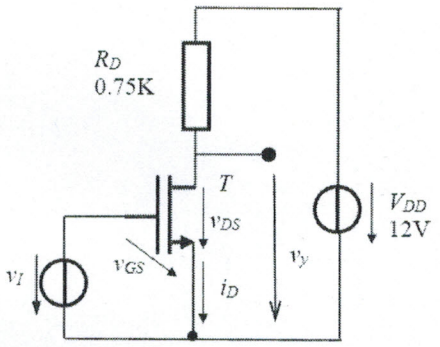
Homework 10 – MOSFET operation

$\beta = 2$ mA/V^2, $V_{Th} = 3$ V

a) What is the operating region of T for $v_I = 1.5$ V? Justify your answer.

b) What is the operating region of T for $v_I = 5$ V? Justify your answer. Compute I_D and V_{DS}.

c) Find a value for v_I for which T works in extreme conduction (exc). Prove that T works in the desired region.



a) T - off bc $v_I < V_{TH}$

b) $v_I = 5V > V_{TH} \Rightarrow$ T - a.f. or exc. Assume T - a.f.

$I_D = \beta(v_{GS} - V_{TH})^2 = \beta(v_I - V_{TH})^2 = 2 \cdot 2^2 = 8$ mA

$V_{DS} = V_{DD} - I_D R_D = 12 - 8 \cdot 0{,}75 = 6$ V

$V_{DSsat} = v_{GS} - V_{TH} = 2 < V_{DS} \Rightarrow$ T - a.f. $I_D = 8$ mA, $V_{DS} = 6$ V

c) T - exc ~~$I_D = \beta[2(v_{GS} - V_{TH})v_{DS} - v_{DS}^2]$~~

$V_{DS} = V_{DD} - I_D R_D < V_{DSsat}$

Let x be $v_{GS} - V_{TH}$, so $V_{DD} - I_D R_D = V_{DSsat} \Leftrightarrow$

$\Leftrightarrow V_{DD} - \beta x^2 \frac{R_D}{2} = x \Rightarrow 12 - 1{,}5x^2 - x = 0$; $1{,}5x^2 + x - 12 = 0$

$x_{1,2} = \frac{-1 \pm \sqrt{1+72}}{3}$ < $\frac{-1-8{,}54}{3} = -3{,}18$, $\frac{-1+8{,}54}{3} = 2{,}51$ $\Rightarrow x = v_{GS} - V_{TH} = 2{,}51$ V >

$\Rightarrow V_{GS} \geq V_{TH} + 2{,}51 = 5{,}51 \Rightarrow v_I = v_{GS} = 6$ V is a good value

Proof: $I_D = \beta[2(v_{GS} - V_{TH})v_{DS} - V_{DS}^2]$ ~~exc~~ exc. Assume T in a.f. so $I_D = \beta(v_{GS} - V_{TH})^2 = 2 \cdot 9 = 18$ mA, $V_{DS} = 12 - 13{,}5 = -1{,}5 < 0$

$\Rightarrow$ assumption = false $\Rightarrow$ T - (exc)