Feedback

- Assume you are familiar with feedback benefits, issues
  - Review: G&M Ch. 8 & 9, Razavi Ch. 8

- Focus here on:
  - Stability
    - Analysis and simulation
  - Settling
    - Often amplifying pulses and not sinusoids
    - More next lecture

Generic Feedback Circuit

- Open-loop gain: \( a \)
- Feedback factor: \( f \)
- Loop gain: \( T = \frac{a_f}{f} \)
- Closed-loop gain: \( A = \frac{V_o}{V_i} = a_f \cdot \frac{1}{1 + f} \)

Electronic Feedback Circuit

- Careful with mapping circuit feedback to generic diagram...

Stability

- Nearly all circuits are actually non-linear and time-varying
  - "Poles" only accurate for given bias, temp., etc.

- What we usually mean by stability:
  - Circuit always converges to the "origin" for zero input within finite time
    - (Exponential stability)
  - Another common definition: BIBO stability

Stability In Practice

- Linearize the circuit and look at its poles
  - Remember: this is only an approximation!
    - Perform linear analysis over several corners, temps, supplies, etc.
    - May want to do a couple of transient sims too
Linear Circuit Stability

- Stability set by $T(s)$
- $T(s)$ is an open-loop parameter - need to break the loop
  - Easy to do in hand analysis: break at controlled source
  - Not as easy in simulation...

Simulating Stability

- Measure $T_v$ and $T_i$, then calculate actual $T$

Middlebrook Method (1975)

- True Loop Gain:
  - $T = g_v\frac{Z_1Z_2}{Z_1 + Z_2}$

  Solving yields:
  - $T = \frac{F_1T_1 - 1}{F_1 + T_1 + 2}$

  • Measure $T_v$ and $T_i$, then calculate actual $T$

Phase Margin

- Approximate method to evaluate stability: phase margin
  - Works well for most circuits of interest
    - Sometimes have to use Nyquist stability test

Common Approach

Multi-Loop Feedback