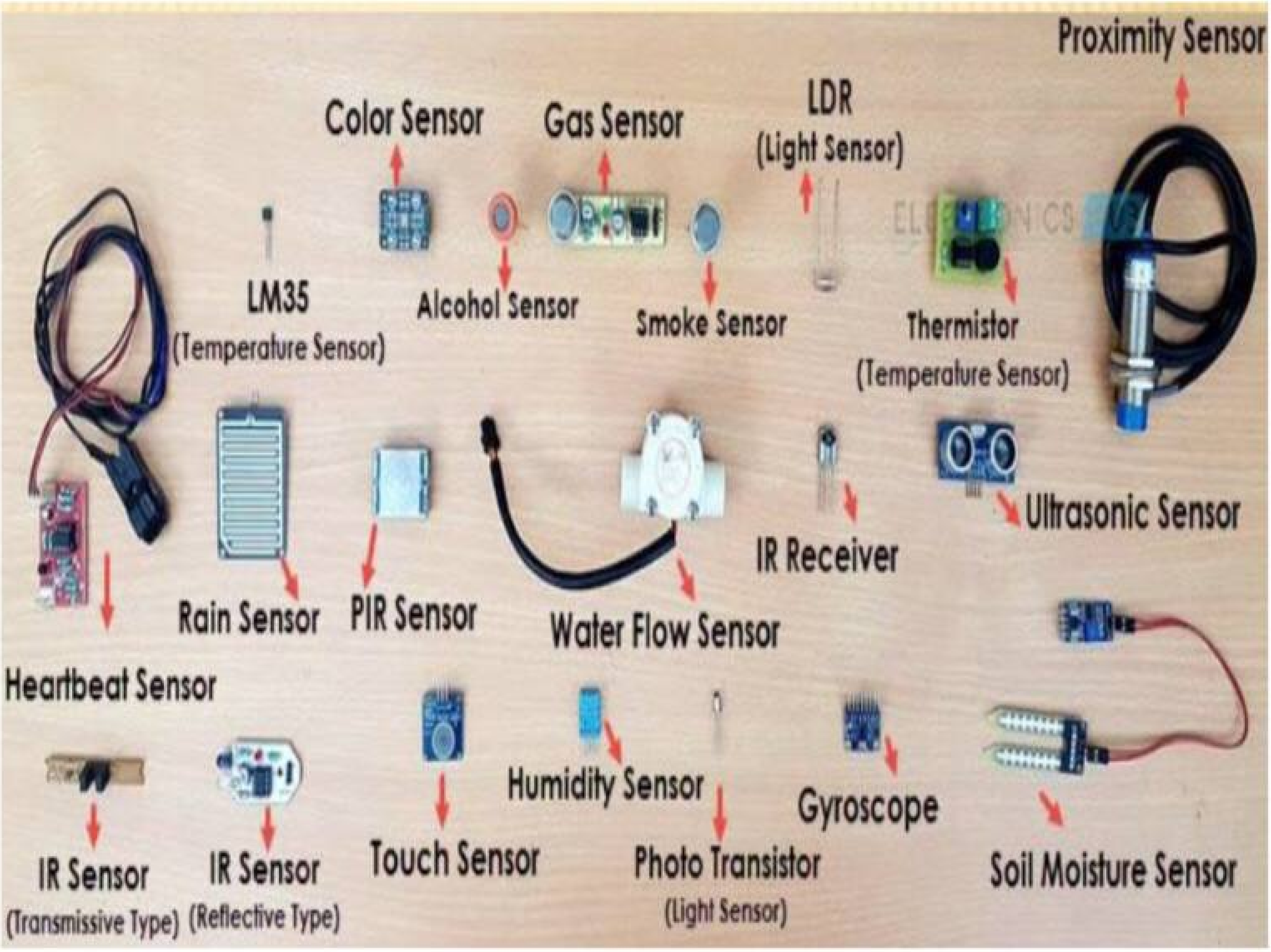
محاضره 2

أجهزه طبيه

SENSORS AND ACTUATORS



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Lecture notes on Sensors and Actuators

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III	BMTF183T60	Sensors and Actuators	3

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INDEX

Aim & objectives: To study the various instruments displays and panels in the aircraft and to discuss the cock pit layout. The objective of the study of aircraft instrumentation is to know the functions of all the flight, gyroscopic and power plant instruments in the aircraft and enable the learners to rectify the problems occurring in the aircraft.

Prerequisite: Basic electronics, Measurements and Instruments

SYLLABUS:

UNIT – I SENSORS

Difference between sensor, transmitter and transducer - Primary measuring elements - selection and characteristics: Range; resolution, Sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, Response time, Dead band. Signal transmission - Types of signal: Pneumatic signal; Hydraulic signal; Electronic Signal.

Principle of operation, construction details, characteristics and applications of potentiometer, Proving Rings, Strain Gauges, Resistance thermometer, Thermistor, Hot-wire anemometer, Resistance Hygrometer, Photo-resistive sensor.

UNIT- II INDUCTIVE & CAPACITIVE TRANSDUCER

Inductive transducers: - Principle of operation, construction details, characteristics and applications of LVDT, Induction potentiometer, variable reluctance transducer, synchros, microsyn.

Capacitive transducers: - Principle of operation, construction details, characteristics of Capacitive transducers – different types & signal conditioning- Applications:- capacitor microphone, capacitive pressure sensor, proximity sensor.

UNIT III ACTUATORS

Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria.

Electrical actuating systems: Solid-state switches, Solenoids, Electric Motors- Principle of operation and its application: D.C motors - AC motors - Single phase & 3 Phase Induction Motor; Synchronous Motor; Stepper motors - Piezoelectric Actuator.

UNIT IV MICRO SENSORS AND MICRO ACTUATORS

Micro Sensors: Principles and examples, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors.

Micro Actuators: Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of micro actuators- Electrostatic, Magnetic, Fluidic, Inverse piezo effect, other principles.

UNIT V SENSOR MATERIALS AND PROCESSING TECHNIQUES

Materials for sensors: Silicon, Plastics, metals, ceramics, glasses, nano materials
Processing techniques: Vacuum deposition, sputtering, chemical vapour deposition, electro plating, photolithography, silicon micro machining, Bulk silicon micro machining, Surface silicon micro machining, LIGA process.

TEXT BOOKS

1. Patranabis.D, "Sensors and Transducers", Wheeler publisher, 1994.
2. Sergej Fatikow and Ulrich Rembold, " Microsystem Technology and Microbotics", First edition, Springer –Verlag NEwyork, Inc, 1997.
3. Jacob Fraden, "Hand Book of Modern Sensors: Physics, Designs and Application" Fourth edition, Springer, 2010.

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1. Robert H Bishop, "The Mechatronics Hand Book", CRC Press, 2002.
2. Thomas. G. Bekwith and Lewis Buck.N, Mechanical Measurements, Oxford and IBH publishing Co. Pvt. Ltd.,
3. Massood Tabib and Azar, "Microactuators Electrical, Magnetic, thermal, optical, mechanical, chemical and smart structures", First edition, Kluwer academic publishers, Springer, 1997.
4. Manfred Kohl, "Shape Memory Actuators", first edition, Springer.

UNIT – I SENSORS

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THEORY

1. BASICS – MEASUREMENT DEVICES

Measurement devices perform a complete measuring function, from initial detection to final indication. The important aspects of measurement system are

i) Sensor – Primary sensing element
ii) Transducer – changes one form of energy to another form energy
iii) Transmitter – Contains the transducer and produces an amplified, standardized energy signal.

INTRODUCTION – SENSORS

- A device which provides a usable output in response to a specified measurand.
- Sensor is a device that detects and responds to some type of input from the physical environment
- Input could be light, heat, motion, moisture, force, pressure, displacement, etc.
- It produces a proportional output signal (electrical, mechanical, magnetic, etc.).
- Human beings are equipped with 5 different types of sensors.
- Eyes detect light energy, ears detect acoustic energy, a tongue and a nose detect certain chemicals, and skin detects pressures and temperatures. The eyes, ears, tongue, nose, and skin receive these signals then send messages to the brain which outputs a response.
- For example, when you touch a hot plate, it is your brain that tells you it is hot, not your skin.

Fig. 1. Sensors of human beings.

2. THE BASIC BIOLOGICAL SENSING PROCESS

- A stimulus is received at the receptor where the dendrites of the neurons convert the energy of the stimulus into electromechanical impulses in the dendrites of the neurons.
- The action potentials interpreted by the brain to create the corresponding sensory perception

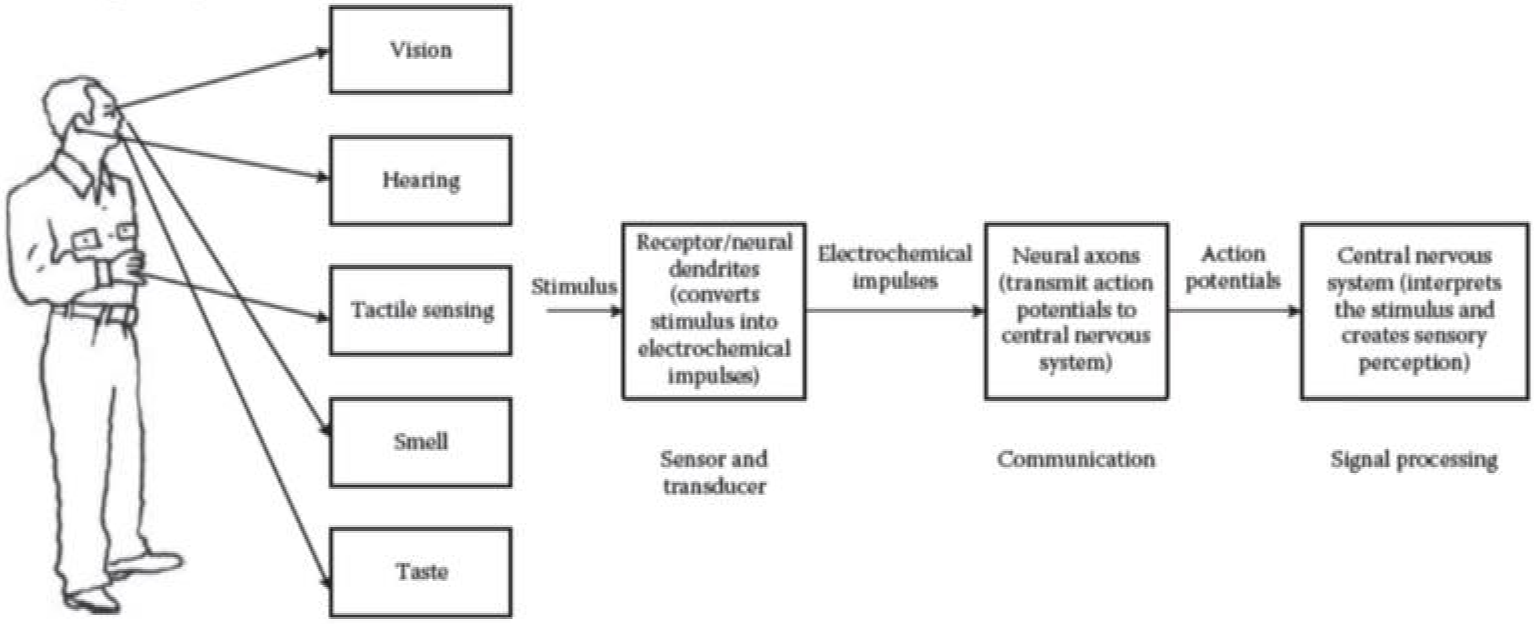

Fig.2. Sensing Process

3. PHYSICAL PRINCIPLES

Amperes's Law

A current carrying conductor in a magnetic field experiences a force (e.g. Galvanometer)

Curie-Weiss Law

There is a transition temperature at which ferromagnetic materials exhibit paramagnetic behaviour

Faraday's Law of Induction

A coil resist a change in magnetic field by generating an opposing voltage/current (e.g. transformer)

Photoconductive Effect

When light strikes certain semiconductor materials, the resistance of the material decreases (e.g. photo resistor)

4. NEED FOR SENSORS

- Sensors are omnipresent. They embedded in our bodies, automobiles, airplanes, cellular telephones, radios, chemical plants, industrial plants and countless other applications.
- Sensors in industrial applications being used for process control, monitoring, and safety, and in medicine being used for diagnostics, There monitoring, critical care, and public health.
- Sensors can improve the world through diagnostics in medical applications; improved performance of energy sources like fuel cells and batteries and solar power; improved health and safety and security for people; sensors for exploring space and improved environmental monitoring.

- Without the use of sensors, there would be no automation!
- We live in the World of Sensors.
- In our day-to-day life we frequently use different types of sensors in several applications
- We can find different types of Sensors in our homes, offices, cars etc. Working to make our lives easier by turning on the lights by detecting our presence, adjusting the room temperature, detect smoke or fire, make us delicious coffee and open garage doors as soon as our car is near the door and many other tasks.

5. CHARACTERISTICS

1. Range

It is the difference between the maximum and minimum value of the sensed parameter. Temperature range of a thermocouple is 25-225°C.

2. Resolution

The smallest change the sensor can differentiate. It is also frequently known as the least count of the sensor. Resolution of an digital sensor is easily determined.

3. Sensitivity

It is the ratio of change in output to a unit change of the input. The sensitivity of digital sensors is closely related to the resolution. The sensitivity of an analog sensor is the slope of the output vs input line, or sensor exhibiting truly linear behaviour has a constant sensitivity over the entire input range.

4. Error

Error is the difference between the result of the measurement and the true value of the quantity being measured. The classification of errors are as follows:

- Bias errors (systematic errors)
- Precision (Random errors)

Bias errors are present in all measurement made with a given sensor and cannot be detected (or) removed by statically means.

5. Accuracy

It is the difference between measured value and true value.
The accuracy defines the closeness between the actual measured value and a true value.

6. Precision

Precision is the ability to reproduce repeatedly with a given accuracy.

7. Repeatability

The ability of a sensor to give same output for repeated applications of same input value.
Repeatability = (maximum – minimum values given) X 100 / full range

8. Impedance

It is the ratio of voltage and current flow for sensor. For a resistive sensor, the impedance Z is same as the resistance R& its unit is ohms.

$Z_R = V/I = R$

9. Response time

Response time is the amount of time required for a sensor to respond completely to a change in input. It describes the speed of change in the output on a step-wise change of the measurand.

10. Linearity

Percentage of deviation from the best fit linear calibration curve

Non-Linearity

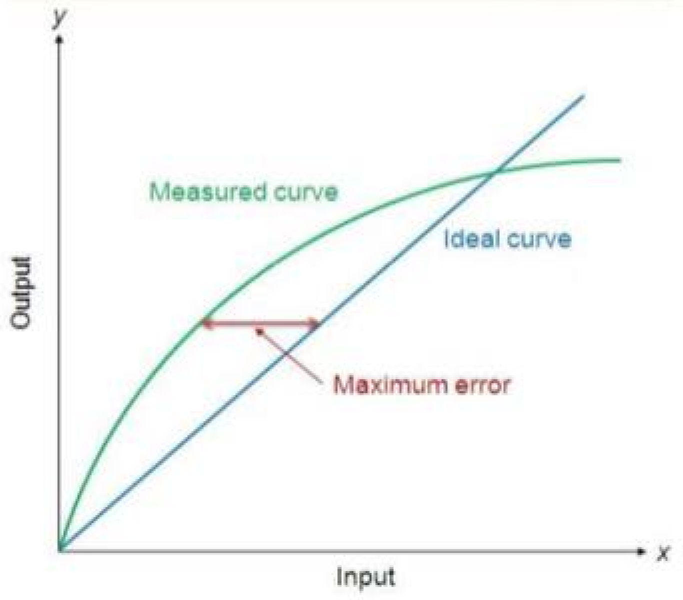

Fig. 3. Non linearity

The nonlinearity indicates the maximum deviation of the actual measured curve of a sensor from the ideal curve.

Nonlinearity (%) = Maximum deviation in input / Maximum full scale input

11. Dead band/time

The dead band or dead space of a transducer is the range of input values for which there is no output. The dead time of a sensor device is the time duration from the application of an input until the output begins to respond or change.

12. Backlash

In engineering, backlash, sometimes called lash or play, is a clearance or lost motion in a mechanism caused by gaps between the parts.

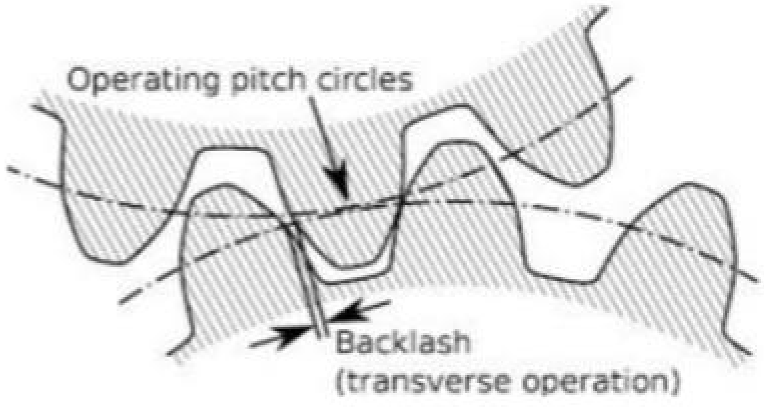

Fig. 4. Backlash

6. SIGNAL TRANSMISSION

- Pneumatic signal – Pneumatic Signal is pressure of a gas (or air) in a pipe, instead of electrical current. It is difficult to control very low pressures accurately with a simple regulator, plus you have to provide vacuum to allow for calibration and measurement hysteresis & repeatability errors.
- Hydraulic signal -Hydraulic signals are self-propagating changes in water (fluid) pressure.
- Electric signal - An electrical signal is a voltage OR current which conveys information, usually it means a voltage.

7. STANDARD SIGNAL TYPES

Most modern equipment works on the following standard signal ranges

- Electric – 4 to 20 mA
- Pneumatic – 0.2 to 1.0 bar (or) 3 to 15 psi
- Digital standards

The advantage of having a standard range is that all equipment is sold readily calibrated. This means that minimum signal (temperature, speed, force, pressure and so on)is represented by 4 mA or 0.2 bar and the maximum signal is represented by 20 mA or 1.0 bar.

8. HYDRAULIC SIGNAL TRANSMISSION SYSTEM

- The hydraulic systems consists a number of parts which include storage tank, filter, hydraulic pump, pressure regulator, control valve, hydraulic cylinder, piston and leak proof fluid flow pipelines.
- The output shaft with piston transfers the motion or force however all other parts help to control the system.