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Lab 4 Log-Antilog-Amplifier

1. The values were plotted using Python on Jupyter Notebook.

2. For Diode D1 :

   Ideality factor (n) = 1.880

   Saturation Current (I_S) = $4.097e^{-09}$ A

   For Diode D2 :

   Ideality factor (n) = 1.852

   Saturation Current (I_S) = $4.994e^{-09}$ A

3. LTSPICE model file created.

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

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

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

   $$\ln(I_D) = V_D/nV_T + \ln(I_S)$$

   from plotting the graphs ⇒

   for D1 $V_d = 0.5V$ $I_d = 1.192e^{-04}$ A

   $V_d = 0.6V$ $I_d = 9.315e^{-04}$ A

   for D2 $V_d = 0.5V$ $I_d = 1.698e^{-04}$ A

   $V_d = 0.6V$ $I_d = 1.368e^{-03}$ A

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for D_1, $R = \frac{V_{in}}{(I_d)_{max}}$

$V_{in} = +15\,V$ $\quad I_d = 9.315 \times 10^{-4}\,A$

$\Rightarrow R = \frac{15}{9.315 \times 10^{-4}} = 1.6103 \times 10^{4}\,\Omega$

$= 16.103\,K\Omega$

5. $I_D = \frac{V_{in}}{R}$ $\quad V_{out1} = -V_D$

$V_{out1} = nV_T\left(\ln(I_S R) - \ln(V_{in})\right)$

$V_{out1} = -a_1 \ln(V_{in}) + a_2$

$a_1 = n_1 V_T = 0.048645$

$a_2 = n_1 V_T \ln(I_S R) = -0.3562596779110000994$

6. Let $R_1 = 10K$

from circuit $V_{out2} = -V_{out1} + 2V_{b1}$

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

$\Rightarrow V_{b1} = \frac{a_2}{2} = -0.178129838$

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7. $V_{out3} = -a_1 \beta \ln(V_{in}) = \ln(V_{in}^{-a_1\beta})$

$\beta = \frac{R_{22}}{R_{21}}$ $\quad V_{D2} = V_{b2} - V_{out3}$

$V_{out} = R_3 I_{D2} + V_{b2}$

$= R_3 I_{S2} e^{\frac{V_{b2} - V_{out3}}{n_2 V_T}} + V_{b2}$

$V_{out} = R_3 I_{S2} e^{\frac{V_{b2}}{n_2 V_T}} V_{in}^{\frac{n_1}{n_2}\beta} + V_{b2}$

$V_{R_3} = V_{out} - V_x = R_3 I_{S2} e^{\frac{V_{b2}}{n_2 V_T}} V_{in}^{\frac{n_1}{n_2}\beta}$

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

$b_1 = R_3 I_{S2} e^{\frac{V_{b2}}{n_2 V_T}}$ $\quad b_2 = \frac{n_1}{n_2}\beta\left(\frac{R_{22}}{R_{21}}\right)$

$b_1 = 1$ $\quad b_2 = \frac{1}{2}$

$\Rightarrow \quad 1 = R_3 I_{S2} e^{\frac{V_{b2}}{n_2 V_T}} \quad -①$ $\quad \frac{1}{2} = \frac{n_1}{n_2}\frac{R_{22}}{R_{21}}$

from plotted graphs,
$(V_d)_{max} = 0.6V$ to get the diode in linear region $\Rightarrow V_{b2} = 0.6V$

$\frac{1}{2} = \frac{1.880}{1.852}\frac{R_{22}}{R_{21}}$

~~from ① $\Rightarrow$ Taking log~~

$\Rightarrow \frac{R_{22}}{R_{21}} = 0.492553 = \beta$

let $R_{21} = 10\,k\Omega$

$\Rightarrow R_{22} = 4.92553\,k\Omega$

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from ① and using $V_{b_2} = 0.6V$

$$\Rightarrow \quad 1 = R_3 I_{s_2} e^{\frac{V_{b_2}}{\eta V_T}}$$

$$\Rightarrow \quad R_3 = 730.9106$$

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