

Condition Monitoring of Railways Using Wireless Sensor Networks

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ABSTRACT: In recent years, the range of sensing technologies has expanded rapidly, whereas sensor devices have become cheaper. This has led to a rapid expansion in condition monitoring of systems, structures, vehicles, and machinery using sensors. Key factors are the recent advances in networking technologies such as wireless communication and mobile ad hoc networking coupled with the technology to integrate devices. Wireless sensor networks (WSNs) can be used for monitoring the railway infrastructure such as cracks in bridges, rail tracks, track beds, and track equipment along with obstacle detection. Condition monitoring reduces human inspection requirements through automated monitoring, and improves safety and reliability. This is vital for the development, upgrading, and expansion of railway networks. This paper surveys these wireless sensors network technology for monitoring in the railway industry for analyzing systems, structures, vehicles, and machinery. This paper focuses on practical engineering solutions, principally, which sensor devices are used and what they are used for; and the identification of sensor configurations and network topologies. It identifies their respective motivations and distinguishes their advantages and disadvantages in a comparative review.

KEYWORDS: Condition monitoring, Obstacle detection, Crack detection, Maintenance engineering, Preventive maintenance, Railway engineering, Wireless Sensor networks(WSNs).

I.INTRODUCTION

In railway bridges, any time the bridge is striking due to weather conditions, floods, earthquake, cyclone, etc. Nowadays the system has some limitations, if the bridges or track damaged, that information goes to railway authority people, they notifies and inform to the corresponding trains it will takes more time informing those information. So to avoid delays, our proposed system will immediately notifies and informs the current train comes on the track through wireless medium techniques that employ ultrasonic and tide over some of the problems mentioned earlier, but they can only inspect the core of the track; that is, it cannot check for surface and near surface cracking where most faults are usually located. LDR sensor can't operate in slab tracks and the system can be operated in tunnels without interruption where it is not possible to work with GNSS receivers. The problem inherent in all these techniques is that the cost incurred is high.

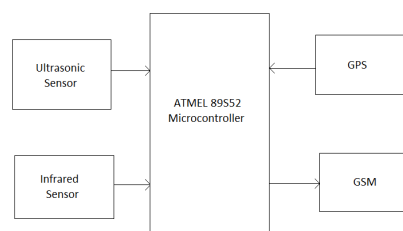


Fig.1: Figure shows a typical WSN setup for condition monitoring of Railways. Ultrasonic sensor is used for crack detection in railway tracks. IR sensor is used for obstacle detection. The location is calculated using GPS and the detected information is transmitted to the base station through GSM technology

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To avoid this problems, Bridge damage status is monitored by the IR sensor and ultrasonic sensor. When the sensor is not getting signal, immediately nearby wireless system notifies and alert or informs to the current train on the track. The above task can achieve through microcontrollers, GSM,GPS. The same information can be passed to all trains coming on the track. IR and Ultrasonic sensors are very accurate detection and it will send information immediately by using GSM. The introduced surveying system in the paper is operational on both ballast and slab tracks. the system can be operated in tunnels without interruption.

II.SENSOR DESIGN

There are number of sensors used in condition monitoring of railway. Generally, transducers convert energy from one form to another. Sensor converts measured mechanical energy into electrical energy. They are cheap and efficient.

A. Ultrasonic Sensor

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work: Using IO trigger for at least 10us high level signal, The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back. IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning.

Test distance = (high level time×velocity of sound (340M/S) / 2

The Timing diagram is shown below. You only need to supply a short 10uSpulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal.

Formula: $\mu S / 58 = \text{centimeters}$ or $\mu S / 148 = \text{inch}$; or: the range = high level time * velocity (340M/S) / 2; we suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal

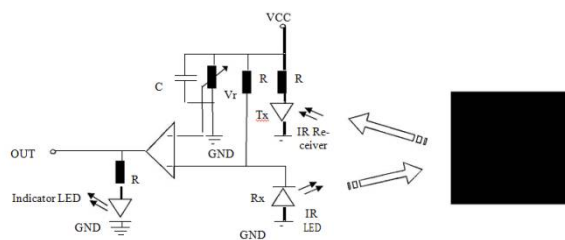


Fig.2:Figure shows the timing diagram of Ultrasonic sensor.

B. Infrared Sensor

The IR Sensor-Single is a general purpose proximity sensor. Here we use it for collision detection. The module consist of a IR emitter and IR receiver pair. The high precision IR receiver always detects a IR signal.The module consists of 358 comparator IC. The output of sensor is high whenever it IR frequency and low otherwise. The on- board LED indicator helps user to check status of the sensor without using any additional hardware.

The sensitivity of the IR Sensor is tuned using the potentiometer. The potentiometer is tuneable in both the directions. Initially tune the potentiometer in clockwise direction such that the Indicator LED starts glowing. Once that is achieved, turn the potentiometer just enough in anti-clockwise direction to turn off the Indicator LED. At this point the sensitivity of the receiver is maximum. Thus, its sensing distance is maximum at this point. If the sensing distance (i.e., Sensitivity) of the receiver is needed to be reduced, then one can tune the potentiometer in the anti-clockwise direction from this point.

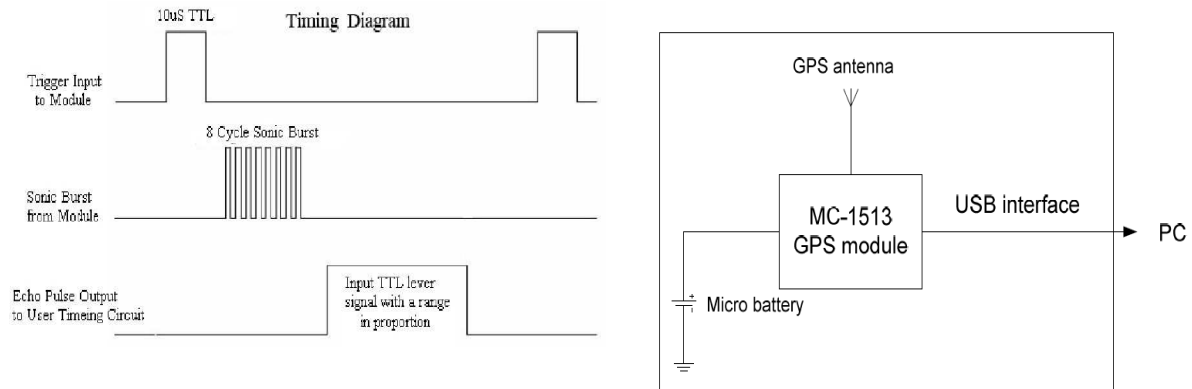


Fig.3: Figure shows the functional block diagram of IR sensor.

Further, if the orientation of both Tx and Rx LED's is parallel to each other, such that both are facing out-wards, then their sensitivity is maximum. If they are moved away from each other, such that they are inclined to each other at their soldered end, then their sensitivity reduces.

Tuned sensitivity of the sensors is limited to the surroundings. Once tuned for a particular surrounding, they will work perfectly until the IR illumination conditions of that region nearly constant. For example, if the potentiometer is tuned inside room/building for maximum sensitivity and then taken out in open sunlight, it will require retuning, since sun's rays also contain Infrared (IR) frequencies, thus acting as a IR source (transmitter). This will disturb the receiver's sensing capacity. Hence it needs to be retuned to work perfectly in the new surroundings.

The output of IR receiver goes low when it receives IR signal. Hence the **output** pin is normally low because, though the IR LED is continuously transmitting, due to no obstacle, nothing is reflected back to the IR receiver. The indication LED is off. When an obstacle is encountered, the output of IR receiver goes low, IR signal is reflected from the obstacle surface. This drives the output of the comparator low. This output is connected to the cathode of the LED, which then turns ON.

III.CONTROLLER SECTION

Microcontroller is the heart of this project. Here, ATMEL 89S52 controller is used. It belongs to 8051 microcontroller family.

The AT89S52 is a low power, high performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry standard 80C51 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 in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly flexible and cost-effective solution to many embedded control applications.

The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 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, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

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IV.COMMUNICATION SECTION

The location is calculated using GPS technology. The sensors detect the obstacle and crack in the track. The detected information along with the location is transmitted to the nearer base station and the train coming in that track through GSM technology.

A. Global Positioning System

LS20030~3 series products are complete GPS smart antenna receivers, including an embedded antenna and GPS receiver circuits, designed for a broad spectrum of OEM system applications. The product is based on the proven technology found in LOCOSYS 66 channel GPSSMD type receivers MC-1513 that use MediaTek chip solution. The GPS smart antenna will acquire up to 66 satellites at a time while providing fast time-to-first-fix, one-second navigation update and low power consumption. It can provide you with superior sensitivity and performance even in urban canyon and dense foliage environment. Its far-reaching capability meets the sensitivity requirements of car navigation as well as other location-based applications.

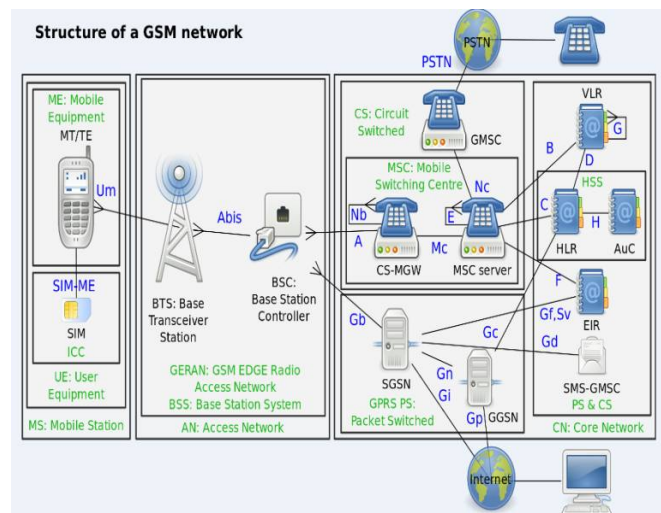


Fig.4: Figure shows the block diagram of GPS

The features of GPS includes:

MediaTek high sensitivity solution

Support 66-channel GPS

Fast TTFF at low signal level

Support AGPS

Up to 10 Hz update rate

Capable of SBAS (WAAS, EGNOS, MSAS)

Build-in micro battery to reserve system data for rapid satellite acquisition (not in LS20033) LED indicator for GPS fix or not fix (not in LS20033).

B. Global System for Mobile communication

GSM is a cellular network, which means that cell phones connect to it by searching for cells in the immediate vicinity. There are five different cell sizes in a GSM network—macro, micro, pico, femto, and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average rooftop level. Micro cells are cells whose antenna height is under average rooftop level; they are typically used in urban areas. Picocells are small cells whose coverage

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diameter is a few dozen metres; they are mainly used indoors. Femtocells are cells designed for use in residential or small business environments and connect to the service provider's network via a broadband internet connection. Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells. Cell horizontal radius varies depending on antenna height, antenna gain, and propagation conditions from a couple of hundred meters to several tens of kilometres. The longest distance the GSM specification supports in practical use is 35 kilometres (22 mi). There are also several implementations of the concept of an extended cell,^[14] where the cell radius could be double or even more, depending on the antenna system, the type of terrain, and the timing advance. Indoor coverage is also supported by GSM and may be achieved by using an indoor picocell base station, or an indoor repeater with distributed indoor antennas fed through power splitters, to deliver the radio signals from an antenna outdoors to the separate indoor distributed antenna system. These are typically deployed when significant call capacity is needed indoors, like in shopping centers or airports. However, this is not a prerequisite, since indoor coverage is also provided by in-building penetration of the radio signals from any nearby cell.

V. CONCLUSION

This paper focuses on the sensor technology used to generate condition monitoring data to enable practical condition monitoring systems. These data must be managed and turned into useful information to generate useful information. Condition monitoring systems must store large quantities of data to build models for analysis. The data must be validated first to ensure that they are correct and error-free (sensor faults, noise, null values, communication errors, etc.). This process may even be performed in the sensor node's microcontroller; thus, only valid data are transmitted thus minimizing the transmission load. These data can then be processed in a number of different ways to generate information. Once data are collated, they can be analyzed using robust algorithms to identify faults in near realtime. Algorithms need to be robust as WSN data is noisy, can be intermittent, may contain errors, has many interdependencies and the data volume is very high. The WSN data can also be stored and analyzed over longer time periods to identify longterm progressive faults such as a slowly developing crack. Some systems incorporate contextual data that describe the ambient conditions, which will affect the object monitored. These contextual data can be built into models to improve the coverage and accuracy of the model and to help provide explanation of condition monitoring decisions. It includes: train speed, position along the line (longitude and latitude from GPS system) and wind speed and direction when analyzing bogie vibrations, whereas it includes structural criteria (route) and environmental criteria (weather, travel characteristics, travel duration) when analyzing bogie temperatures.

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