Operational Amplifier as inverting amplifier

Aim :- To compare the experimental voltage gain of the operational amplifier with that of the theoretical value and also to observe the in put and the out put are out of phase.

Apparatus :- Operational amplifier (IC 741), C.R.O., signal generator, power supply to the amplifier, non inductive resistors of different values and connecting terminals.

Formula :-

$$\frac{e_0}{e_I} = -\frac{R_f}{R_I}$$

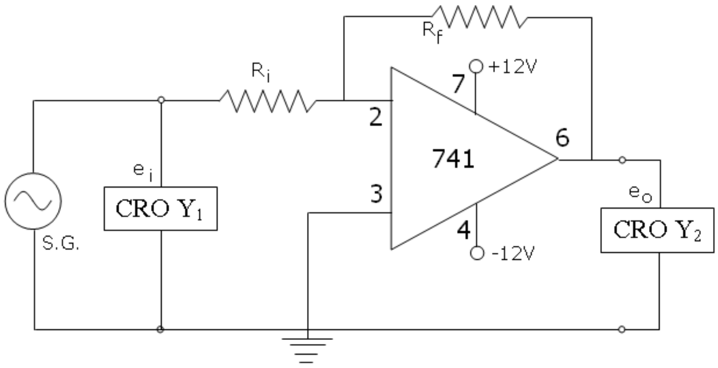
Where e_i and e_o are in put and out put voltages (peak to peak voltages in C.R.O.)

R_i and R_f are in put and feed back resistors.

Description :- The heart of an analog computer is the Operational Amplifier. The Operational Amplifier is a stable, high gain DC coupled amplifier which is widely used with a large amount of negative feed back. Many important mathematical operations such as signal addition (or subtraction), differentiation, integration, comparison, isolation, amplification, oscillators, arbitrary function generators etc. are performed in analog computer by using Op-Amp.

An ideal Operational Amplifier would have very high open loop gain, bandwidth and zero noise, off set and drift. The basic circuit block of the amplifier is shown in the Fig. as a triangle with 3 signal terminals. Any signal fed to the inverting input terminal (marked '-') appears amplified at the output with reverse phase, while signal fed to the non-inverting input (marked '+') appears amplified at the output without phase reversal. Now for ideal amplifier in which the input impedance is infinite, no current is drawn from the signal source, and the difference in potential between two input terminals is zero due to infinite gain. But non-ideal amplifier has high voltage gain in the range from 10^3 to 10^7 and input impedance is high and of the order of millions of ohms. So these two conditions are satisfied in the case of non-ideal amplifier also. The amplifier does not distort the waveform of the input voltage regardless of the frequency component. In practice, however, the band width of operational amplifier (namely the range of frequencies of input signal over which A is constant) extends from 0 Hz to few MHz. As the gain of the amplifier equals A at 0 Hz, the amplifier is called direct coupled.

Theory :-Operational Amplifier has odd number of stages for obtaining negative feed back, Since for performing various mathematical operations we need negative feed back.



Inverting amplifier (Fig)

Now from Fig. we can derive closed loop gain (i.e. gain with feed back) for an Operational Amplifier, in the Fig R_f is Feed back Resistor. Now applying Kirchoffs current law at place e_g.

We get $$\frac{e_i - e_g}{R_i} = \frac{e_g - e_0}{R_f} \quad \text{---------} \quad (1)$$

OR

$$\frac{e_i}{R_i} + \frac{e_0}{AR_i} = \frac{-e_0}{AR_f} - \frac{e_0}{R_f} \quad \text{----------} \ (2)$$

As per the operational amplifier $e_o = -Ae_g$ and putting $e_g = -e_o/A$

OR

$$e_o \left(\frac{1}{AR_i} + \frac{1}{AR_f} + \frac{1}{R_f}\right) = -\frac{e_i}{R_i}$$

$$\frac{e_o}{R_f}\left(\frac{R_f}{AR_i} + \frac{1}{A} + 1\right) = -\frac{e_i}{R_i}$$

Now R_f / R_i is of the order of 1 to 10 & $A = 10^6$.

$\therefore \frac{R_f}{AR_i}$ and 1/A can be neglected.

There fore the above equation becomes $$\frac{e_o}{R_f} = -\frac{e_i}{R_i}$$

OR $$\frac{e_o}{e_i} = -\frac{R_f}{R_i}$$

The ratio = R_f / R_i must not exceed 10. The reason is that greater will be ratio, lesser will be precision. We also see that the output voltage depends only upon the input voltage and values of the two passive components, namely, the resistors. This implies that the precision by the mathematical operation performance depends only on the precision of the externally connected passive components.

Procedure :- The phase terminal of the signal generator is given to the inverting in put (2) of the Op. Amp. IC 741 through an in put resistor R_i. The other terminal of the signal generator and the non- inverting terminal (3) of the amplifier are grounded. The out put (6) of the amplifier is fed back to the in put (2) through a feed back resistor R_f .To measure the I/P and O/P voltages, the signal generator phase terminal and the out put (6) of the amplifier are given to Y_1 and Y_2 plates of the CRO respectively. The other terminals of the CRO are grounded. The terminals 7 and 4 of the op. amp. are connected to +12V and -12V of the power supply.

First the in put resistor R_i (nearly 1KΩ), feed back resistor R_f (nearly 2 KΩ to 10 KΩ) values and in put voltage e_i (0.1V to 0.5V) are fixed. Then observe the input and out put signals on CRO screen. Adjust the time base and vertical gain (volts/div.) of the y_1 and y_2 plates to a convenient value, such that the two signals are stationary and completely observable. Adjust the frequency of the in put signal such that in put and out put signals are out of phase. Measure the in put and out put voltages e_i and e_o (vertical peak to peak) and note the values in the table. The experiment is repeated by changing the values of R_i and R_f..

The theoretical gain (R_f/R_i) and experimental gain (e_o/e_i) are calculated and compared in the table.

Precautions :- 1.Out put of Op. Amp. Can not beyond 15V if so, the Op. Amp. Will go in to saturation state. So do not feed in put more than 1.5 V.

2. Adjust the in put frequency such that in put and out put signals are out of phase.

3. Check the continuity of the connecting terminals before connecting them.

4. See that the ratio = R_f / R_i should not exceed 10

Result :-

Table

S. No.	R_i Ω	R_f Ω	Input voltage (e_i)			Out put Voltage (e_o)			Gain	
			Peak to peak (Vertical) (Divisions) (n)	Voltage Sensitivity. (Volt/Div) (d)	Voltage (e_i)=nxd (volts)	Peak to peak (Vertical) (Divisions) (n)	Voltage Sensitivity. (Volt/Div) (d)	Voltage e_o= nxd (volts)	Theoretical (R_f/R_i)	Experimental (e_o/e_i)