

$$\frac{\partial V_{BE}}{\partial T} = \eta \frac{k}{q} \left[\ln \frac{I}{I_S} - \left(\frac{E_g}{kT} + 4+m \right) \right]$$

EEL782: Analog Integrated Circuits

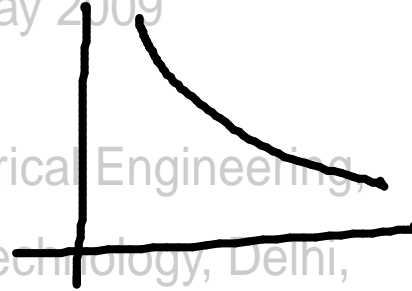
$$V_{BE} = \eta V_T \ln \frac{I}{I_S}$$

$$I_S = b T^{4+m} \exp(-E_g/kT)$$

$$V_{BE} = \eta V_T \left(\ln I + \frac{E_g}{kT} - \ln(b T^{4+m}) \right)$$

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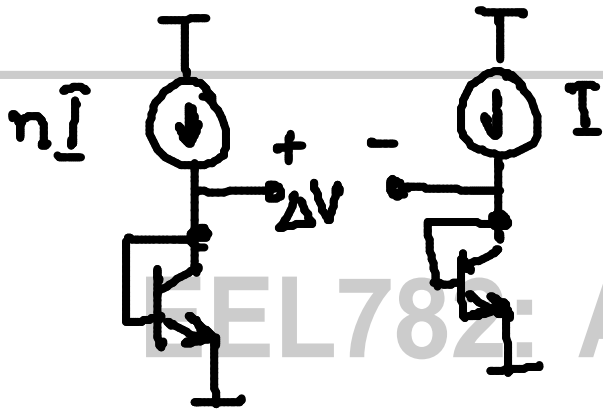


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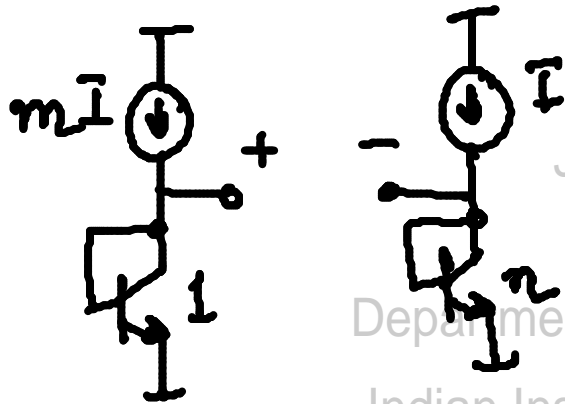
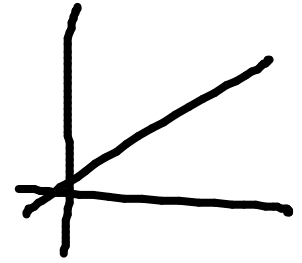
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$$\frac{\partial \Delta V}{\partial T} = \eta \frac{k}{q} \ln(n)$$

$$\Delta V = \eta V_T \ln(n)$$



$$V_{BE1} = \eta V_T \ln\left(\frac{I}{I_S}\right)$$

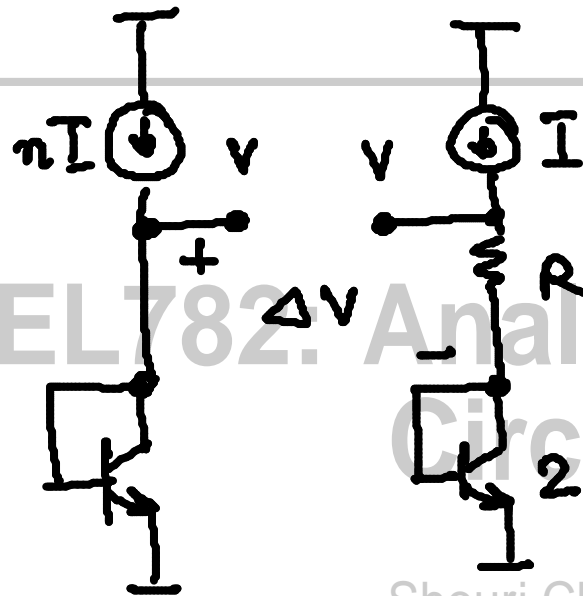
$$V_{BE2} = \eta V_T \ln\left(\frac{I}{nI_S}\right)$$

$$\Delta V = \eta V_T \ln(mn)$$

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$$\frac{\partial \Delta V}{\partial T} = \eta \frac{k}{q} \ln(n)$$

$$V = \Delta V + V_{BE_2}$$

$$= V_{BE_2} + IR$$

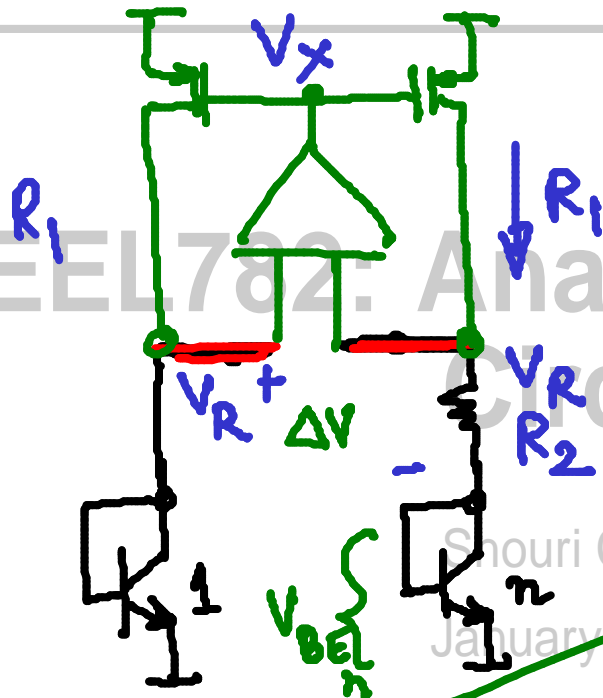
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$$I = \frac{V_x - V_R}{R_1}$$



$$V_R = \Delta V + V_{BE2}$$

$$= \eta V_T \ln(n) + \eta V_T \ln\left(\frac{I}{n I_S}\right)$$

$$\frac{\partial V_R}{\partial T} = \eta \frac{k}{q} \ln(n) + \eta \frac{k}{q} \left[\ln \frac{I}{n I_S} + T \cdot \frac{n I_S}{I} \frac{\partial}{\partial T} \left(\frac{I}{n I_S} \right) \right]$$

$$T \left(\frac{\partial I}{\partial T} / I - \frac{\partial I_S}{\partial T} / I_S \right)$$

$$I_S = b T^{4+m} \exp(-E_g/kT)$$

$$\frac{\partial I_S}{\partial T} = b(4+m) T^{3+m} \exp(-E_g/kT) + b T^{4+m} \cdot \exp(-E_g/kT) \cdot \frac{E_g}{kT^2}$$

$$= I_S \left[(4+m)/T + E_g/kT^2 \right]$$

$$\frac{\partial V_R}{\partial T} = \eta \frac{k}{q} \left[\ln(n) + \ln\left(\frac{I}{n I_s}\right) - (4+m) - \frac{E_g}{kT} + \frac{\partial I/I}{\partial T/T} \right]$$

$$V_R = \eta V_T \ln\left(\frac{I}{I_s}\right) \quad (4+m)$$

$$= \eta V_T \left[\ln(I) - \ln(I_s) \right]$$

$$= \eta \left[V_T \ln(I) - V_T \ln(b T^{4+m}) + \frac{E_g}{q} \right]$$

$$I \stackrel{?}{=} b T^{4+m}$$

$$\begin{aligned} \frac{\partial I}{\partial T} &= b(4+m) T^{3+m} \\ &= \frac{I}{T} \cdot (4+m) \end{aligned}$$



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