Detection Of Structural Damages In Bridge Based On ZigBee Networks Using Sensors

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Abstract

Monitoring the damages in the bridge is an increasing concern for the benefit of public .The major challenge is to ensure that the condition of the civil infrastructure bridge is capable of can withstanding the cumulative weight of all the vehicles that travel in the bridge. In this framework, the ZigBee protocol is used for monitoring the bridges damages that exist in civil infrastructure, these damages are identified by using three types of sensors namely flex, load cell and vibration sensor. The load cell is used to find the capacity of bridge. The flex and vibration sensor is used to identify the internal and external damages .If damage is detected via ZigBee communication the damage detection is informed to the Base Station.

Keywords: ZigBee, flex sensor, vibration sensor, load cell.

1. Introduction

1.1 ZigBee

ZigBee protocol is an open standard for low-power wireless networking of monitoring and control devices. IEEE 802.15.4 standard focus on low-rate personal area networking and defines the lower protocol layers.

ZigBee uses the IEEE 802.15.4 physical and Medium Access Control layers to provide the reliable Wireless data transfer. ZigBee adds network structure, routing, and security to complete the communications suite. 802.15.4 as the physical radio and ZigBee like the logical network and application software. ZigBee and their fundamental 802.15.4 standard propose the system designer several classes of devices. The devices are reduced-functionality device (RFD), the full-functional device (FFD), and the network coordinator. All ZigBee networks have at least one RFD or FFD and a network coordinator. Most sensor applications drop natively into the RFD class, with extended networks making use of both FFDs and network coordinators to form bridges and links required by the network topology. ZigBee networks can form autonomously, based on connectivity and function.

1.2 ZigBee Data Reliability

The 802.15.4 standard provides strong reliability through several mechanisms at multiple layers. IEEE 802.15.4 provides three frequency bands for communications. Global utility, propagation, path loss, and data rate differences let ZigBee profile developers optimize system performance. The 2.4 GHz band is used worldwide and has 16 channels and a maximum over-the-air data rate of 250 Kbps. Lower frequency bands are also specified. The path between the transmitter and

receiver has become less reliable or there is any failure in network has occurred and then the ZigBee provides the network with self-healing capabilities when alternate paths can be established separately.

1.3 ATMEL 89C51 MICROCONTROLLER

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4 Kbytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard MCS-51 instruction set and pin out The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C51 is a powerful microcomputer which provides a highly flexible and cost effective solution to many embedded control applications. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters. In 40 pin AT89C51, there are four ports designated as P_1, P_2, P_3 and P_0. All these ports are 8-bit bi-directional ports, *i.e.*, they can be used as both input and output ports. Except P_0 which needs external pull-ups, rest of the ports have internal pull-ups. When 1s are written to these port pins, they are pulled high by the internal pull-ups and can be used as inputs. These ports are also bit addressable and so their bits can also be accessed individually.

Features

- Compatible with MCS-51 Products
- 4 Kbytes of In-System Reprogrammable Flash Memory.
- Endurance 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- Three-Level Program Memory Lock
- 128 x 8-Bit Internal RAM
- 32 Programmable I/O Lines
- Two 16-Bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low Power Idle and Power Down Modes

3. RELATED WORK

The structural health monitoring of bridges and where the sensors are located in the bridges are explained in [1].The damages will be detected by using the variations of the sensors are discussed in[1].The ZigBee IEE 802.15.4 and the charactertics are discussed in [2]. The ZigBee security and data integrity and types of devices used in ZigBee networks are discussed in [4].Using the wireless sensor networks how the structural monitoring is analyzed in [3]. The A/D converter and how the zigBee sends the data to other zigBee modules are explained [5].

3. DESIGN OF DAMAGE DETECTION

In proposed work, the flex sensor is used to find the internal bridges of the bridges. The load cell is used to find the capacity of the bridges. Then the vibration sensor is used to find the external damages and it will indicate the vibration alert to the base station. The input from the sensor cannot be given directly to the microcontroller because the signals are in the analog form. Using ADC converter the signals will be converted to digital form. Thus ADC passes the signal to the microcontroller and ZigBee is used to transmits and also receive the signal.

ZigBee transmit the data from microcontroller to the base station pc acts as the base Station receiver

receives the signal. If the weight is more than the capacity of the bridge and then load cell indicates to the check post through the ZigBee transmitter. The signal is received to the check post if the strength of the signal is high the gate may be get closed. ZigBee transceiver transfer the data to IC and detect any receiver is connected. If the ZigBee receiver is connected the data will be passed from IC to ZigBee receiver.

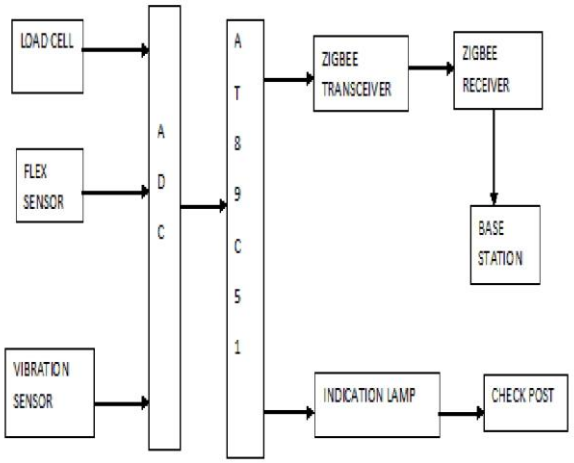

Fig 1: System Architecture

3.1 Liquid Crystal display

Liquid Crystal Displays (LCD) which combine the properties of both liquids and crystals. LCD is a flat electronic visual display. Light modulating properties of liquid crystals are being used for the video display in the LCD. The Liquid Crystal Display is intrinsically a passive device and it is a simple light control device. The managing and control of the data to be displayed is performed by one or more circuits. An LCD consists of two glass panels, with the liquid crystal materials sand witched between them LCD are more reliable and energy efficient. Its low power energy consumption makes it to be used in battery powered electronic devices. LCD consists of array of small pixels. Each pixel of an LCD consists of a layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axis of transmission is perpendicular to each other.

3.1 SENSORS

Flex sensor is changes the resistance depending on the amount of bend on the sensor. This sensor will convert the change in bend to electrical resistance - the more the bend, the more the resistance value. They are usually in the form of a thin strip from 1"-5" long that vary in resistance from approximately 10 to 50 kilohms. A property of bend sensors worth noting is that bending the sensor at one point to a prescribed angle is not the most effective use of the sensor. Bending the sensor at one point to more than 90˚ it may permanently damage the sensor. The Load Cell converts the applied force into electrical signals.

Vibration is an oscillatory motion. A body is said to vibrate when it describes an oscillating motion about a reference position. Motion is a vector quantity, exhibiting a direction as well as a magnitude. The extent of the oscillation determines the magnitude of the vibration and the repetition rate of the cycles of oscillation determines the frequency of vibration.

The piezoelectric transducer is displaced from the mechanical neutral axis, bending creates strain within the piezoelectric element and generates voltages. The Vibration Sensor Detector is designed for the security practice, When Vibration Sensor Alarm recognizes movement or vibration, it sends a signal to either control panel developed a new type of Omni-directional high sensitivity Security Vibration Detector with Omni-directional detection.

4. EXPERIMENTAL VALIDATION

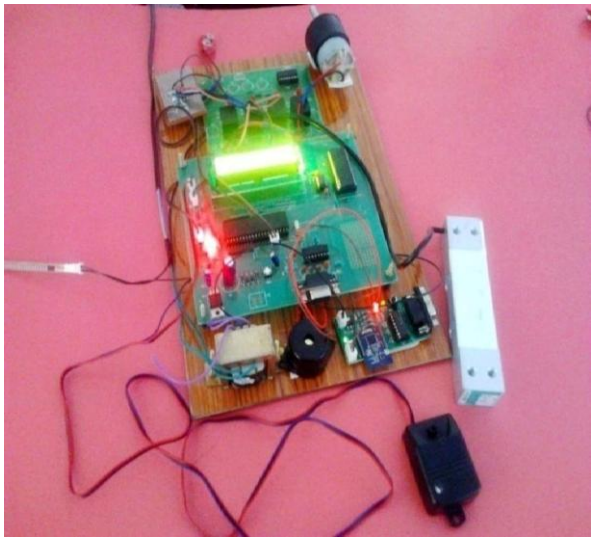

Fig 2: Monitoring Kit

The operation of the system is as follows:

1. The AT89C51 microcontroller detects and monitors the changes in sensors by displaying the values in LCD.

2. All the changes of sensors will be passed to the IC 89C51 which is detected by the LCD.

3. The detected values will be transferred to ZigBee transceiver from the IC and it pass the data to the antenna

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4. The ZigBee transceiver sends the signal to the ZigBee receiver by using its antenna CC2530 through RF communication.

5. The base Station (BS) receives the signal from the ZigBee receiver through PL-2303 serial port and alerts the BS.

5. IMPLEMENTATION AND RESULTS

Here, the flex sensor work is implemented and it is indicate the internal damage detection in bridges.

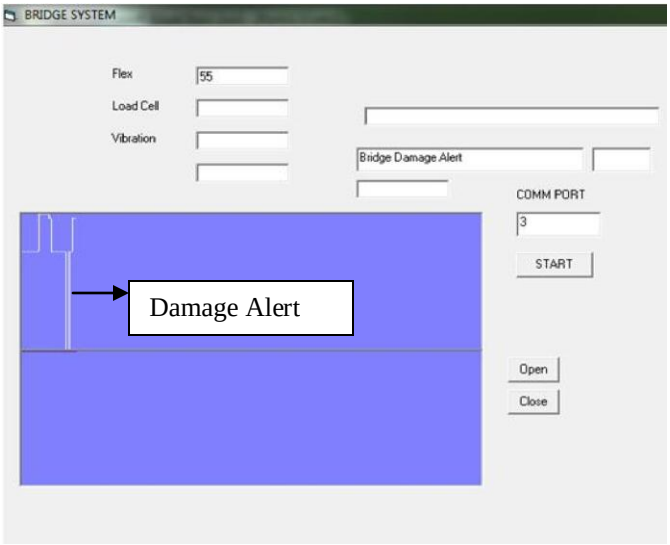

Fig 3: Indication of damage using Flex sensor

The load cell implemented and the weightage is calculated to find the capacity of the bridge.

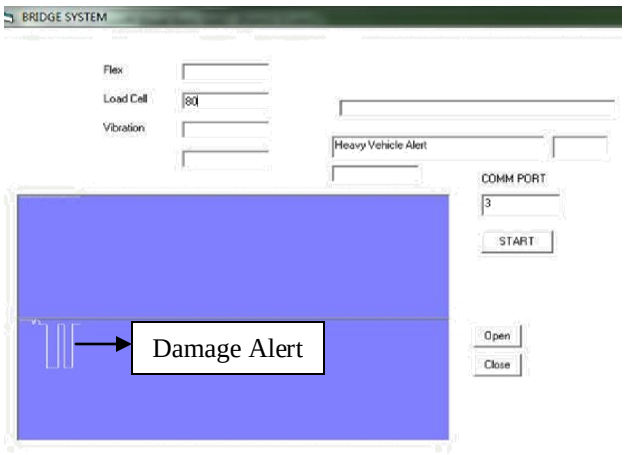

Fig 4: Indication of damages using Load cell sensor

Here, the vibration sensor work is implemented and find the external damages in bridge.

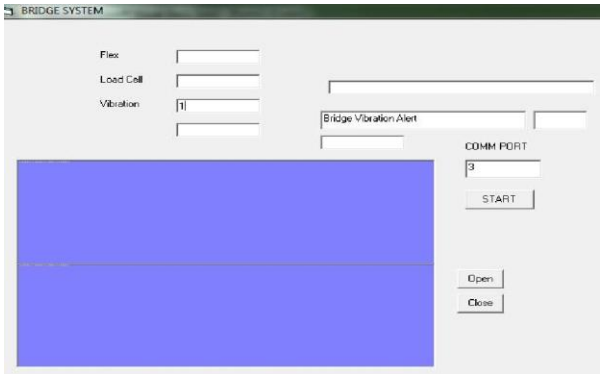

Fig 5: Indication of damages using Vibration sensor

CONCULSION

This framework is designed to identify the damages in the bridges using ATMEL 89C51 microcontroller. The internal and external damages and the maximum load capacity that can be tolerated by bridge is monitored by Flex, Vibration and Load Cell Sensor respectively. The changes of the sensing values will be displayed in the LCD. The ZigBee is used to control and monitor the sensors and then the detected values passed to the IC. Then, the ZigBee transceiver will pass the signal to ZigBee receiver by using the antenna. Using the PL-2303 serial port the alert will be pass to Base Station. Hence the damage in the bridge can be detected in the civil infrastructure.

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