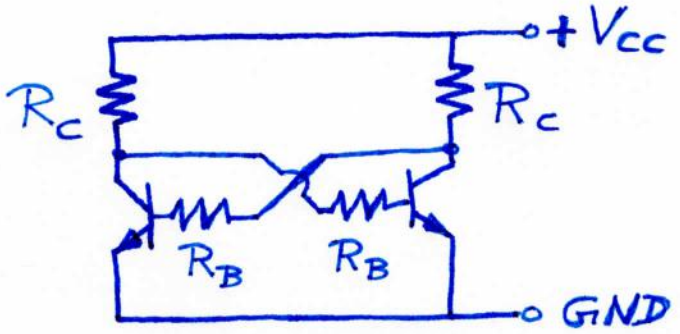
ITE – Homework II – Solution

Problem 1 SRAM cell

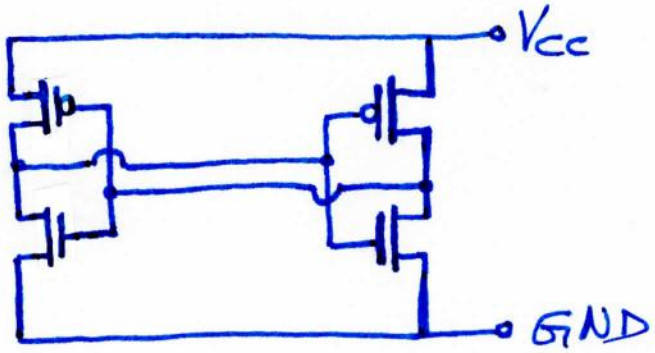
(a) BJT SRAM cell



One of the two branches is ON ⇒ Current flowing. One BJT is in saturation (ON or conductive) and a voltage drops across R_C.

The approximate power consumption is given by $P = V_{cc}^2 / R_C$

(b) CMOS FET SRAM cell

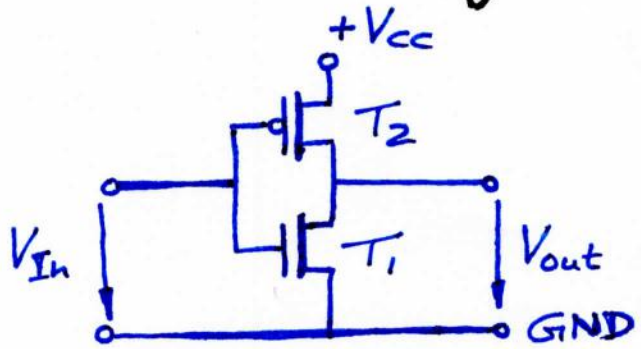


None of the two branches is fully conductive. In each branch, one of the FETs is always OFF. ⇒ $I = 0$ in each branch. ⇒ $P = 0$

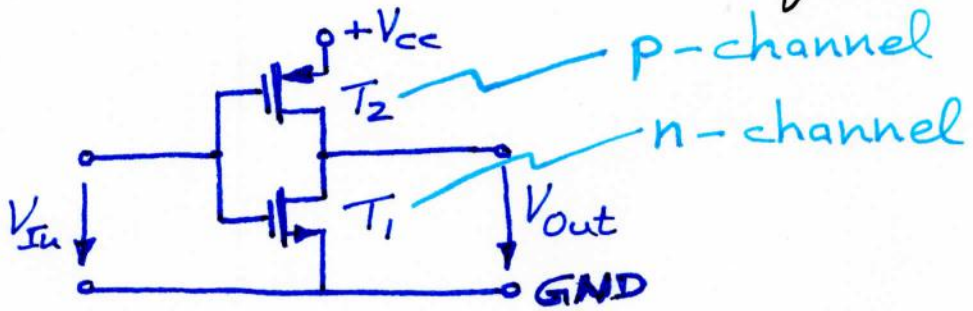
(c) BJT SRAM is **not** suitable for high degrees of integration because the power consumption is too high ⇒ Heat problem.

Problem 2 CMOS inverter

(a) Circuit diagram



Alternative circuit diagram



T_1 turns ON for $+V_{GS}$

T_2 turns ON for $-V_{GS}$

V_{In} is either $+V_{cc}$ or GND

$V_{In} = +V_{cc} \Rightarrow T_1 = ON \quad T_2 = OFF$

$\Rightarrow V_{out} = 0$

$V_{In} = GND \Rightarrow T_1 = OFF \quad T_2 = ON$

(GND → 0V)

$\Rightarrow V_{out} = +V_{cc}$

(b) Small-signal equivalent circuit is of no interest because we have no small-signal signal source.

(c) Static power consumption is always zero, because one of the FETs is always OFF.

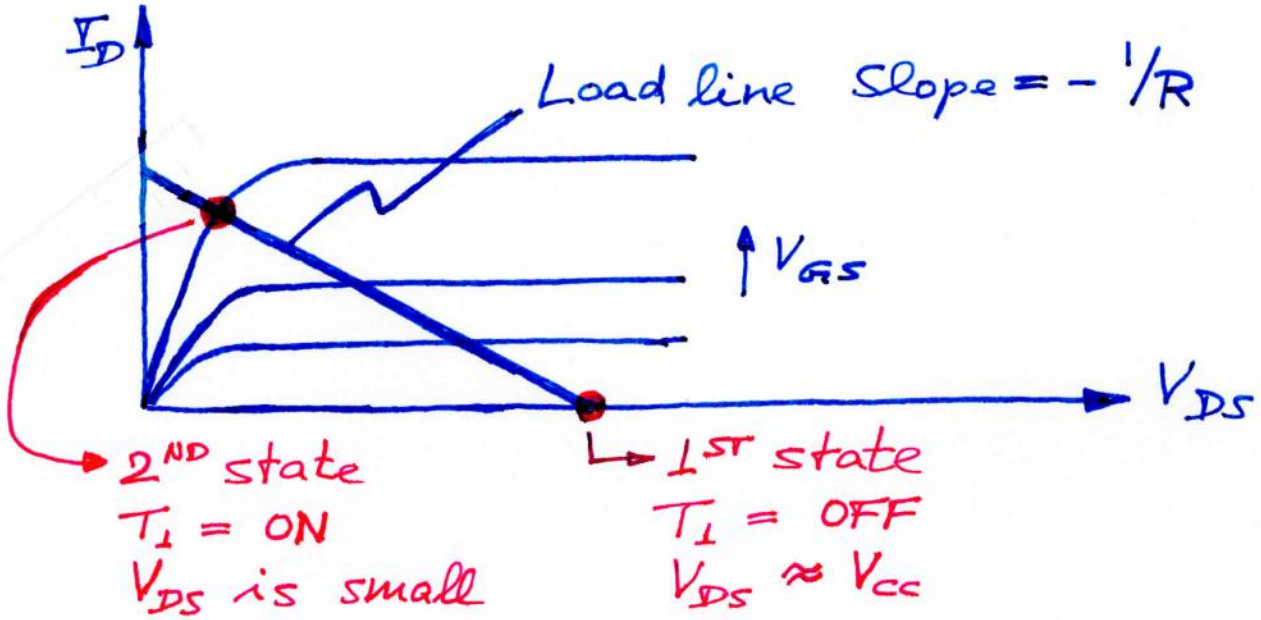
(d) Power consumption of CMOS FET inverter is zero ⇒ No heat problem.

(e) Power consumption of BJT inverter is always > 0 (greater zero). BJT has finite input impedance ($< \infty$) ⇒ Big heat problem.

Problem 3 CMOS inverter

(a) LHS circuit has resistive load

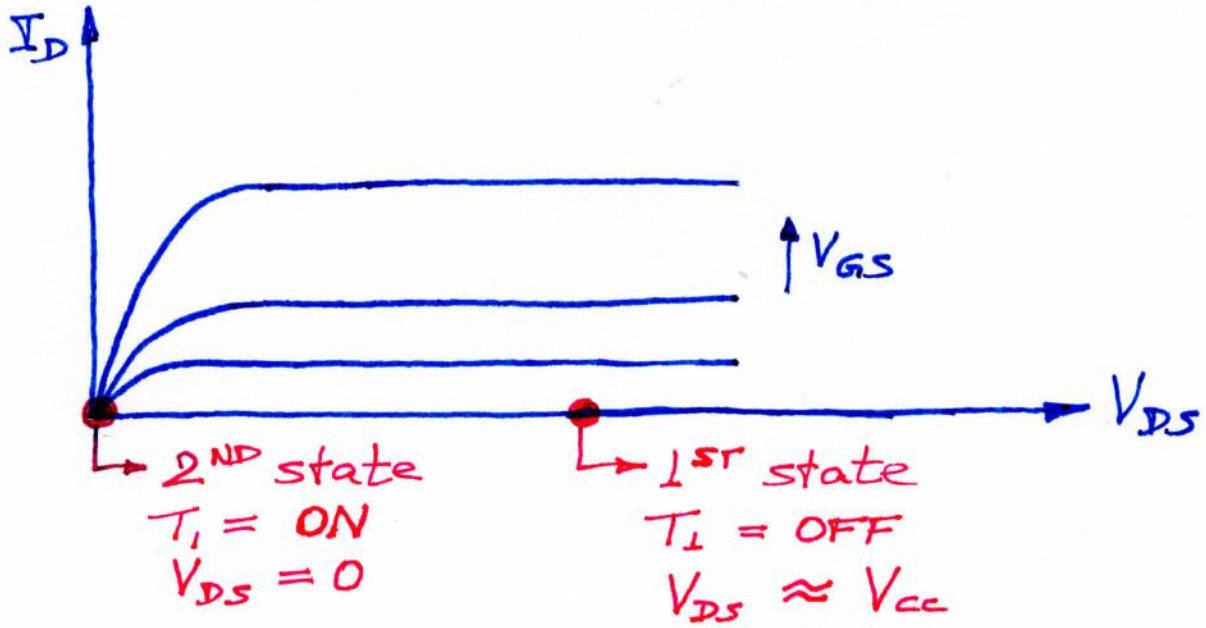
T_1 output characteristic



1ST state $\Rightarrow$ $I_D = 0$

2ND state $\Rightarrow$ $I_D \neq 0$

(b) RHS circuit has T_2 as load



Note that $I_D = 0$ in 1ST and 2ND state ⇒ No power consumption

(c) LHS circuit consumes power $P = V_{cc}^2 / R$. Power consumption is not good for VLSI (very large scale integration). ⇒ Heat problem.

RHS circuit, a CMOS circuit, consumes no power ⇒ **No** heat problem ⇒ Suitable for VLSI.

Problem 4 True/false statements

(a) True Heat problem of BJTs prevents them from being used in VLSI (very large scale integrated circuits).

(b) True The $Z_{in} = \infty$ characteristic of FETs makes them very suitable for the amplification of weak signals.