$A_1 = 1.8871638074125776$ $\quad V \propto \ln(I)$

$I_{S_1} = 4.6049886734771e^{-09}$

$R = 15\,K\Omega$

$I_{D_1} = 5 \times 10^{-4}\,A \quad I_{D_2} = 10^{-3}\,A$

for diode-1

$\boxed{V_{in_2} = 15\,V}$

$R = \frac{15}{I_{D_2}} = 15\,K\Omega$

$I_{D_1} = 5 \times 10^{-4}\,A$

$V_{in_1} = V_{in_2} \times \frac{I_{D_1}}{I_{D_2}} = 15 \times \frac{10^{-3}}{10^{-4}}$

$\boxed{V_{in_1} = 1.5V}$

range of voltages $\in [1.5, 15V]$

$\boxed{R = 15\,K\Omega}$

V_D: voltage across diode

I_S: reverse saturn (const.)

I_D: current through diode

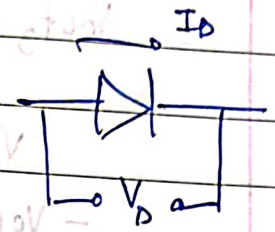
$$I_D = I_S \left(e^{\frac{V_D}{nV_T}} - 1\right)$$

$$V_T = \frac{KT}{q} = 0.026\,V$$

$$I_D = I_S\, e^{\left(\frac{V_D}{nV_T}\right)}$$

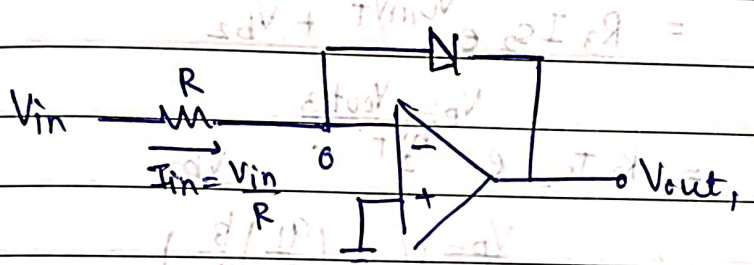
$$V_D \gg nV_T$$

$$V_D = nV_T \left(\ln(I_D) - \ln(I_S)\right)$$



$$\ln(I_D) = \frac{V_D}{nV_T} + \ln(I_S)$$

multiplying factor — offset



$$I_D = \frac{V_{in}}{R} \qquad \frac{V_D}{nV_T} + \ln(I_S) = \ln(I_D)$$

$$V_{out_1} = -V_D = nV_T \left(\ln(I_S) - \ln(I_D)\right)$$

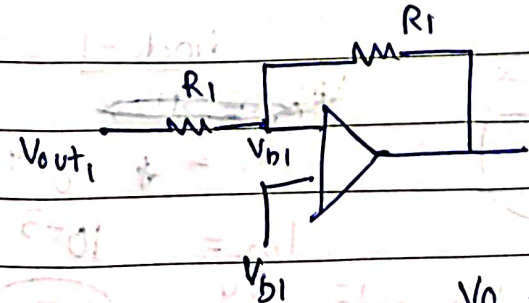
$$= nV_T \left(\ln\left(\frac{I_S R}{V_{in}}\right)\right)$$

$$V_{out_1} = nV_T \left(\ln(I_S R) - \ln(V_{in})\right)$$

$$V_{out_1} = -a_1 \ln(V_{in}) + a_2$$

$$a_1 = nV_T \qquad a_2 = nV_T \ln(I_S R)$$

$$V_{b1} = \frac{1}{2} a_2$$



$$\frac{V_{O_2} - V_{b1}}{R_1} = \frac{V_{b1} - V_{O_1}}{R_1}$$

$$V_{O_2} = 2V_{b1} - V_{O_1}$$

$$V_{O_2} = a_1 \ln(V_{in})$$

$$a_1 \ln V_{in} = 2V_{b1} + a_1 \ln(V_{in}) - a_2$$

$$V_{out_3} = -\left(\frac{R_{22}}{R_{21}}\right) V_{out_2}$$

$$V_{out_3} = -\, q_1 \beta \ln(V_{in})$$

$$V_{out_3} = \ln\left(V_{in}^{-q_1\beta}\right)$$

$$\beta = \frac{R_{22}}{R_{21}}$$

$$V_x = V_{b2}$$

$$-V_{out_3} + V_{b2} = V_D$$

$$V_{out} = V_{b2} + R_3 I_{D_2}$$

$$= R_3 I_{S_2} e^{V_D/nV_T} + V_{b2}$$

$$= R_3 I_{S_2} e^{\frac{V_{b2} - V_{out_3}}{n_2 V_T}} + V_{b2}$$

$$V_{R_3} = \left(R_3 I_{S_2} e^{\frac{V_{b2}}{nV_T}}\right)\left(V_{in}^{\left(\frac{q_1}{n_2}\right)\frac{\beta}{V_T}}\right)$$

$$= \boxed{R_3 I_{S_2} e^{\frac{V_{b2}}{nV_T}} V_{in}^{\left(\frac{n_1}{n_2}\right)\beta}}$$

$$V_{R_3} = b_1 V_{in}^{b_2}$$

$$b_1 = R_3 I_{S_2} e^{\frac{V_{b2}}{nV_T}} \qquad b_2 = \left(\frac{n_1}{n_2}\right)\beta$$

$$b_1 = 1 \qquad b_1 = \frac{1}{2}$$

$$\boxed{V_{R_3} = V_{in}^{1/2}}$$

$V_{in_1} = 1.5V$

$R = 15$

I_{D_2}

$\boxed{R = 15K\Omega}$

diode-1

~~$R = 15$~~

$I_{D_1} = 10^{-4}\ A$

$I_{D_2} = 10^{-3}\ A$

$V_{in_2} = 15 \qquad V_{in_1} = 15 \times \frac{10^{-4}}{10^{-3}} = 1.5V$

LAB-4

$I_{S_1} = 4.61 \times 10^{-9}$ A

$n_1 = 1.89$

$I_{S_2} = 6.01 \times 10^{-9}$ A

$n = 1.88$

Linear range ⇒ 0.45 - 0.65V

$Id_1 \in [443\ \mu A \text{ to } 2.61\ mA]$

$Id_2 \in [61\ \mu A \text{ to } 3.08\ mA]$

$V_{in} = 15\ V \longrightarrow R = \frac{15}{2.61 \times 10^{-3}} \longrightarrow 5.75\ k\Omega$

$V_{out_1} = -n_1 V_T \ln(V_{in}) + n_1 V_T \ln(I_S R)$

$1.89 \quad 0.029 \quad 4.61 \times 10^{-9} \times 5.75\ k\Omega$

$V_{out_1} = -0.049 \ln V_{in} - 0.518$

$V_{b1} = \frac{-0.518}{2} = \boxed{-0.259\ V}$

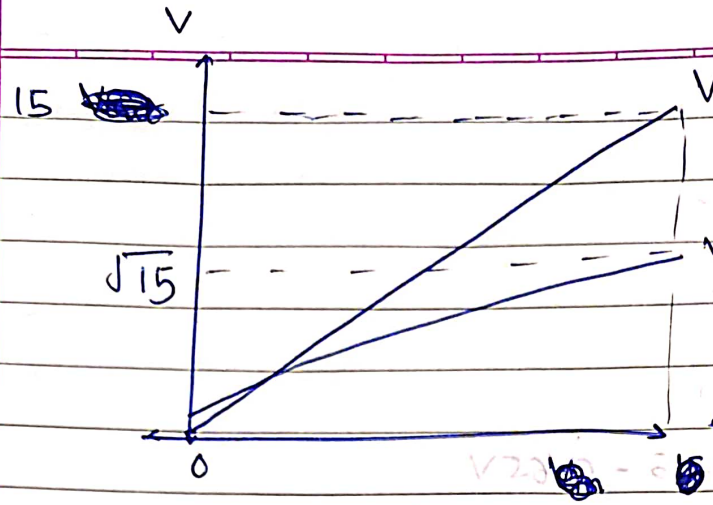
$R_1 = 5K\Omega$ (b/w 1 - 10kΩ)

Now, let $V_{b2} = 0.5V$

$R_3 I_{S_2} e^{\frac{V_{b2}}{nV_T}} = 1 \Rightarrow R_3 = 6k\Omega$

$V_3 = b_1 V_{in}^{b_2} \longrightarrow b_1 = 1$

for square root amplifier $\beta = \frac{n_2}{2n_1} = 0.497$



(plot of Vin & Vout while DC sweeping)

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25/1/24