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: $T = a_v f$
- Closed-loop gain: $A = \frac{V_v}{V_i} = a_v \frac{1}{1 + \frac{1}{f}} + \frac{1}{f}$

Electronic Feedback Circuit

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

Is This Circuit “Stable”?

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

Middlebrook Method (1975)

- 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
Multi-Loop Feedback

Multi-Loop Feedback

Multi-Loop Feedback Example