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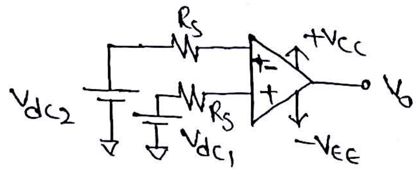
ICA
* ASSIGNMENT-I *

*1. DC Characteristics of op-Amp :→

(a) * Input off set Voltage (V_{io}) :→

* The input off-set voltage is the voltage that must be applied between the two terminals of the op-Amp to Null the o/p.

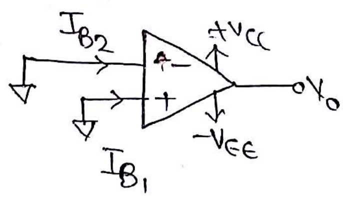
* For IC741 the max Value of V_{io} is 6mV



* $V_{io} = V_{dc_1} - V_{dc_2}$

(b) * Input off-set current (I_{io}) :→

* The difference between the currents into the Non-inverting & inverting terminals.



* $I_{B_{io}} = I_{B_1} - I_{B_2}$

* I_{io} for IC741 is 200 nAmps.

(c) * Input Bias current (I_B) :→

* Average of the Currents that flow into inverting & non-inverting terminals $I_B = \frac{I_{B_1} + I_{B_2}}{2}$

(d) * Thermal drift :→

* OFF-Set Voltage, Off-set Current, Bias current Changes with the temperature., it is called thermal drift.

* AC- Characteristics of op-Amp :→

* (a) Gain - Bandwidth product :→

* It is B.W of op-Amp when Voltage gain is 1.

* for IC741 it is 1MHz.

* (b) large Scale voltage gain :→

* The Voltage gain of an op-Amp is given as

$A = \frac{V_o}{V_{id}}$.

* If $R_L > 2k\Omega$, & $V_o = \pm 10V$ then $A = 2 \times 10^5$.

* (c) Slew rate :→

* Defined as max rate of change of o/p Voltage per unit time.

* Expressed as V/μSecs.

* $SR = \frac{dV_o}{dt}$ V/μsecs

* SR = 0.5V/μSecs for IC741.

* (d) Supply voltage rejection ratio :→

* Change in op-Amp's i/p off-Set Voltage with the Variations in supply Voltage.

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* $SVRR = \frac{\Delta V_{io}}{\Delta V}$

* For 741IC SVRR = 150 $\mu V/V$.

*5. Differential input Resistance (R_i):→

* Equivalent Resistance that is measured at Either inverting or non-inverting terminals with the other terminal at ground.

* For IC741 it is 2MΩ.

*6. Input Capacitance (C_i):→

* Equivalent Capacitance that is measured Either at inverting or non-inverting terminal with the other terminal Connected to ground.

* For IC741 it is 1.4pF

*7. Transient Response:→

* It is based on Rise time & over shoot.

* For IC741 Rise time = 0.3 μsec

Over Shoot = 5%

*8. output Resistance (R_o):→

* The Equivalent resistance that is measured at the o/p terminal of an op-Amp.

* IC741 R_o = 75Ω.

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(9) * Supply Current :→

* The current that is drawn by the op-Amp from the Supply Voltage

* $I_S = 2.8mA$ for IC741.

* (10) Power Consumption :→ (P_c)

* P_c is the Quiescent power that must be Consumed by the op-Amp to operate properly.

* IC741 $P_c = 85mW$.

*2. * Instrumentation Amplifier :→

* In a number of Consumer & Industrial applications their is a need to measure & Control physical Quantities such as Control of the temperature, measuring of light intensity, water flow Etc.

* These are measured with the help of transducer.

* Transducer is a device that Converts one form of Energy into another.

* The o/p of the transducer should be amplified So that it Can drive the indicator or display System.

* This function is performed by an Instrumentation amplifier.

* Features :→

*1. High gain accuracy.

*2. High CMRR.

*3 High gain Stability with low temperature Co-Efficient.

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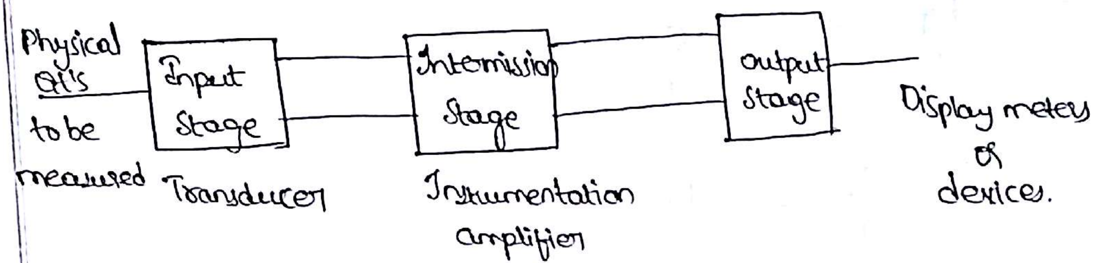
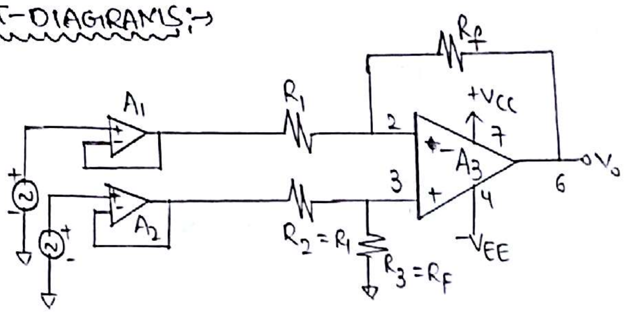
*4. low DC off-set Voltage

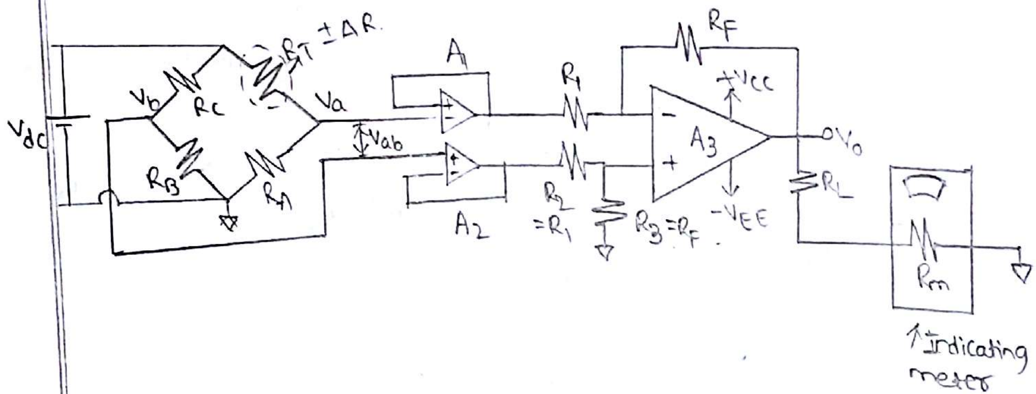
*5. low o/p Impedence.



CIRCUIT-DIAGRAMS:→



* Instrumentation amplifier using transducer Bridge:→



* AS shown in the above circuit as resistive transducer i.e.. the resistance Changes as a function of Some physical Energy is Connected in arm of bridge with a Small circle around it.

* where R_T is Resistance of the transducer & ΔR is the change in the Resistance.

* For a balance bridge no change in "R_T" Value then

$$V_a = V_b.$$

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* $V_{dc} \cdot \frac{R_A}{R_A + R_T} = V_{dc} \cdot \frac{R_B}{R_B + R_C}$

$\Rightarrow \frac{R_T}{R_A} + \cancel{1} = \frac{R_C}{R_B} + \cancel{1}$

$\Rightarrow \frac{R_A}{R_T} = \frac{R_B}{R_C}$.

* V_a & V_b Voltages are given to op-Amp (A_3) then.

$$V_0 = \frac{-R_F}{R_1} \cdot V_{ab} = \frac{-R_F}{R_1}\left[V_a - V_b\right] \longrightarrow ①$$

* If their is a change in resistance then

$$V_a = V_{dc} \cdot \frac{R_A}{R_A + R_T \pm \Delta R} ; \quad V_b = V_{dc} \cdot \frac{R_B}{R_B + R_C}.$$

$$\Rightarrow V_{ab} = V_a - V_b = V_{dc}\left[\frac{R_A R_B + R_A R_C \mp R_B R_A - R_T R_B \mp \Delta R R_B}{(R_A + R_T \pm \Delta R)(R_B + R_C)}\right]$$

If $R_A = R_B = R_C = R_T = R$.

$$\Rightarrow V_{ab} = -V_{dc}\left[\frac{\pm \Delta R \cancel{R}}{(2R \pm \Delta R)(2\cancel{R})}\right]$$

$$\Rightarrow V_{ab} = -V_{dc}\left[\frac{\pm \Delta R}{2(2R \pm \Delta R)}\right]$$

* o/p voltage $V_0 = \frac{-R_F}{R_1} \times -V_{dc}\left[\frac{\pm \Delta R}{2(2R \pm \Delta R)}\right]$

$$\Rightarrow \boxed{V_0 = \frac{R_F}{R_1} \times \frac{(\pm \Delta R)}{4R} \times V_{dc}} \quad \{2R \pm \Delta R \simeq 2R\}$$

i.e.. $\boxed{V_0 \propto \Delta R}$

...ically we have $V_0' = +V_{sat}$, then the o/p of the integrator will be -ve going ramp {because $V_0 = -\frac{1}{RC}\int V_{in} \, dt$}.

(3) * Triangular wave generator :-

* It can be obtained using Astable m.v & an Integrator.

* The triangular wave generator can also be designed using a comparator ckt & an integrator.

* The comparator is used because it has lesser number of components than Astable m.v.

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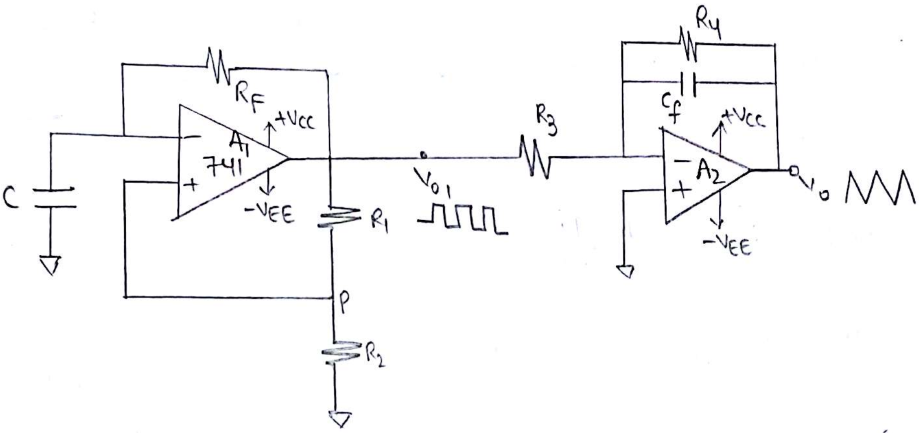
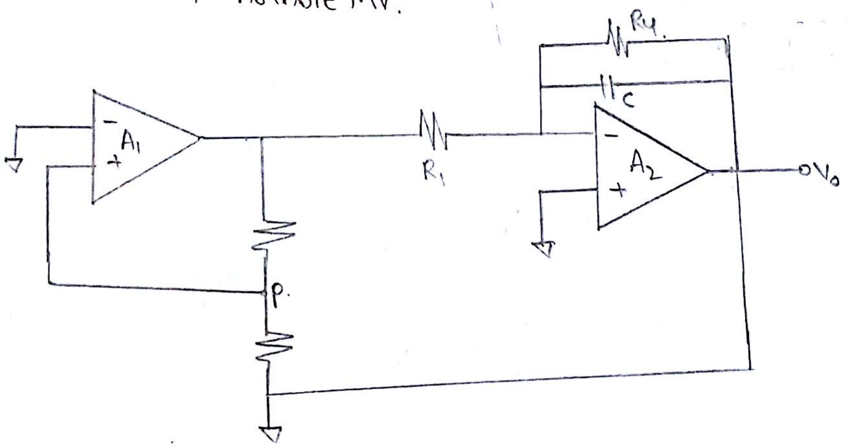


USING ASTABLE MV.



USING COMPARATOR.

* The voltage at "p" is compared with "0"

* Initially we have $V_o' = +V_{sat}$, then the o/p of the integrator will be -ve going ramp {because $V_o = -\frac{1}{RC}\int V_{in}\, dt$}.

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* The circuit consists of Comparator "A_1" & an integrator "A_2", the Comparator "A_1" Compares the voltage at "p" with the zero volts at -ve terminal of "A_1".

* when the voltage at 'p' goes slightly below or above zero volts the o/p at A_1 is -ve or +ve Sat Values respectively.

* Initially let o/p of "A_1" is at $+V_{sat}$, which acts as i/p to A_2.

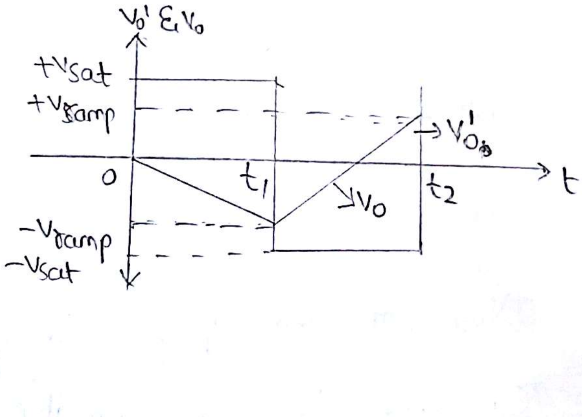
* Then the o/p of A_2 is a -ve going ramp & the voltage divider Circuit R_1 & R_2 has $+V_{sat}$ of A_1 at one End & $-V_{ramp}$ A_2 at other End.

* At Certain point of -ve ramp, the point "p" goes below zero volts, then the o/p of A_1 will be -ve & o/p of A_2 will be a +ve going ramp.

* Hence, this cycle repeats & a Δgular wave is generated.

* <u>Note</u>:-
  Δgular & Square wave freq's are Same.

* The amplitude of Δgular wave decreases as frequency increases.



$= f = \overline{4R_2R_1C_1}$

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* at P we get $I_1 = I_2$.

$$\Rightarrow \frac{+V_{sat} - 0}{R_3} = \frac{0 - V_o}{R_2} = \frac{0 - (-V_{ramp})}{R_2}$$

$$\Rightarrow \frac{V_{sat}}{R_3} = \frac{V_{ramp}}{R_2}.$$

$$\Rightarrow -V_{ramp} = \frac{-R_2}{R_3} \cdot V_{sat} \rightarrow ①.$$

Similarly for $V_o' = -V_{sat}$ then $V_o = +V_{ramp}$.

$$\Rightarrow \frac{-V_{sat} - 0}{R_3} = \frac{0 - (+V_{ramp})}{R_2}$$

$$\Rightarrow V_{ramp} = \frac{R_2}{R_3} \cdot V_{sat} \rightarrow ②$$

* P-P Voltage is

$$V_{o(p-p)} = ① - ② = \frac{2R_2}{R_3} \cdot V_{sat} \rightarrow ③$$

* The time, the o/p swings from $-V_{ramp}$ to $+V_{ramp}$ is Equal to $T/2$.
* The time Period Can be calculated by using Integrator o/p Equation

$$\Rightarrow V_{o(p-p)} = \frac{-1}{R_1C_1} \int_0^{T/2} -V_{sat} \cdot dt \quad \{ \text{at } V_o' = -V_{sat}, \; V_{o4} = V_{o(p-p)} \}.$$

$$\Rightarrow V_{o(p-p)} = \frac{V_{sat}}{R_1C_1} \left[\frac{T}{2} \right] \rightarrow ④$$

* from ③ & ④ we get.

$$\Rightarrow \frac{\cancel{V_{sat}}}{R_1C_1} \cdot \frac{T}{2} = \frac{2R_2}{R_3} \cdot \cancel{V_{sat}}$$

$$\Rightarrow T = \frac{4R_2R_1C_1}{R_3}$$

$$\Rightarrow f = \frac{R_3}{4R_2R_1C_1}$$

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