Lecture 27w: Feedback Analysis By Inspection

- **Announcements**:
- HW#12 due Tuesday, next week
- Lab#3 (your project) due on Friday, May 10, at 5 p.m. in the EE140/240A Homework Box
- Passed out Feedback Inspection Handout last time
  - Will cover it this time
- Passed out Final Exam Info Sheet and past final exam solutions
- **Lecture Topics**:
  - Feedback By Inspection
  - Final Exam Info & Course Wrap Up
- **Note**: The projection system was not working, so had to use the board. The notes here are actually from Spring 2012.
- You can also watch the video from Spring 2012, as well, to get the sound from the lecture
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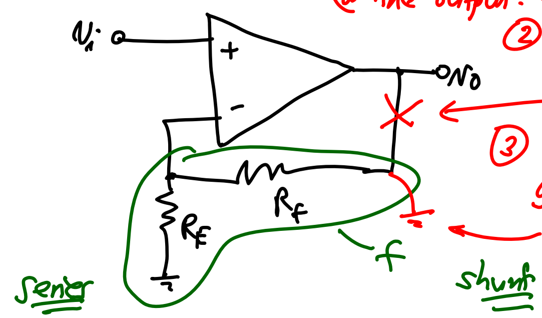
- **Last Time**:
- Devised method to separate amplifier from feedback circuits to enable inspection analysis
- Procedure for determining loading due to FB
- Start by going through the Feedback By Inspection Handout (which we did without the aid of video)

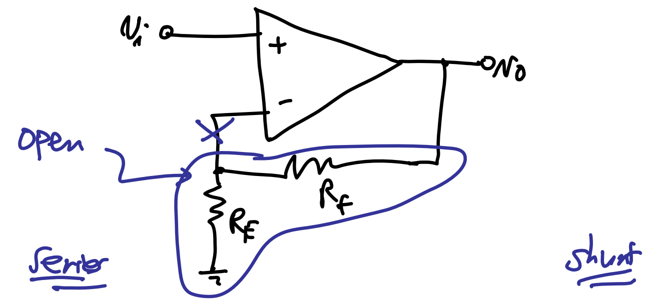
To determine loading by FB:

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.)

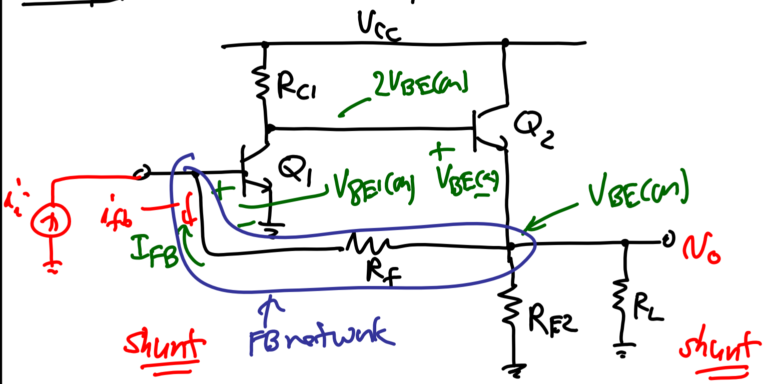


Output loading:



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.)

Example. Transresistance Amplifier



① Determine type of FB: → determines type of gain

② Biasing: ← Note: Don't do this if R_F = large

$I_{FB} = I_{B1}$ ← tiny ≈ 0

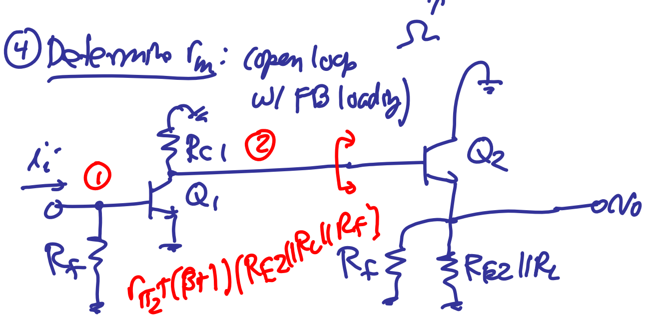
$I_{C2} \approx I_{E2} = \frac{V_{BE(on)}}{R_{E2} \| R_L}$; $I_{C1} = \frac{V_{CC} - 2V_{BE(on)}}{R_{C1}}$

③ What kind of gain?

shunt-shunt FB → $i \to v$ gain

∴ we're looking for $R_m = \frac{v_o}{i_i} = \frac{r_m}{1 + r_m f}$ ← Ω

④ Determine r_m: (open loop w/ FB loading)



Get Gain:

$$\frac{v_o}{i_i} = \frac{v_①}{i_i} \cdot \frac{v_②}{v_①} \cdot \frac{v_o}{v_②} = \frac{v_o}{i_i}\Big|_{\text{OL w/ FB loading}} = r_m$$

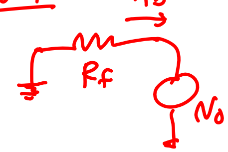
$$v_① = i_i (r_\pi \| R_F) \rightarrow \frac{v_①}{i_i} = r_\pi \| R_F$$

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

$$\frac{v_o}{v_②} \approx 1$$

$$r_m = \frac{v_o}{i_i}\Big|_{\text{OL w/ FB loading}} = -g_m (r_\pi \| R_F)\left[R_{C1} \| (\quad)\right] = r_m$$

Find f:



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

Thus:

$$T = r_m f = \left(-g_{m1}(r_\pi \| R_F)\left[R_{C1} \| (\quad)\right]\right)\left(-\frac{1}{R_F}\right)$$

(large)

$$T = r_m f = g_{m1} R_{C1} \left(\frac{r_\pi \| R_F}{R_F}\right)$$

⑤ Finally, set all parameters: [if $r_m f \gg 1$]

$$R_m = \frac{r_m}{1 + r_m f} \approx \frac{1}{f} = -R_F \Rightarrow \boxed{R_m = -R_F}$$

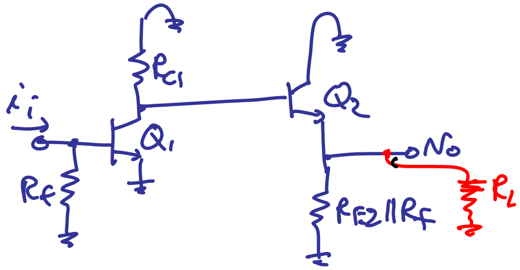
$$R_i = \frac{R_{ia}|_{w/FB\ loading}}{1+T_{mf}} = \frac{r_{\pi}||R_f}{1+g_{m1}R_{C1}\frac{(r_{\pi 1}||R_f)}{R_f}} = R_i$$

large ∴ this = tiny

$$R_o = \frac{R_{oa}|_{w/FB\ loading}}{1+T_{mf}} = \frac{\frac{r_{\pi 2}+R_{C1}}{\beta_f}||R_{E2}||R_f||R_L}{1+g_{m1}R_{C1}\frac{(r_{\pi}||R_f)}{R_f}} = R_o$$

Find ω_{-3dB}:

① Find the ω_{-3dB} of the open-loop amplifier w/ FB loading, i.e., of this: → use OCTC analysis



② Multiply by (1+T):

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

- Go through Final Exam Information Sheet

- 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
- 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.