EE230: Labwork-8
Logarithmic Amplifier

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1 Overview of the experiment

1.1 Aim of the experiment

To understand the structure and workings of logarithmic amplifier by:

1. Observing the $\ln(I_D)$ vs V_D plot.
2. Constructing the model in NGSpice
3. Theoretical analysis

1.2 Methods

Firstly, we plotted the $\ln(I_D)$ vs V_D data, which was provided to us. Next, we identified the linear region and thus parameters like I_s and n. Next we determined the values of V_{offset}, R_1, R_2 and R_3 followed by simulating the model in NGSpice and fine-tuning.

2 Design

The 4-stage logarithmic amplifier consists of 4 blocks as shown in figure 1 below:

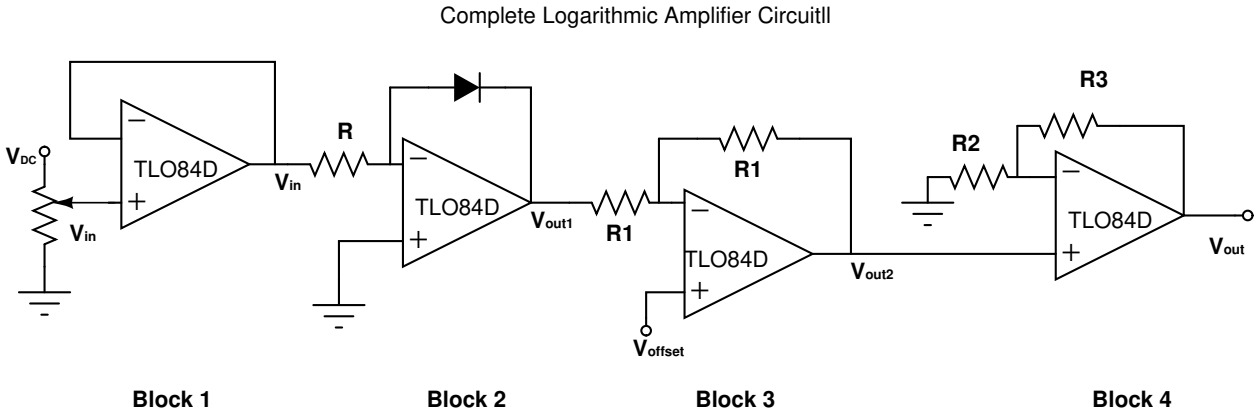

Figure 1: 4-stage logarithmic amplifier

Voltage is converted into current, which is forced through a diode in block 2.

$$I_D = \frac{V_{in}}{R} \tag{1}$$

By theoretical analysis:

$$V_{out1} = a_1 ln(V_{in}) + a_2 \tag{2}$$

$$a_1 = -nV_T \tag{3}$$

$$a_2 = nV_T ln(I_S R) \tag{4}$$

Block 3 is used to remove the offset voltage with value a_2 from output voltage V_{out1}.

$$V_{out2} = -a_1 ln(V_{in}) - a_2 + 2V_{offset} \tag{5}$$

Block 4 is used to scale the output voltage V_{out2} by a factor of a_2, thus giving us the true natural logarithm of V_{in}.

$$V_{out} = -a_1(1 + \frac{R_3}{R_2})ln(V_{in}) \tag{6}$$

Then choose:

$$\frac{1}{1 + R_3/R_2} = -a_1 \tag{7}$$

$$\therefore V_{out} = ln(V_{in}) \tag{8}$$

3 Experimental results

3.1 Part-1

$ln(I_D)$ **vs** V_D plot:

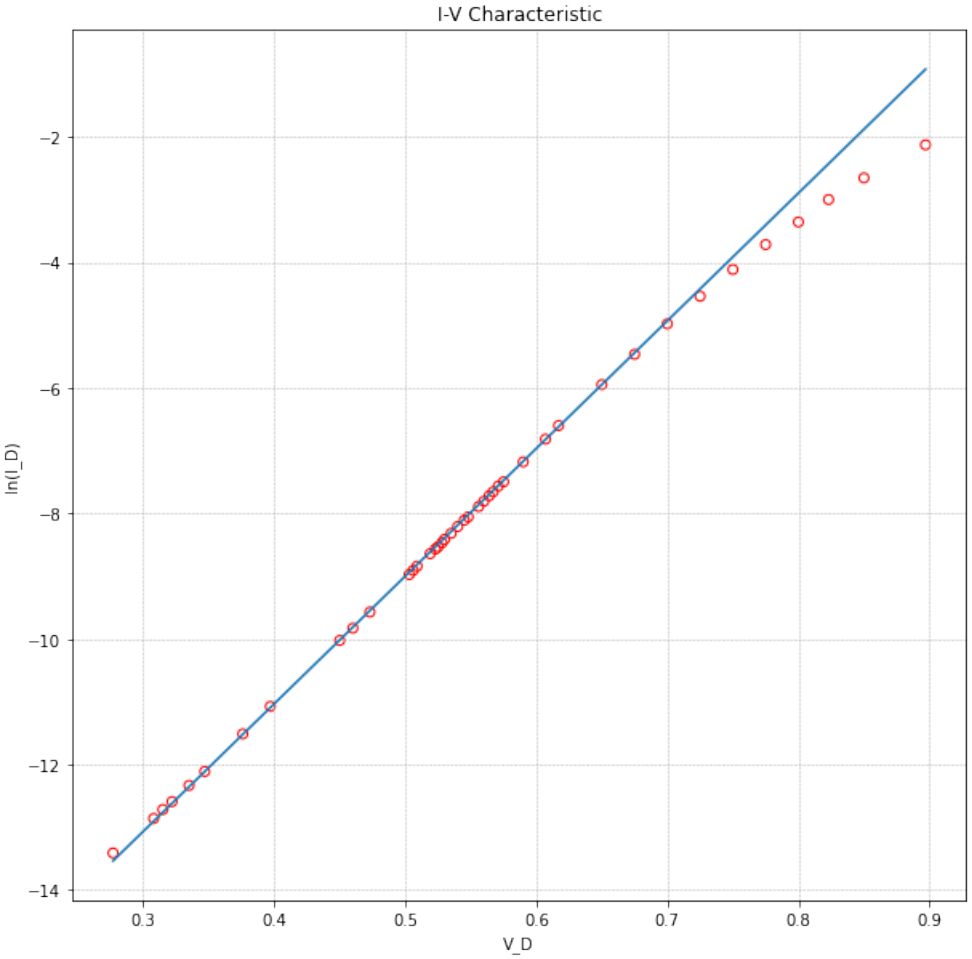

Figure 2: $ln(I_D)$ vs V_D

3.2 Part-2

Observe that the graph is linear in the region between $V_D = 0.315$ and $V_D = 0.7$
Equation of the line passing through these two points is:

$$ln(I_D) = 20.1V_D - 19 \tag{9}$$

$$\therefore n = 1.91 \tag{10}$$

$$\therefore I_S = 5.6 * 10^{-9} \tag{11}$$

3.3 Part-3

From figure 2 given above, $ln(I_{D2}) = -4.11$.

$$\therefore R = \frac{10}{I_{D2}} = 612ohms \tag{12}$$

3.4 Part-4

$$V_{out1} = -0.0497ln(V_{in}) - 0.626 \tag{13}$$

3.5 Part-5

$$V_{offset} = -0.313V \tag{14}$$

$R_1 = 1$k ohm

$$\frac{1}{1 + R_3/R_2} = -a_1 \tag{15}$$

$$\therefore \frac{R_3}{R_2} = 19.1 \tag{16}$$

Choose: $R_1 = 19.1$k ohm
$R_1 = 1$k ohm

3.6 Part-67

Netlist code:

```
    lab8


.include 1N4148.txt
.include TL084.txt

vin 1 0 1

r0 1 2 612
r11 5 6 1k
r12 6 10 1k
r21 11 0 1000
r31 11 14 18k

v3 3 0 12
v4 4 0 -12

v8 8 0 12
v9 9 0 -12

v12 12 0 12
v13 13 0 -12


* v7 7 0 -0.391
v7 7 0 -0.3047

x1 0 2 3 4 5 TL084
x2 7 6 8 9 10 TL084
x3 10 11 12 13 14 TL084

D1 2 5 1N4148

.dc vin 0.1 10 0.1
```

```
.control
run
plot v(14) vs ln(v(1))
* print v(14) vs v(1)
```

3.7 Part-8

V_{out} vs V_{in}:

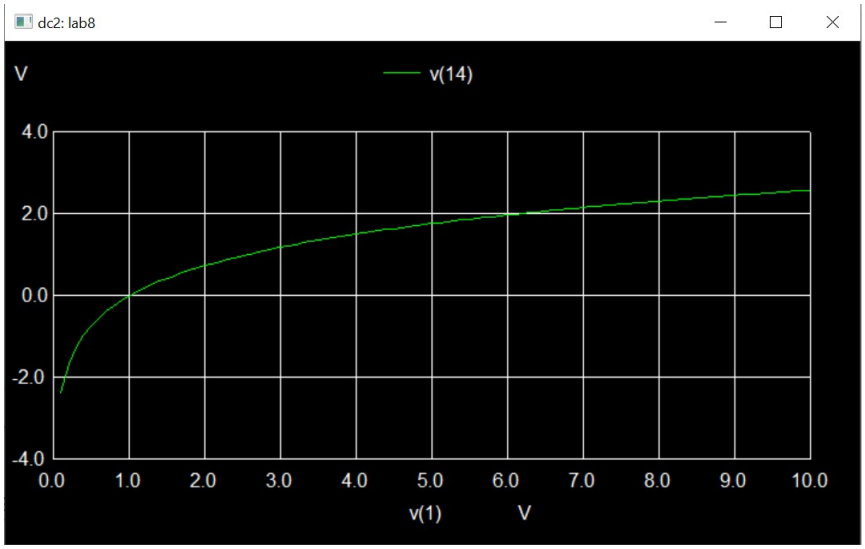

Figure 3: V_{out} vs V_{in}

V_{out} **vs** $ln(V_{in})$**:**

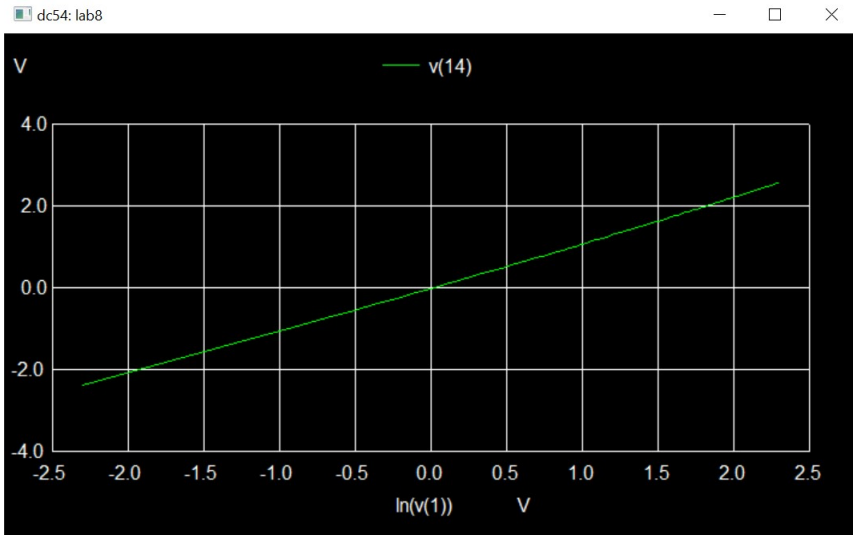

Figure 4: V_{out} vs $ln(V_{in})$