LINEAR INTEGRATED CIRCUITS LAB- EE322P

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2. APPLICATIONS OF OP-AMP

Aim: To observe the applications of the op-amp.

Apparatus:

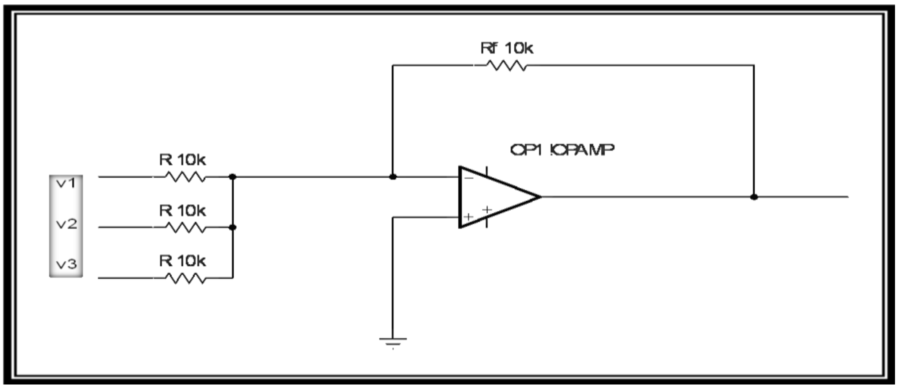
1) Op-Amp (uA- 741)-3 No.s
2) DC Power Supply (12-0- 12) V
3) CRO(0-20MHz range)
4) Signal Generator (0 -1MHz range)
5) Bread Board

Theory and Procedure:

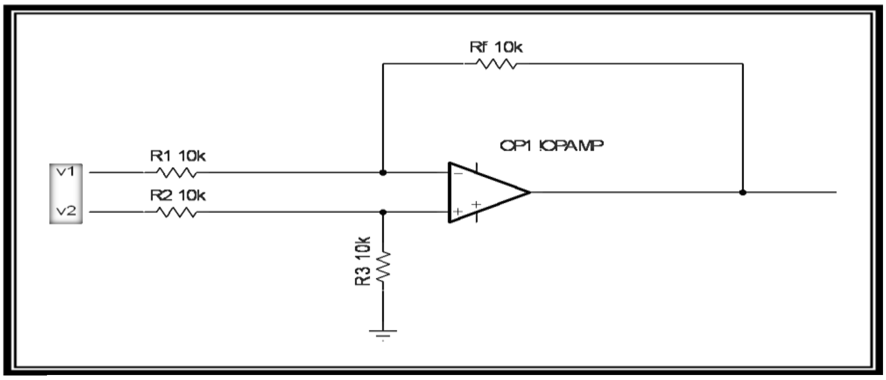
a) Summing Amplifier: Summing amplifier is used to add different voltage values applied at the input.

1. Connections are made as per the circuit diagram
2. Give input voltages from the DC power supply to the inverting terminal as shown in the figure.
3. Measure the output voltage with the help of a multimeter.
4. Verify the output voltage with the voltage obtained practically by using the formula

$$V_o=-(R_f/R)\ [V_1 + V_2 + V_3]$$



b).Subtractor: A basic differential amplifier can be used as a subtractor, as shown in the figure. If all the resistors are equal in value, then the output voltage can be derived by using superposition principle

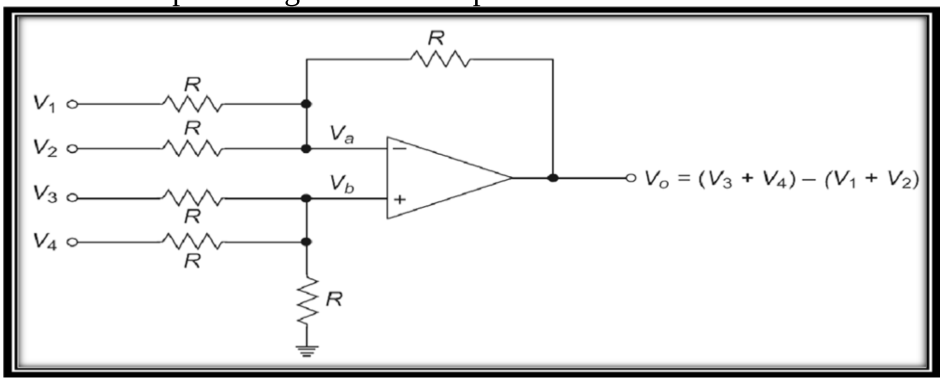


1. Connections are made as per the circuit diagram
2. Give input values from the DC power supply to both inverting terminal and non-inverting terminals as shown in the figure.
3. Measure the output voltage with the help of a multimeter.
4. Verify the output voltage with the voltage obtained practically by using the formula

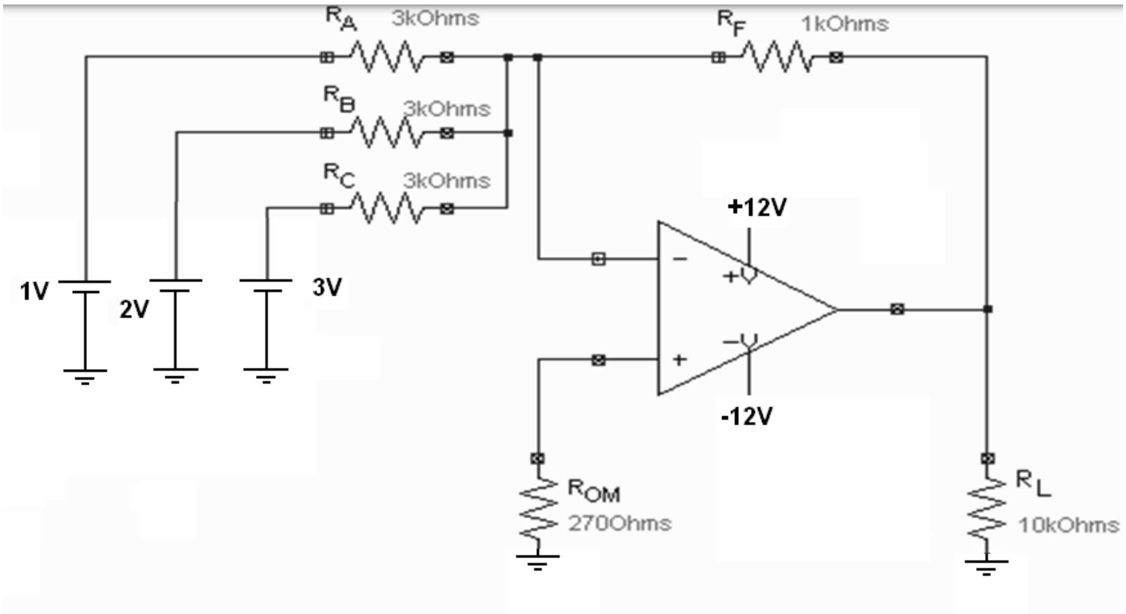
$$V_o = [V_2 - V_1] \text{ (since } R_f = R \text{ considered)}$$

c). Adder-Subtractor

1. Connections are made as per the circuit diagram
2. Give input values from the DC power supply to both inverting terminal and non-inverting terminals as shown in the figure.
3. Measure the output voltage with the help of a multimeter.



d). Averaging amplifier



1. Connections are made as per the circuit diagram
2. Give input values from the DC power supply to both inverting terminal and non-inverting terminals as shown in the figure.
3. Measure the Average output voltage with the help of a multimeter.

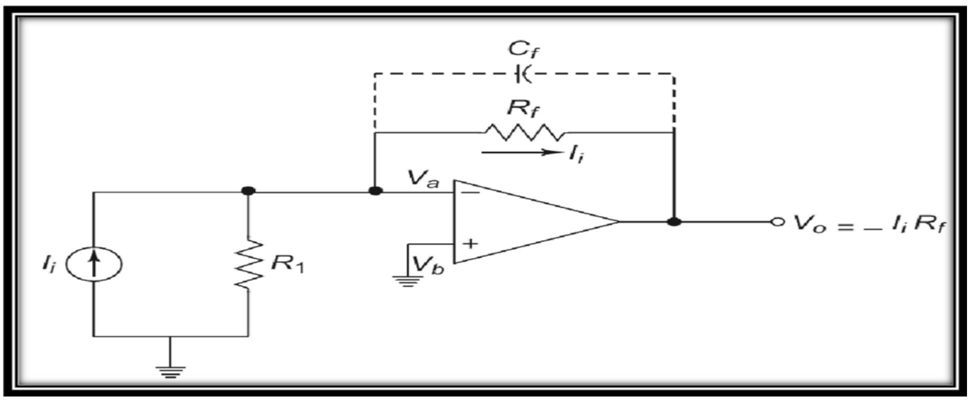
The above circuit can be used as an averaging circuit in which the output of the circuit is equal to the average of all the input voltages. This is accomplished by using all resistors of equal value, $R_a= R_b= R_c=R$

In addition, the gain by which each input is amplified must be equal to 1 over the number of inputs; that is, $R_F/R=1/n$. where n is the number of inputs.

Thus for a circuit with 3 inputs, consequently from equation3 Vo= (Va+Vb+Vc)/3

e). Current to voltage converter

Photocell, photodiode and photovoltaic cell give an output current that is proportional to an incident radiant energy or light. The current through these devices can be converted to voltage by using a current-to-voltage converter and thereby the amount of light or radiant energy incident on the photo-device can be measured.



Above figure shows an op-amp used as I to V Converter Since the (-) input terminal is at virtual ground, no current flows through R_s and current i_i flows through the feedback resistor R_f. Thus the output voltage v_0 = - i_i Rf. It may be pointed out that the lowest current that this circuit can measure will depend upon the bias current I_B of the op-amp. This means that 741

(I_B = 3 nA) can be used to detect lower currents. The resistor R_f is sometimes shunted with a capacitor C_f to reduce high frequency noise and the possibility of oscillations.

Result:

Review questions:

1) System applications for the 741 op amp?
2) What are the uses for a 741 op amp?
3) Which amplifier is a summing amplifier with a closed loop gain equal to the reciprocal of number of inputs?
4) A current-to-voltage converter produces?

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3. OP-AMP AS INTEGRATOR AND DIFFERENTIATOR

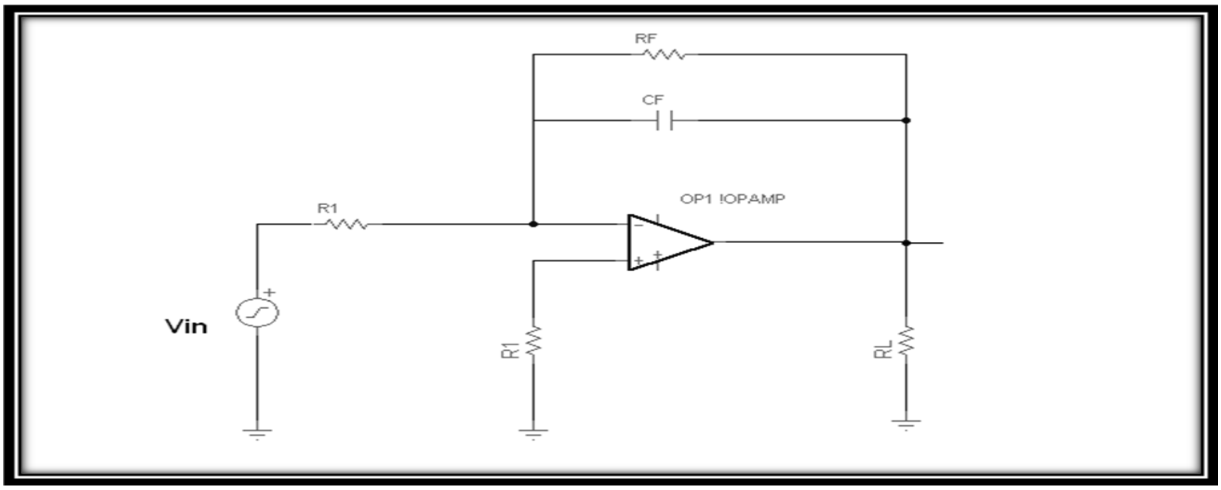
Aim: To observe Op-Amp as integrator and differentiator.

Apparatus:

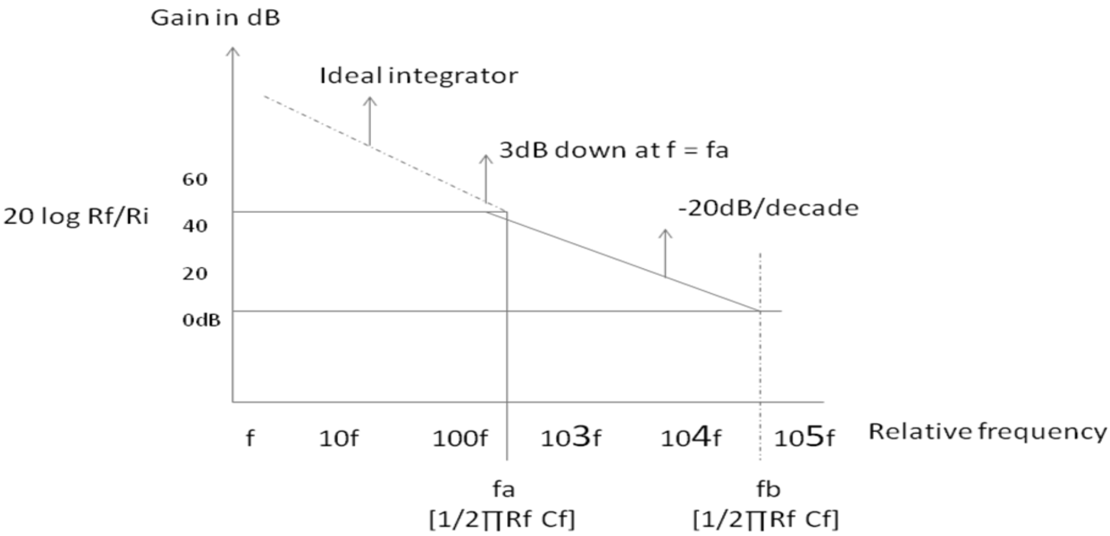
1) Op-Amp (µA- 741)- 3 No.s
2) DC Power Supply (1 2 - 0 - 12) V
3) CRO(0-20MHz range)
4) Signal Generator (0 -1MHz range)
5) Bread Board
6) Resistors 1K, 10K
7) Capacitors 0.01uf

Theory and Procedure:

a). Integrator: Integrators produce output voltages that are proportional to the running time integral of the input voltages. In a running time integral, the upper limit of integration is *t*.



$$Vo = -\frac{1}{R_1 C_F}\int_0^t Vin\,dt$$



<u>Integrator procedure:</u>

1. Connections are made as per circuit diagram.
2. Give a square wave input 1 V_{pp}, 1 KHz from the AC power supply to the inverting terminal as shown in the figure.
3. Observe and measure the output wave obtained in the CRO.

b). Differentiator: differentiator produce output voltages that are proportional to the differentiation of the input voltages.

Simple differentiator without R_1 and C_f will not function well since the gain R_f/X_{c1} increases with increase in frequency at a rate of 20dB/decade. This makes the circuit unstable. Input impedance X_{c1} decreases with increase of frequency which makes the circuit very susceptible to high frequency noise. When amplified this noise can completely over ride the differentiated output signal. The frequency f_a is the frequency at which the gain is 0dB.

$f_a = 1/(2\pi R_f C_1)$ [for simple differentiator]

f_c is the unity gain

Bandwidth and f is some relative operating frequency. The response of practical differentiator (with R_f and C_f) is given by RED lines. From f to f_b the gain increases at 20db/decade.

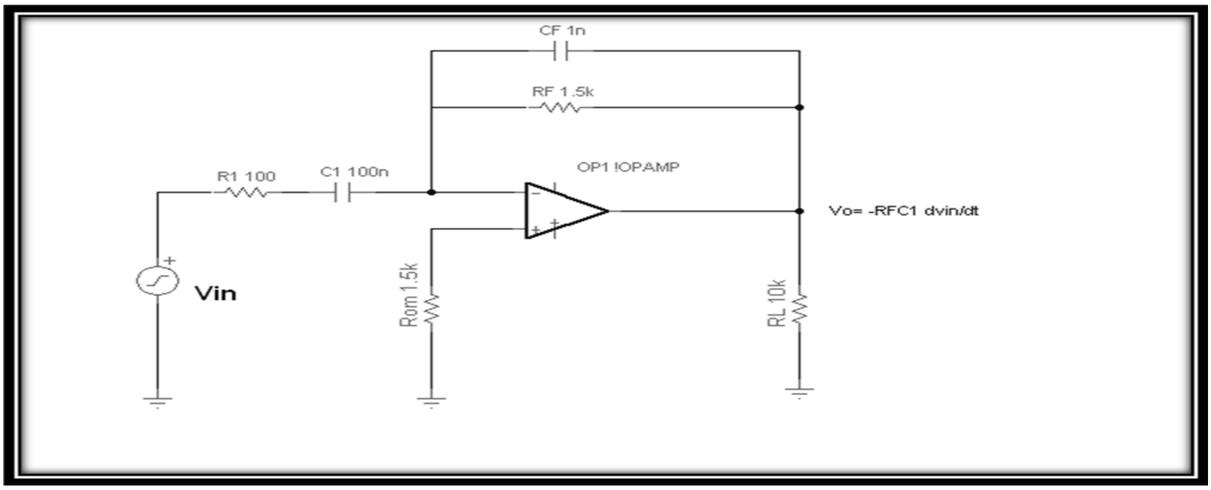
$f_b= 1/(2\pi R_1C_1)$; $R_1C_1=R_fC_f$ if $f_a < f_b < f_c$
$f_a=1/(2\pi R_fC_1)$;
$f_b=1/(2\pi R_1C_1)=1/(2\pi R_fC_f)$;
f_c=unity gain bandwidth

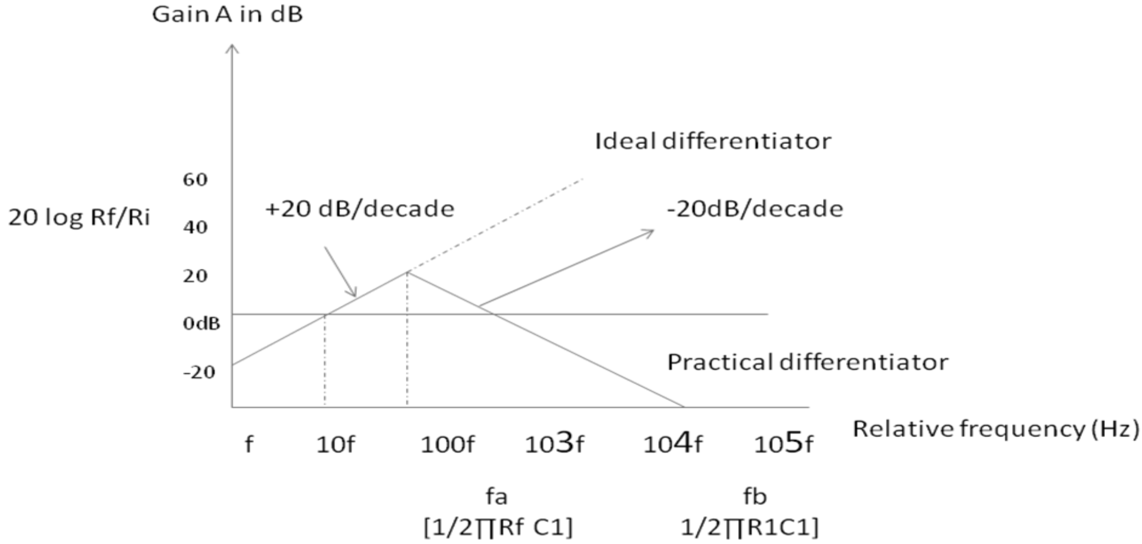
The input signal will be differentiated properly if the time period T of the signal $T \geq R_fC_1$.

Differentiator procedure:

1. Connections are made as per circuit diagram.
2. Give a square wave input 1 V_{pp}, 1 KHz from the AC power supply to the inverting terminal as shown in the figure.
3. Observe and measure the output wave obtained in the CRO.
4. Verify the output voltage with the voltage obtained practically by using the formula

$$V_o= -R_fC_1dV_1/dt$$





Comparison between Integrator and Differentiator

The process of integration involves the accumulation of signal over time and hence sudden changes in the signal are suppressed. Therefore an effective smoothing of signal is achieved and hence, integration can be viewed as low-pass filtering. The process of differentiation involves identification of sudden changes in the input signal. Constant and slowly changing signals are suppressed by a differentiator. It can be viewed as high-pass filtering.

Result:

Review Questions:

1) Why op amp integrator has high value resistor connected across input?
2) Why op amp integrators are not used?
3) Integrator produces an output that approximates the area under the curve of an input function(T/F)
4) differentiator is used to measure________________.
5) Mention the drawback of differentiator.

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4. INSTRUMENTATION AMPLIFIER USING OP-AMP

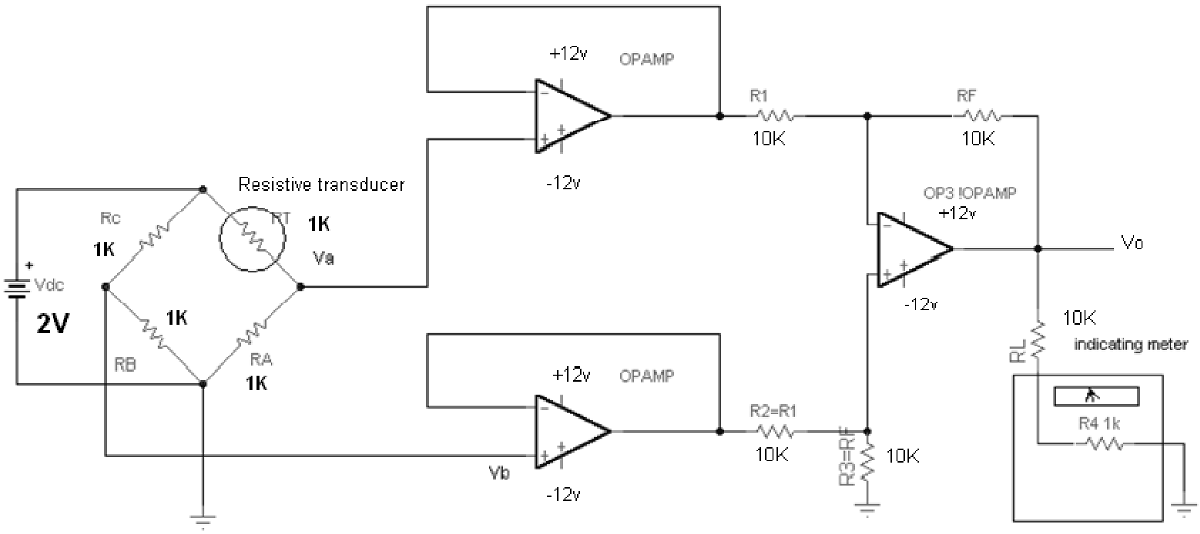
Aim: To study the performance of an Instrumentation amplifier.

Apparatus:

1) Op-Amp (µA -741)- 3 No.s
2) DC Power Supply (12-0- 12) V
3) CRO (0-20MHz range)
4) Resistors 1KΩ, 10KΩ
5) Bread board

Theory: Instrumentation Amplifier Using Transducer Bridge:

Fig shows a simplified differential instrumentation amplifier using a transducer bridge. A resistive transducer whose resistance changes as a function of some physical energy is connected in one arm of the bridge with a small circle around it and is denoted by ($R_T \pm \Delta R$), where R_T is the resistance of the transducer and ΔR is the change in resistance R_T.



The bridge in the circuit of fig is dc excited but could be ac excited as well. For the balanced bridge at some reference condition,

$$V_b=V_a$$

$$R_B(V_{dc})/ R_B+ R_C = R_A(V_{dc})/R_A+R_T$$

$$R_C / R_B = R_T/ R_A$$

Generally resistors R_A,R_B, R_C are selected so that they are equal in value to the transducer resistance R_T at some reference condition. The reference condition is specific value of the physical quantity under measurement at which the bridge is balanced. This value is normally established by the designer and depends on the transducers characteristics, the type of physical quantity to be measured, and the desired application.

The bridge is balanced initially at a desired reference condition. However, as the physical quantity to be measured changes, the resistance of the transducer also changes, which causes the bridge to unbalance ($V_a \neq V_b$).The output voltage of the bridge can be expressed as a function off the change in resistance of the transducer.

Let the change in resistance of the transducer be ΔR.Since R_B and $R_C$are fixed resistors, the voltage V_b is constant.However,voltage V_a varies as a function of the change in transducer resistance.Therefore, according to the voltage divider rule,

$$V_a=R_A(V_{DC})/R_A+R_T+\Delta R$$

$$V_b= R_B(V_{DC})/R_B+R_C$$

Consequently, the voltage V_{ab} across the output terminals of the bridge is

$$V_{ab}= V_a-V_b$$

$$=(R_A(V_{DC})/R_A+R_T+\Delta R) - R_B(V_{DC})/R_B+R_C$$

However if $R_A=R_B=R_C=R_T=R$, then $V_{ab}=-\Delta R(V_{dc})/2(2R+\Delta R)$

The negative sign indicates the $V_a<V_b$ because of the increase in the value of ΔR.

The output voltage V_{out} of the bridge is then applied to the differential instrumentation amplifier composed of three op-amps. The voltage followers preceding the basic differential amplifier help to eliminate the loading of the bridge circuit. The gain of the basic differential amplifier is $(-R_F/R_1)$: therefore the output V_0 of the circuit is

$$V_0=V_{ab}(-R_F/R_1)$$

$$= [(\Delta R)V_{dc}/2(2R+\Delta R)] (R_F/R_1)$$

Generally, the change in resistance of the transducer ΔR is very small. Therefore we can approximate $(2R+\Delta R)\approx 2R$.Thus the output voltage

$$V_0=(R_F /R_1) (\Delta R/4R) (V_{DC})$$

The equation indicates that V_0 is directly proportional to the change in resistance ΔR of the transducer. Since the change in resistance is caused by a change in physical energy, a meter connected at the output can be calibrated in terms of the units of that physical energy.

Result:

Practical Gain Value:.............
Theoretical Gain Value:..................

Review questions:

1) The main purpose of an instrumentation amplifier is to amplify small signals that are riding on large common-mode voltages.(T/F)
2) What is a key characteristic of an instrumentation amplifier?
3) The voltage gain of instrumentation amplifier is set by which component
4) Instrumentation amplifier is used to measure________________

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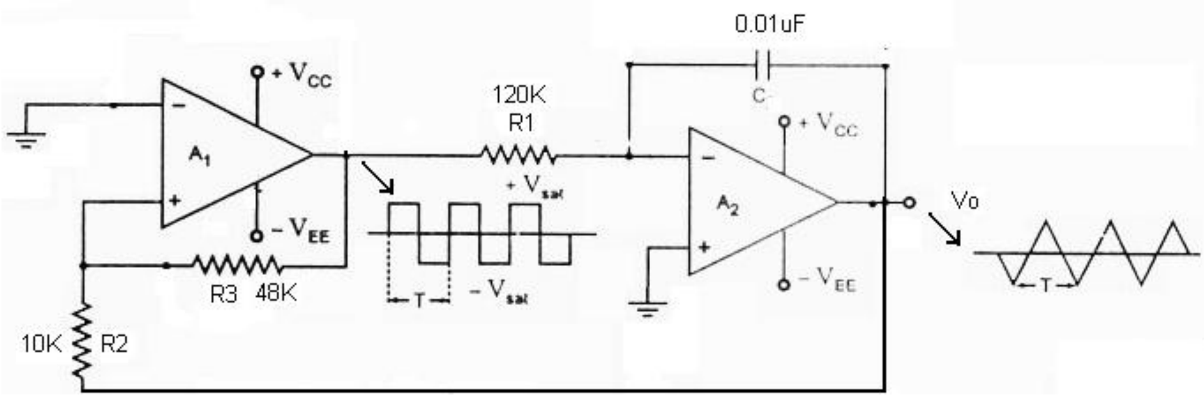
5. WAVEFORM GENERATION USING OP-AMP

Aim: To generate square wave and triangular wave using Op-Amp

Apparatus:

1) Op-Amp (µA -741)- 2 No's
2) DC Power Supply (12-0- 12) V
3) CRO (0-20MHz range)
4) Signal Generator (0 to 1MHz range)
5) Bread board

Theory:



We know that the integrator output waveform will be triangular if the input to it is square-wave. It means that a triangular-wave generator can be formed by simply cascading an integrator and a square-wave generator, as illustrated in figure. This circuit needs a dual op-amp, a capacitor, and at least three resistors. The rectangular-wave output of the square-wave generator drives the integrator which produces a triangular output waveform.
The input of integrator A_2 is a square wave and its output is a triangular waveform, the output of integrator will be triangular wave only when R_1 C> T/ 2 where T is the (period of square wave.

Procedure:

1) Connections are made as per the circuit diagram
2) Give the biasing voltage as power to the IC
3) Observe the square wave output at 1^{st} op-amp sixth pin and triangular wave output at 2^{nd} op-amp sixth pin.
4) Adjust the potentiometer to observe the undistorted square wave output.
5) Calculate the frequency and amplitude of the square and triangular wave observed from the CRO.
6) Compare the practical waves obtained with the theoretical values

Result:

Frequency:........................
Amplitude of square wave:..................
Amplitude of triangular wave :..........................

Review Questions:

1) In which region the op amp is acts like a wave form generator
2) Another name for square wave generator is --------------------
3) The triangular wave amplitude is depends on --------------------

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