Lecture 17: Output Stages

- Announcements:
  - Midterm's graded - will pass back at the end of lecture
  - HW#9 will be online on Thursday
  - Lab#2 due this Friday
    - Grade depends heavily on the report
    - Make sure you spend enough effort on the report per your TA's requirements
  - Lab#3 update online (update for 240A folks)
  - No lecture next Tuesday - we will make this up by going 2 hours the next three lectures

- Lecture Topics:
  - Stability

- Last Time:

Stability 

- Output Stages

Stability 

- Compensation in Op Amps

Stability Compensation

- In general, op amps are used in many FB loops.
- Feedback sets the biasing - no large coupling or bypass caps needed.
- FB increases BW.
- FB increases linearity at input range.
- Gain determined by external FB components → more accurate than op amp gain.
- FB sets R_i and R_o.
- FB can improve temperature stability.

- Settling Time

Function of Amplifier Stability!
When does instability come from? practical
= any reg. FB becomes unstable under certain
conditions -> must compensate to
supress instability

Ex. Non-Inverting Amplifier

\[ V_0 = V_e \frac{A(s)}{1 + A(s)} \]

Closed loop gain

Instability occurs when \( A(s) \to \infty \)

<table>
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<tr>
<th>A(s)</th>
<th>1 + A(s)</th>
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In General,

If \( a(s) \cdot f \to 1 \) when \( a(s) \cdot f = -180^\circ \) \( \Rightarrow \) Instability

This is a simplified form of the Nyquist Criterion.

Stability of a FB Clk, Using a Single-Pole OpAmp

For a single pole op amp: \( a(s) = \frac{a_0}{1 - s/p} \)

Thus: closed loop T.F.

\[ A(s) = \frac{a_0}{1 + a(s)f} \]

\( A(s) \) closed loop degen

\( f \) shaping term

(1+af) smaller than \( a_0 \)

\[ \approx \frac{1}{f} \]

To: \( a(s) \to \) loop gain (defined @ dc)

\( T(s) \cdot a(s) = \) loop transmission (defined for general frequencies)
Bode Plot: use to determine stability when $|G(j\omega)| = 1$. Then can determine stability.

$20 \log (1000) = 20 \log (G(j\omega))$

Original open loop op amp T.F.

Closed loop T.F. $\frac{A_0}{1 + 1000}$

$\angle G(j\omega) = -80^\circ$

No crossover. 1800°.

This is unstable.

$|G(j\omega)| = 1 \ (\in \text{dB})$

$\log \omega$

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