Ex: 5.2

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = \frac{34.5 \text{ pF/m}}{4 \text{ nm}} = 2.30 \text{ fF}/\mu\text{m}^2$$

$$\mu_n = 550 \text{ cm}^2/\text{VS}$$

$$k_n' = \mu_n C_{ox} = 127 \ \mu\text{A}/\text{V}^2$$

$$I_D = \frac{1}{2} k_n' \frac{W}{L} V_{OV}^2 = 0.2 \text{ mA}, \frac{W}{L} = 20$$

$$\therefore V_{OV} = 0.40 \text{ V}.$$

$$V_{DS,\,\min} = V_{OV} = 0.40 \text{ V, for saturation}$$

5.5 The transistor size will be minimized if *W/L* is minimized, since *W/L* appears in the equations that must be satisifyed, we can minimize (*W/L*). Clearly we want to minimize L by using the smallest feture size.

$L = 0.18\,\mu\text{m}$

$$r_{DS} = \frac{1}{k_n'(W/L)(v_{GS} - V_t)}$$

$$r_{DS} = \frac{1}{k_n'(W/L)v_{OV}}$$

Two conditions need to met for v_{OV} and r_{DS}

Condition 1:

$$r_{DS,1} = \frac{1}{400 \times 10^{-6}(W/L)v_{OV,1}}$$

$$= 200 \Rightarrow (W/L)v_{OV,1} = 12.5$$

Condition 2:

$$r_{DS,2} = \frac{1}{400 \times 10^{-6}(W/L)v_{OV,2}}$$

$$= 1000 \Rightarrow (W/L)v_{OV,2} = 2.5$$

If condition 1 is met, condition 2 will be met since the over-voltage can always be reduced to satisfy this requirement. For condition 1, we want to decrease *W/L* as much as possible (so long as it is greater than or equal to 1), while still meeting all of the other constraints.

This requires our using the largest possible $v_{GS,1}$ voltage. $v_{GS,1} = 1.8$ Volts, so $v_{OV,1} = 1.4$ Volts that

$$W/L = \frac{12.5}{v_{OV,1}} = \frac{12.5}{1.4} \cong 8.93$$

Condition 2 now can be used to find $v_{GS,2}$

$$v_{OV,2} = \frac{12.5}{W/L} = \frac{2.5}{12.5/1.4} = 0.28$$

$$\Rightarrow v_{GS,2} = 0.68\,\text{Volts} \Rightarrow 0.68 \le v_{GS} \le 1.8$$