- Capacitive Coupling
- Fixed bias
- Emitter degeneration bias with voltage divider
- Self bias
- Similar bias circuits for MOSFETs
- Current Mirrors
- Diode small signal model
- MOSFET small signal model
- BJT small signal model

Capacitive coupling

- DC signals (bias) see capacitors as open circuit
- AC signals see capacitors as short circuit
  assuming capacitor is large enough, frequency is high enough
- Used to separate AC signal from DC bias

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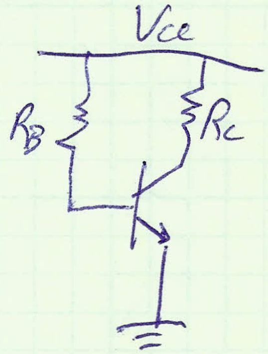
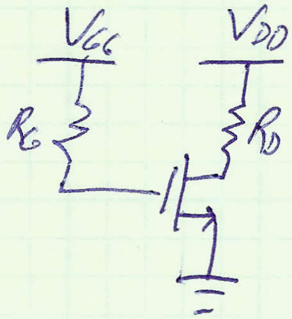
Fixed bias

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

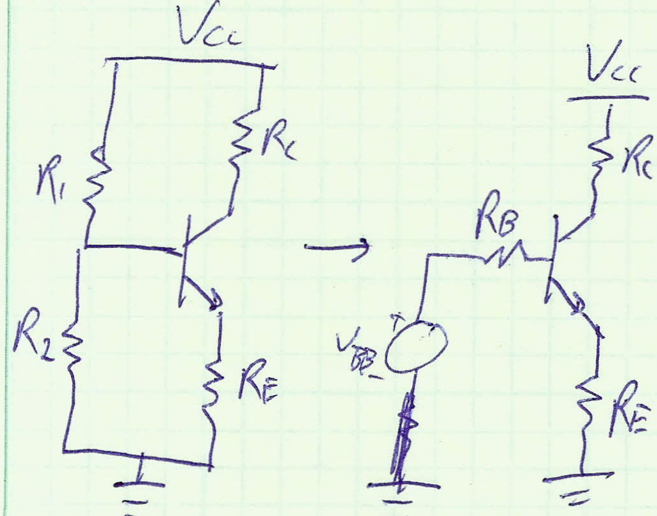




need 2 voltage sources for MOSFET

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

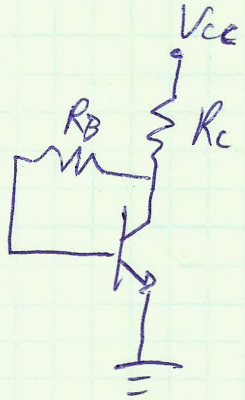
$R_B \ll (1+\beta)R_E$

$V_E > 1V$

$\gg$ means ~10x

Self bias

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

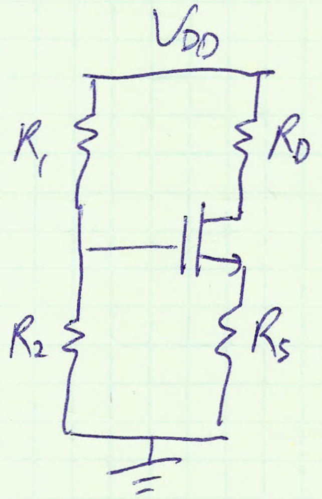


Stability condition

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

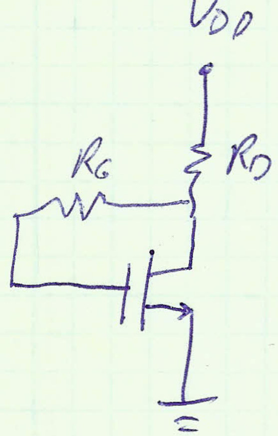
MOSFET bias circuits

Source degeneration:



R_1, R_2 can be large ($M\Omega$)

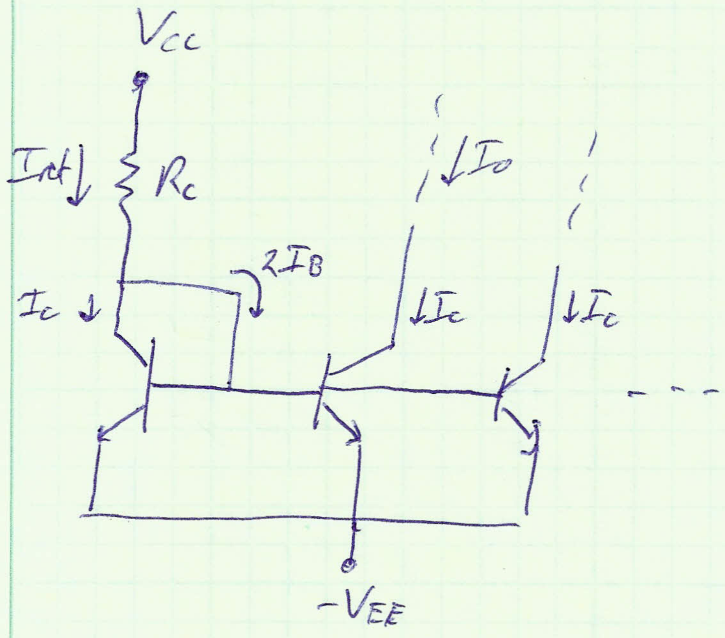
Self bias:



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

Current Mirrors



for single current mirror

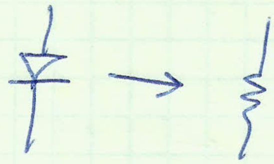
$$\frac{I_O}{I_{ref}} = \frac{\beta}{\beta + 2}$$

I_O can be multiplied by using multiple transistors at output

- MOSFET current mirror is similar but we can scale W/L instead of using multiple transistors

Diode Small Signal Model

In on state:



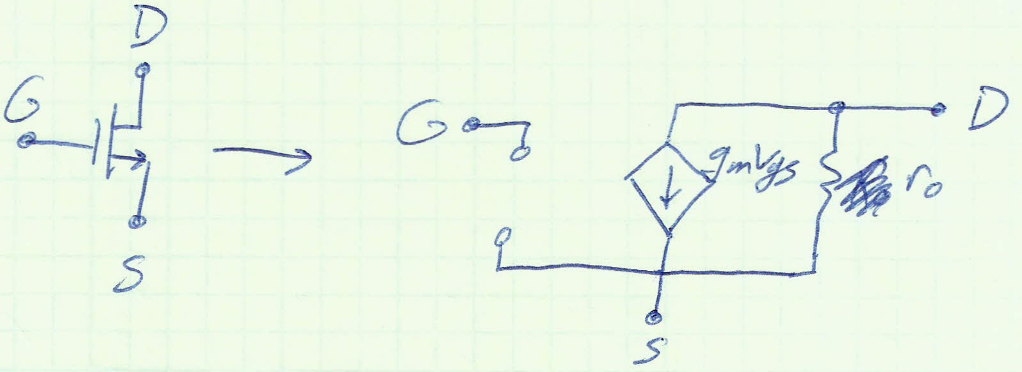
$$r_d = \frac{nV_T}{I_D}$$

I_D is DC bias current

$n = 2$ for discrete silicon diodes

$V_T = 25 mV$ at $300K$

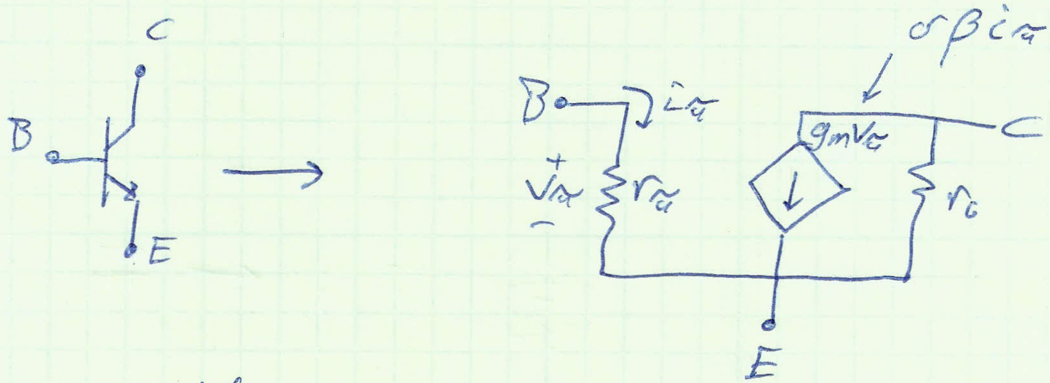
MOSFET small signal model



$$g_m = \frac{2I_D}{V_{GS} - V_T} \quad \text{or} \quad \frac{2I_D}{V_{SG} - |V_T|}$$

$$r_o = \frac{V_A + V_{DS}}{I_D} \simeq \frac{V_A}{I_D}$$

BJT small signal model



$$r_\pi = \frac{nV_T}{I_B}$$

$$g_m r_\pi = \beta$$

$$g_m = \frac{I_C}{nV_T}$$

$$r_o = \frac{V_A + V_{CE}}{I_C} \simeq \frac{V_A}{I_C}$$