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Measurement of Angular Dispalcement Using Potentiometer

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***Abstract:** A potentiometer can be used to measure angular displacement by converting the rotational motion into a corresponding voltage change. This method involves using a rotary potentiometer, where the angle of rotation is directly proportional to the output voltage. The angular displacement is determined by the amount of rotation of the potentiometer's shaft, which is then translated into a voltage reading.*

I. INTRODUCTION

The measurement of angular displacement is crucial in various mechanical and electronic applications, such as robotics, automation systems, and control mechanisms. One of the most common and cost-effective methods to measure angular displacement is by using a rotary potentiometer.

A potentiometer Is an electro-mechanical device that functions as a variable resistor. In the context of angular displacement measurement, a rotary potentiometer converts the mechanical angular position of a rotating shaft into a corresponding electrical signal. The device consists of a resistive element and a wiper (or slider) that moves along the element as the shaft rotates. As the wiper moves, the resistance between the wiper and the ends of the resistive track changes, which in turn alters the output voltage.

By applying a fixed voltage across the two ends of the resistive element, the voltage at the wiper can be measured and directly correlated with the angular position of the shaft. This allows for a simple, real-time, and analog representation of angular displacement.

Potentiometers are widely used due to their simplicity, low cost, and ease of integration into electronic systems, although they may suffer from mechanical wear over time.

II. LITERATURE REVIEW

Measurement of angular displacement using potentiometers has been extensively studied due to the simplicity, affordability, and effectiveness of these devices in various applications such as robotics, automotive systems, and industrial automation. A potentiometer operates by converting angular motion into a corresponding change in resistance, which can then be interpreted as a voltage output in a voltage divider configuration. Bhattacharya (2011) noted that this voltage output is linearly related to the angular displacement within the working range of the sensor. Rotary potentiometers, being the most common type used for this purpose, allow continuous monitoring of angular position. Norton (2013) classified potentiometers into analog rotary and digital types, with the former being widely used for continuous angular measurements and the latter suitable for digital systems requiring discrete output.

Despite their advantages, potentiometers are not without limitations. Kumar et al. (2017) highlighted that mechanical wear and contact noise can reduce their long-term accuracy and reliability. Contact-type potentiometers, in particular, are prone to hysteresis and mechanical degradation due to friction at the contact point. This wear can lead to signal drift, affecting the accuracy of angular displacement readings. Calibration is essential to ensure reliable measurements. Zhou and Wang (2019) emphasized the importance of regular calibration to compensate for non-linearity and mechanical inconsistencies in potentiometers. Although many potentiometers are designed to have a linear voltage-to-angle relationship, variations in manufacturing and usage can lead to deviations that must be corrected through calibration procedures.

Potentiometers are widely applied in scenarios where high precision is not a primary requirement. Patel and Singh (2020) discussed their use in throttle position sensors, low-cost robotic systems, and CNC machines, where their ease of integration and cost-effectiveness are major advantages. However, as technology progresses, newer sensing methods such as optical encoders and Hall-effect sensors are gaining popularity due to their non-contact operation and higher resolution. Chen and Li (2021) compared these modern sensors with potentiometers, noting that while the former offer better performance and longevity, the latter still hold relevance in basic applications where simplicity and budget constraints are more critical.

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In conclusion, potentiometers remain a practical choice for angular displacement measurement in many engineering and educational settings, despite the emergence of more advanced alternatives.

III. SYSTEM DESIGN AND METHODOLOGY

Measuring angular displacement using a potentiometer involves converting rotational movement into a corresponding voltage. A rotary potentiometer changes resistance as its shaft rotates. By applying a constant voltage across its ends and measuring the voltage at the wiper, the angular position can be determined. This output voltage varies with the angle and can be calibrated to give accurate displacement values. The method is simple, cost-effective, and widely used, though it has limitations like a restricted rotation range and potential wear over time.

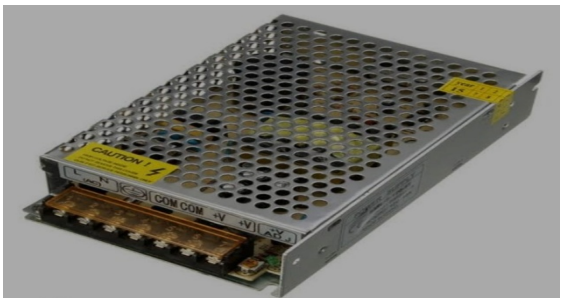
The measurement of angular displacement using a potentiometer is based on the principle that a rotary potentiometer converts angular position into a corresponding change in electrical resistance. As the shaft of the potentiometer rotates, the wiper moves along a resistive element, altering the output voltage. To measure angular displacement, the potentiometer is connected with one terminal to a voltage supply (e.g., 5V), the other terminal to ground, and the wiper to a voltmeter or an analog-to-digital converter if interfacing with a microcontroller. The potentiometer is mechanically linked to the rotating object whose angular position is to be measured.

Before actual measurements, the system is calibrated by rotating the potentiometer through known angles and recording the corresponding output voltages. This data is used to establish a linear relationship between voltage and angle, typically expressed as: angle (θ) = (measured voltage / supply voltage) × maximum angular range of the potentiometer. During measurement, the output voltage from the wiper is read and converted to angular displacement using this calibration equation. This method is simple, cost-effective, and suitable for many low to moderate precision applications. However, it may suffer from wear over time due to mechanical contact and may not be ideal for high-speed or highly precise measurements.

IV. HARDWARE COMPONENT AND CONFIGURATION

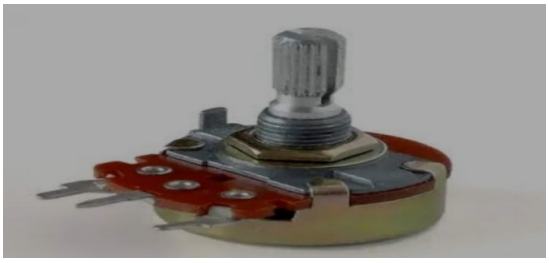
1) SMPS

A Switch Mode Power Supply (SMPS) is an electronic power supply that uses switching regulators to convert electrical power efficiently. It's commonly used in devices like computers, laptops, and chargers to change voltage and current characteristics. SMPS offers advantages like higher efficiency, smaller size, and lighter weight compared to traditional linear power supplies.



2) Potentiometer

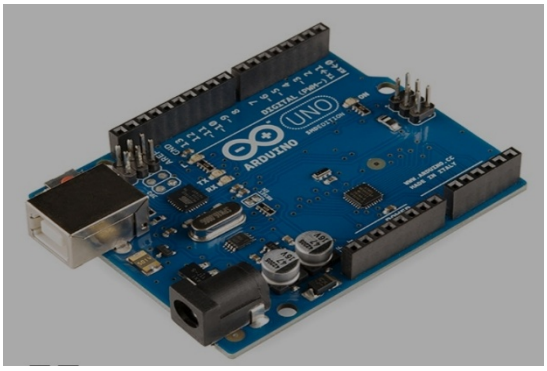
An angular potentiometer is a type of potentiometer used to measure angular displacement, meaning the rotation of a shaft or a part. It works by converting the angular movement into a corresponding electrical signal, typically a voltage. This makes it a useful tool for various applications, such as monitoring steering angles in vehicles, measuring the position of a lever, or adjusting the volume on a radio.



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3) Arduino

Arduino is an open-source electronics platform designed for creating interactive objects and experiences. It's a simple and versatile tool that allows users to read input from sensors and control outputs like lights or motors. Arduino boards are programmed using the Arduino programming language and the Arduino Software.



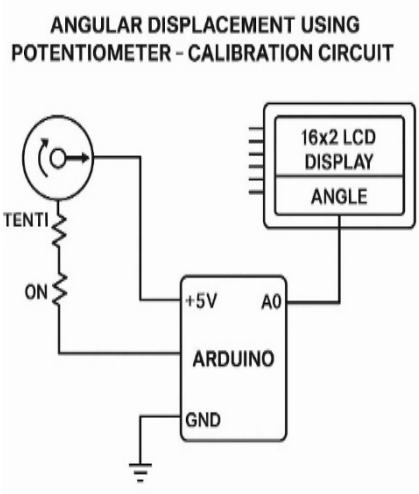
4) Display Board

A line LCD display, or character LCD, uses liquid crystal to display text or graphics in fixed-size character cells. It's commonly used in simple electronic devices like calculators, older smartphones, and Arduino projects, offering a basic way to display information.



5) Power Supply

Potentiometers, as passive sensors, don't require a dedicated power supply to measure angular displacement. Instead, they utilize a voltage divider circuit where an external voltage source provides the input, and the potentiometer's resistive element acts as the divider, generating an output voltage proportional to the wiper's position, which corresponds to the angular displacemSoftware



Experimental Setup

V. RESULT AND DISCUSSION

A. Calibration Results

Sample Data Table:

Angle (°)	Voltage (V)
0	0.00
30	0.82
60	1.65
90	2.48
120	3.32
150	4.15
180	4.98

Calibration Equation:
V=0.0277
ΘOrΘ=36.1V
V=0.0277θorθ=36.1V
Where:V
V is the output voltage in volts.
Θ is the angular displacement in degrees.

B. Linearity Results

In real-world conditions, potentiometers exhibit non-linearity, typically:±1% to ±5% of full-scale (depending on quality and type)
A linearity error of ±1% means the output deviates from the ideal linear line by up to 1% of the full output.

C. Hysteresis Results

.For a good-quality potentiometer:
Hysteresis error might be < 0.1% to 1%
For lower-grade or worn-out potentiometers:
It can go beyond 2-3%, affecting measurement repeatability.

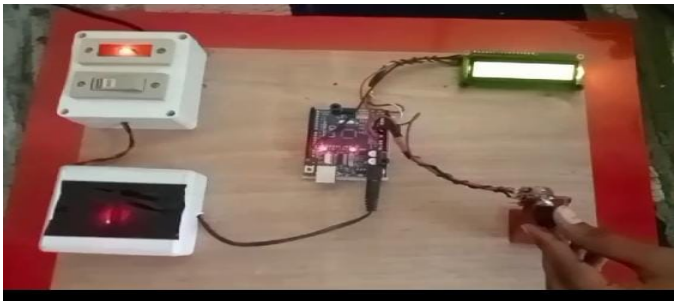
D. Repeatability Results

Let's say you rotated a potentiometer shaft to 90° and recorded the output voltage 10 times. If the output voltages corresponded to angles like:
Copy code
89.8°, 90.1°, 89.9°, 90.0°, 90.2°, 89.9

E. Discussion

Angular displacement refers to the angle through which an object rotates about a fixed point or axis. One of the simplest and most common ways to measure angular displacement is by using a rotary potentiometer.

F. Model



VI. ONCLUSION

The experiment to measure angular displacement using a potentiometer successfully demonstrates how rotational motion can be converted into a measurable change in electrical resistance. As the shaft connected to the potentiometer rotates, the resistance varies proportionally, allowing the angular displacement to be determined accurately. The method is simple, cost-effective, and suitable for applications requiring precise measurement of angular position in control systems and robotics. However, factors such as mechanical wear, linearity of the potentiometer, and resolution should be considered for high-precision requirements.

VII. FUTURE WORK

Future studies can focus on:
Future research could explore more accurate and efficient methods for measuring angular displacement using potentiometers, potentially enhancing precision in motion sensing applications."

VIII. RECOMMENDATIONS

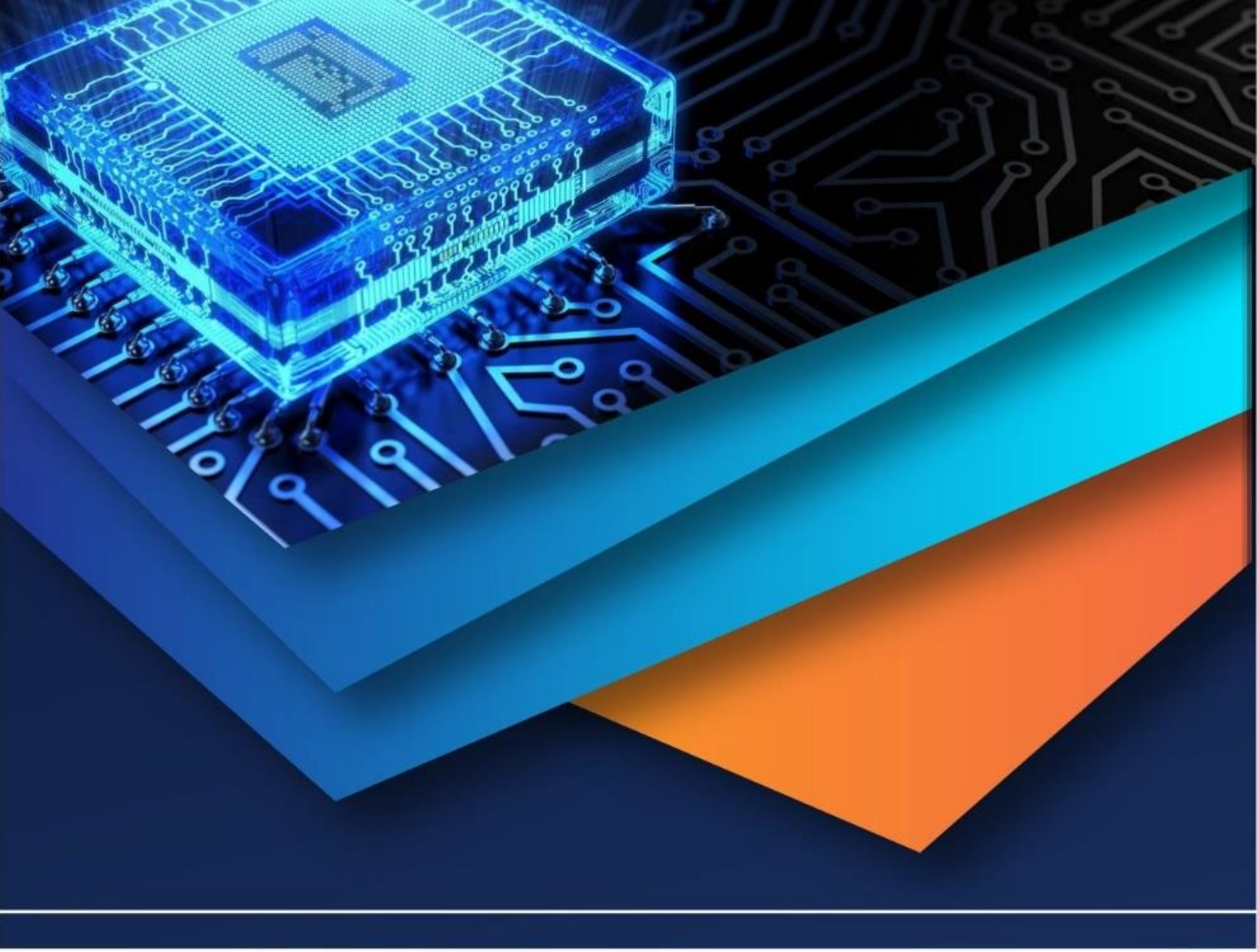
A rotary potentiometer can be effectively used to measure angular displacement by converting rotational movement into a varying voltage signal. When connected to a voltage source, the wiper terminal outputs a voltage proportional to the shaft's angle. This voltage can be read using an analog-to-digital converter (ADC) on a microcontroller. By calibrating the output voltage against known angles, the angular displacement can be accurately determined. This method is simple, cost-effective, and suitable for applications where high precision and durability are not critical.

IX. ACKNOWLEDGMENT

A potentiometer can be used to measure angular displacement by converting rotational motion into a proportional electrical signal. This signal, typically a DC voltage, can then be used to determine the angle of rotation. The potentiometer acts as a variable resistor, with the wiper's position along the resistive element corresponding to the angular displacement.

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