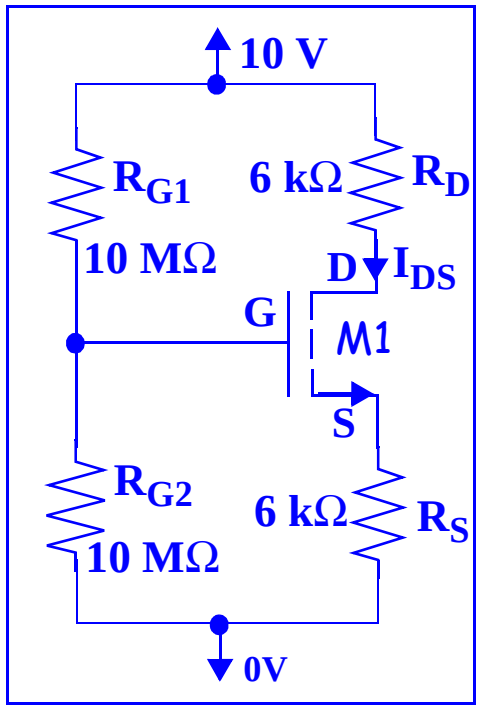
Example: For the circuit shown, $V_{TN} = 1V$, $K_n = 1\ mA/V^2$ and $\lambda = 0V^{-1}$. Determine the gate voltage, the mode of operation of the n-channel MOSFET (M1), the drain current I_{DS} and the drain-source voltage.



$$V_G = \frac{R_{G2}}{R_{G1} + R_{G2}} \bullet 10 = \frac{10M}{10M + 10M} \bullet 10 = 5V$$

Assume M1 is in saturation mode,

$$\therefore I_{DS} = \frac{K_n}{2}(V_{GS} - V_{TN})^2 = \frac{1m}{2}(5 - 6kI_{DS} - 1)^2$$

$$18MI_{DS}^2 - 25kI_{DS} + 8 = 0 \Rightarrow I_{DS} = 0.889mA \ \ or \ \ 0.5mA$$

$$\therefore V_S = 6k \times 0.889m = 5.33V > V_G \Rightarrow rejected \ \ since \ \ V_{GS} < V_{TN}$$

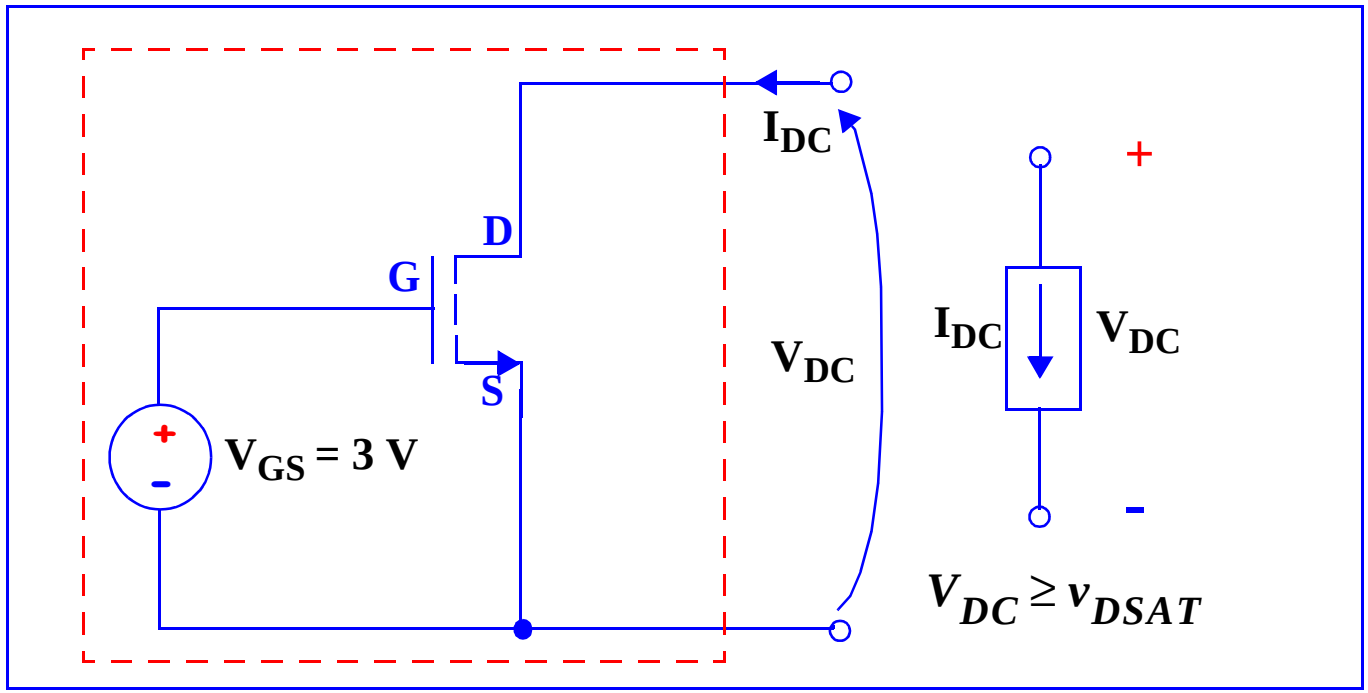
or $V_S = 6k \times 0.5m = 3V < V_G$

$$\therefore V_{GS} - V_{TN} = 5 - 3 - 1 = 1V \text{ and}$$

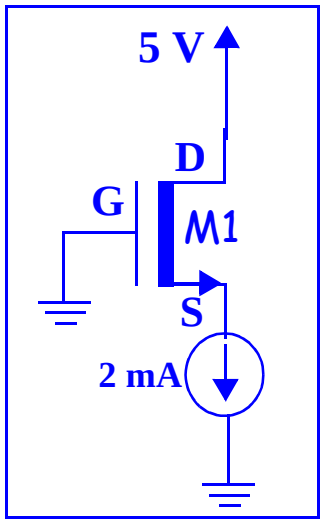
$$V_{DS} = 10 - I_{DS}R_D - 3 = 10 - (0.5m)(6k) - 3 = 4V \Rightarrow V_{DS} > V_{GS} - V_{TN}$$

Therefore, our assumption of the operating mode of M1 is correct, and the Q-point of M1 is $(I_{DS}, V_{DS}) = (0.5mA, 4V)$

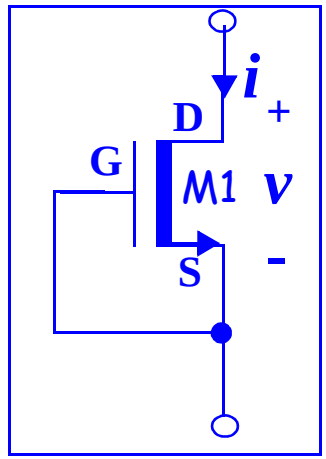
Electronic Current Source



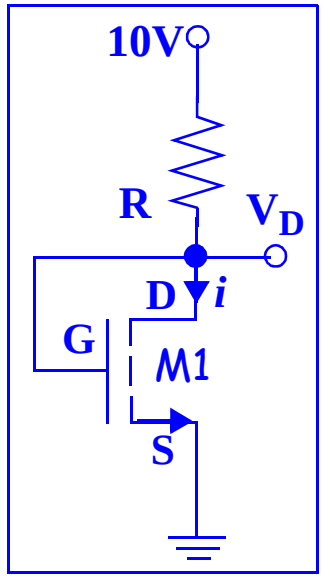
A depletion mode nMOSFET has V_{TN} = -2V, K_n = 4mA/V^2 and λ = 0V^{-1} and is used as a current source. Determine the voltage at the source S of M1.



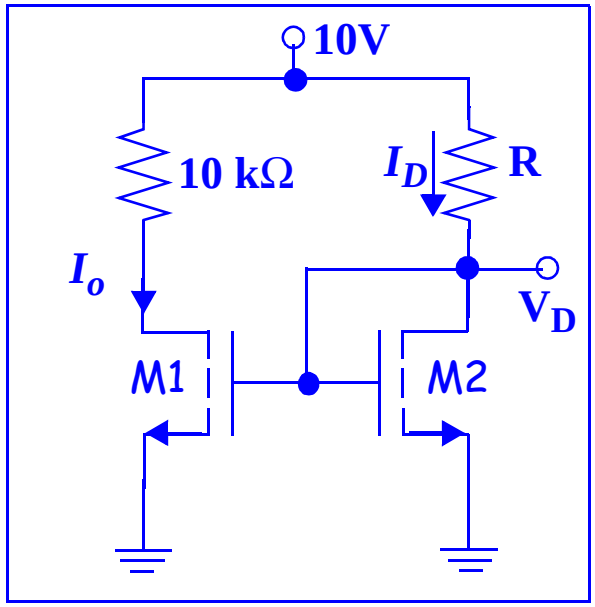
A depletion mode nMOSFET is configured as shown. Find ***i*** as a function of ***v***. Assume that λ is 0 V^{-1}.



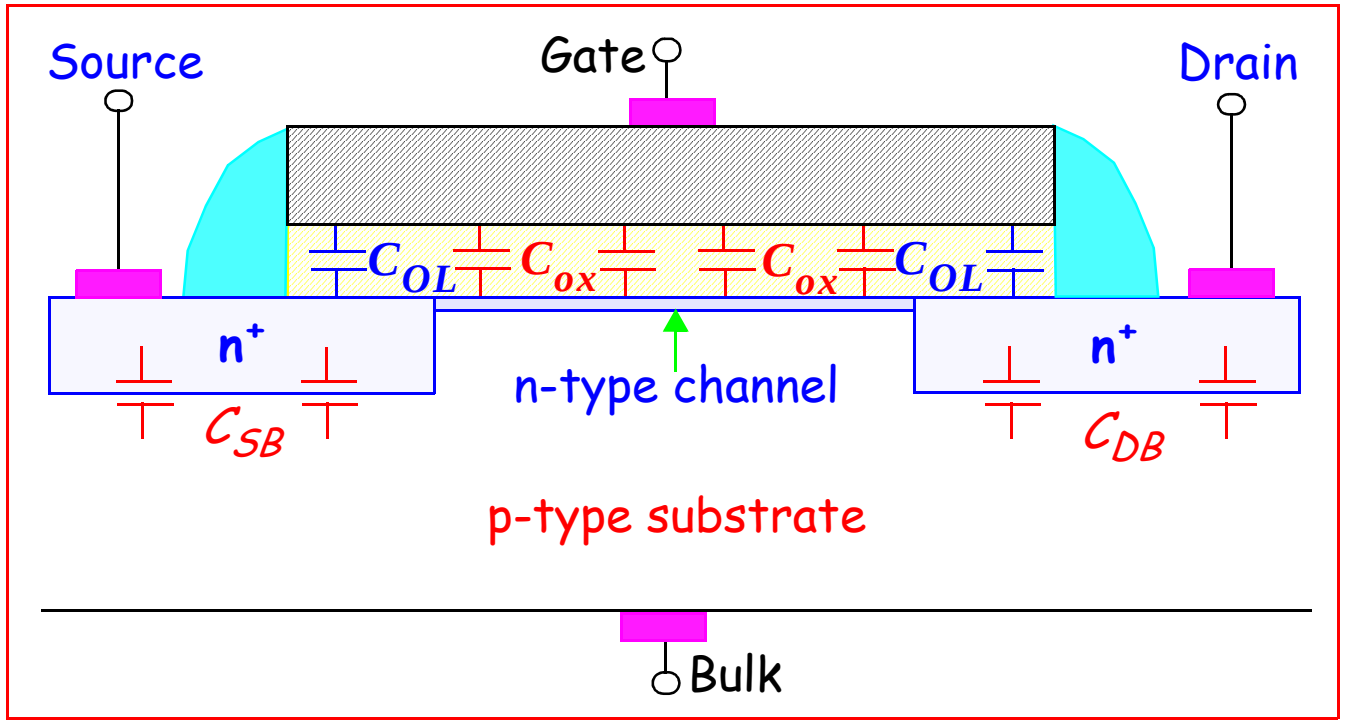
Design Problem. An enhancement mode nMOSFET is used to obtain a current of 0.4 mA. Its parameters are V_{TN} = 1V, K_n = 0.2mA/V^2, W = 100 μm, L = 10 μm and λ = 0V^{-1}. Design a circuit that would perform as above, and determine its mode of operation. (Here, one design is the circuit shown on the right.)



Design Problem. Enhancement mode nMOSFETs are used to make a current mirror in which I_o is controlled by I_D and the dimensions of M1 and M2, assuming that all other parameters are the same.

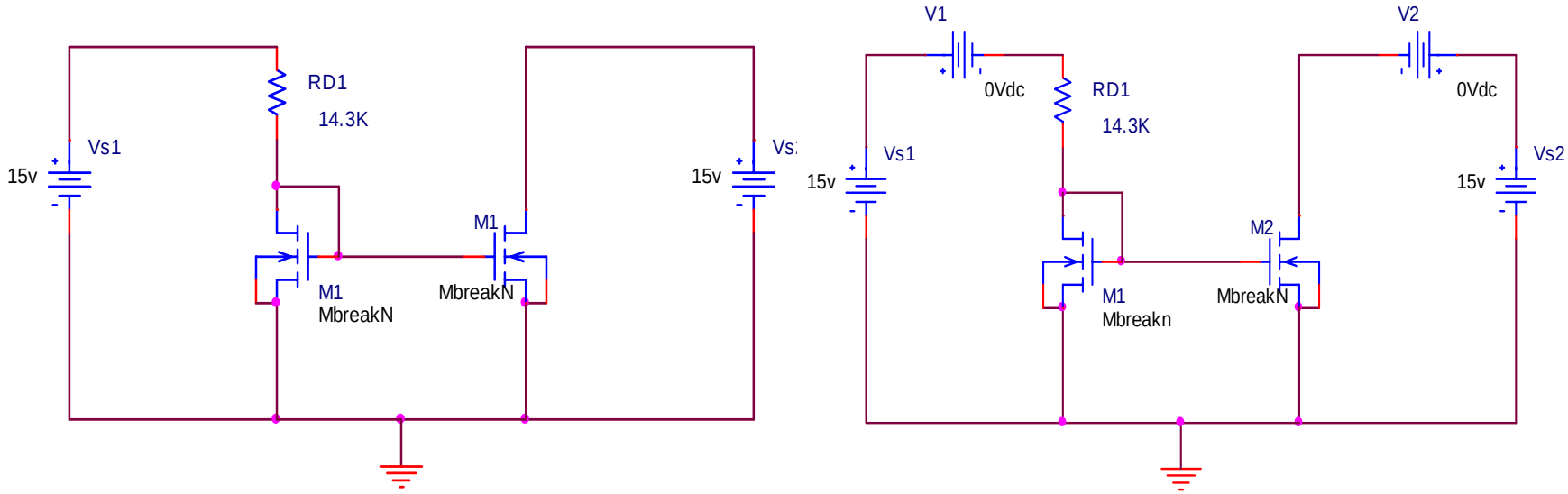


Find I_o assuming that M1 and M2 are identical and I_D = 0.4 mA. Each transistor has the same parameters - V_{TN} = 1V, K_n = 0.2mA/V^2, W = 100 μm, L = 10 μm and $\lambda = 0V^{-1}$. Can you generalize your result if the aspect rations (W/L) of M1 and M2 are different.



please read the capacitances part

PSPICE EXAMPLE



***Libraries:**
*** Local Libraries :**
.LIB ".\example7.lib"
*** From [PSPICE NETLIST] section of C:\Program Files\OrcadLite\PSpice\PSpice.ini file:**
.lib "nom.lib"

***Analysis directives:**
.OP
.TF I(V_V2) V_Vs1
.PROBE V(*) I(*) W(*) D(*) NOISE(*)
.INC ".\example7-SCHEMATIC1.net"

****** INCLUDING example7-SCHEMATIC1.net ******
*** source EXAMPLE7**
M_M2 N00368 N00234 0 0 MbreakN

PSPICE EXAMPLE (Cont'd)

```
V_V2        N00645 N00368 0Vdc
V_Vs1        N00545 0 15v
R_RD1         N00234 N00850  14.3K
M_M1         N00234 N00234 0 0 Mbreakn
V_V1        N00545 N00850 0Vdc
V_Vs2        N00645 0 15v

**** RESUMING example7-SCHEMATIC1-Example6Profile.sim.cir ****
.END

****     MOSFET MODEL PARAMETERS
******************************************************************************
 MbreakN
 NMOS
 LEVEL    1
 L  100.000000E-06
 W  100.000000E-06
 VTO    1
 KP   50.000000E-06
      .
      .
 ****     SMALL SIGNAL BIAS SOLUTION       TEMPERATURE =   27.000 DEG C
******************************************************************************
 NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE     NODE   VOLTAGE
(N00234)    6.0136 (N00368)   15.0000 (N00545)   15.0000 (N00645)   15.0000    (N00850)   15.0000
```

PSPICE EXAMPLE (Cont'd)

VOLTAGE SOURCE CURRENTS

NAME	CURRENT
V_V2	6.284E-04
V_Vs1	-6.284E-04
V_V1	6.284E-04
V_Vs2	-6.284E-04

TOTAL POWER DISSIPATION 1.89E-02 WATTS

****** SMALL-SIGNAL CHARACTERISTICS**

I(V_V2)/V_Vs1 = 5.468E-05

INPUT RESISTANCE AT V_Vs1 = 1.829E+04

OUTPUT RESISTANCE AT I(V_V2) = 1.000E+12

JOB CONCLUDED

TOTAL JOB TIME .10