EECS240 – Spring 2010

Lecture 12: Feedback

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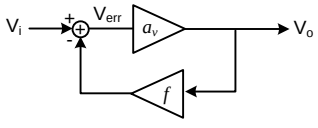
Feedback

- 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

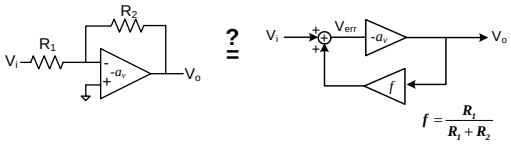
Generic Feedback Circuit



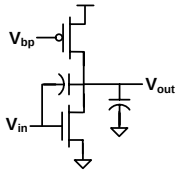
- Open-loop gain: a_v
- Feedback factor: f
- Loop gain: $T = a_v f$
- Closed-loop gain: $A = \frac{V_o}{V_i} = \frac{a_v}{1+T} = \frac{1}{f}\frac{1}{1+\frac{1}{T}} \approx \frac{1}{f}$

Electronic Feedback Circuit

- Careful with mapping circuit feedback to generic diagram…

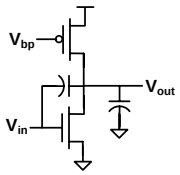


Is This Circuit "Stable"?



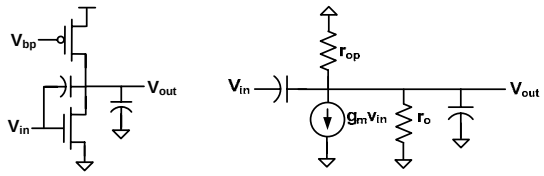
Stability

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



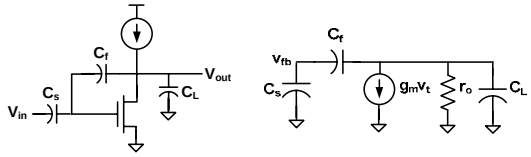
- What we usually mean by stability:
  - Circuit always converges to the "origin" for zero input within finite time
    - (Exponential stability)
  - Another common definition: BIBO stability

Stability In Practice



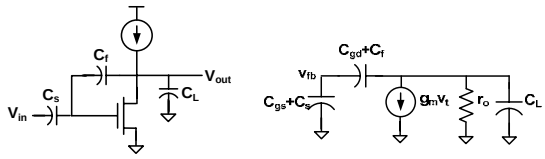
- Linearize the circuit and look at its poles
- Remember: this is only an approximation!
  - Perform linear analysis over several corners, temps, supplies, etc.
  - May want to do a couple of transient sims too

Linear Circuit Stability



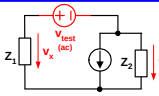
- Stability set by T(s)
- T(s) is an open-loop parameter - need to break the loop
  - Easy to do in hand analysis: break at controlled source
  - Not as easy in simulation…

Simulating Stability

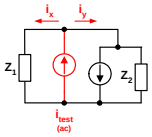


Common Approach

Middlebrook Method (1975)



$$\left|\frac{v_y}{v_x}\right| \equiv T_v = g_m \cdot Z_2 + \frac{Z_2}{Z_1}$$



$$\frac{i_y}{i_x} \equiv T_i = g_m \cdot Z_1 + \frac{Z_1}{Z_2}$$

True Loop Gain: $T = g_m \cdot \frac{Z_1 Z_2}{Z_1 + Z_2}$

Solving yields: $T = \frac{T_v T_i - 1}{T_v + T_i + 2}$

- 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

Multi-Loop Feedback

Multi-Loop Feedback

Multi-Loop Feedback Example