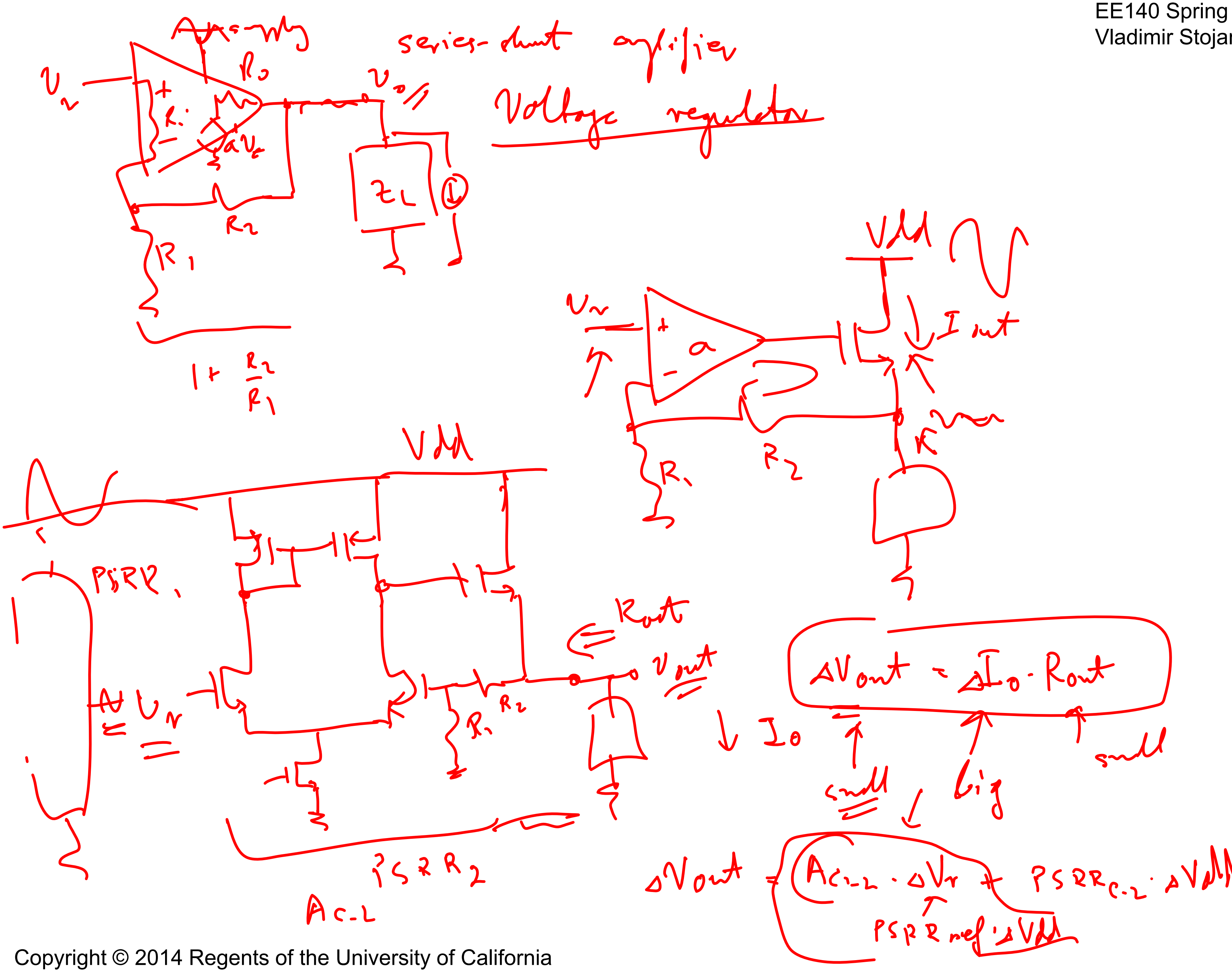

series-shunt amplifier
Voltage regulator
Z_L
R_1
R_2
1 + R_2/R_1
Vdd
I_out
PSRR
Rout
Vout
I_o
ΔVout = ΔI_o · Rout
small
big
small
ΔVout = A_CL · ΔVr + PSRR_CL · ΔVdd
PSRR_ref · ΔVdd
A_CL
PSRR_2

$$R_{out} = R_{out}(a=0) \cdot \frac{1}{1+RR}$$

$$A_{CL} = \frac{A_{eq}}{1+RR} + \frac{A_0}{1+RR} = \frac{V_0}{V_R} \Rightarrow \frac{1}{1+RR} = \frac{V_0}{(A_{eq}+A_0)\cdot V_R}$$

$$R_{out} = R_{out}(a=0) \cdot \frac{V_0}{(A_{eq}+A_0)\cdot V_R}$$

$$\Delta V_0 = R_{out} \cdot \Delta I_0$$

$$\Delta V_0 = R_{out}(a=0) \cdot \frac{V_0}{(A_{eq}+A_0) V_R} \cdot \Delta I_0$$

$$\frac{\Delta V_0}{V_0} = \frac{R_{out}(a=0)}{(A_{eq}+A_0) V_R} \cdot \Delta I_0$$

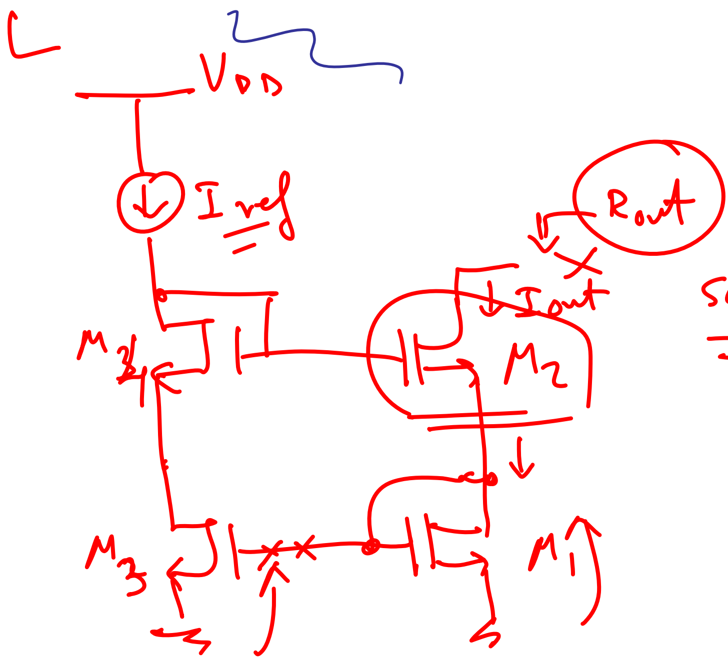
Load regulation spec.

$$\frac{\Delta V_0}{V_0} = \underline{\quad} \cdot \frac{\Delta V_{dd}}{V_{dd}}$$

Line regulation spec.

# Wilson current source:

Type of feedback?



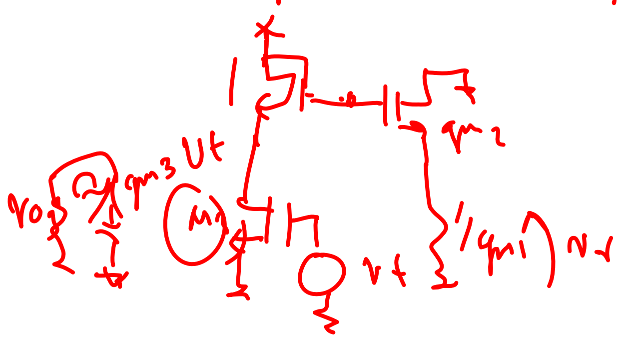
series → sense $I_{out}$

$$R_{out}(g_{m2}=0) = r_{o2} + \frac{1}{g_{m1}} \approx r_{o2}$$

$$R_{out} = r_{o2}\cdot(1 + g_{m2} r_{o3})$$

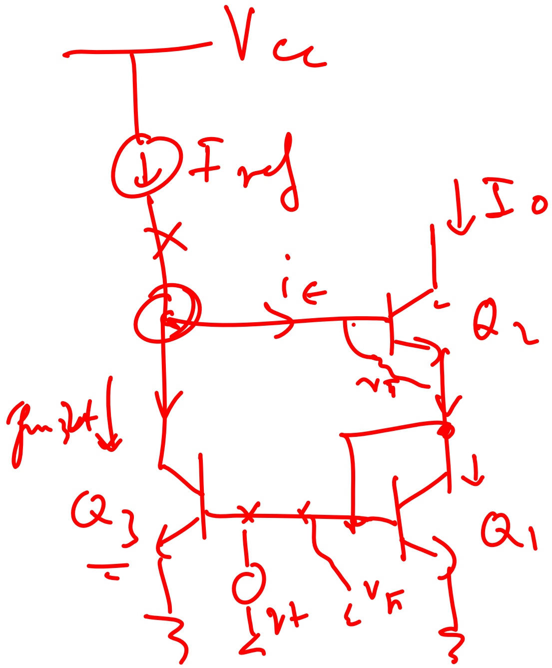
RR (output open) = 0

RR (output shorted) = RR



$$RR = g_{m3}\cdot r_{o3}\cdot\frac{g_{m2}\cdot\frac{1}{g_{m3}}}{1+g_{m2}\cdot\frac{1}{g_{m3}}} \simeq g_{m3}\cdot r_{o3}$$

BJT version:




FB type:

shunt - series

$$R_{out}(=0) = r_{o2} + \frac{1}{g_{m1}} \| r_{\pi 3} \approx r_{o2}$$

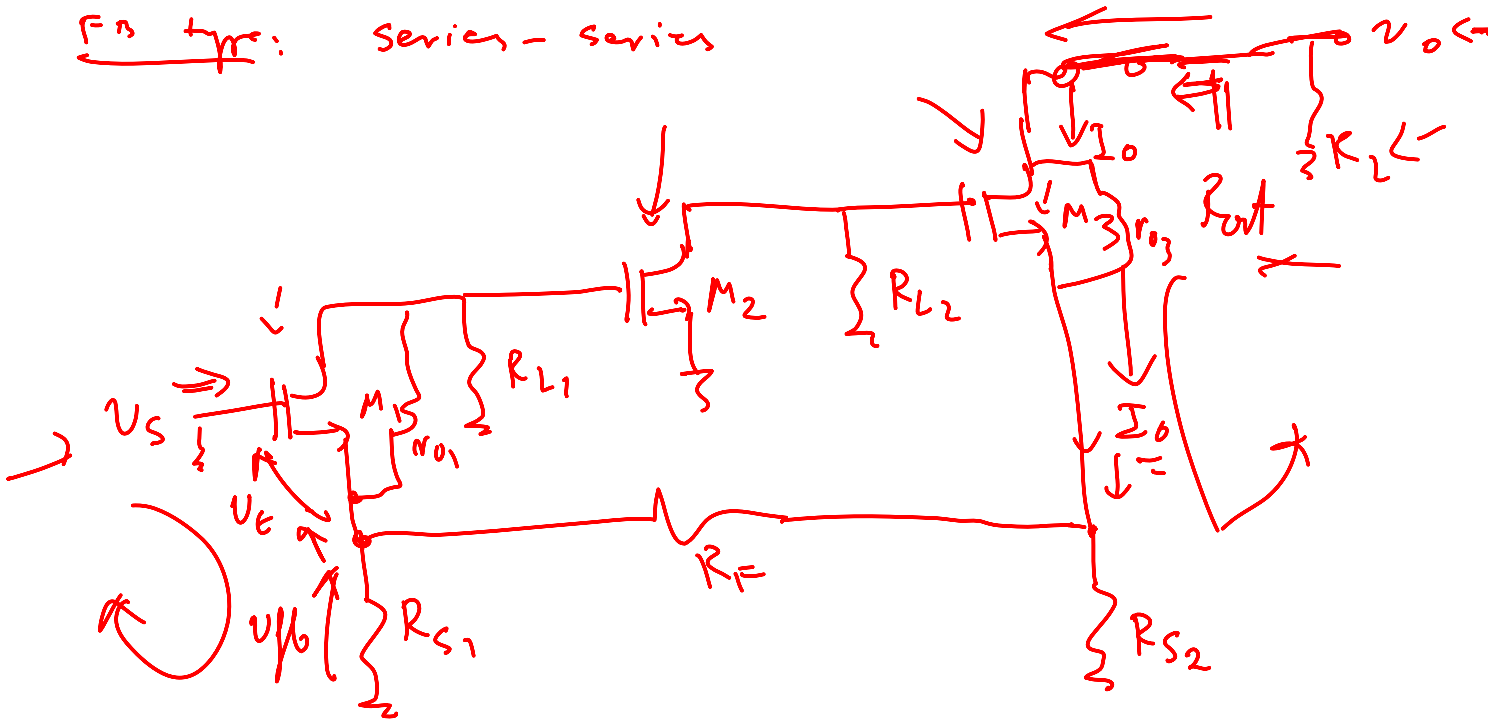
$$RR(\text{open out}) = g_{m3} \cdot \frac{1}{g_{m1}} \approx 1$$

$$RR(\text{short out}) = g_{m3} \cdot (1+\beta_0)\left(\frac{1}{g_{m1}} \| r_{\pi 3}\right)$$

$$\approx \beta_0$$

$$R_{out} = r_{o2} \frac{1+\beta_0}{1+1} \approx r_{o2} \cdot \frac{\beta_0}{2}$$

FB type: series - series



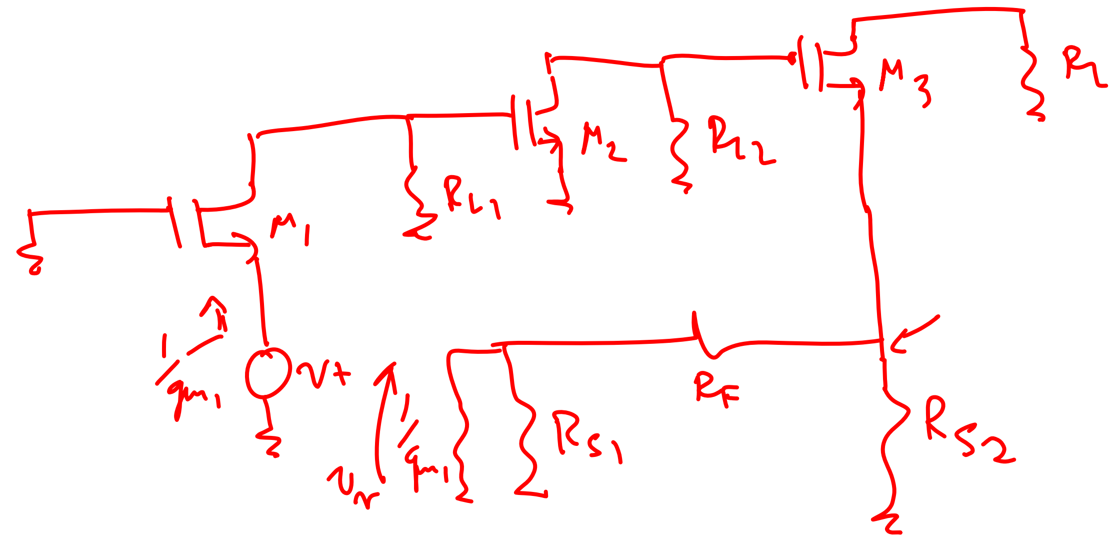

RR( output open) = 0

RR( output shorted) = RR

$R_{out} = R_{out}(\_\_ = 0) \cdot (1 + RR)$

$R_{out}(\quad = 0) = r_{o3} + R_{S2} \,||\, (R_F + R_{S1} \,||\, (r_{o1} + R_{L1}))$

## RR:

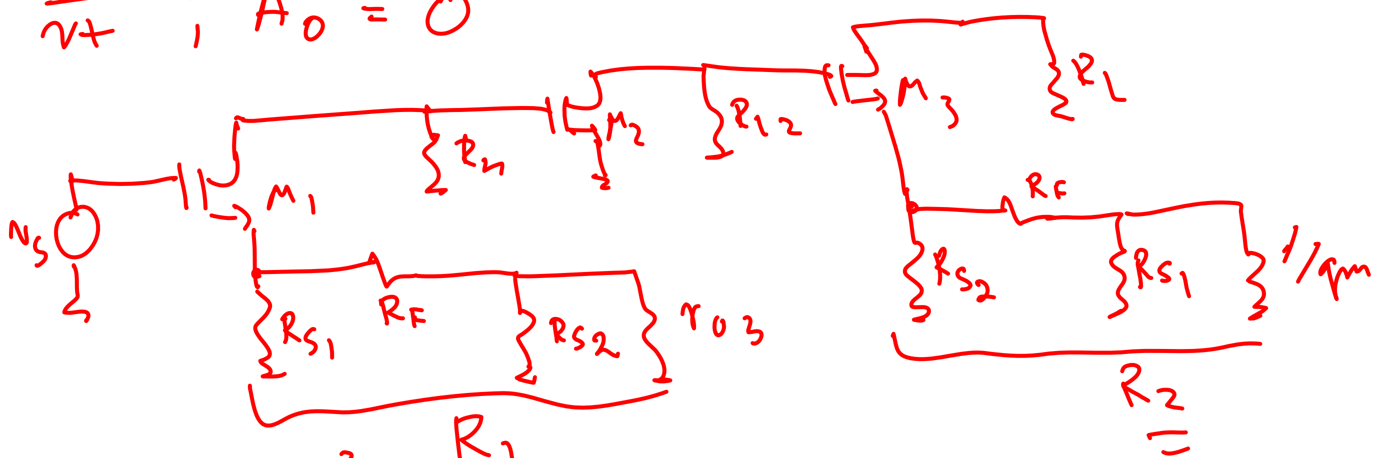



$$v_r = v_t \cdot g_{m1} \cdot R_{L1} \cdot (-g_{m2} R_{L2}) \cdot \frac{g_{m3} \cdot \overbrace{(R_{S2} \| (R_F + R_{S1} \| \frac{1}{g_{m1}}))}^{R_2}}{1 + g_{m3} \cdot (\;\;)} \cdot \frac{\frac{1}{g_{m1}} \| R_{S1}}{R_F + \frac{1}{g_{m1}} \| R_{S1}}$$

$$\frac{1}{1 + g_{m1} R_F}$$

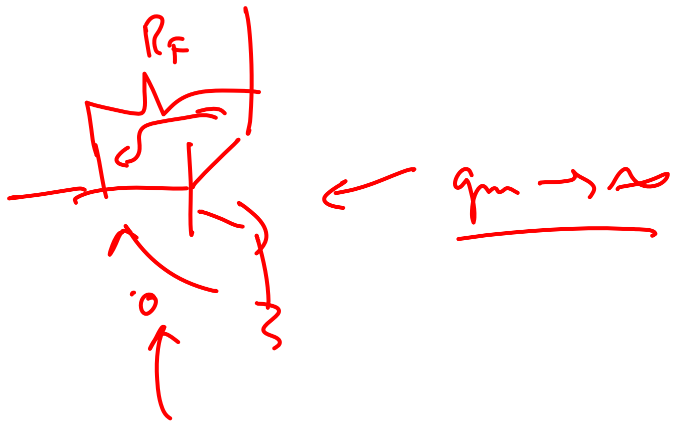
$RR = -\frac{v_r}{v_t}$ ; $A_0 = 0$

## Acy:




$$\frac{I_0}{v_s} = A_{cy} = \frac{-g_{m1} R_{L1}}{1 + g_{m1} R_1} \cdot (-g_{m2} R_{L2}) \cdot \left(-\frac{g_{m3}}{1 + g_{m3} R_2}\right) = -RR \cdot \frac{R_L}{R_{S1} \| R_{S2}}$$

$-A_\infty$


$R_F$
$g_m \to \infty$