ECE 515 Lecture 9

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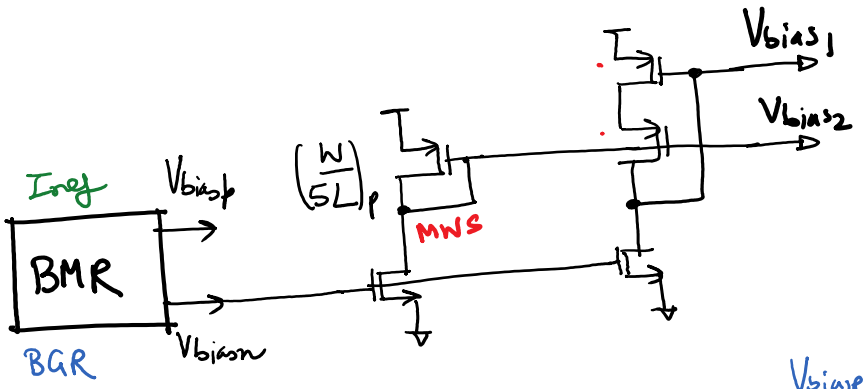
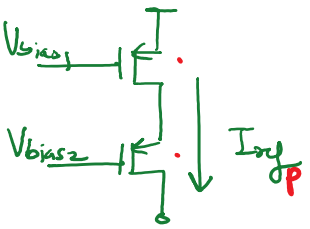
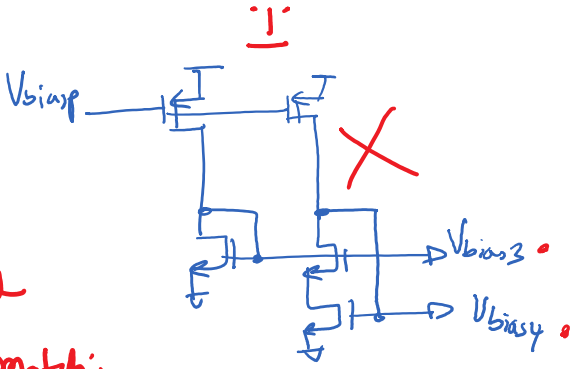
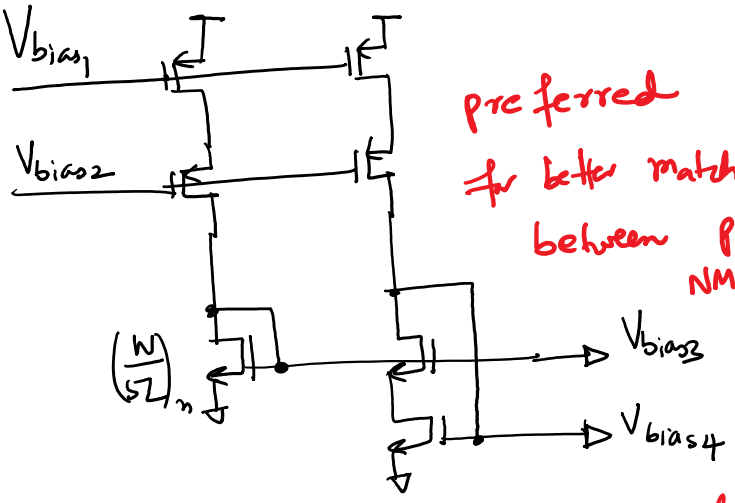
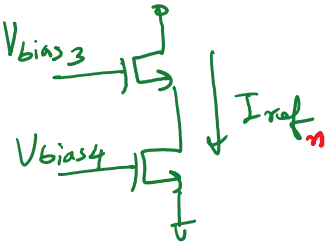








preferred for better matching between PMOS & NMOS current mirrors



for short channel design use longer L in MWS transistor

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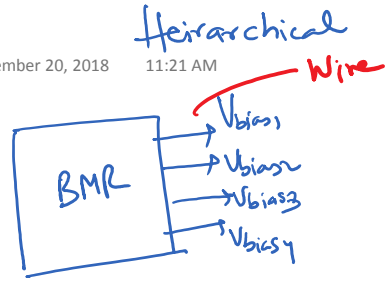
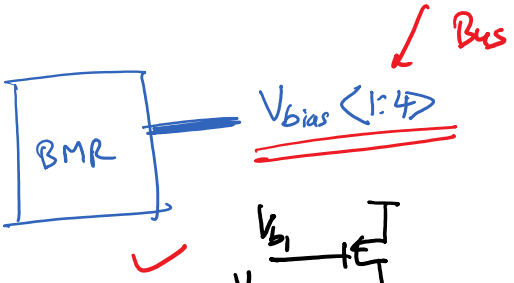
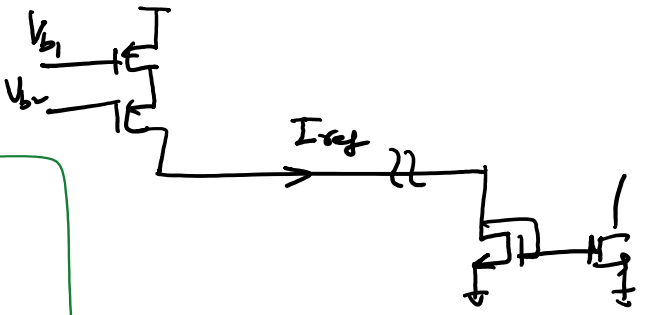
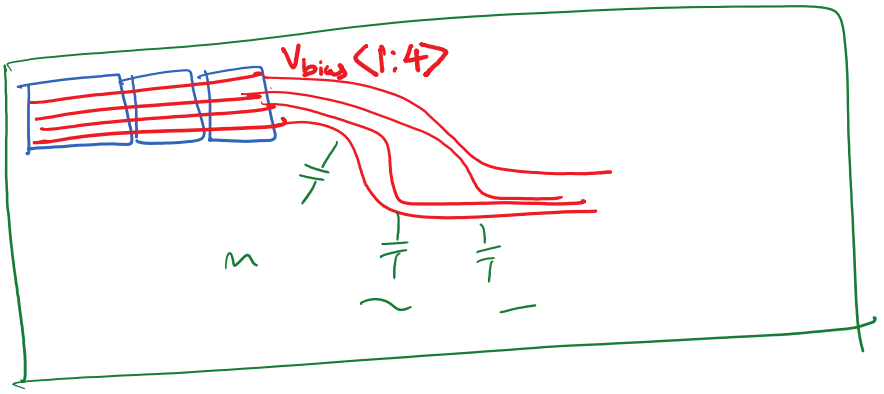
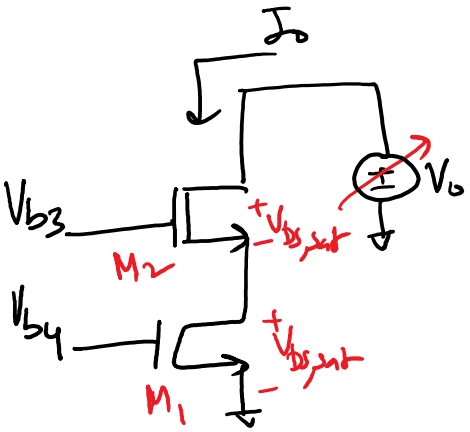
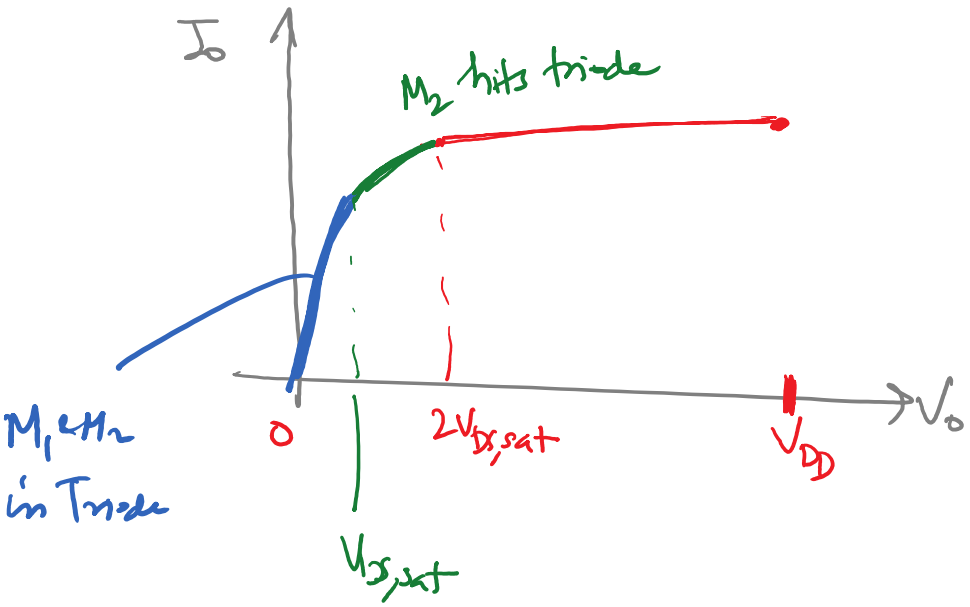




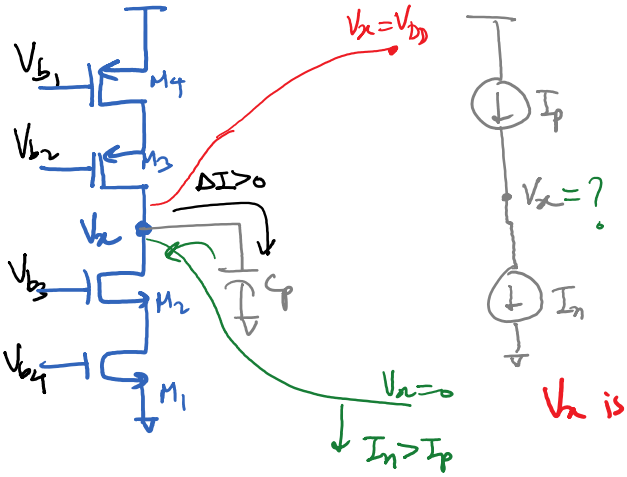





I_o
V_o
V_{b3}
M_2
V_{b4}
M_1


I_o
M_2 hits triode
M_1 & M_2 in Triode
0
$2V_{DS,sat}$
V_{DD}
V_o
$V_{DS,sat}$

I_p & I_n refer to I_{mag}



$V_x = ?$

$I_p \neq I_n$

V_x is not well-defined.

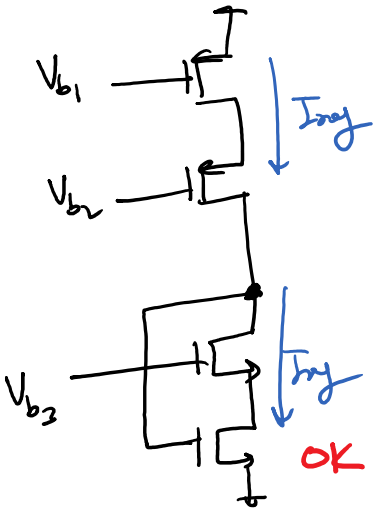
* Can never have two independent current source "fight" with each other.

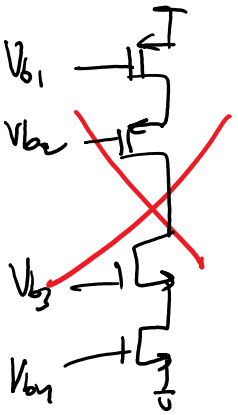
$I_p > I_n$

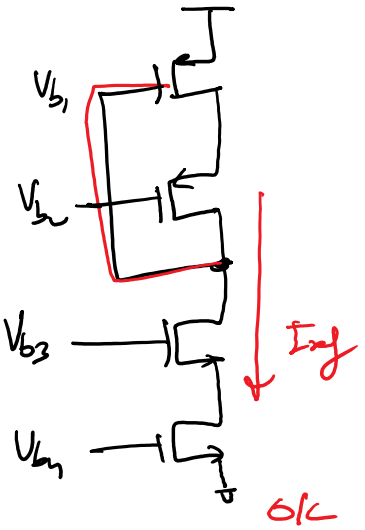
$\Delta I = I_p - I_n$

* Small current mismatch

* Always make one source dependent on the other.







Review

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Short-channel

transition frequency $\Rightarrow f_T \propto \frac{V_{ov}}{L}$

at which the current gain is 1

$\Rightarrow g_m r_o \propto \frac{L}{V_{ov}}$

Maximum gain extract from a transistor

gain x BW tradeoff in a transistor

$V_{ov} \uparrow \Rightarrow f_T \downarrow \Rightarrow g_m r_o \downarrow$ → cascoding to increase gain

→ lower swing

Typically $L = 2\text{-}5 \times L_{min}$

Long-channel CMOS

$$\frac{f_{Tp}}{f_{Tn}} = \frac{\mu_p}{\mu_n} \simeq \frac{1}{3}$$ in silicon

PMOS are 3X slower than NMOS

Short-channel CMOS

$$\frac{f_{Tp}}{f_{Tn}} \simeq \frac{v_{satp}}{v_{satn}} \simeq \frac{1}{2}$$

PMOS are 2X slower than NMOS

* Really need to check the datasheet/sims for 40 nm or below

→ FINFET (<14 nm)

V_{OV} ⇒ sets the "speed" → BW of the design

good speed $V_{OV} \simeq 5\%$ of V_{DD}

$$g_m = \frac{2I_D}{V_{ov}}$$

Either fix V_{ov} for a design or fix $\left(\frac{g_m}{I_D}\right)$

$$\Rightarrow \frac{g_m}{I_D} = \frac{2}{V_{ov}}$$

$\frac{g_m}{I_D}$ design methodology.

Single-Stage Amplifiers:

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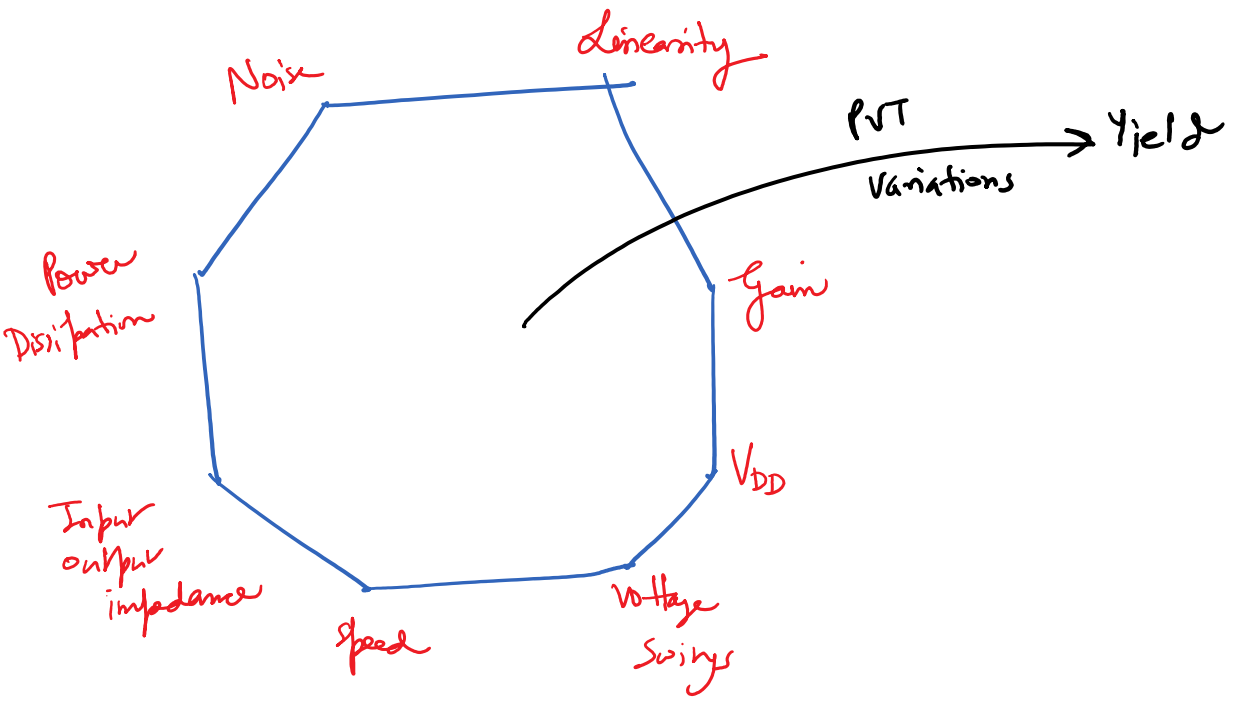
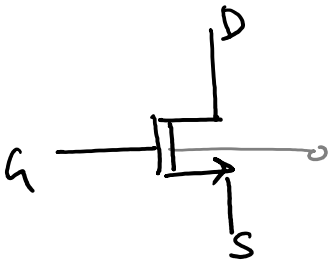
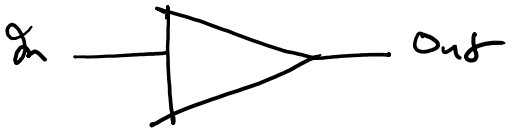
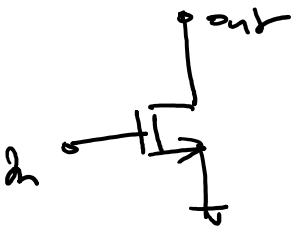
Analog Design ⇒ octagon ⇒ multidimensional trade-off

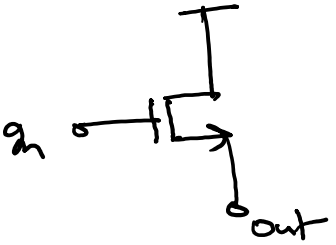




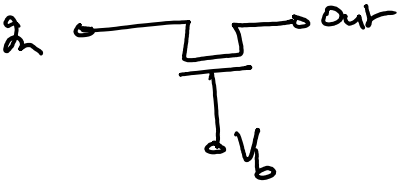




CS



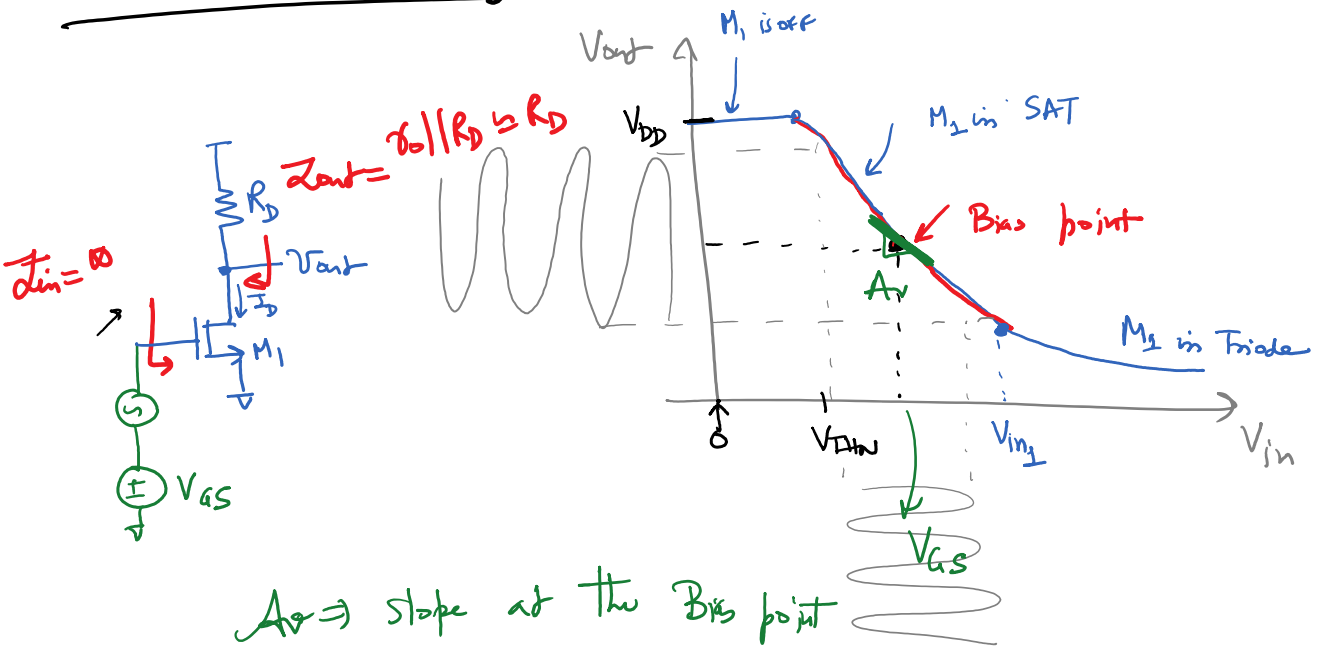
CD



CG

Common Source Stage:

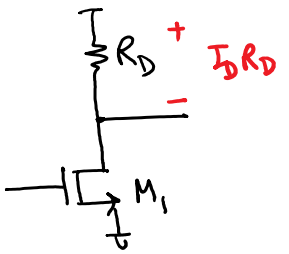
Large Signal Characteristics



$A_v \Rightarrow$ slope at the Bias point

$R_D \ll r_o$

$$A_v = -g_m(r_o \| R_D) \simeq -g_m R_D$$



$|A_v| = g_m R_D$

$A_v \uparrow \Rightarrow$ $R_D \uparrow$

$g_m \uparrow \Rightarrow$ $I_D \uparrow$

Current Mirror Load