Section-V
Signal Conditioning, Transmission & Processing

Introduction

- "First stage" of the instrumentation which detects the measureand is termed as **Detector-transducer stage**.
- The o/p needs certain modifications for making compatible with data presenting stage, carried out in an intermediate stage a. k. a. **s/g conditioning stage**.
- **Last stage-** consist of indicating, recording, displaying, data processing elements.

- Measurement of dynamic mechanical quantities places special requirements places special requirements on the elements in the signal conditioning stage.

Electrical s/g conditioning

Why ESC..???

- When amplification is required frictional forces are also amplified, resulting in considerable undesirable signal loading. These effects, coupled with backlash & elastic deformation, result in poor response.
- Initial loading results in reduced frequency response & in certain cases, depending on the particular configuration of the system, phase response is also a problem.

Advantages:

- For converting resistance change to voltage change;
- Subtracting offset voltages;
- Increasing s/g voltages;
- Removing unwanted frequency components.

Functions of s/g Conditioning Equipment

- Amplification
- Modification/Modulation
- Impedance Matching
- Data Processing
- Data Transmission

Functions of s/g Conditioning Equipment

Amplifications:

- Enhance the s/g level (which are in low level range).
- It should bring the level of transducer s/g to a value adequate enough to make it useful for
  - Conversion
  - Processing
  - Indicating
  - Recording

Functions of s/g Conditioning Equipment

Modification/Modulation:

- To change the form of s/g.
- Smoothening
- Linearizing
- Filtering
- Converting into digital form

Impedance Matching:

- Arranges the i/p, o/p impedances of the matching devices so as to prevent loading of the transducer & to maintain a high s/g level at the recorder.

Functions of s/g Conditioning Equipment

Data Processing:

To carry out mathematical operations (e.g., addition, subtraction, differentiation, integration etc.) before indication or recording of data.

Data Transmission:

To transmit s/g from one location to another without changing the contents of the information.

Amplifier

- A device used to augment the weak s/g.
- Can be operated on mechanical, optical, pneumatic and hydraulic, or electrical & electronic principles.
- For an amplifier;

$$G = I_0/I_i$$

where G: gain, amplification or magnification.

Classifications:

i. Mechanical amplifiers
ii. Fluid amplifiers
iii. Optical amplifiers
iv. Electrical/Electronic amplifiers

Mechanical Amplifiers

Simple & Compound Levers: Self explanatory.

e. g. Huggenberger extensometer

Simple & Compound Gears: Self explanatory.

e.g. Compound gear train.

Limitations:

- Internal loading
- Elastic Deformation
- Friction at the mating parts
- Backlash

Fluid Amplifiers

- **Hydraulic amplifiers**: Hydraulic Ram (relate with principle of pressure measurement).

  e.g. mercury-in-glass thermometer & single column manometers.

- **Pneumatic amplifiers.**

Optical Amplifiers

Principle: light ray strikes----angle of incidence = angle of reflection----now rotate the mirror by θ---- angle of incidence becomes (i + θ).

angle of incidence;

before rotation = 2i

After rotation = 2(i+ θ)

- Hence angular magnification of 2θ b/w incidence and reflected rays.

By increasing the no of mirrors, angle can be further modified.

Electrical/Electronic Amplifiers

- Used to amplify voltages, current s/g,s.

Characteristics:

- High i/p impedance for min. loading effect on transducer.
- Low o/p impedance.
- Good frequency response as that of transducer.

A. C. & D. C. Amplifiers

Consist of;

- A.C. coupled amplifiers
- D.C. amplifiers

A.C. amplifiers:

- only capable of dealing with rapid, repeatitve s/g but are usually simpler & cheaper when compared with their D.C. counterparts.
- The amplifier drift & spurious noise are not significant; the main frequency pick-up rejection is very high.

D.C. amplifiers:

- capable of amplifying static, slowly changing or rapid-repetitive i/p s/g,s.
- easy to calibrate at low frequencies, and have the ability to recover rapidly from overload conditions.

Modulated & Unmodulated Signals

The measurand affects the carrier by varying either its amplitude or its frequency:

- If the carrier freq. = const. and its amplitude is varied by measurand, process known as Amplitude Modulation **(AM)**.
- If the carrier amplitude = const. and its freq. is varied by measurand, process known as Frequency Modulation **(FM)**.

Afterwards it is also required to extract s/g info from modulated carrier:

- Demodulated by using an "*Oscilloscope"* or "*Oscillograph*".
- The mixed s/g & carrier are demodulated by "*rectification & filtering".*
- FM demodulation includes;
  - Freq. discrimination
  - Ratio detection
  - IC phase-locked loops

Integrated Circuits (ICs)

- Group of circuit elements such as transistors, diodes, resistors & capacitors etc.
- Used to construct more complex circuit such as;
  - Differential amplifiers;
  - Mixers;
  - Timers;
  - Filters;
  - Audio preamps,
  - Auto power amplifiers,
  - Regulators & comparators,
  - Several digital devices.

Op-Amps/Attenuators

Op-Amps:

- A linear IC that has a very high voltage gain, a high i/p impedance and a low o/p impedance.
- Used for mathematical operations like “addition”, “subtraction”, “multiplication”, “division”, “integration”, “differentiation”.

Attenuators:

- To reduce the s/g level.

$$\textbf{Attenuation in dB} = 10 \log_{10}(P_i/P_0)$$

Where P is power.

Filters

- Used for attenuating the unwanted components of a measurement while permitting the desired components to pass.
- **Pass band:** band of frequencies which will pass through filter.
- **Attenuation band:** band of all remaining frequencies.

What if there is an ideal filter used???

Classifications: (Self-study)

- Low pass filters (allows low frequencies to pass)
- High pass filters
- Band pass filters (allows a band of frequencies only)
- Band stop filters

Signal Transmission

Transmitters:

- The devices used to transmit the value of the primary variable at a considerable distance from the primary elements.
- If used for long distances, known as "**telemeters**".

Different methods of data transmission: (explain in class)

- Mechanical Transmission
- Hydraulic Transmission
- Pneumatic Transmission
- Magnetic Transmission

Signal Display & Recording Devices

How to prove/present yourself if sth happened in past…???

or

How to give live coverage???

(Explain the same with practicality)

- **Display devices:** for instant observation.
- **Recorders:** for storage for observation at a later stage.

Types: explained in further slides.

Light Emitting Diode (LED)

Light energy ↔ electric current

A P-N junction diode, which emits light when forwarded biased is known as a light emitting diode (LED).

Principle: free e^- moves from N to P→ electron combines with holes → release conduction energy.

In Si or Ge diode: heat energy

In Gallium arsenide or gallium phosphide: light energy.

Advantages:

- Size = f(stock).
- light= f(current), hence smoothly controllable.
- High efficiency at moderate power.
- Economic.

Applications: (Self-study)

Liquid Crystal Display

Liquid crystal: A material, usually an organic compound, flows like a liquid at room temp.

- Sandwiched b/w two transparent glass sheets.

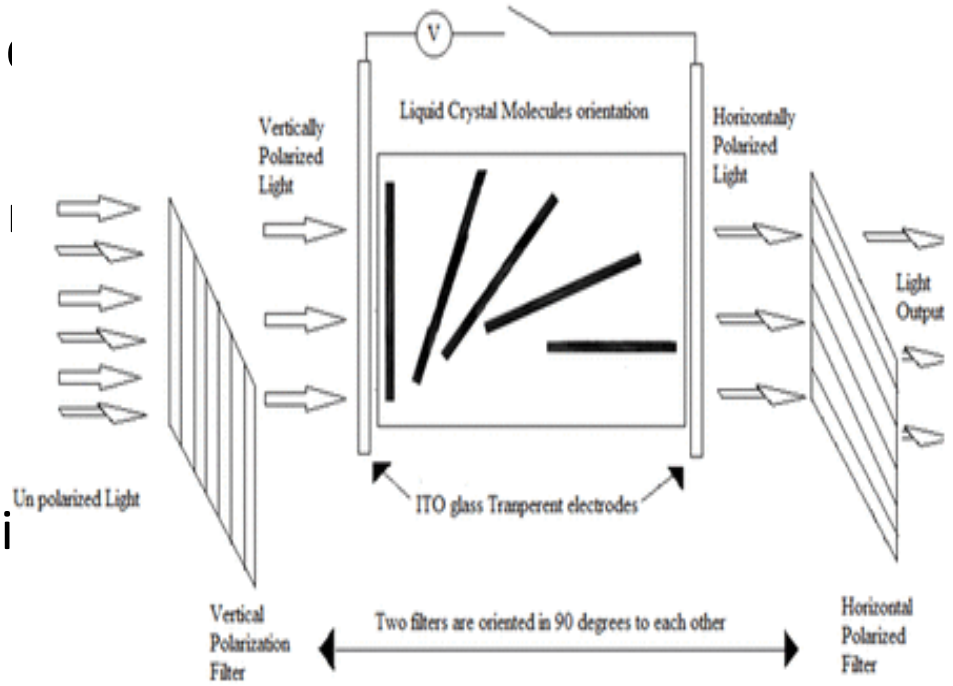
Principle: light incident on activated laver → absorbed/scattered by

Advantages:

- Extrm. Low power
- Higher life time.

Applications:

- Mobiles.
- Desk top/Laptop di
- Watches etc.



Numerical indicator Tubes (NIT)/ Hot film or Bar Tubes

Numerical indicator Tubes (NIT): (relate with time clock)

High voltage applied → gas become ionized → current flows through the gas → excited at higher energy level → emit light/glow after relaxation of energy.

Thus a particular no. is displayed.

Hot film or Bar Tubes:

- Hot filament consist of small bars of light emitting tubes.
- By using same (as stated above) principle, they display characters.

Digclampter/Digital Tach

- Use lab. for full specification/Explanation.

Types of Recorders:

1. Analog Recorders:

(i) Graphic recorders

(a) Strip chart recorders

- Galvanometer type
- Null type
- Potentiometric recorders
- Bridge recorders
- LVDT recorders

(b) X-Y recorders

(ii) Oscilloscope recorders

(iii)Magnetic tape recorders

2. Digital recorders

Strip Chart Recorders

Principle/working: A stylus driving system which moves the stylus in nearby exact replica or analog of the quantity being measured (A spring wound mechanism may be used but in most of the recorders a synchronous motor is used for driving the paper).

Marking Mechanism: ink filled/ he ric/ electrostatic/ optical stylus.

Tracing System: Curvilinear/Rectiline

Classifications:

i. **Galvanometer type:** deflection

ii. **Null type:** Comparison basis pr

   a) Potentiometric recorders
   b) Bridge recorders
   c) LVDT recorders

RD200 Strip Chart Recorder

X-Y Recorders

- An instrument which gives a graphic record of the relationship between two variables.
- Consist of a pen which can be positioned along two axis with the writing paper remain stationary. **(relate with UTM machine).**
- there are two amplifier units one amplifier actuates the pen in Y-direction as the i/p s/g is applied, while second does the same in X-direction.
- Pen is controlled by means of a motor, pulleys and a linear potentiometer.
- An emf is plotted as a fn. of another emf.
- Examples:
  - Stress strain curves/P-V diagrams for IC engines./R-T diag./Speed torque characteristics etc.

Magnetic Tape Recorders

Consist of

- Recording head
- Magnetic tape
- Reproducing head
- Tape transport mechanism
- Conditioning devices.

Advantages:

- Low distortion
- Wide frequency range
- Immediate s/g available
- s/g can be played back/reproduced.
- Multi Channel recording possible

Ultra-Violet Recorders

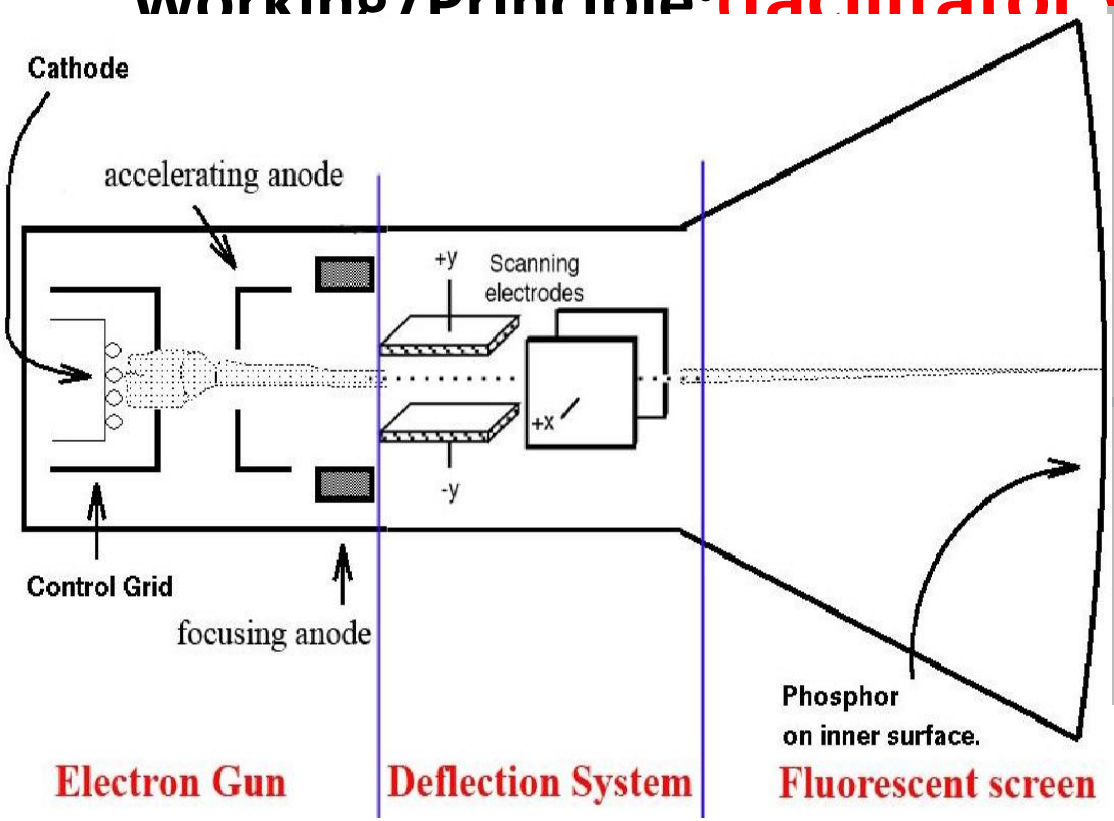
(Self-Study)

Cathode Ray Oscilloscope (CRO)

- An instrument which present s/g waveforms visually.
- Has the ability to hold the display for a short/long time for many hours.
- **<u>Cathod Ray Tube</u>: (Heart of an oscilloscope)**
- **<u>Components</u>: (Explain the fn. of each component if asked in exam)**
  - Electron gun
  - Focusing & accelerating anodes
  - Horizontal & vertical deflecting plates
  - An evacuated glass envelope with a phosphorous screen.

Cathode Ray Oscilloscope (CRO)

Working /Principle: (facilitator will explain by



Cathode Ray Oscilloscope (CRO)

Applications

- Tracing of an actual waveform of current/voltage.
- Determination of amplitude of a variable quantity.
- Comparison of phase & frequency.
- In television.
- In RADAR.
- For finding B.H. curves for hysterises loop.
- For engine pressure analysis.
- For studying the heartbeats.
- For engine pressure analysis.
- For tracing transistor curves.

Components of Aircrafts

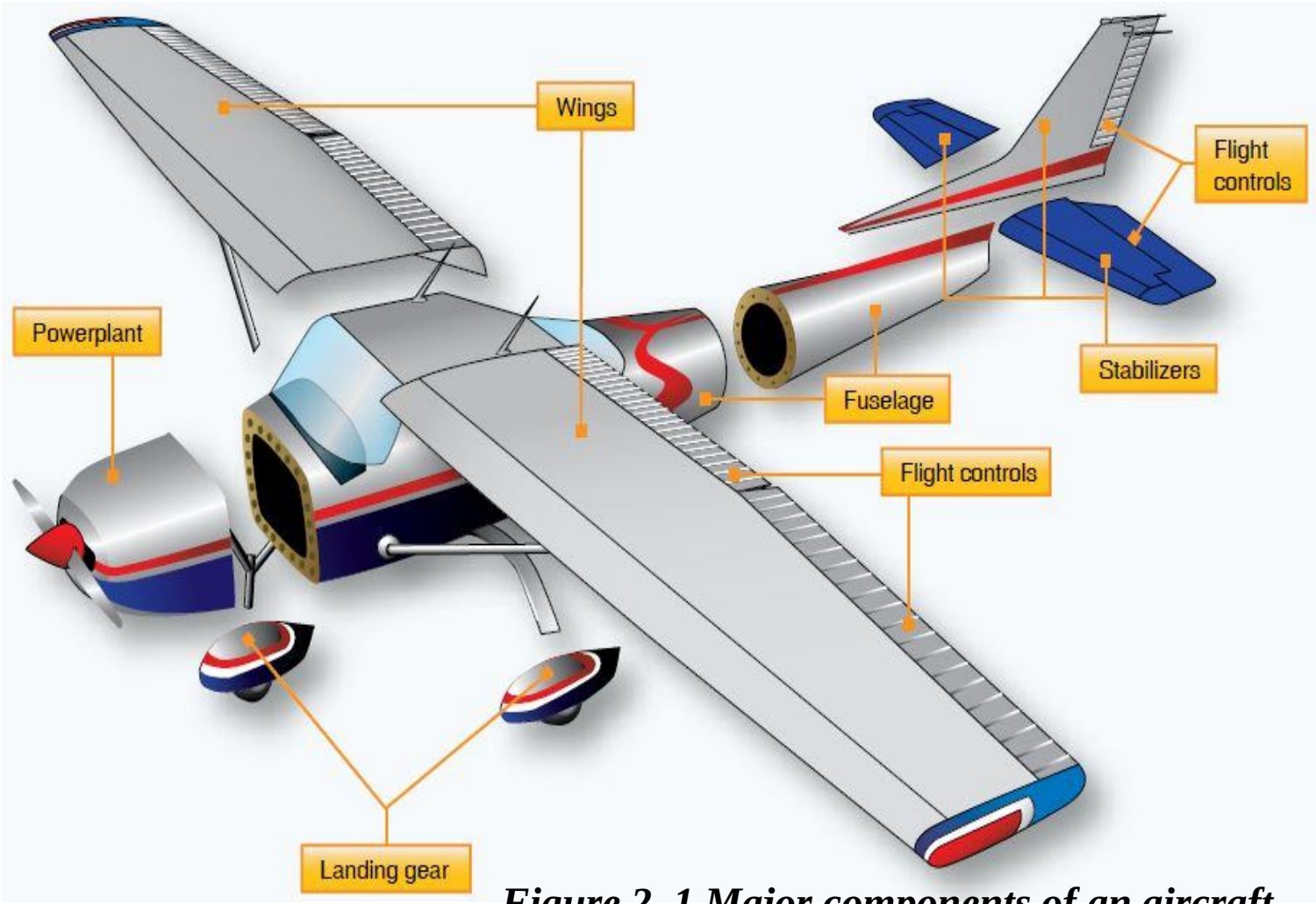


Figure 2. 1 Major components of an aircraft.