Automated Train Control System with Real Time Train Tracking Facility Based On GPS and Onboard Disaster Prevention Network

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Abstract: ***A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, and pressure to cooperatively pass their data through the network to a main location. It provides a bridge between the real physical and virtual worlds. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control.The aim of the project is to design a system that will run the train autonomously without any human operators. This will avoid train to train collisions, over speeding problem, signalling errors and unmanned railway crossing incidents. Provide a way for a passenger to know the train location, speed and direction in real time from anywhere in India through his mobile phone using GPS. The train unit has an on-board GPS module and a GSM module. A passenger can simply query the location of a train via SMS from his mobile phone. The train unit will reply to the user mobile with the GPS coordinates of the present location it is travelling. Driverless train control system operates on the principle of a central railway server and communication devices fixed in each trains. In unmanned railway crossing truck/car/humans/animals may cross a railway line. The train control system oversees this and can adapt to slow down the speed accordingly. It has a front SONAR ultrasonic range finder for this purpose. Interconnect all the train compartments with embedded network to ensure safety and security of passengers during disasters occurring within trains such as bomb blasts and fire outbreaks. Have audio speakers to inform the passengers about the approaching station and also to provide alert messages during a crisis situation.***

Keywords: CAN bus (Controller Area Network), Inertial measurement unit (IMU), GNSS (Global Navigation Satellite Systems), inertial navigation systems (INS)

1. Introduction

The train unit has an on-board GPS module and a GSM module. A passenger can simply query the location of a train via SMS from his mobile phone. The train unit will reply to the user mobile with the GPS coordinates of the present location it is travelling.

Automated train control system operates on the principle of a central railway server and communication devices fixed in each trains. All the trains on that particular route will update the central railway server with their location, speed and direction information [5]. The server collects all such information, calculates the optimum speed of travel for each train and sends this information to those trains on the route.

The train control system will send its present GPS location information periodically (typically every 30 sec) to the central railway server. This message will immediately be acknowledged with a reply message from the server that will indicate the speed to travel. The train control system will automatically adjust its speed to the speed indicated by the server [2]. The railway server is a software application that will be running on a secured PC environment and will not be implemented in our project as it is out of the scope of an embedded system. In unmanned railway crossings, truck/car/humans/animals may cross a railway line. The train control system oversees this and can adapt to slow down the speed accordingly [5]. This overrides the speed setting from the server. It has a front SONAR ultrasonic range finder for this purpose.

The on-board disaster prevention network connects all the compartments of the train with the main control node over CAN bus (Controller Area Network). CAN is a networking protocol widely used in automotive applications to interconnect different parts of the vehicle [3]. It is also being used in industrial automation networks. Each CAN node has got a variety of sensors and devices to ensure the safety and comfort of the passengers. Metal detector sensor detects explosives by sensing the variations in the magnetic field around it. A Digital MEMS Magnetometer is used for this. Thermal sensor detects fire outbreak by sensing large temperature variation in its proximity. An analog output Temperature Sensor helps to find this out.

a. Emergency push button to stop the train in critical situation.
b. In the event of an emergency detected via these sensors, a critical emergency message will be sent immediately to the railway authorities about the location and the nature of incident [1].

Audio announcement system is designed to announce the approaching station names found out via GPS location. This is also used to update critical emergency information with the passengers such as fire outbreak. The mp3 audio files are stored in an external 2-GB Micro SD memory card and an

MP3 Decoder chip is used to play it in speaker. The microcontroller is able to access the files in memory card via a FAT-32 file system library [1].

LPC11C14, a 32-bit ARM Cortex-M0 microcontroller is used to control the robot unit and the handheld display unit. This microcontroller is chosen for its low power, high code density and high performance characteristics. It is manufactured by NxP Semiconductors. The robot unit is built with a four wheel driving mechanism using Quad DC Motors driven by means of a Motor Driver circuit. A trailer is also included to make it look like train coaches. A high energy battery is used to provide power to all the units including the robot wheel motors.

2. Related Work

Isaac Skog Peter & H¨andel , *et al* (2004) -*"In-car positioning and navigation technologies – a survey"*, IEEE Transactions on Intelligent Transportation Systems.This paper has been main application for the GPS receivers. ADAS (Advance driver assistant systems) controls the traffic and automatic positioning of the accidents. GNSS (Global Navigation Satellite Systems) which provides vehicle motion sensors and also provide to estimate the vehicle state [2]. The performances of measurements are calculated as accuracy, integrity, adoptability, continuity of services.

Shi-Lu Dai, Hai Lin, Shuzhi Sam Ge , *et al*(2010)- "*Scheduling and control co-design for a collection of networked control system with uncertain delays"* .This paper talks about simultaneous stabilization of a collection of continuous-time linear-time invariant (LTI) Plants.NCS is an feedback control system in which communication between spatially distributed system through digital communication networks [3] .CAN –controlled area network which combines group of mobile robot for communication to an real time process.

Teresa, Milan´es, E. Naranjo, Gonzalez & Alonso, *et al* (2008)-*"Autonomous vehicle based in cooperative GPS and inertial systems", Instituto de Automática Industrial, Madrid (España).*. This paper presents about a cooperative system based on GPS and inertial navigation systems (INS**)** for automated vehicle position. INS provides a vehicle position by measuring the linear acceleration and angular velocity exerted on Inertial measurement unit (IMU).IMU is an measurement system consists of angular rate sensor and accelerometers [5].

Rail Radar is the new technology launched by Indian Railways recently, which updates train position on a map every time it crosses a station on its way .This system does not provide real-time tracking since each station is located at least 1 km apart in cities and 10-20 km apart in remote places [4]. It does not use GPS which is a major drawback because the train location is virtually unknown until it reaches the next station that may be 5 to 20 minutes away. Human error is one of the major reasons for train accidents. Every year we end up with at least 2 or 3 major train accidents purely based on human errors. Train to train collisions, over speeding trains and signalling errors are typical cases where hundreds of lives have been lost. Most of the time the reason would be on errors from drivers and signal operators.

Another important problem is safety and security of passengers within trains. Terrorist organizations want to make the country unsafe and one of their ways is to plant bombs and explosives in trains. Although security is available in railway stations, it is still not enough to prevent such attacks. Also, we hear news such as fire outbreak that originated in one compartment that quickly spread to other part of the trains resulting in loss of huge number of lives. The driver has got no way to know the happenings behind the engine. Lives are also lost when people/vehicles try to cross the tracks without noticing an approaching train. Unmanned railway crossings are the spot for this kind of mishaps. The existing technology does not hold a clue to prevent this [1]. The on-board passengers are not able to know the approaching station. They are also not getting alerted during an emergency situation.

2.1 Limitations of the Existing System

- This system does not provide real-time tracking since each station is located at least 1 km apart in cities and 10-20 km apart in remote places.
- It does not use GPS which is a major drawback because the train location is virtually unknown until it reaches the next station that may be 5 to 20 minutes away.
- The driver has got no way to know the happenings behind the engine.
- Unmanned railway crossings are the spot for this kind of mishaps. The existing technology does not hold a clue to prevent this.

3. System Modeling

The train unit has an onboard GPS module and a GSM module. A passenger can simply query the location of a train via SMS from his mobile phone. The train unit will reply to the user mobile with the GPS coordinates of the present location it is travelling. Automated train control system operates on the principle of a central railway server and communication devices fixed in each trains. In unmanned railway crossings, truck/car/humans/animals may cross a railway line. The train control system oversees this and can adapt to slow down the speed accordingly [5] & [2]. It has a front SONAR ultrasonic range finder for this purpose.

The onboard disaster prevention network connects all the compartments of the train with the main control node over **CAN** bus (Controller Area Network). Each CAN node has got a variety of sensors and devices to ensure the safety and comfort of the passengers [2]. Metal detector sensor detects explosives by sensing the variations in the magnetic field around it. A Digital MEMS Magnetometer is used for this. Thermal sensor detects fire outbreak by sensing large temperature variation in its proximity. An analog output Temperature Sensor helps to find this out [1]. Emergency push button to stop the train in critical situation.

LPC11C14, a 32-bit ARM Cortex-M0 microcontroller is used to control the robot unit and the handheld display unit.

The robot unit is built with a four wheel driving mechanism using Quad DC Motors driven by means of a Motor_Driver circuit. A trailer is also included to make it look like train coaches. A high energy battery is used to provide power to all the units including the robot wheel motor which has been connected in figure 1.

3.1 Overall System Design

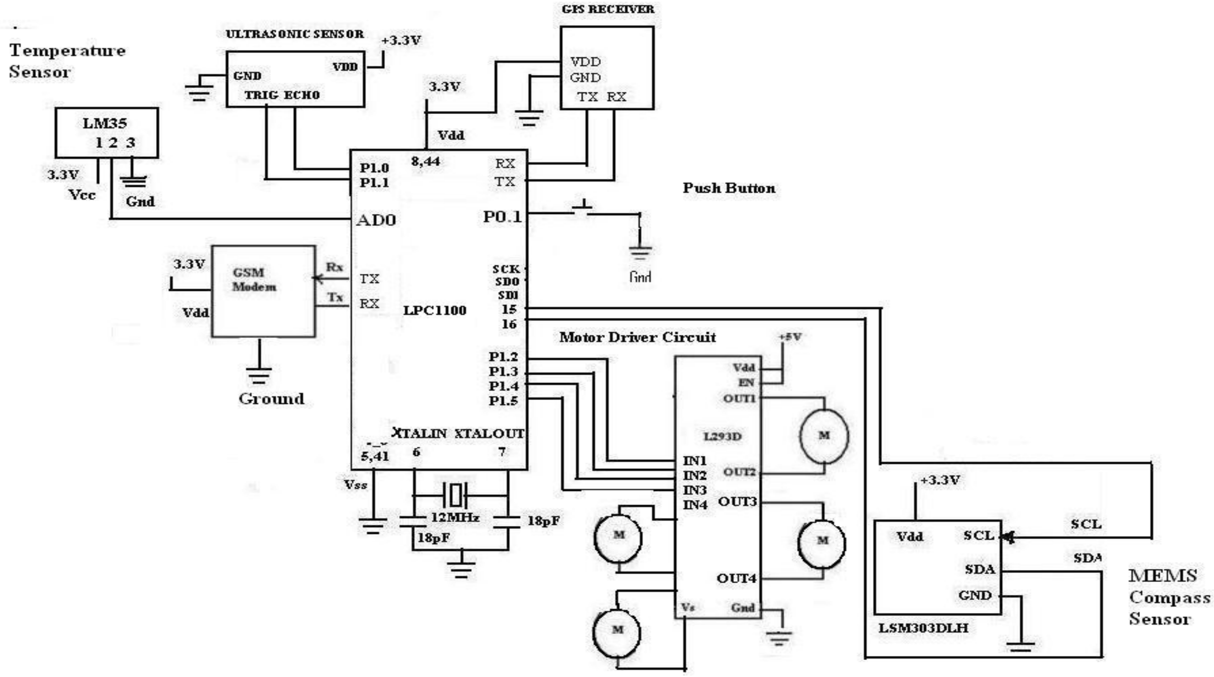

Figure 1:.Compartment 1

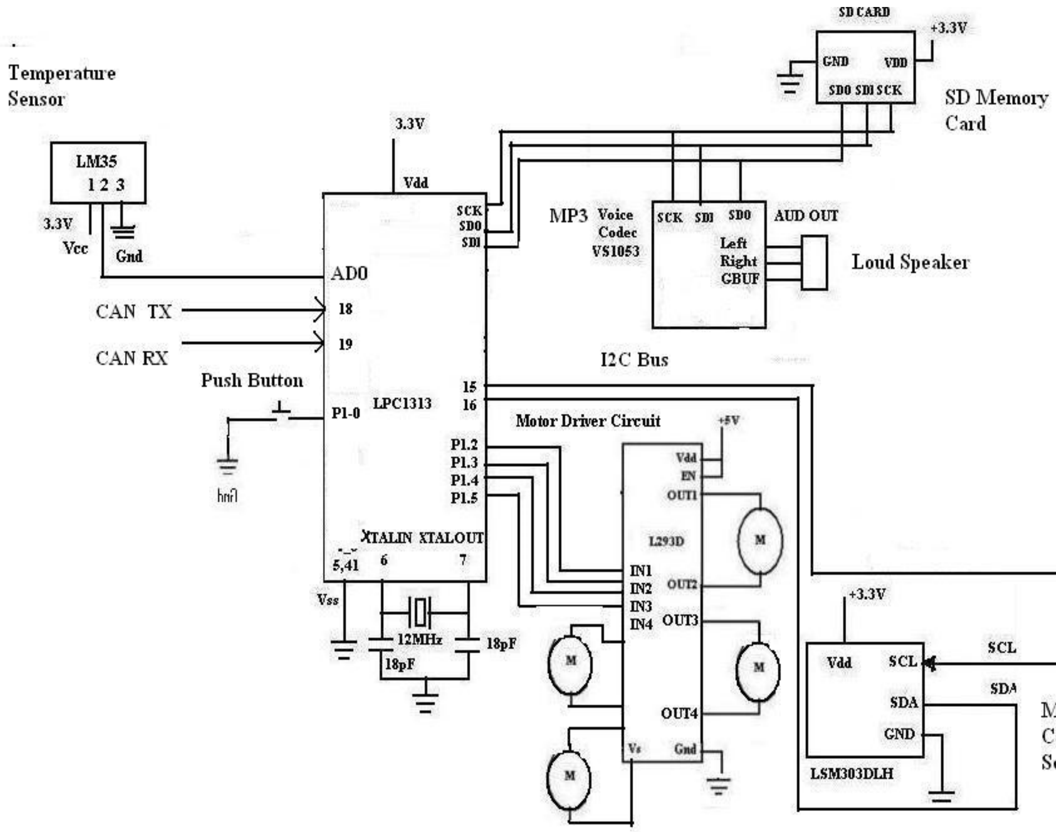

Figure 2: Compartment 2

The mp3 audio files are stored in an external 2-GB Micro SD memory card and an MP3 Decoder chip is used to play it in speaker. The microcontroller is able to access the files in memory card via a FAT-32 file system library. The overall block diagram of compartment 2 is shown in figure 2.

3.2 ARM Cortex-M0

32-bit RISC Architecture based on ARMv6-M. Efficient 3-stage processor pipeline1.62 Core Mark/MHz - 0.9 DMIPS/MHz.Integrated Interrupt Controller (NVIC).

Thumb-2 code density Core Sight debug support Wakeup Interrupt Controller (WIC) AMBA AHB-lite Interface Bus Architecture shown in figure 3.

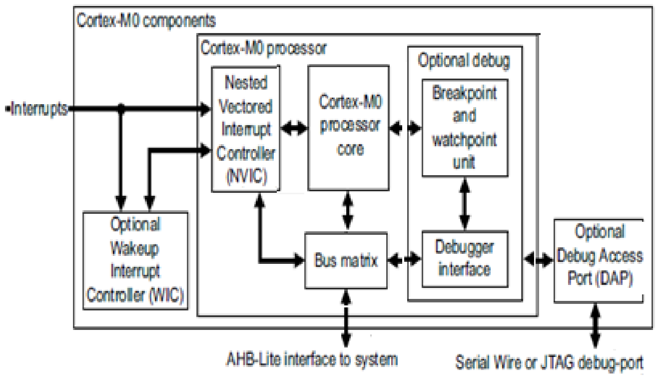

Figure 3: ARM cortex-Microcontroller

3.3 LPC1100

ARM Cortex-M0 processor, running at frequencies of up to 50 MHz. ARM Cortex-M0 built-in Nested Vectored Interrupt Controller (NVIC).42 General Purpose I/O (GPIO) pins with configurable pull-up/-down resistors. High-current output driver (20 mA) on one pin. Programmable Watch Dog Timer (WDT).10-bit ADC with input multiplexing among 8 pins.Two SPI controllers with SSP features and FIFO and multi-protocol capabilities. Integrated PMU (Power Management Unit) to minimize power consumption. Single 3.3 V power supply (1.8 V to 3.6 V) shown in figure 4.

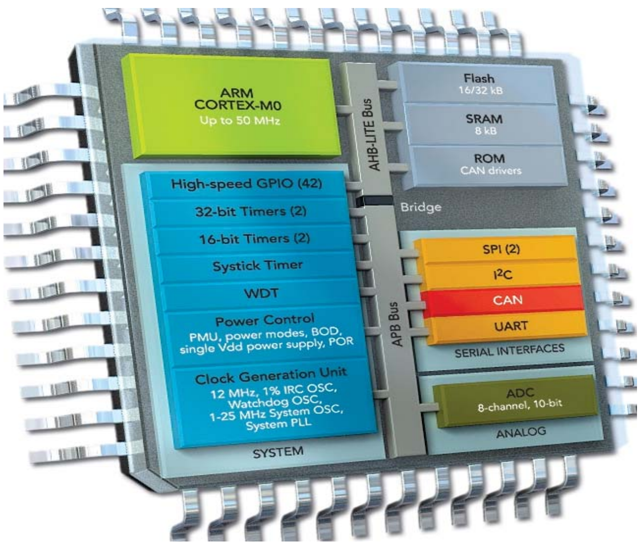

Figure 4: LPC11C14 32bitARM Cortex-M0

4. System Implementation

- LPC11C14
- ARM Cortex-M0
- MEMS
- SONAR
- Quad DC Motor
- GPS
- GSM
- Buzzer
- Temperature Sensor
- Power Supply

Software Tools Used:

The Programming Language used in this system is Embedded C.
The Development Tool is LPCXpressoIDE which is an Eclipse based

Embedded Protocols Used:

I2C, SPI, UART and CAN

In Figure 5 and 6 the overall system design is shown with several components. The compartment 1 and 2 consists of almost same components except that compartment 1 consists of sonar and compartment2 consists of audio speakers and memory card slot. The each compartment is connected via CAN (Controller Area Network).The compartments are designed such that if an emergency situation arrives in compartment 1,the message alert and beep sounds is immediately transferred to the passengers of each compartment via CAN cable .Also an emergency alert is sent to central server. This will enable the approaching station to take emergency preventive measures to control the situation also GSM modem enables the central server to track the exact location and position of the train in the crisis situation.

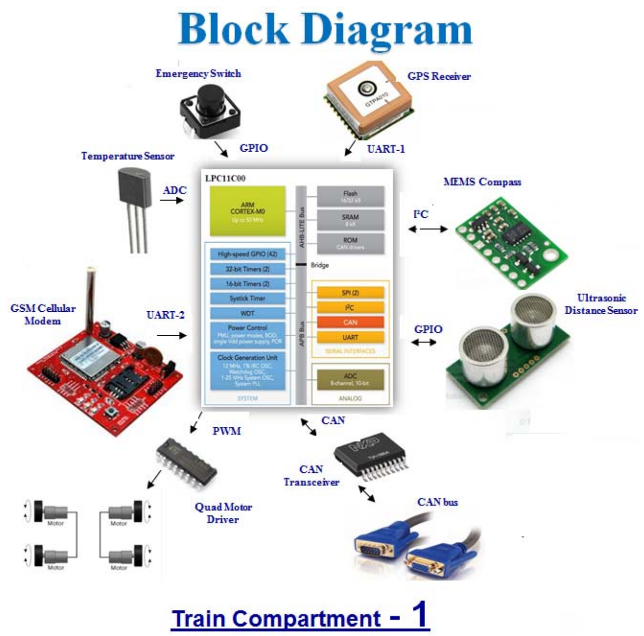

Figure 5: Components involved in Compartment1

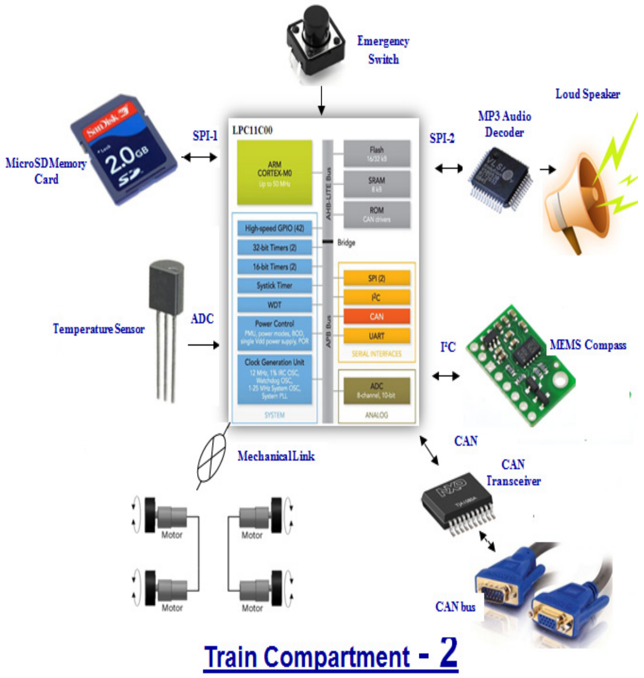

Figure 6: Components involved in Compartment2

5. Conclusion

There is a rise in number of train accidents caused due to human errors. In order to avoid such accidents, an automatic train control system without any human operators is proposed. This will avoid train to train collisions, over speeding problem, signaling errors and unmanned railway crossing incidents. Also this system has the facility to provide a way for a passenger to know the train location, speed and direction in real time. A passenger can query the location of a train via SMS from his mobile phone.. An onboard disaster prevention network is to be connected to all the compartments of the train with the main control node over CAN bus (Controller Area Network), Also an implementation of this approach keeping in an industrial terrain will be performed as the future work. The development tool used to program the device is LPCXpresso IDE (Eclipse based).

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Author Profile

R Karthik received B.E. degree in Electronics and Tele Communication Engineering from Sathyabama University, Chennai in 2012. He has done his UG Project in (ISRO).He also attended Industrial Training in BSNL, Meenambakkam. He has participated in many International and National Conferences. Currently, he is pursuing M. Tech. degree in Communication Systems from Hindustan University, Chennai.

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