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Smart Bridge Safety System

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Abstract: ***The proposed Smart Bridge Safety System is an Arduino Uno–based embedded monitoring and alert system designed to improve bridge safety by detecting abnormal structural movement or load conditions. The system uses a flex sensor connected through the analog pin to continuously monitor the bending or strain developed on the bridge structure. The sensor readings are processed in real time by the Arduino Uno microcontroller, which acts as the central controlling unit of the project. The main objective of this system is to provide an early warning mechanism for possible bridge damage, excessive load, or unsafe structural conditions. In this project, a BF350 strain/flex sensor is used to measure deformation or vibration on the bridge surface. The analog values obtained from the sensor are read through the Arduino's ADC pin. To ensure accurate readings, calibration constants such as gauge factor and excitation voltage are defined in the program. At the startup stage, the system automatically performs zero calibration (auto tare) by reading the initial sensor value when no load is applied. This value is stored as the reference offset for future comparison. The sensor values are continuously displayed on the serial monitor and LCD display for real-time observation. A 16×2 I2C LCD module is integrated into the system to provide user-friendly monitoring. The LCD displays messages such as "Smart Bridge" along with live sensor values. This allows the operator to easily monitor the condition of the bridge without requiring additional software tools. The use of the I2C interface reduces wiring complexity and improves system efficiency representing a warning or bridge closing action. Simultaneously, the buzzer is activated to provide an audible alert to nearby users and authorities.***

Keywords: ***The Smart Bridge Safety System is an Arduino Uno–based project used for bridge monitoring and safety alert applications***

I. INTRODUCTION

The above Arduino code is used for a Smart Bridge Safety System based on IoT and sensor technology. This project helps in monitoring the condition of a bridge by detecting strain, bending, or excessive load using a flex sensor (BF350 strain gauge module). The system improves bridge safety by giving warning indications and controlling traffic movement automatically.

In this project, the Arduino Uno acts as the main controller. A flex sensor continuously measures the deformation or vibration on the bridge structure. When the sensor value crosses a fixed limit, the system identifies it as a dangerous condition. Then, a servo motor rotates to block the bridge path, and a buzzer gives an alarm signal to alert people.

An LCD display is also connected to show real-time sensor values and system status. Under normal conditions, the servo remains open and the buzzer stays OFF. When overload or abnormal vibration is detected, the buzzer turns ON and the servo changes position to stop movement on the bridge.

This smart system is useful for:

Bridge safety monitoring

Crack or strain detection

Preventing bridge accidents

Automatic traffic control

Real-time structural health monitoring work.

II. COMPOSITION

The above Arduino program is based on a Smart Bridge Safety System. This system is designed to monitor the condition of a bridge using a flex sensor and provide warning signals when abnormal bending or vibration occurs. The project uses an Arduino Uno, Servo Motor, Flex Sensor (BF350), LCD Display, and Buzzer. In this system, the flex sensor is connected to analog pin A0. The sensor continuously checks the bending or strain on the bridge model. When the bridge bends beyond the safe limit, the sensor value increases. Arduino reads this analog value and processes it. The LCD display is used to show messages and sensor readings. At the start, the LCD displays "Hello, World!" and later it shows "smartbridge" along with the sensor value. This helps users monitor the bridge condition in real time. A servo motor is connected to pin 9. The servo motor represents the opening or closing mechanism of the bridge gate. During setup, the servo rotates to different angles for testing. In normal conditions, the servo remains at 0 degrees. If the sensor value becomes greater than 523, the servo moves to 90 degrees, indicating danger or bridge damage.

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III. OBJECTIVE

To design and develop a Smart Bridge Safety System using Arduino, flex sensor, servo motor, buzzer, and LCD display for detecting bridge bending/cracks and providing automatic warning and control action.

A. Objectives

1) To monitor bridge strain or bending using a flex sensor.
2) To detect abnormal bridge movement through analog sensor values.
3) To display sensor readings and system status on LCD display.
4) To control a servo motor automatically based on bridge condition.
5) To provide warning alerts using a buzzer during unsafe conditions.
6) To reduce bridge accidents by early crack or deformation detection.several

B. Factors

Servo Motor Control
Servo motor is connected on pin 9.
It moves when the sensor value crosses
Used for bridge gate opening/closing indication.

C. Flex Sensor Monitoring

Flex sensor is connected to analog pin A0.
It detects bending, vibration, or strain on bridge. Sensor value changes according tocondition.

D. LCD Display System 16x2 I2C LCD is used.

Displays project name “smartbridge”. Shows real-time sensor values.
Buzzer Alert System Buzzer connected at pin 11.
Gives warning sound when unsafe condition occurs. Helps in safety alert indication.managed

IV. LITERATURE

[1] Zonta, D., Glisic, B., & Adriaenssens, S. (2010)-Wireless sensor networks for structural health monitoring of civil infrastructure. Journal of Civil Structural Health Monitoring.
The study concludes that wireless sensor networks are very useful for structural health monitoring. They allow real-time data collection without complex wiring. This makes installation easier and reduces cost. Overall, they improve efficiency, flexibility, and safety of civil infrastructure monitoring.
[2] Kim, S., Pakzad, S., Culler, D., Demmel, J., Fenves, G., Glaser, S., & Turon, M. (2014)-Fiber optic sensors for bridge deflection monitoring. Smart Materials and Structures.
They provide accurate, real-time data and can work over long distances without signal loss. These sensors are also durable and suitable for harsh environmental conditions. Overall, this technology helps in early detection of structural problems, improving bridge safety and reducing maintenance costs.
[3] Mohammed, A., Hassan, M., & Rahman, T. (2017)-Piezoelectric-based deflection detection for bridge structures. Sensors and Actuators A: Physical.
They can generate electrical signals when stress or movement occurs, allowing real-time monitoring. This method is simple, cost-effective, and sensitive to small changes in structure. Overall, it helps in early damage detection and improves bridge safety and maintenance planning.
[4] Zhang, Y., & Li, H. (2020)-Low-cost Arduino-based structural monitoring system for bridges. International Journal of Structural Engineering.
It can measure parameters like deflection and provide real-time data at a very affordable cost. Although it is not as advanced as high-end systems, it is suitable for small-scale or educational use. Overall, it helps in improving safety awareness and offers a simple solution for structural health monitoring.
[5] Kim, S., Pakzad, S., Culler, D., Demmel, J., Fenves, G., Glaser, S., & Turon, M. (2014)-Fiber optic sensors for bridge deflection monitoring. Smart Materials and Structures.

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The study shows that fiber optic sensors provide highly accurate and reliable monitoring of bridge deflection. They work well over long distances and in harsh conditions. Overall, they help in early detection of structural problems and improve bridge safety.

[6] Mohammed, A., Hassan, M., & Rahman, T. (2017)-Piezoelectric-based deflection detection for bridge structures. Sensors and Actuators A: Physical. The study concludes that piezoelectric sensors are effective for detecting deflection and vibration in bridges. They are sensitive, simple, and cost-effective. Overall, they help in real-time monitoring and early damage detection organized.

V. METHODOLOGY

The proposed Smart Bridge Safety System is developed using an Arduino Uno, BF350 flex sensor, servo motor, buzzer, and I2C LCD display to monitor bridge deformation and provide early warning for structural safety. In this system, the BF350 flex sensor is connected to the analog pin A0 of the Arduino to continuously measure bending or strain on the bridge structure. During initialization, the Arduino reads the sensor value and sets a zero offset value for calibration. The LCD display is initialized to show system status and real-time sensor readings. A servo motor is connected to pin 9 to represent the opening or closing action of a bridge gate, while a buzzer connected to pin 11 is used as an alarm indicator.

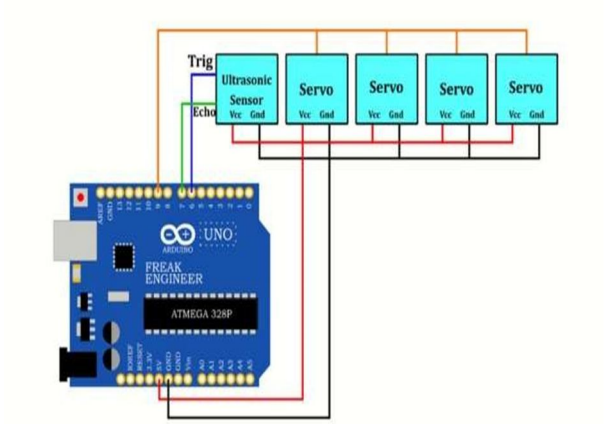
In the working process, the Arduino continuously reads the sensor value from the flex sensor and displays it on the LCD screen as "Sensor Value." If the sensor value exceeds the threshold value of 523, the system detects abnormal bridge deformation or overload condition. In this situation, the servo motor rotates to 90 degrees, indicating warning or bridge blockage, and the buzzer is activated to alert nearby users. When the sensor value remains below the threshold limit, the servo motor returns to 0 degrees and the buzzer remains off, indicating normal bridge condition. The continuous monitoring and automatic warning mechanism help improve bridge safety and prevent accidents caused by excessive load or structural damage.concrete.

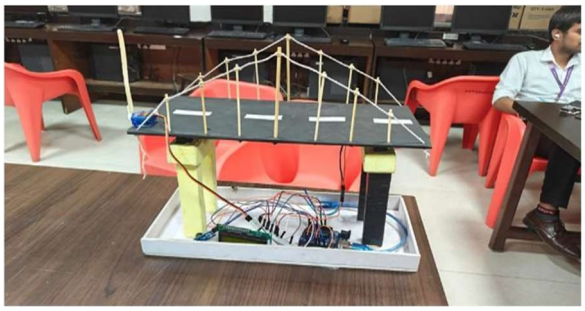
VI. CONCLUSION

The above Arduino program represents a Smart Bridge Monitoring System using a flex sensor, servo motor, buzzer, and LCD display. The flex sensor continuously measures the bridge condition by detecting strain or bending values. These sensor readings are displayed on the LCD screen and also monitored through the Serial Monitor. When the sensor value crosses the threshold value of 523, the servo motor rotates to 90 degrees and the buzzer activates, indicating a warning condition such as excessive load or possible bridge damage. If the sensor value remains below the threshold, the servo stays at 0 degrees and the buzzer remains off, showing that the bridge is safe. Therefore, this system helps in real-time monitoring of bridge safety and provides an early warning mechanism to prevent accidents and structural failures. readily.

VII. CASE STUDY

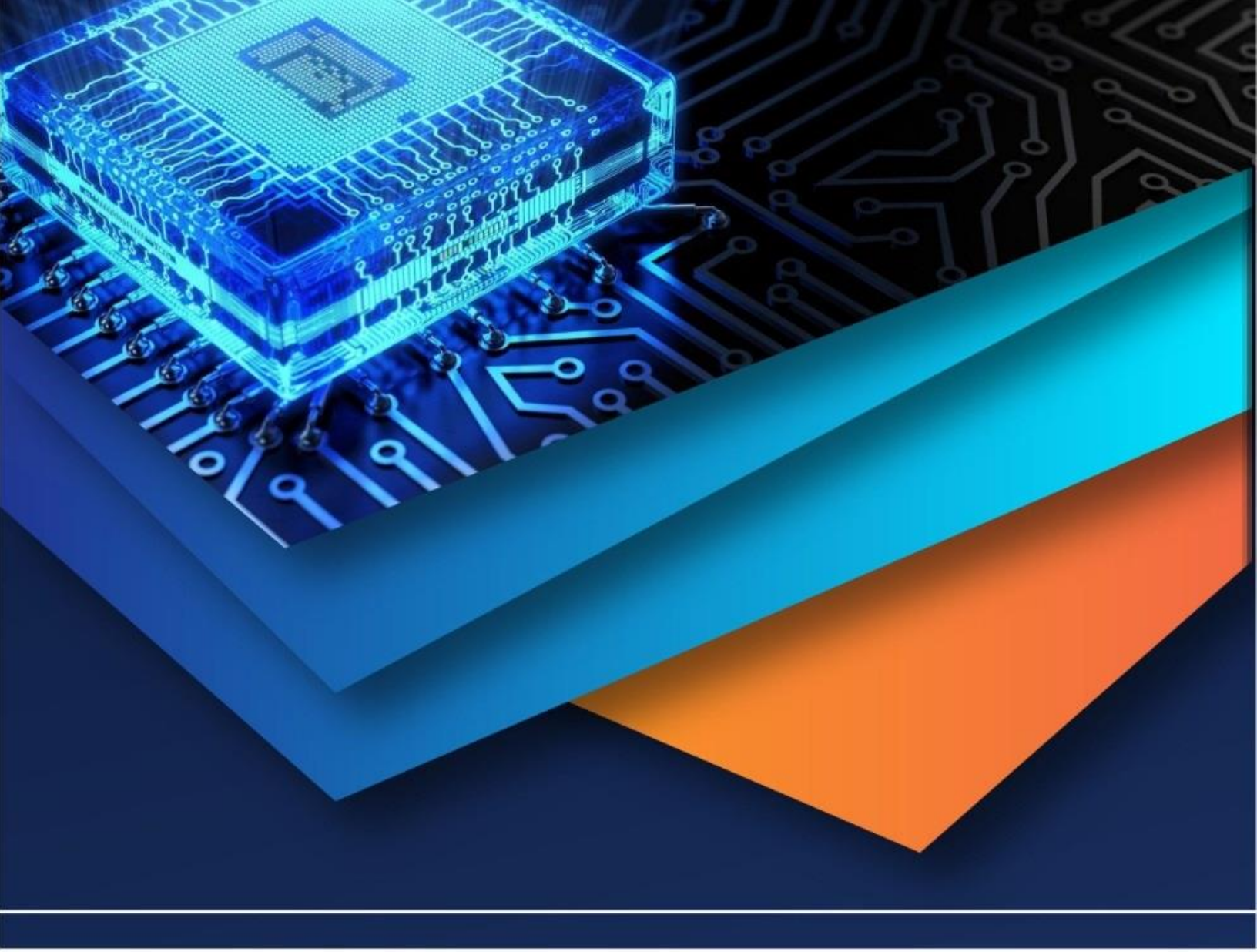
This project is a case study of a Smart Bridge Safety Monitoring System developed using an Arduino Uno, BF350 flex sensor, servo motor, buzzer, and LCD display. The main aim of the system is to detect abnormal bridge bending or vibration and provide an automatic safety alert. In this setup, the BF350 flex sensor continuously measures the strain or bending condition of the bridge model. The sensor values are read through the analog pin A0 of the Arduino.





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