VEB₂ = \( V_T \ln \frac{I_{C₂}}{I_{S₂}} \) = \( V_T \ln \frac{I_{E₂}}{I_{S₂}} \) because base current is ignored

\[ I_{E₂} = \frac{\Delta V_{EB}}{R₃} \]

Now double \( I_{S₁} \) and \( I_{S₂} \). \( \Delta V_{EB} \) is constant. See (4.272)

Therefore \( I_{E₂} \) and \( I_{C₂} \) are constant

so \( V_{EB₂} \) changes by \( V_T \ln \frac{1}{2} = -18 \text{ mV} \)

From (4.248)

\[ V_{EB₂} = V_{60} - V_T \left[ (6-\alpha) \ln T - \ln (E_0) \right] \]

\[
\frac{dV_{EB₂}}{dT} = \frac{-V_T (6-\alpha) - (6-\alpha) \ln T \frac{V_T}{T} + \frac{V_T \ln (E_0)}{V_{EB₂}}}{T}
\]

\[ = \frac{-V_T (6-\alpha) - V_T \left[ (6-\alpha) \ln T - \ln (E_0) \right] - V_{60} \ln (E_0)}{T} \]

Under nominal conditions, the slope of the \( V_{EB₂} \) term and the slope of the \( \Delta V_{EB} \) term at the output are set equal in magnitude and opposite in polarity at 25°C to set \( I_C = 0 \). However, under the specified conditions, \( V_{EB₂} \) has fallen by 18 mV, and its slope has fallen by \( \frac{18 \text{ mV}}{25 + 273} = \frac{18}{298} = 60 \text{ mV} \). Since \( V_{EB₂} \) contributes directly to the output, we see (4.269),

the output slope changes by the same amount.

Therefore \( \frac{dV_{out}}{dT} \mid T = 25°C = -60 \text{ mV} / °C \)

Initially, \( \frac{dV_{out}}{dT} = 0 \) for \( V_{out} = 1.16 \text{ V} = \text{target in my sim.} \) with \( I_{S₁} \) and \( I_{S₂} \) doubled from the nominal value but the gain equal to the nominal value.

SPICE gives \( \frac{dV_{out}}{dT} \mid T = 25°C = -58 \text{ mV} / °C \)

at \( V_{out} = 1.14 \text{ V} \)

With the gain readjusted so that \( V_{out} = \text{target at 25°C} \), \( \frac{dV_{out}}{dT} \mid T = 25°C = 0 \)

1.14 V

Therefore, the case of \( I_S \neq \text{nominal} \) can be corrected by trimming the gain to set the output equal to the target.
Because $m_3 = m_4$, $|I_{D3}| = |I_{D4}| = |I_D1| = |I_D2| = I_{BIAS}$

**KVL:** $V_{CS1} - V_{CS2} = I_{BIAS} R$

Ignore body effect $\Rightarrow V_{L1} = V_{L2}$

$I_{O1} - I_{O2} = I_{BIAS} R$

$$\sqrt{\frac{2I_{BIAS}}{m_nC_W1}} - \sqrt{\frac{2I_{BIAS}}{m_nC_W2}} = I_{BIAS} R$$

$$\sqrt{\frac{2I_{BIAS}}{m_nC_W1}} \left\{ \frac{1}{(W/L)_1} - \frac{1}{(W/L)_2} \right\} = I_{BIAS} R$$

$$I_{BIAS} = \frac{2}{m_nC_W R^2} \left\{ \frac{1}{(W/L)_1} - \frac{1}{(W/L)_2} \right\}$$

As $T \uparrow$, $R \uparrow$ and $m_n \downarrow$ ($m_n \times T^{-n}$). These effects tend to cancel. The precise behavior depends on the exact dependence of $m_n$ and $R$ versus $T$. 