Queue is open:

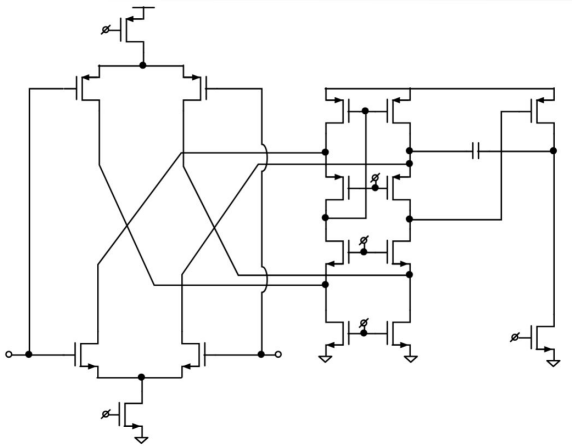
DP2 Recitation (4:10 ~)

Ching-Yi Lin

Outline

- Testbench & SPECs
- Stability and Phase Margin
- Advices
- OH

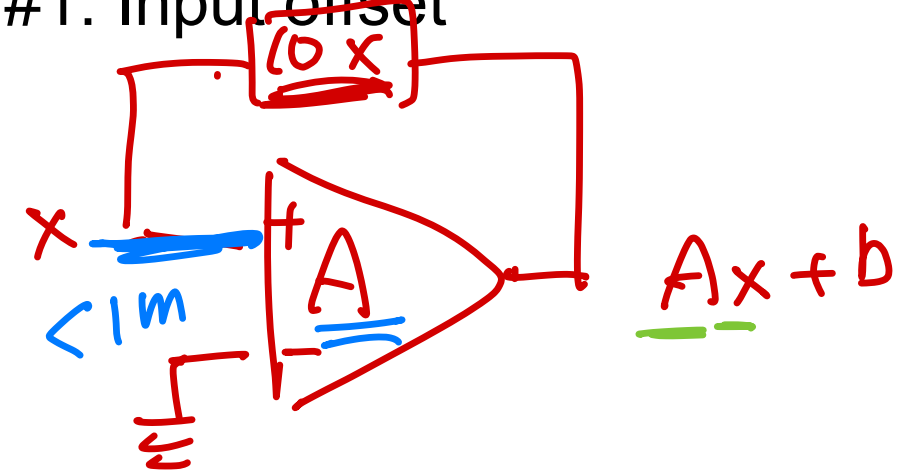
Current Result



VCM		-100m	0	100m
OLG	> 600	**685**	**705**	**697**
IN_OFFSET	< 1m	**0.92**	**0.22**	**0.97**
ULGF	> 100M	**237**	**271**	**311**
PM	> 70	**84**	**81**	**76**
POS_SR	> 100	**164**	**192**	**217**
NEG_SR	> 100	**132**	**140**	**134**
POS_SW	> 500m	**557**	**596**	**594**
NEG_SW	> 500m	**527**	**523**	**552**
PWR	< 550u	**535**	**543**	**548**

SPEC & Testbench #1: Input offset

- Open Loop
  - ~~Gain~~
  - Input offset < 1m
  - ~~Power~~
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing

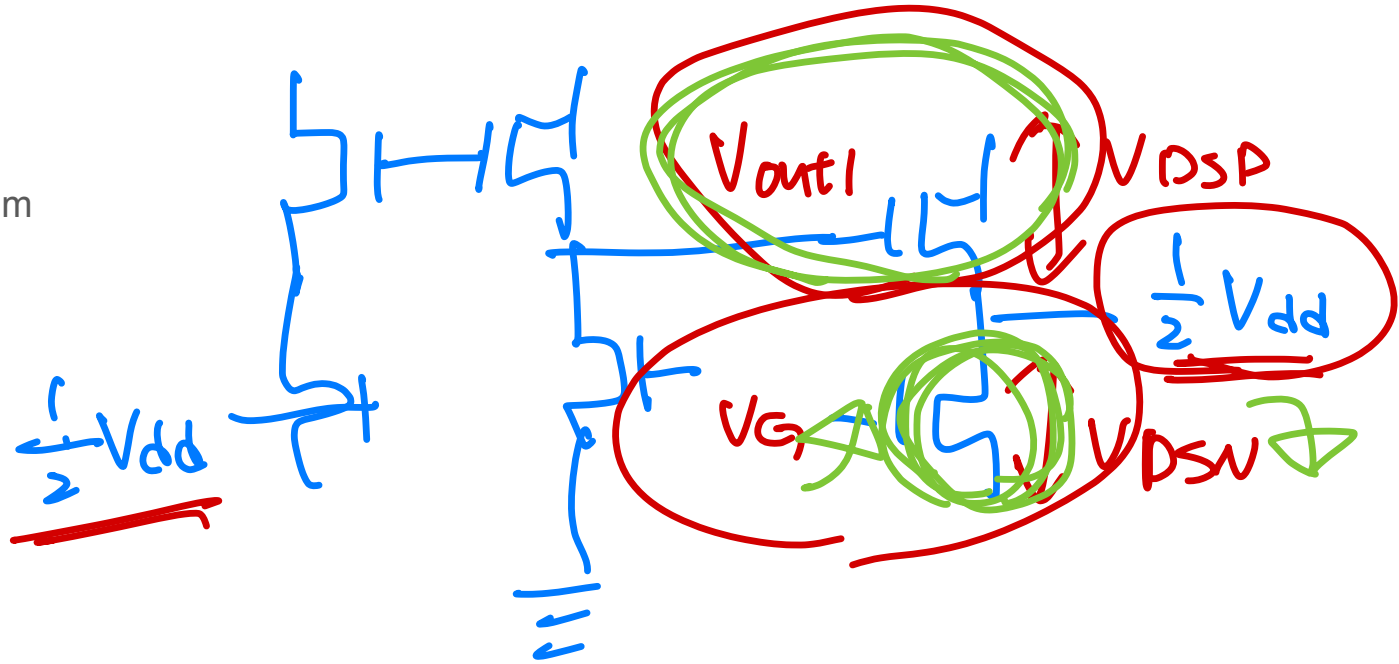


$$10(Ax+b)=x$$

$$x=\frac{10b}{10A+1}$$

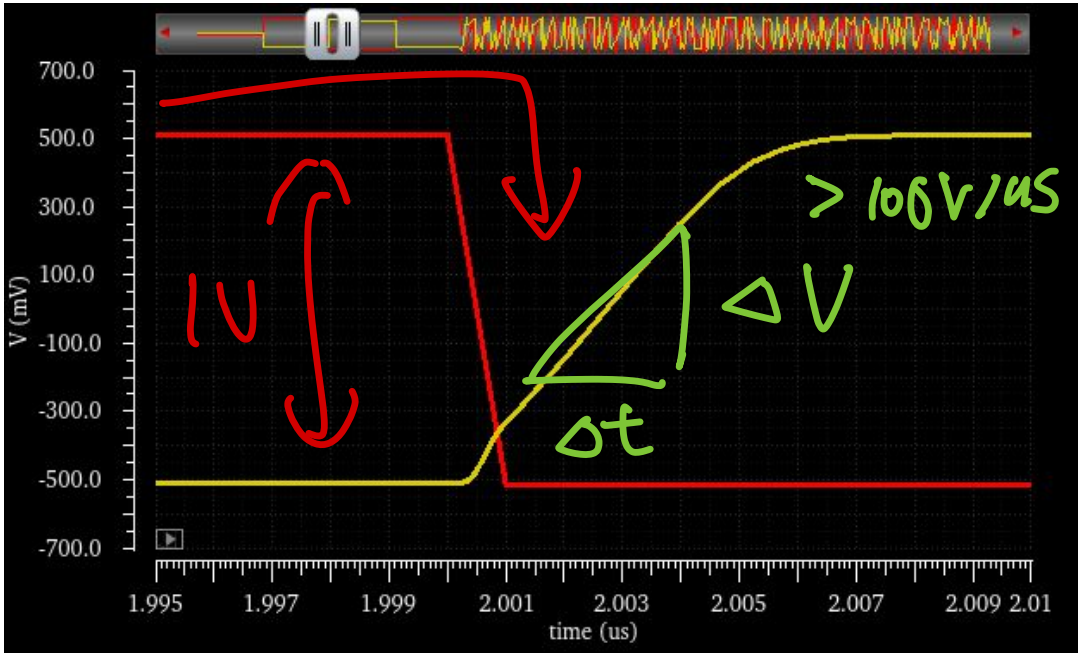
SPEC & Testbench #1: Input offset

- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing



SPEC & Testbench #2: Slew

- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing

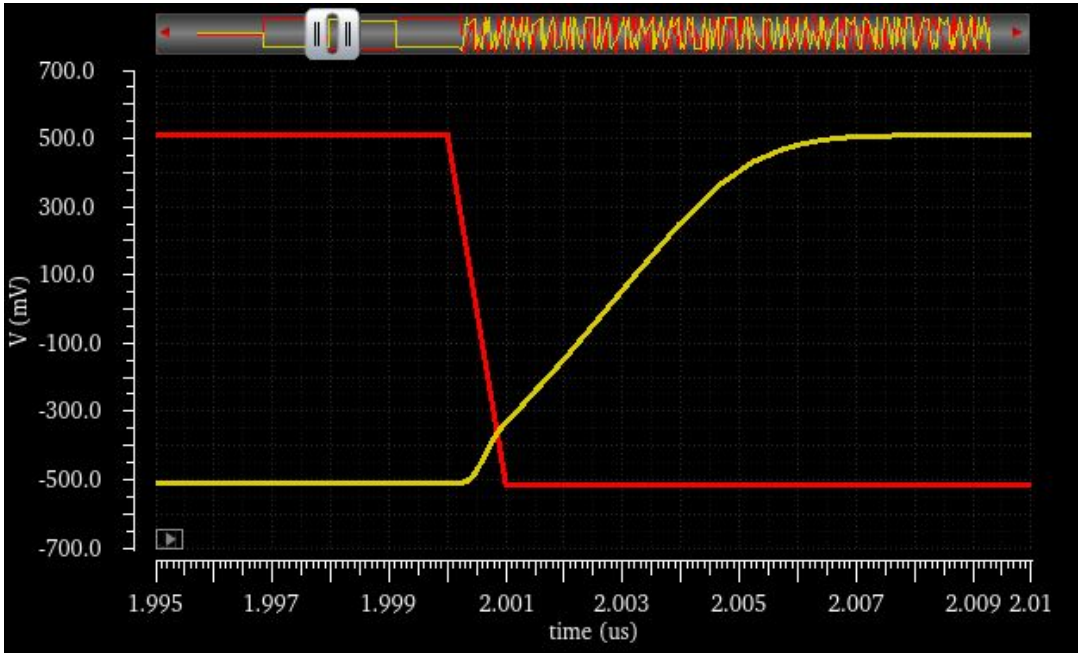


SPEC & Testbench #2: Slew

$I = C \times \frac{dv}{dt} \Rightarrow \frac{dv}{dt} \approx \frac{I}{C}$

$C_{LOAD} = 500fF$

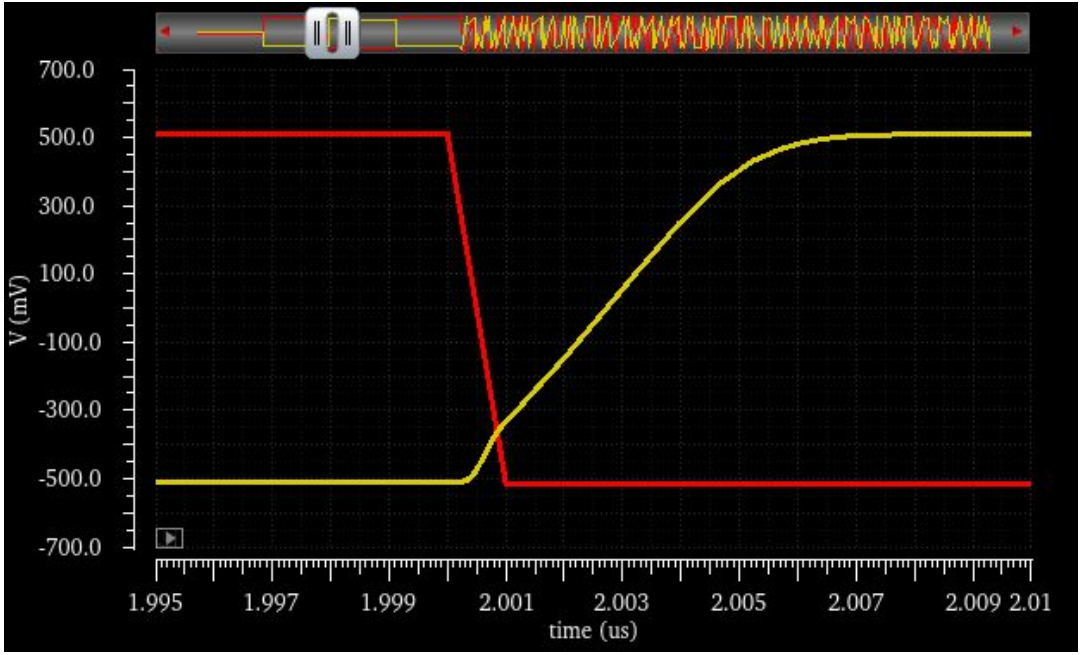
- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing



SPEC & Testbench #2: Slew

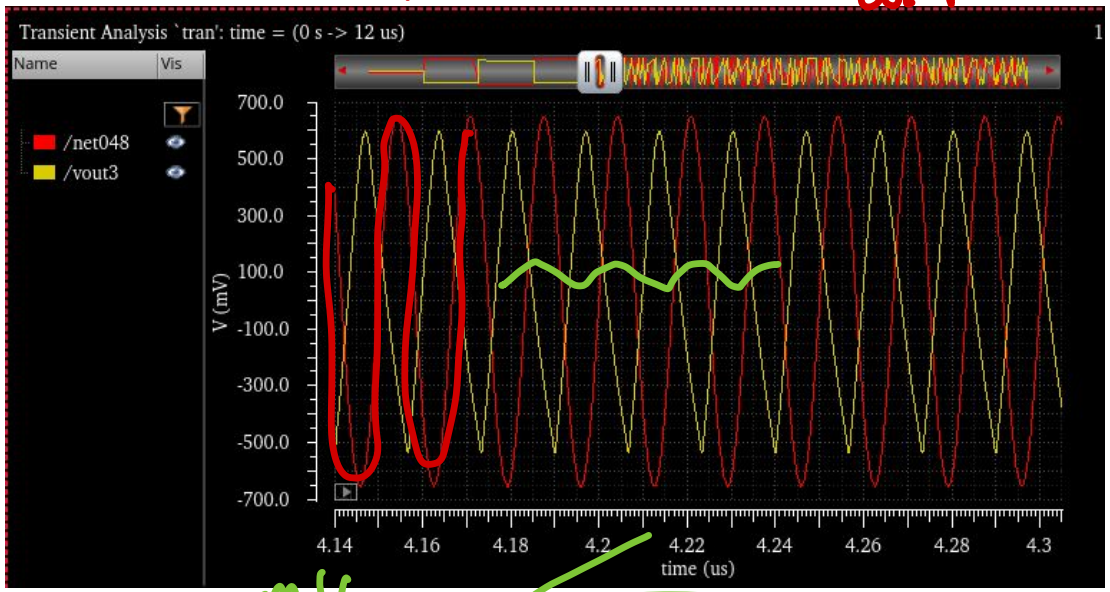
$\frac{I}{C} = 100\ V/\mu s = \frac{I}{500fF}$

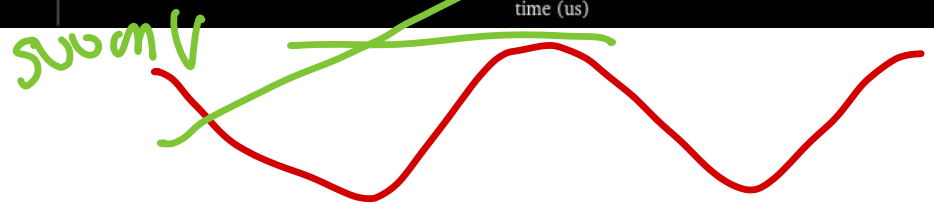
- Open Loop $I = 50\mu$
  - Gain
  - Input offset < 1m
  - Power 175 μW
- Loop Gain
  - Unit Gain Freq 550M W
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing



SPEC & Testbench #3: Swing

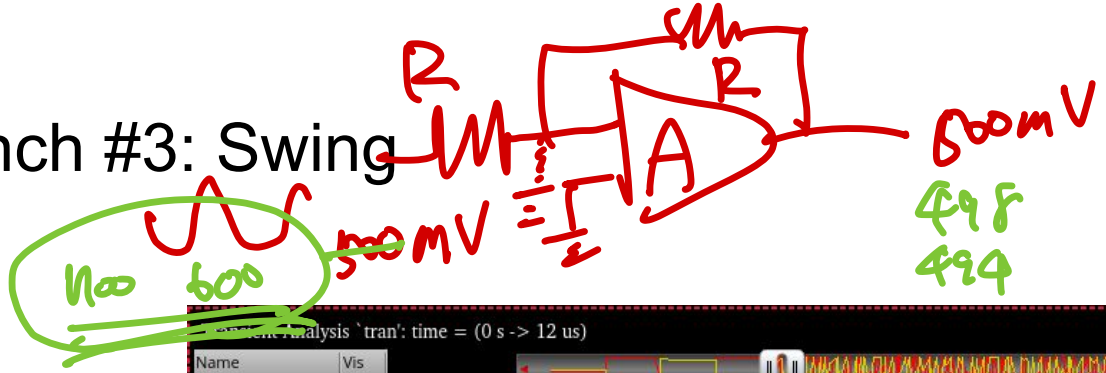
- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing

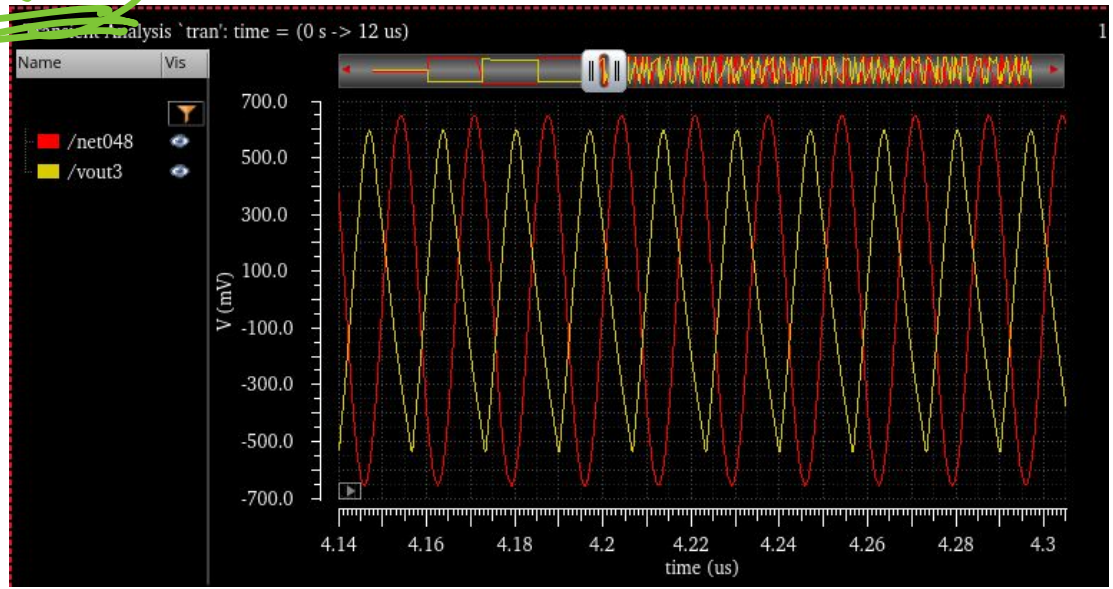




SPEC & Testbench #3: Swing

- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing



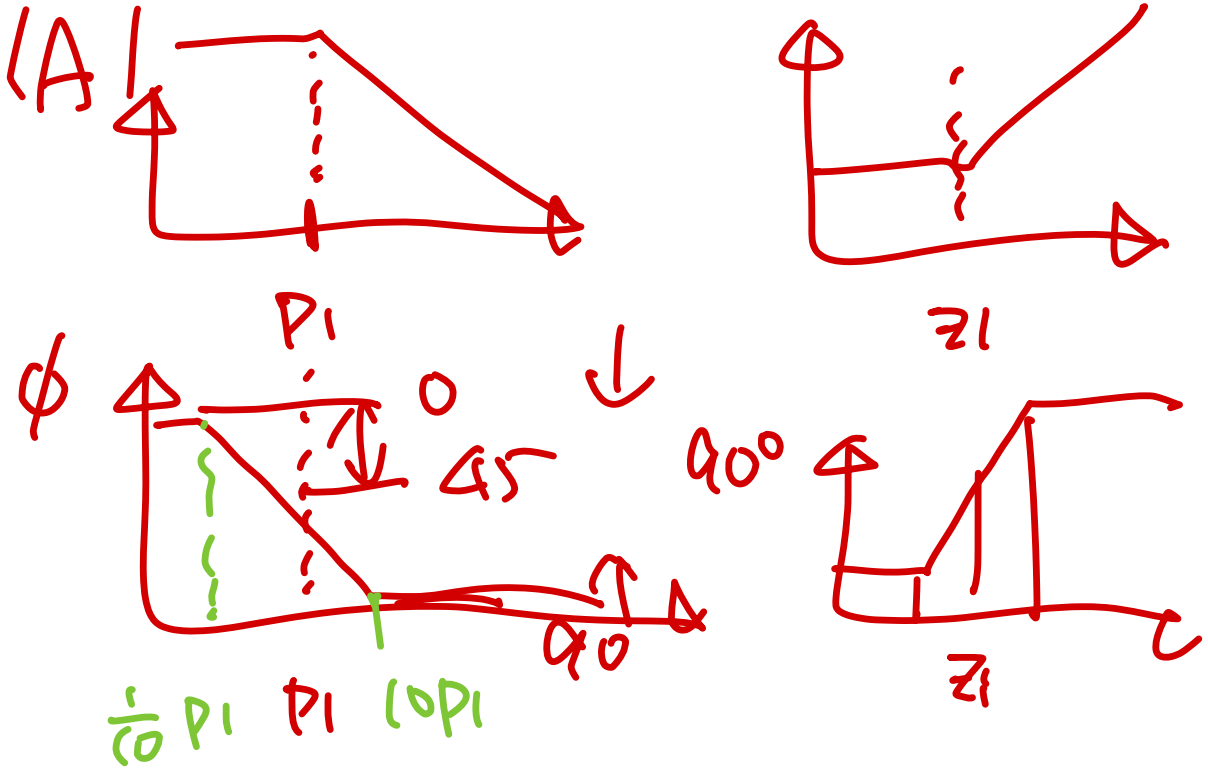


Testbench

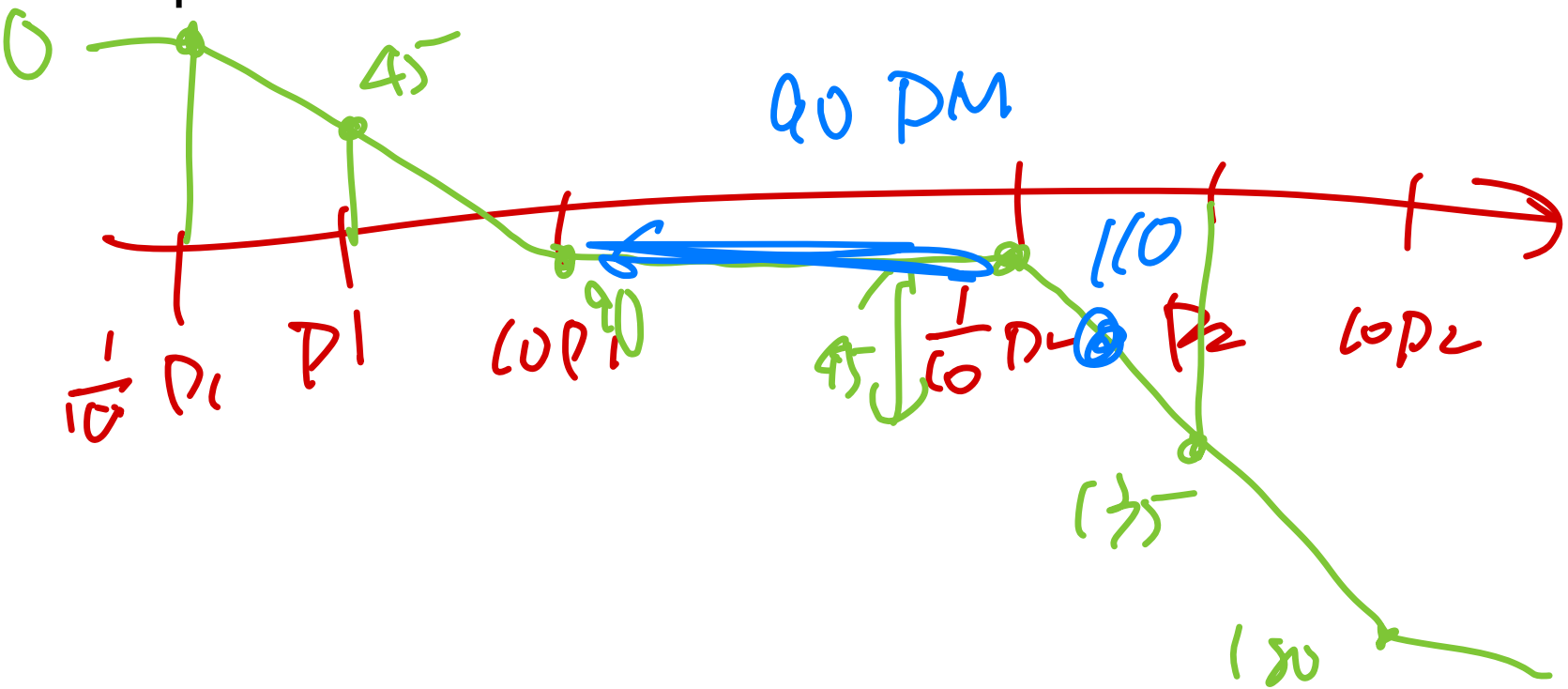
- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing

Recap: Bode Plot

pole slope 20 dB/dec
−90° phase

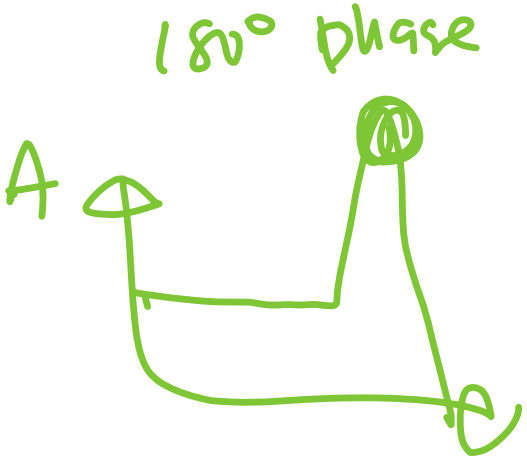


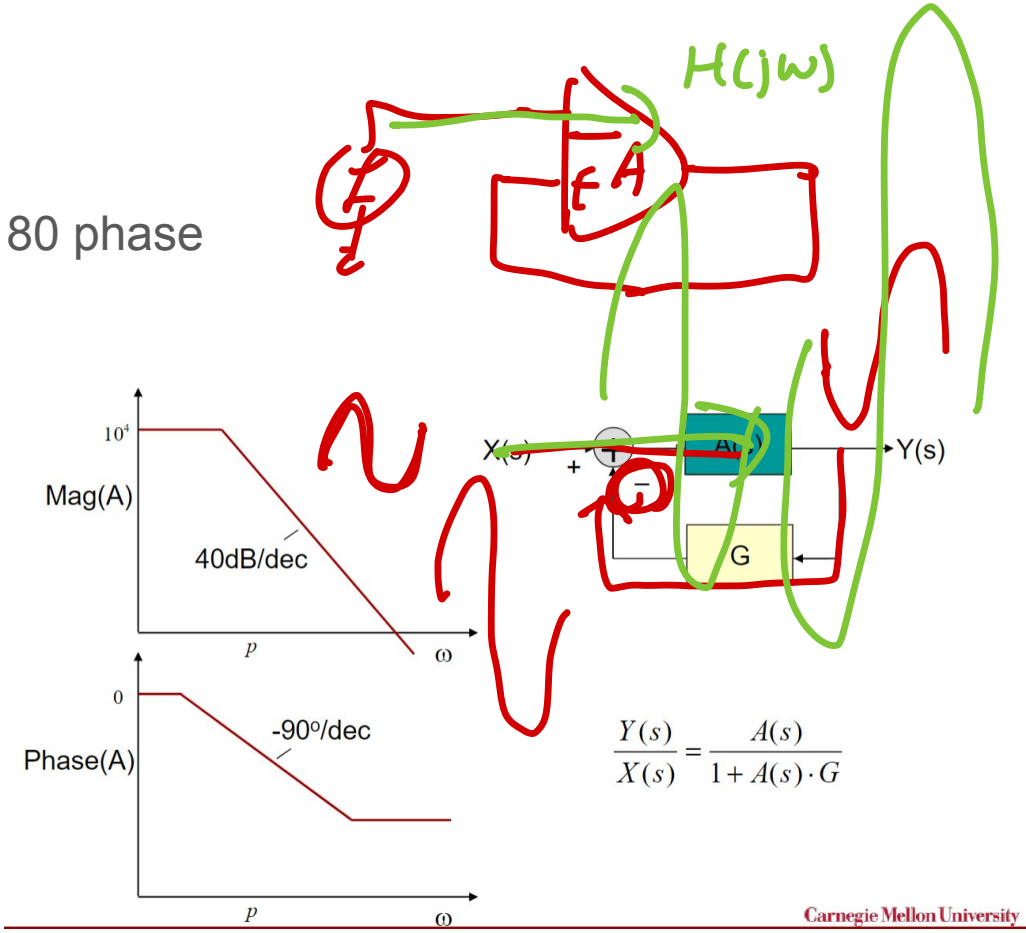
Recap: Bode Plot



Stability

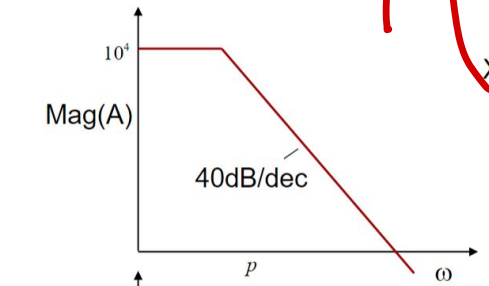
- Criteria: Gain < 1 when A(s) has 180 phase

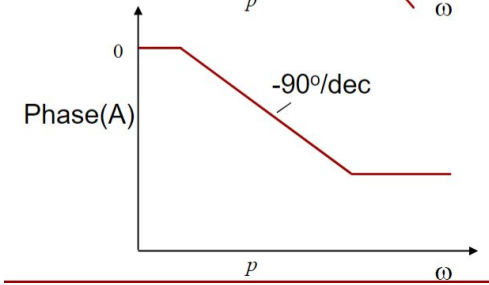


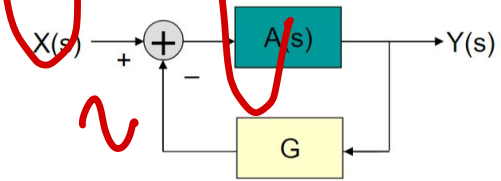


Stability

- Criteria: Gain < 1 when A(s) has 180 phase





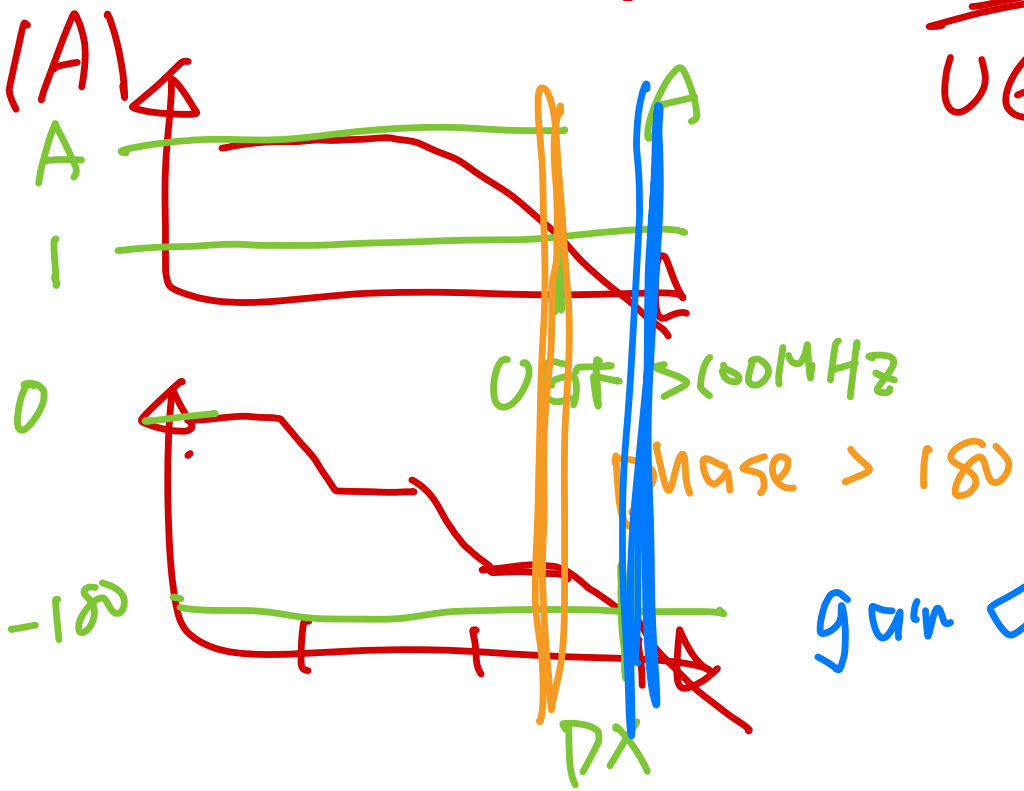


$$\frac{Y(s)}{X(s)} = \frac{A(s)}{1 + A(s) \cdot G}$$

Stability – UGF and PX

Gain < 1 @ 180 phase

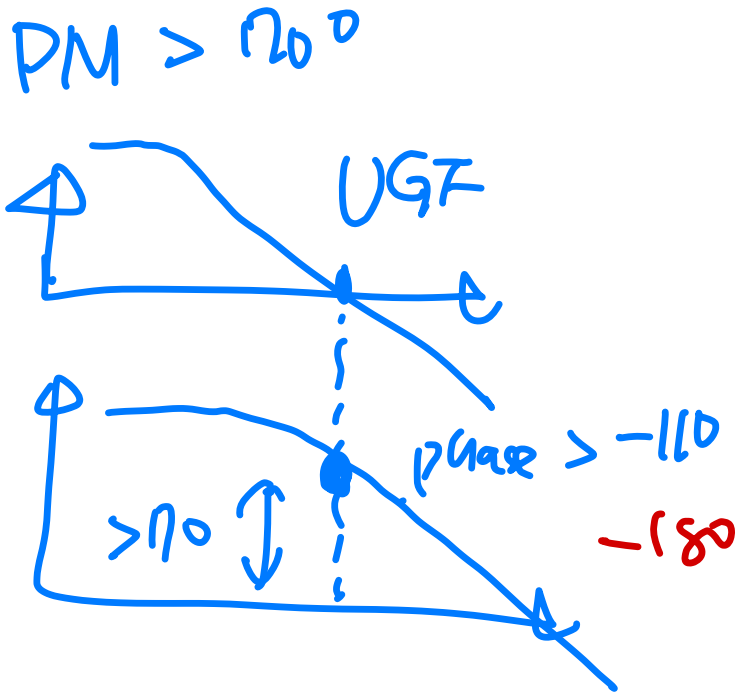
UGF PX

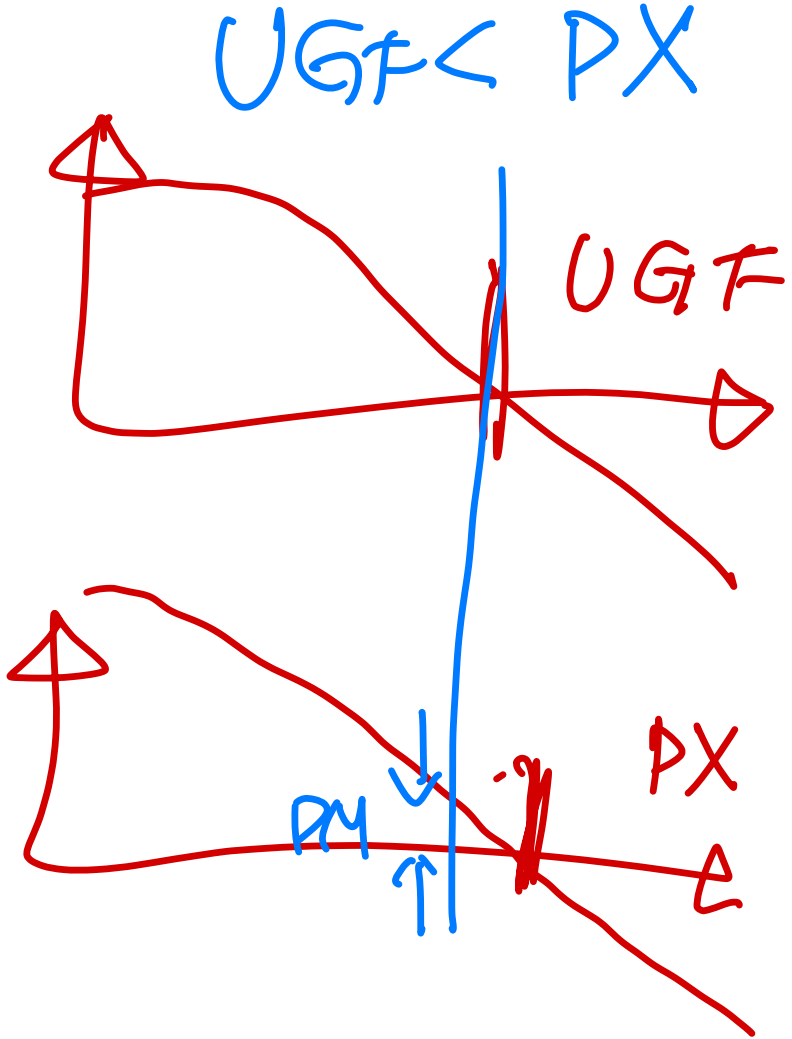


UGF < PX

Stability – Phase Margin

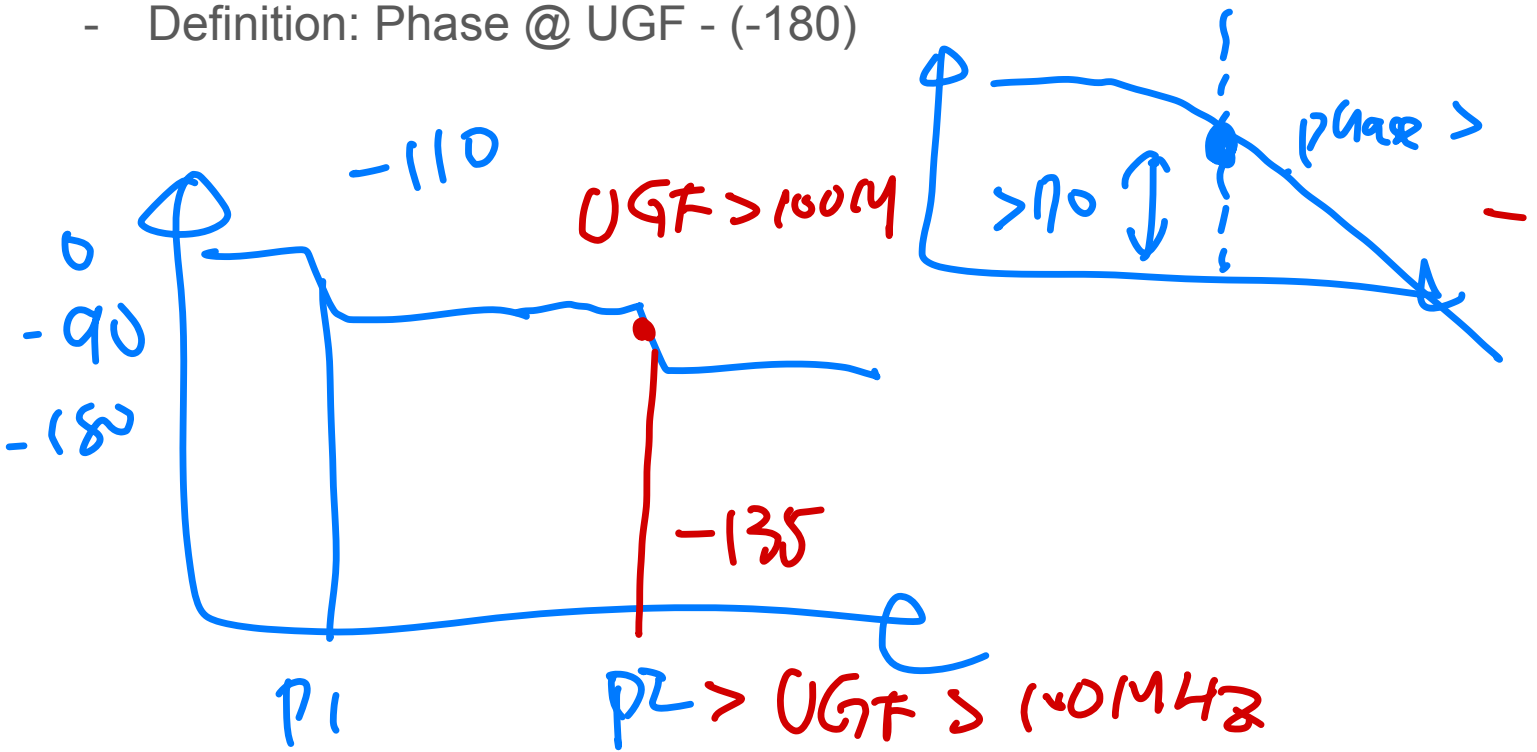
- Definition: Phase @ UGF - (-180)





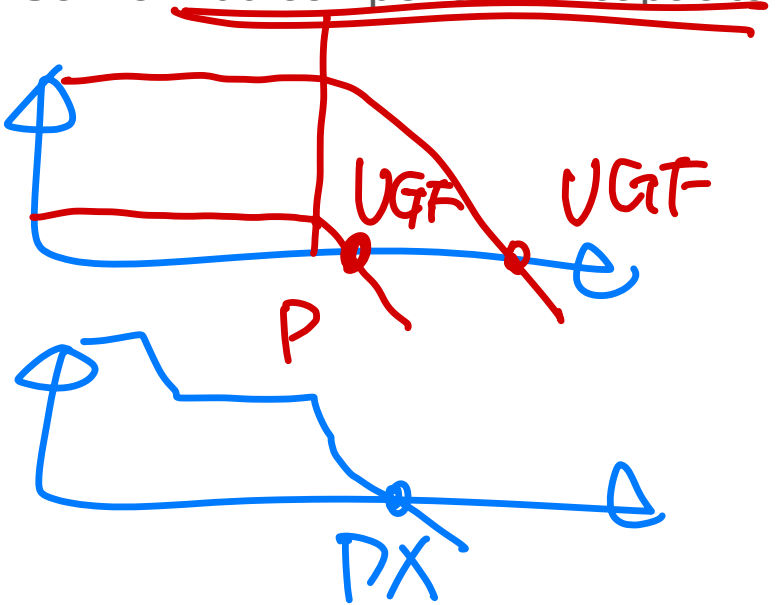
Stability – Phase Margin

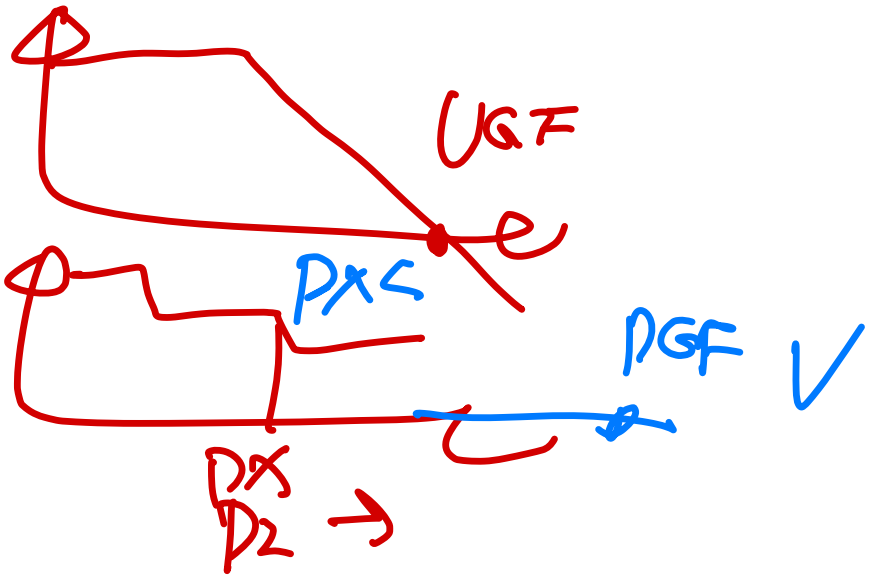
- Definition: Phase @ UGF - (-180)



Stability – Solutions

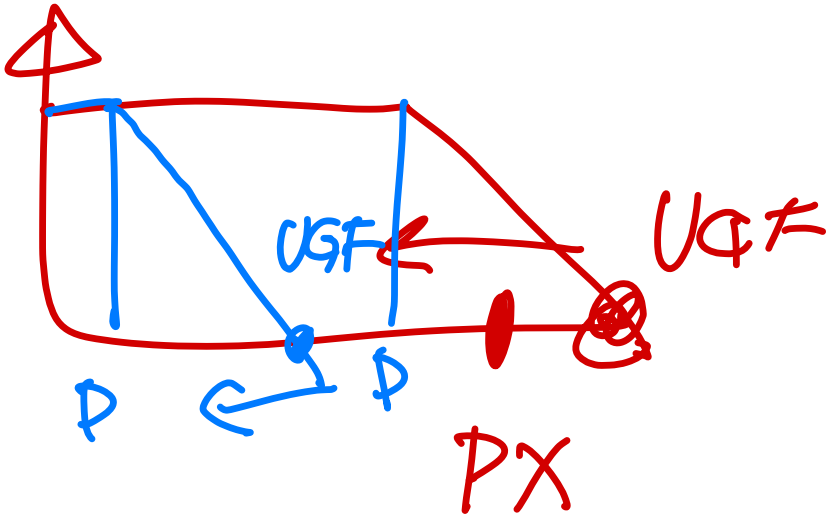
- Sol #1: Increase your 2nd pole freq
- Sol #2: Reduce your gain
- Sol #3: Add compensation capacitor

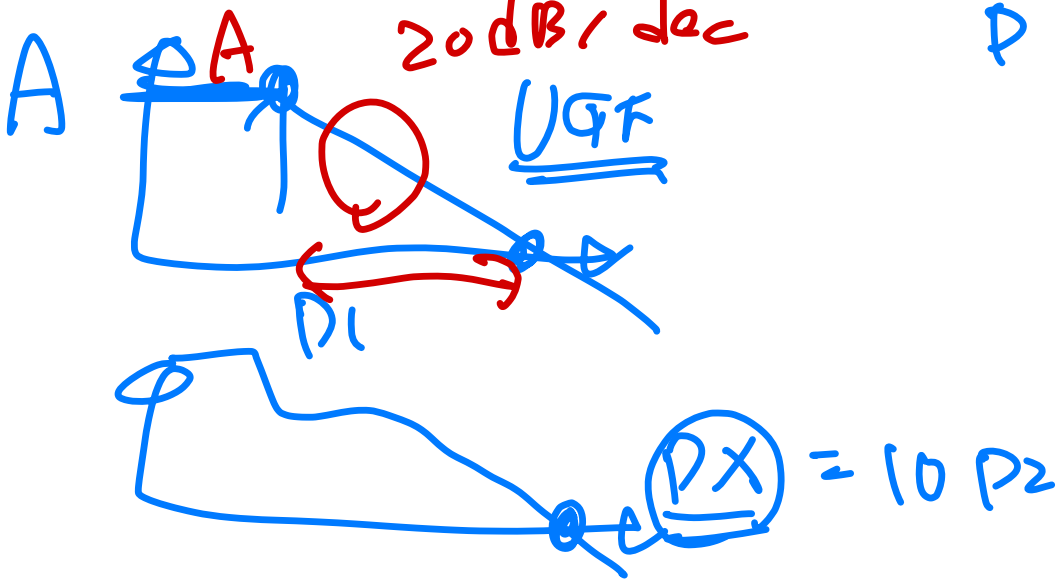




Stability – Solutions

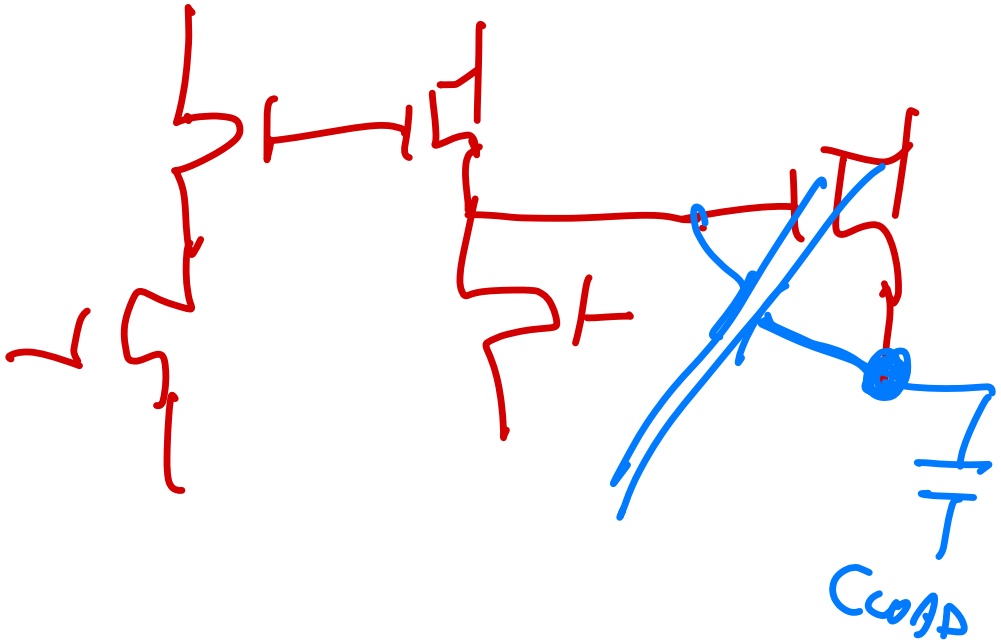
- Sol #1: Increase your 2nd pole freq
- Sol #2: Reduce your gain
- Sol #3: Add compensation capacitor





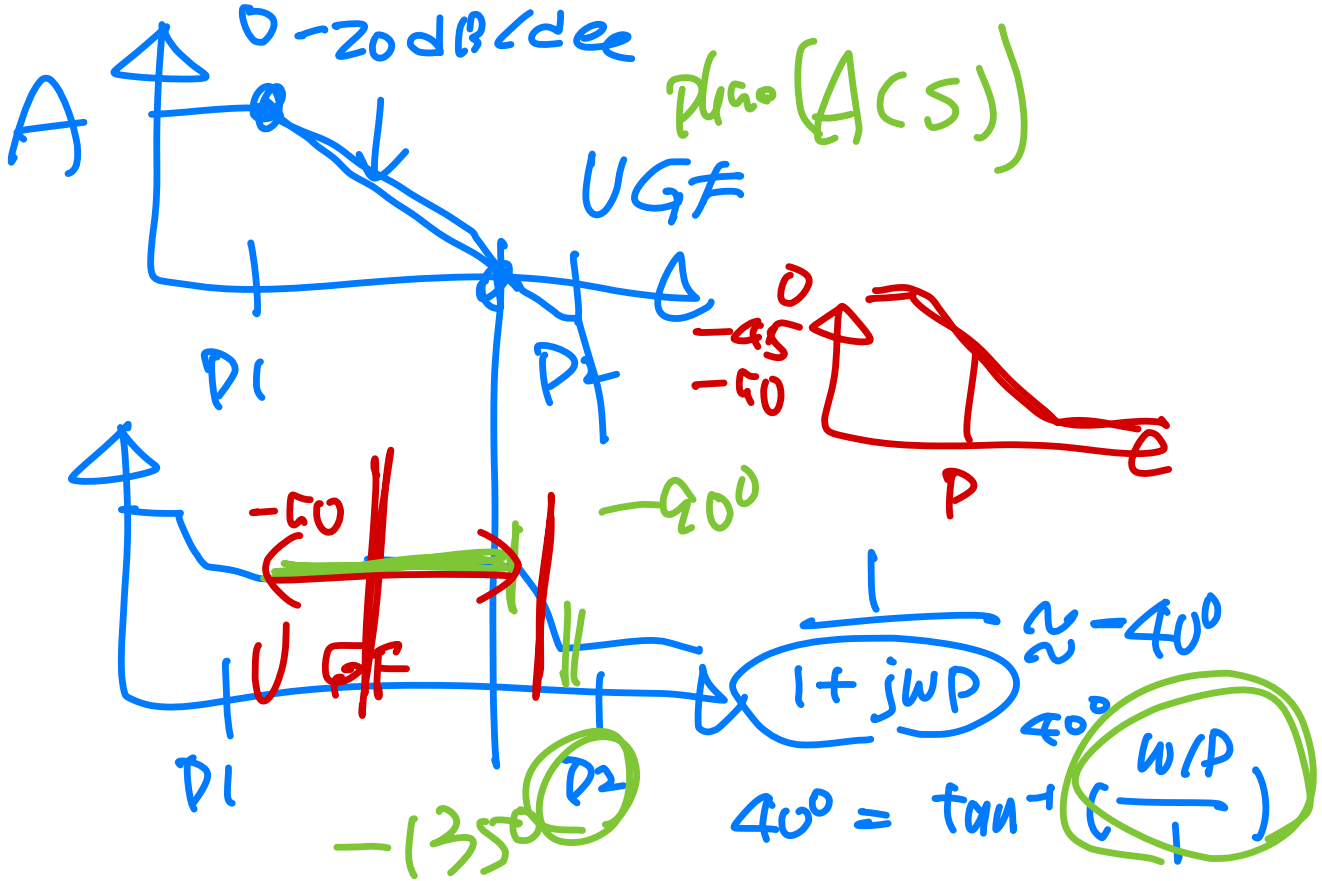
Case Discussion – Trade off of compensation Capacitor

- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing



Case Discussion – Trade off of compensation Capacitor

- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
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Case Discussion – Trade off of compensation Capacitor

- Open Loop
  - Gain
  - Input offset < 1m
  - Power
- Loop Gain
  - Unit Gain Freq
  - Phase Margin
- Close Loop
  - Slew Rate
  - Output Swing

$$A(s) = \frac{A}{1 + j\frac{w}{10}} \qquad p_1 = 10$$

$$w = 5$$

$$\text{phase } A(s) = \underbrace{P(A)}_{0} - P\underbrace{\left(1 + \frac{jw}{10}\right)}_{\text{real} \quad \text{imag}}$$

$$\tan^{-1}\left(\frac{w/10}{1}\right)$$

$$\tan^{-1}(0.5) = 30^\circ$$

Several Advices

- Get a number first for all specs in all cases
  - Gain is better at 0C or 100C?
  - Bandwidth is better at 0C or 100C?

- Burn your power first

Questions?

