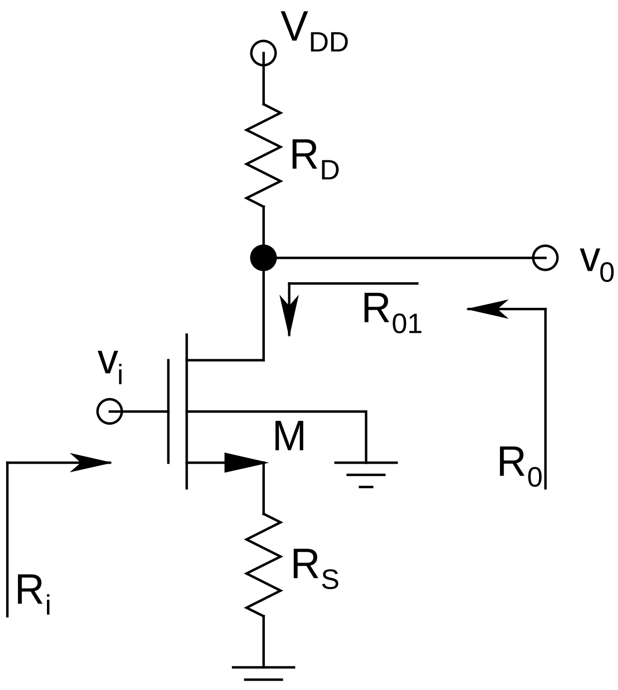
- $(1 + g_m R_E)$ is known as the ***Degeneration Factor***
- R_i can also be written as:

  $R_i \approx r_\pi + \beta R_E = r_\pi(1 + g_m R_E)$

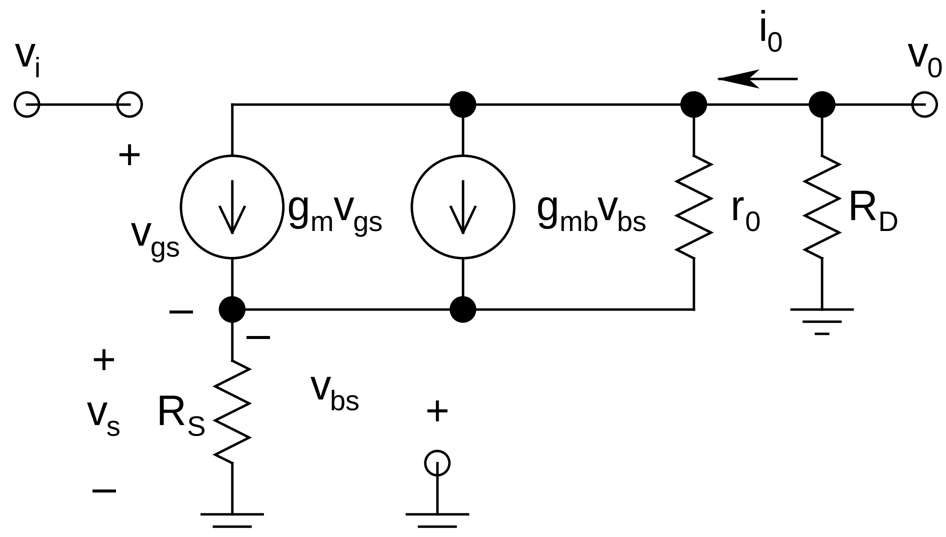
  Thus, $R_i\uparrow$ by the ***Degeneration Factor*** as compared to the ***CE stage***
- ***Interesting to note that the loss in gain is returned by this circuit to its R_i by the same factor***!

- ***Why do we sacrifice gain***?
  - Later on, we will see that this ***sacrifice in gain*** leads to a ***commensurate increase in the bandwidth*** of the circuit
- ***For a given DC bias point***, the ***gain-bandwidth product (GBP) of a circuit remains constant*** (will be explored later)
- This is one of the ***famous paradoxes*** of analog circuits:
  - ***To increase gain, sacrifice bandwidth, and vice versa***

- ***Common-Source (Degeneration)*** [CS(D)]:



ac Schematic



ac Low-Frequency Equivalent

- ***Defining Relations***:

$$v_0 = -\, i_0 R_D$$

$$i_0 = g_m v_{gs} + g_{mb} v_{bs} + (v_0 - v_s)/r_0$$

$$v_s = i_0 R_S$$

$$v_{gs} = v_i - v_s$$

$$v_{bs} = -\, v_s$$

$$\Rightarrow A_v = \frac{v_0}{v_i} = -\frac{g_m R_D}{1 + \left(g_m + g_{mb}\right) R_S + \left(R_S + R_D\right)/r_0}$$

- Pretty ***complicated*** expression, however, ***simplifications*** can be made

- Generally, $(R_S + R_D)/r_0$ can be ***neglected***:

$$\Rightarrow A_v = \frac{v_0}{v_i} \simeq -\frac{g_m R_D}{1+\left(g_m + g_{mb}\right)R_S}$$

- ***Neglect body effect***:

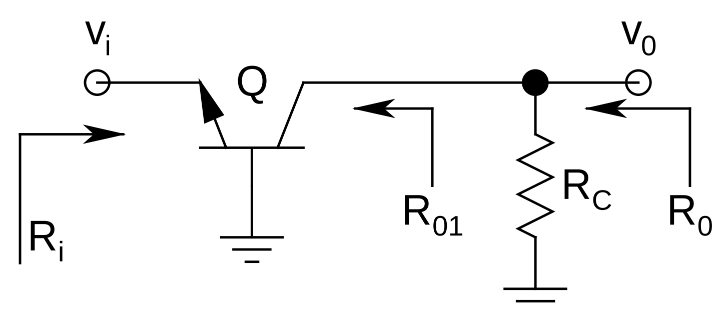
$$\Rightarrow A_v \simeq -\frac{g_m R_D}{1+g_m R_S} = -\frac{R_D}{1/g_m + R_S}$$

- Again, ***remarkable similarity with CE(D) stage***
- ***Golden Observation***:
  - ***MOS stages, in absence of body effect, is absolutely similar to BJT stages, with r_E replaced by $1/g_m$, and both β and $r_\pi \rightarrow \infty$***

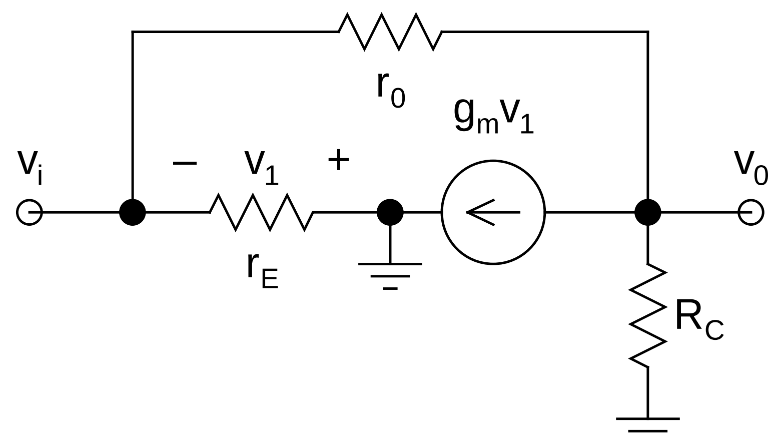
- Note that here the ***Degeneracy Factor*** is $(1 + g_m R_S)$
- $R_i \rightarrow \infty$
- $R_0 = R_{01} || R_D$

  $R_{01} = r_0[1 + (g_m + g_{mb})R_S]$ (***Show***!)
- Again ***gain is sacrificed*** in order to ***improve the bandwidth*** by the ***same amount***
- The complexity of analysis of this circuit is slightly more than the others encountered so far

- ***Common-Base*** (CB):



ac Schematic



ac Low-Frequency Equivalent

- Note that the ***alternate hybrid-π model appropriate for CB circuit*** has been used
- ***r_0 appears between input and output***