Instrumentation Amplifier

The physical quantities (eg. temp., humidity, light intensity etc) are usually measured with the help of transducers. The o/p of transducers amplified so that it can drive the indicator or display system. This function is performed by an instrumentation amper.

The important features of an instrumentation amper

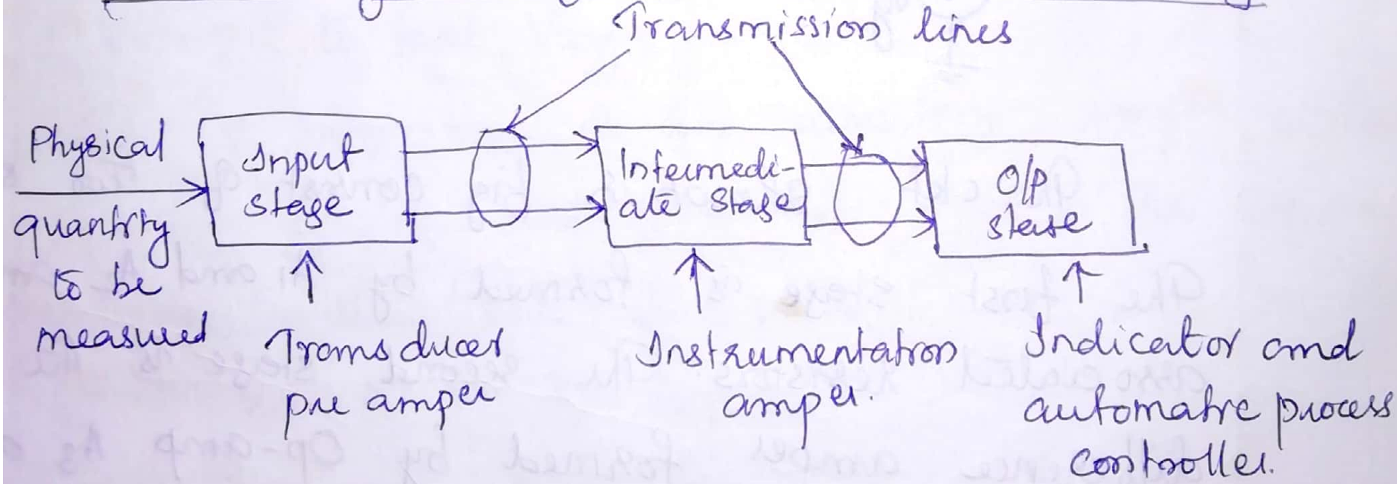
① high gain accuracy ② high CMRR.

③ High gain stability with low temp. coefficient

④ Low dc offset ⑤ Low o/p impedance

⑥ High i/p resistence.

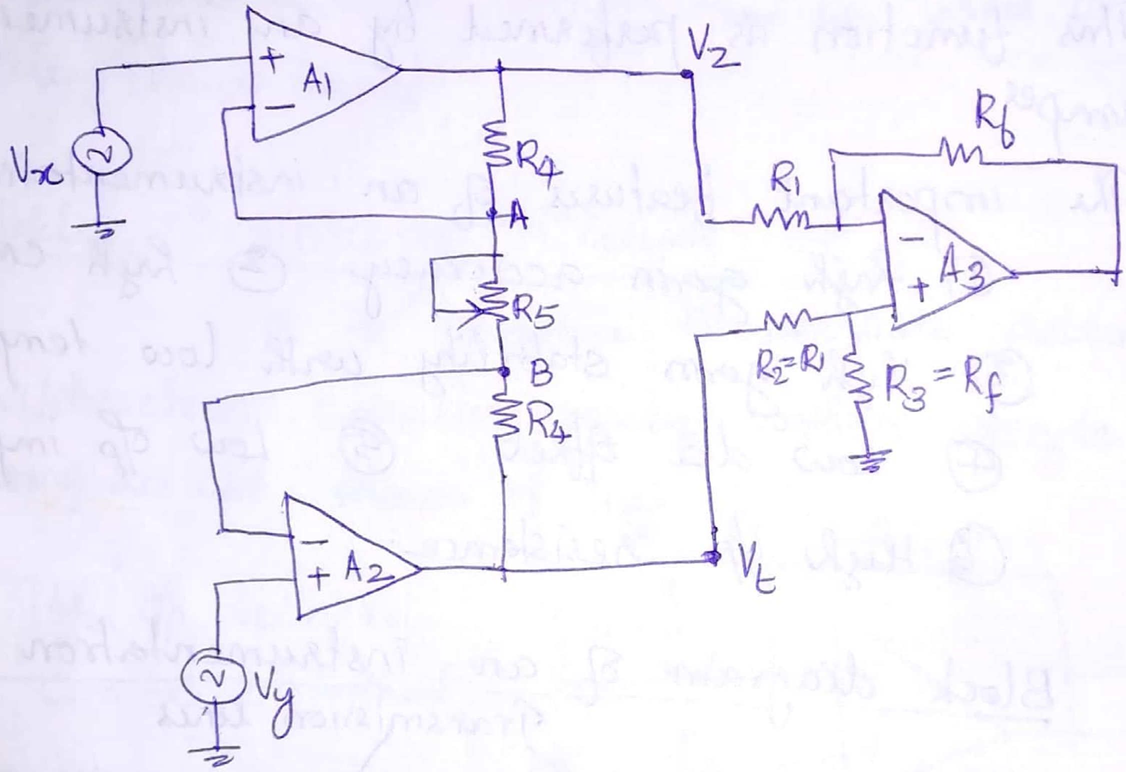
Block diagram of an instrumentation system.



An instrumentation system is used to measure the o/p signal produced by a transducer and often to control the physical signal producing it.

The i/p stage composed of a pre-amper and some sort of transducer. The o/p stage may use the devices such as meters, oscilloscopes, charts etc.

<u>Instrumentation</u> <u>Ampr</u> ~~with~~ (Differential ampr with three op-a



The ckt shown in fig consist of two stages. The first stage is formed by A1 and A_2 and their associated resistors. The second stage is the difference ampr formed by Op-amp A_3 and its four associated resistors.

The o/p of instrumentation ampr or the o/p of differential ampr is

$$V_o = -\frac{R_f}{R_1}(V_2 - V_t) \quad \text{——— (1)}$$

where V_Z and V_t are the i/p voltages to the difference amps. Also V_Z is the o/p of op-amp A_1 and V_t as the o/p of op-amp A_2.

V_Z can be obtained using superposition Theorem

$V_Z = V_{Zx} + V_{Zy}$ $\quad V_{Zx} \rightarrow V_Z$ due to V_x alone

$V_{Zy} \rightarrow V_Z$ due to V_y alone

Case 1

$V_y = 0$ to find V_{Zx}.

when $V_y = 0$ node B is at virtual gnd or $V_B = 0V$.

Thus A_1 is now a non-inv ampl with $R_f = R_4$ and $R_1 = R_5$

$$\therefore V_{Zx} = \left(1 + \frac{R_4}{R_5}\right) V_x.$$

Case 2

$V_x = 0$ to find V_{Zy}.

When $V_x = 0V$, A_1 is an inverting ampl with $R_f = R_4$, $R_1 = R_5$ and $V_i = V_B$. Since the op-amp terminals will track the potential $V_B - V_y$ (since $V_{id} = 0$ in op-amp A_2)

$$V_y - V_B = 0V \quad \text{or} \quad V_B = V_y.$$

Thus $V_{Zy} = \frac{-R_4}{R_5} V_B = \frac{-R_4}{R_5} V_y.$

Hence the net o/p of op-amp A_1 is

$$V_Z = V_{Zx} + V_{Zy} = \left(1 + \frac{R_4}{R_5}\right) V_x - \frac{R_4}{R_5} V_y \quad \text{— (2)}$$

Since the circuit of instrumentation amper is symmetric the net o/p of op-amp A2 can be obtained in the similar manner as

$$V_t = V_{tx} + V_{ty} = \left(1+\frac{R_4}{R_5}\right)V_y - \frac{R_4}{R_5}V_x \quad \text{---} (3)$$

The o/p of instrumentation amper can now be obtained by substituting (2) and (3) in (1)

$$\therefore V_0 = \frac{-R_f}{R_1}(V_2 - V_t)$$

$$= -\frac{R_f}{R_1}\left[\left(1+\frac{R_4}{R_5}\right)V_x - \frac{R_4}{R_5}V_y\right] - \left[\left(1+\frac{R_4}{R_5}\right)V_y - \frac{R_4 V_x}{R_5}\right]$$

$$= \frac{-R_f}{R_1}\left\{\left(1+\frac{R_4}{R_5}\right)(V_x - V_y) + \frac{R_4}{R_5}[V_x - V_y]\right]$$

$$= \frac{-R_f}{R_1}\left[\left(1+\frac{R_4}{R_5}+\frac{R_4}{R_5}\right)(V_x - V_y)\right]$$

$$\boxed{V_0 = \frac{-R_f}{R_1}\left(1+\frac{2R_4}{R_5}\right)(V_x - V_y)}$$

The difference mode gain of instrumentation amper is $\boxed{A_D = \frac{V_0}{V_x - V_y} = \frac{-R_f}{R_1}\left(1+\frac{2R_4}{R_5}\right)}$

The common mode gain will be zero because of the differencing action of the second stage ampes. Since both the sources V_x and V_y are connected to non inv. configurations, the i/p resistance seen by both the sources will be same. The i/p resistance seen by both the sources will be

$$R_{ix} = R_{iy} = R_i(1+A\beta) \quad \text{where } \beta = \frac{R_4+R_5}{2R_4+R_5}$$

$R_i \rightarrow$ i/p ~~impedance~~ resistance of op-amp and 'A' — op-amp open loop gain.

The input impedance is very large ideally infinite is an advantage

The difference gain of the ampes can be varied by varying pot R_5.

This ckt also has high differential gain. Also if A_1 and A_2 and its corresponding resistors are matched, the signal ~~pathsons~~ paths are symmetric is an adv. ~~if~~ in the design of differential ampes.

features of instr. amps back side

V to I and I to V ...