Data Acquisition system for Monitoring Variation in Bridge parameters

Venkatesh H, Jagadish M C

***Abstract*— To perform a qualitative as well as a quantitative assessment of the bridge, proper diagnosing data on its parameters are compulsory required. Considering different case of industries such as the automotive ones, some distinct techniques are used to practical examine the integrity of civil engineering structures consider example as bridge. There are the visual inspection technique, the destructive methods and the non-destructive evaluation methods (NDE). Among the various conventional NDE methods are the following procedures includes ultrasonic, acoustic, pulse echo, X-ray Imaging. The first two methods are very active and many of these NDE techniques are passive, often expensive, sometimes results will be unexpected , and mostly expandable externals to the civil structure. As we travel in a vehicle we will expect while crossing an bridge we have to cross the bridge to be secure and more safe, but many of the bridges are extinct old and few bridges have already collapsed, so we have developed a new data acquisition system which monitors the bridges and sends the measured parameters data .**

The Data Acquisition system is designed in such a way that the analog input in the range of +/-5V DC can be acquired to the PC through GPRS Modem using ADC & Microcontroller. The Microcontroller will transfer the ADC data to the GPRS Modem through UART [Serial Communication] and also to SD memory card through SPI protocol. The data transferred from the Transmitter will be received by PC through internet.

***Index Terms*— Smart Bridges, Linear variable differential transformer sensor (LVDT), Load cell sensor, Lab VIEW.**

I. INTRODUCTION

The Data Acquisition is a versatile system where in multiple channels can be logged into system automatically and continuously for Months together without human intervention. GPRS Modem is a wireless technology developed as an open global standard to address the unique needs of low-cost, low-power, wireless sensor networks.

A load cell is a transducer that is used to convert a force into an electrical signal as shown in figure 1 This conversion is indirect and happens in two stages. Through a mechanical arrangement, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as an electrical signal, because the strain changes the effective electrical resistance of the wire. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration.

The linear variable differential transformer (LVDT) (also called just a differential transformer) is a type of electrical transformer used for measuring linear displacement (position).The LVDT converts a position or linear displacement from a mechanical reference (zero, or null position) into a proportional electrical signal containing phase (for direction) and amplitude (for distance) information. The LVDT operation does not require an electrical contact between the moving part (probe or core assembly) and the coil assembly, but instead relies on electromagnetic coupling.

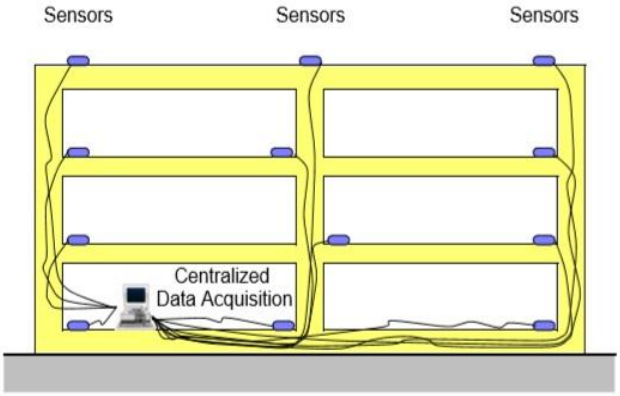

Figure 1. Traditional SHM System using Centralized Data Acquisition.

Secure Digital (SD) is a non-volatile memory card format for use in portable devices. An SD card is an ultra small flash memory card designed to provide high-capacity memory in a small size. An SD card typically measures 32 x 24 x 2.1 mm and weighs approximately 2grams. It is faster compared to MMU (multimedia cards) or any memory device.

II. PREVIOUS WORK

Most of the bridges have some sort of structural damage. Most bridges still require field methods to assess this damage, including visual inspection, dye penetrate testing, ultrasonic techniques. These field methods can miss structural problems or fail to catch in time to prevent a catastrophe. Earlier the entire data acquisition system was connected through lengthy wiring system. Because of the voltage drop in long distance wiring lines, the voltage needs to be converted to current in order to transmit long distances. Once again at the remote end the current has to be converted to voltage. Lot of human intervention is involved. These wiring technique create the harness and complexity for wiring and whenever a failure or damage occurs in wire it is very had to find the faulty area hence replacing replacing the wires by wireless sensor nodes hence it is easy to analyze.

Currently structural engineers use wired data acquisition system to acquire data. However power and wired constraints imposed by these systems can increase the cost of acquiring data and limit number and location of sensor. In this paper we are going to give a wireless solution by using GPRS modem. We transmit the data to the internet through GPRS modem so we can view the data from remote places, and also we are using SD card to store the data for future use.

Manuscript received April 10, 2015.
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III. BLOCK DIAGRAM

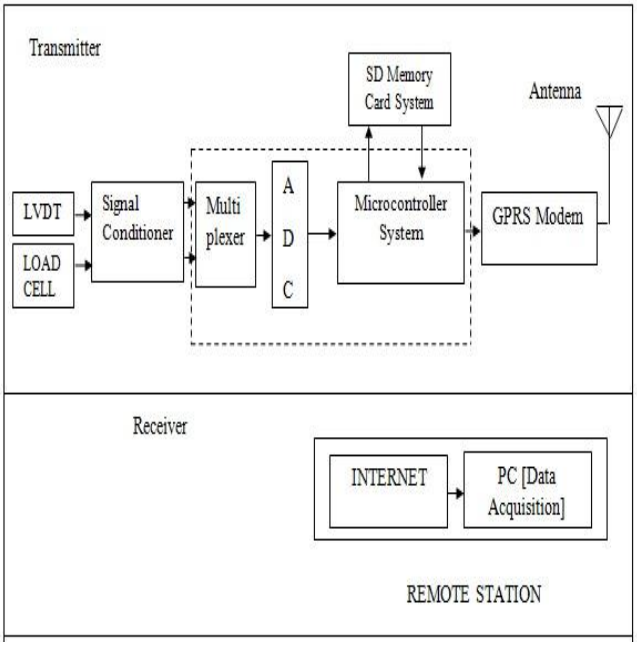

Fig 2 Block Diagram Of Proposed model

We are using the system for detecting variation in the bridge parameters, which involves the observation of a system over time using periodically sampled measurements from an array of sensors.

In order to avoid the lengthy wiring systems we are using GPRS wireless technology. By using the Wireless Data Acquisition System, Voltage - Current & Current – Voltage Conversion in long distance transmission can be completely avoided

Microcontroller program is developed in such a way that the analog input connected to the multiplexer is connected to ADC sequentially and the converted data is transferred to the GPRS through serial communication. The microcontroller timing clock is selected in such a way that the data transmission speed for all the connected analog channels is exactly one second.

The labVIEW based data acquisition program is developed in such a way that the GPRS data is acquired through internet. A memory device is introduced in which the data will be stored continuously by SPI protocol. If the GPRS modem fails to acquire data due to low network coverage, the data stored in the SD card memory device can be used for further analysis. The acquired raw data will be stored in the user defined path and folder with respected to their selected engineering units for ex: load in kgs, displacement in mm, pressure in bar etc.

To develop an embedded system that constantly monitors the bridge parameters with the help of load cell sensor and LVDT sensor this data is made available to real time through real time feed over the internet.

The system is a good design in such a manner that the setup circuit is implemented in the bridge. It was in such a manner that, if there is any variation in the bridge parameters the sensors sense the variation and sends the signal to the microcontroller unit and then microcontroller unit stores the data in SD card and then it sends the data to the internet through GPRS modem, so we can view the data from remote places. LabVIEW is used to see the sensor response.

IV. SMART SENSOR

In general, a sensor is a device that is designed to acquire information from an object and transform it into an electrical signal. As shown in Fig. 3, a traditional integrated sensor Fig. 4 can be divided into three parts:

(i) the sensing element (e.g., resistors, capacitor, transistor, piezo-electric materials, photodiode, etc.),

(ii) (ii) signal conditioning and processing (e.g., amplifications, linearization, compensation, and filtering), and

(iii) (iii) a sensor interface (e.g., the wires, plugs and sockets to communicate with other electronic components)

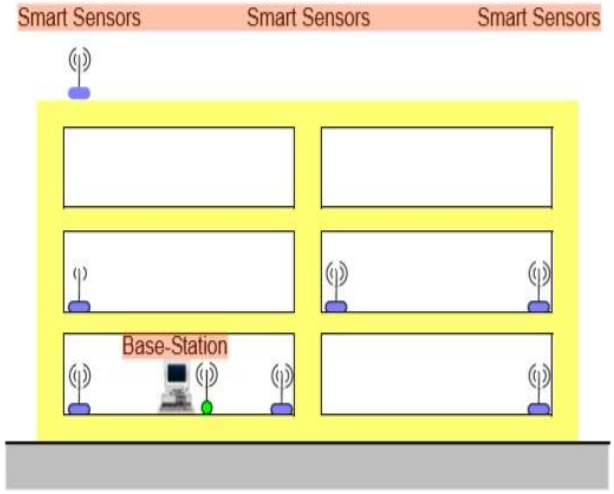

Figure 3. SHM System with Smart Sensors..

As illustrated in Fig. 5, the essential difference between a smart sensor and a standard integrated sensor is its intelligence capabilities, i.e., the on-board microprocessor. The microprocessor is typically used for digital processing,

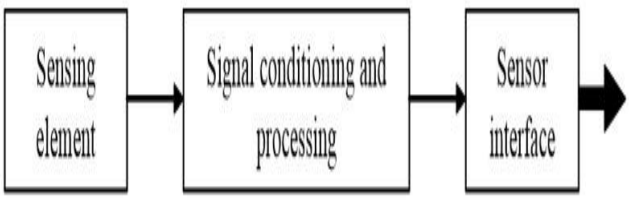

Figure 4. Traditional Integrated Sensors.

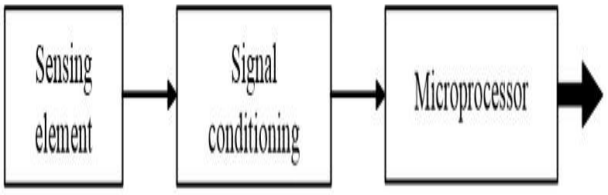

Figure 5. Smart Sensor.

analog to digital or frequency to code conversions, calculations, and interfacing functions, which can facilitate self-diagnostics, self-identification, or self-adaptation (decision making). It can also decide when to dump/store data, and control when and for how long it will be fully awake so as to minimize power consumption. The size of smart sensors has been decreasing with time. The use of MEMS has made possible the dream of having ubiquitous sensing and in particular small "smart" sensing. MEMS devices are manufactured using very large scale integration technology

(VLSI) and can embody both mechanical and electrical functions. MEMS can be used in an environment to both sense and actuate.Sensing requires that a physical or chemical phenomenon be converted to an electrical signal for display, processing, transmission, and/or recording. Actuation reverses this flow and converts an electrical signal to a physical or chemical change in the environment. The main advantage brought by this technology and its design paradigm to applications is miniaturization. MEMS features are typically on the scale of microns (10–6 m). MEMS devices can be found in a wide-range of applications from accelerometers for airbag deployment to electronic particle detector that helps fornuclear, biological, and chemical inspection.

V. HARDWARE DESCRIPTION

1. **Pic18f4520-- PIC** is a family of modified Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to "**Peripheral Interface Controller**'" now it is "**PIC**'" only. PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

2. **GSM MODULE--** This GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily. This GSM modem is a highly flexible plug and play quad band GSM modem for direct and easy integration to RS232 applications. Supports features like Voice, SMS, Data/Fax, GPRS and integrated TCP/IP stack

3. **SD CARD--** Secure Digital (SD) is a non-volatile memory card format for use in portable devices, such as mobile phones, digital cameras, GPS navigation devices, form factors. The four families are the original Standard-Capacity (SDSC), the High-Capacity (SDHC), the extended-Capacity (SDXC), and the SDIO, which combines input/output functions with data storage. The three form factors are the original size, the "mini" size, and the "micro" size. Electrically passive adapters allow the use of a smaller card in a host device built to hold larger card.and computers. The secure digital standard was introduced in 1999 as an evolutionary improvement over Multi Media Cards (MMC). The Secure Digital standard is maintained by the SD Card Association (SDA). SD technologies have been implemented in more than 400 brands across dozens of product categories and more than 8,000 models.

4. **LVDT--** The linear variable differential transformer (LVDT) (also called just a differential transformer, linear variable displacement transformer, or linear variable displacement transducer) is a type of electrical transformer used for measuring linear displacement (position). An LVDT Displacement Transducer comprises 3 coils; a primary and two secondaries. The transfer of current between the primary and the secondaries of the LVDT displacement transducer is controlled by the position of a magnetic core called an armature. On our position measurement LVDTs, the two transducer secondaries are connected in opposition.

5. **LOAD CELL** A load cell is a device that is used to convert a force into electrical signal. Strain gauge load cells are the most common types of load cells. There are other types of load cells such as hydraulic (or hydrostatic), Pneumatic Load Cells, Piezoelectric load cells, Capacitive load cells, Piezo resistive load cells etc. Load cells are used for quick and precise measurements. Compared with other sensors, load cells are relatively more affordable and have a longer life span.

VI. SOFTWARE DESCRIPTION

- MikroC is a full-featured ANSI C compiler that is available for six different microcontroller architectures. It features an intuitive IDE, a powerful compiler with advanced SSA optimizations, lots of hardware and software libraries, and additional tools that will help you in your work. The mikroC PRO for PIC compiler supports 504 PIC microcontrollers. Newly released PIC microcontrollers will be supported by new versions of the compiler software that is updated regularly. MikroC PRO for PIC comes equipped with fully functional software tools that can boost your efficiency and do the job for you, so you can be more productive in your work: LCD Custom Character Tool, GLCD Bitmap Editor, Seven-Segment Editor, UART Terminal, UDP Terminal, HID Terminal, ASCII Chart, Active Comments Editor, Advanced Statistics and more.

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- Quick Converter-Use the Quick Converter to turn binary, float, HEX and Radix 1.15 formats into formats you need in your code. It even displays ASCII values of your bytes.

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- LABVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments.The graphical language is named "G" (not to be confused with G-code). Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various versions of UNIX, Linux, and Mac OS X. The latest version of LabVIEW is LabVIEW 2013, released in August 2013.
- Graphical programming LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel and a connector pane. The last is used to represent the VI in the block diagrams of other, calling VIs. The front panel is built using controls and indicators. Controls are inputs – they allow a user to supply information to the VI. Indicators are outputs – they indicate, or display, the results

based on the inputs given to the VI. The back panel, which is a block diagram, contains the graphical source code. All of the objects placed on the front panel will appear on the back panel as terminals. The back panel also contains structures and functions which perform operations on controls and supply data to indicators. The structures and functions are found on the Functions palette and can be placed on the back panel. Collectively controls, indicators, structures and functions will be referred to as nodes. Nodes are connected to one another using wires – e.g. two controls and an indicator can be wired to the addition function so that the indicator displays the sum of the two controls. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program.

- HERCULES SETUP is a lightweight tool developed to work as a terminal which can handle serial ports UDP/IP and TCT/IP protocols. It displays a user-friendly interface that has a tabbed structure and makes it easy to switch between its functions. Everything is straightforward when it comes to its 'Serial', 'TCP Client', 'TCT Server', 'UDP' and 'test mode' sections.

- HYPER TERMINAL is a program that you can use to connect to other computers, Telnet sites, bulletin board system (BBSs), online services, and host computers, using either your modem, a null modem cable or Ethernet connection. Though using HyperTerminal with a BBS to access information on remote computers is a practice that has become less common with the availability of the World Wide Web, HyperTerminal is still a useful means of configuring and testing your modem or examining your connection with other sites. For more information, see Set up a new connection.

VII. IMPLEMENTATION

Data acquisition system for monitoring variation in bridge parameters using SD card and GPRS, in which there are two sensors LVDT and Load cell, LVDT is a displacement transducer which is used to sense the displacement occurred in the bridges, and load cell is a transducer which is used to convert load in to electrical signals.

The output of the LVDT and load cell is given to signal conditioner which is used to calibrate LVDT and load cell, we calibrate +/-5mm LVDT to 5v and 20kg load cell to 5v. then the output of the signal conditioner is given to the multiplexer, and then it is given to ADC which converts incoming analog signal to digital signals and then it is given to the microcontroller. The microcontroller store the data in SD card by using SPI protocol, as well as it transmits the data to the internet through GPRS modem.

At the receiving side the labview program is developed in such a way that the GPRS data is acquired through the internet for analyzing the response of the sensors.

VIII. RESULTS

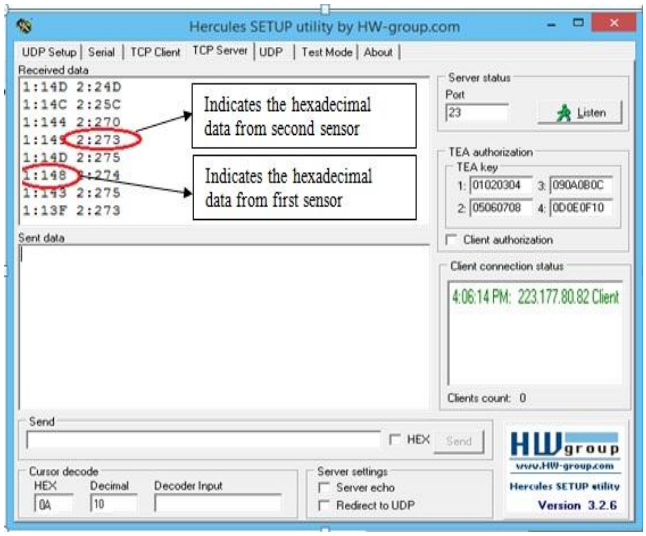

Fig 6: Sensors data receiving through internet

Above Fig 6 shows the output of both sensors in hexadecimal value which is of 10bit is received through the internet by using a HERCULES software

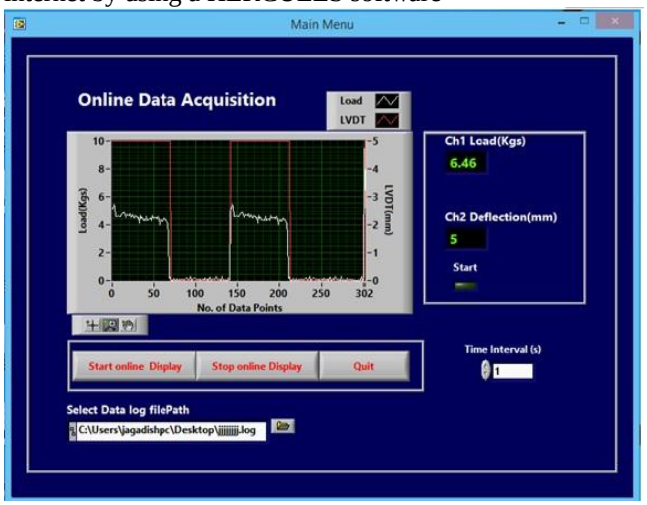

Fig 7 Sensors response is observed in Labview

The above Fig 7 shows the LABVIEW window which is used to view the sensors response in graphical form. In this the graph which is marked red shows the LVDT response and the graph which is marked white shows the load cell response.

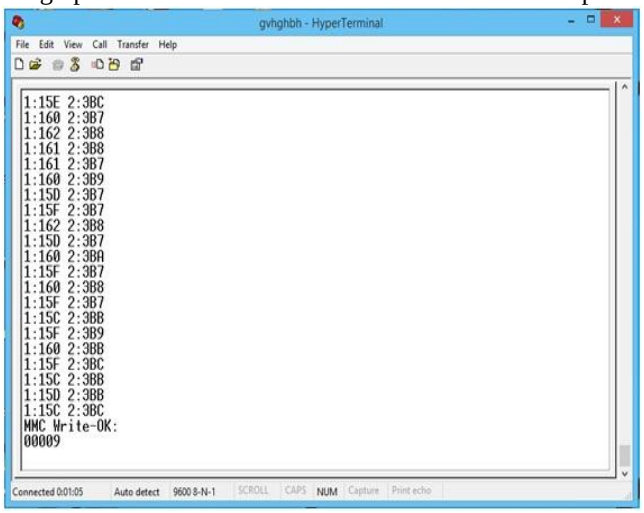

Fig 8. Sensors data stored in SD card

The above fig 8 shows the response of both the sensors which is stored in memory card and the stored data is displaying in hyper terminal software.

IX. CONCLUSION

This paper provided a brief introduction to smart sensing technology, identifying a number of the opportunities, as well as some of the associated challenges. Smart sensors based on the Mote par- adigm will provide the impetus for development of the next generation of structural health moni-toring systems, opening new horizons for research and development. Multi-agent system technology offers a computational framework for new algorithms implementation. Data acquisition system for monitoring variation in bridge parameters using SD memory card and GPRS modem and Smart sensors was successfully implemented. The circuit is designed to recognize the variation in the bridge parameters using sensors and sends the signal to the microcontroller unit and then microcontroller unit stores the data in SD card and then it sends the data to the internet through GPRS modem, so we can view the data from remote places. LabVIEW is used to see the sensor response and this model is efficiently implemented and obtained practical and successful results

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