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Real Time Bridge Monitoring System

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ABSTRACT

Bridges play an important role while considering a transport infrastructure. As such, closing them for repair, inspection or replacement entails large costs for users. This comes naturally due to the fact that failure of a bridge could have severe consequences in material damage and human lives. Introducing monitoring techniques in its different forms i.e. damage detection, traffic monitoring, reliability assessment, etc. can save wealth by improving the understanding of a structure, thus reducing the need of overly safe assumptions and by granting the possibility to get early warnings of problems that develop. Bridges form a crucial part in a country's infrastructure, as they require a huge amount to build and maintain. There is, therefore, much need to focus on bridges for monitoring which can enhance the life of a bridge. It can directly impact on avoiding or postponing any type of replacement, repair onto that bridge. Bridge monitoring system is significant to health diagnosis of bridges and flyovers.

Keywords : Bridge Monitoring, Structural Health, Wireless Sensor Network, IOT.

I. INTRODUCTION

Bridge is one of the most important transportation infrastructures for social and economic activities of country which has long rivers. Bridge monitoring system (BMS) provides previous indication to us where we can easily save too many lives and we can avoid the loss. BMS is a tool to improve the safety and maintainability of bridge. BMS provides real time and accurate information about the structural health condition. It is a process of non-destructive evaluations to detect location and extent of damage, calculate the remaining life, and predict upcoming accident. Bridges are important aspect of traffic. Human life and property will be in severe situation when bridges are damaged. Bridges are one of the critical cross points of a country's transport network but they are expensive to build and maintain. So care should be taken of bridges. For that purpose wireless sensor network is used.

Wireless sensor network consists of Vibration sensor, ultrasonic sensor, strain gauge and Node MCU. These sensors continuously monitor desired parameter such as structure's acceleration, height, strain. Bridge parameters are monitored using wireless sensor network (WSN). The whole process or procedures is done in real time. Finally, a gate will close the road to warn an abnormal behavior. Optical fiber Sensors are to be attached along the civil structures at various locations. Optical fibers as sensors are found as the best method for measuring wide variety of physical parameters which can be used in many application.

The monitoring of civil structures such as bridges, dams and buildings etc.

Fig. Bridge collapsed at Satara on the Savitri river

II. SYSTEM BLOCK DIAGRAM

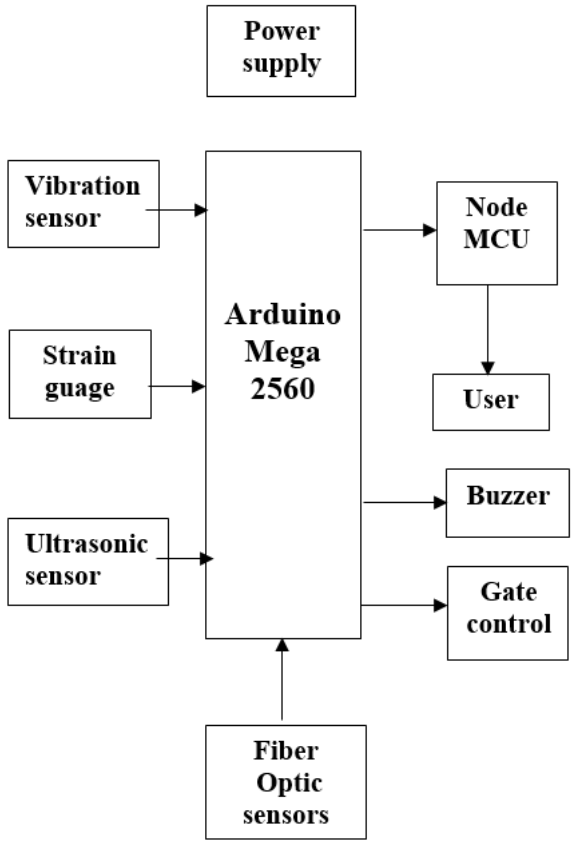

Fig 2.1: Block Diagram of Real Time Bridge Monitoring system

Working:

The block diagram of Real Time Bridge Monitoring System is shown in the above fig. The proposed system consist of controlling unit named, Arduino Mega 2560. It is further connected to the Node MCU. Node MCU board consist of ESP8266 Wi Fi module. The power supply is given to the Arduino Mega 2560. System consists of several sensors such as Vibration sensor, Strain gauge, Ultrasonic Sensor & Buzzer. These sensors are connected to the Arduino Mega 2560. Fiber optic sensors are also used as a sensing parameter in the above system.

The system collects the data from sensors and the status is collected by the controller and is transferred to wireless network. This data at transmitter is sent to the receiver and is analyzed by the Arduino Mega 2560. Analyzed data is sent to the node mcu and an alert message is sent to the operator email Id. We will use sensors like vibration sensor, strain gauge, Ultrasonic sensor as sensing devices. These sensors will be responsible for sensing the load on the bridge, pressure of the water, level of the water rising in the river. The data sensed by sensors will get converted into an electrical signal. The devices which generate output are generally called as actuators (sound buzzer). Both sensor and actuator are collectively called as a transducer. The electrical signal will be given to the Arduino Mega 2560 and further to the Node MCU. Accordingly the controller will perform the gate controlling action with the help of a servo motor.

III. HARDWARE DESCRIPTION

1. ATMega 2560:

The microcontroller board, Arduino Mega 2560, has 54 pins for digital input/output (I/O) and has 15 pins that can be used as pulse width modulation (PWM) outputs. It also has 16 analog inputs, 4 hardware serial ports (UARTs), 1 USB connection port, 16 MHz crystal oscillator, a power jack, an ICSP header and a reset button. The ATmega 2560 can store code because it has 256 kB of flash memory, 8 kB is used by the boot loader, 8 kB is used by the SRAM and 4 kB is used by the EEPROM. In this project, Arduino Mega 2560 is used to interface with all of the hardware used in this project, such as the vibration sensor, ultrasonic sensors, node mcu, strain gauge etc.

Fig 1 : Arduino mega 2560

2. Node MCU

Node MCU is based on ESP8266 Node MCU development board which is a true plug-and-play solution for IOT projects. Node MCU is an open source IoT platform and runs on the ESP8266 Wi-Fi SoC from Espressif Systems. The term "Node MCU" by default refers to the firmware rather than the development kits. ESP8266 Core for the Arduino IDE can be used if you would like to program your Node MCU from the Arduino IDE.

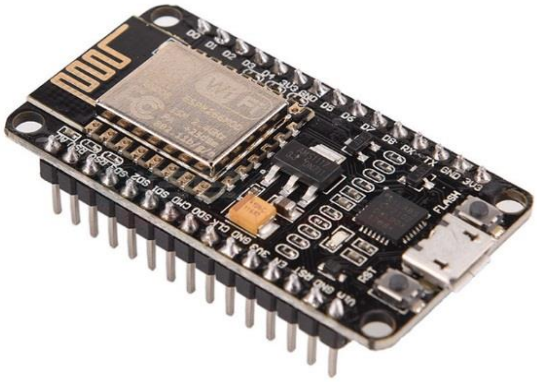

Fig 2 : Node MCU

3. Vibration Sensor:

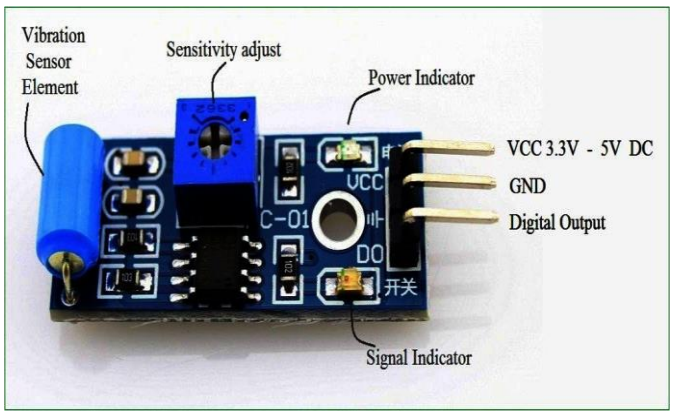

Fig 3 : Vibration Sensor Module SW-420

This is an **SW-420 vibration module**, which can work from 3.3V to the 5V. The sensor uses LM393 comparator to detect the vibration over a threshold point and provide digital data, Logic Low or Logic High, 0 or 1. **During normal operation, the sensor provides Logic Low and when the vibration is detected, the sensor provides Logic High.** There are three peripherals available in the module, two LEDs, one for the Power state and other for the sensor's output. Additionally, a potentiometer is available which can be further used to control the threshold point of the vibration. In this project, we will use 5V to power the module.

4. Strain Gauge:

What is Strain? Strain is the amount of deformation of a body due to an applied force. More specifically, strain is defined as the fractional change in length. When a force is applied to a structure, the components of the structure change slightly in their dimensions and are said to be strained. Devices to measure these small changes in dimensions are called strain gages. Strain Gauge or Strain Gage was invented in 1938 by Edward E. Simmons and Arthur C. Ruge. It is one of the significant sensors used in the geotechnical field to measure the amount of strain on any structure (Dams, Buildings, Nuclear Plants, Tunnels, etc.). The resistance of a strain gauge varies with applied force and, it converts parameters such as force, pressure, tension, weight, etc. into a change in resistance that can be measured later on.

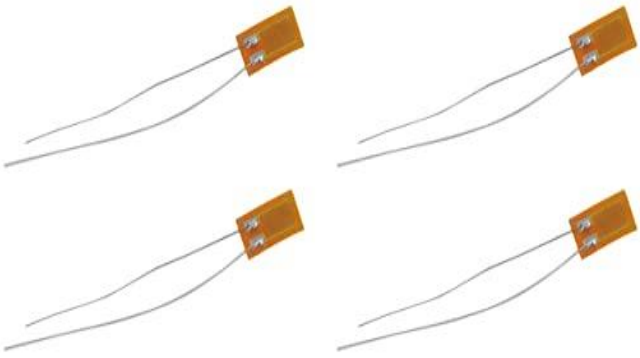

Fig 4 : NIE Nia Strain Gauge

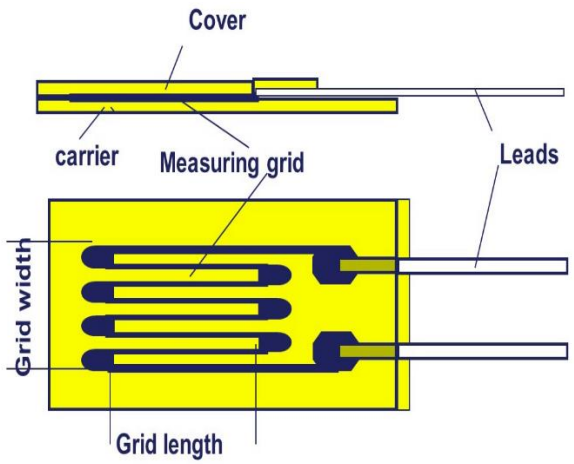

Fig 5: How does a metal foil Strain Gauge works

5. Ultrasonic Sensor:

Fig 6 : Ultrasonic sensor HC-SR04

The ultrasonic module, HC-SR04, is chosen for the project. It has 4 pins, which are 5V pin, ground pin, trigger pin and echo pin. The ultrasonic sensor has an ultrasonic transmitter and ultrasonic receiver. Its centre frequency is 40 KHz with 1 KHz tolerance. The ranging distance is from 2 cm to 400 cm and the resolution is up to 0.3 cm. The effectual angle of this sensor module is less than 15 degrees and its measuring angle is 30degrees. The trigger input pulse width is 10 μs. In this project, the ultrasonic sensor is used to measure the water level from the bridge [5].

6. Buzzer:

A **buzzer** is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications. This buzzer can be used by simply powering it using a DC power supply ranging from 4V to 9V. A simple 9V battery can also be used, but it is recommended to use a regulated +5V or +6V DC supply. The buzzer is normally associated with a switching circuit to turn ON or turn OFF the buzzer at required time and require interval. In this project, the buzzer is used as alarm in order to give indications to the peoples.

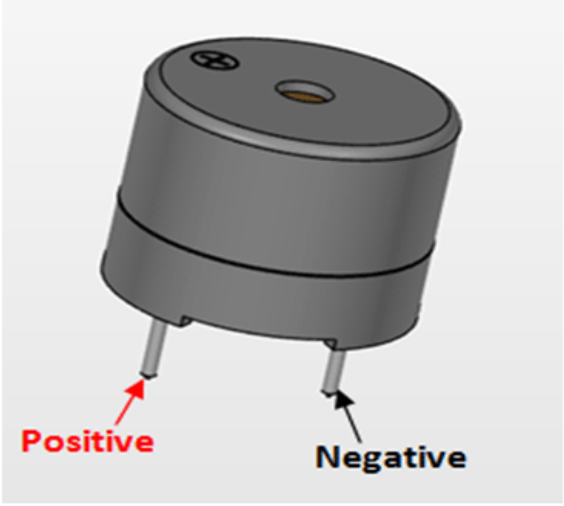

Fig 7 : Active Passive Buzzer

7. Fiber Optic sensor:

Generally, an optical fiber sensor system consists of a light transmitter, a receiver, an optical fiber, a modulator element, and a signal processing unit. As the core part of an optical fiber sensor, the optical fiber is usually made from silica glass or polymer material, which itself can act as a sensing element or carry the light from the source to the modulator element.

The E32-DC200 is a general purpose diffuse Fiber optic Cable Sensing Head offers a wide variety of unique solutions for tough problems. Fiber-optic sensor detect small, fast-moving objects in space-confined installations and harsh environments. For a custom fit in the field, most plastic filament cables can be cut to length. For detection in hard-to-reach places, sensing heads with bendable stainless steel

tubing retain complex shapes. Coiled and ultra-flexible cables are ideal for flexing and reciprocating machinery such as robots. Side-view sensing heads save space in right angle detection. Highly flexible fibers with minimum 1mm bending radius allows cable to confirm to machine contours. IP67 protection rating.

Fig 8 : Omron Plastic Fiber Optic Sensor, IP67, 12 → 24 V dc.

8. Servo Motor (for Gate controlling purpose) :

A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft. In this project, the servo motor is used for the gate controlling purpose on the bridge.

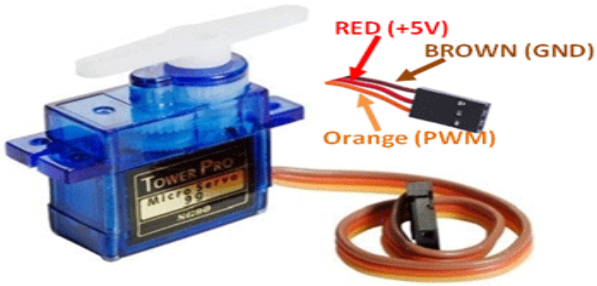

Fig 9 : Servo Motor

Advantages

Proposed system will avoid death of people due to bridge collapse. We can determine which bridge requires repairing before it gets break. Traffic can be routed prior of Bridge collapse as alert of extreme levels are continuously monitored on IOT server. It generates the alert if flow, water level, and the load are increased. It saves the life of people. It provides live data of the load, water level, and pressure. Early damage detection, Quick action and responses.

IV. Conclusion

The project is developed with low cost, low power consumption. With our project, we can give early indications to the peoples about the bridge accidents and can save many lives along with the prevention of severe property damage. The proposed system will continuously monitors the bridge parameter value and judges whether the bridge is safe or not for travelling. This implementation is greatly useful to provide the safety for human lives.

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