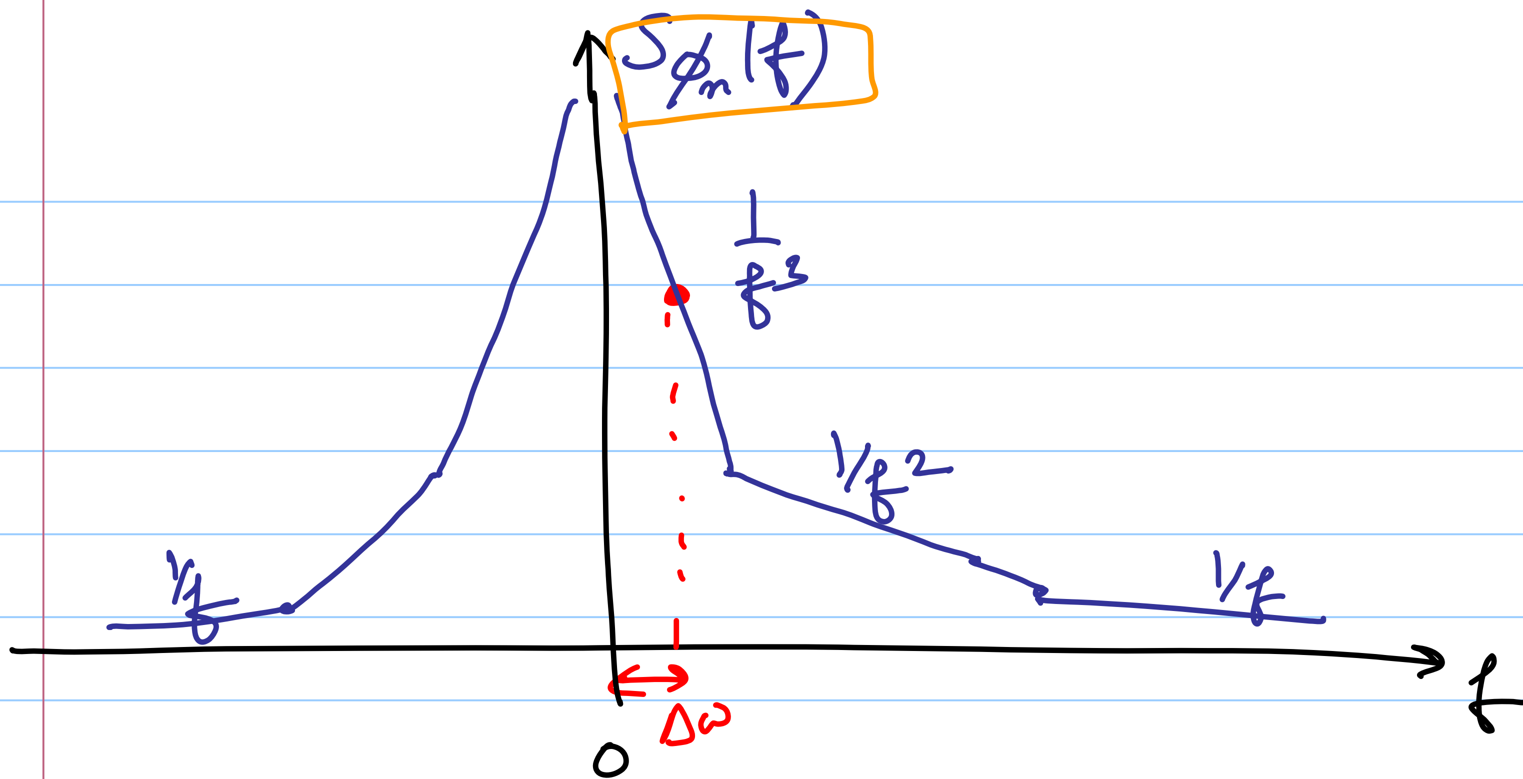


$\Rightarrow$

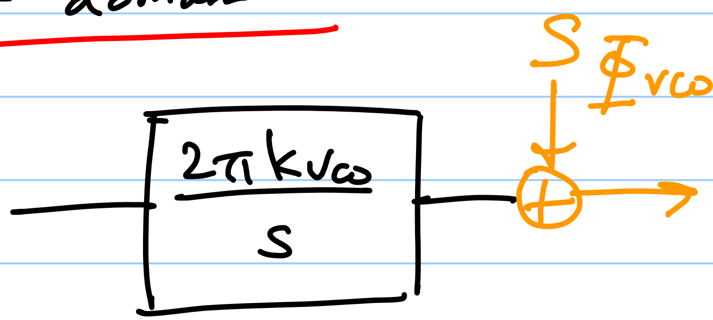


$$x(t) = A\cos(\omega_0 t + \phi_n)$$


0
ω
⊗
ω₀
ω
⇒
ω₀
ω



In phase domain Model



Noise in PLL (Phase domain Model)