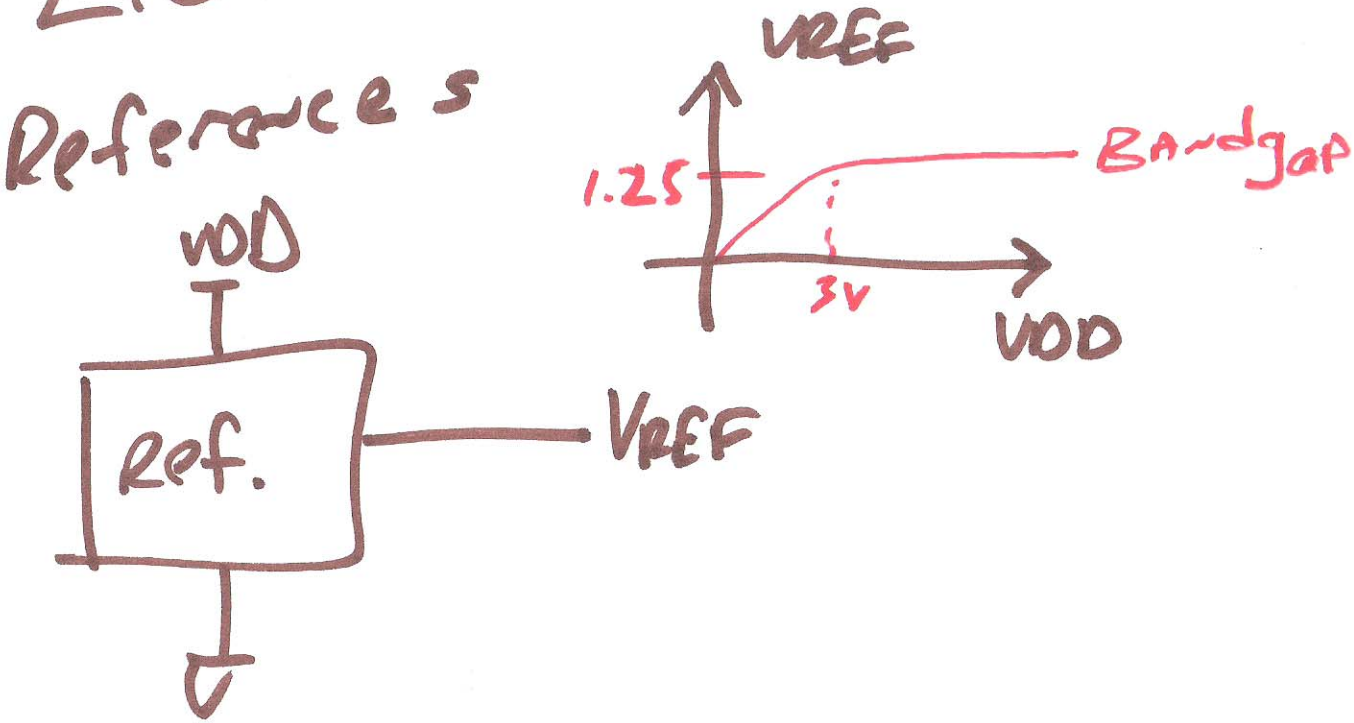
EE 420 / ECE 620

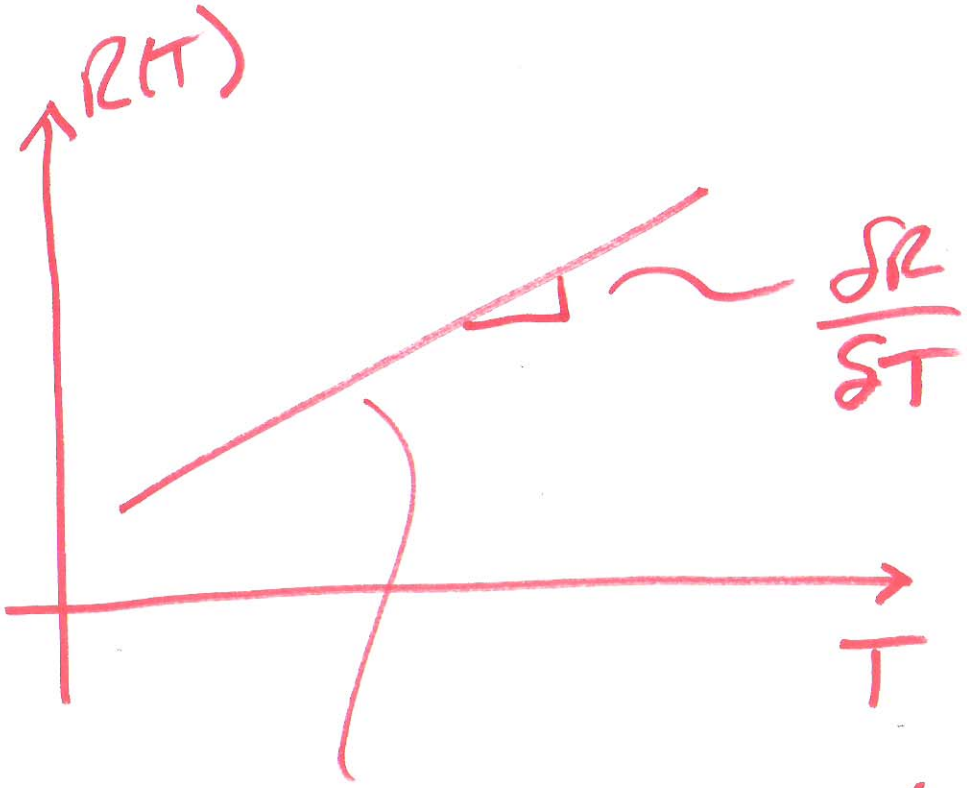
Analog IC Design

April 8, 2015

Lecture 21

References





$$R(T) = R(T_0)\left(1 + TCR(T - T_0)\right)$$

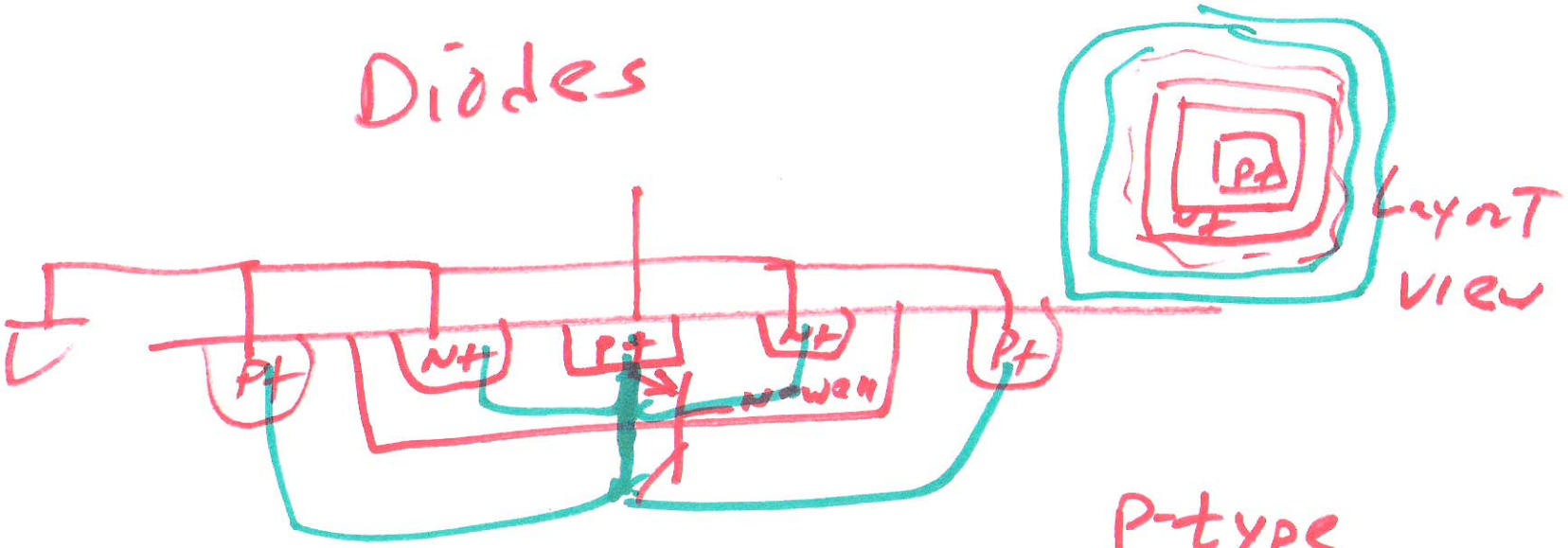
$$R(T_0) \cdot TCR = \frac{\delta R}{\delta T}$$

$$TCR = \frac{1}{R}\frac{\delta R}{\delta T}$$

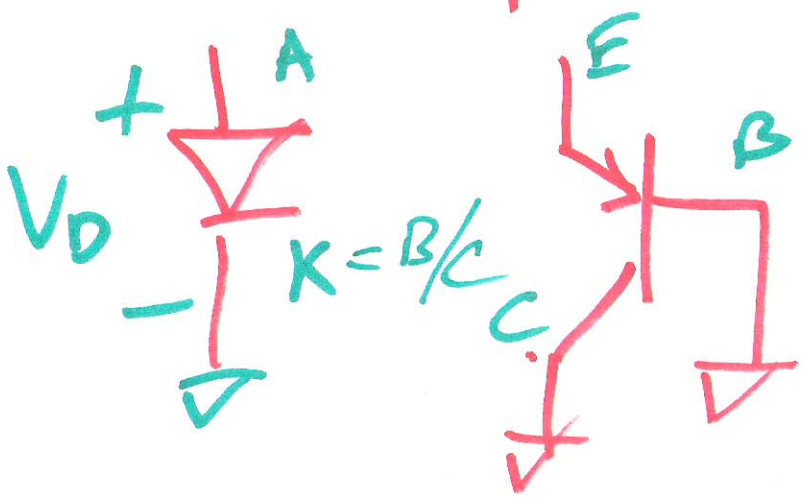
$\times 10^6$

$0{,}002 = 2{,}000 \frac{ppm}{C^\circ}$

Diodes



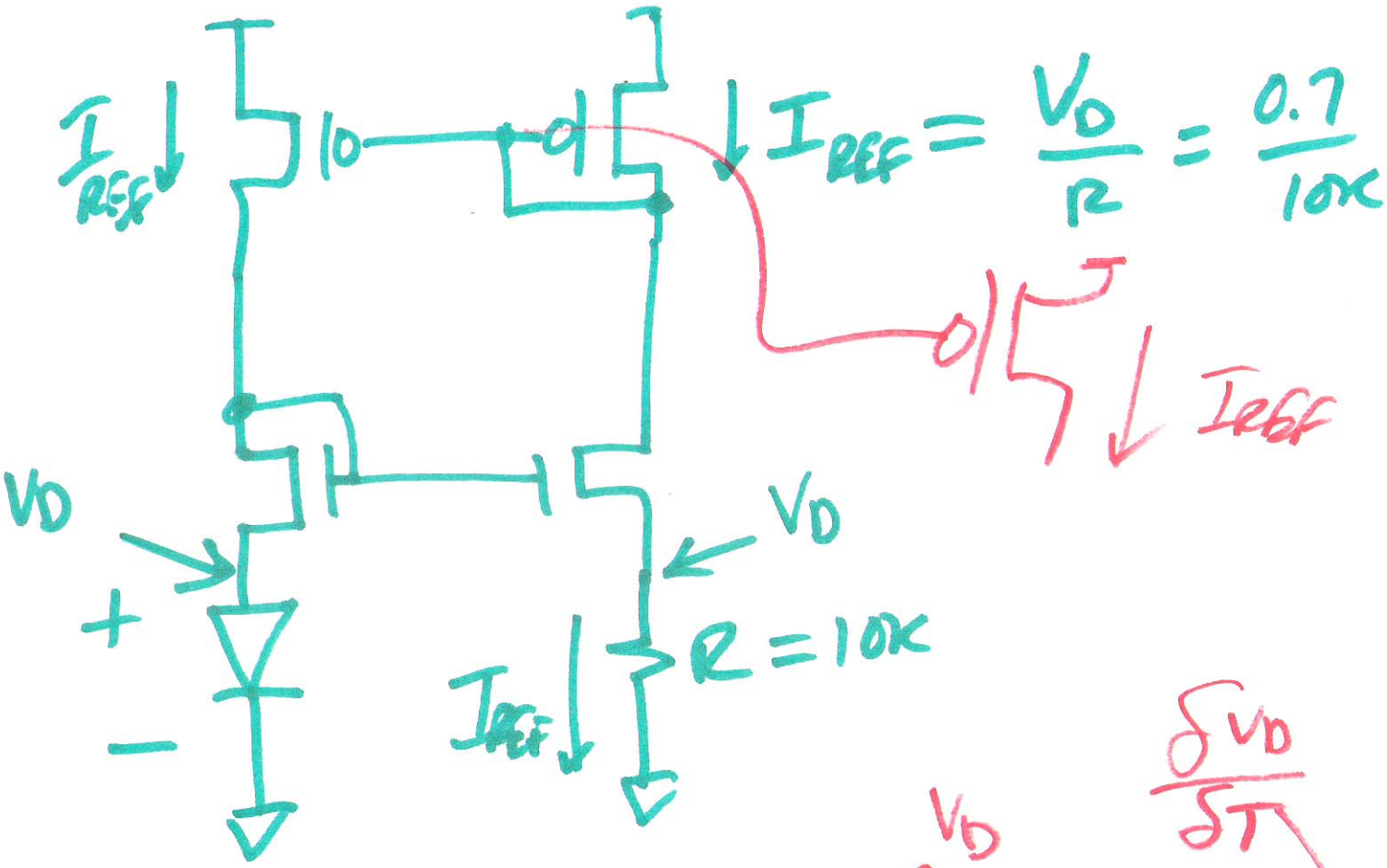
PARASITIC PNP



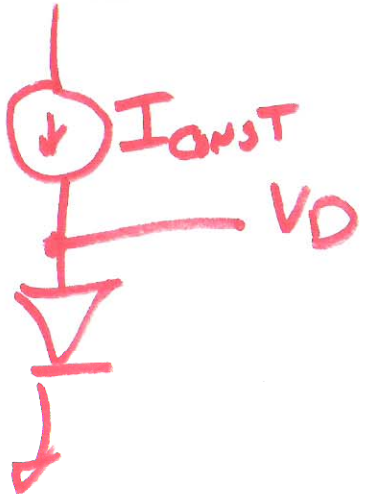
$$I_D = I_S e^{V_D/nV_T}$$

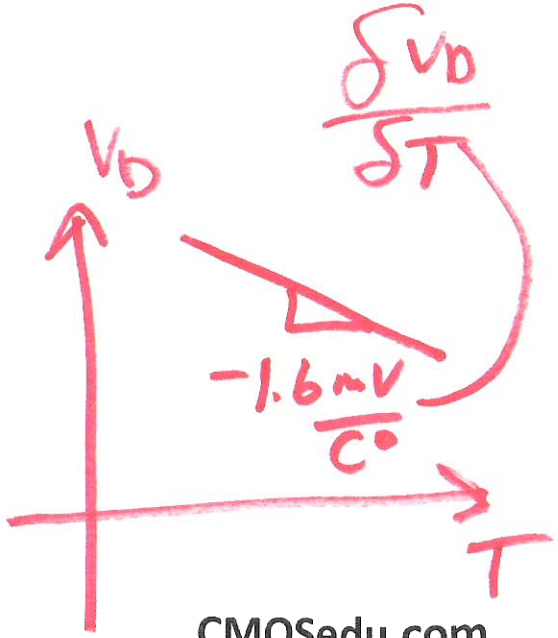
forward bias

$$V_D = nV_T \ln \frac{I_D}{I_S}$$



$$V_{bi} = \frac{KT}{q} \ln \frac{N_A N_D}{n_i^2}$$





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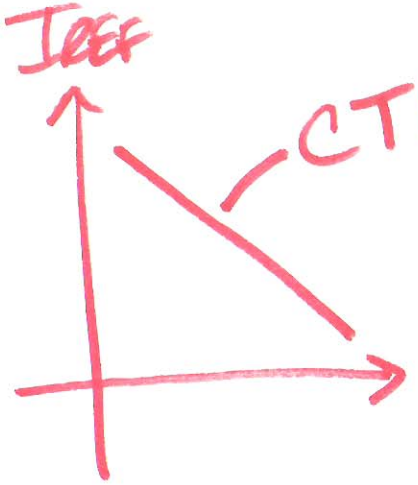
4)

$$\frac{\delta I_{REF}}{\delta T} = \frac{\delta \frac{V_D}{R}}{\delta T} = \frac{\delta}{\delta T} V_D R^{-1}$$

$$= \frac{\delta V_D}{\delta T} \cdot R^{-1} + V_D \cdot (-1) R^{-2} \frac{\delta R}{\delta T}$$



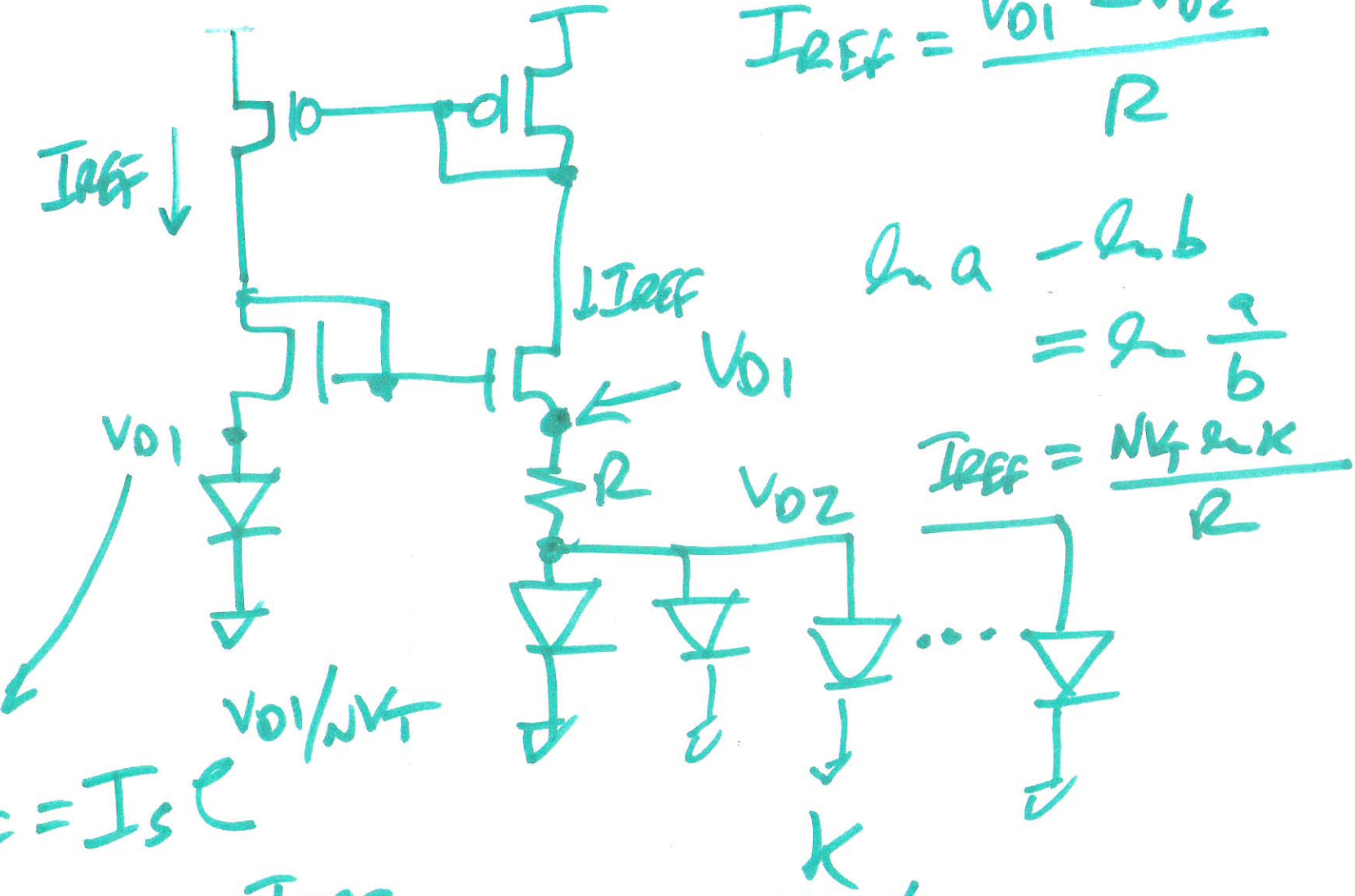
$$= \frac{1}{V_D} \frac{V_D}{R} \frac{\delta V_D}{\delta T} + -\frac{V_D}{R} \cdot \frac{1}{R} \frac{\delta R}{\delta T}$$

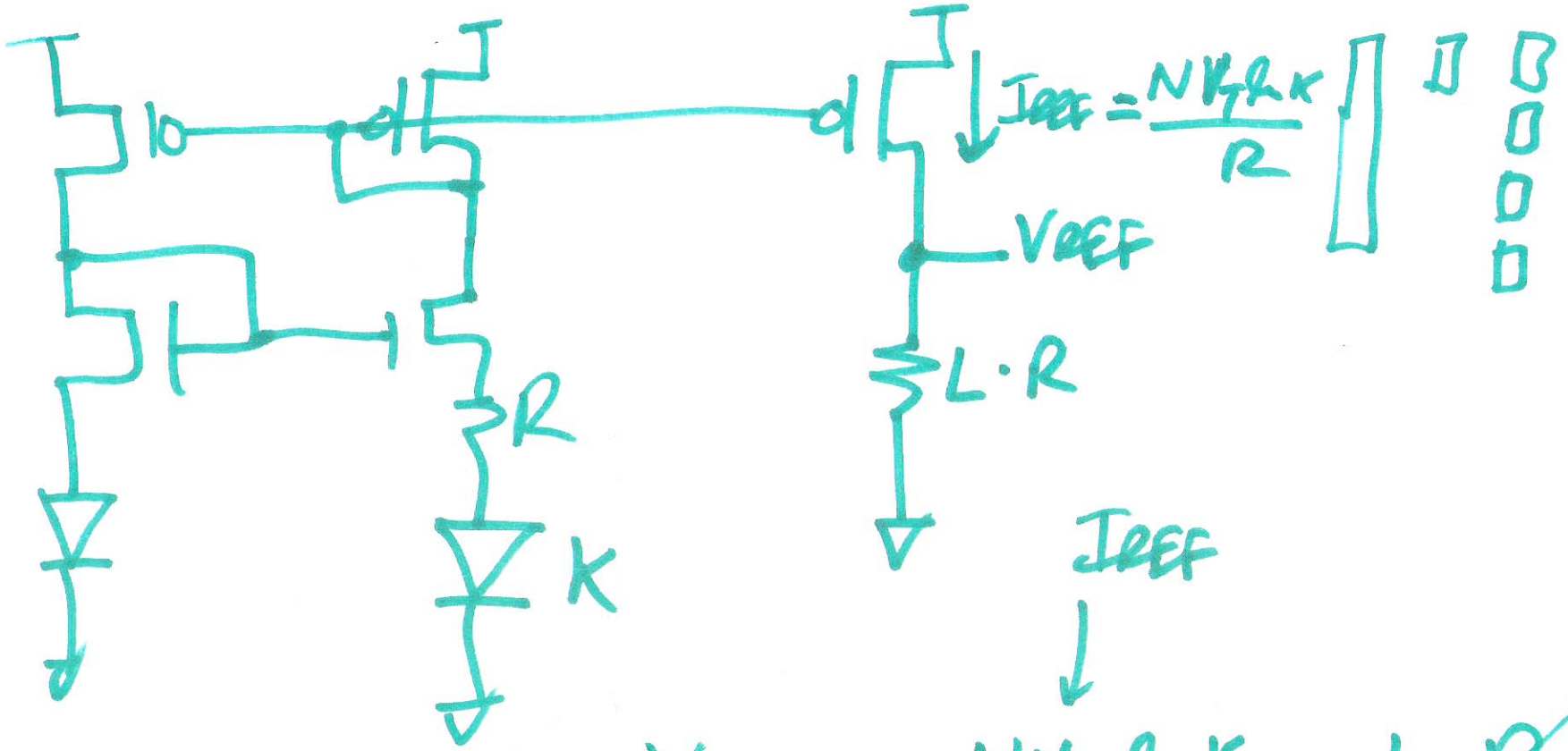
I_{REF} I_{REF}

$$TCI_{REF} = \frac{-.0016}{.7} - 0.002$$

$$TCI_{REF} = \frac{1}{I_{REF}} \frac{\delta I_{REF}}{\delta T} = \frac{1}{V_D} \frac{\delta V_D}{\delta T} - \frac{1}{R} \frac{\delta R}{\delta T}$$

$$I_{REF}(T) = I_{REF}(T_0)\left(1 + TI_{REF}(T - T_0)\right)$$


$I_{REF} = \frac{V_{D1} - V_{D2}}{R}$
$\ln a - \ln b = \ln \frac{a}{b}$
$I_{REF} = \frac{NV_T \ln K}{R}$
I_{REF}
1
1
I_{REF}
V_{D1}
V_{D1}
R
V_{D2}
V_{D1}/NV_T
$I_{REF} = I_S e^{V_{D1}/NV_T}$
K
$V_{D1} = NV_T \ln \frac{I_{REF}}{I_S}$
$I_{REF} = KI_S e^{V_{D2}/NV_T}$
$V_{D2} = NV_T \ln \frac{I_{REF}}{KI_S}$



$$V_{REF} = \frac{N V_T \ln K}{R} \cdot L \cdot R$$

$$V_T = \frac{kT}{q}$$

$$\frac{\delta V_T}{\delta T} = \frac{k}{q} \approx +0.085\,mV/^\circ$$

$$V_{REF} = N V_T (\ln K) \cdot L$$

7)

$$V_{REF} = N V_T \ln K \cdot L$$

$$\frac{\delta V_{REF}}{\delta T} = N \cdot \frac{k}{q} \cdot \ln K \cdot L$$

$K = 8$

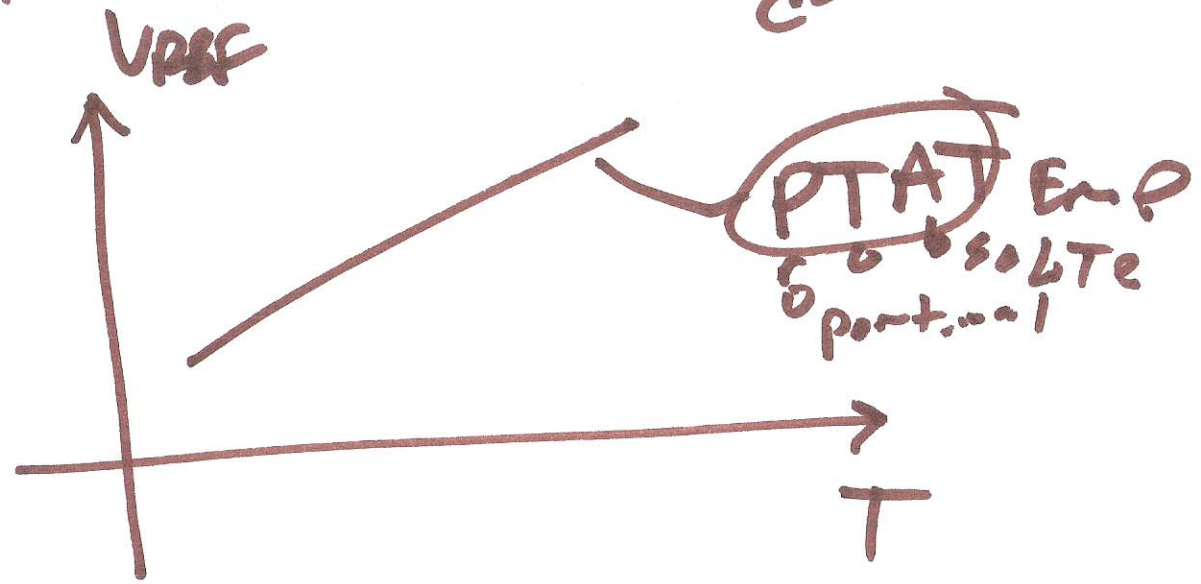
N → const 1

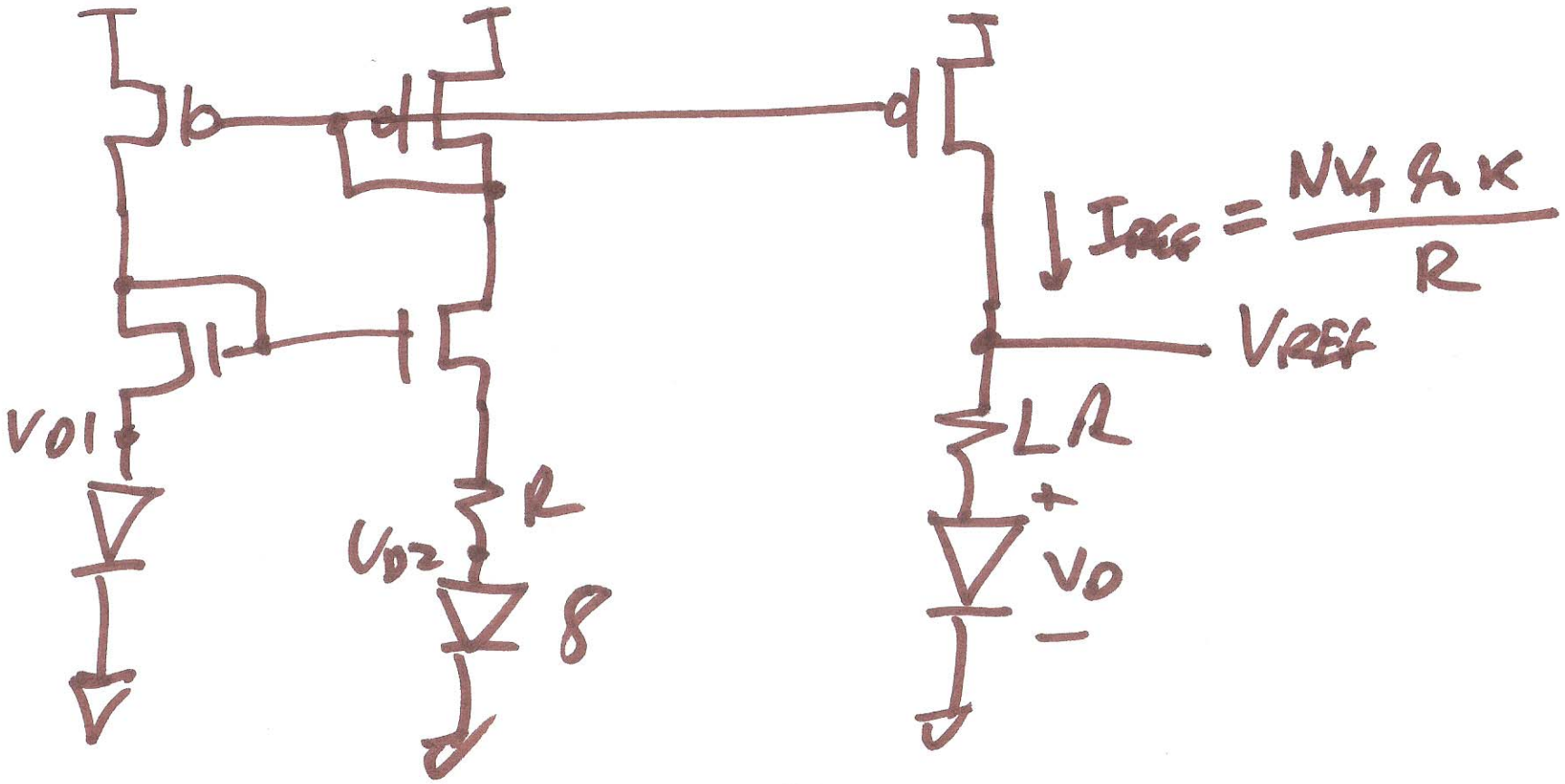
$\frac{k}{q}$ → $+.085 \frac{mV}{C^\circ}$

K → 2

L → 10

$$\frac{1}{V_{REF}} \cdot \frac{\delta V_{REF}}{\delta T} = \text{const}$$





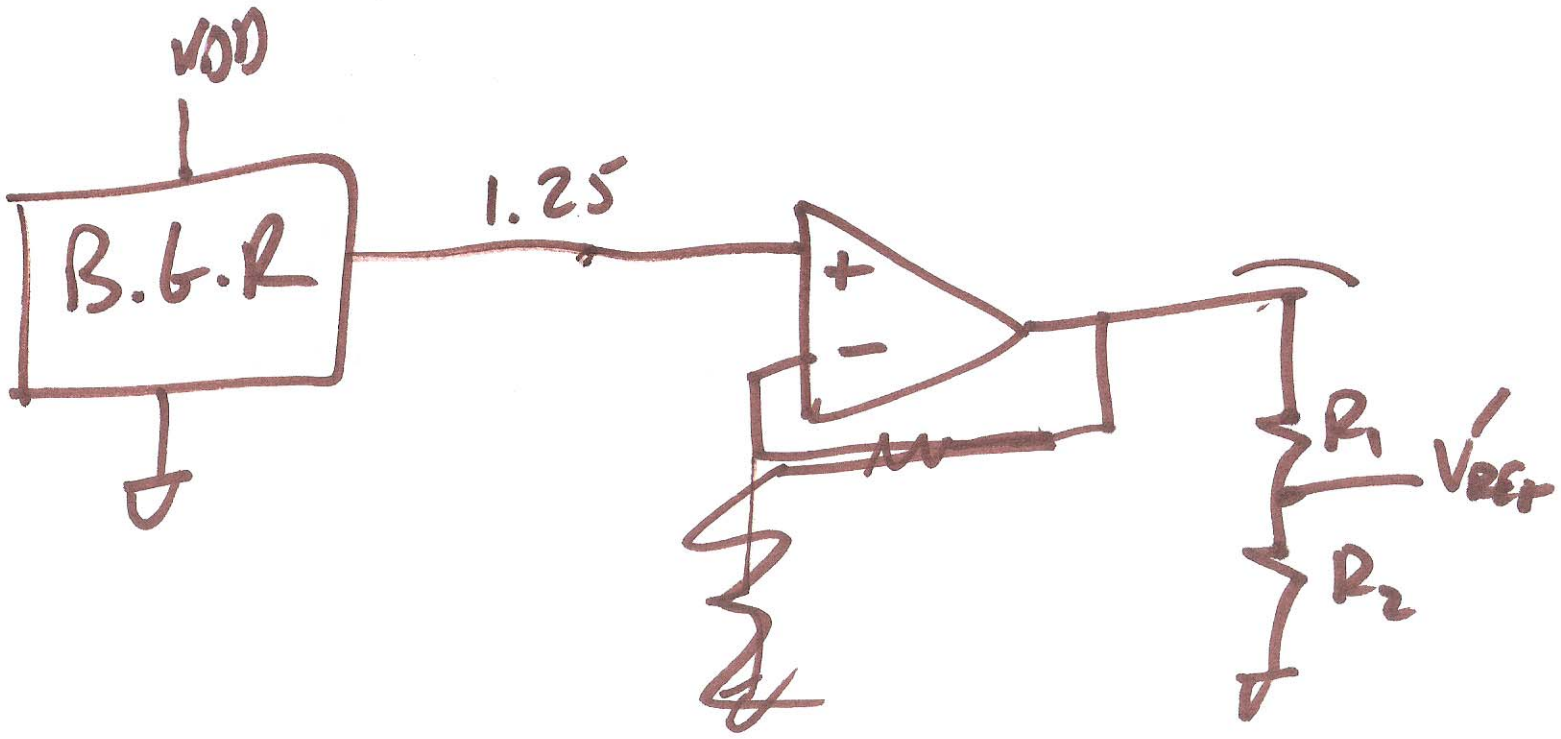
$$V_{REF} = L \cdot N V_t R_n K + V_O$$

$$\frac{\delta V_{REF}}{\delta T} = \frac{\delta L \cdot N \cdot V_T \ln K}{\delta T} + \frac{\delta V_D}{\delta T} = 0$$

$+0.085\frac{mV}{°C^2}$

$$L \cdot \cancel{5'} \cdot \frac{K}{\cancel{7}} \cdot \cancel{\ln K} - 1.6\frac{mV}{°C} = 0$$

$$L = \frac{1.6mV}{2..085mV} = \boxed{9.4}$$



$$V'_{REF} = 1.25 \cdot \frac{R_2}{R_1 + R_2} = \frac{R_2(1 + TCR(T - T_0))}{(R_1 + R_2)(1 + TCR(T - T_0))}$$