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Automation in Railway Industry Based on Zigbee Wireless Sensor Network

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ABSTRACT: Railway is best media for transportation, travelling. Nowadays, use of sensing technology is tremendously increased and widely used in various application field. In this paper, we have proposed system for automation in railway industry with the help of zigbee technology with wireless sensor network. In the railway industry, monitoring of different structural parts rail tracks, wheels, boogies, chassis, wagons from remote location in smarter way reducing human presence in actual rail field. In this paper we proposed automation in railway industry with the help of zigbee based WSN network. By placing WSN node on each structural part which wants to monitor. These sensor data is uploaded on webpage. Using mobile internet facility, data can be easily accessed from anywhere. Proposed system is best for detecting progressively worse situation in rail structural parts before condition turns to accident. Accidents happening due to track misalignment, over weighted boogies in train have been a big problem for railways for life security and timely management of services. This bending angle of tracks required to be identified in real time before a train actually comes near to the defected track and get subjected to an accident. In this paper, different types of rail fault analysis and monitoring methods are described and it used a basic algorithm is readdressed that makes use of wireless sensors for detecting faults in rail tracks beds, boogies and misalignment in the rail tracks.

KEYWORDS: LPC2148 ARM7 Development Board, zigbee module, GSM SIM 800 modem, wireless sensor network

I.INTRODUCTION

Day by bay sensing technologies has expanded and widely used in different applications, sensor devices have become cheaper. It has led to a fast elaboration in structural condition monitoring of systems using various sensor devices. Main factors are the recent innovation in networking technology such as zigbee based wireless communication and cell phone ad-hoc networking coupled with technology to integrate devices. WSN (i.e. wireless sensor network) used for monitoring structural health of the railway structure such as railway tracks, rail bridges, track beds, rail boogies, and track equipment along with railway health monitoring such as chassis, wagons, boogies and wheels. The rail accidents are occurring due to misalignment of rail tracks, wheel irregularities. The train wheels wear over time and also suffer flat wheels and out-of-round wheels. WSN condition monitoring minimizes human presence in the actual rail field area and also reduces maintenance through detecting faults before they become more critical and hence it improves safety and also reliability. This is very essential for the expansion, upgrading, and development of railway networks. These wireless sensors network technology for structural health monitoring in the railway industry for analyzing system, structures, vehicles and machinery.

Condition monitoring by zigbee based WSN technique detect and identify progressively worse condition in structures and infrastructure before such situation avoids rail accidental operations. In regular structural monitoring, sensor device monitors condition of various structure of railway. Within these days, track information data is send to the base station. Then base station information data is further send towards the train and displayed on LCD. The main objective of this paper is to help railway department for automation in rail industry.

Wireless Sensor Networks (i.e.WSN): A WSN consists of a number of sensors, each of sensor which looks like physically small devices, and they are equipped with the ability of sensing physical environment, processing of data and wireless communication with other sensors. Generally, we assume that wsn sensor has certain constraints regarding to its power, memory, energy source, and computational capability.[7]

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II. LITERATURE SURVEY

The system in [1] detects overall moisture present in the soil, which is based on that pumping motor which will automatically pumps the water in the farm. Soil sensor give the present status of the soil moisture contents to the microcontroller, and it get displayed on LCD and provided power ON or OFF the pumping motor through relay. System [2] shows design and development of WSN node for wireless sensor network monitoring the industrial environmental parameters. This system uses RF module ZigBee, WSN, PIC 18F4550 microcontroller water measuring various parameter in collected water samples. The project system in [4]which gives solar energy parameters calculation like voltage, current, temperature and intensity with the help of various sensors. Parameters displayed on LCD interfaced with PIC microcontroller. The system [3] consists of various sensors to measure the standard of water, GSM and microcontroller used to transfer the information to the watching centre at predefined time. The system in [9] detects greenhouse parameters in order to maintain environmental condition for greenhouse suitable for plants growth using PIC and zigbee based WSN.

III. PROPOSED SYSTEM DESCRIPTION

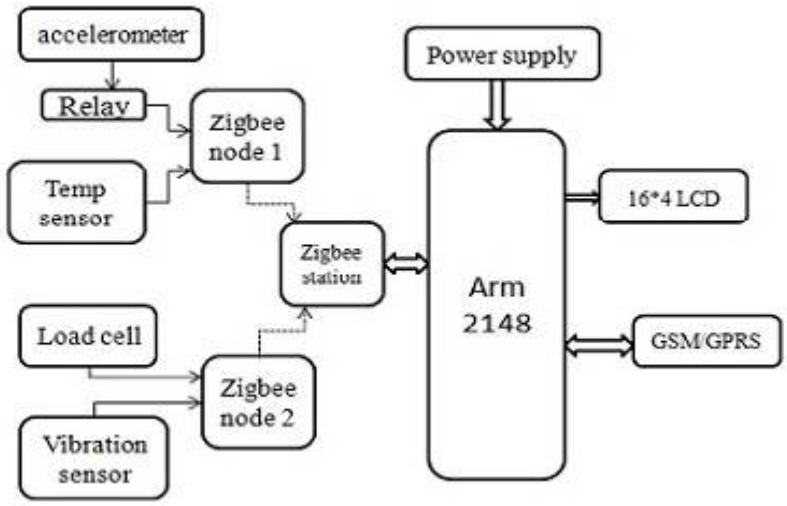

Fig 1: Block diagram of proposed system

In proposed system, we have used two nodes that each of wsn node which carries two sensor data. Communication between these WSN nodes and base station is done by zigbee module wirelessly. Here we have integrated the GSM SIM 800 module with the ARM 7 microcontroller and with the help of GPRS service, we can upload these sensors data near real time and this sensor data can be accessed from webpage. Proposed system implemented on arm 7 development board. It uses 32 bit processor with on chip timer/counter, ADC and UART got interfaced with zigbee module. This proposed system uses GSM technology which gives current sensor reading also shows status of condition whether it is normal, then you need not to go rail field area. And if status is bad, you have to go in rail field. Proposed system provides preventive action of rail accidents.

Proposed system works given in following sequence:

1. First we will check real time conditions sensor data reading in railway industry.
2. Data of each sensor from each WSN node is collected at base station using zigbee technology.
3. Then this collected sensor data from base station is easily uploaded on webpage using GPRS technology.
4. With the help of internet we easily access actual condition in railway industry.

Features of this system

- We have used ARM 7 microcontroller which provides greater access speed with more peripherals also it provides better reliability.

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- There is no necessity of any android application in this proposed system.
- GSM module and zigbee module are easily available in electronics market. Hence it does not need to do system implementation.
- Proposed system required dedicated web page which get accessed from any mobile device which supports internet service.
- There is no necessity of human presence and his inspection in actual rail field.

IV. HARDWARE DESCRIPTION

A. MICROCONTROLLER:

Here in this proposed system, we used ARM7 LPC 2148 microcontroller that is heart of this system as shown in fig. 2 given below. This ARM is faster in operation in comparison to all other microcontroller, it processes 32 bit data simultaneously. System is performing all real time data operations simultaneously, hence microcontroller should be faster. Microcontroller 8051, AVR, PIC have more slow data processing speed compared to LPC2148 controller. Because of in-built pipelining feature of ARM controller which made MCU faster also it executes more than one instruction simultaneously in pipelining queue.

Fig.2- LPC 2148 Development board

- ARM controller LPC 2148 is 64 pin IC.
- ARM LPC 2148 is having 32 bit ARM7 TDMI core.
- It is also having 32KB on chip static RAM.
- It is having 512KB Flash ROM with In Application Programming (IAP) and In System Programming (ISP) and ARM controller is Vectored Interrupt Controller.
- Having 14 channels with in-built 10-bit ADC.
- It also have PWM unit, Watchdog Timer and two 32-bit timers.
- LPC2148 is having CPU clock frequency up to 60 MHz, on-chip crystal oscillator and on-chip PLL.
- It also have 128 bit wide interface enables high speed 60MHz frequency operation.
- Having in-built pipelining feature which makes faster execution of instruction.

B. GSM MODULE:

GSM module is digital mobile telephony system as shown in figure 3. GSM SIM 800 accepts any GSM network operator SIM card (i.e. Subscriber Identity Module) which operates on 900 MHz, 850 MHz, 1800 MHz and 1900 MHz frequency band. GSM module provides advantages of using serial RS-232 port in order to communicate and development in embedded technology. GSM modem connected to microcontroller by MAX 232 IC that can be connected to personal computer by rs-232(i.e. serial port). By GSM module connection with internet it get operated in GPRS mode and performs various operations. GSM module communicates to microcontroller using serial port (i.e. RS-232 cable).

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Fig.3 GSM module

C. ACCELEROMETER:

In this system, ADXL345 accelerometer used which is from analog device, having triple axes x, y and z. In railway industry, accelerometer is used to measure bending angle of track. Hence we used relay at particular set point for x axis. When accelerometer crosses this set point, relay will turned ON. This indicates that tracks horizontal axes get changed. This indicates precaution step for track misalignment. This sensor operates at 5 volt and gives 3.3v at output pin. It measures both static and dynamic acceleration.

D. TEMPERATURE SENSOR:

We have used LM 35 temperature sensor for sensing temperature of rail boogies, tracks, wheels etc. There is wear and tear of train wheels and tracks because of over load in trail boogies results in great friction between wheels and rail tracks. Due to extra load, track temperatures raise and further more increment in temperature which will result in track misalignment and also train wheels wear over time which suffer from flat and out-of-round wheels. Temperature sensor on boogie used to detect burning. Temp sensor is shown in fig.4 below. LM35 is of low cost temperature sensor and easy to use which generates high output voltage hence no need of amplification. LM35 IC is an integrated circuit which generates output voltage linearly proportional to its degree centigrade temperature.

$$\text{Analog input Voltage} = \frac{\text{ADC Reading}}{\text{Resolution of ADC}} * V_{ref}$$

Using above formula we can calculate temperature in degree centigrade.

E. LOAD CELL:

Here in the proposed system, we have used CZL601 load cell for weight measurement purpose. We can use this sensor on rail track, on boogies for over load measurement purpose. It is a transducer that converts force exerted on it into an electrical signal. Load cell consists of 4 strain gauge in Wheatstone bridge configuration which gives output in order of few milivolt (mV). Hence it needs amplification strengthen to weaker signal. Load cell needs 12volt supply for its operation and gives 3.3 volt at output.

PIEZOELECTRIC SENSOR:

This sensor used in proposed system for vibration measurement. It works under piezoelectric effect. Piezoelectric sensor available in market in rounded metal plates. Direct piezoelectricity of some substances like quartz, as mentioned above, can generate potential differences of thousands of volts. Detection of pressure variations in the form of sound is the most common sensor application, e.g. piezoelectric microphone. Sound waves bend the piezoelectric material, creating a changing voltage.

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V. FLOW CHART FOR SENSOR SIDE AND BASE STATION:

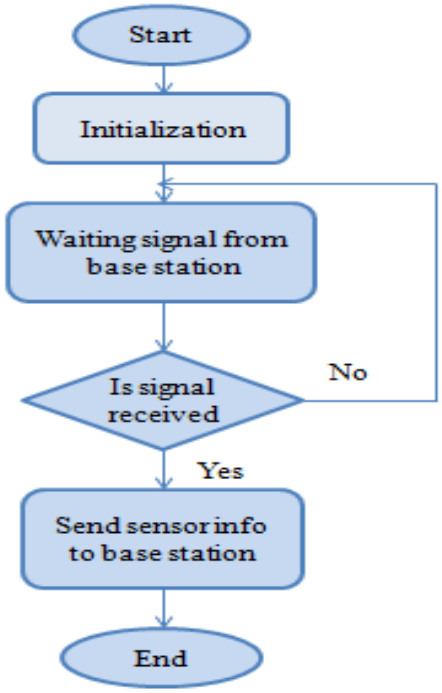

Fig.4: Flow chart for sensor side

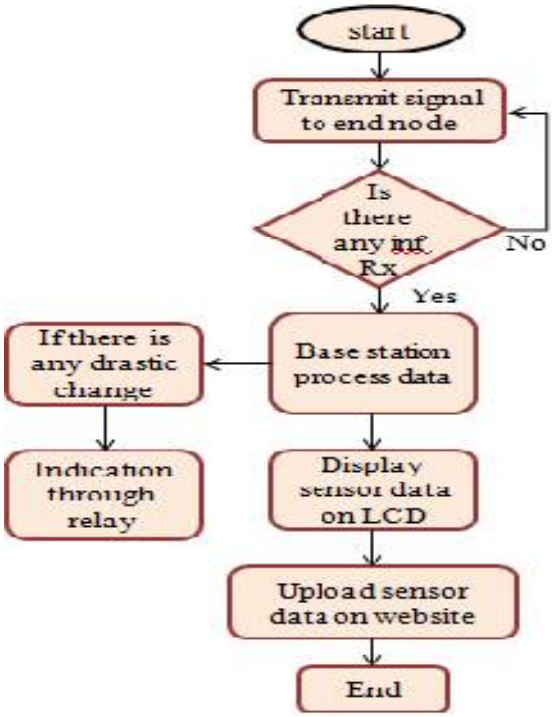

Fig.5: flow chart for base station

Here flowchart of transmitter node and base station is given above in fig 4 & 5. Here flowchart for sensor node and base station is given below. Zigbee at base station send some frames to sensor node's zigbee in order to initiate communication. When any signal is received at sensor node, it further transmitted towards base station. Then this signal is get displayed on LCD and uploaded on webpage. Readings from each sensor is uploaded on webpage continuously with few milliseconds delay.

VI. RESULT AND DISCUSSION

In this section, we have discussed results of proposed system shown in fig 6. This system is designed for condition monitoring of different rail structural parts like chassis, boogies, tracks, wagons and wheels. If any drastic change in temperature, weight, vibrations, accelerometer's axes which indicates current position of wear and tear of wheels, bending angle of rail track (i.e. misalignment), boogies. Intention of proposed system is to monitor current status from remote location using GPRS, zigbee technology.

All time we are continuously monitoring current status of railway structure system which can be accessed from dedicated webpage. In the proposed system, there are two WSN node and base station those communicated via zigbee. Base station content advanced efficient microcontroller LPC 2148 with GSM SIM 800 module and zigbee module shown in fig 6. Condition monitoring reduces human presence in rail field and also detects progressively worse condition in various rail structure which progressively get subjected into accidents. In short we described proposed system as automation in rail industry.

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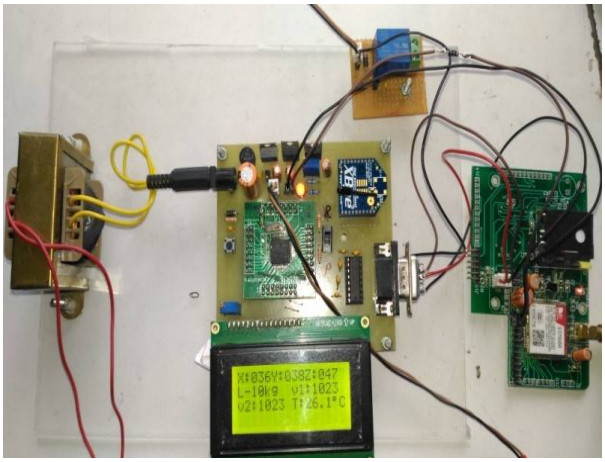

Fig 6- system implementation

Here sensors on WSN nodes are continuously reads values and sends data to microcontroller at base station. After processing, microcontroller will continuously update data on webpage. With the help of data uploaded on webpage, we can easily access real time data using cell phone or personal computer.

Wireless sensor network provides continuous and near real-time data acquisition and autonomous data acquisition; no supervision is required. Data uploaded on webpage shown in fig. 7 provide present situation of train chassis, boogies, tracks structures, infrastructure global data view that allows this information to be determined where degradation is happening slowly over a relatively long period of time. The global data view that allows trending information to be determined where degradation is happening slowly over a relatively long period of time. In such a way, we can monitor the conditions of rail industry with real time data using WSN, zigbee technology.

Fig. 7- webpage of the system

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In the webpage shown in fig.7, there are 2 sensor nodes. In first node, first 3 sensor readings indicates value of accelerometers x axis, y axis and z axis respectively and temperature value indicated by sensor 4.
Whereas in second node, weight measured by load cell that indicated by sensor1 and vibration signal measured by piezoelectric plates indicated by sensor 2 and sensor 3.

VII. CONCLUSION

In this paper, we have implemented wireless sensor network with zigbee technology concept as automation system in railway industry. The proposed system detects faults in various railway structures hence avoids accidents, provide safety and also reduce maintenance cost of overall railway industry. Without of human presence in actual rail field, we get current situation of rail structures simply accessing dedicated webpage.

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