ISSN: 2320 – 8791
www.ijreat.org

Train Collision Avoidance System Using Vibration Sensors And Zigbee Technology

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Abstract-There is an increasing with the number of accidents at railroad railings. Collisions with train are generally catastrophic, in that the destructive forces of a train usually no match for any other type of vehicle. Train collisions form a major catastrophe, as they cause severe damage to life and property. Train collisions occur frequently eluding all the latest technology. This paper deals about one of the efficient methods to avoid Train Collisions. In the existing system, approach uses the Vibration sensor and a Proximity LASER Detector and the communication mechanism of PLC (Power Line Communication) to communicate the Critical Details about the Train to the Control Room. In this paper, a Wireless communication enables transfer of data or signals over part of the entire communication network. Wireless implementation of sensor network ensures safety in terms of saving lives and property. In this paper wireless sensor network is realized using ARM 7 based microcontroller. The LPC2148 is a very popular ARM7 microcontroller with 512 KB flash, 64 KB of RAM and with several I/O peripherals. When the gap in the track is detected or when a running train is detected in front of the standing train, the sensors(vibration sensor and the gap detector) sounds an alarm which is fitted in the operating room in the engine. The microcontroller form the main unit of the system .It receives input from the sensors and wirelessly sends information to other sensors in the network to sound an alarm thereby preventing any disaster from occurring.The sensors are capable of detecting the gap 800 to 900 meters away. we use this same module at a few places fitted below the engine. Thus zigbee is used to communicate with the other sensor modules. This helps the driver to stop the train immediately.

Keywords— Collision detection, zibgee, vibration sensor, gap detector, ARM 7 LPC2148 Micro Controller.

1. INTRODUCTION

Sensor networks become more and more popular as cost of sensor gets cheaper and cheaper. The sensor network is a wireless network formed by a group of sensors deployed in same region, which can be used to measure air pressure, temperature, acceleration, etc. Sensors transmit signals via radio signal. Since sensors are now small and cheap, they can be deployed on a large scale. They become more and more important for applications like security, traffic monitoring, agriculture, battlefield, etc. Most of those sensors are powered by batteries. The lifespan of an energy-constrained sensor is determined by how fast the sensor consumes energy. Sensors use energy to run circuitry and send radio signals. The later is usually a function of distance and takes a large portion of the energy. Researchers are now developing new routing mechanisms for sensor networks to save energy and prolong the sensor lifespan. Four primary routing mechanisms are direct transmission, minimum energy transmission, static clustering and dynamic clustering. Sensor lifespan is an important performance index for comparison of different routing mechanisms. So far, the comparison between routing mechanisms is based on simulation results. A wireless sensor device is a battery-operated device, capable of sensing physical quantities. In addition to sensing, it is capable of wireless communication, data storage, and a limited amount of computation and signal processing. Advances in integrated circuit design are continually shrinking the size, weight and cost of sensor devices, while simultaneously improving their resolution and accuracy. At the same time, modern wireless networking technologies enable the coordination and networking of a large number of such devices. The additional nodes are added to enhance the detecting capability and if one node fails to sense, the other nodes will sense.

2. BLOCK DIAGRAM OF EXISITING SYSTEM

Published by: PIONEER RESEARCH & DEVELOPMENT GROUP(www.prdg.org)

ISSN: 2320 – 8791
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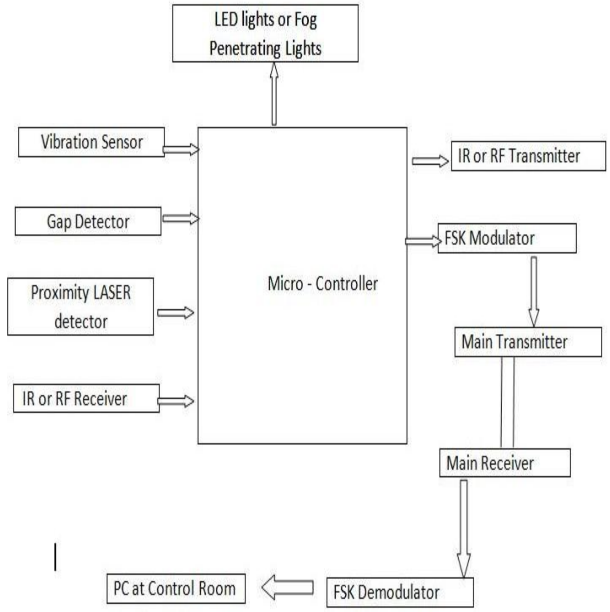

Figure 1. Architecture of previous system

BLOCK DIAGRAM OF PROPOSED SYSTEM

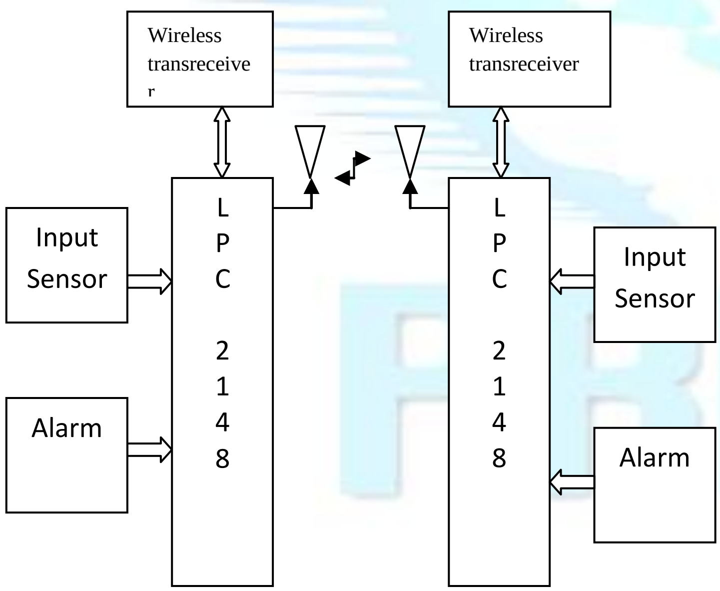

Figure 2. Architecture of proposed system

3. COMPONENTS

To realize a collision detection unit system using ARM 7 microcontroller we require total four blocks.

1. Input devices
2. Output devices
3. Control panel
4. Power supply

3.1. Input devices

The different blocks used to avoid the Collisions by above mentioned reasons are:1.Gap Detector, 2.Vibration Sensor, 3.Proximity LASER Detector, 4.LED lighting or Fog penetrating Lights, 5.FSK Modulator and FSK Demodulator (For Power Line Communication) .These are given as input to the microcontroller.

3.1.1.Gap Detector:

In bends or curves, there should be gap between the rails of successive different paths. Even if there is a small gap, the train would get mislead and travel in a different path which leads to collisions in most of the cases. Already there are sensors to indicate the short circuiting of the gaps but practically even a small dust can short circuit the gap which makes the current system futile sometimes. Hence we use adjustable **mechanical or elastic claw** to find the gap and indicate the gap immediately to the Control Room. In the above figure, a rail road indicating a gap and next to it is a Electrostatic; capacitance-type Gap Detector : VE Series.

Figure 3. An example track which contains gap

3.1.2. Vibration Sensor:

It uses piezoelectric effect to detect the vibrations in the rails due to the arrival or departure of train and the direction of vibration indicate the arrival or departure. This could sense the train's position at roughly at 800 to 900 m away. This input is fed to the microcontroller. This could help in avoiding accidents between trains in slopes because the arrival of one train found out using vibration sensor can be immediately sent to the Control Room and the power supply can be switched off within 3 minutes so trains could be stopped without colliding each other. Vibration or shock sensors are commonly used in alarm systems to activate an alarm whenever the devices to which they are attached are touched,

Published by: PIONEER RESEARCH & DEVELOPMENT GROUP(www.prdg.org)

IJREAT International Journal of Research in Engineering & Advanced Technology, Volume 1, Issue 1, March, 2013
ISSN: 2320 – 8791
www.ijreat.org

moved, or otherwise vibrated. Commercial vibration sensors use a piezoelectric ceramic strain transducer attached to a metallic proof mass in order to respond to an externally imposed acceleration. Piezoelectric vibration sensors used for detecting vibration from various vibration sources are generally classified into two large types, resonant type and nonresonant type.

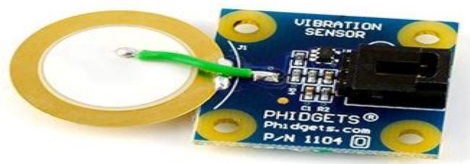

Figure 4. An Example of Piezo-electric Vibration Sensor

3.1.3. Proximity LASER Detector:

Most of the collisions are of running train colliding with the Standing Train Types.A LASER detector can be used to detect the presence of any train before the running train. D A laser proximity sensor for a train includes a laser diode having front and rear facets. The diode generates a main laser signal and directs a first portion thereof out of the front facet as a source beam. Focusing means focuses the source beam on a target, and focuses the return beam reflected from the target into the laser diode through the front facet. The laser diode receives the return light beam, provides it with a positive gain, mixes it with the main laser signal, and guides it out the rear facet as a mixed beam. A detection focusing device focuses the mixed beam onto a PIN detector. The PIN detector coherently detects the mixed beam and provides an output signal having a perturbation where the target enters the local field of the focusing optics. A processor detects the output signal from the PIN detector and may activate a breaking mechanism in the train. The processor is also capable of determining the relative velocity between the train and the target from measurement of the Doppler shifted signal or from the shape of the perturbation of the output signal from the PIN detector.

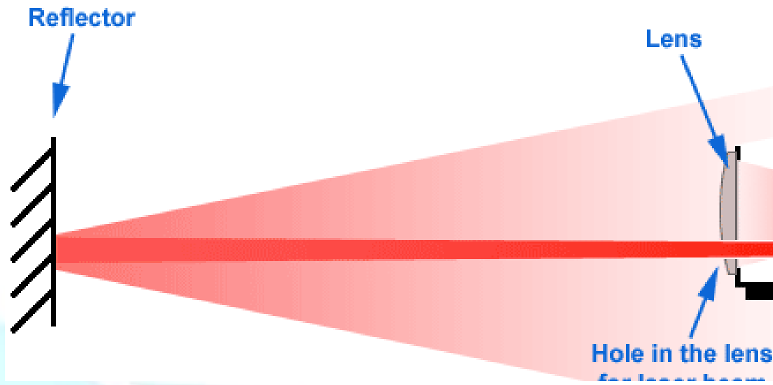

Figure 5. LASER Proximity Detector – setup

3.1.4. LED or Fog penetrating Lights:

They are very useful during mist or fog seasons, as, near the signals, still many employees use explosives or other form of lights which involves the manual monitoring next to the signal 24*7. So, detecting the arrival of signal using Vibration Sensor, the LED lights can be made to switch off automatically in the signals reducing the manual labour and monitoring and the driver from the train could get the signal easily even in fog times Any given snowy, foggy or rainy night can turn into a disaster because low visibility in these conditions can maximize the potential of danger. Rough weather conditions call for precision driving. The PLC system is not used here instead, a zigbee technology is used to communicate with the neighbour nodes

3.2. Output devices

In output devices we require Buzzers for alerting people and Wireless module for sending signal to other nodes. To achieve wireless communication here ZigBee module is used. To generate alarm sound here we used Buzzer Alarm.

4.2.1. ZIGBEE: There are a multitude of standards like Bluetooth and Wi-Fi that address mid to high data rates for voice, PC LANs, video, etc. Sensors and controls don't need high bandwidth but they do need low latency and very low energy consumption for long battery lives and for large device arrays. There are a multitude of proprietary wireless systems manufactured today to solve a multitude of problems that don't require high data rates but do require low cost and very low current drain. These proprietary systems were designed because there were no standards that met their application requirements. These legacy systems are creating significant interoperability problems with each other and with newer technologies. The ZigBee Alliance is not pushing a technology; rather it is providing a standardized base set of solutions for sensor and control systems. The physical layer was designed to accommodate the need for a low cost yet allowing for high levels of integration. The use of direct sequence allows the analog circuitry to be very simple and very tolerant towards inexpensive implementations. The media access control (MAC) layer was designed to allow multiple topologies without complexity. The power management operation doesn't require multiple modes of operation. The MAC allows a reduced functionality device (RFD) that needn't have flash nor large amounts of ROM or RAM. The MAC was designed to handle large numbers of devices without requiring them to be "parked". The network layer has been designed to allow the network to spatially grow without requiring high power transmitters. The network layer also can handle large amounts of nodes with relatively low latencies. ZigBee is poised to become the global control/sensor network standard. It has been designed to provide the following features.

1. Low power consumption, simply implemented
2. Users expect batteries to last many months to years

In contrast to Bluetooth, which has many different modes and states depending upon your latency and power requirements, ZigBee/IEEE 802.15.4 has two major states: active (transmit/receive) or sleep. The application software needs to focus on the application, not on which power mode is optimum for each aspect of operation. Even mains powered equipment needs to be conscious of energy.

3. Low device cost, low installation cost and low maintenance.
4. ZigBee devices allow batteries to last up to years using primary cells (low cost) without any chargers (low cost and easy installation). ZigBee's simplicity allows for inherent configuration and redundancy of network devices provides low maintenance.
5. High density of nodes per network
6. ZigBee's use of the IEEE 802.15.4 PHY and MAC allows networks to handle any number of devices. This attribute is critical for massive sensor arrays and control networks.
7. Simple protocol, global implementation ZigBee's protocol code stack is estimated to be about 1/4th of Bluetooth's or 802.11's. Simplicity is essential to cost, interoperability, and maintenance. The IEEE 802.15.4 PHY adopted by ZigBee has been designed for the 868 MHz band in Europe, the 915 MHz band in N America, Australia, etc; and the 2.4 GHz band is now recognized to be a global band accepted in almost all countries.

I) ZigBee/IEEE 802.15.4 - General Characteristics

- Dual PHY (2.4GHz and 868/915 MHz)
- Data rates of 250 kbps (@2.4 GHz), 40 kbps (@ 915 MHz), and 20 kbps (@868 MHz)
- Optimized for low duty-cycle applications (<0.1%)
- CSMA-CA channel access yields high throughput and low latency for low duty cycle devices like sensors and controls
- Low power (battery life multi-month two years).
- Multiple topologies: star, peer-to-peer, mesh
- Addressing space of up to: - 18,450,000,000,000,000,000 devices (64 bit IEEE address) - 65,535 networks
- Optional guaranteed time slot for applications requiring
- low latency
- Fully hand-shaked protocol for transfer reliability
- Range: 50m typical (5-500m based on environment)

II) ZigBee/IEEE802.15.4 - Typical Traffic Types Addressed

- Periodic data
- Application defined rate (e.g., sensors)
- Intermittent data
- Repetitive low latency data
- Allocation of time slots (e.g., mouse)

Each of these traffic types mandates different attributes from the MAC. The IEEE802.15.4 MAC is flexible enough to handle each of these types.

- Periodic data can be handled using the beaconing system whereby the sensor will wake up for the beacon
- Intermittent data can be handled either in a beaconless system or in a disconnected fashion.
- In a disconnected operation the device will only attach to the network when it needs to communicate saving significant energy.
- Low latency applications may choose to the guaranteed time slot (GTS) option. GTS is a method of QoS in that it allows each device a specific duration of time each

The IEEE 802.15.4 PHY and MAC along with ZigBee's Network and Application Support Layer provide:

- Extremely low cost
- Ease of implementation
- Reliable data transfer
- Short range operation
- Very low power consumption
- Appropriate levels of security

There are two physical device types for the lowest system cost.

The IEEE standard defines two types of devices:

- Full function device (FFD)
  - Can function in any topology
  - Capable of being the network
  - Coordinator
  - Capable of being a coordinator
  - Can talk to any other device
- Reduced function device (RFD)
  - Limited to star topology
  - Cannot become a network coordinator
  - Talks only to a network coordinator
  - Very simple implementation

3.3. Control panel

In control panel the total function and controlling is done by ARM7 LPC2148 microcontroller. A microprocessor system consists of a microprocessor with memory, input ports and output ports connected to it externally.. We have several other basic microcontroller families such as PIC, M68HCXX, and AVR etc. One advanced architecture is ARM. ARM stands for Advanced RISC machine. The first processor in ARM family was developed at Acorn Computers Ltd between October 1983 and April 1985. Acorn Computers was a British computer company established in Cambridge, England, in 1978. The company worked for Reduced Instruction Set Computer (RISC) processor design.

1) ARM Architecture: The ARM core uses RISC architecture. Its design philosophy is aimed at delivering simple but powerful instructions that execute within a single cycle at a high clock speed. The RISC philosophy concentrates on reducing the complexity of instructions performed by the hardware because it is easier to provide greater flexibility and intelligence in software rather than hardware. As, a result RISC design plays greater demands on the compiler.

Certain design features have been characteristic of most RISC processors.

- *One Cycle Execution Time:* RISC processors have a CPI (clock per instruction) of one cycle. This is due to the optimization of each instruction on the CPU. Each instruction is of a fixed length to allow the pipeline to fetch future instructions before decoding the current instruction.

Pipelining: The processing of instructions is broken down into smaller units that can be executed in parallel by pipelines. Ideally the pipeline advances by one step on each cycle for maximum throughput. Instructions can be decoded in one pipeline stage.

- *Large Number of Registers:* The RISC design philosophy generally incorporates a larger number of registers to prevent large amount of interactions with memory. Any register can contain either data or an address. Registers act as the fast local memory store for all data processing operation.

I) AMBA (Advanced Microcontroller Bus Architecture) Bus Protocol: AMBA Bus was introduced in 1996 and has been widely adopted as the On Chip bus architecture used for ARM processors.

The first AMBA buses were

1. ARM System Bus (ASB)
2. ARM Peripheral Bus (APB)

Later ARM introduced another bus design called the ARM High performance Bus (AHB).

Using AMBA

1. Peripheral designers can reuse the same design on multiple projects
2. A Peripheral can simply be bolted on the On Chip bus without having to redesign an interface for different processor architecture.

This plug-and-play interface for hardware developers improves availability and time to market.

ARM introduced two variations on the AHB bus

1. Multi-layer AHB
2. AHB-Lite

AHB bus allows multiple active bus masters. AHB-Lite is a subset of the AHB bus and it is limited to a single bus master. This bus was developed for designs that do not require the full features of the standard AHB bus. AHB and Multiple-layer AHB support the same protocol for master and slave but have different interconnects. The new interconnects in Multi-layer AHB are good for systems with multiple processors. They permit operations to occur in parallel and allow for higher throughput rates.

II) Introduction to ARM7TDMI Core: The ARM7TDMI core is a 32-bit embedded RISC processor delivered as a hard macro cell optimized to provide the best combination of performance, power and area characteristics.

(a) 2.3.6. ARM7TDMI Features

- 32/16-bit RISC architecture (ARM v4T)
- 32-bit ARM instruction set for maximum performance and flexibility
- 16-bit Thumb instruction set for increased code density
- Unified bus interface, 32-bit data bus carries both instructions and data
- Three-stage pipeline
- 32-bit ALU
- Generic layout can be ported to specific process technologies
- Unified memory bus simplifies SoC integration process
- ARM and Thumb instructions sets can be mixed with minimal overhead to support application requirements for speed and code density
- Code written for ARM7TDMI-S is binary compatible with other members of the ARM7 Family and forwards compatible with ARM9, ARM9E and
- extensive, real-time debug facilities

III) LPC2148 (ARM7) Microcontroller: The LPC2148 microcontrollers are based on a 32 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory of 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces the code by more than 30 % with minimal performance penalty. LPC2148 microcontrollers are ideal for the applications where miniaturization is a key requirement, such as access control and point-of-sale. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTS, SPI, SSP to I2Cs and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable for industrial control and medical systems.

Features of LPC2148 Microcontroller:

- 16/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package.
- 8 to 40 kB of on-chip static RAM and 32 to 512 kB of on-chip flash program memory.
- 128 bit wide interface/accelerator enables high speed 60 MHz operation.
- In-System/In-Application Programming (ISP/IAP) via on-chip boot-loader software. Single flash sector or full chip erase in 400 ms and programming of 256 bytes in 1ms.
- Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real
- Monitor software and high speed tracing of instruction execution.
- USB 2.0 Full Speed compliant Device Controller with 2 kB of endpoint RAM.

In addition, the LPC2146/8 provides 8 kB of on-chip RAM accessible to USB by DMA.

- One or two (LPC2141/2 vs. LPC2144/6/8) 10-bit A/D converters provide a total of 6/14 analog inputs, with conversion times as low as 2.44 μs per channel.
- Single 10-bit D/A converter provide variable analog output.
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit
- (six outputs) and watchdog.
- Low power real-time clock with independent power and dedicated 32 kHz clock input.
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C-bus (400 Kbits/s), SPI and SSP with buffering and variable data length capabilities.
- 60 MHz maximum CPU clock available from programmable on-chip PLL with settling time of 100 μs.
- On-chip integrated oscillator operates with an external crystal in range from 1 MHz to 30 MHz and with an external oscillator up to 50 MHz.
- Processor wake-up from Power-down mode via external interrupt, USB, Brown-Out Detect (BOD) or Real-Time Clock (RTC).
- Single power supply chip with Power-On Reset (POR) and BOD circuits: CPU operating voltage range of 3.0V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads.

V. RESULT AND DISCUSSION

The sensors sense the input and sends to the microcontroller, where it responds and gives command to the particular component with predefined algorithm. The time parameters are crucial which can be easily changed and modified using Micro-controllers. Thus, this device would work in coherence would help to reduce the train collisions.

A) Wireless Technology

Cable is expensive, less flexible than RF coverage and is prone to damage. For new facilities, implementing a wireless infrastructure may be more cost effective than running cable through industrial environments, especially if the space configuration may change to support different storage space allocation or flexible manufacturing stations.

B) ZigBee Communication

Real-time ZigBee communication include a significant improvement in order accuracy (>99%), the elimination of paperwork, replacement of time-consuming batch processing by rapid real-time data processing, prompt response times and improved service levels. Complementing a real-time data collection system with automated data entry by bar code scanning or another automatic data collection technology improves the accuracy of information and eliminates the need for redundant data entry.

C) ARM Controller

- Low power Consumption
- Low cost
- Execution speed is faster

D) Future Scope

The collision detector system can be enhanced by connecting it with a personal computer for monitoring and controlling purposes and using the GSM (Global System for Mobile Communications) to send and receive an SMS (short message Service) from the place of the detector to the involved person. Therefore, improve the chances for reducing the risks to life and property.The Anti Collision Device (ACD) is a self-acting microprocessor-based data communication device designed and developed by Konkan Railway (KR). When installed on locomotives (along with an auto braking unit- ABU), guard vans, stations and level-crossing gates (both manned and unmanned), the network of ACD systems prevents high-speed head on collisions in mid-sections, station areas and at level-crossing gates, thereby saving the lives of rail passengers and road users. This device can be integrated with the Anti Collision Device for better sophistication and optimisation.

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