ELECTRONICS LABORATORY

PART 10

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CONTENTS

OPERATIONAL AMPLIFIERS

10.1 ANALYZING DC OPERATION OF OPERATIONAL AMPLIFIERS

Inverting operation of operational amplifier is given in Figure 10.1. Operational amplifiers are useful at DC amplification. Input is applied to the negative pin of the inverting amplifier. There is a 180-degree phase difference between the input and the output. If a positive signal is applied to the input, a negative signal is taken from the output with an amplitude as much as the gain value. Similarly, if a negative signal is applied to the input, a positive signal is taken from the output with amplitude as much as the gain value.

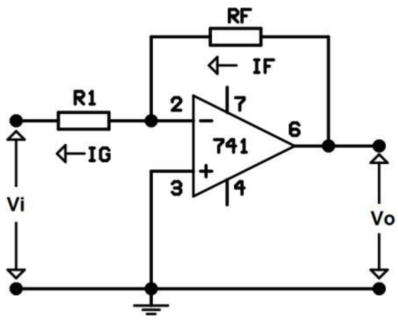

Figure 10.1

The resistance R1 is the input resistance, and the resistance RF is the feedback resistance in the circuit. The voltage between the negative input (2nd pin) of the operational amplifier and the chassis is zero volts. For that case;

Vi= Ii . R1

For the output Ii=IF, so,

Vo=Ii . RF = IF . RF.

In electronic circuits gain always equals to the ratio of the output to the input.

$$A = \frac{V_0}{V_i} = \frac{I_i \cdot RF}{I_i \cdot RI} = \frac{RF}{RI}$$

It must always be remembered that there is a 180-degree phase difference between the inputs and the outputs of the inverting amplifier. For example, if the input voltage is Vi=0,5 and the gain is A=20;

Vo= - (Vi . A) = - (0, 5 .20) = -10Volts.

As another example, if Vi= -0,2Volts;

Vo= - (Vi . A) = - (0,2. 20) = -(-4) = 4Volts.

Operational amplifiers operate with both negative input signal and positive input signal. So, they are used for AC amplification. If the input and the output signals are visualized by using an oscilloscope with two channels, phase relation is easily observed.

In our experiment set, in the operational amplifier experiments, we have chosen 10K, 50K, and 100K for resistance RF for simplicity in calculations. 50K resistance is obtained by parallel combination of two 100K resistances since 50K is not a standard value.

10.2 OUTPUT OFFSET VOLTAGE OF OPERATIONAL AMPLIFIERS

When no signal is applied to the inputs of the operational amplifier, the voltage between the input pins must be zero. But practically, due to the difference in the characteristics of the transistors connected to the input pins, there may be a small voltage difference. That difference is multiplied by the gain of the operational amplifier and transferred to the output. That unbalanced situation is undesired in most of the applications. That undesired voltage at the output is called output offset voltage (**Voo**). The output offset voltage is generally prevented by connecting an adjustable resistor between the negative supply voltage and the offset pins of the operational amplifier (generally the middle pins).

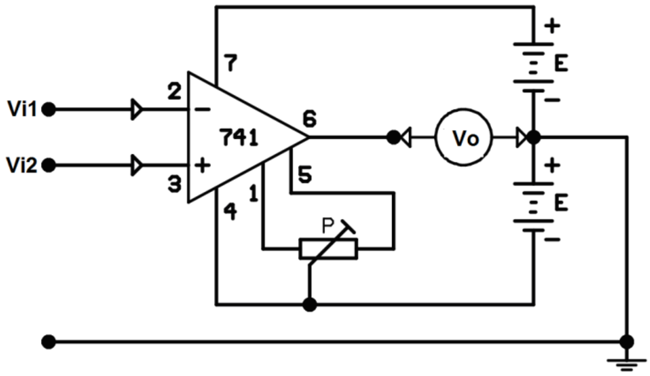

Figure 10.2

The circuit used to adjust the offset voltage is given in Figure 10.2. The potentiometer P is adjusted until zero voltage is obtained at the output while there is not any signal at the input.

The output offset voltage is formed by three parameters.

1- Input bias current **(IB)**

2- Input offset current **(IOC)**

3- Input offset voltage **(Vio)**

Operational amplifiers are fabricated by using transistor technology. So, the input offset voltage is increased by the increasing temperature and the operation of the circuit. That increase is approximately 5µVolt for 1 C increase in the temperature.

10.3 THE INPUT BIAS CURRENT OF OPERATIONAL AMPLIFIERS

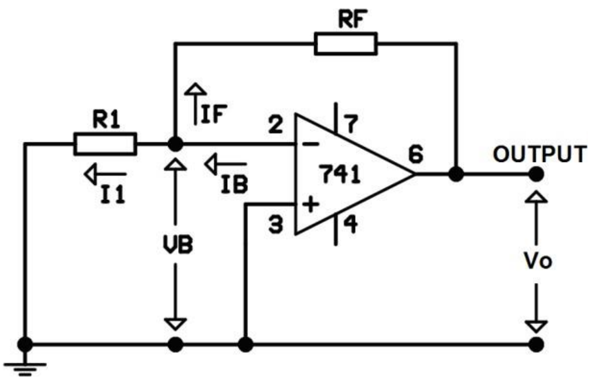

Figure 10.3

The input currents of the operational amplifier are seen in Figure 10.3 The input bias current is the average of the input currents. As we know, input bias current is one of the reasons for output offset voltage (Voo).

Input Bias Current is IB= I1+IF.

$I1 = \frac{V_B}{R1}$ $IF = \frac{V_B - V_0}{RF}$ so $IB = \frac{V_B}{R1} + \frac{V_B - V_0}{RF}$

The current I1 is assumed to be zero since the voltage VB is too small. Then the effect of the input bias current to the output offset voltage is calculated by Voo=IB.RF. The methods given in Figure 10.4 and 10.5 are used to minimize the effect of the input bias current to the output offset voltage.

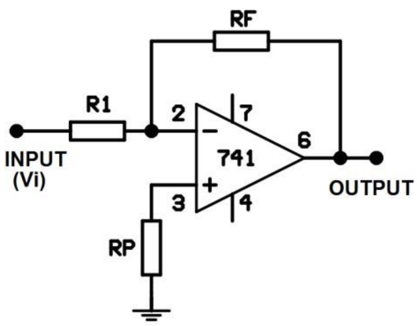

Figure 10.4

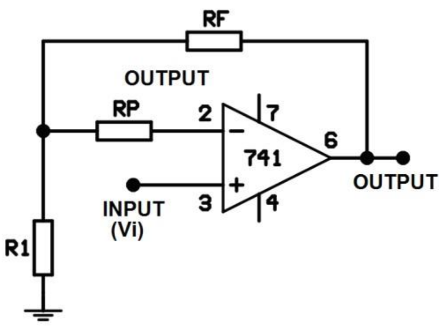

Figure 10.5

The resistance R1 is the input resistance and the resistance RF is the feedback resistance in the figure. RP is the resistance used to minimize the effect of the input bias current to the output offset voltage.

The value of the resistance RP is;

$$RP = \frac{R1.RF}{R1 + RF}$$

10.4 INPUT OFFSET VOLTAGE OF OPERATIONAL AMPLIFIERS

The input offset current is the difference between the currents when the inputs are grounded, and the output offset voltage is set to zero.

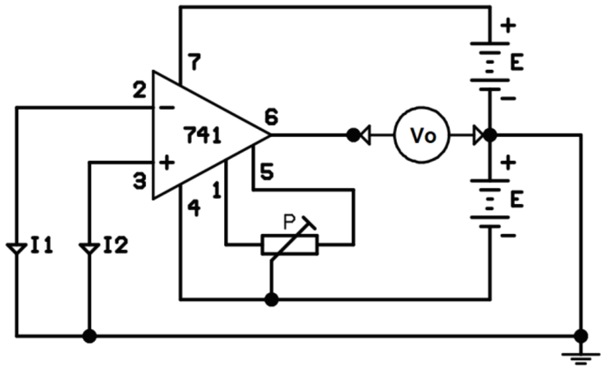

Figure 10.6

Input offset current is:

Iio = I1 - I2 or Iio = I2 - I1

The input offset current causes the output offset voltage to increase Voo=RF . Iio when a signal is applied to the inputs of the operational amplifier.

As we know, input offset voltage is the voltage between the inputs when no signal is applied to the inputs.

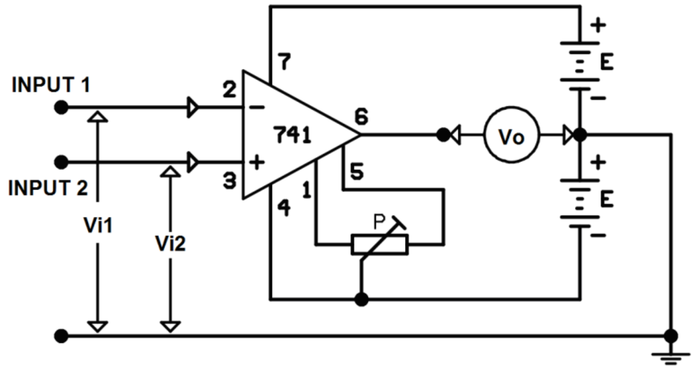

Figure 10.7

Input offset voltage is;

Vio = Vi1 - Vi2 or Vio = Vi2 - Vi1

Input offset voltage causes the output offset voltage to increase Voo=Vio . A. **(A)** is the gain of the operational amplifier.