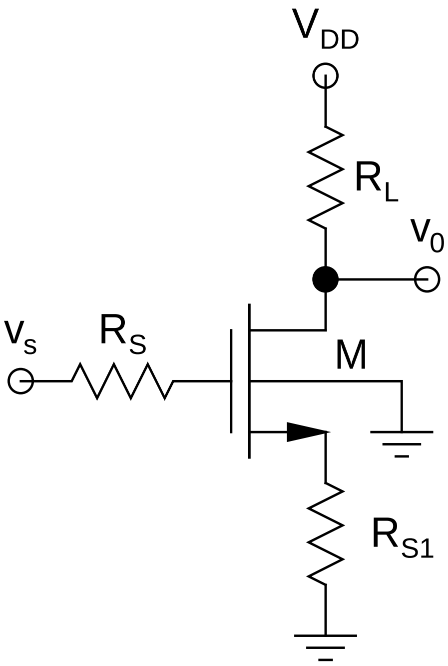
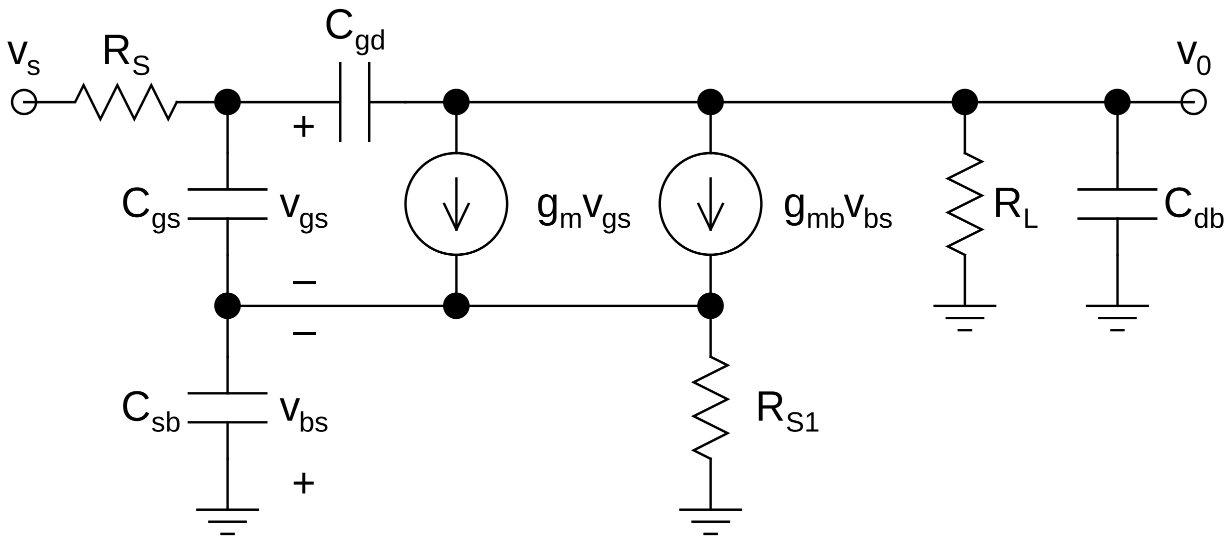
- ***CS(D)*:**

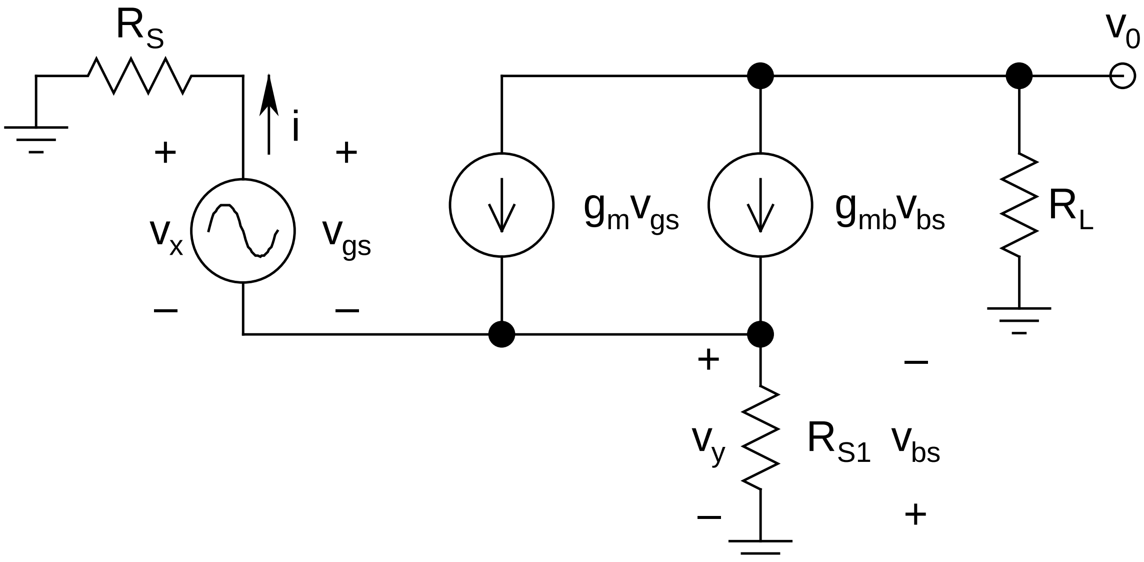


ac Schematic



High-Frequency Equivalent

- ***Inarguably, the most complex module***
  - ***All the capacitors will be present***
  - ***None will have Standard Form***
  - ***Detailed analysis needed for each of them***
- ***C_{gs}*:**



- ***Open all other capacitors***
- ***Replace C_{gs} by a voltage source v_x***
- $v_{gs} = v_x$ and $v_{bs} = -v_y$
- $i = (v_x + v_y)/R_S$

  $= g_m v_{gs} + g_{mb} v_{bs} - v_y/R_{S1}$

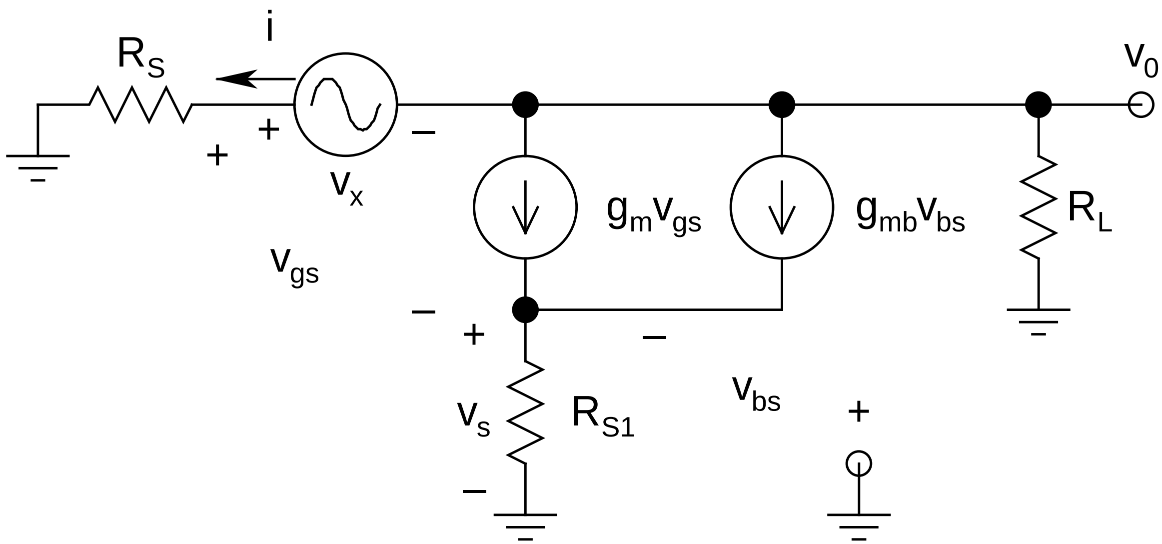
  $= g_m v_x - g_{mb} v_y - v_y/R_{S1}$

  $\Rightarrow v_y = [R_{S1}(g_m R_S - 1)]v_x/(R_{S1} + R_S + g_{mb} R_S R_{S1})$

  $$\Rightarrow R_{gs}^0 = \frac{v_x}{i} = \frac{R_S + R_{S1} + g_{mb} R_S R_{S1}}{1 + \left(g_m + g_{mb}\right) R_{S1}}$$

  $$\Rightarrow \tau_1 = R_{gs}^0 C_{gs}$$
- Note that ***if body effect is neglected*** (***g_{mb} ignored***), then it becomes ***identical to that of a CD stage***

- ***C_{gd}:***



- *Open all other capacitors*
- *Replace C_{gd} by v_x*
- $v_{gs} = (v_0 + v_x - v_s)$ and $v_{bs} = -v_s$

- $i = (v_0 + v_x)/R_S$
- $v_s = (g_m v_{gs} + g_{mb} v_{bs})R_{S1}$

  $\Rightarrow v_s = g_m R_{S1}(v_0 + v_x)/[1 + (g_m + g_{mb})R_{S1}]$
- ***KCL at output node***:

  $i + g_m v_{gs} + g_{mb} v_{bs} + v_0/R_L = 0$
- ***The rest of the process involves huge amount of algebra***!
- ***Finally, if done right*** (***check***!)

$$R_{gd}^{0} = \frac{v_x}{i} = R_L\left[1 + g_m R_S + \frac{R_S}{R_L} - \frac{(g_m + g_{mb})g_m R_S R_{S1}}{1 + (g_m + g_{mb})R_{S1}}\right]$$

$$\Rightarrow \tau_2 = R_{gd}^{0} C_{gd}$$

- ***This is by far the most complicated calculation/expression***
- However, an ***exact analysis*** would have yielded a ***4^th^-order transfer function*** in ω, which had to be ***solved*** to get the ***individual poles***
- ***This is still simpler than that*** :)

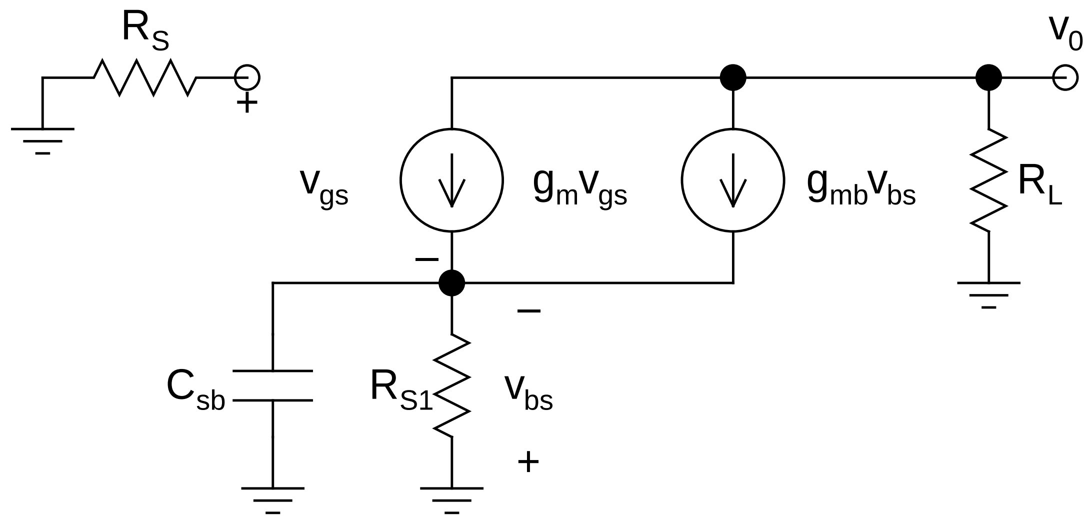
➢ ***C_{db}***:

- ***The easiest of the lot***
- ***By inspection***:

$$R_{db}^{0} = R_L$$

$$\Rightarrow \tau_3 = R_{db}^{0} C_{db}$$

➢ C_{sb}:



- *Analysis of this circuit is pretty straightforward*

$$R_{sb}^{0} = \frac{R_{S1}}{1+\left(g_m + g_{mb}\right)R_{S1}} \quad \Rightarrow \quad \tau_4 = R_{sb}^{0} C_{sb}$$