

WIRELESS SENSOR BASED ONBOARD SAFE RAILWAY SYSTEM

COLLEGE : THIAGARAJAR COLLEGE OF ENGINEERING,
MADURAI, TAMIL NADU
GUIDE : MR. K. HARIHARAN
STUDENTS : G. SHANKAR
S. JEEVA
E. ANAND SOLOMON
BRANCH : ELECTRICAL AND COMMUNICATION

1. Introduction

The Railways is the chief mode of transport for the people across various strata in the society. In such a situation there is a need for ultimate security to be implemented across the railway network. Conventional Railway networks lack the necessary infrastructure to respond swiftly to the emergencies such as fire accidents.

An Automatic wireless sensor based on board railway safety system is a project that involves implanting sensor nodes at specific points in the carriage. These sensor nodes are used for collecting data such as room temperature, concentration of smoke in air, intra and inter bogie temperatures automatically. These collected data are processed to monitor room temperature and bogie temperature.

2. Problem Definition

- The coach should be monitored continuously and the collected data are to be processed for issuing a fire alert.
- The inter-bogie and intra-bogie temperatures has to be measured and processed for on board wheel safety system.



- Automation of the bogie temperature measurement and monitoring thereby eliminating the need for manual monitoring as in conventional system.
- Since the bogie temperature is transferred wirelessly between the nodes, a network that has a high reliability is required..
- A mechanism has to be devised to periodically transfer all the data from the Centralized Data base in the train to the Data base off board.

A Panoramic view of the Problems Tackled by the System

The fire alarm although available in the conventional system they are prone to false triggering and they panic the passengers in other carriages by means of alarm. These problems have been overcome in this system by using two sensors smoke and temperature, only when both are triggered the fire alert message is passed on to the base node in the engine. Based on the fire alert message appropriate actions are taken rather than agonizing the passengers.

The alignment of wheel along the tracks is based on the intra and inter bogie temperature. Hence as these bogie temperatures are of paramount importance they are measured by the Railway officials at every station manually. To measure the temperature of the respective bogies the Railway employees have to walk a long distance covering the entire distance of train. The Indian Railways too spend a huge amount of money for such a manual monitoring. These manual monitoring is tedious, prone to human errors and not precise. Thus this System helps to overcome this problem by measuring the bogie temperatures periodically and transmitting it to the off board database via the base node.

3. Design

Design of Sensor Node

The sensor node consists of fire sensor and bogie temperature monitoring sensor.

Design of Temperature Sensor

LM 35 has been chosen as the temperature sensor as it has the following properties. The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm 1/4^\circ\text{C}$ at room temperature and $\pm 3/4^\circ\text{C}$ over a full -55 to $+150^\circ\text{C}$ temperature range. It is also of low cost and it can be glued to any surface.

Design of Smoke Sensor

Smoke sensor should be a logical type i.e. this system uses a sensor which will detect the presence/absence of smoke. It should also be cheap and of low cost, that made us to develop our own indigenous smoke sensor. The smoke sensor is based on the principle of photo detection with IR transmitter and receiver on either side.

Design of Transceiver node

Design Parameters

This system uses CC2500 as transceiver. The features and interfaces are discussed below, the CC 2500 is a Small size (QLP 4x4 mm package, 20pins) in a True single chip operating frequency range: *2400-2483.5 MHz*. The transceiver has a high sensitivity and it operates at a data rate up to 500 Kbps.

Design of Networking Protocol

The networking protocol that are available in literature were not suited for our application, hence we have designed our own indigenous transport protocol.

Protocol Description

The description of the various mechanisms involved in the protocol designed for the system has been described briefly in the following topics.

Initial START UP Mechanism

Initially when the carriages are connected to the engine and the power is switched on the START UP_PACKET is transmitted to make the nodes aware of the address of the



nodes on either sides and the address of the source. This start up mechanism is absolutely essential as the coach alignment changes from time to time could change even before the train reaches the destination.

Consider a train with three carriages for analysis, the steps involved in start up mechanism is as follows:

Step 1: Start signal is initiated by engine by sending the STARTUP_PACKET.

Step 2: The acknowledgement signal is sent to the Engine by the nearby node. Then the Engine module goes to meditation state that it does not respond to wakeup signal by the nearby nodes and acknowledgment signal until the ID_COMPLETE packet is received.

Step 3: The STARTUP_PACKET is again transmitted by the first node to the next node. This is again acknowledged with acknowledgement signal. The first node then goes into idle state i.e. does not respond to the wakeup signal and acknowledgment signal until the ID_COMPLETE packet is received. This process is again repeated by the second node and it goes on.

Step 4: The process is continued until the packet reaches the Engine. After each node has received the ID_COMPLETE packet, it starts processing the sensors and sense for the abnormality.

Fire Alert Mechanism in the Protocol

When the sensors detect a fire alert, the fire alert is sent with the help of a URGENT_PACKET. This packet has the highest priority over other packets. When this packet is transmitted all other nodes suspends its functions and just transmits the URGENT_PACKET.

Thus the important ideas of the novel transport protocol have been brought about.

4. Implementation:

Fire Sensor

The fire sensor consist of a smoke and a temperature sensor, when there is a large temperature variation in a compartment(> 3 degree C -after testing) and when the smoke amount triggers the smoke sensor the fire alert is passed on to the base node.

Temperature & Smoke Sensor

In this system, we are using LM35 as temperature sensor. Temperature difference is used to issue a fire alert. . It uses the principle of photoelectric detection. The prototype model has been developed and it is tested. It consists of a IR transmitter and a IR receiver.



Figure 1: Prototype model of temperature Sensor

The placement of the temperature and smoke sensor was decided after extensive testing the position of placing smoke sensor is shown below.

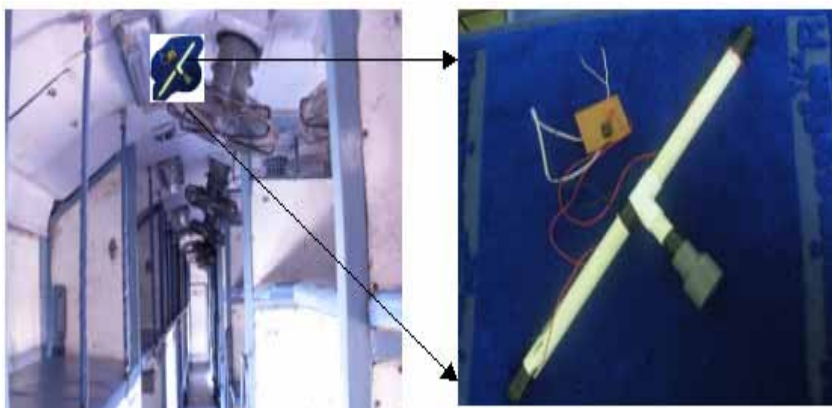


Figure 2: Placing of smoke sensor in a carriage

Implementation of Bogie Temperature Monitoring

To monitor the bogie temperatures continuously the temperature sensor is placed in the axle and the placing of the temperature sensor for bogie was decided after consultation with railway authorities and extensive testing.

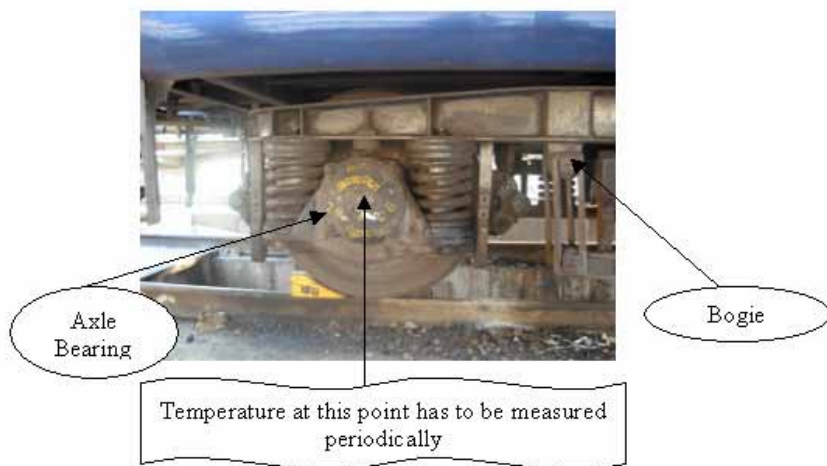


Figure 3: Bogie Temperature monitoring

6. Software tools used:

- ADS (HP –Advanced Design System) for designing the antenna.
- AVR Studio – for programming the micro controller.
- RF Studio and packet sniffer for analyzing the data sent in network.

7. Testing

The system was tested for range in an open environment, and then it was tested in a real time environment in a Stationary Train carriage.

Range Testing

The range of the system was tested using the experimental set as shown below.

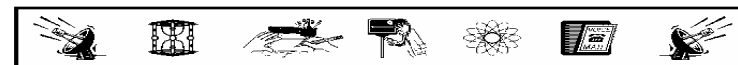
The transmitter is kept stationary, and the distance of the receiver is continuously varied. The RSSI value is calculated for each of the distance and it has been tabulated in the table.

| Sl. no | Distance(feet) | RSSI(dBm) |
|--------|----------------|-----------|
| 1 | 0 | -5 |
| 2 | 100 | -95 |
| 3 | 125 | -96 |
| 4 | 150 | -96 |
| 5 | 175 | -95 |
| 6 | 200 | -95 |
| 7 | 210 | -96 |

Table : Distance Vs RSSI

Testing in Real Time Environment:

The testing of the sensor nodes was done in a real time environment in the actual train carriage 2nd class AC chair car in the Madurai – Nizamuddin Sampark kranti express after prior permission from the Southern Railway authorities.



Test 2

Aim: To find the variation of temperature at the various points in the compartment.

Experiment: The receiver was placed in the slab near the seats, while the transmitter was placed at various points in the carriage and temperature at the various places were calculated.



Figure 4: Receiver setup in real time environment

Observation:

| Sl.no | Position of Tx | Temp(degree C) |
|-------|-------------------|----------------|
| 1 | Below lower seats | 35.1 |
| 2 | Middle berth(R) | 35.2 |
| 3 | Middle berth(L) | 35.4 |
| 4 | Upper Berth(L) | 35.3 |
| 5 | Upper Berth(R) | 35.2 |
| 6 | Side upper | 34.9 |
| 7 | Side lower | 35 |

Table 2: Position of Tx Vs Temperature

The above testing was done at mid afternoon 2 pm.

$$\begin{aligned} \text{Range} &= (\text{highest value}) - (\text{lowest value}) \\ &= 35.4 - 34.9 = 0.5 \text{ (degree)C} \end{aligned}$$

8. Result:

The temperature variation within a single compartment was less than 0.5°C. The threshold of variation of the temperature can be up to 10°C for dynamic conditions.

9. Problems Encountered

- Range of transceiver
- Placement of nodes
- Variation of Channel model as train moves.

10. Advantages

- Holistic automation of wheel monitoring
- Quick emergency response
- Ruggedness and flexibility

11. Improvements

- This setup can be extended to any sort of working environment for automatic safety system.
- This system can be deployed to analyze the channel variation over time and environment in moving condition.



12. Conclusion

The System has been designed and implemented after optimizing it on a number of factors. The System helps in efficient data transfer with the help of the indigenously developed Networking protocol and physical layer systems. The placing of nodes in the appropriate places is also done after extensive testing. The Complete automation of bogie temperature monitoring, and quick fire alert are the high light of the System.

Acknowledgements

The project would like to thank Principal **Dr. V. Abhai Kumar**, department HOD **Dr. Raju** and all Professors of Thiagarajar College of Engineering, Madurai, India, especially project guide **Mr. K. Hariharan**, Lecturer, ECE, for providing immense support and guidance.

References

1. Myung j. lee and jianliang zheng, city university of New York young-bae ko and deepesh man shrestha, ajou university, Korea "Emerging standards for Wireless mesh technology" 1536-1284/06 April 2006.
2. IEEE standards for Information technology, Telecommunications and information, Exchange between systems, Local and metropolitan area networks, Specific requirements- 2006
3. System Architecture for Wireless Sensor Networks Jason Lester Hill, Doctor of Philosophy in Computer Science, University of California at Berkeley, Professor David Culler, Chair.
4. Chieh-Yih Wan, Andrew T. Campbell, and Lakshman Krishnamurthy. Psfq: a reliable transport protocol for wireless sensor networks. In *WSNA '02: Proceedings of the 1st ACM international workshop on Wireless sensor networks and applications*, pages 1–11, New York, NY, USA, 2002. ACM Press.

