EE230: Labwork-6
Measurement of offset voltage and bias currents
Measurement of DC open-loop gain

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1 Overview of the experiment

1.1 Aim of the experiment

1. To measure the offset voltage and bias currents of an op-map.
2. To measure the DC open-loop gain of an op-amp.

by implementing the circuits on breadboard and observing various parameters of the circuit.

1.2 Methods

We first constructed the circuits for the measurement of offset voltage V_{os}, bias currents I_B^- and I_B^+ on the breadboard as shown in the figures in the section 2.
We recorded various parameters and found out the values of the same and verified them with the values given in the op-amp 741 datasheet.

2 Design

2.1 Equivalent Circuit for measurement of V_{OS}

The equivalent circuit consisting of the offset voltage and bias currents for measurement of V_{OS} is shown in figure 1 below.

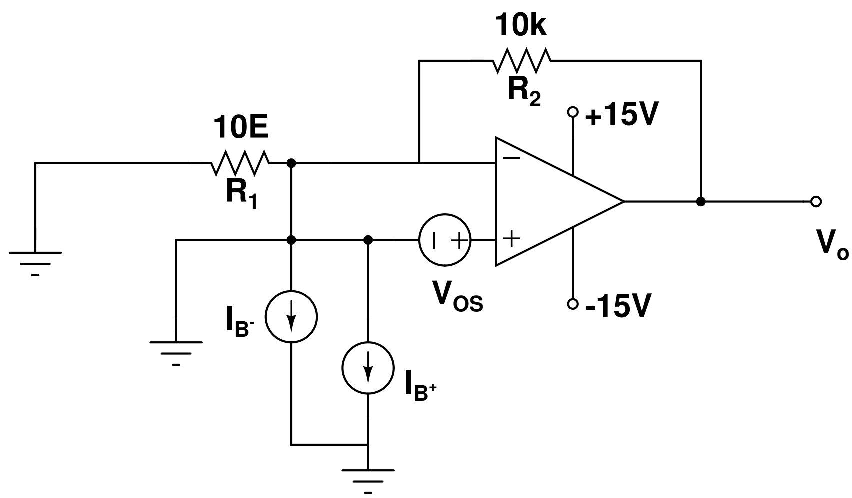

Figure 1: Equivalent Circuit for measurement of V_{OS}

2.2 Equivalent Circuit for measurement of I_B^-

The equivalent circuit consisting of the offset voltage and bias currents for measurement of I_B^- is shown in figure 2 below.

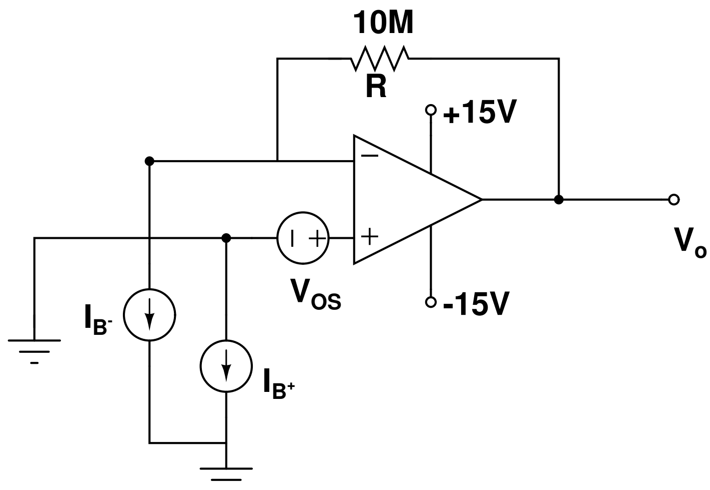

Figure 2: Equivalent Circuit for measurement of I_B^-

2.3 Equivalent Circuit for measurement of I_B^+

The equivalent circuit consisting of the offset voltage and bias currents for measurement of I_B^+ is shown in figure 3 below.

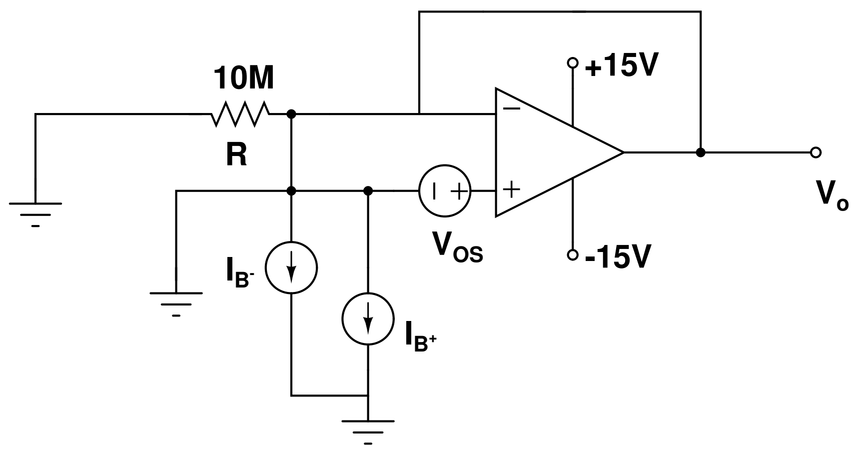

Figure 3: Equivalent Circuit for measurement of I_B^+

2.4 Circuit for measurement of DC open-loop gain A_{OL}

The following circuit shown in figure 4 is used to measure the DC open loop gain A_{OL}.

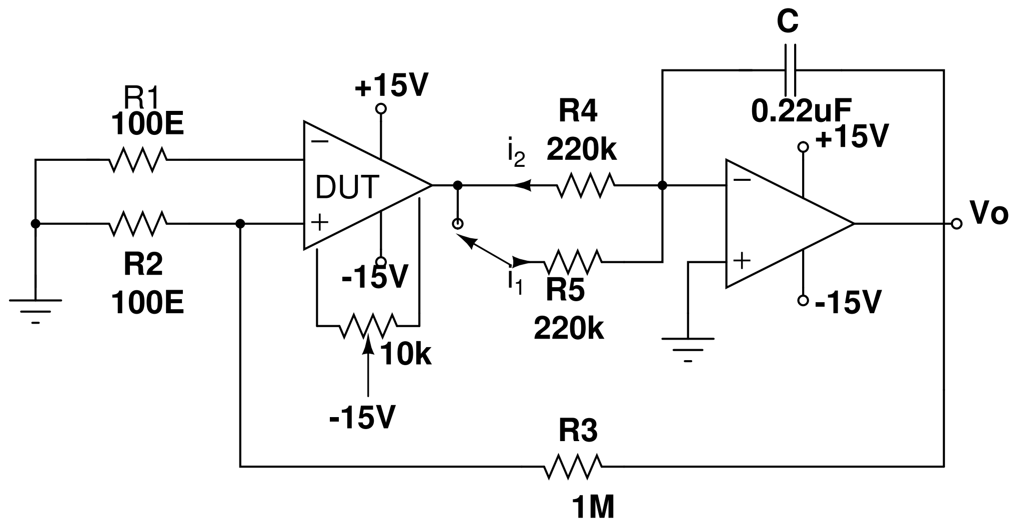

Figure 4: Circuit for measurement of DC open-loop gain A_{OL}

3 Procedure

3.1 1. Measurement of offset voltage and bias currents

3.1.1 a. Measurement of offset voltage

We construct a circuit as shown in the figure 1 on the breadboard. The equivalent circuit shown in the figure one comprises of the offset voltage as well as the bias currents.
Implementing the superposition theorem, we get:

$$V_o = V_{OS}(1 + \frac{R_2}{R_1}) + R_2 I_B^- \tag{1}$$

Practically, $R_2 >> R_1$.

$$V_{OS} = \frac{V_o}{1 + \frac{R_2}{R_1}} \approx \frac{V_o}{R_2/R_1} \tag{2}$$

We then measured the output voltage V_o and therefore from equation 2, got the offset voltage.

3.1.2 b1. Measurement of bias current I_B^-

Similarly, for I_B^- we construct the circuit as shown in the figure 2.
Assuming the op-amp to be ideal, we get:

$$V_o = V_{OS} + I_B^- R \tag{3}$$

Since I_B^-R is very large as compared to V_o:

$$I_B^- = \frac{V_o}{R} \tag{4}$$

We then measured the output voltage V_o and therefore from equation 4, got the bias current I_B^-.

3.1.3 b2. Measurement of bias current I_B^+

Similarly, for I_B^+ we construct the circuit as shown in the figure 3.
Assuming the op-amp to be ideal, we get:

$$V_o = V_{OS} + I_B^+ R \tag{5}$$

Since I_B^+R is very large as compared to V_o:

$$I_B^+ = \frac{V_o}{R} \tag{6}$$

We then measured the output voltage V_o and therefore from equation 6, got the bias current I_B^+.

3.2 2. Measurement of DC open-loop gain

Here we construct a circuit such that the op-amp is in a "servo loop" to obtain an input voltage which is small enough such the output does not go to saturation.
First, we adjust the variable 10k ohm resistor to nullify the offset voltage and make output voltage V_o close to 0V with the switch in position 1.
Next, we turn the switch to position 2. Due to virtual ground and presence of capacitor,

$$i_1 = i_2 \tag{7}$$

$$V_{o1B} - V_{o1A} = -V' \tag{8}$$

$$\therefore -V' = \frac{R_2}{R_2 + R_3}(V_o B - V_o A)A_{OL} \tag{9}$$

Finally, we take measurements of A_{OL} for values of V' = 1V, 2V and 3V.

4 Experimental results

4.1 1. Measurement of offset voltage and bias currents

The values of various parameters used for these recordings (such as resistors and Vcc) are mentioned in the figures 1 2 and 3.

4.1.1 1.a. Measurement of offset voltage

The **offset voltage measured** is : **0.38mV**
The **max offset voltage** mentioned in the datasheet is : **6mV**

The **typical offset voltage** mentioned in the datasheet is : **1mV**

4.1.2 1.b. Measurement of bias current I_B^-

The **bias current** I_B^- **measured** is : **43.9nA**
The **max offset voltage** mentioned in the datasheet is : **800nA**
The **typical offset voltage** mentioned in the datasheet is : **80nA** at 25 degree Celsius.

4.1.3 1.c. Measurement of bias current I_B^+

The **bias current** I_B^+ **measured** is : **39.8nA**
The **max offset voltage** mentioned in the datasheet is : **800nA**
The **typical offset voltage** mentioned in the datasheet is : **80nA** at 25 degree Celsius.

4.2 2. Measurement of DC open-loop gain

The values of various parameters used for these recordings (such as resistors and Vcc) is mentioned in the figure 4.

Table 1: Measurement of A_{OL}

Sr. No.	V'	V_{oB}	A_{OL}
1.	1V	13.7V	8.4x10^5
2.	2V	47.3V	4.49x10^5
3.	3V	69.2V	4.5x10^5

The typical value of A_{OL} mentioned in the datasheet is: **2x10^5**

5 Experiment completion status

All of the sections of the lab-6 were completed in the lab:

1. **1. Measurement of offset voltage and bias currents**
2. **2. Measurement of DC open-loop gain**