ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY
AUTONOMOUS INSTITUTION
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Anjugramam - Kanyakumari Main Road, Palkulam, Variyoor P.O. - 629 401, Kanyakumari District.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VII Semester

AU3008 Sensors and Actuators

UNIT – 2 - Variable Resistance and Inductance Sensors

2.8 EI Pick up (Electrical Instrumentation Pick up)

Electrical Instrumentation Pickups are specialized transducers that convert mechanical energy into electrical signals. They are widely used in various industries, including manufacturing, aerospace, and automotive, to monitor and control equipment performance.

Common Types of Electrical Instrumentation Pickups:

1. **Magnetic Pickups**: These sensors detect changes in magnetic fields caused by the movement of metal parts. They are often used in speed sensing applications, such as measuring the rotational speed of machinery.
2. **Piezoelectric Pickups**: These generate electrical voltage when subjected to mechanical stress, such as pressure or vibration. They are often used in pressure sensors, accelerometers, and vibration monitors due to their sensitivity to dynamic changes.
3. **Inductive Pickups**: Inductive pickups measure the proximity or displacement of a metallic object by detecting changes in inductance. These are commonly used in position sensors and proximity switches.
4. **Capacitive Pickups**: These measure changes in capacitance to detect variations in displacement or material properties. Capacitive pickups are used in applications that require high precision, such as fluid level sensors and proximity detection.

Other Pick-ups:

1. **Voltage Pick-up**: A voltage pick-up measures the voltage of an electrical signal. It is commonly used to measure the voltage of a circuit or to monitor the output of a voltage source.
2. **Current Pick-up**: A current pick-up measures the current flowing through an electrical circuit. It is commonly used to measure the current drawn by a device or to monitor the flow of current in a circuit.
3. **Power Pick-up**: A power pick-up measures the power consumed by an electrical circuit. It is commonly used to measure the power consumption of a device or to monitor the power consumption of a circuit.
4. **Strain Gauge Pick-up:** A strain gauge pick-up measures the strain or deformation of a material due to mechanical stress. It is commonly used to measure the stress or pressure in a mechanical system.
5. **Thermocouple Pick-up**: A thermocouple pick-up measures the temperature of an object or system. It is commonly used to measure the temperature of a process or to monitor the temperature of a system.

How Electrical Instrumentation Pick ups works:

1. Electrical signals are generated by devices such as sensors, transducers, and instruments.
2. The signals are transmitted through wires or cables to the instrumentation pick-up.
3. The pick-up converts the electrical signal into a physical signal that can be measured by an instrument.
4. The physical signal is then measured by an instrument such as a meter, oscilloscope, or computer.
5. The measurement is then displayed on a screen or printed out for further analysis.

Applications of Electrical Instrumentation Pick-ups:

1. **Industrial automation**: Electrical instrumentation pick-ups are used in industrial automation systems to monitor and control processes.
2. **Power generation and distribution**: Electrical instrumentation pick-ups are used in power generation and distribution systems to monitor and control power flow.
3. **Medical devices**: Electrical instrumentation pick-ups are used in medical devices such as ECG machines, blood pressure monitors, and ultrasound machines.
4. **Aerospace:** Electrical instrumentation pick-ups are used in aerospace systems to monitor and control systems such as navigation, communication, and propulsion.
5. **Research and development**: Electrical instrumentation pick-ups are used in research and development applications to measure and analyze electrical signals.
6. **Vibration Monitoring:** Detecting and diagnosing mechanical faults in machinery.
7. **Process Control:** Ensuring optimal operation of industrial processes.
8. **Structural Health Monitoring:** Assessing the integrity of structures.
9. **Machine Condition Monitoring:** Predicting equipment failures and reducing downtime.
10. **Safety Systems:** Protecting personnel and equipment from hazards.

Key Considerations for Selecting Electrical Instrumentation Pickups:

- **Measurement Range:** The maximum and minimum values the pickup can measure.
- **Accuracy:** The degree of precision of the measurement.
- **Frequency Response:** The range of frequencies the pickup can measure.
- **Environmental Factors:** The ability of the pickup to withstand harsh conditions such as temperature extremes, humidity, and vibration.

- **Compatibility:** The compatibility of the pickup with the associated instrumentation and control systems.

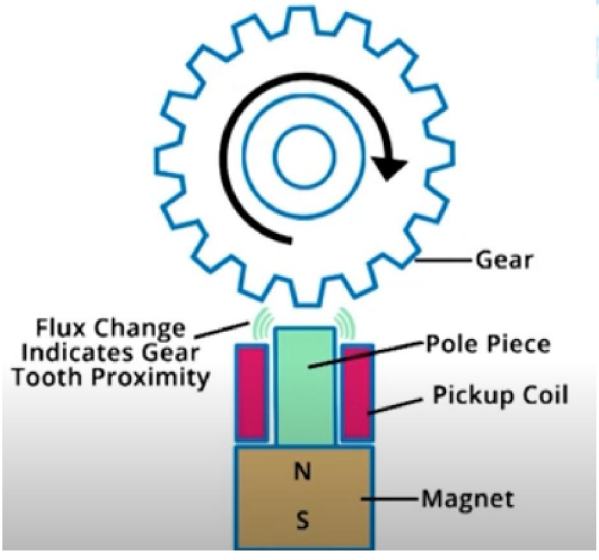
I. Construction and working of Magnetic Pick up:

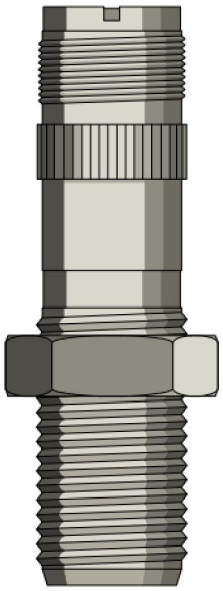
Magnetic pickups are electromechanical devices used to detect the presence or absence of a ferrous metal object. They work on the principle of electromagnetic induction.

Construction:

A typical magnetic pickup consists of:

1. **Permanent Magnet:** This generates a constant magnetic field.
2. **Coil:** Wrapped around the magnet, it induces an electrical current when the magnetic field changes.
3. **Housing:** A protective case that encloses the magnet and coil.

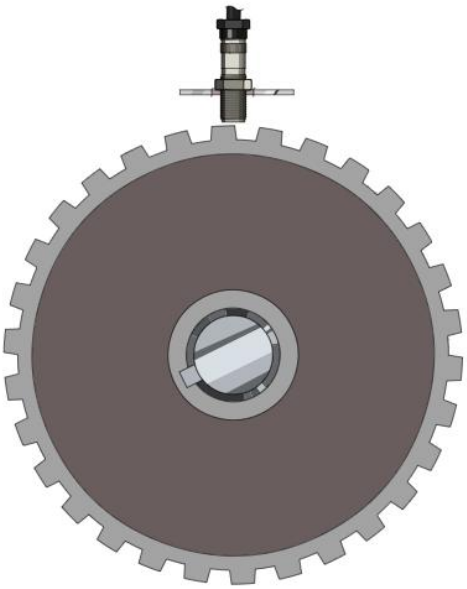




Working

1. **Idle State:** In the absence of a ferrous metal object, the magnetic field from the permanent magnet remains constant. This results in no change in the magnetic flux through the coil, and hence no induced current.

2. **Detection:** When a ferrous metal object approaches the pickup, it interacts with the magnetic field. This interaction can cause the magnetic field lines to distort or concentrate, leading to a change in the magnetic flux through the coil.
3. **Induced Current:** This change in magnetic flux induces an electrical current in the coil, according to Faraday's Law of Electromagnetic Induction. The magnitude of the induced current depends on the rate of change of magnetic flux.
4. **Output:** The induced current can be amplified and used to trigger a switch or provide an electrical signal indicating the presence of the ferrous metal object.



Applications

Magnetic pickups are widely used in various industries, including:

- **Automotive:** To detect the position of crankshaft, camshaft, and other rotating parts.
- **Industrial Automation:** For proximity sensing, speed measurement, and position control.
- **Security Systems:** In metal detectors and intrusion alarms.
- **Medical Equipment:** For detecting the presence of metal implants or foreign objects.

Advantages of Magnetic Pickups:

- **Non-contact:** They do not require physical contact with the detected object, making them suitable for applications where direct contact is undesirable or impractical.
- **Reliability:** Magnetic pickups are generally reliable and have a long lifespan.
- **Versatility:** They can be used in a wide range of applications, from simple to complex.

Limitations:

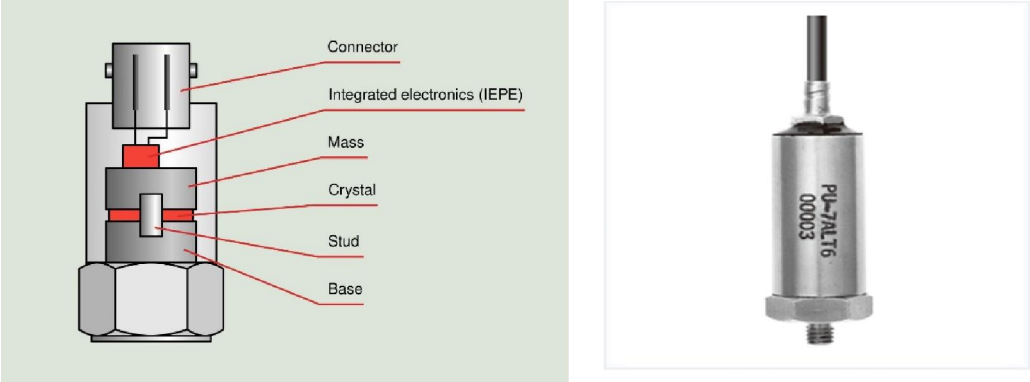
- **Sensitivity to Ferrous Metals:** Magnetic pickups can only detect ferrous (iron-containing) metals. They are not sensitive to non-ferrous metals like aluminum or copper.
- **Distance Limitations:** The detection range of magnetic pickups is limited, depending on the strength of the permanent magnet and the size of the detected object.

II. Construction and Working of Piezo-electric Vibration Pick ups:

A **piezoelectric vibration pickup** consists of the following key components:

1. **Piezoelectric Element**: This is typically a ceramic material like lead zirconate titanate (PZT), or sometimes quartz crystals. These materials generate an electric charge when subjected to mechanical stress. The piezo element can be shaped into discs, bars, or strips, depending on the application.
2. **Electrodes**: Metal electrodes are attached to the surface of the piezoelectric material. These electrodes capture the electrical charge generated by the piezoelectric effect and direct it into the connected circuitry.
3. **Backing and Mounting Material**: The piezoelectric element is often mounted on a rigid base or backing material to optimize sensitivity to vibrations. A flexible adhesive may be used to attach the pickup to a vibrating surface like a machine or an instrument.

4. **Protective Casing**: The entire assembly is encased in a protective shell to shield it from environmental factors like dust, moisture, or physical damage. This is especially important in industrial settings where vibration monitoring is critical.



Piezo electric vibration Pick ups

Piezo's are widely used in acoustic guitars to amplify their natural sound without significantly altering the tone.

Working Principle of Piezo Pickups:

Piezoelectric vibration pickups operate based on the **piezoelectric effect**, where certain materials generate an electrical charge when they undergo mechanical deformation due to vibrations or stress.

1. **Vibration or Mechanical Stress**: When the piezoelectric pickup is attached to a vibrating surface (such as a machine or instrument), the vibrations cause the piezo material to compress and expand. This results in the deformation of the crystalline structure within the piezo element.

2. **Generation of Electrical Charge**: The deformation of the piezoelectric element creates an electric charge across its electrodes. The magnitude of the charge is proportional to the intensity of the vibration or mechanical stress.
3. **Signal Output**: The generated electrical signal is typically low-level and represents the vibration frequency and amplitude. This signal can be amplified and analyzed for various purposes, such as monitoring machine health, detecting resonance in musical instruments, or measuring shock and impact in structures.

Applications:

1. **Vibration Monitoring**: Piezoelectric vibration pickups are widely used in industrial settings for condition monitoring of rotating machinery, such as motors, turbines, and compressors. The pickup detects excessive vibrations that may indicate mechanical issues like misalignment or bearing failures.
2. **Musical Instruments**: In musical instruments (such as acoustic guitars or violins), piezo pickups are placed in direct contact with vibrating surfaces (e.g., the bridge or soundboard). They detect the mechanical vibrations produced by the strings or body of the instrument and convert them into an electrical signal, which can be amplified or recorded.
3. **Structural Health Monitoring**: Piezoelectric pickups are also used in engineering to detect vibrations and monitor the integrity of structures like bridges, buildings, or aircraft components. They provide real-time feedback on stress and strain in materials, helping engineers detect potential failures early.
4. **Accelerometers**: Piezoelectric vibration pickups form the core of many accelerometers, which are used to measure acceleration forces in various applications, including automotive crash tests, seismic monitoring, and mobile device orientation sensing.

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