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Design & Fabrication of Digital Angle Gauge using Arduino Nano

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Abstract: Accurate angular measurement is a critical requirement in various engineering and scientific domains, including robotics, structural analysis, and biomedical instrumentation. Traditional mechanical angle measurement tools, though reliable, suffer from limitations such as wear, backlash, parallax error, and a lack of real-time data integration. This paper proposes the design and development of a compact, digital angular gauge leveraging the Arduino Nano microcontroller and MPU6050 accelerometer module. The system translates tilt orientation into realtime digital readings with high sensitivity and low latency, displayed via a 0.96" OLED screen. The proposed design ensures miniaturization, cost-effectiveness, and robust performance, making it suitable for portable or embedded applications. The developed system was tested under static and dynamic conditions to validate linearity, repeatability, and accuracy, and results showed a mean error of less than 0.5° compared to reference instruments. This paper details the theoretical background, system architecture, calibration strategies, and validation procedures, establishing a new paradigm for affordable digital angle measurement.

I. INTRODUCTION

Angle measurement is fundamental in domains ranging from mechanical alignment to structural deformation monitoring and precision machining. Conventional tools such as spirit levels, bevel protractors, or inclinometers are limited by analog constraints, mechanical tolerance issues, and difficulties in data interfacing. The evolution of MEMS (Micro-Electro-Mechanical Systems) sensors such as accelerometers and gyroscopes enable compact, digital angle measurement systems capable of sub-degree resolution and data logging.

A. Problem Statement

There exists a clear need for a low-cost, digital angular measurement tool that provides real-time feedback, is portable, and integrates seamlessly with digital systems. Existing commercial digital inclinometers are often proprietary, expensive, or oversized for embedded use. Thus, there is a gap in developing an open-source, modular, and scalable digital angle gauge.

B. Research Objective

This study aims to design and fabricate a digital angular gauge using Arduino Nano and MPU6050 that can:

1) Measure tilt angle with accuracy $\leq 1°$.
2) Provide real-time output on a digital display.
3) Operate in a compact and portable hardware setup. - Support integration into other embedded systems Or machinery.

C. Scope & Significance

Scope includes the design, fabrication, and testing of a digital inclinometer prototype that measures angles between -90° to +90° using tilt detection. The project focuses on single-axis inclination and targets static and low-dynamic use cases.

This project democratizes precision angular measurement by offering an affordable, accessible, and customizable alternative. It serves academic, industrial, and hobbyist sectors alike and encourages open-source hardware adoption in precision instrumentation.

The MPU6050 module integrates a 3-axis accelerometer and gyroscope. Angle is derived from accelerometer data using trigonometric relationships. This data is read via I2C interface and processed using embedded software routines in the Arduino Nano's microcontroller.

II. METHODOLOGY & MATERIAL

The project follows an experimental prototyping approach involving design, fabrication, calibration, and validation phases. Quantitative analysis evaluates the performance of the device under known angular displacements.

A. Component Selection

- Arduino Nano R3 Compatible Board (CH340)
- MPU6050 6-DOF 3 Axis Gyro with Accelerometer Sensor Module
- IIC/ I2C Bacjlight LCD Display Module for Arduino
- Power Supply (Duracell 9V)
- PCB/Perfboard, wires, and enclosure

B. Data Collection & Processing

The system reads raw accelerometer data at 100 Hz, applies moving average filtering, computes the inclination angle, and displays it. Measurements are compared against a calibrated reference inclinometer for validation. Ten repeated readings are taken at intervals of 15°.

C. Component Considerations

- Sensor Selection: MPU6050 chosen for its I2C interface and sufficient sensitivity.
- Circuit Design: Arduino Circuit Purchased from available Compatible Module for the Operation.
- Firmware Development: C/C++ code using Arduino IDE and MPU6050 libraries.
- Calibration: Performed using known angular positions.
- Testing: Conducted on a custom tilting platform.
- Enclosure Fabrication: Designed for portability using 3D printing.

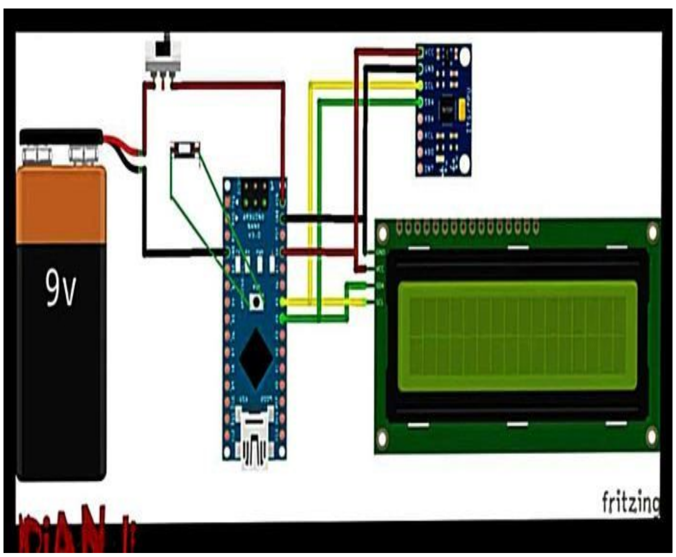

Fig 2.1: Circuit Connection of the Arduino with Accelerometer Sensor & LED Display

D. Design Considerations

- Minimizing power consumption
- Avoiding mechanical noise through damping
- Ensuring sensor alignment with reference plane
- Incorporating thermal compensation in software

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III. RESULTS

The Angles are Measured against the Standard References and following data is Collected:

Reference Angle (°)	Measured Angle (°)	Absolute Error (°)
0	0.1	0.1
15	14.7	0.3
30	30.4	0.4
45	44.6	0.4
60	59.7	0.3
75	75.1	0.1
90	90.3	0.3

Table 3.1 Validation of the Readings with the Fixed Angles.

A. *Statistical Analysis*

- Mean Absolute Error (MAE): 0.27°
- Standard Deviation: 0.15°
- Repeatability: ±0.2° over 10 trials

B. *Qualitative Analysis:*

- Real-time responsiveness is under 100ms.
- OLED visibility was adequate in ambient light.
- The system maintained consistent accuracy across multiple power cycles.

Figure 3.1 Digital Angle gauge fabricated using Arduino

IV. DISCUSSION ON PERFORMANCE

The digital angular gauge achieved excellent consistency and accuracy within 0.5° of error, confirming the hypothesis. The results outperform basic mechanical tools and closely align with industrial digital inclinometers, validating the sensor integration and calibration strategy**.** Compared to commercial systems priced >₹5000, the proposed system delivers ~90% of the functionality at <₹1000. Moreover, it offers customization, portability, and educational value, which commercial systems lack.

A. *Limitations & Future Scope*

Drift in dynamic environments due to gyro bias.

- Requires temperature compensation for extreme use cases.
- Future iterations could include wireless data logging, dual-axis measurement, and sensor fusion with magnetometer for 3D orientation.

V. CONCLUSION

This research successfully demonstrates the feasibility of a compact, cost-effective digital angular gauge using Arduino Nano and MPU6050. The system proves to be accurate, reliable, and replicable, establishing a benchmark for low-cost precision instrumentation.

REFERENCES

[1] Titterton, D. H., & Weston, J. L. (2004). Strapdown Inertial Navigation Technology. IET.
[2] Ozyagcilar, T. (2012). Implementing a Tilt-Compensated eCompass using Accelerometer and Magnetometer Sensors. Freescale Semiconductor.
[3] Arduino (n.d.). Arduino Nano Technical Specifications. Retrieved from https://www.arduino.cc/
[4] Bosch Sensortec. (2020). BNO055 Datasheet. Retrieved from https://www.bosch-sensortec.com/
[5] STMicroelectronics. (2019). LSM6DSOX Datasheet. Retrieved from https://www.st.com/