Use the Unified model eq

$$I_D = K'\left(\frac{W}{L}\right)\left((V_{GS}-V_T)V_{min} - \frac{V_{min}^2}{2}\right)(1+\lambda V_{DS})$$

where $V_{min} = \min(V_{GS}-V_T, V_{DS}, V_{Dsat})$

#1

(a) observing Table 1, we see a I_{DS} only when V_{GS} is -ve. So, the transistor is a **PMOS**, Also, V_{Dsat} is -ve → PMOS

(b) $V_{TO} = ?$ Take ratio of 2 currents with same V_{DS} & V_{SB} - ex I_{DS1} & I_{DS4}

$$\frac{I_{DS1}}{I_{DS4}} = \frac{+84.375\,\mu A}{+56.25\,\mu A} = \frac{K'_P(W/L)\left((+2.5-V_T)(1) - 1^2/2\right)(1+\lambda(2.5))}{K'_P(W/L)\left((2-V_T)(1) - 1^2/2\right)(1+\lambda(2.5))}$$

$$= \frac{84.375}{56.25} = \frac{2.5-V_T-1/2}{2-V_T-1/2} \Rightarrow V_T = 0.5V$$

$$\boxed{V_{TP} = -0.5V}$$

(c) $\gamma = ?$ Take Ratio of current with diffrent V_{SB}, but Similar V_{DS} - ex I_{DS1} & I_{DS5}

$$\frac{I_{DS1}}{I_{DS5}} = \frac{+84.375\,\mu A}{+72.\,\mu A} = \frac{K'_P(W/L)\left((2.5-V_{TO})(1) - 1^2/2\right)(1+\lambda(2.5))}{K'_P(W/L)\left((2.5-V_T)(1) - 1^2/2\right)(1+\lambda(2.5))}$$

$$= \frac{84.375}{72} = \frac{2.5-0.5-1/2}{2.5-V_T-1/2} \Rightarrow V_T = 0.72$$

$$V_T = V_{TO} + \gamma\left(\sqrt{|2\phi_F - V_{BS}|} - \sqrt{|2\phi_F|}\right)$$

$$0.72 = 0.5 + \gamma\left(\sqrt{0.6 + 1} - \sqrt{0.6}\right)$$

$$\boxed{\gamma = 0.448\ V^{1/2}}$$

(d) Ratio of 2 current with different V_{DS}

Ex- I_{DS1} and I_{DS6}

$$\frac{+84.375\,\mu A}{+80.625\,\mu A} = \frac{K'p(W/L)(2.5 - 0.5)(1)^{1/2})(1+\lambda(2.5))}{K'p(W/L)((2.5 - 0.5)(1)^{1/2})(1+\lambda(1.5))}$$

$$\frac{84.375}{80.625} = \frac{1+\lambda(2.5)}{1+\lambda(1.5)} \Rightarrow \boxed{\lambda_p = -0.05\ V^{-1}}$$

(e) $\min(|V_{GS} - V_T|, |V_{DS}|, |V_{dsat}|)$

(1) $\min(2, 2.5, (1)) \Rightarrow$ Velocity sat

(2) $\min(0.5, 1, 1) \Rightarrow I_{DS} = 0 \quad V_{GT} > 0 \Rightarrow$ Cutoff

(3) $\min((0.2), 0.8, 1) \Rightarrow$ Saturation

(4) $\min(1.5, 2.5, 1) \Rightarrow$ Vel Sat

(5) $\min(2, 2.5, 1) \Rightarrow$ Vel Sat

(6) $\min(2, 1.5, 1) \Rightarrow$ Vel Sat

(7) $\min(2, 0.8, 1) \Rightarrow$ Linear