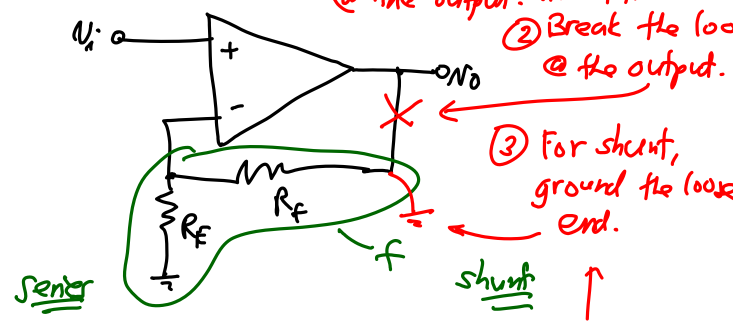
Lecture 27: Feedback Examples

- Announcements:
- HW#11 due Wednesday, 12/9 @ 8 a.m.
- Lab#3 (Design Project) due Friday, Dec. 11, at 11:59 p.m. in the 140/240a homework box
  - For 240A: use resistor temperature coefficients previously given in lecture
  - Best to be finished with design by next Monday, so you have plenty of time to write the report
  - Make sure the report is good, since it is what is graded in the end
  - Minimize (sum of W's)*(total I)*V
- Handed out old final exams
- Lecture Topics:
  - Feedback By Inspection Example
  - Final Exam Info
  - Course Wrap Up
  - Course Evaluations
- ---------------------------------------
- Last Time:
- Going through the "Inspection Analysis of Feedback Circuits" Handout
- In the end, if one can determine the open loop gain with FB loading and feedback factor, then the rest of the problem becomes simple
- Study the table in the handout
  - Be able to fluently go between different types of gain, from v → v, to i → v, etc.

To determine loading by FB:

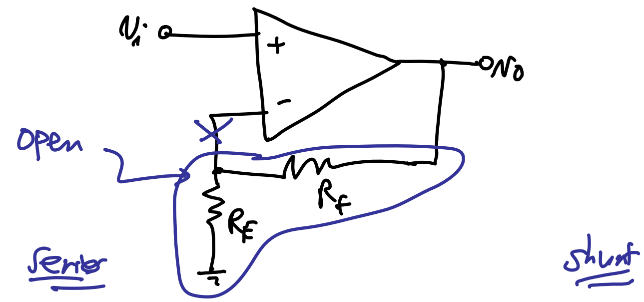
Input loading:

① Determine the feedback type @ the output. (Here, it's shunt.)
② Break the loop @ the output.
③ For shunt, ground the loose end.



(If series, open it.)

Output loading:



① Determine the feedback type @ the input. (Here, it's series.)

② Break the loop @ the input.

③ For series, open the loose end.

(If shunt, short it.)

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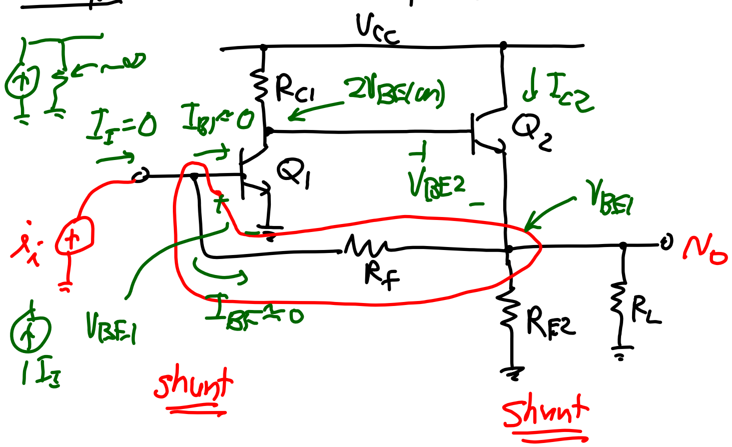
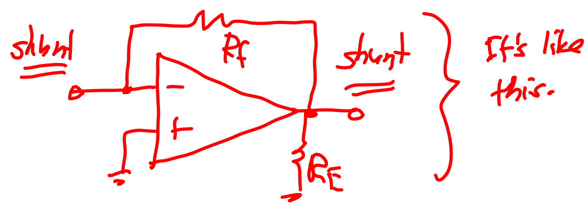
Example. Transresistance Amplifier



① Determine the feedback connections (type)

shunt-shunt → $i \to v$ (transresistance)



② Get bias pt.

$I_{B1} \approx 0 \to I_{BF} \approx 0$ ← don't do this if R_F = large

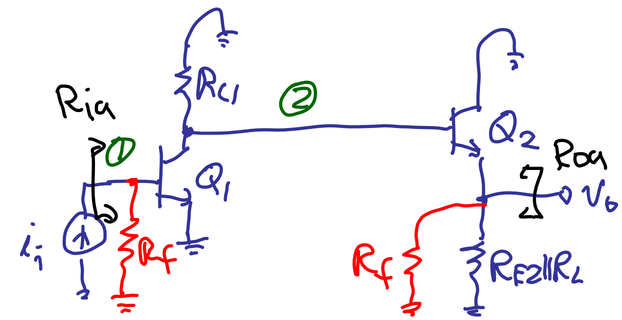
$I_{C2} \approx I_{E2} = \frac{V_{BE1}}{R_{E2} \| R_L}$; $I_{C1} = \frac{V_{CC} - 2V_{BE(on)}}{R_{C1}}$

From these, get g_m's, r_π's, r_o's, etc.

③ Get gain:

$$R_m = \frac{r_{mFBL}}{1 + r_{mFBL} f} = \frac{r_{mFBL}}{1 + T}$$

Get r_{mFBL}:



$$r_{mFBL} = \left.\frac{v_o}{i_i}\right|_{\text{OL w/ FB loading}} = \frac{v_①}{i_i} \cdot \frac{v_②}{v_①} \cdot \frac{v_o}{v_②}$$

$$v_① = i_i (r_{\pi 1} \| R_F) \to \frac{v_①}{i_i} = r_{\pi 1} \| R_F$$

$$\frac{v_②}{v_①} = -g_{m1}\left(R_{C1} \| (r_{\pi 2} + (\beta+1)(R_{E2} \| R_L \| R_F))\right)$$

$$\frac{v_o}{v_②} = 1$$

$$r_{mFBL} = \left.\frac{v_o}{i_i}\right|_{\text{OL w/ FB loading}} = -g_{m1}(r_{\pi 1} \| R_F)[\quad]$$

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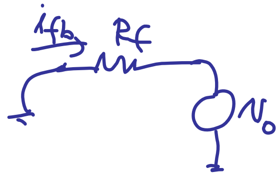
Get the FB factor:



$$\frac{i_{fb}}{v_o} = -\frac{1}{R_f} = f$$

Loop Gain (w/ FB loading):

$$r_{mFBL} f = \left(-g_{m1}(r_{\pi}\|R_f)[\quad]\right)\left(-\frac{1}{R_f}\right) = (+) = T$$

$$T = g_{m1}R_{C1}\left(\frac{r_{\pi1}\|R_f}{R_f}\right)$$

Closed-Loop Gain:

$$R_m = \frac{r_{mFBL}}{1+\underbrace{r_{mFBL}f}_{(+)}} = \frac{r_{mFBL}}{1+T} \cong \frac{1}{f} = -R_f$$

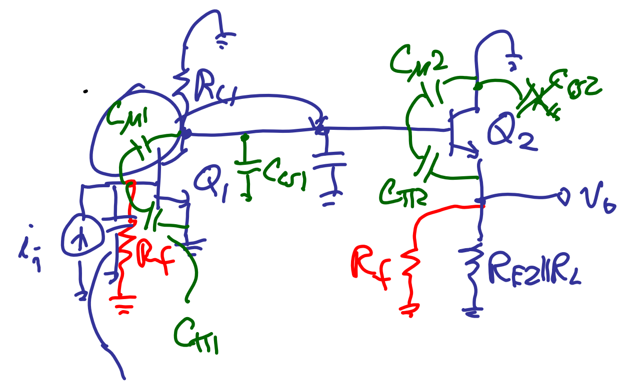
(r_{mFBL} – large)

④ Get R_i & R_o:

$$R_i = \frac{R_{io}}{1+T} = \frac{r_{\pi1}\|R_f}{1+T} = \frac{r_{\pi1}\|R_f}{1+g_{m1}R_{C1}\left(\frac{r_{\pi1}\|R_f}{R_f}\right)} = R_i$$

$$R_o = \frac{R_{oo}}{1+T} = \frac{\frac{r_{\pi2}+R_{C1}}{\beta+1}\|R_f\|R_{E2}\|R_L}{1+g_{m1}R_{C1}\left(\frac{r_{\pi1}\|R_f}{R_f}\right)} = R_o$$

⑤ Freq Response → $\omega_H = \omega_{-3dB}$:



$$C_M = C_{\mu1}(1+g_{m1}R_{eq})$$

⇒ determine τ's, but do it w/ FB loading!

$$\omega_{-3dB}\big|_{closed-loop} = \omega_{-3dB}\big|_{OL\ w/\ FB\ loading} \times (1+T)$$

$$= \frac{1}{\sum \tau's} \times (1+T)$$

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- What's next?
- EE 240B: Advanced Analog Integrated Circuits
- Analysis and optimized design of integrated analog systems and building blocks. Specific topics include operational and wide-band amplifiers, gain-bandwidth and power considerations, analysis of noise in integrated circuits, low noise design, feedback, precision passive elements, analog switches, comparators, CMOS voltage references, non-idealities such as matching and supply/IO/substrate coupling. The course will include a significant design project applying the techniques taught in class to implement the analog front-end of a high-speed serial link.
- EE 142/242A: Integrated Ckts for Communication
- Analysis and design of electronic circuits for communication systems, with an emphasis on integrated circuits for wireless communication systems. Analysis of noise and distortion in amplifiers with application to radio receiver design. Power amplifier design with application to wireless radio transmitters. Radio-frequency mixers, oscillators, phase-locked loops, modulators, and demodulators.
- EE 147/247A: Introduction to MEMS Design
- Physics, fabrication, and design of micro-electromechanical systems (MEMS). Micro and nanofabrication processes, including silicon surface and bulk micromachining and non-silicon micromachining. Integration strategies and assembly processes. Transduction strategies and mechanical circuits. Electronic position-sensing circuits and electrical and mechanical noise. CAD for MEMS.

- One more thing: (since many of you might be near graduation)
- The MAS-IC program
  - An internet-based Masters in Integrated Circuits from the UC Berkeley Dept. of EECS
  - This course, 240A, was actually offered as a MAS-IC course this semester, using pre-taped lectures from Spring 2013 (more professionally taped than the ETS taping we did this semester)
  - If you're interested in getting a Masters Degree while working or otherwise remotely, this is an opportunity
  - Go to www.eecs.berkeley.edu/masic

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