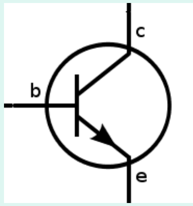
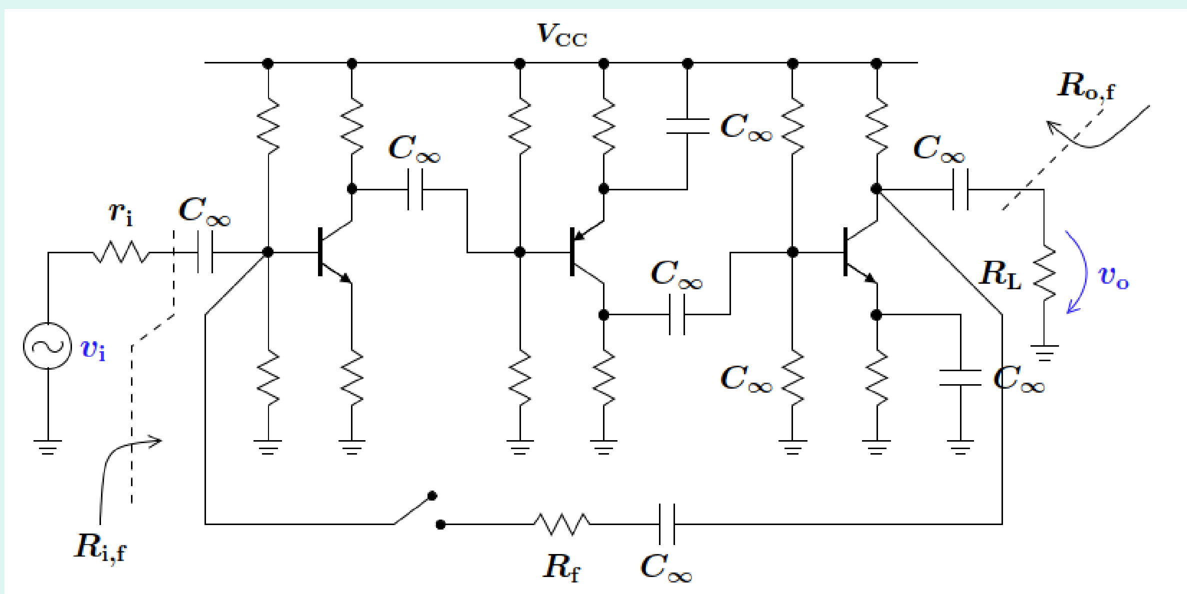
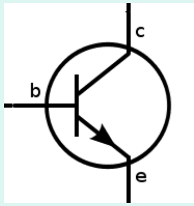


ELEC 301 - CC amplifier (2)

L16 - Oct 14

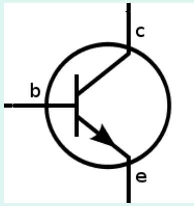
Instructor: Edmond Cretu





Last time

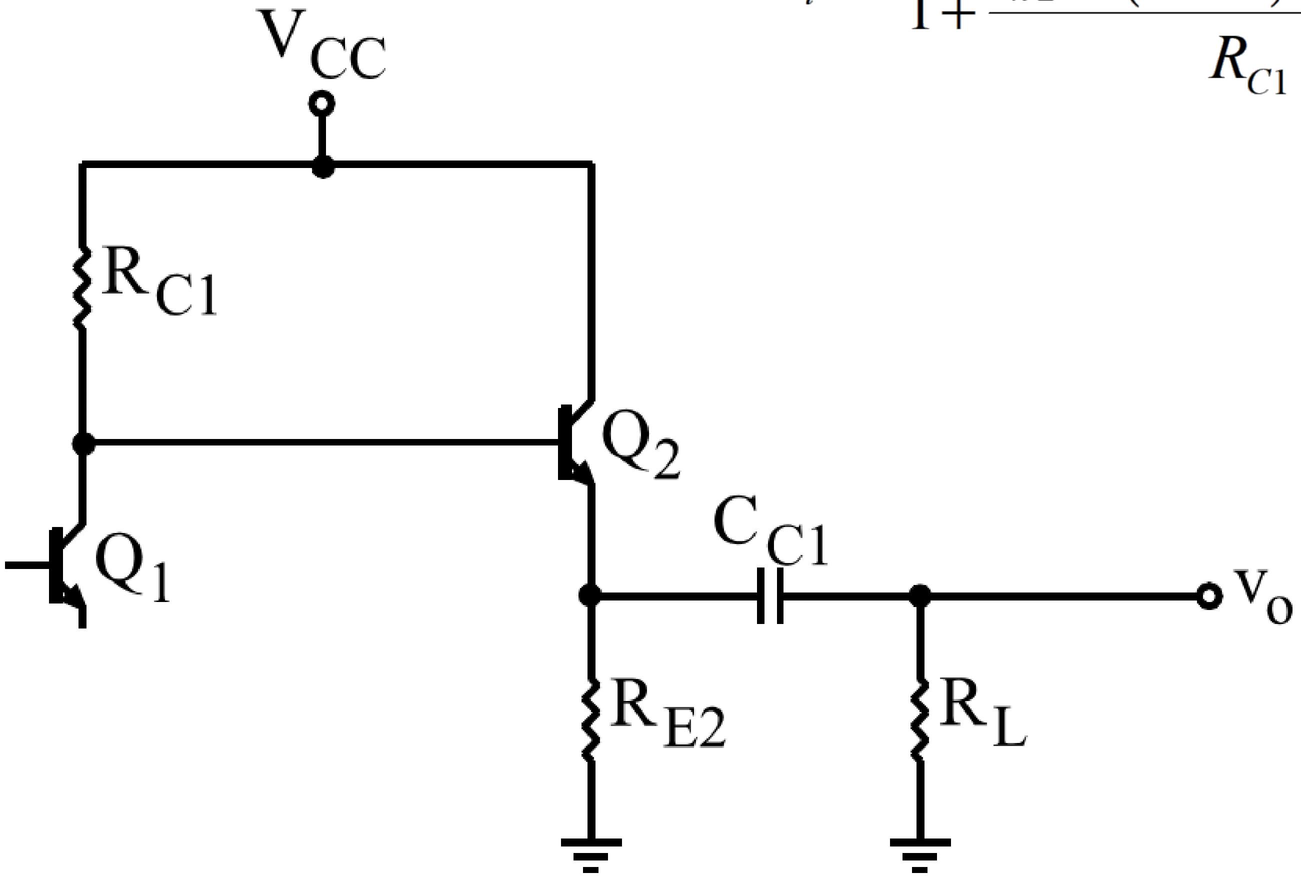
- Ideal amplifier diports: voltage amplifier, current amplifier, transimpedance amplifier, transadmittance amplifier
- CB amplifier
- CC amplifier: high input impedance, low output impedance, power gain, DC coupled at input, wide BW

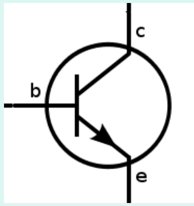


CC amplifier

- current gain, almost unity voltage gain

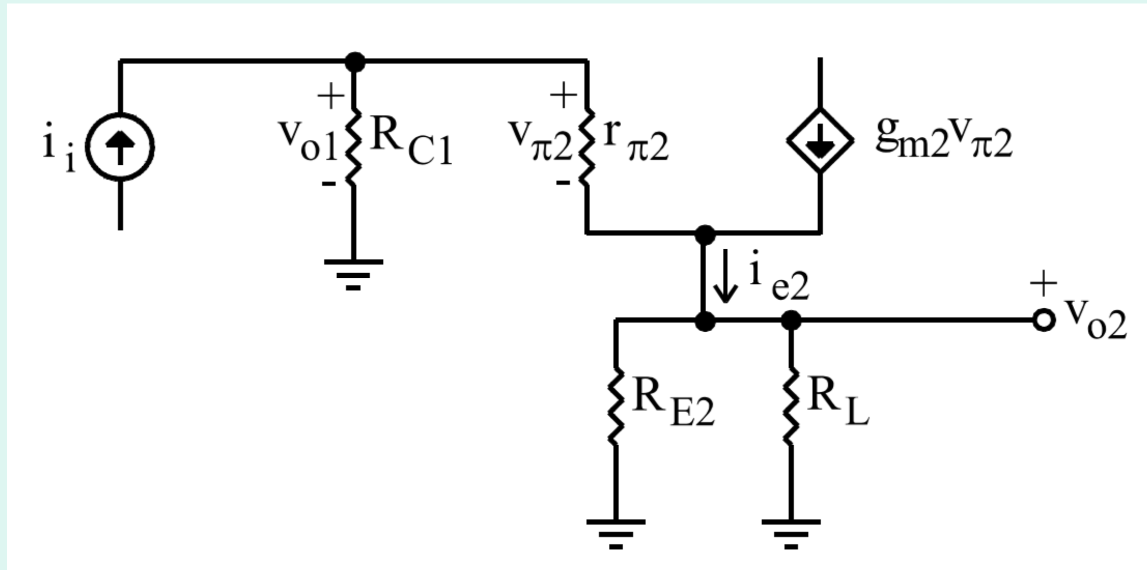
$$A_i = \frac{i_{e2}}{i_i} = \frac{\beta + 1}{1 + \frac{r_{\pi 2} + (\beta + 1) R_{E2} \parallel R_L}{R_{C1}}} \approx \frac{R_{C1}}{R_{E2} \parallel R_L}$$





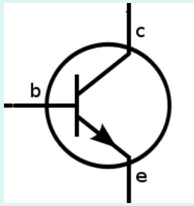
CC amplifier - voltage gain

- $A_{v2}=v_{o2}/v_{o1}\sim 1$ => the power gain is given by the current gain



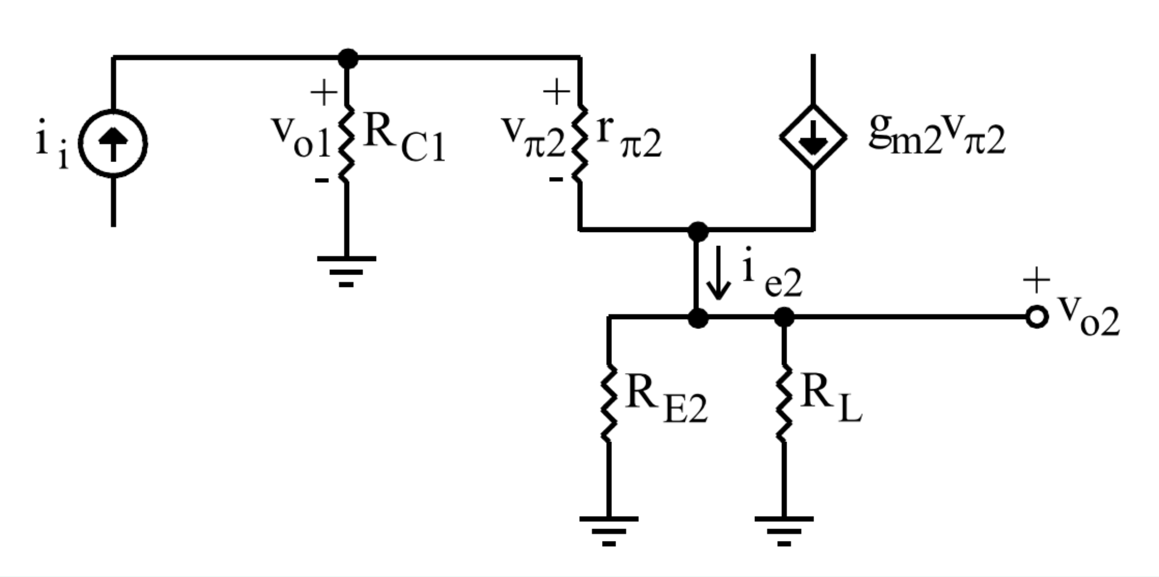
$$v_{o2}=\left(R_{E2}\parallel R_L\right)i_{e2}=\left(R_{E2}\parallel R_L\right)\frac{\left(\beta+1\right)v_{o1}}{r_{\pi 2}+\left(\beta+1\right)R_{E2}\parallel R_L}$$

$$A_{v2}=\frac{v_{o2}}{v_{o1}}=\frac{\left(\beta+1\right)\left(R_{E2}\parallel R_L\right)}{r_{\pi 2}+\left(\beta+1\right)R_{E2}\parallel R_L}\leq 1$$



CC amplifier - output impedance at midband

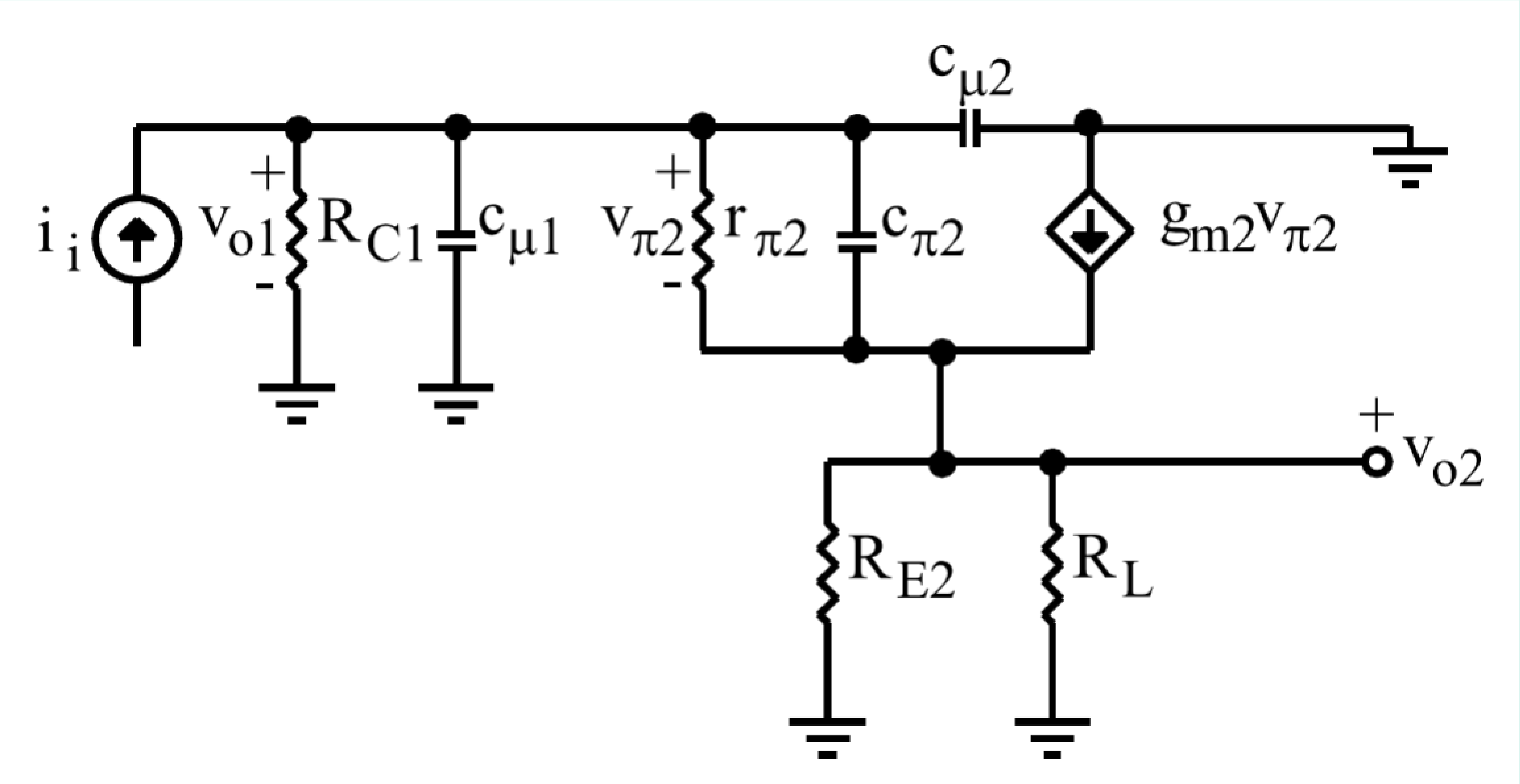
- Remove R_L, look from v_{o2} - low output impedance



$$R_{o2} = R_{E2} \,||\, \frac{r_{\pi 2} + R_{C1}}{\beta_2 + 1} \approx \frac{r_{\pi 2} + R_{C1}}{\beta_2 + 1}$$

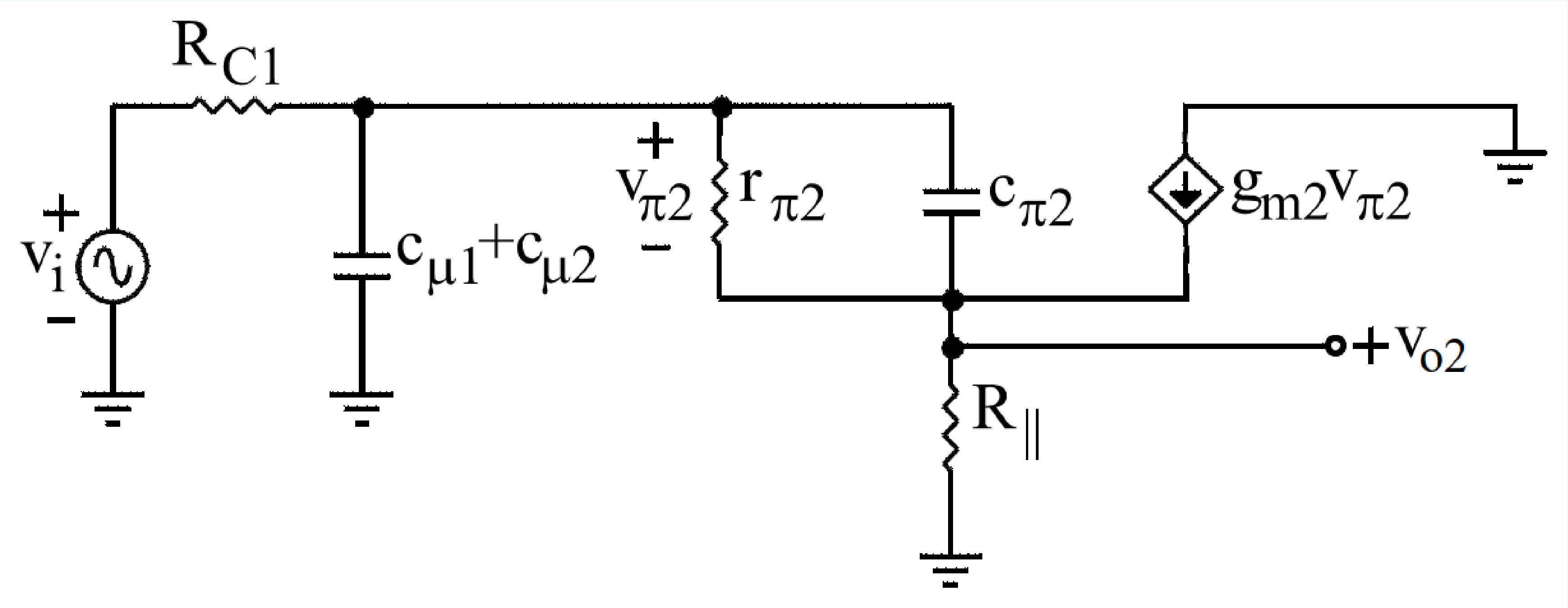
$F_H(s)$ - HF response

- HF small-signal circuit



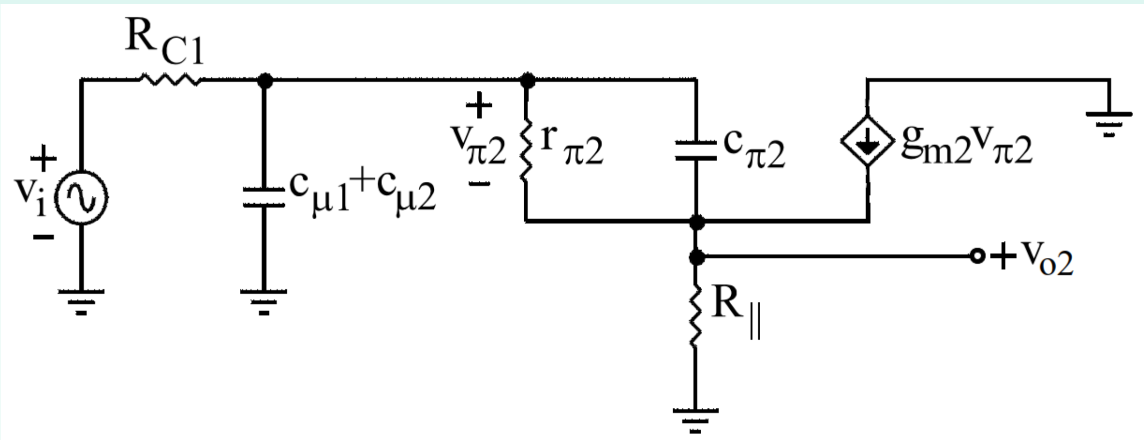
HF response - redrawn circuit

- $R_{\|} = R_{E2} \| R_L$, $v_i = R_{C1} i_i$



$C_{\pi 2}$ OC and SC time constants

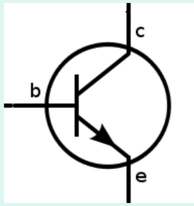
- For $C_{\pi 2}$



$$\tau^{oc}_{c\pi 2} = \left(c_{\pi 2} \times \frac{r_{\pi 2}}{R_{in2}} \right) \left(R_{C1} \| R_{in2} \right) \left(1 + \frac{R_{\|}}{R_{C1}} \right) \approx$$

$$\left(c_{\pi 2} \times \frac{r_{\pi 2}}{R_{in2}} \right) \left(R_{C1} \| R_{in2} \right)$$

$$\tau^{sc}_{c\pi 2} = c_{\pi 2}\, R_{\|} \,\|\, \frac{r_{\pi 2}}{1+\beta_2} \approx c_{\pi 2} \frac{r_{\pi 2}}{1+\beta_2}$$



CC HF - dominant high frequency

- Dominant pole ω_{Hp1}

$$\frac{1}{\omega_{H3dB}} = \frac{1}{\omega_{C_\mu}^{OC}} + \frac{1}{\omega_{C_\pi}^{OC}} = \tau_\mu^{OC} + \tau_\pi^{OC}$$

$$\tau_\mu^{oc} = R_{C1} \| \underbrace{\left(r_{\pi 2} + (\beta+1) R_\|\right)}_{R_{in2}} \left(C_{\mu 1} + C_{\mu 2}\right)$$

$$\omega_{Hp1} \approx \frac{1}{\left(c_{\mu 1} + c_{\mu 2}\right) R_{C1} \| R_{in2}}$$

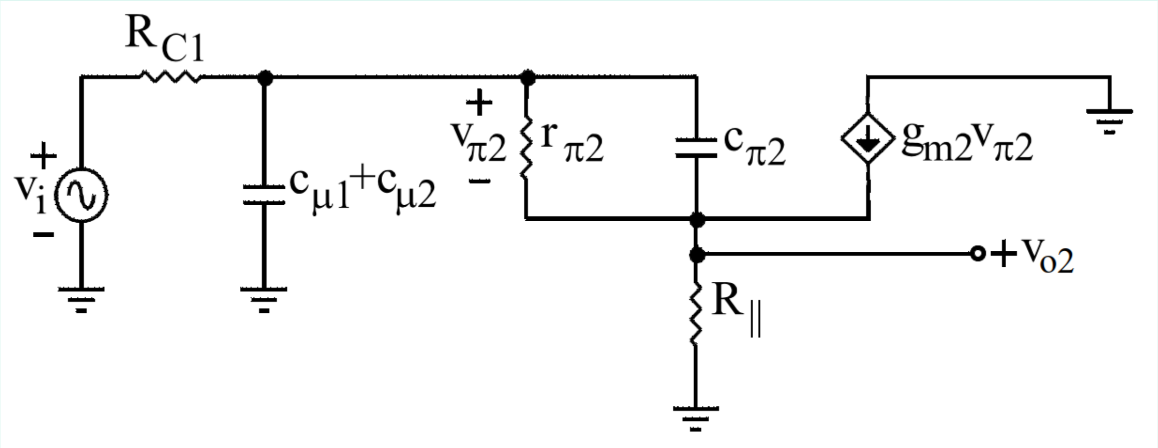
$$\tau_{\pi 2}^{oc} = \frac{r_{\pi 2} R_{C1}}{r_{\pi 2} + (\beta_2 + 1) R_\| + R_{C1}} C_{\pi 2}$$

The sub-dominant pole ω_{Hp2}:

$$\omega_{Hp2} \simeq \frac{1}{\tau_{\pi 2}^{sc}} \approx \frac{\beta_2 + 1}{r_{\pi 2} C_{\pi 2}}$$

CC - HF zero

- This circuit also has a high frequency zero



$$v_{o2}=0 \Leftrightarrow R_{\|}\left(y_{\pi 2}v_{\pi 2}+g_{m2}v_{\pi 2}\right)=0$$

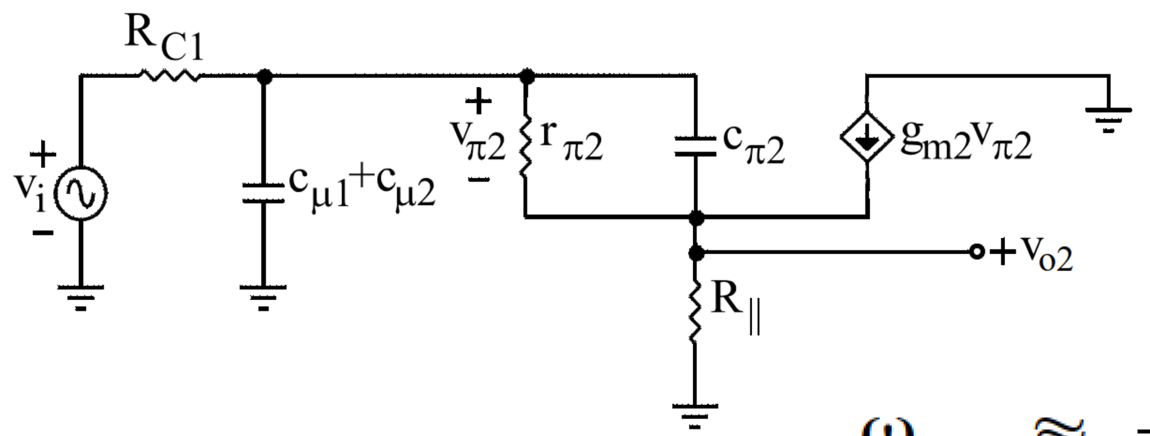
$$\frac{1}{r_{\pi 2}}+s_{Hz}C_{\pi 2}+\underbrace{\frac{\beta_2}{r_{\pi 2}}}_{g_{m2}}=0 \Rightarrow s_{Hz}=-\frac{\beta_2+1}{r_{\pi 2}C_{\pi 2}}$$

The HF zero and the sub-dominant HF pole are nearly coincident and cancel each other out - this is known as "**pole-zero cancellation**" (used sometimes in the control system to tailor the frequency response of a system

$$\frac{\dfrac{s}{\omega_{Hz}}+1}{\dfrac{s}{\omega_{Hp2}}+1} \approx 1$$

CC HF response

- Very similar to a first order LP filter

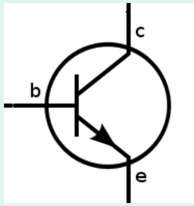


$$F_H(s) \approx \frac{\omega_{Hp}}{s + \omega_{Hp}}$$

$$\omega_{Hp} \approx \frac{1}{\left(c_{\mu 1} + c_{\mu 2}\right) R_{C1} \| R_{in2}}$$

When similar transistors are used so that $C_{\mu 1} \approx C_{\mu 2}$

$$\omega_{Hp} \approx \frac{1}{2\, c_{\mu 1}\, R_{C1} \| R_{in2}}$$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