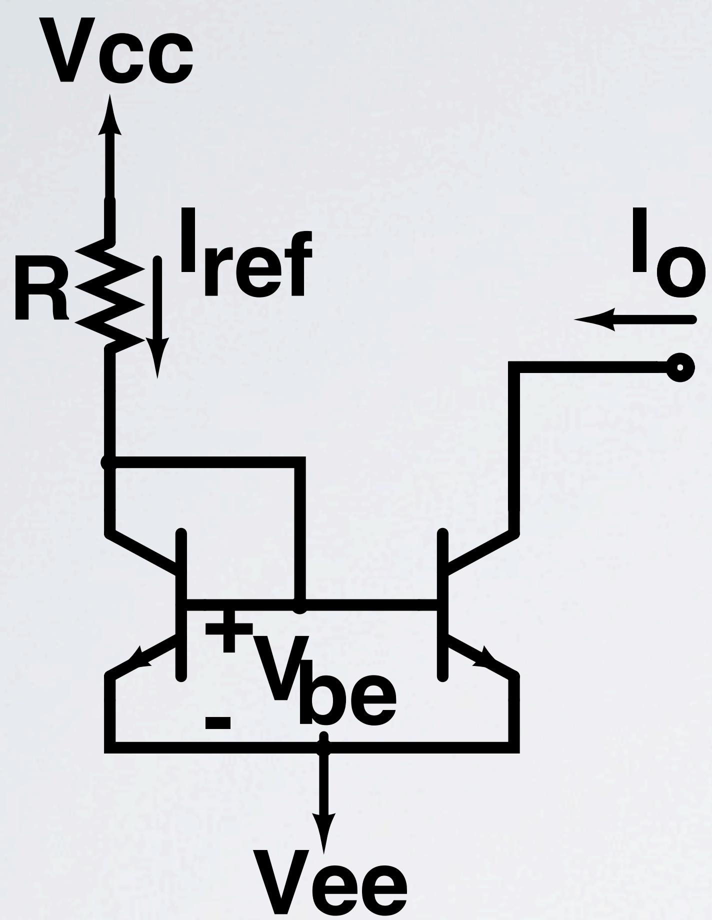
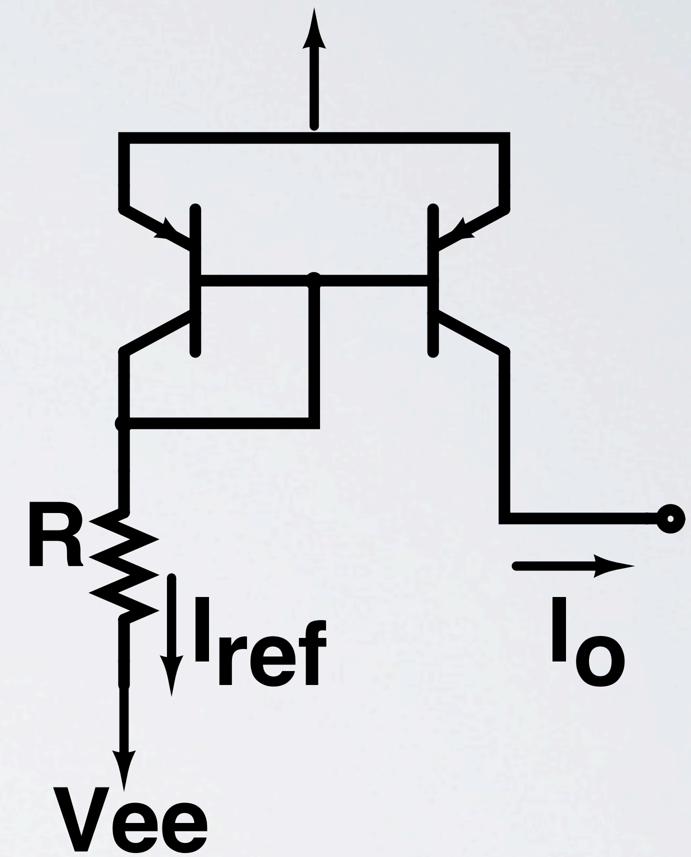
# CURRENT SOURCES
# &
# ACTIVE LOADS

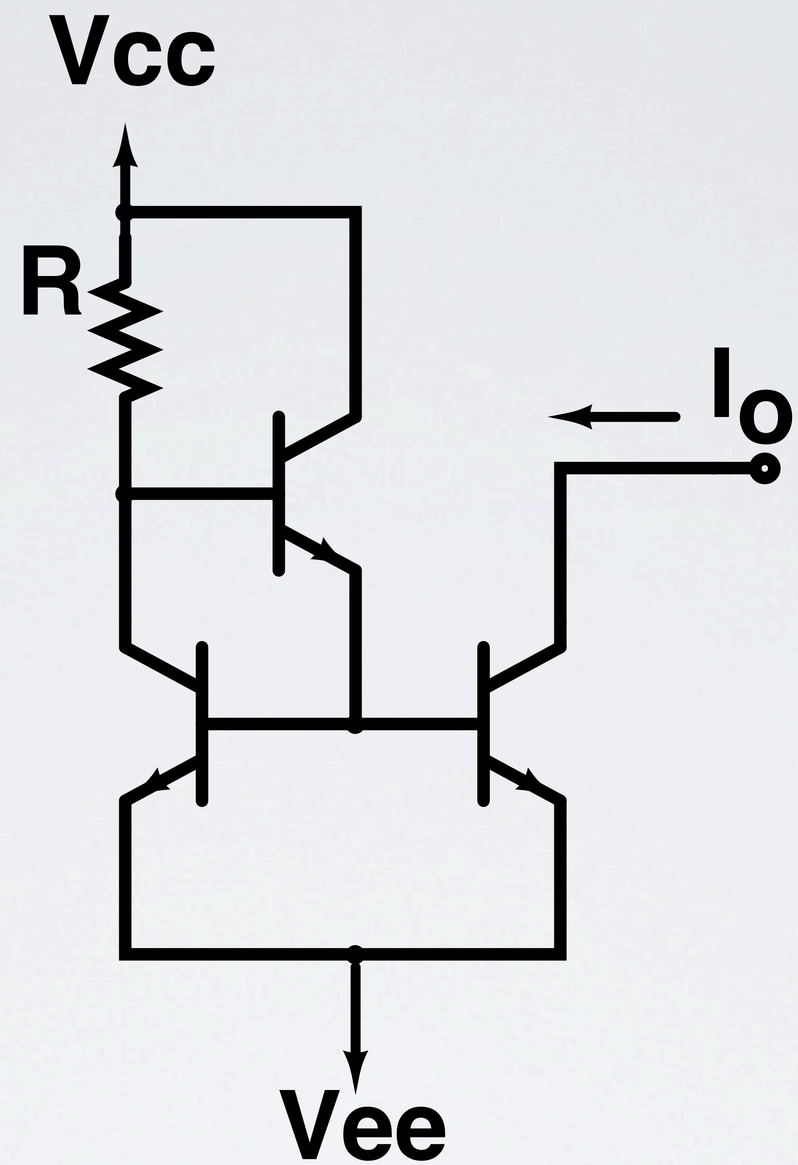
INEL 4202 - Electronics II - Fall 2012



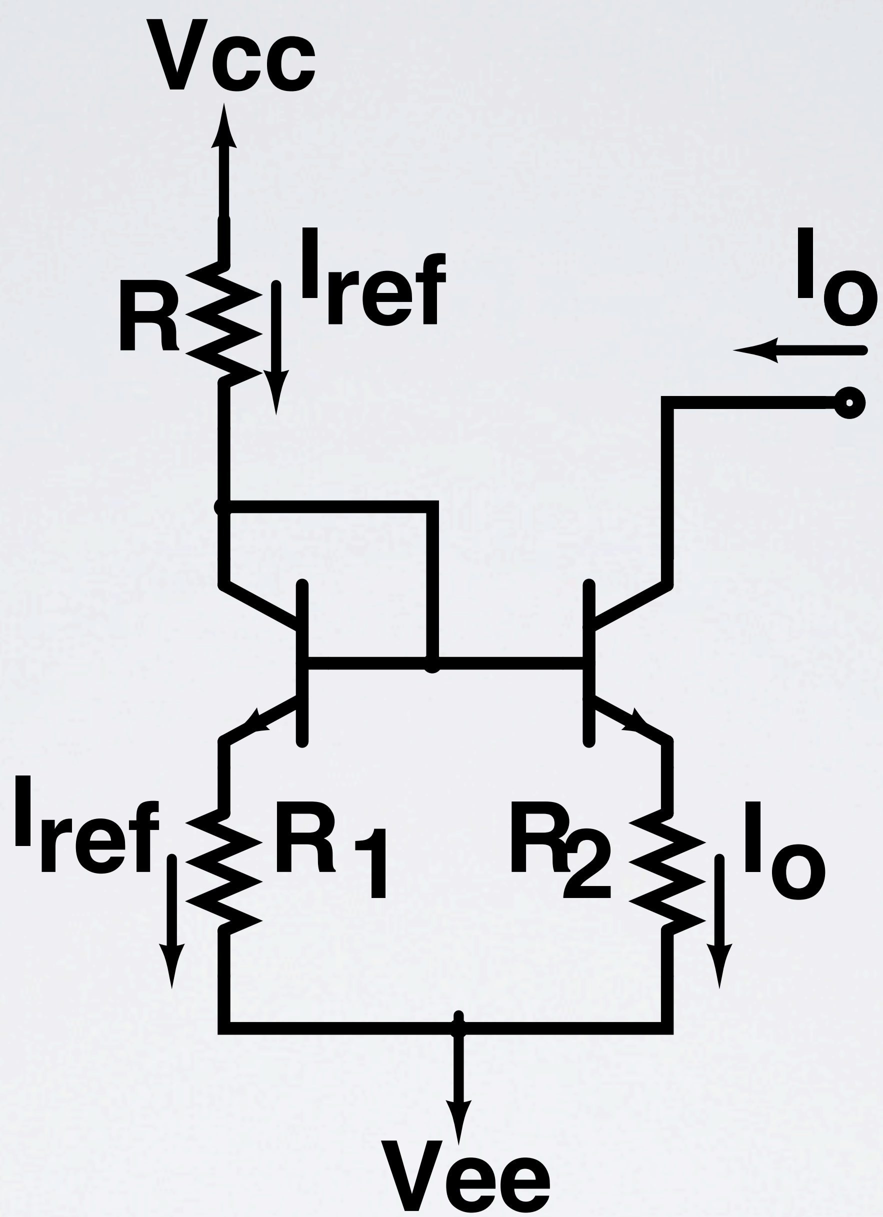

**Basic C.S.**




**Basic C.S. with PNP BJTs**

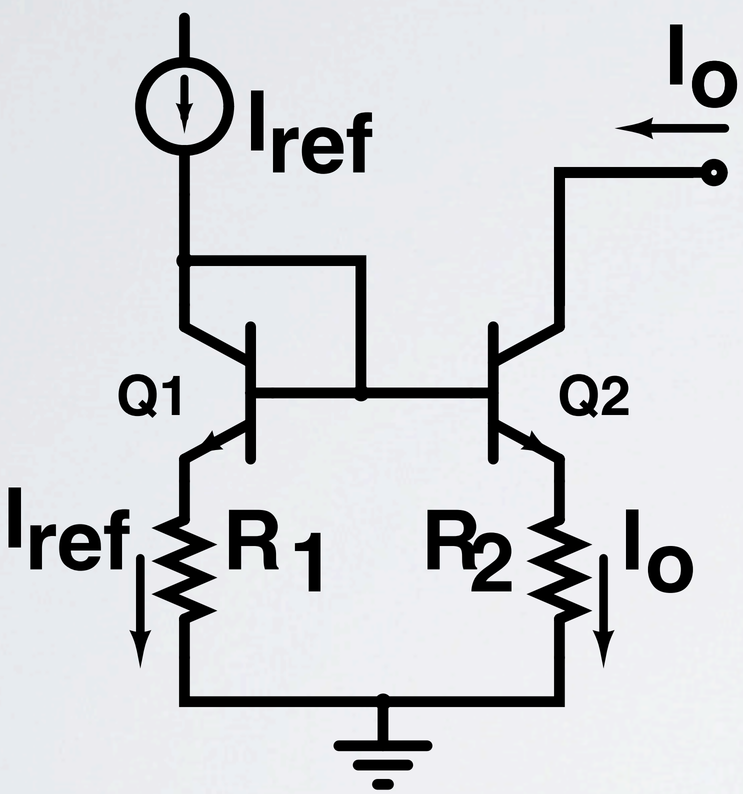



**Mirror with base-current compensation**

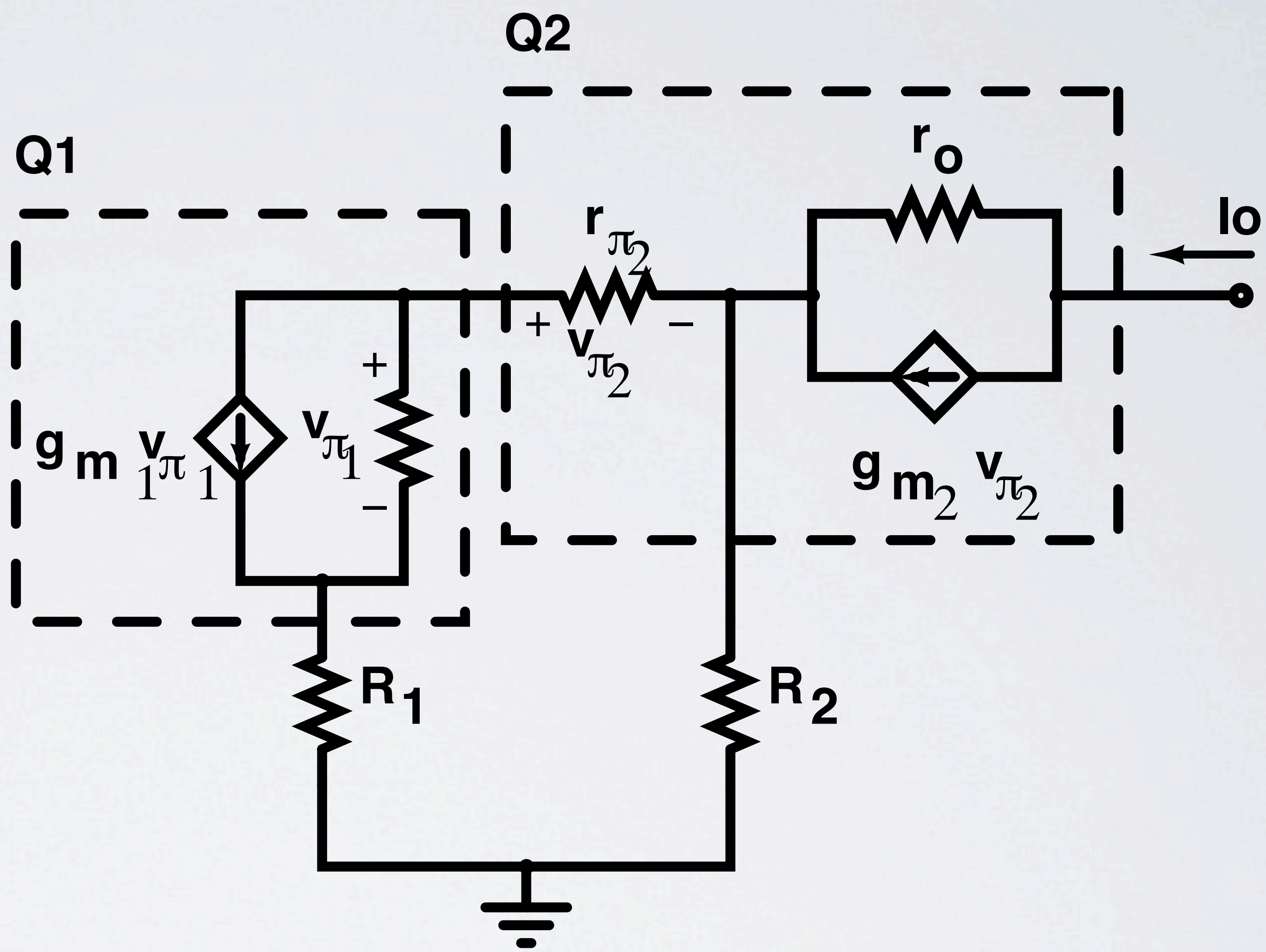



**Basic Source with Emitter Resistors**

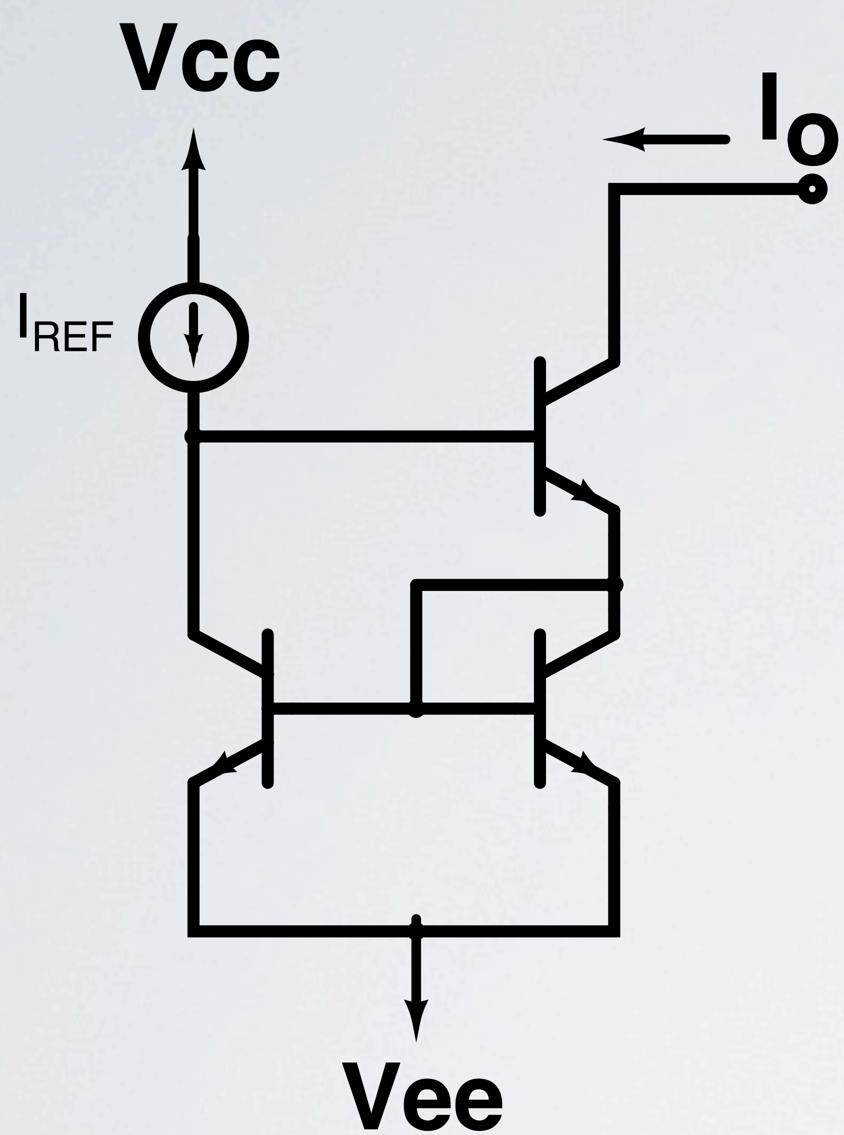
# Output Resistance




Mirror with emitter resistors

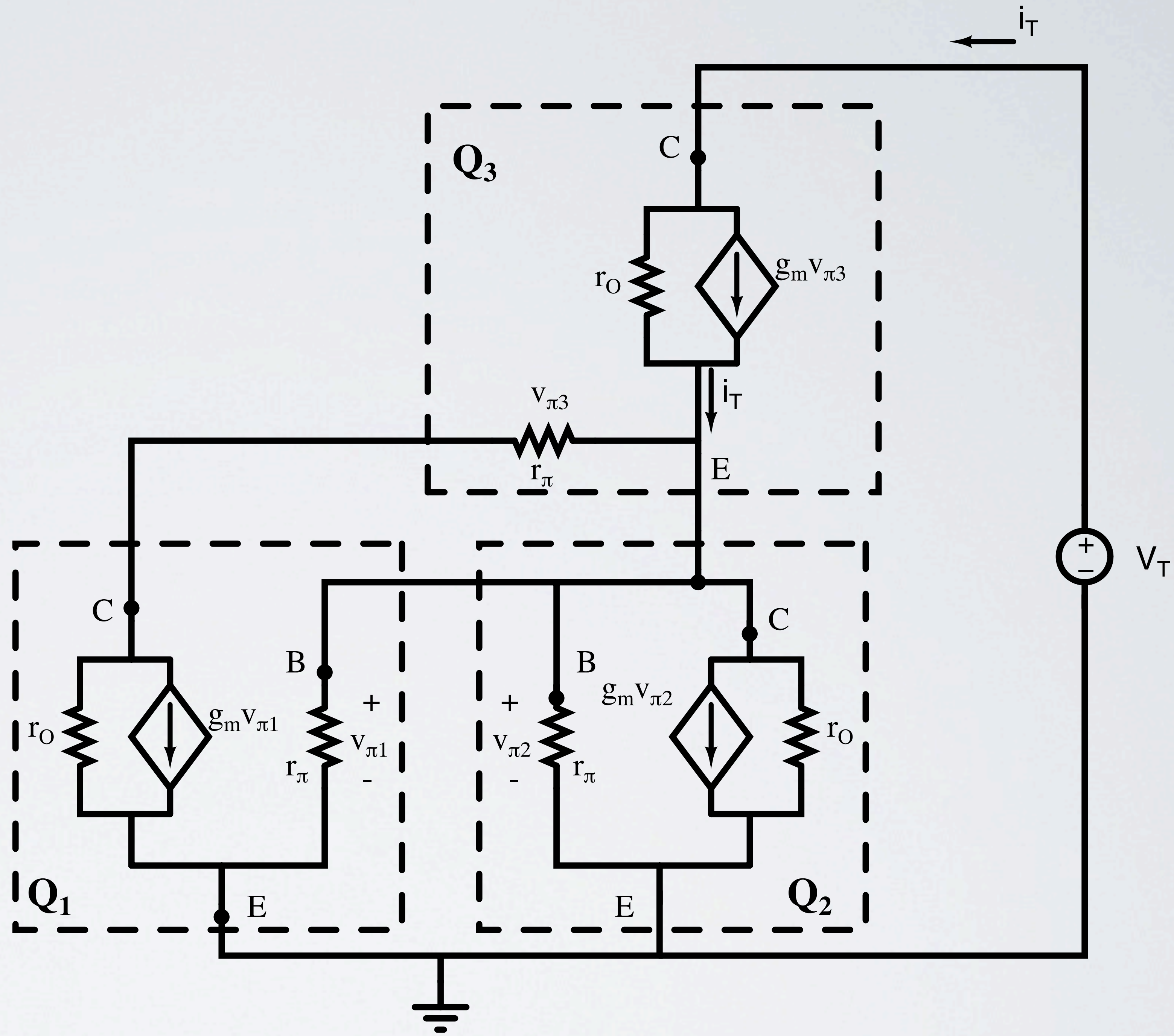



small-signal equivalent circuit

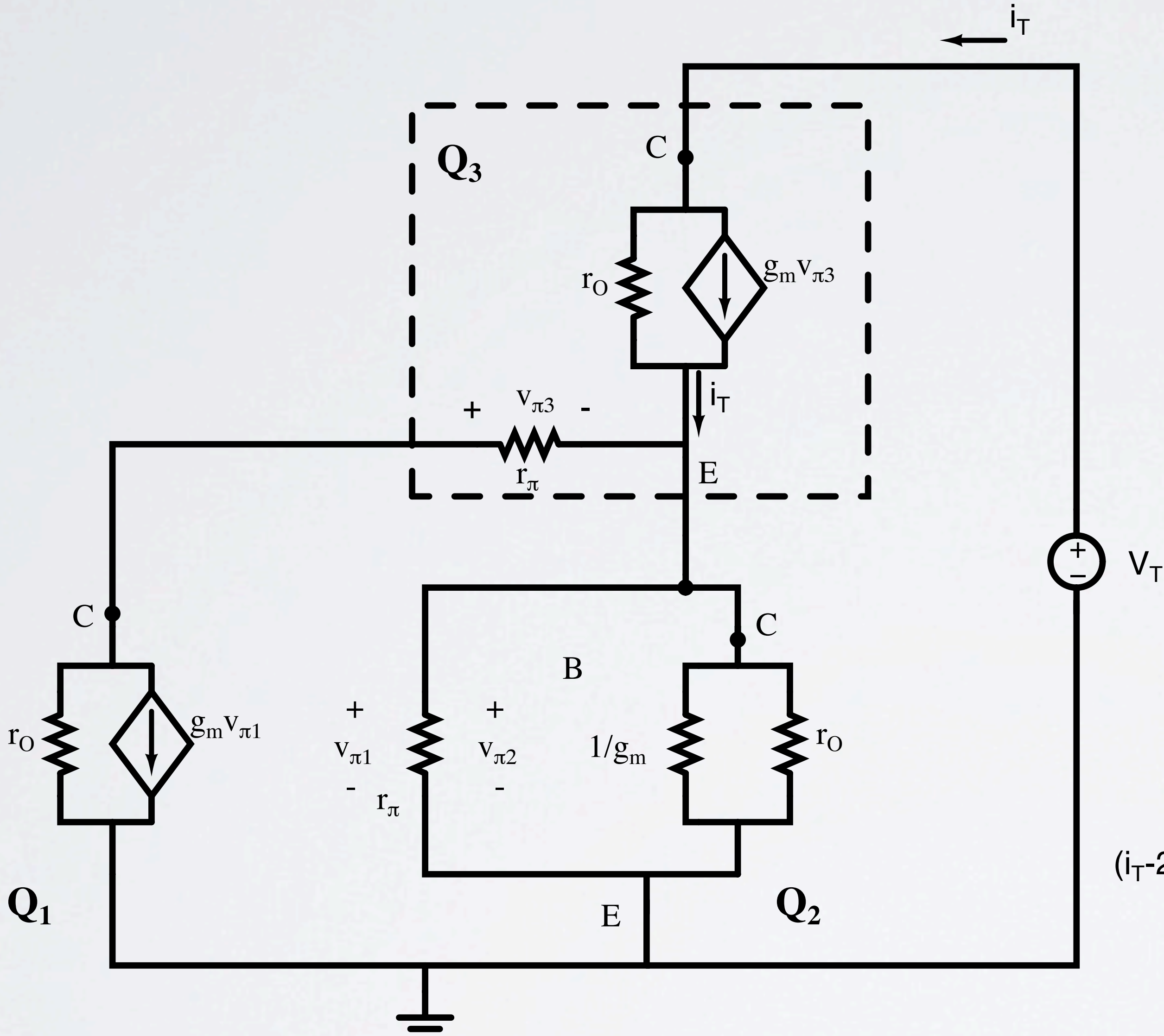


Vcc
Io
IREF
Vee

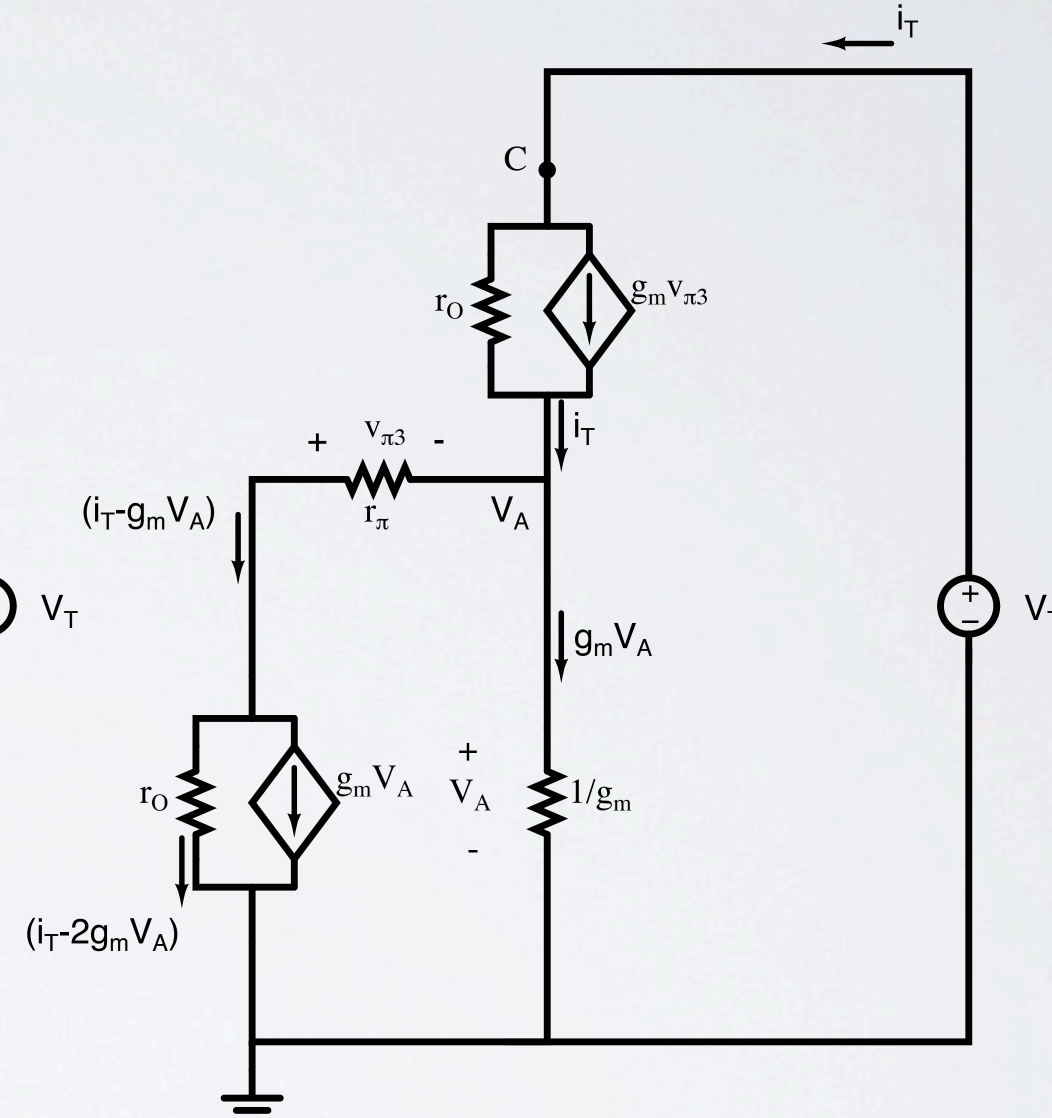

**Wilson C.S.**



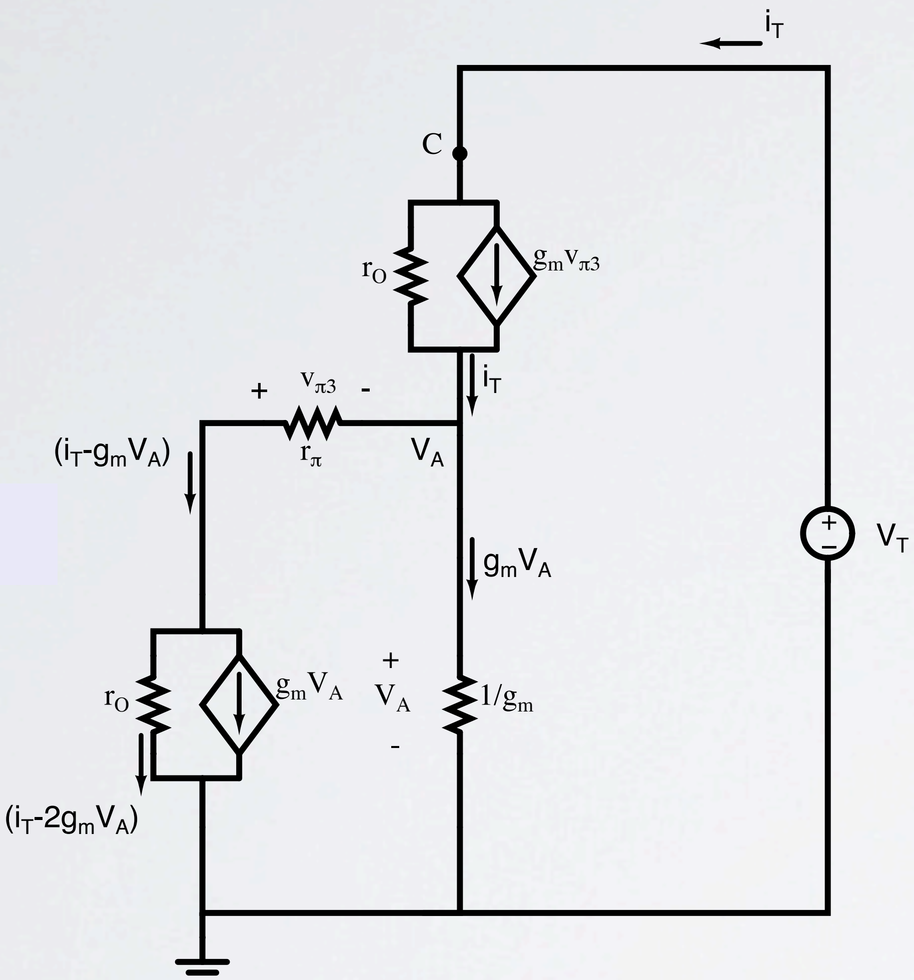
iT
Q3
C
rO
gmvπ3
iT
vπ3
rπ
E
VT
C
B
+
rO
gmvπ1
vπ1
rπ
-
Q1
E
+
vπ2
-
B
rπ
gmvπ2
C
rO
E
Q2



$i_T$
$Q_3$
C
$r_O$
$g_m v_{\pi 3}$
$i_T$
+ $v_{\pi 3}$ -
$r_\pi$
E
$V_T$
C
$r_O$
$g_m v_{\pi 1}$
C
B
+ $v_{\pi 1}$ -
+ $v_{\pi 2}$ -
$r_\pi$
$1/g_m$
$r_O$
$Q_1$
E
$Q_2$

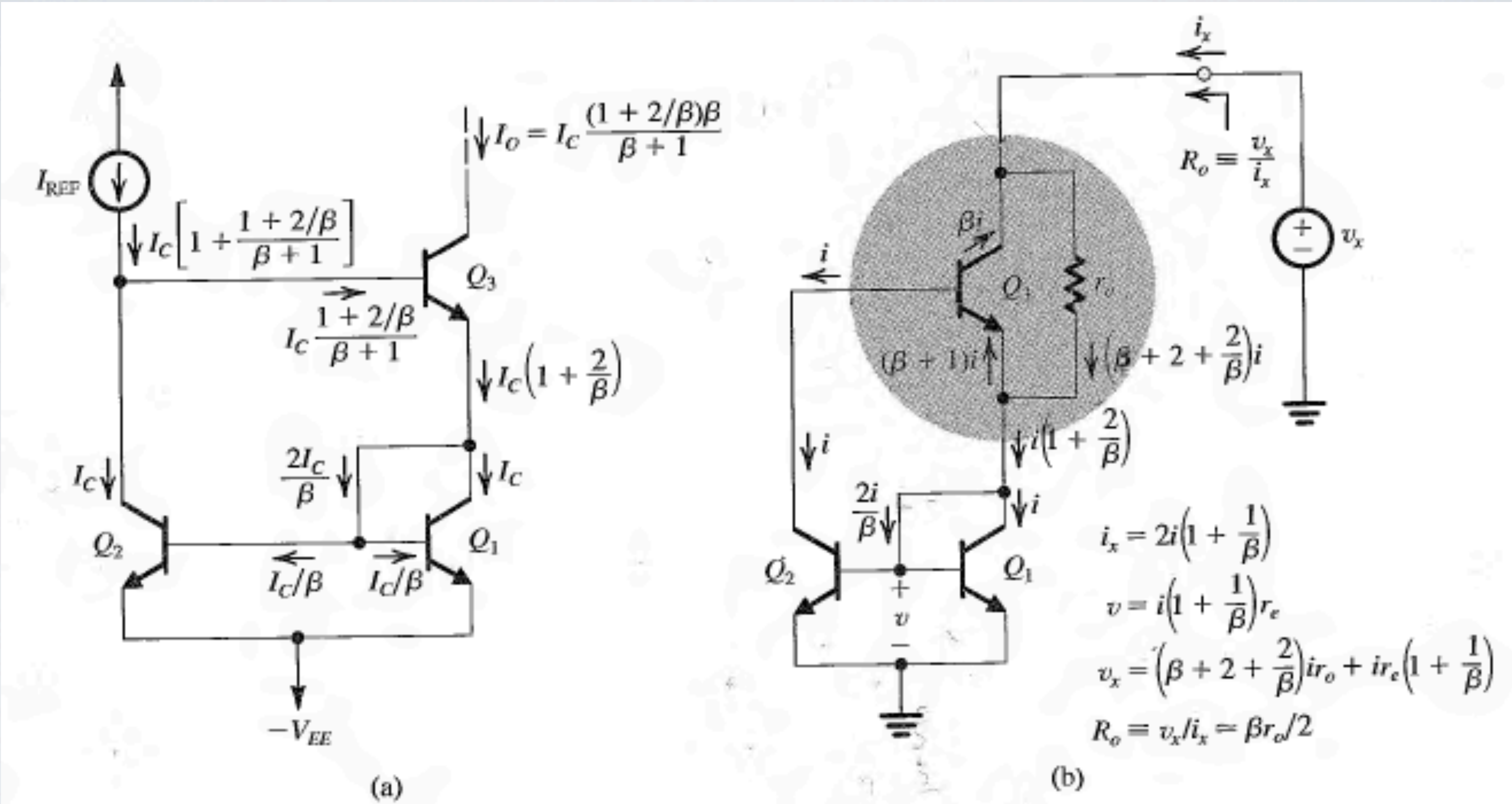



$i_T$
C
$r_O$
$g_m v_{\pi 3}$
$i_T$
+ $v_{\pi 3}$ -
$(i_T - g_m V_A)$
$r_\pi$
$V_A$
$g_m V_A$
$V_T$
$r_O$
$g_m V_A$
+ $V_A$ -
$1/g_m$
$(i_T - 2g_m V_A)$

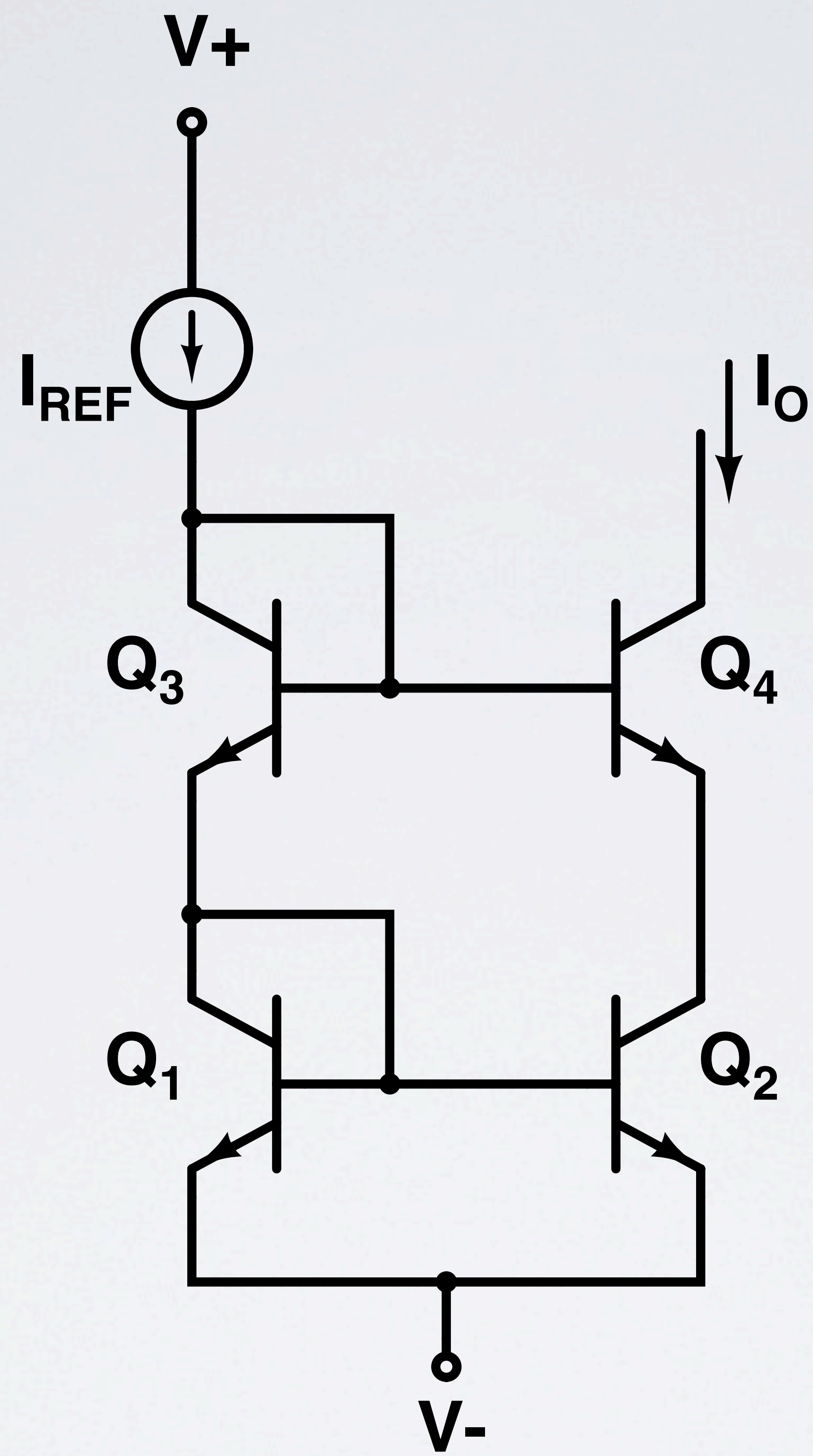


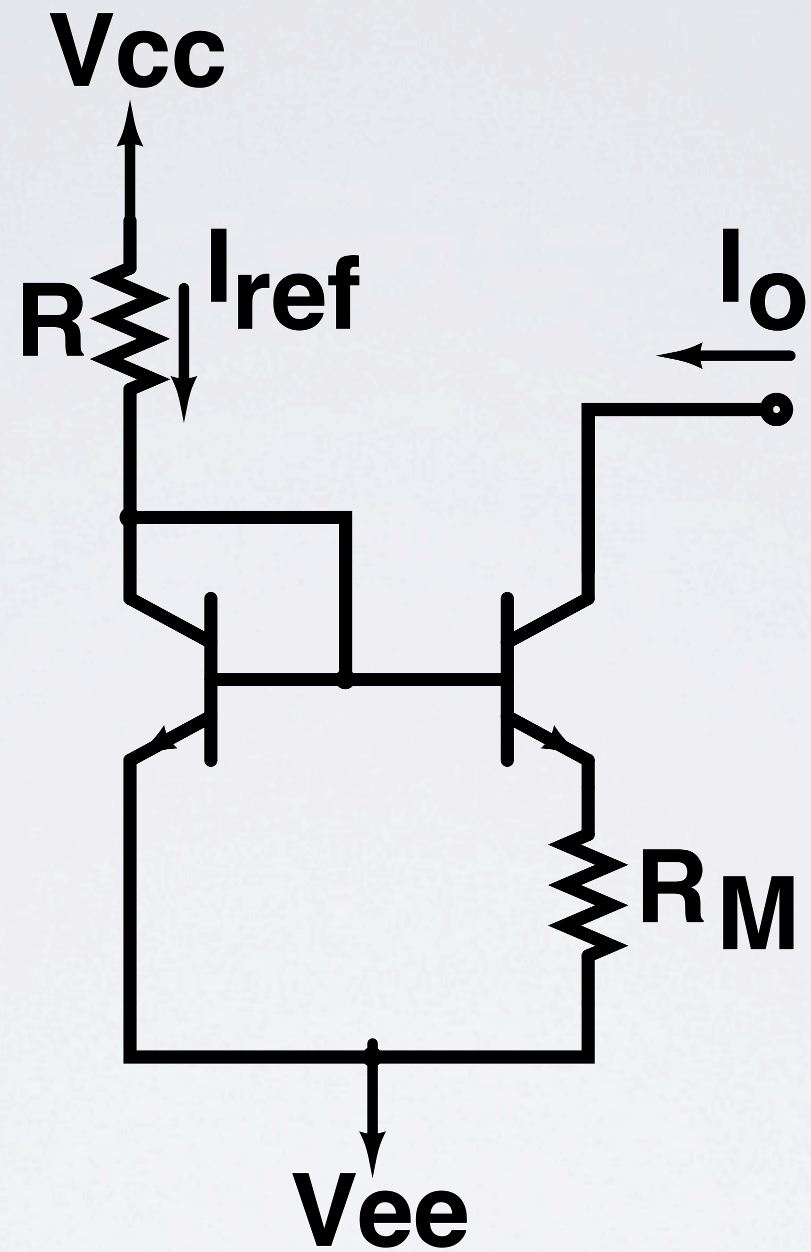

$$
\begin{aligned}
V_T &= \left(i_T - g_m v_{\pi 3}\right) r_O + v_A \\
V_A &= \left(i_T - g_m V_A\right) r_\pi + \left(i_T - 2 g_m V_A\right) r_O \\
&= \frac{r_\pi + r_O}{1 + \beta + 2 g_m r_O} i_T \simeq \frac{1}{2 g_m} i_T \\
v_{\pi,3} &= -(i_T - g_m V_A) r_\pi = -i_T r_\pi + \beta V_A \\
&= -i_T r_\pi + \beta \frac{1}{2 g_m} i_T = i_T \frac{\beta - 2\beta}{2 g_m} = -i_T \frac{\beta}{2 g_m} \\
V_T &= i_T r_O + i_T \frac{\beta \cancel{g_m}}{2 \cancel{g_m}} r_O + \frac{1}{2 g_m} i_T \\
R_{OUT} &= \frac{V_T}{i_T} = r_O + \frac{\beta r_O}{2} + \frac{1}{2 g_m} \simeq \boxed{\frac{\beta r_O}{2}}
\end{aligned}
$$

# Textbook approach



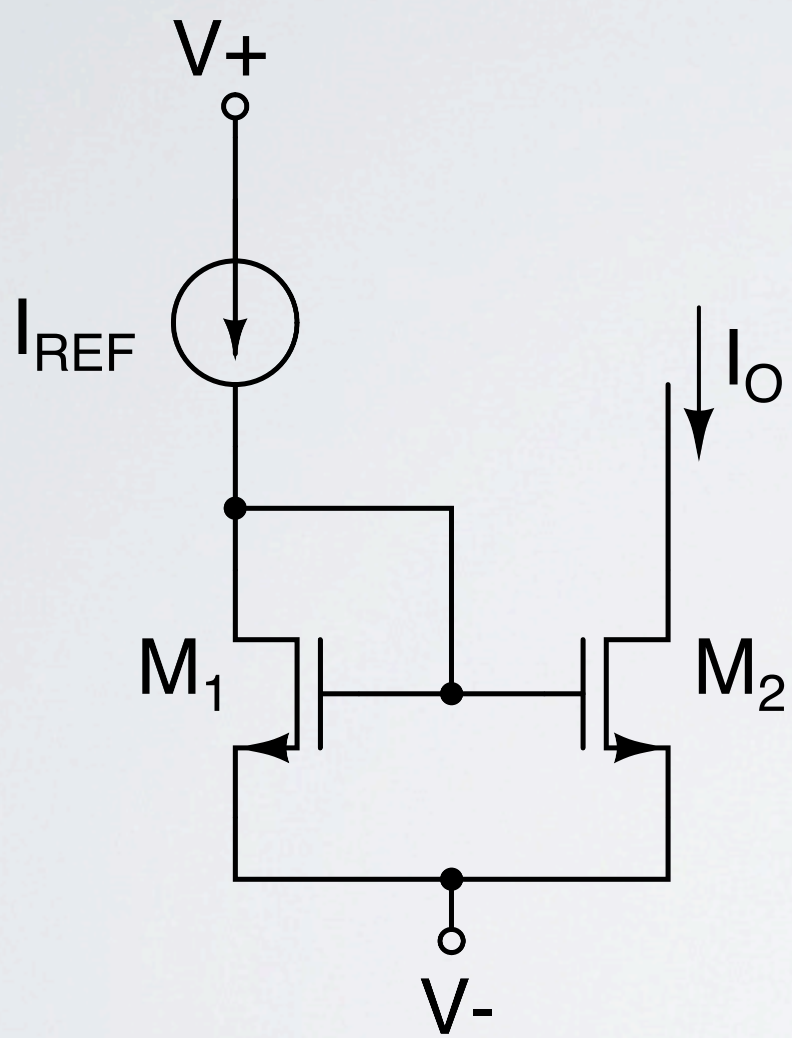
# Cascode C.S.

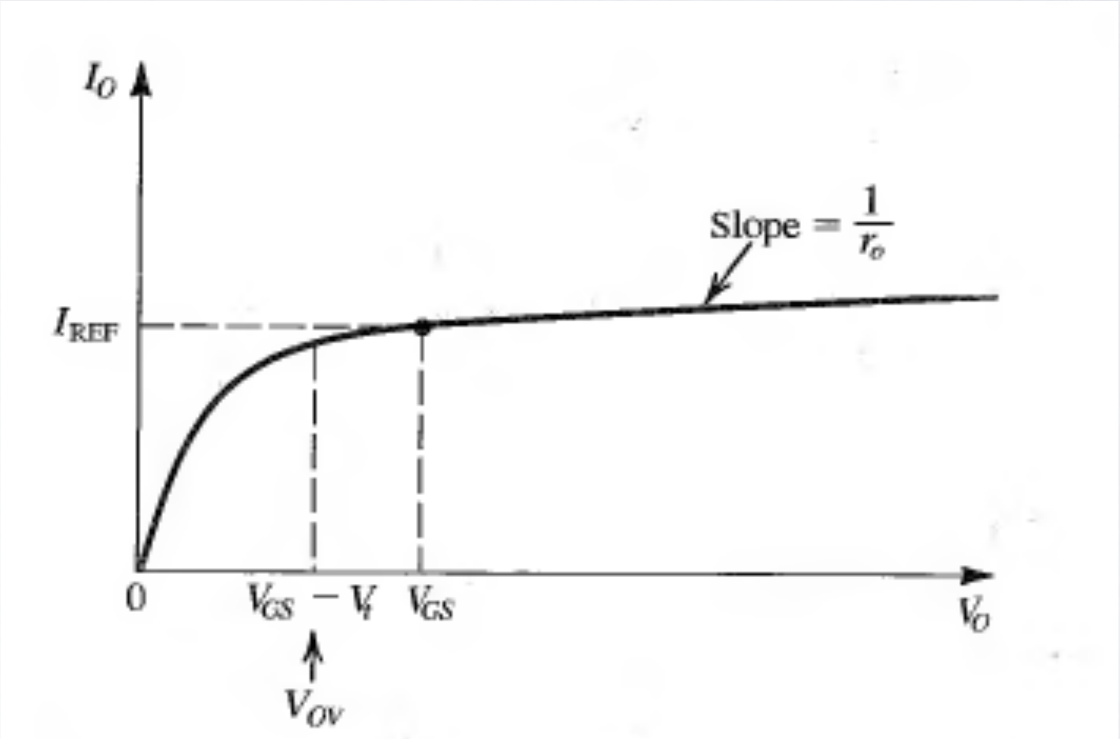





Widlar C.S.

# MOSFET CSs



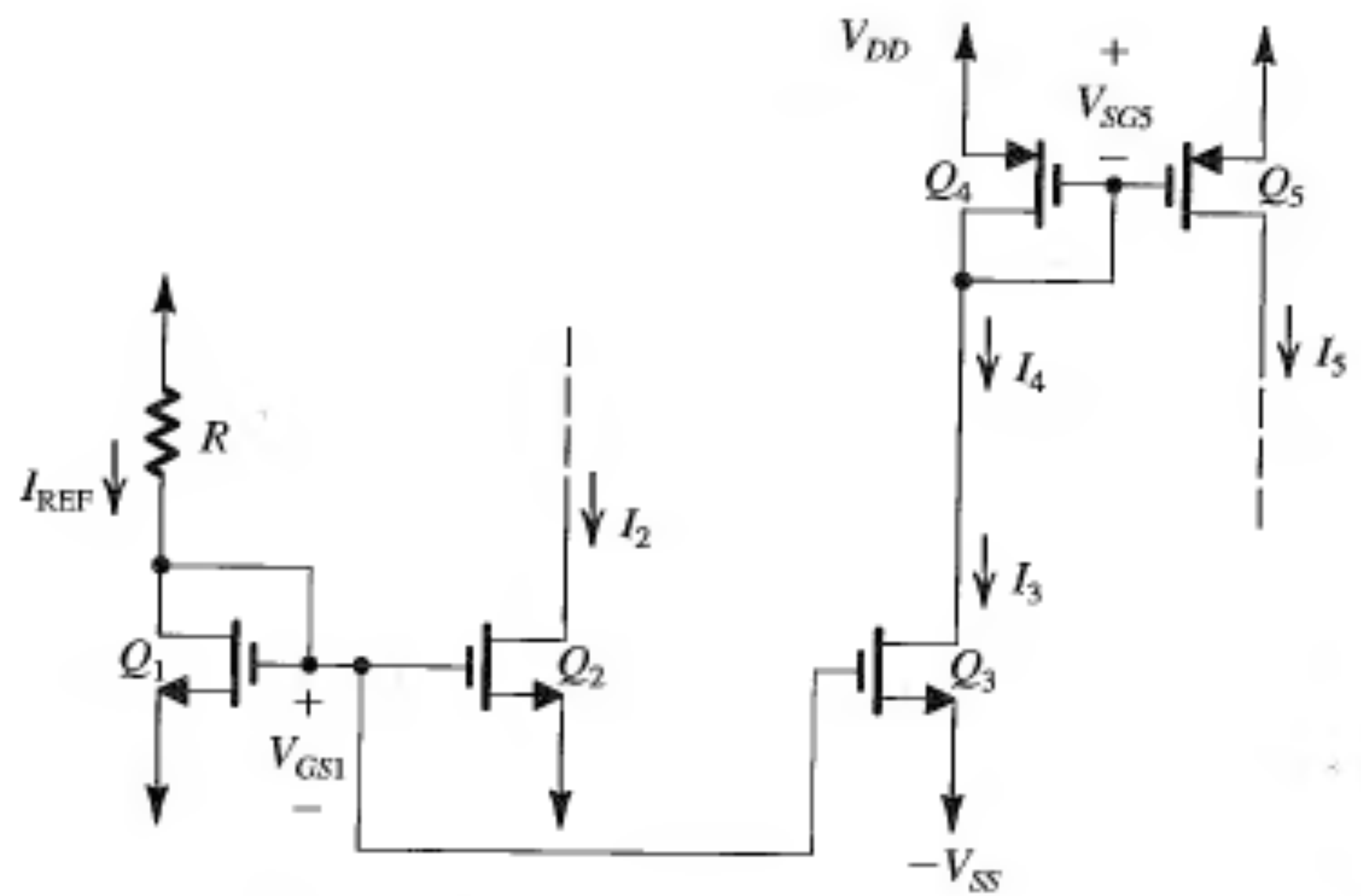
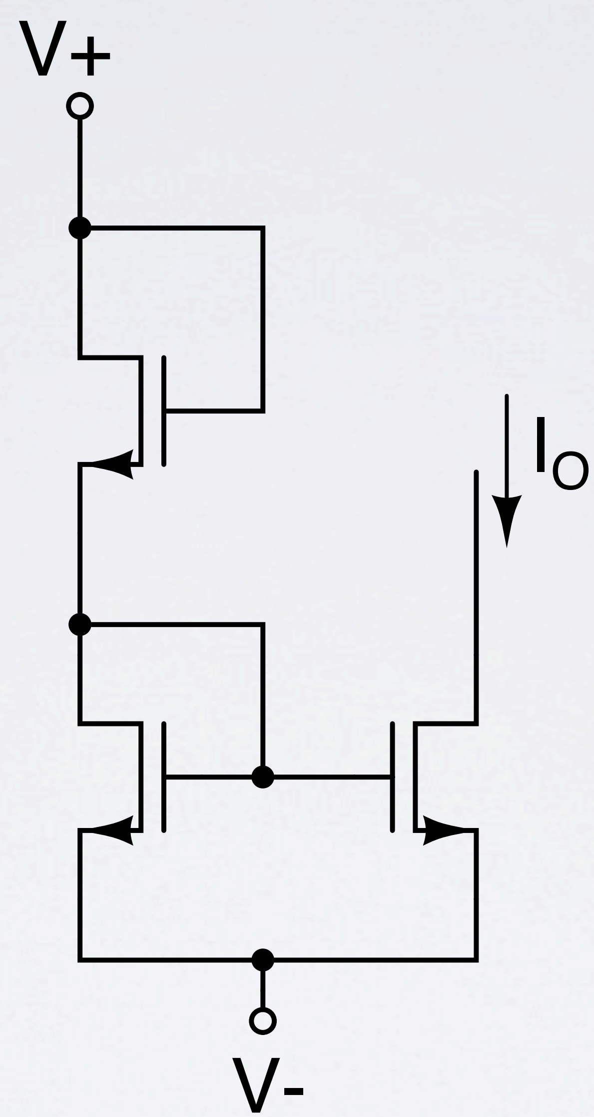



**FIGURE 6.7** A current-steering circuit.

# MOSFET CSs



# Active Loads