Example 7.2 Repeat example 7.1 using the variable depletion layer model. Use V_{FB} = -0.807 V and $N_a = 10^{17}$ cm^{-3}.

Solution To find out whether the MOSFET is biased in saturation, one first calculates the saturation voltage, $V_{D,sat}$:

$$V_{DS,sat} = V_{GS} - V_{FB} - 2f_F - \frac{qN_a e_s}{C_{ox}^2}\{\sqrt{1 + 2\frac{C_{ox}^2}{qN_a e_s}(V_{GB} - V_{FB})} - 1\}$$

$$= 1.39 \text{ V}$$

The drain current is then obtained from:

$$I_D = \frac{m_n C_{ox} W}{L}(V_{GS} - V_{FB} - 2f_F - \frac{V_{DS,sat}}{2})V_{DS,sat} - \frac{2}{3}m_n \frac{W}{L}\sqrt{2e_s qN_a}((2f_F + V_{DB})^{3/2} - (2f_F + V_{SB})^{3/2})$$

$$= 0.7 \text{ mA}$$

The transconductance equals:

$$g_{m,sat} = m_n C_{ox}\frac{W}{L}[V_{GS} - V_{FB} - 2f_F - \frac{qN_a e_s}{C_{ox}^2}\{\sqrt{1 + 2\frac{C_{ox}^2}{qN_a e_s}(V_{GB} - V_{FB})} - 1\}]$$

$$= 0.52 \text{ mS}$$

corresponding to a modified mobility m_n^* = 149 cm^2/V-s.

The output conductance at V_{DS} = 0 V equals:

$$g_d = \frac{\partial I_D}{\partial V_{DS}}\bigg|_{V_{GS}} = 1.04 \text{ mS}$$

Which is the same as that of example 7.1 since the depletion layer width is constant for V_{DS} = 0.