EE 105 | Discussion 10

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Discussion Outline

- [Lab 5] Attenuation network
- [Homework 8] Problem 7 – Feedback Resistor
- [Exercises]

Attenuation Network

First, let's assume our amplifier meets the gain spec.

→ Need to determine max input signal amplitude

$$|v_o| = 1.5\,V \rightarrow 3\,V_{pp}$$

$$|v_i| = \frac{|v_o|}{A_v} = \frac{3\,V_{pp}}{(270\,V/V)} = 0.011\,V < V_{sig,\,min} = 50\,mV$$

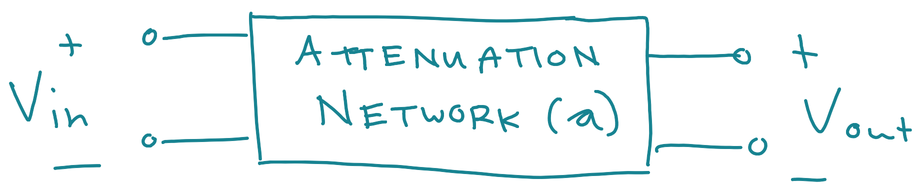
→ We need a smaller input amplitude than the minimum setting on our function generators!

→ Solution:

- Insert an ***attenuation network***

$$V_{out} = a\,V_{in}$$

where $a < 1$



Attenuation Network

- Don't forget ~~input~~ source impedance!

Ideally, $R_s = 0$

→ Need to demonstrate that amplifier works with $R_s \geq 680\Omega$

$$A_v = \frac{V_o}{V_{in,oc}} = \frac{V_o}{V_s}$$

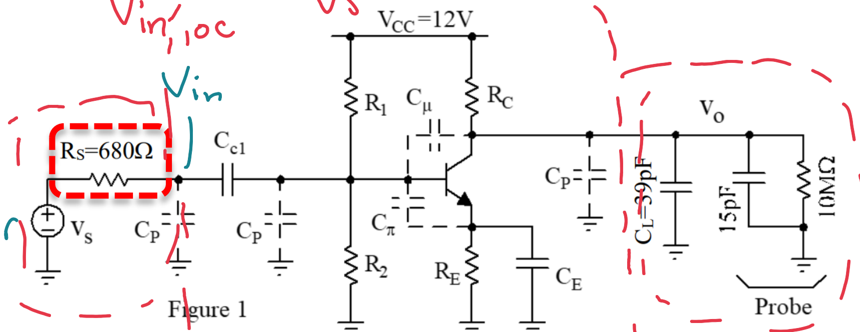
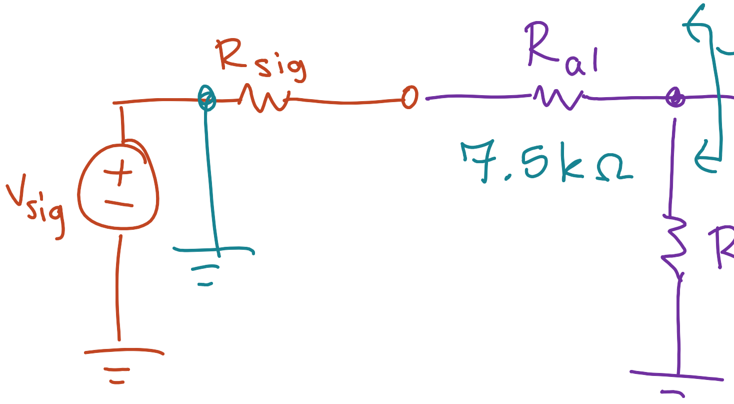


Figure 1



$$v_{in} = a V_{sig} \quad \left(|V_{sig}| = 50\,mV, \; a \leq 0.22 \right)$$

$$a = \frac{R_2}{R_1 + R_2} = \frac{1}{10}$$

$$R_s = (R_1 + R_{sig}) \parallel R_2 \approx 700\Omega$$

Attenuation Network

$v_{in,loaded} = \frac{(R_1 \| R_2)}{R_s + (R_1 \| R_2)} (a v_{sig})$

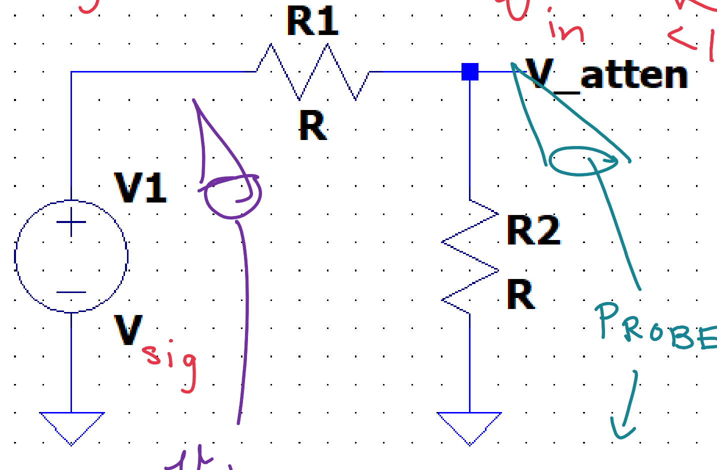
- How to determine the gain of the amplifier
  - Measure the ***CORRECT*** input signal

$A_v = \frac{v_o}{(a v_{sig})} = \left(\frac{v_o}{v_{in}}\right)\left(\frac{v_{in}}{a v_{sig}}\right)$ ($\frac{v_o}{v_{in}} > A_v$, $\frac{v_{in}}{a v_{sig}} < 1$)

× Don't use $v_{in}/v_{atten.}$ as your input signal when calculating A_v (i.e. $A_v \neq \frac{v_o}{v_{in}}$)

✓ Do use $a \cdot v_{sig}$ as input signal when calculating gain

Because when amplifier is connected, v_{in} is loaded & $\neq a v_{sig}$



v_{in} 10mV

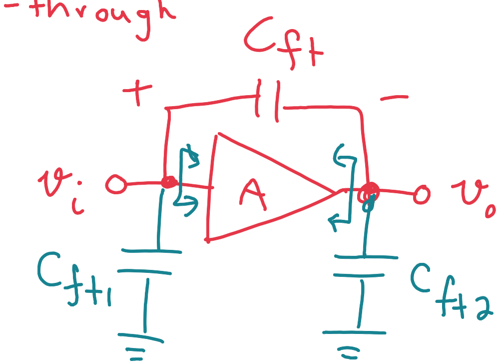
PROBE → $v_{sig} \cdot \frac{R_2}{R_1 + R_2}$ → unloaded v_{in}

v_{sig} → Calculate $a \rightarrow a \cdot v_{sig}$

Miller Effect

$$C_{in} = (1 - A_v) * C_{ft}$$ ← feed-through

$$C \triangleq \frac{\Delta Q}{\Delta V} \rightarrow C_{ft} = \frac{\Delta Q}{v_i - v_o}$$

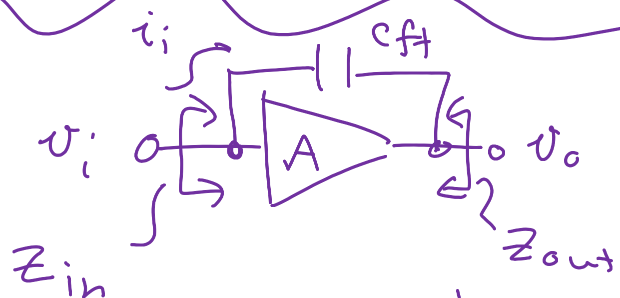


$$v_o = -\underbrace{g_m r_o}_{A_v} v_i = A_v v_i$$

$$\Delta Q = C_{ft}(-A_v v_i + v_i) = C_{ft} v_i (1 - A_v)$$

$$C_{ft1} = \frac{\Delta Q}{\Delta v_i} = C_{ft}(1 - A_v)$$

$$C_{ft} = C_{ft}\left(1 - \frac{1}{A_v}\right) = C_{ft}\left(\frac{A-1}{A}\right)$$



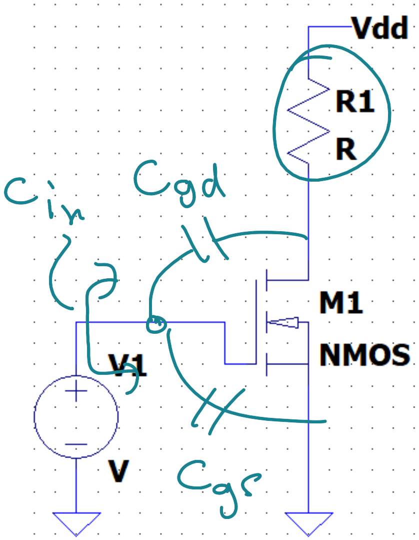
$$Z_{in} = \frac{v_i}{i_i} = \frac{v_i}{(v_i - v_o)/\left(\frac{1}{sC_{ft}}\right)} = \frac{v_i}{v_i(1 - A_v) \cdot sC_{ft}}$$

$$Z_{out} = \frac{1}{s\left[C_{ft}\left(1 - \frac{1}{A_v}\right)\right]}$$

$$Z_{in} = \frac{1}{s(C_{ft} \cdot (1 - A_v))}$$

Miller Effect

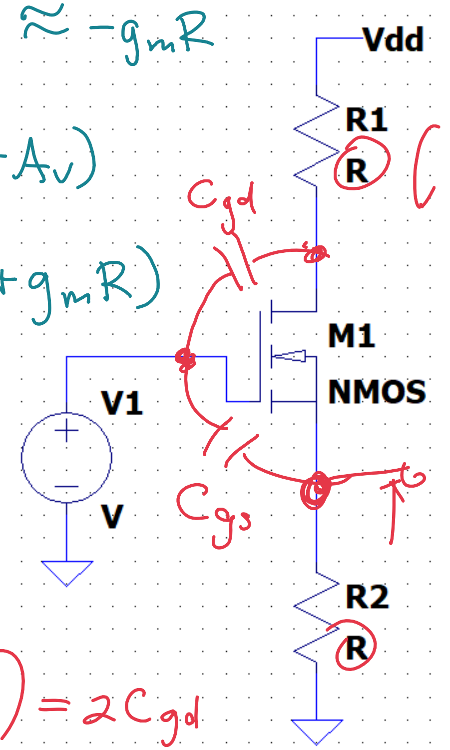
$$C_{in} = (1 - A_v) * C_{ft}$$



$$A_v = -g_m (r_o \| R) \approx -g_m R$$

$$C_{in} = C_{gs} + C_{gd}(1 - A_v)$$

$$= C_{gs} + C_{gd}(1 + g_m R)$$



$$g_m \triangleq \frac{i_d}{v_{gs}}, \quad v_1 \neq v_{gs}$$

$$G_m = \frac{g_m}{1 + g_m R_2}$$

$$G_m \triangleq \frac{i_d}{v_1} \rightarrow \frac{1}{R_2} \text{ if } g_m R_2 >> 1$$

$$C_{gs_1} = C_{gs}(1 - A_v) = 0$$

$$\frac{v_s}{v_g} \approx 1$$

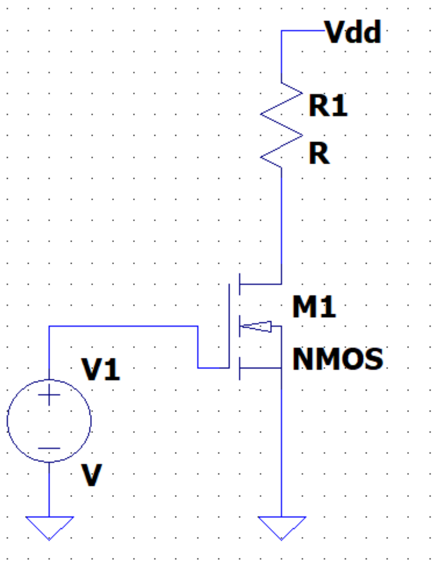
$$C_{gd_1} = C_{gd}(1 - (-1)) = 2C_{gd}$$

$$C_{in} = 2C_{gd}$$

$$A_v = -G_m R_1 = -\frac{1}{R_2} R_1 = -1$$

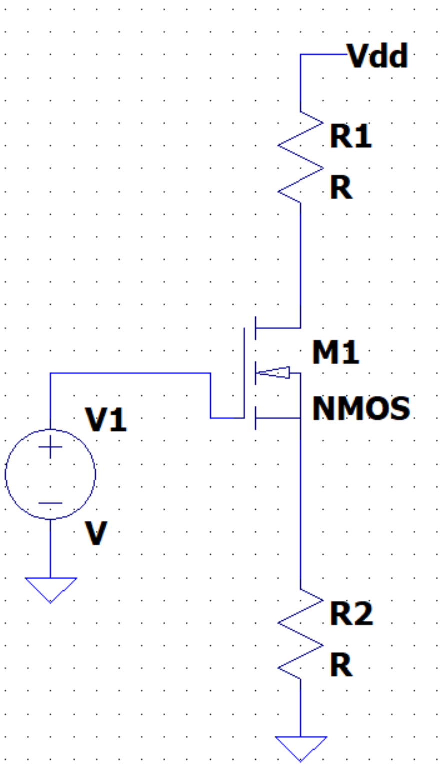
Miller Effect

$$C_{in} = (1 - A_v) * C_{ft}$$



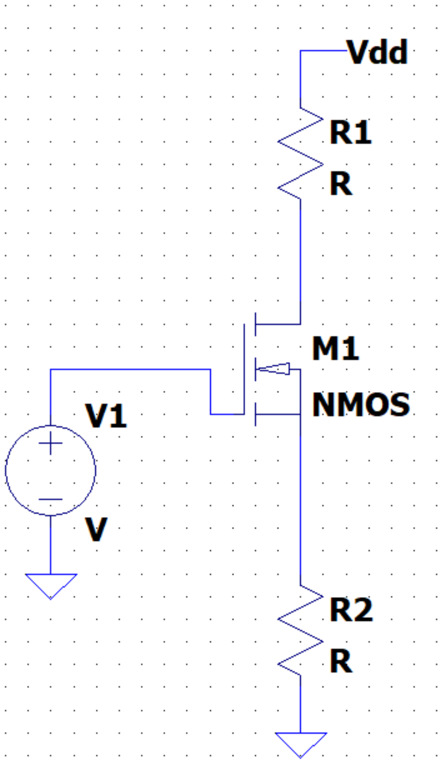
Miller Effect

$$C_{in} = (1 - A_v) * C_{ft}$$



Miller Effect

$$C_{in} = (1 - A_v) * C_{ft}$$



CE Amp w/ Feedback Resistor

- Impact of adding a feedback resistor
  - Change the Q-point
  - Change the small-signal gain

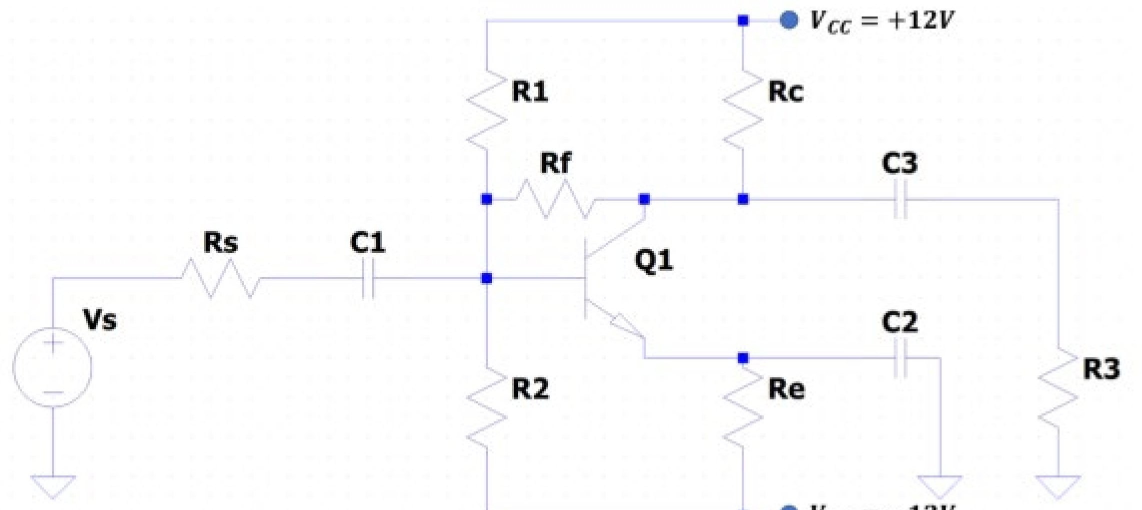


Figure PS8.1

CE Amp w/ Feedback Resistor

- Common use of this circuit
  - Trans-Impedance Amplifier

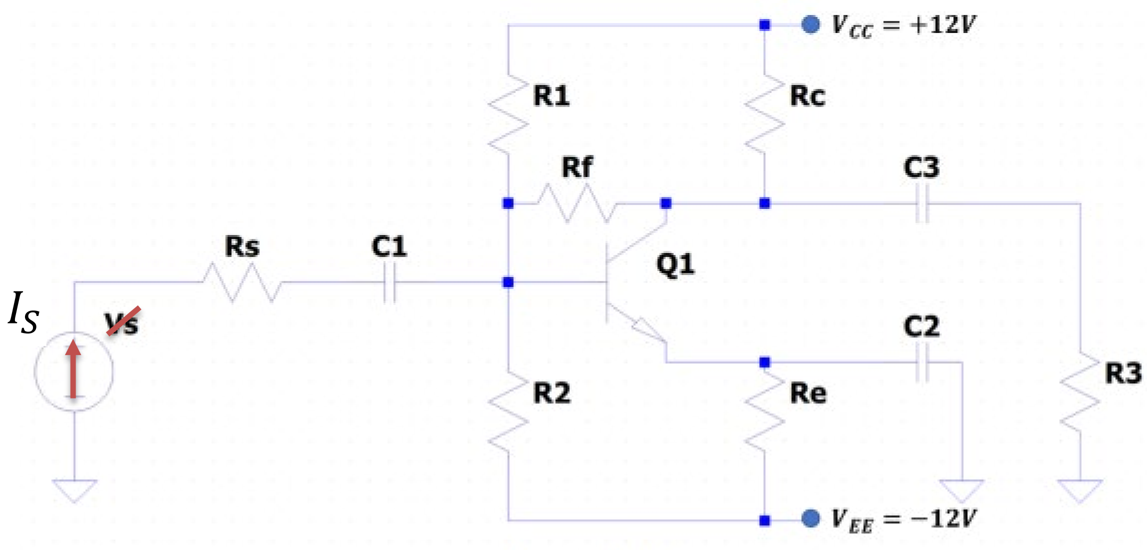


Figure PS8.1