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Advanced Railway Accident Prevention System Using Sensor Networks

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Abstract: The increased growth in the railway sector has resulted in an increase in the train traffic density across the world. This has resulted in the increase in the number of accidents involving trains. In this paper, the proposed system includes several features which prevent train accidents. It includes automatic speed controlling in curves, collision detection, fire detection, detaching of couch automatically when fire is detected in it, automatic railway gate control and track continuity. This system makes use of IR sensors, fire sensor, zigBee and other embedded systems.

Keywords: Train control block, track control block, zigbee, IR sensors

I. INTRODUCTION

The Indian Railways has the world's fourth largest railway network in the world, after that of the United States, Russia and China [3]. The railways traverse the length and breadth of the country and carry over 20 million passengers and 2 million tons of freight daily. It is one of the world's largest commercial or utility employers, with more than 1.6 million employees. About 15000 trains work every day. Unfortunately there have been many accidents involved in the railways.

The Railways has the most intricate and involved inter-dependencies. Safety on the Railways is the end product of the cohesive fusion of its myriad parts. A single flaw in the 64,600 route kms of track that criss-cross the country, a defect in over 9,500 locos, 55,000 coaches and 2.39 lakhs wagons that haul about 23 million passengers and nearly 2.7 million tons of freight every day, an incorrect indication on one of the thousands of signals that dot the rail landscape, a mistake or an act of negligence by one of its staff directly associated with train running, even a rash act by one of the millions of road users who daily negotiate around odd level crossing gates spread across the system, an irresponsible act of carrying inflammable goods – any one of these multiple possibilities has the potential to cause a major tragedy. Added to these are the acts of sabotage by misguided elements spanning the whole country, Thus utmost vigil is safety in operations and also security of the traveling public.

II. VARIOUS IMPORTANT COMPONENTS OF ADVANCED RAILWAYS ACCIDENT PREVENTION SYSTEM

Some of the major components utilized in this system are microcontrollers, IR sensors and zigbee.

A. AT89S52 Microcontroller

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 pinout. 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. 32 I/O lines can be used to output data and order other devices to do certain work, or to read the state of a sensor, or a switch. Most of the ports of the 89S52 have 'dual function meaning that they can be used for two different functions.

B. IR Sensors

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. It is also capable of measuring heat of an object and detecting motion. Infrared waves are not visible to the human eye.

A typical system for detecting infrared radiation using infrared sensors includes the infrared source such as blackbody radiators, tungsten lamps, and silicon carbide. In case of active IR sensors, the sources are infrared lasers and LEDs of specific IR wavelengths. Next is the transmission medium used for infrared transmission, which includes vacuum, the atmosphere, optical fibers. Finally, the infrared detector completes the system for detecting infrared radiation. The output from the detector is usually very small, hence pre amplifiers coupled with circuitry are added to further process the received signals.

C. Zigbee Device

ZigBee standard is managed by the Zigbee Alliance, a global consortium of more than 50 companies (OEMs, IC vendors & tech companies). ZigBee is a short-range, low-data-rate wireless network technology, which is based on the IEEE 802.15.4 wireless personal area network standard. And the ZigBee's data rate is between l0 Kbit/s and 250 Kbit/s, so it is suitable for low-rate wireless transmission applications. But ZigBee can build up to a few tens of thousands of wireless transmission module consisting of wireless-data transmission network platform through the network node, which is very similar to the

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existed CDMA mobile communications network or GSM Network. And each network node can extend the distance from the standard 75 meters to several hundred meters, and even a few kilometers. And ZigBee network primarily for the automatic control and the establishment of data transmission but the mobile communications network for voice communications is established, which is the difference between ZigBee network and the mobile communications network. ZigBee technology has low data rate and the characteristics of the smaller range of communication, which also determines the ZigBee technology is suitable for carrying data traffic smaller business. ZigBee which is based on the 802.15.4 protocol stack standards possess a powerful networking capability.

III.HARDWARE IMPLEMENTATION

The fig 1 shows block diagram of train control system and fig 2 shows the block diagram of track control system. It consists of the following main parts.

A. ZigBee RF module:

ZigBee module is used for transmission of train data, station data, and train accident information between base station and trains.

B. Microcontroller (AT89S52):

The microcontroller AT89S52 of Atmel is used as hardware platform to monitor and control the track and train operations like checking track continuity, detecting obstacles and curves using IR sensors connected to microcontroller. It is used to start train and gate motors by sending appropriate control signals. It is used to receive or send data to zigbee device for communication between train and base station. It is also used for sending messages to LCD which acts as warning information in both train and base station.

C. Track continuity circuit:

Is used to check for any breakage or discontinuity of track and send appropriate signals to base station.

D. IR obstacle sensors:

This sensor is fitted in front of train engine to detect any obstacle present on track with in the line of sight. It sends appropriate signal to train control system, which in-turn stops train immediately if an obstacle is detected.

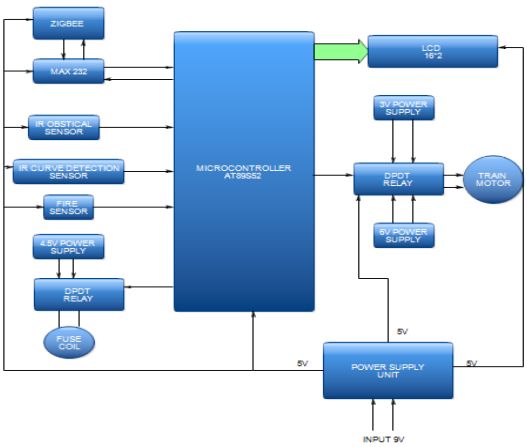

Fig 1. Train control system

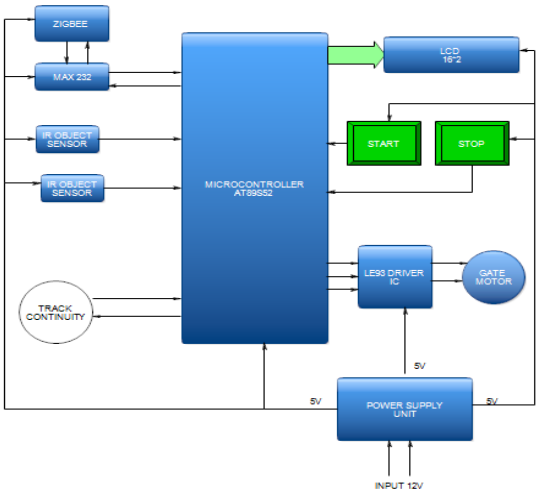

Fig 2: track control system

E. IR curve detection sensors:

This sensor is fitted to left side of train engine. An obstacle is placed near the curves to the left of the track. When train nearer a curve, obstacle is detected by this sensor and curve detection signal is sent to the train control block which in-turn controls the train speed in curve.

F. Fire sensor:

A fire sensor is placed inside every couch of train. When a fire is detected whose temperature is above some particular value, then a signal is sent to the train control system which detaches the couch which caught fire and stops the train.

G. DPDT relay:

We use two relay in train control block. One is used for controlling the speed of train when curve or obstacle is detected and when couch catches fire. Another relay is used for turn on/off fuse coil which helps in detaching couches in case of fire accidents.

H. DC motor:

We use two DC motors in this system. One is used as train motor to run train with suitable speed and another is used to open or close railway gate when train is approaching or leaving the gate.

I. LCD display:

It is used both is train control system and track control system in order to display appropriate warning messages to base station and train operators.

J. Power Supply:

We use 3V, 4.5V and 6V DC power supply for two DPDT relay used in the system. The standard 5V DC power supply is used for controlling all other blocks of the system.

IV. WORKING OF TRACK AND TRAIN CONTROL SYSTEMS

A. Track Control system

The main function of this block is to check for track continuity and control railway gate operation. First it

checks for track for any kind of discontinuity using track continuity circuit. Upon receiving appropriate signal it sends signal to train control system throw zigbee to start or stop the train. It has a manual start and stop switch too which can start/stop train remotely from track control block with the help of track continuity circuit.

Second, it controls the railway gate in the train-road junction. Once the first IR object sensor connected to microcontroller detects train approaching it sends signal to controller when then closes the gate using relay and DC motor. When the second IR object sensor detects train leaving it sends signal to controller when then opens the gate using same replay and DC motor. The two sensors are placed at appropriate distance to perform required operation.

The messages related to all the operations that occur in both train and track control system are displayed on LCD screen connected to the microcontroller.

B. Train Control System

This system performs four major functions curve detection, obstacle detection, fire detection and speed control of train. We have two IR sensors, one fitted in front of train which acts as obstacle sensor and other fitted to left side of train to behave as curve detecting sensor. These two sensors are connected to train control block placed on train. We have placed objects near curves to help curve detection functionality.

With the appropriate signals received from tack control block train starts. The IR obstacle sensor fitted in front of train continually senses the track in line of sight, if an obstacle of large size which may derail train is detected then signals is sent to control block which immediately stops train using DPDT relay.

When train approach a curve the object placed near the curve behaves as an obstacle to the sensor in line of sight and sends signal back to the controller. As a response to this signal controller reduces the speed of the train in curve.

When a fire accident occurs in any couch attached to train, fire sensor present in that particular couch detects the fire and send signal to the controller which in turn detaches that particular couch and stops the train.

Similar to LCD connected to track control system. The messages related to all the operations that occur in both train and track control system are displayed on LCD screen connected to the microcontroller present in train control block.

V. PERFORMANCE EVALUATION

As final stage of this development, we have tested this proposed system to confirm feasibility of the system design. In this test we construct small network which consists of track control system and train control system mounted on a train. This system took all the above mentioned measures to avoid train accidents.

Important results of this test are as follows.

1. *Response of ZigBee*: Delay of signal control caused by delay on transmission is about 500 msec for ZigBee. This is no problem for safety and practical use.

2. *Range test:* Maximum distance between transmitter and receiver for reliable Communication which is about 50 meters. But it is insufficient range for remote Stations, hence it is desired that range should be improved by using long range ZigBee modules.

3. Security: ZigBee uses ISM 2.4 GHz Wireless band of communication with data encryption, which uses symmetric key 128-bit advanced encryption Standard (AES).

4. *Response of controllers:* The response to curve detection, obstacle detection and fire detection is reasonably fast to perform appropriate operations.

VI. CONCLUSION

This paper introduced a low cost, low-power embedded system for railway accidents control system. In this paper, we discuss the design of proposed safety system for railway, using AT89S52 Microcontroller of Atmel as hardware platform, and combines with ZigBee as a communications platform of wireless area network, which can transmit, receive and display the track, train information. Introduced ZigBee wireless communication will assemble Ad-hoc network among stations and trains and work in phase with each other. ZigBee is designed for low cost and low power consumption. The result shows that this new innovative technology will increase the reliability of safety systems in railway transport. . By implementing these features in real time application railways can avoid accidents upto approximately 70%.

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