We assume in the following analysis that the contributions to the Early voltage from all mechanisms are independent and can be calculated separately.

5.7.1 Channel Length Modulation (CLM)

If channel length modulation is the only physical mechanism to be taken into account, the Early voltage can be calculated by

$$V_{ACLM} = I_{dsat} \cdot \left[\frac{\partial I_{ds}\left(V_{gs}, V_{ds}\right)}{\partial L} \cdot \frac{\partial L}{\partial V_d} \right]^{-1} \tag{5.33}$$

Based on quasi two-dimensional analysis and through integration, we propose V_{ACLM} to be

$$V_{ACLM} = C_{clm} \cdot \left(V_{ds} - V_{dsat}\right) \tag{5.34}$$

where

$$C_{clm} = \frac{1}{PCLM} \cdot F \cdot \left(1 + PVAG \frac{V_{gsteff}}{E_{sat} L_{eff}}\right)\left(1 + \frac{R_{ds} \cdot I_{dso}}{V_{dseff}}\right)\left(L_{eff} + \frac{V_{dsat}}{E_{sat}}\right) \cdot \frac{1}{litl} \tag{5.35}$$

and the F factor to account for the impact of pocket implant technology is

$$F = \frac{1}{1 + FPROUT \cdot \dfrac{\sqrt{L_{eff}}}{V_{gsteff} + 2v_t}} \tag{5.36}$$

and $litl$ in (6.34) is given by

$$litl = \sqrt{\frac{\varepsilon_{si} TOXE \cdot XJ}{EPSROX}} \tag{5.37}$$

$PCLM$ is introduced into V_{ACLM} to compensate for the error caused by XJ since the junction depth XJ cannot be determined very accurately.

5.7.2 Drain-Induced Barrier Lowering (DIBL)

The Early voltage V_{ADIBLC} due to DIBL is defined as