Lecture 16: Amplifier Stability

0. Review
1. Frequency Response
2. Feedback Stability

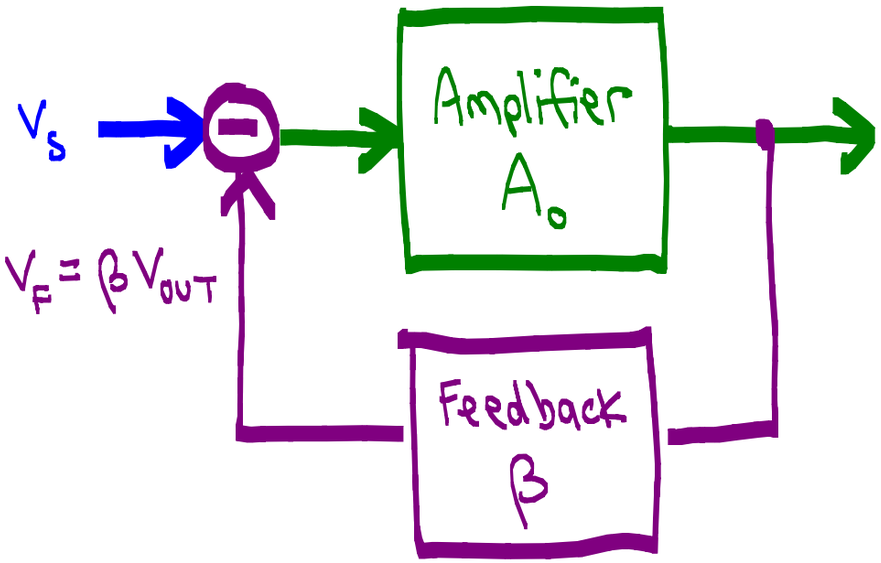
Textbook reading:

Ch 14.6 Bode plots
14.7 More Bode plots

- Exam #2 re-do due today
- HW7 due Thu (Nov 21)
  (box outside my office)
- Lab 5 report due Nov 26 (Tue)
  (1 per team)
- Final Exam Nov 26 (Tue)
  - ↳ Location TBD
    (NICO not available)
  - ↳ See course website for sample exam, solutions

0. Review

① Negative feedback for voltage amplifier



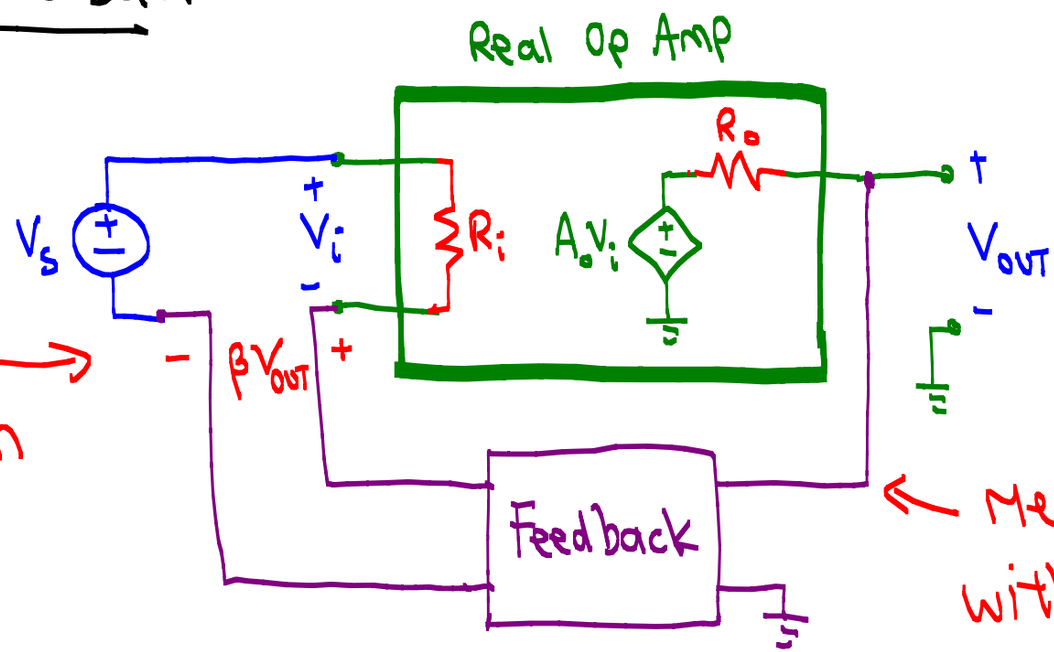
$$V_{OUT} = A_o(V_s - V_F) = G V_s$$

$$\star \quad G = \frac{A_o}{1 + A_o\beta}$$

$$\star \quad Z_{IN} = (1 + A_o\beta) R_i$$

$$\star \quad Z_{OUT} = \frac{1}{(1 + A_o\beta)} R_o$$

② "Series-shunt" Feedback

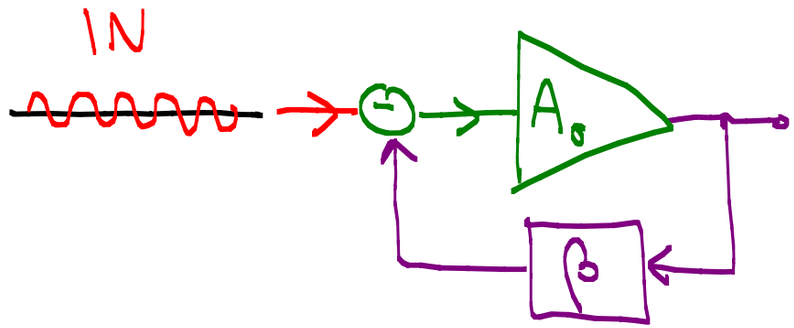


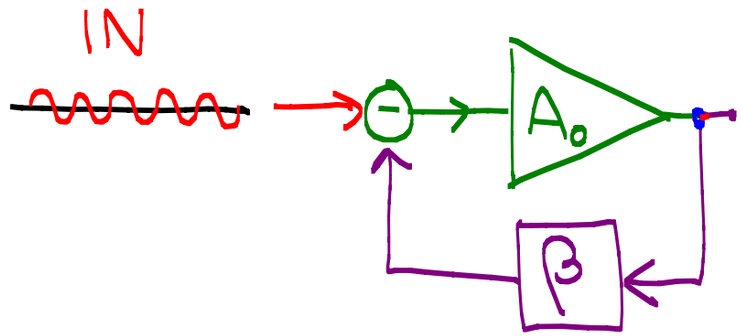
Subtract voltage with series connection →

← Measure voltage with shunt connection

1. Frequency Response

- Negative feedback usually improves circuit properties
- HOWEVER, both A and β can depend on freq!

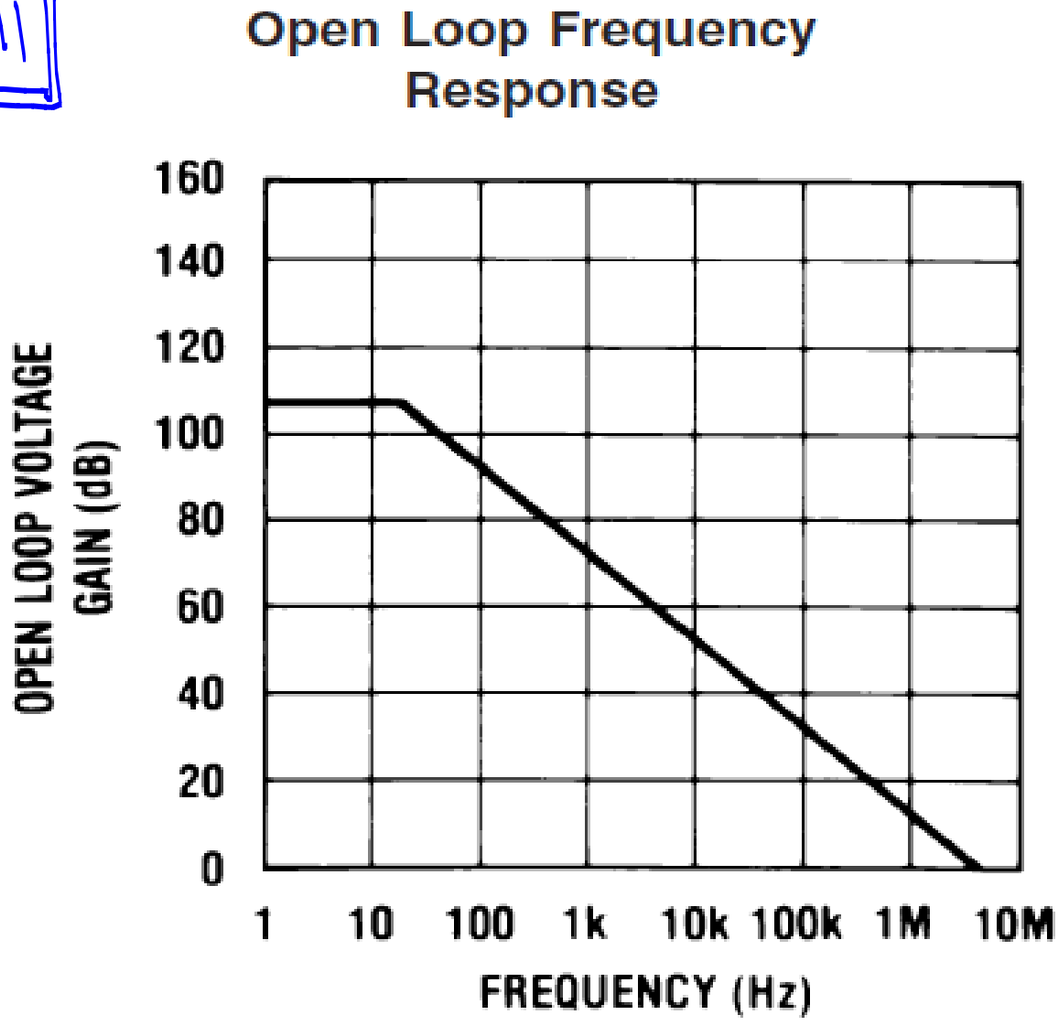




A. Dominant Pole

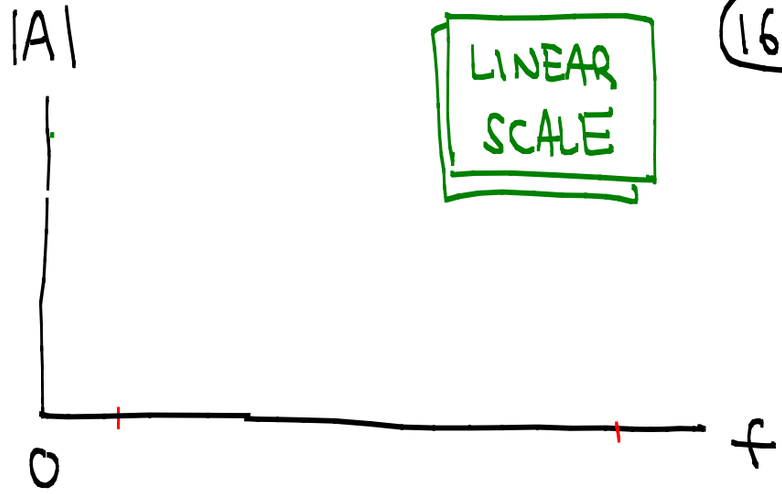
LF411

- For most op amps,
  A is really high (e.g. 10^5)
  only at very low freq!
- A(f) typically resembles 1st order low-pass filter



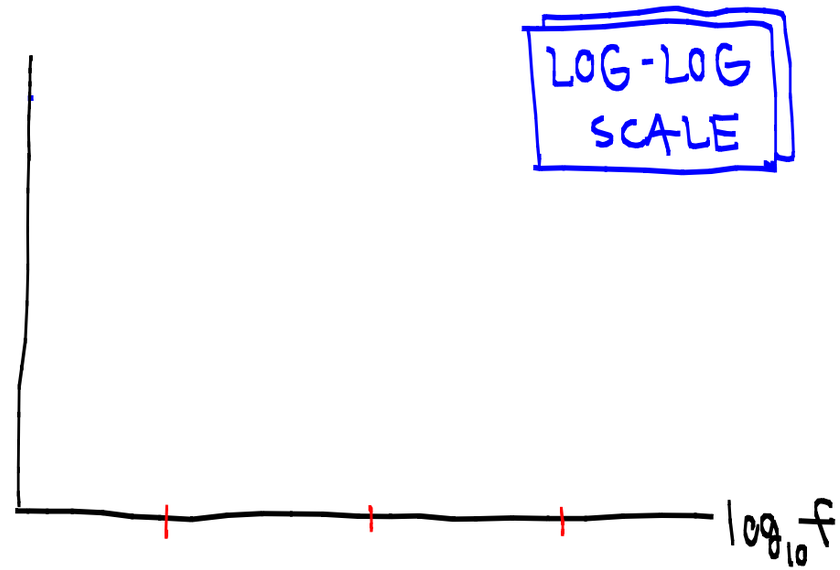
B. Bode Plots ← Textbook Ch 14.6 is useful

- Linear scale is NOT very useful



- Log-Log scale is most common.

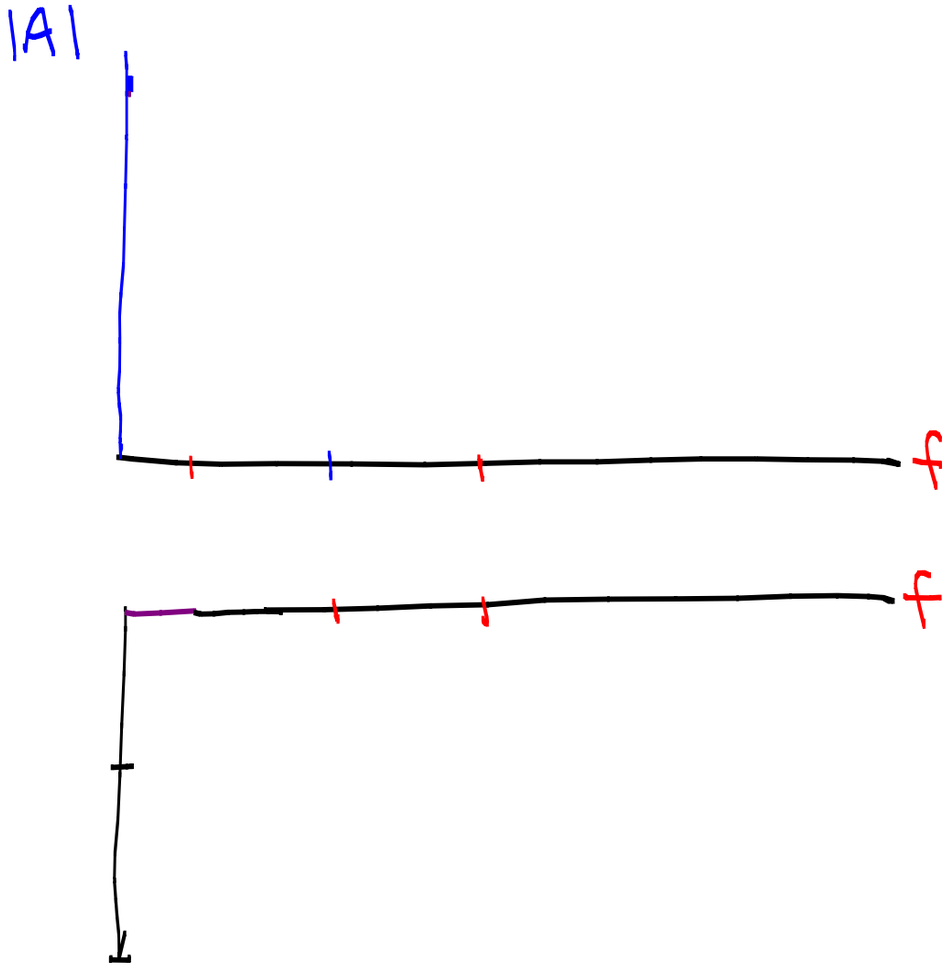
Ex: $|A(f)| = \dfrac{A_0}{\sqrt{1+(f/f_p)^2}}$



- what about phase?

$$A = \frac{A_0}{1 + jf/f_p}$$

★ Bode plot is an approximation using straight line segments



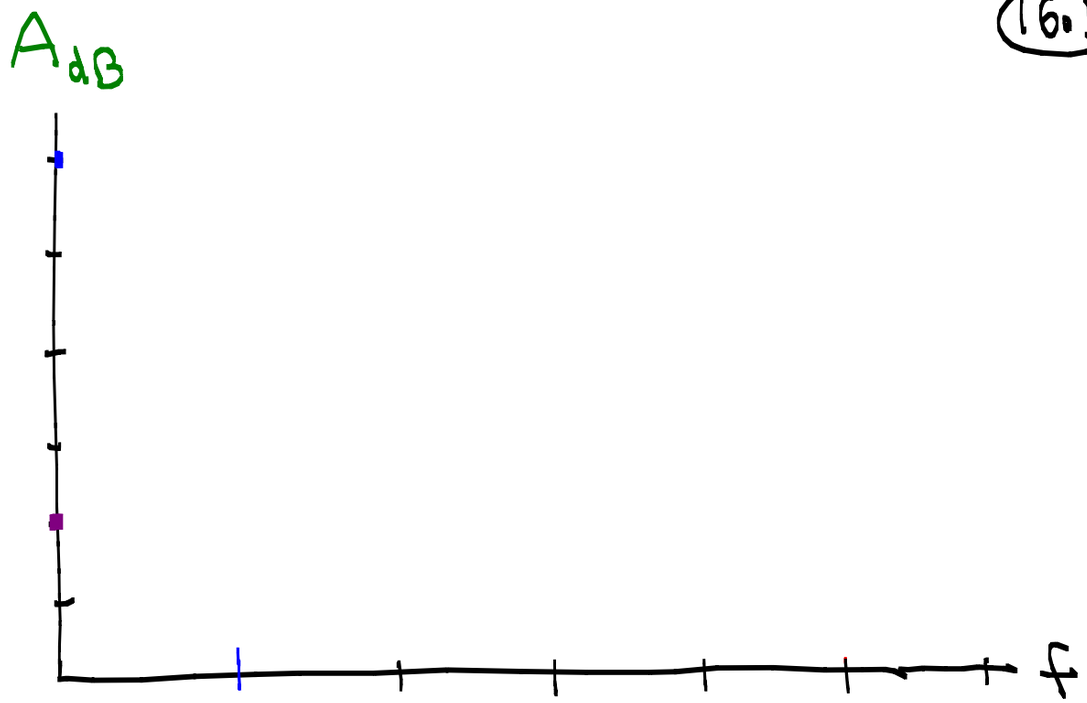
2. Amplifier Stability

Example 1-pole amplifier

Consider an amplifier with $G = 100$

and $A(f) = 10^6 \dfrac{1}{1 + j(f/100)}$

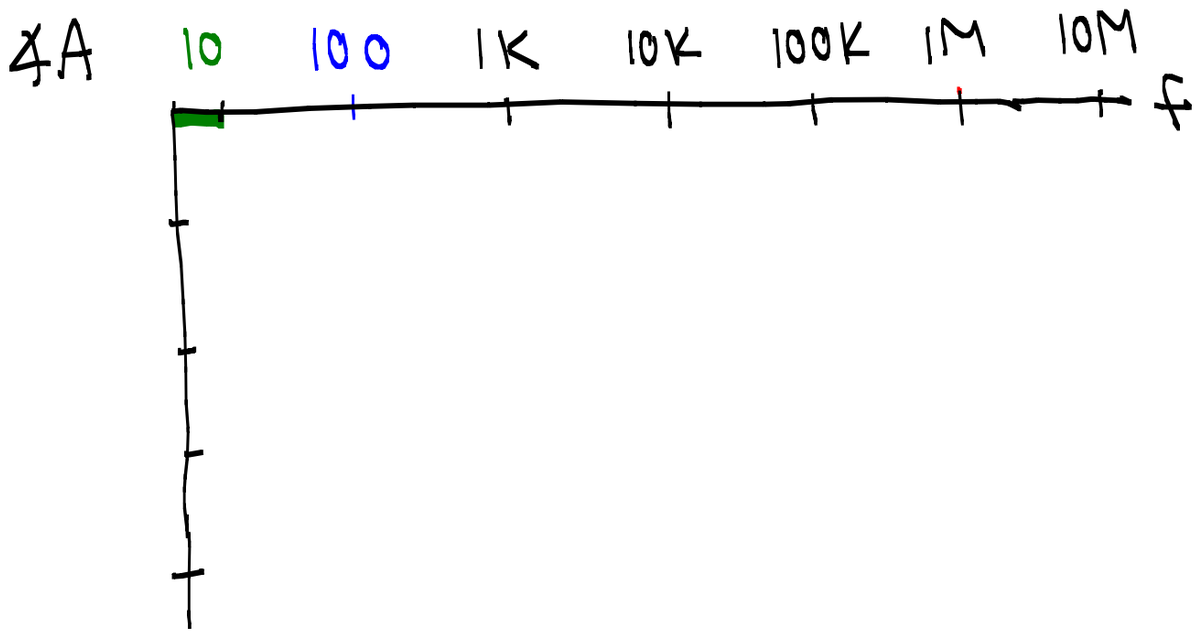
Is the amplifier stable?



STEP 1 Draw

STEP 2 Find

STEP 3 Draw

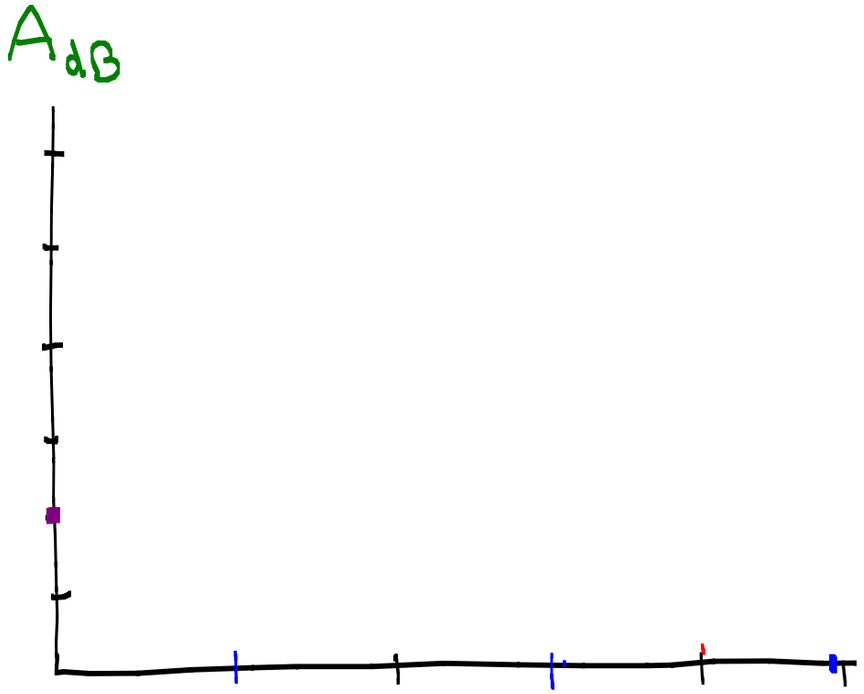


STEP 4 Phase Margin

Example 2-pole amplifier with $G = 100$

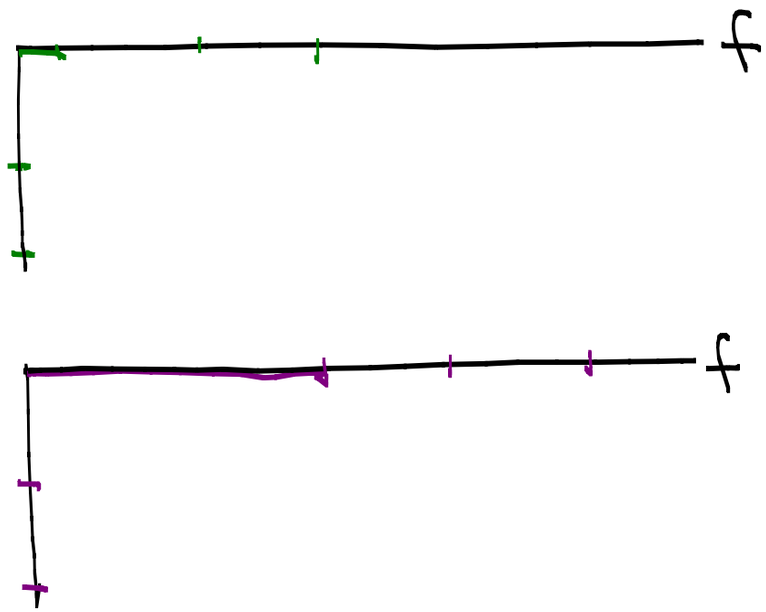
$$A = 10^6 \frac{1}{1+j(f/100)} \frac{1}{1+j(f/10k)}$$

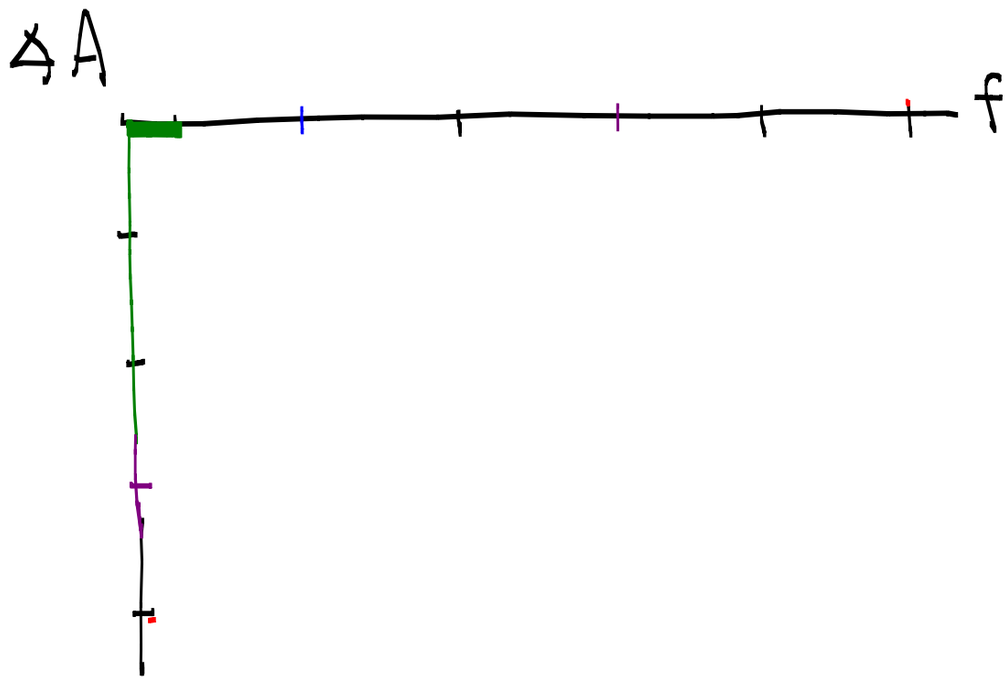
STEP 1 Draw Bode plot for $|A|$



STEP 2 Find Ω

STEP 3 Draw Bode plot for $\angle A =$

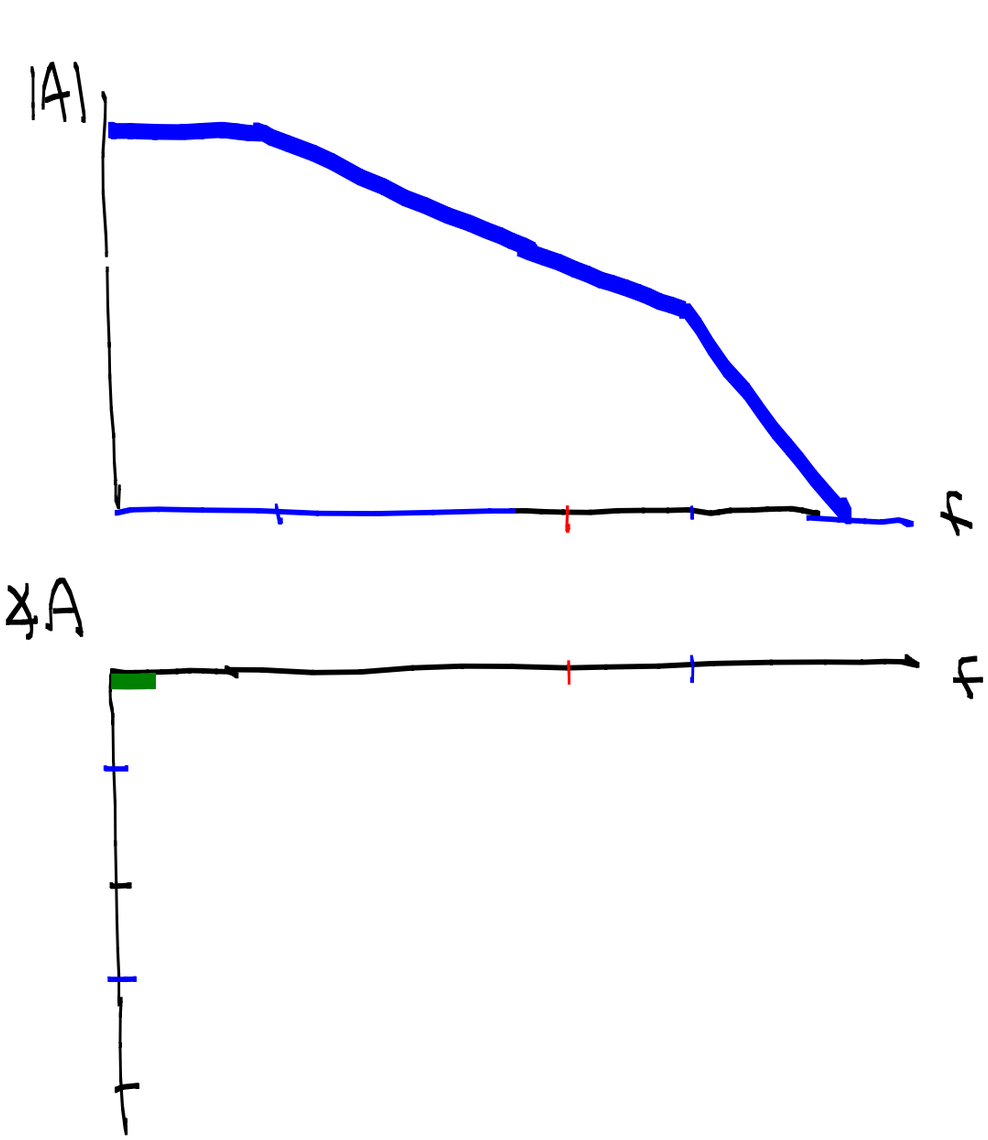


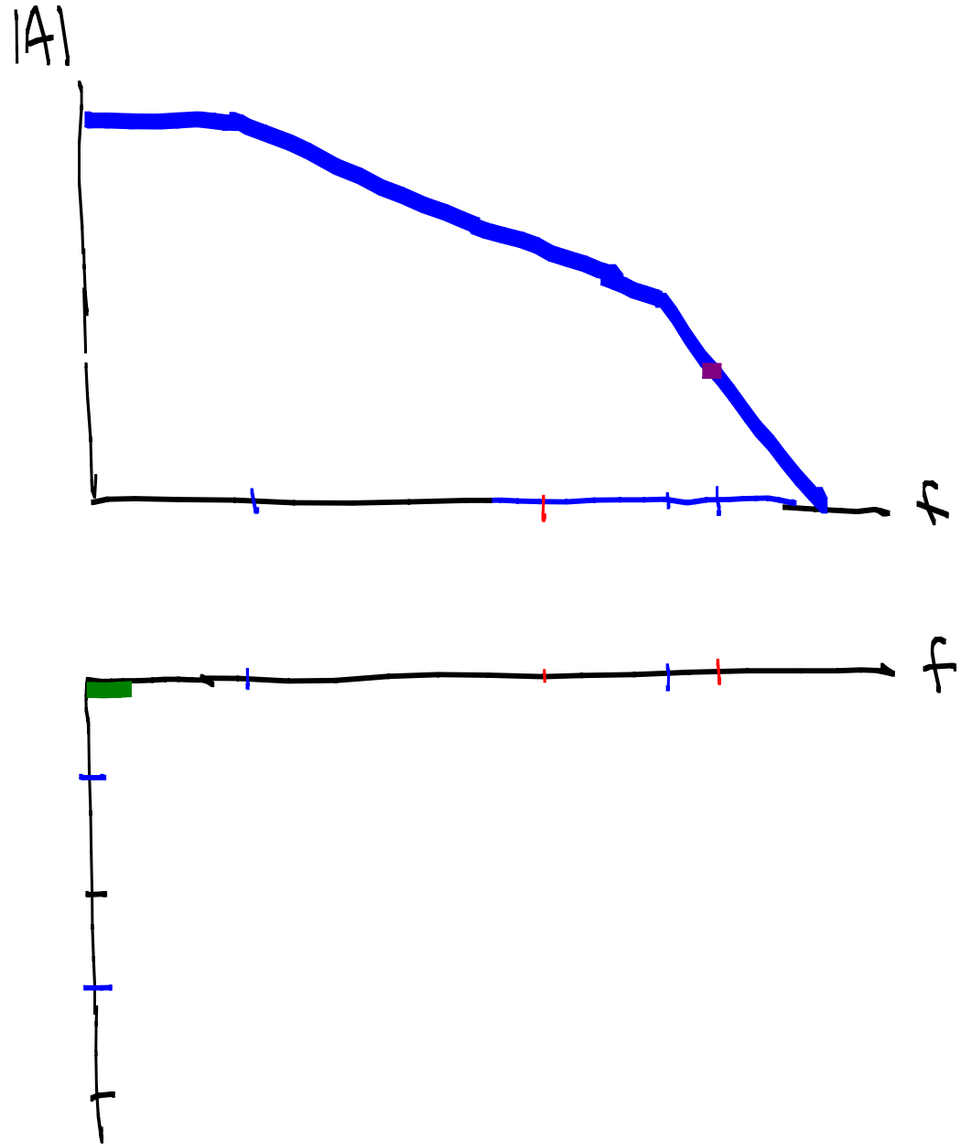


STEP 4 Exact phase margin

- 2-pole amplifier may or may not be stable!

$$A(f) = A_0 \frac{1}{1 + j\, f/f_{p1}} \frac{1}{1 + j\, f/f_{p2}}$$





- Same with 3-pole amplifier

$$A_o(f) = A_o \frac{1}{1+j\,f/f_{p1}} \frac{1}{1+j\,f/f_{p2}} \frac{1}{1+j\,f/f_{p3}}$$