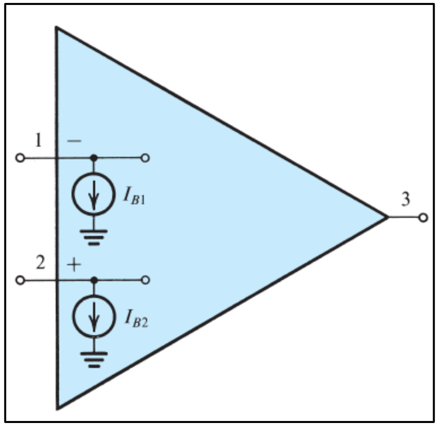
Op Amp
DC Imperfections

- Input Bias Current
- Input Offset Current

1 The second dc problem encountered in op amps (ones constructed using BJTs) is illustrated below. **In order for the op amp to operate, its two input terminals have to be supplied with dc currents, termed the input bias currents.**

The op-amp input bias currents



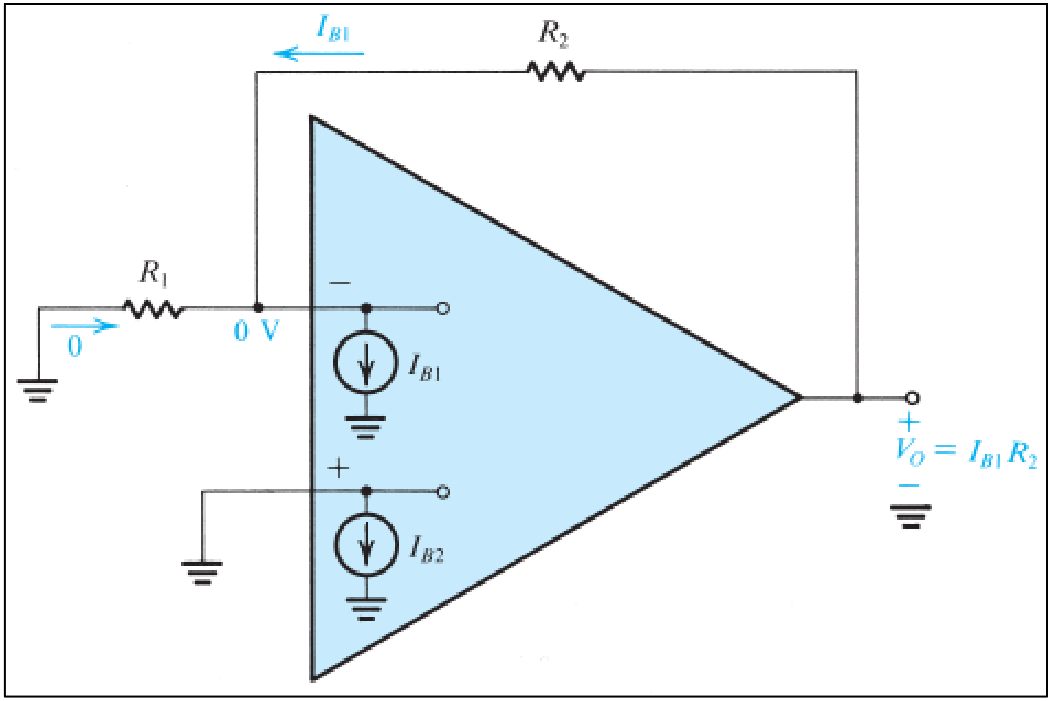
2 These two currents are represented by two current sources, I_{B1} and I_{B2}, connected to the two input terminals.

The op-amp manufacturer usually specifies the following currents:

Input Bias Current $$I_B = \frac{I_{B1} + I_{B2}}{2}$$ (Typical value: I_B = 100nA)

Input Offset Current $$I_{OS} = |I_{B1} - I_{B2}|$$ (Typical value: I_{os} = 10nA)

3 We now wish **to find the dc output voltage of the closed-loop amplifier due to the input bias currents**. To do this we ground the signal source and obtain the circuit shown below for both the inverting and noninverting configurations.



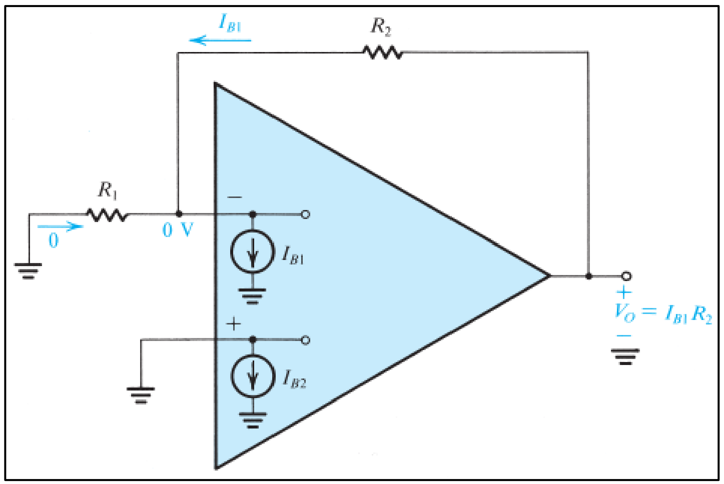
The output dc voltage is given by:

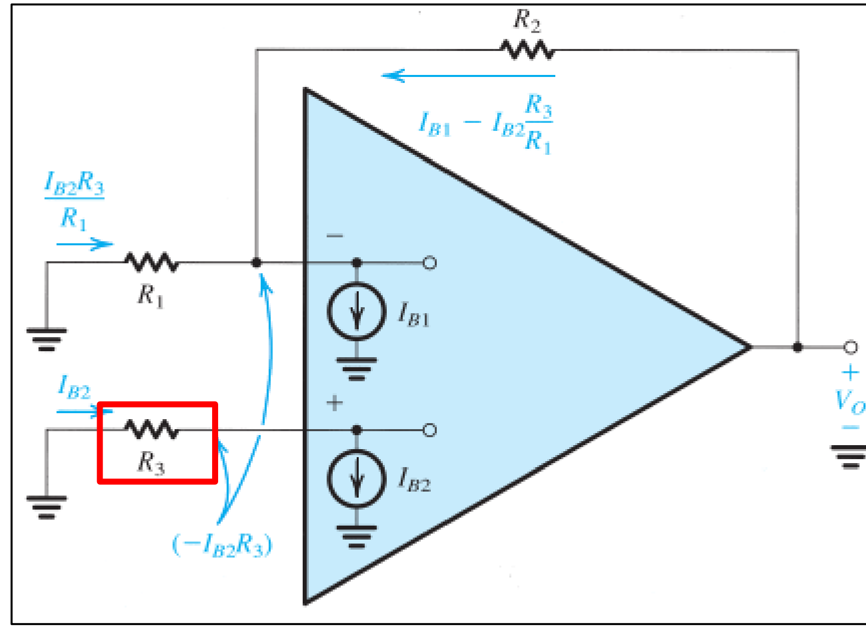
$$V_O = I_{B1}R_2 \cong I_B R_2$$

$$I_B = \frac{I_{B1} + I_{B2}}{2}$$

4 Fortunately, however, a technique exists for reducing the value of the output dc voltage due to the input bias currents.

The method consists of introducing a resistance R_3 in series with the noninverting input lead, as shown below.





The appropriate value for R_3 can be determined by analyzing the circuit, and the output voltage is given by:

$$V_O = \underbrace{-I_{B2}R_3}_{V_-} + \underbrace{R_2\underbrace{(I_{B1} - I_{B2}R_3/R_1)}_{I_{R1}}}_{V_{R2}}$$

If $R_3 = 0$ → $V_O = R_2 I_{B1}$

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$$V_O = -I_{B2}R_3 + R_2(I_{B1} - I_{B2}R_3/R_1)$$

If $R_3 \neq 0$

5.1 If $I_{B1} = I_{B2} = I_B$

$$V_O = I_B[R_2 - R_3(1 + R_2/R_1)]$$

$$R_3 = \frac{R_2}{1 + R_2/R_1} = \frac{R_1 R_2}{R_1 + R_2}$$

⇒ $V_o = 0$

5.2 If $I_{B1} \neq I_{B2}$

$$I_{OS} = |I_{B1} - I_{B2}|$$

→

$$I_{B1} = I_B + \frac{I_{OS}}{2}$$

$$I_{B2} = I_B - \frac{I_{OS}}{2}$$

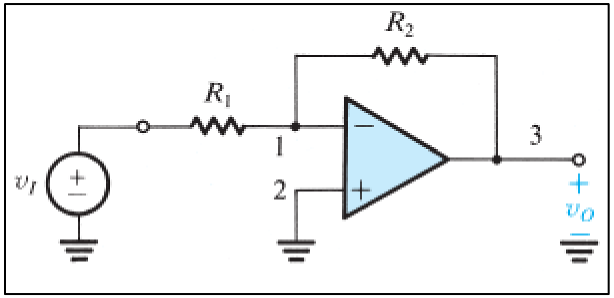
$$R_3 = \frac{R_2}{1 + R_2/R_1} = \frac{R_1 R_2}{R_1 + R_2}$$

⇒ $V_O = I_{OS}R_2$

It is usually about an order of magnitude smaller than the value obtained without R_3 !

Exercise

Consider an inverting amplifier circuit designed using an op amp and two resistors, R_1 = 10 kΩ and R_2 = 1 MΩ. The op amp is specified to have an **input bias current of 100nA and an input offset current of 10 nA.**



1) Find the output dc offset voltage resulting.

$$V_O = -I_{B2}R_3 + R_2(I_{B1} - I_{B2}R_3/R_1)$$
$$R_3 = 0$$

$$V_o = I_{B1}R_2 = 100nAx1M\Omega \rightarrow V_o = 0.1V$$

2) Find the value of a resistor R_3 to be placed in series with the positive input lead in order to minimize the output offset voltage. What is the new value of V_O?

$$R_3 = \frac{R_1R_2}{R_1 + R_2} = \frac{10k\Omega x1M\Omega}{10k\Omega + 1M\Omega} = 9.9k\Omega \rightarrow R_3 = 10K\Omega$$

$$\rightarrow V_o = I_{OS}R_2 = 10nAx1M\Omega \rightarrow V_o = 0.01V$$

An order of magnitude smaller than the value obtained without R_3 !