

Development of Renewable Energy Based Bridge Safety Monitoring And Controlling System Using IoT

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ABSTRACT

India is highly populated and there is a continuous need to focus on expanding the infrastructure and maintaining or renewing the old ones. One such example is roads and bridges. Every year; we come across news stating the collapsing of the bridge due to excessive load on it. Heavy load vehicles such as trucks, vans are the main reason for the excess weight on the bridge. Thousands of people lose their lives because of bridge collapse every year. This is an entirely avoidable disaster. To ensure the safety of people, we introduced a bridge monitoring system. This will be made possible with the help of the WIFI module, Arduino controller. To make it energy-efficient and pollution-free, we are using solar energy as the source of energy. The usage of the IoT module in the study will help in getting real-time data.

Keywords – Bridge safety; Monitoring; Controlling System; IoT.

1. INTRODUCTION

Infrastructure is responsible for economic growth and development of the nation. This is the main reason why the government spends billions of dollars on infrastructure. It can give employments to thousands [1, 2]. Roads and bridges are essential factors under foundation. It affects the lives of millions of people. Hence it is vital to have the right highways and bridges [3, 4]. In 2015 there was a bridge collapse in Kolkata, which led to the deaths of hundreds of people [5, 6]. Similar incidents of bridge collapse occurred in Varanasi in the year 2018, which also took many lives [6,7]. The main reason for the failure of the overweight on bridge [8, 9]. Hence it is essential to develop a system that generates a timely alert to the bridge operator in case of overloading on the deck [10, 11]. In this study, a model which produces alert in case of overloading of the bridge was created. To have a real-time analysis, we introduced the IoT model. This would ensure timely alert operators could monitor smartly. Further, to make it energy-efficient, we used solar energy as a source of energy, this made the model clean and this pollution-free. This system can be a lifesaver. It can reduce the bridge collapse disaster, saving millions of dollars. The bridge safety has been the prime focus of our research paper. We have tried to give a solution to overcome the disaster-related to bridge collapse. In this paper, we have used a non-conventional source of energy, i.e., solar energy, to make the proposed system clean and pollution-free. In this paper, we have

discussed the materials used to ensure the accurate working of the model. In this paper, we have used the IoT model for the generation of real-time data analysis. This has enabled our system more productive and accurate.

2. MATERIALS REQUIRED

2.1 Internet of Things

In today's world, most of the people are dependent on the internet [12]. We use it for surfing, booking tickets, e-commerce, sending e-mails, and other educational purposes. Hence to exchange information among ourselves, IoT plays a vital role. We can say that it is a platform used to exchange information. It has connected the world like never before. It has enabled social work more smartly and efficiently on the internet (Fig. 1).



Fig 1. IOT Module

2.2 Components of IOT

Sensors: As the human is getting smarter and more innovative sensors have played a significant role in this process. Sensors are devices or electronic machines that help us in our daily lives. E.g., light sensors, when a person enters the room, the light switches on, when living the room, it switches off. The primary function of the sensor is to detect the changes in surrounding and send information [13].

Networks: We can say that a network is a group of computers connected via one medium. The primary purpose is to share common data and have a single communication medium. Usually, it is used in schools and colleges where a group of computers is connected through a single medium. Many companies and firms also use a network of computers [14, 15].

2.3 Solar Panel

It is designed to absorb the sun's rays as a source of energy and convert them into electricity or heat [16]. It is actually a collection of solar or photovoltaic cell which can be used to generate electricity through photovoltaic effect. In solar panel solar cells are arranged in a grid like pattern on its surface. We also described it as a set of photovoltaic module mounted on a structure. A photovoltaic module is a connected assembly of 6 X 10 solar cells as a packaged. Our solar panel is made up of using crystalline silicon solar cell.

Traditional methods of bridge safety monitoring have the following problems: The existing system fails to give a timely alert to the bridge operator. It also doesn't have a wireless communication, so it makes the task tedious. As the existing system operated manually; hence, there are a lot of chances of inaccurate data. The existing system fails to use a non-conventional form of energy, making it expensive. It leads to an increase in the level of pollution.

The modified system develop in the IoT technologies. The system is consists of three major subsystems:

- (1) Monitoring units
- (2) Photovoltaic units
- (3) Wireless communication system

Monitoring Units: The primary use of monitoring units is to monitor data. They help us get accurate real-time data. As this model depends on real-time data analysis, it is essential for us to have proper monitoring units.eg- when the vehicle load on the bridge exceeds the safety

limit. We can have excess to real-time data to prevent future disasters. It is crucial to have accurate monitoring units [17].

Photovoltaic Units: To make our model renewable, we have used a non-conventional source of energy. The energy source which we used here is solar energy. The use of solar panels helps us in converting solar energy into electrical energy. The electrical energy is then used by our system to run the model. Hence the photovoltaic units are an essential part of our system [18].

Wireless Communication System: The wireless communication system makes our device hassle-free. We can get real-time alerts on a timely basis. The use of wifi model helps us get data on the server. In today's world, where all the technology is advancing, we can get a real-time bridge load on our mobile phones. Our wireless communication system is based on the Zigbee protocol [19].

2.4 System and Functional Requirements and Description

2.4.1 Hardware Required

The following hardware's are required to operate this system such as Solar panel, Regulated power supply, Arduino, Weight sensor, LCD's with driver, L293d Motor, IOT Module, Reset Buttona, Dc motor, Buzzer with driver, LED indicators [20].

2.4.2 Software Required

The following software's are required to run this system such as, Arduino software, Embedded C programming, HTML (Fig. 2).

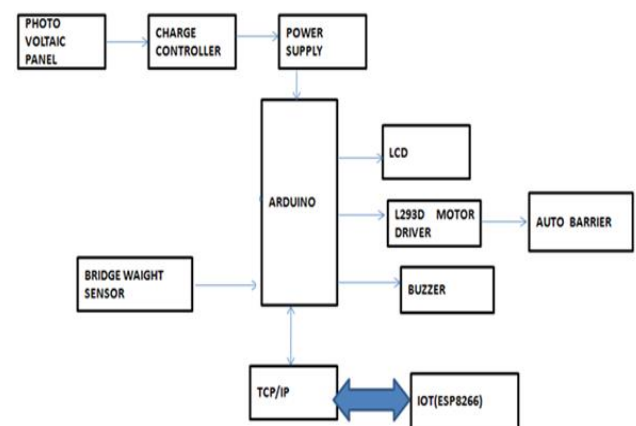


Fig. 2 Block diagram

2.4.3 Arduino

Arduino controls our model. With the help of Arduino software, we can control our model working [21, 22]. The USB port on the Arduino helps it connect to the laptop. The reset button on the Arduino helps to restart our system (Fig. 3).

2.4.4 Weight Sensor

A weight detecting sensor was used. This will help us in knowing the actual amount of load on the bridge due to weight of vehicle. Sensors are devices which help us measure a physical parameter (such as pressure, temperature, acceleration, force, etc.) by providing a signal that either measures quantitatively (level) that physical parameter [23, 24].

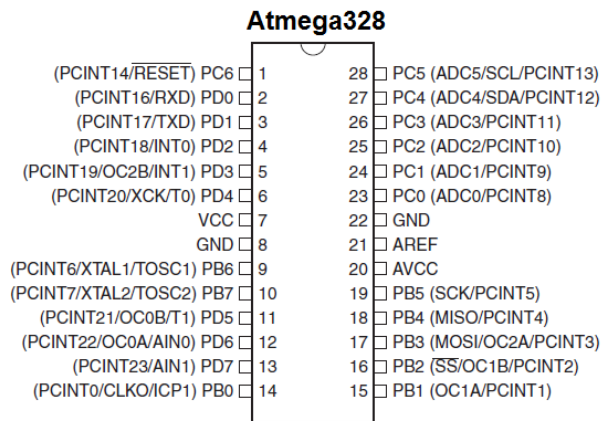


Fig. 3 PIN Diagram Atmega328

2.4.5 IOT Module

An IoT module is a small electronic system that links to wireless networks and sends and receives data and is embedded in objects, computers, and things. The IoT board, also known as a "radio chip" or "IoT chip," incorporates the same hardware and data circuits as a cell phone but without the monitor or keypad. IoT modules also have always-on networking, which is a major differentiator. This is due to the fact that IoT applications must send data automatically and in real-time without the use of a send button. They are designed for extreme durability and longevity, and they must run continuously for at least a decade to justify the technology's business case and cost.

2.4.6 LCD (Liquid Crystal Display)

Another important device of our model. It helps the bridge operator in checking the bridge weight manually. LCD (Liquid Crystal Display) screen is an electronic

display module and find a wide range of applications (Fig. 4). A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable (Table. 1 & 2); have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.



Fig. 4 LCD PIN Details

Pin Description

Table 1 Milestones

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V _{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V _{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

2.4.7 L293D Motor driver Pin Description

Table 2 L293 Motor driver pin description

Pin No.	Function	Name
1	Enable pin for Motor 1; active high	Enable 1,2
2	Input 1 for Motor 1	Input 1
3	Output 1 for Motor 1	Output 1
4	Ground (0V)	Ground
5	Ground (0V)	Ground
6	Output 2 for Motor 1	Output 2
7	Input 2 for Motor 1	Input 2
8	Supply voltage for Motors; 9-12V (up to 36V)	Vcc 2
9	Enable pin for Motor 2; active high	Enable 3,4
10	Input 1 for Motor 1	Input 3
11	Output 1 for Motor 1	Output 3
12	Ground (0V)	Ground
13	Ground (0V)	Ground
14	Output 2 for Motor 1	Output 4
15	Input2 for Motor 1	Input 4
16	Supply voltage; 5V (up to 36V)	Vcc 1

2.4.8 12V Battery

We used 12V Battery (store solar energy) to run our circuit. This 12V battery was connected with a solar panel which helped us to get Energy which was renewable and eco-friendly.

2.4.9 Motor Driver

As we have assigned gates at the end of bridges the main role comes that of Motor driver. It works as an amplifier in controlling the current signal. It plays vital role in opening up and closing down our gates.

2.4.10 Buzzer

Buzzer helped us to get the alert when the weight or the load bearing capacity of our bridge was more than safe load bearing. In our prototype model we kept it as a weight of 5kg limit.

2.4.11 ESP8266 Wifi Model

To help in real time analysis of data through Google Drive link the Wi-Fi model is important. With its help we can also get the data on our mobile phones making our task easy. Google drive

link: https://drive.google.com/drive/folders/1XMy5iTIv igQJ8X-sw6V_pkiC19WBjYjuJ?usp=sharing

3. RESULT AND DISCUSSION

We are getting real time data on server on <http://192.168.4.1/>



Arduino software to help us give real-time information about the vehicle movement on the bridge. If the load on the bridge is above the specified level, the buzzer rings notifying the concerned authorities further; the gate is closed to restrict the movement of vehicles, which would further increase the load on the bridge. The main highlight of our project is the use of solar panels, which makes it completely energy-efficient, also decreasing any further unnecessary cost. We believe this is a one-time investment which we give limitless benefits in coming future. This system can save thousands of lives and millions of government expenditures. The system can be a lifesaver as well as game changer in the coming future.

4. CONCLUSION

The bridge monitoring system can be a lifesaver in the coming days. The use of a non-conventional source of energy has made it even more futuristic. The purpose of the IoT model in the system has helped us send real-time data to the bridge operator. In a country like India, where a lot of bridges are old and on the verge of collapsing but are ignored due to the carelessness of government and also people, this can save much future bridge collapse disaster. The use of the Wifi model helps the server collect data, and with the help of google drive link, we can get real-time data. The use of a weight sensor will enable us to control the load on the bridge. We are getting real time data on server on <http://192.168.4.1/>.

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