ECI Assignment
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Page ①

ⓐ Define instrumentation system and explain the static performance parameter of measuring system.

Soln Instrumentation system can be defined as the collection of instrument, used to measure, monitor and control a process. It is a branch of engineering that deals with various type of instrument to record, monitor, indicate, and control physical parameters such as: pressure, temperature.

Static performance parameter is a type of performance parameter. Performance parameter can be defined as the functional behaviour of any instrument with detailed specification. Performance parameters helps to find the features, characteristics and limitations of any instrumentation system.

Those types of performance parameter which is always constant and doesn't vary with time is known as static performance parameter. It is further categorized as below:

ⓐ **Accuracy**: It is the degree of closeness with which the instrument reading approaches to ~~the~~ the true value of the instrument to be measured. It helps to find how exact the system reading with respect to the value to be measured.

ⓑ **Precision**: Precision can be defined as the measurement of consistency. It measures the reproducibility of the measurement.

ⓒ **Sensitivity**: Sensitivity denotes the smallest change in measured to which the instrument responds. It has its unit in mm/μA or mm/Ω

Mathematically, it can be defined as the infinitesimal change in output to the infinitesimal change in input

$$\therefore \text{Sensitivity} = \frac{\Delta q_o}{\Delta q_i}$$

sensitivity value must as much higher possible. and to achieve this the range such not be greater than value to be measured.

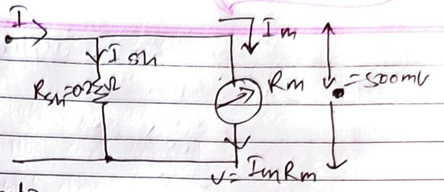
(d) Resolution : It is the smallest measurable input change. It is the smallest increment of quantity being measured which can be detected by instrument with certainty. Resolution can affect the accuracy of measurement.

(e) Range or span : The minimum and maximum value of quantity for which the instrument is designed to measure is called Range. Sometimes the accuracy is specified in terms of range or span.

(2) A moving coil ammeter has fixed shunt of 0.2 Ω with a coil resistance of $R_m = 1000\Omega$ and a potential difference of 500 mV across it, full scale deflection is obtained.

(i) Find shunt ~~resistance~~ current at full scale deflection.
(ii) Calculate the value of R_m to give full scale deflection when shunted current is 10A.
(iii) Find value of R_m for 40% deflection with shunted current of 100A.

Soln



Soln Given,

$R_{sh} = 0.2\Omega$

$R_m = 1000\Omega$

$V = 500mV$

(i), we know, At full scale deflection,

$I_{sh} R_{sh} = I_m R_m$

$\therefore I_{sh} = \frac{I_m R_m}{R_{sh}}$ ——(i)

$\therefore I_m = \frac{V}{R_m}$

$I_m = \frac{500}{1000}$

$= 0.5mA$

$\therefore I_m$

from eqn (i),

$I_{sh} = \frac{I_m R_m}{R_{sh}}$

$= \frac{0.5 \times 1000}{0.2}$

$= \frac{500}{0.2}$

$= 2500 mA$

$\therefore I_{sh} = 2.5A$

Here $I_{sh} > I_m$.

(ii) $R_m = ?$ when $I_{sh} = 10A$,

Here To give full scale deflection when shunted current is 10A is:

$I_m R_m = I_{sh} R_{sh}$

$R_m = \frac{I_{sh} R_{sh}}{I_m} = \frac{10 \times 0.2}{0.5 \times 10^{-3}} = \frac{2}{0.0005} = 4000\Omega$

(iii) $R_m = ?$ for 40% deflection with $I_{sh} = 1000$ mA.

Soln $I_m' = 40\% \, I_m$

$= \frac{40}{100} \times 0.5$

$= \frac{20}{100}$

$= 0.2$ mA

we have,

$I_{sh} R_{sh} = I_m R_m'$

$\therefore R_m' = \frac{I_{sh} R_{sh}}{I_m}$

$R_m' = \frac{100 \times 0.2}{0.2}$

$\therefore R_m' = 100 \Omega$

So, The required parameters is obtained.

(4) A strain guage with a guage factor of 2 is fastened to a steel member subjected to a stress of 1250 kg/cm². The modulus of elastic of a steel is approximately 2.1×10^6 kg/cm². Calculate the change in resistance of strain guage element due to applied stress and also compute poisson's ratio.

Soln Given

Guage factor $(G) = 2$

Stress $(\sigma) = 1250$ kg/cm²

modulus of elasticity $(Y) = 2.1 \times 10^6$ kg/cm²

change in resistance of strain guage due to applied stress = ?

poisson's ratio = ?

Page (5)

We know, Stress = Y strain

$1250 = 2.1 \times 10^6 \times$ strain,

Strain $= \frac{1250}{2.1 \times 10^6} =$

$\therefore$ Strain (ϵ) = 0.000595

we have,

$G = \frac{\Delta R/R}{\Delta l/l}$

$\frac{\Delta R}{R} = G \times \frac{\Delta l}{l}$

$= 2 \times 0.000595$

$\therefore \frac{\Delta R}{R} = 0.00119$

poisson's ration (μ) = ?

$G = 1 + 2\mu$

$\mu = \frac{G-1}{2}$

$\therefore \mu = \frac{2-1}{2} = 0.5$ //

So all the required parameters is calculated.

(8) Define slew Rate, CMRR and virtual ground in op-Amp.

Soln Slew Rate, CMRR, virtual ground, all of these are the parameters of an operational amplifiers. Parameter of an operational amplifier define the performance and behaviour of operational amplifier.

(a) Slew Rate: Slew Rate can be defined as maximum rate at which amplifier output can change in volts per microsecond.

Mathematically, it is the ratio of change in output voltage with respect to time,

$$SR = \frac{\Delta V_o}{\Delta t},$$

$$\text{or } SR = \frac{dV_o}{dt}$$

where, t will be in μsecond unit.

Actually, the slew Rate is the measure of op-amp's ability to follow fast changing input signals.

CMRR : CMRR which stands for Common Mode Rejection Ratio. It is the measure of op-Amp's ability to reject common-mode signals. The common mode signals means, the same signal appears at both input terminals.

That means, when signal of same polarity appears at both input, common mode operation results. It is one of the significant features of differential connection. As we know that, noise (any unwanted input signal) is common to both end, so the differential connection tends to provide attenuations while providing amplified output to different polarity signals.

Mathematically, CMRR is expressed as.

$$\rho = \frac{|A_d|}{|A_c|}$$ where A_d = difference mode gain

A_c = common mode gain.

where $A_d = \frac{V_o}{V_d}$.

$A_c = \frac{V_o}{V_{cm}}$.

<u>Virtual ground</u>

(5) Define Transducer and explain the working principle of LVDT with neat diagram.

Soln Transducer can be defined as the device that converts a signal from one form to another. The term "transducer" is commonly used in the field of electrical engineering, electronics and physics. It is used to represent wide range of device that perform these conversion. Some of the example of transducers are:- optical transducer, sensors, Actuators.

The LVDT stands for Linear variable differentiable Transformer. It is the most widely used inductive transducer for translating the linear motion into an electrical signal. The basic construction of LVDT is shown below:

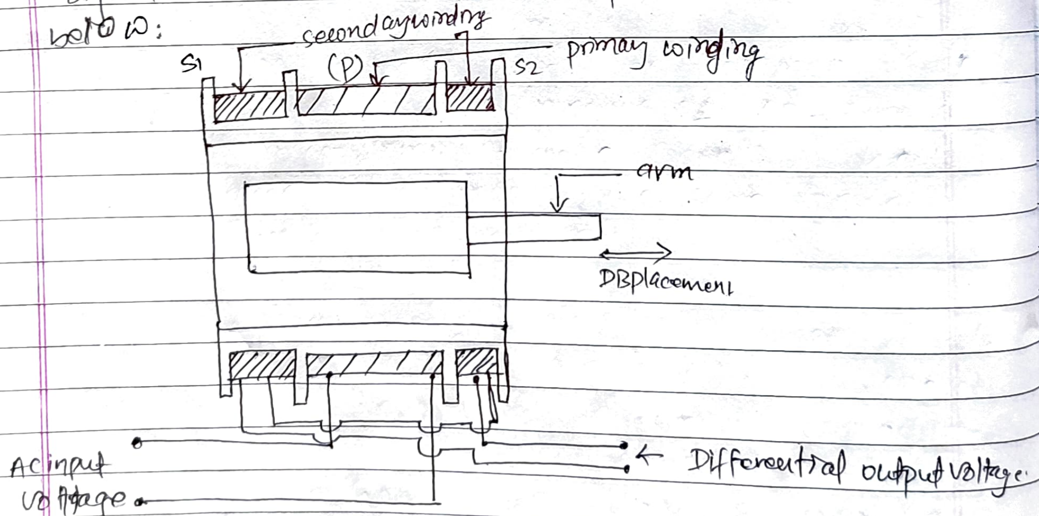


fig:- LVDT

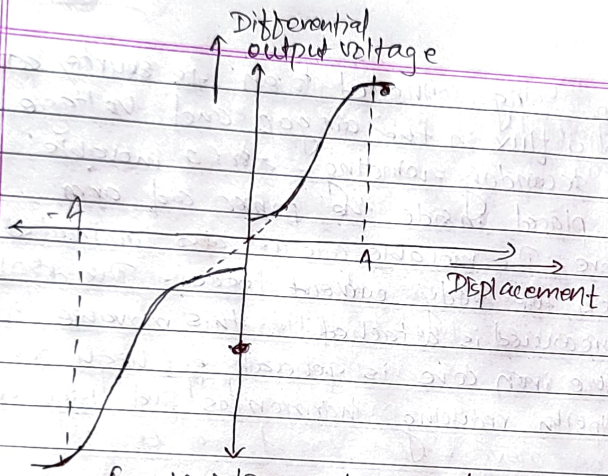


fig:- Variation of differential output voltage w.r.t displacement

LVDT is a differential transformer consisting of one primary winding 'p' and two identical secondary winding S_1 and S_2 wound over a hollow bobbin (cylinder) of non magnetic and insulating material. The secondary winding S_1 and S_2 have equal no. of turns and are arranged concentrically and placed either side of the primary winding 'p'. Here also a soft iron core in the shape of rod or cylinder is attached to the sensing element and slides freely in the hollow portion of the bobbins. The primary winding is connected to an AC source.

When the core is moved inside the bobbin, it varies coupling of primary winding to secondary winding S_1 and S_2.

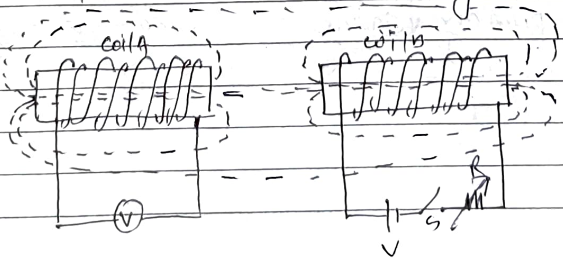
The primary winding being connected to an AC source, which produces a flux in the air gap and voltage are induced in secondary winding. Also a movable soft iron core is placed inside the former and arm is connected to core. The movable core is also laminated in order to reduce the eddy current losses. The displacement to be measured is attached to this movable soft iron core. Here the iron core is generally of high permeability which helps in reducing harmonics and high sensitivity of LVDT

Here secondary winding are connected in such a way that the resulted resulted output is the difference between the voltage of two windings. usually this AC output voltage is converted to high level DC voltage or current that is more convinient to use, by using suitable electronic circuitry. ~~to high level DC voltage~~

i.e. $V_0 = E_1 - E_2$

Working principle

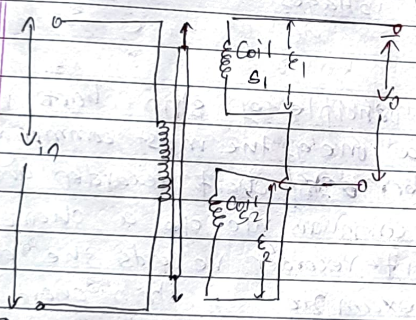
- The working principle of LVDT is mutual induction principle.
- Here the emf induced in one coil by the change of current in other coil is called mutually induced emf.



Here consider two coils A and B lying close to each other; When the switch is closed, current flows through coil B and hence flux is developed. part of this flux cuts A.

When the current in coil B is changed by varying Resistance, flux of coil B also changes, flux which cuts coil A also changes. Hence emf is induced in coil A and coil B.

→ The emf induced in coil B is self induced emf and induced in coil A is mutually induced emf.



There are 3 different cases :-

(a) case I: when the core is at Null position

↳ When it is in null position, there is no any kind of displacement. So the emf generated at both S_1 and S_2 i.e E_1 and E_2 is equal so the net output voltage,

$$\boxed{V_0 = E_1 - E_2 = 0}$$

(b) when the core is moved towards S_1,

↳ Here emf(E_1) linked with coil S_1 is greater. So,

$V_0 = \varepsilon_1 - \varepsilon_2 > 0$, so $V_0 = +ve$

case (3) :- when the core is moved towards S_2, the magnitude of $E_2 > E_1$, so output voltage $V_0 = E_1 - E_2 = -ve$.

So in conclusion, LVDT is called linear variable Differential transducer due to following reason:

(a) Linear:- It measure linear displacement
(b) Transformer: works on the principle of mutual induction.
(c) variable:- It has movable core and fixed coils.
(d) Differential:- Output voltage is the difference between 2 secondary voltages.

(7) Explain the working principle of strip chart recorder.

↳ Strip chart recorder is a one of the most commonly used types of graphic recorder. Strip chart recorder are those where data is recorded on continuous role of a chart paper. So that means strip chart recorder records the data on chart paper. ECG is an example of strip chart recorder. It can record the variation of variable which can be one or more, on the movable paper using a stylus or pen. This paper (roll of paper) is driven by a system known as paper drive system which is nothing but a kind of servo or stepper mechanism. Mostly the stepper mechanism is used for the purpose of paper driver. The speed of chart or drive is normally controlled by speed selector as shown in the diagram. Basically the chart speed which is used inside of the strip chart recorder is in the range of 1 - 100 mm/sec.

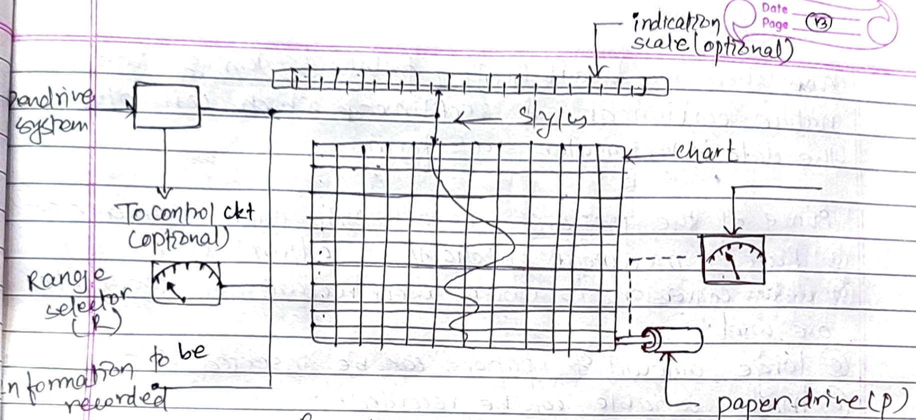


Fig: Strip chart recorder.

There exist another drive system known as pendrive system and a control circuitry for pendrive system which is then connected to the information to be recorded. So as the input supply in this system change according the stylus attend the horizontal movement and continuously plot the data on the chart. Also, the range selector present are used to select the range of variable (processed parameter). There are various types of marking mechanism that are available and are:

(a) ink filled stylus
(b) heated stylus: property of paper should be of high quality
(c) Chopper bars: nothing but a kind of vertical bars plotted on papers.
(d) Electronic stylus.
(e) optical marking system

Also, there are availability of treking system of two nature curvilinear and rectilinear which will plot the data in rectangular block form.

Some of the pros and cons of strip chart recorder are

ⓐ Rate of movement of chart is adjustable
ⓑ data conversion is easier, when rectangular coordinates are used.
ⓒ large amount of papers can be inserted in one time
ⓓ many variable can be recorded.

cons: ⓐ Mechanism is quite complicate w.r.t circular chart recording system.
ⓑ Observation of older data is not easy.

③ Draw the block diagram of successive approximation method. Discuss different steps involve in the method in order to convert analog voltage 10.3V into its digital value.

↳ Successive approximation type ADC is a Analog to Digital signal converter that converts a continuous signal into digital signal (descrete form). There is the block diagram of this type ADC which is similar to counter type ADC. It is developed to remove the cons of counter type ADC which was, that counter type ADC takes almost 2^{n-1} time cycle i.e. to count 'n' bit, it almost takes 2^{n-1} times which is high time complex

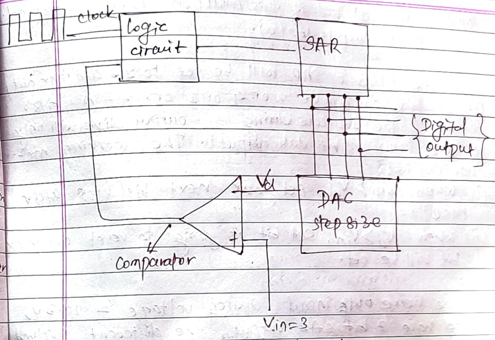


fig: Block diagram of successive approximation type ADC

The construction consists of replacement of n bit counter of counter type ADC to successive approximation register (SAR) in which it is having inbuilt algorithm. All of the remaining construction is same as counter type. Here what ever the SAR value is generated that is converted to analog using DAC and that obtained analog is compared with our input voltage and if the input voltage is greater than DAC output, it will be equal to 1 and the whole circuitry system works otherwise it won't work.

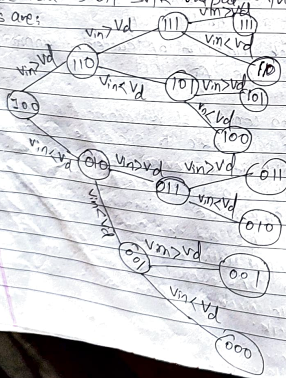
i.e. always the +ve voltage must be high than -ve voltage of OP Amp to make the o/p of op Amp high (1) and if this condition is not satisfied, output of op Amp is low (0).

Here the MSB of SAR will be set to 1 and the outputs of SAR could be 3 or 4 or 2 or ... n bits. for eg: if we are considering 3, output lines will only be 3 (only 3 bit data output). The working mechanism is:

(i) when $V_{in} > V_d$, set your next bit (i.e after MSB)

(ii) when $V_d > V_{in}$, set bit is going to reset and next bit will be set.

Say we have input analog voltage = 10.3V, and we have 3 bit SAR output, the different involved steps are:



So in 3 clock cycles, we compared all the results. So, the time complexity is N. As we were give 10.3 V analog data, since the V_d can be smaller or larger than input voltage, so we show all the possible steps in heirarchical above below.

Thus, for N bits, successive approximation type ADC takes N cycle which is very very small time than 2^{n-1} taken by counter type ADC. The only downside of this circuit, it has its complex circuit but the pros is that it performs way more faster.

⑥ The output of LVDT is connected to a 5V voltmeter through an amplifier with amplification factor of 250. An output of 4mV appears across the terminals of LVDT when the core moves through a distance of 0.5mm. Calculate the sensitivity of LVDT and that of whole setup. The milli-voltmeter scale has 200 divisions. The scale can read 1/5 of a division. Calculate the resolution of the instrument in mm.

Ans