CHAPTER-1

Instrumentation → Yevta + technology ko jaste physical and chemical properties of material ko measure and control gascha e.g. washing machine, fanetc.

Instrument → device which measure physical quantity.

Process Instrumentation → Instrument to use Measure and control gasnako lagi hune process.

Component of Instrumentation → Quantity to be Measured → Primary sensing element → variable conversion element → variable manipulation element → data transmission element → data presentation element

Signal conditioning & transmission → Yesle transducer paxi output anusas ko signal lai amplify, filter, ADC conversion garna. e.g. amplifier, ADC

Signal → Something that passes information.

Types → continuous & discrete time → deterministic & random → even and odd etc.

CHAPTER-2

Unit → funai object lai measure garna chaine physical representation unit of measurement.

Standard Measurement → yo physical representation unit of measurement.

Types ① International ② Primary ③ Secondary ④ working standard

IEEE → (Institute of electrical & electronics engineering):
→ Yesle chai instrument hasu to procedure, nomenclature, definition dinxa.

Measurement Instrument → Yesle physical variable lai numerical value ma change garxa.

Term used in measurement → Accuracy → Precision → sensitivity → Resolution.

Error → difference between actual value and instrument ley lapda aako value

Types → gross → random → systematic → Instrumental
                                            → environmental.

Performance parameters

- **Static characteristics** → Yesto system jun chai time anusas varry hudaina.
  - To check → Accuracy → Precision → Static error → drift → dead zone → linearity.

- **Dynamic characteristics** → Yesto system jun time anusas varry huncha.
  To check → speed of response → measurement lag → fidility → dynamic errors.

Bridges → **Wheatstone bridge** → Yesle unknown resistance patta lagaucha → Yesma galvanometers must be null.

① **Kelvin's Bridge** → Yesma galvanometers balance chaunxa ra galvanometers current nikalna help garna.

② **Maxwell bridge** → Yesle unknown inductance patta lagaucha, Quality factor must be 1<Q<10

③ **Hay bridge** → Yesle unknown inductance patta lagnxa, Quality factors must be greater than 10.

④ **Schering bridge** → Yesle unknown capacitance patta lagaunxa.

Normal distribution → type of continuous probability ho → $Z = \frac{x-M}{\sigma}$

CHAPTER-3

Physical variable → are the variable to be measured in an instrumentation system.

① **Process variable** → Yesma, temp, pressure variable parxa.
   → Electrical variable → Yesma, LVDT, thermocouple, spring garna.

② **Mechanical variables** → Yesma (linear velocity lai angular velocity ma change garna chainxe)

③ **Biophysical variable** → Yesma ECG ECG (Electro cardio graph) EEG (Electro Encephalo graph).

I/p characteristics of transducer
- Input type and operating range
- loading effect

O/p characteristics of transducer
- electrical output characteristics
- output impedance → useful output range

Resistive transducer e.g → strain gauge → potentiometer.

Application → It is used to measure force, displacement and pressure.
→ Yesma resistance change hunxa due to change in temp.

Capacitive transducer → e.g. C_A, area overlapping transducer C/lindrical / tandem
Application → It is used to measure angular, linear and angular velocity.
→ It measure humidity in gases and measure volume liquid level density etc.

Inductive transducer
- by variation of self inductance → by variation of Mutual inductance
- by production of eddy current.
e.g. LVDT, voltage source (i.e ball effect)

Hall effect → stripof conductor ma current carring gariyeko cha in presence of transverse magnetic field is known as hall effect.

Application → Yesle displacement lai voltage ma change garxa.
→ Measure dynamic motion.

Calibration → Yesle instrument lai primary standard wa secondary standard sanga standardized garxa.

Basic requirements of transducer
(a) Ruggedness (b) linearity
(c) Repeatability (d) Highly Reliability and stability
(e) good dynamic response.

Error in transducer
(i) Scale errors ──→ Zero error
                       → sensitive "
(ii) dynamic errors, ──→ non continuity error
(iii) error due to noise → hysteresis.

Selection of transducers
- Range → Sensitivity → Electrical o/p characteristics → physical environment

Classification of transducer
- on the basis of transduction form → As primary and secondary transducers
- Active and passive transducers → As analog and digital transducers.

Transducer → is a device which converts physical quantity to electrical quantity
e.g. LVDT, Microphone.

data transmission → is the process which information regarding the quantity measured is transferred to a remote location.

Types

(A) Wired data transmission

- Types ① Twisted pair → Yo chai two insulated copper wire spiral pattern ma hunxa
  egtelephone
  Advantages → more reliable → easy to work → less weight
  Disadvantages → less bandwidth → susceptibility inference bodi hunxa.

② Co-axial cable both two conduction has common centre is known as co-axial.
  Advantages → more bandwidth → less susceptibility Interference
  Disadvantages → long distance to lagi expensive hunxa → bulky eg LANS.

③ Optical cable → Yesma core, cladding ra jacket hunxa teslai optical cable
  Advantages → sabai band badi bandwidth hunxa, smaller size, light weight
  Disadvantages → expensive hunxa short distance ko lagi, require highly skilled installer.

(B) Wireless data transmission

eg ① Terrestrial microwave → Yo tasai region ma use hunxa.
  → parabolic dish → line of sight → focused beam

② Satellite microwave → Yo chai thula thula pahad vayeko tau ma use hunxa.
  → Yesle pahila signal receive garxa ani arko tarma transmit garxa.

③ Broadcast radio → Yesma omnidirectional antena used hunxa,
  e.g. AM radio.

④ Infrared → Infrared light use garxa eg TV remote.

Transmission schemes → Yesma transmitter and receiver both are participant in everytime of interval.

Modes of Transmission → parallel l serial modes
  → simplex l half duplex l duplex mode.

Data Acquisition system → Yesle data acquire garxa manipulates and transmission garne kaam garxa.

Types:

① Analog data acquisition system	② Digital data acquisition system
- Yesma analog form ma data acquire hunxa. Uses form	Yesma digital form ffi data acquire hunxa. Used form
- transducer, signal conditioning, multiplexer, integral equipment, Analog recorders, Analog computer, high speed equipment	- transducer, signal conditioning, multiplexers, signal converters, A/D converters, Digital recorders, Auxiliary equipment

Indicating Instrument →

Types of Recorders ① Graphic recorders ② Oscillographic recorders ③ Magnetic tape recorders
  - ship chart recorder (x-t recorder)
  - x-y recorders.

Ship chart Recorder → Yesma kunai yeuta wa tyo vanda badi variable time ma dependent hunxa l e.g. scan → Yesma stylus moves in horizontal pages in vertical

X-Y recorder → Yesma kunai yeuta wa tyo vanda badi dependent variable yeuta dependent variable ma dependent hunxa.
  - Yesma papers in stationary - stylus moves in vertical
  e.g. used in zener diode, rectifiers, Brake Hysterisis curve

Magnetic tape recorders → Yesma data Magnetic form ma record hunxa
  e.g. tape recorder.

Strain gauge → are used for Measurement of strain and associated stress in experimental stress analysis.

Application →

CHAPTER-4

Signal conditioning → the signal conditioner takes the output from the censor and converts it into suitable condition. eg. op Amp.

Importance → Yesle voltage lai amplify & filters garna we help garna.
→ Yesle output signal lai manupulate garna, (i.e., addition, substraction integrator, differential)

Signal amplification → Yesle low voltage signal lai high voltage signal ma convert garnu.

Filtering → Yesle unwanted noise than lai reduce garnu.

OP AMP	Instrumentation amplifier
- Yesma voltage gain dhedai ekdamdherai hunxa.	- Yesma voltage gain finite hunxa
- Yesle Adding, comparing, integrating & differentiating	- Yesma op Amp ma jeto operation garnu aldaina.
e.g. radio & TV	- eg, heart beat, blood pressure

Isolation Amplifier → Yo chai buffer amplifier jastai ho jaha feedback resistance (Rf)=0 छैन so, A=1 and Vi = Vo hunxa!

Amplifiers Application
→ It is used to increase the power,
→ It is used to current or voltage of signal pattlagana
→ It is used in TV & radio.

Interference signal → Youta signal ma arko noise ley interface garnu lai Interference signals vanxa.

Main path for interference
① single coupled input & output ② capacitive coupling ③ inductive coupling
④ magnetic coupling ⑤ ff coupling

Elimination
- Direct coupled eliminated by using ground planes.
- magnetic coupling or inductive coupling eliminated by using paid.
- ff coupling eliminated by using shielding.

Instrumentation amplifier → It is used to dedicated differential amplifier optimized for high input impedance and high common mode rejection ratio.

LVDT → linear variable differential transformer.
→ It is most widely used inductive transducer jasle linear motion lau electrical signal ma change garnu.

Signal conversion

Why analog is converted to digital form
→ because digital form gives more accuracy
→ and digital form reduces noise.

Analog to digital converter
① **Successive Approximation ADC (potentiometric type)**
Advantages → more reliable → more accurate → fast kaam garna.
Disadvantages → cost badi lagcha → complexity hunxa.

② **Dual slope or Integrating type ADC.**
Advantages → good accuracy conversion — low cost.
Disadvantages → slow speed of operation

③ **Stair case Ramp Type (counting type) ADC.**
Advantages → easy to count → simple circuit
Disadvantages → time consuming →

④ **Flash (parallel) type ADC**
Advantages → High speed, easy & fast ADC.
Disadvantages → large no of comparator are required.

Digital to Analog conversion
① **Weighted Resistor Network (WRN) DAC.**
Advantages → easy principle (construction — fast conversion
Disadvantages → numbers of n-bit increases complexity of circuit also increases

② **R-2R ladder Network DAC**
Advantages → cheap and easy to manufacture → only two register values.
Disadvantages → slower conversion rate.

OPAMP → Yesma voltage gain ekdam dherai hunxa.
Modes of opAMP → ① Non inverting Mode ② inverting Mode

Characteristics of opAMP
- infinite input impedance
- zero output impedance
- infinite input impedance
- signal to noise ratio

Application.
→ Inverter =) $V_0 = -Vi$ if Rf = Ri
→ Adder =) $V_0 = -(V_1 + V_2 ... + V_n)$ if Rf = R_1 = R_2 = R_n
→ Subtraction =) $V_0 = (V_2 - V_1)$ if R_1 = R_f = R_2 = R_3 = R
→ Multiplication & divider
→ Integrator — differentiator