A Taylor series expansion of the right-hand side of Eq. (3.1.8) yields the following (keeping only the first two terms)

(3.1.9)

$$Q_{chsubs(y)} = Q_{chsubs0}(1 - \frac{A_{bulk}V_{F(y)}}{nv_t})$$

Analogous to Eq. (3.1.6), Eq. (3.1.9) can also be written as

(3.1.10)

$$Q_{chsubs(y)} = Q_{chsubs0} + \Delta Q_{chsubs(y)}$$

The parameter $\Delta Q_{chsubs}(y)$ is the incremental channel charge density induced by the drain voltage in the subthreshold region. It can be written as

(3.1.11)

$$\Delta Q_{chsubs(y)} = -\frac{A_{bulk}V_{F(y)}}{nv_t} Q_{chsubs0}$$

Note that Eq. (3.1.9) is valid only when $V_F(y)$ is very small, which is maintained fortunately, due to the fact that Eq. (3.1.9) is only used in the linear regime (i.e. $V_{ds} \leq 2v_t$).

Eqs. (3.1.6) and (3.1.10) both have drain voltage dependencies. However, they are decupled and a unified expression for $Q_{ch}(y)$ is needed. To obtain a unified expression along the channel, we first assume

(3.1.12)

$$\Delta Q_{ch(y)} = \frac{\Delta Q_{chs(y)} \Delta Q_{chsubs(y)}}{\Delta Q_{chs(y)} + \Delta Q_{chsubs(y)}}$$

Here, $\Delta Q_{ch}(y)$ is the incremental channel charge density induced by the drain voltage. Substituting Eq. (3.1.7) and (3.1.11) into Eq. (3.1.12), we obtain