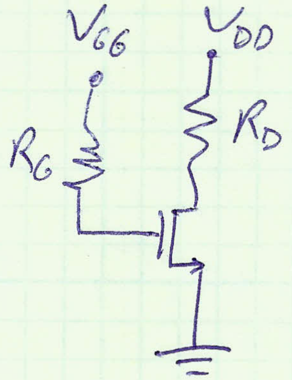
MOSFET fixed bias

- similar to BJT fixed bias
- Not stable



- no current through R_G
- not necessary, but needed if coupling capacitors are used

$V_{GS} = V_{GG}$

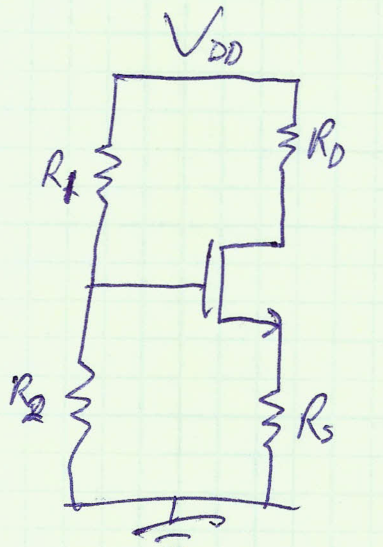
$I_D = \frac{1}{2} k_n' \frac{W}{L} (V_{GS} - V_t)^2 = \frac{1}{2} k_n \frac{W}{L} (V_{GG} - V_T)^2$

DS-KVL: $I_D R_D + V_{DS} = V_{DD}$

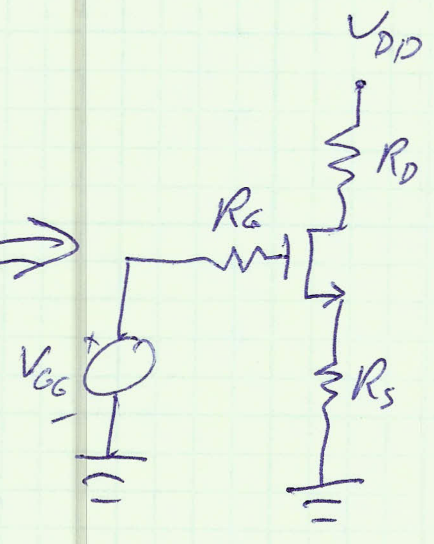
$\rightarrow V_{DS} = V_{DD} - \frac{1}{2} k_n' \frac{W}{L} R_D (V_{GG} - V_T)^2$

- Subject to variations in $\underline{k_n'}$ and $\underline{V_T}$ which vary with temperature

MOSFET bias with source degeneration



$\Rightarrow$



Thevenin equivalent R_G, V_{GG}

$$V_{GG} = \frac{R_2}{R_1+R_2} V_{DD} \quad , \quad R_G = R_1 \| R_2$$

GS-KVL:

$$\left.\begin{aligned} V_{GG} &= V_{GS} + I_D R_S \\ I_D &= \tfrac{1}{2} k_n' \tfrac{W}{L} (V_{GS} - V_T)^2 \end{aligned}\right\} \text{ can solve for } V_{GS} \text{ and } I_D$$

DS-KVL:

$$V_{DD} = I_D R_D + V_{DS} + I_D R_S \quad \leftarrow \text{can solve for } V_{DS}$$

Negative feedback: $V_{GS} = V_{GG} - R_S I_D$

- increase in I_D causes decrease in V_{GS} which causes decrease in I_D.
- not constant because of quadratic relationship but variations are much smaller with feedback
- Don't need to worry about $R_B \ll (1+\beta) R_E$ as in BJT because $I_G = 0$, so R_1 and R_2 can be large ($M\Omega$)

Self Bias – uses R_C as feedback resistor

note $V_{CE} = R_B I_B + V_{BE}$

$= R_B I_B + V_{D0} > V_{D0}$

Transistor is always in <u>active</u> mode

$V_{CC} = R_C I_1 + R_B I_B + V_{BE}$, and $I_1 = I_C + I_B$

$= R_C(I_C + I_B) + R_B I_B + V_{DO}$

$= R_C I_C + (R_B + R_C)\frac{I_C}{\beta} + V_{DO}$

$$I_C = \frac{V_{CC} - V_{DO}}{R_C + (R_C + R_B)/\beta} \simeq \frac{V_{CC} - V_{DO}}{R_C} \quad \underline{\text{If } R_B \ll (\beta - 1) R_C}$$

note $\frac{R_C + R_B}{\beta} \ll R_C \rightarrow R_C + R_B \ll \beta R_C \rightarrow R_B \ll R_C(\beta - 1)$

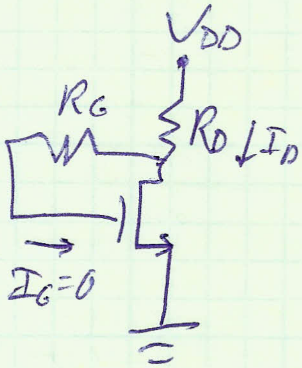
Bias point is stable and independent of β

- Negative feedback illustrated here:

BE-KVL: $$I_B = \frac{V_{CC} - V_{DO} - \overset{\downarrow}{I_C} R_C}{R_B}$$

Increase in I_C will decrease I_B, which decreases I_C

<u>MOSFET self bias</u>



- Transistor always in <u>Saturation</u> $\underline{V_{DS} = V_{GS} > V_{GS} - V_t}$

$$\left.\begin{aligned} V_{DD} &= I_D R_D + V_{GS} \\ I_D &= \frac{1}{2} k_n' \frac{W}{L} (V_{GS} - V_t) \end{aligned}\right\} \text{can find } I_D \text{ and } V_{GS}$$

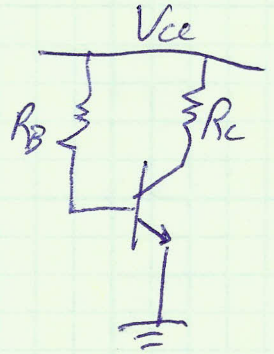
Note: R_D does not affect bias, but cannot be removed

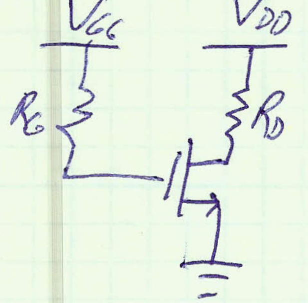
- Removing R_D would mean direct connection from input to output of amp.

Summary of Bias Circuits

Fixed bias

- Simple bias circuit, but not stable
- Q point can vary with β, V_T, and temperature

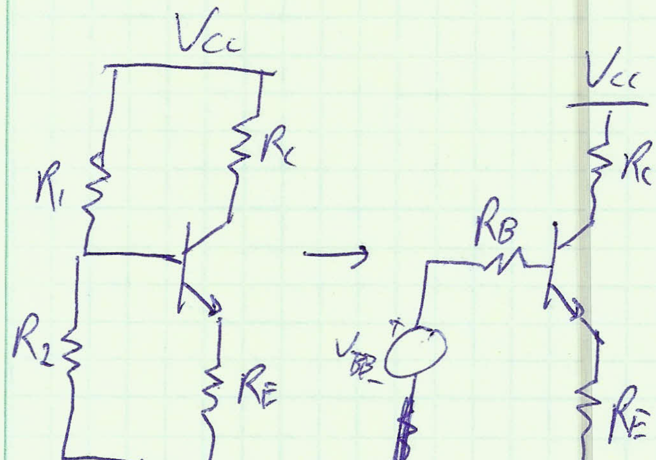




need 2 voltage sources for MOSFET

Emitter degeneration with voltage divider

- Q point is independent of β and V_{be} variations thus independent of temperature and device variations



Conditions for stability

$R_B \ll (1+\beta)R_E$

$V_E > 1V$

$\gg$ means $\sim 10x$

Self bias

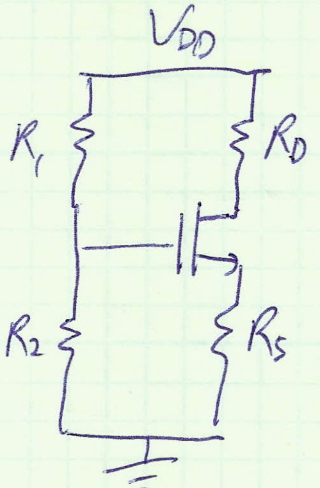
- Stable bias circuit, independent of β and V_{BE}
- Uses R_C as feedback resistor

Stability condition

$R_B \ll (\beta - 1) R_C$

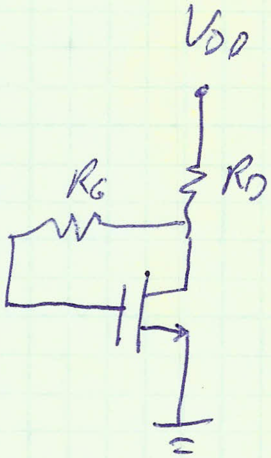
MOSFET bias circuits

Source degeneration:



R_1, R_2 can be large (MΩ)

Self bias:



R_G only needed for amplifier use, otherwise input connected to output

These are not as stable as BJT bias circuits because of quadratic I_D-V_{GS} relationship, but relatively stable