ECE 5411 — Review Session 1

Note Title 3/6/2011

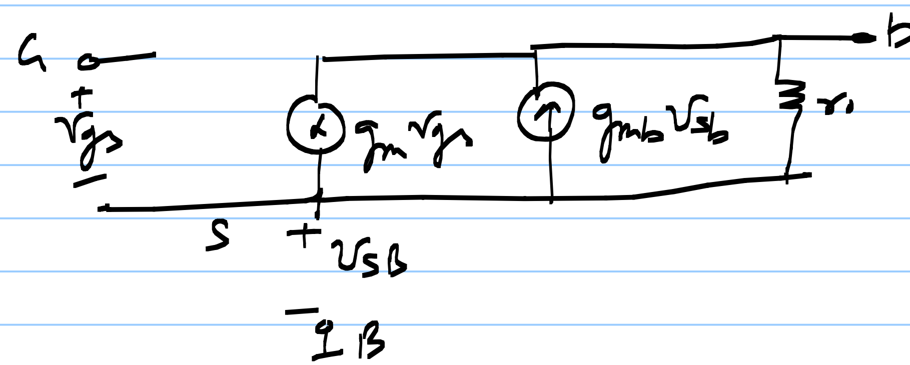
* IV curves
* Small signal parameters (g_m, r_o, g_{mb})
  sketches
* R_{ch} Triode
  Saturation
* Body-effect ⇒ g_{mb}

* Small-signal → Taylor Series

* g_m → vs V_{ov}, $\frac{W}{L}$ constant — $\beta_n (V_{GS} - V_{THN})$
  - → vs I_D, W/L constant — $\sqrt{2 \beta_n I_D}$
  - → vs V_{ov}, I_D constant — $\frac{2 I_D}{V_{ov}}$

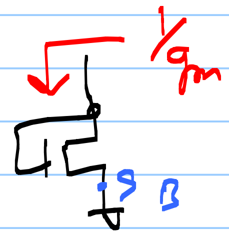
* $r_o = \frac{1}{\lambda I_{D,sat}}$

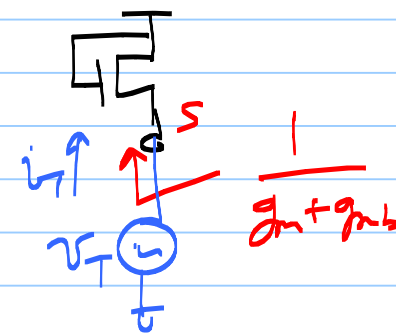
* Small-signal model (low-frequency)



⇒ Diode connected MOSFET

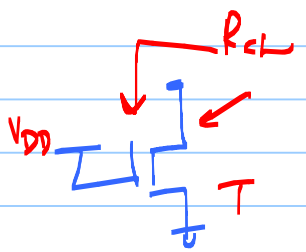
↳ as a load





v_{sb}

⇒



$$R_{ch} = \frac{1}{K'_n \frac{W}{L} (V_{GS} - V_{THN})} \simeq \frac{1}{g_m}$$

deep triode

$V_{DS} << V_{DS,sat}$

* Example 9.5

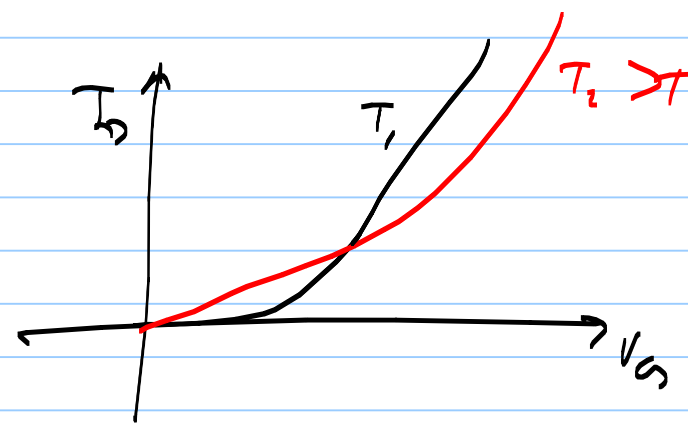
* f_T Derivation & interpretation

$$f_T \propto \frac{V_{ov}}{L^2} \quad \text{Long channel}$$

$$\propto \frac{V_{ov}}{L} \quad \text{Short channel}$$

* g_m behavior in subthreshold.

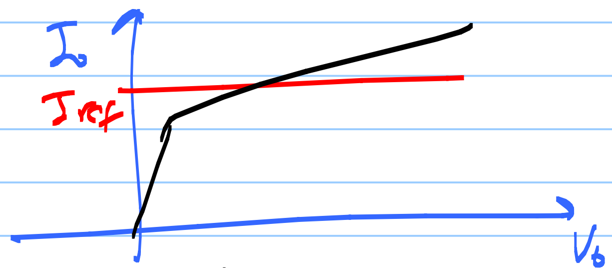
* Temp behavior $I_D - V_{GS}$

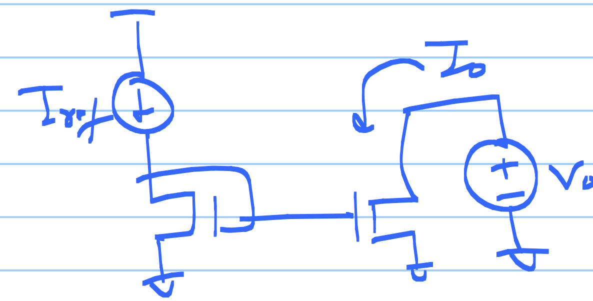


Chap 20

* Additional HW problems

↳ $\frac{I_{out}}{I_{ref}} = \frac{(W/L)_2}{(W/L)_1}$ ⇒ Sketches





↳ cascoded current mirror

* Mismatch analysis of the current mirror

$$\frac{\Delta I_D}{I_D} = \frac{\Delta(W/L)}{W/L} - \frac{2\,\Delta V_{THN}}{(V_{GS} - V_{THN})}$$

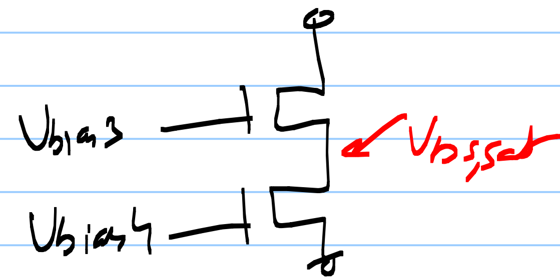
- BMR → derive I_{ref}, V_{GS}, g_m for any variant
- Design start-up circuits
- $V_{DD_{min}}$ for the BMR
- Short-channel BMR design
  - ↳ error amp to regulate the drain
- Temp behavior/analysis of the BMR.

* Cascoding
  ↳ $R_o = g_m r_o^2$ ⟶ small-signal analysis

* ↳ wide-swing cascode biasing
  ↳ MWS ⟹ $2V_{DS,sat} + V_{THN}$

⟹ Derive $\frac{W}{L}$ (4) for MWS devices

⟹ Triple cascode HW problem



* Regulated Drain current mirror

* $R_o \simeq g_m r_o^2 A$

* find bias voltages in such circuits.

* Triple cascoding + Regulated Drain

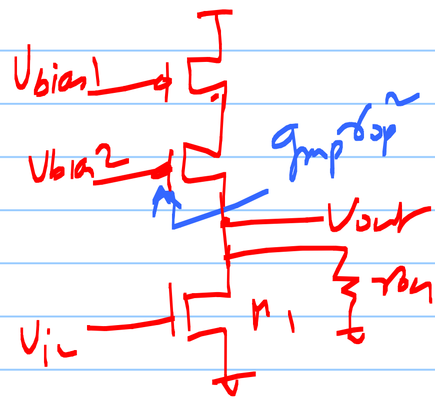
☆☆ * Cascoded Biasing 20.43 / 20.47

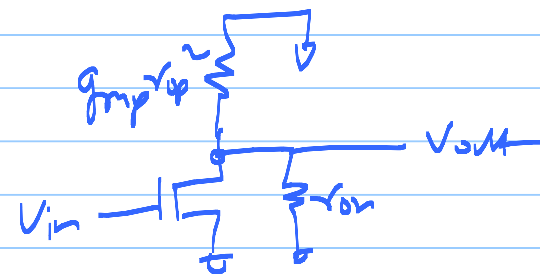
How to generate bias voltages. (V_{bias1} V_{bias3} V_{bias2} V_{bias4})

Chapter 21

⇒ HW 6

* Common Source AC gains





$A_v =$

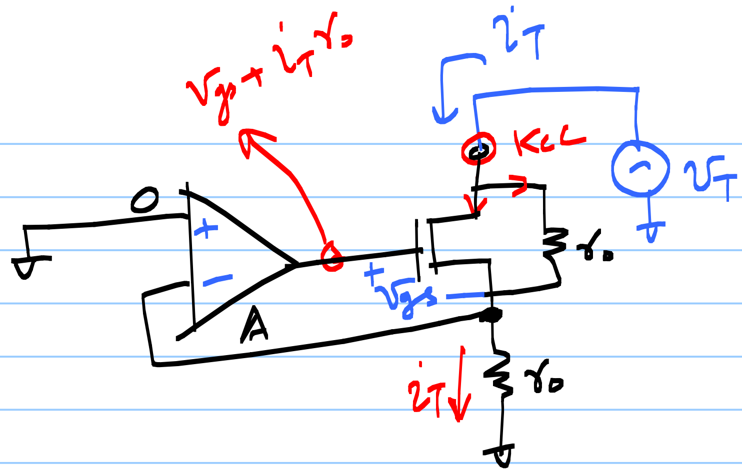
$v_{out} = -g_{mn}\left(Z_D \right)$

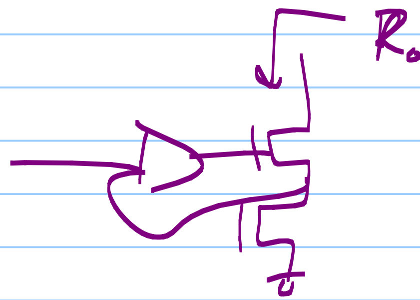
$= -g_{mn}\left(g_{mp} r_{op}^{2} \,||\, r_{on} \right)$

$A_v = -\dfrac{\text{Impedance "attached" to the drain}}{\text{impedance looking into the source}}$

* Source degenerated CS Amplifier.

↳ "linearity"





$$(0 - i_T r_o)A = v_{gs} + i_T r_o$$

$$v_{gs} = -(A+1)\, i_T r_o \longrightarrow (1)$$

$$i_T - g_m v_{gs} - \frac{(v_T - i_T r_o)}{r_o} = 0 \longrightarrow (2)$$

$$i_T + g_m(A+1)i_T r_o - \frac{v_T}{r_o} + i_T = 0$$

$$i_T\left[2 + g_m(A+1)r_o\right] = \frac{v_T}{r_o}$$

$$R_o = \frac{v_T}{i_T} = \left[g_m r_o(A+1) + 2\right]r_o$$

$$\simeq g_m r_o^2 A$$

$A \gg 1$

$g_m r_o \gg 1$