

$$\begin{aligned}
\int_0^L I_D dy &= \mu_n C_{ox} W \int_0^{V_{DS}} (V_{GS} - V_{FB} - 2\phi_F - V_C) dV_C \\
&\quad - \mu_n W \int_0^{V_{DS}} \sqrt{2\varepsilon_s q N_a (2\phi_F + V_{SB} + V_C)} dV_C
\end{aligned}$$