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SATELLITE IMAGING FOR RAIL NAVIGATION FOR DRIVERLESS TRAIN CONTROL SYSTEM

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ABSTRACT

Driverless train control system operates on the principle of a central railway server and communication devices fixed in each train. 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 servers. Run the train autonomously without any human operators. This will avoid train to train collisions, over speeding problem, signaling 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. 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. The robot unit is built with a four wheel driving mechanism using Quad DC Motors driven by means of a Motor Driver circuit.

IndexTerms—Temperature Sensor, MEMS, GSM module, SONAR, Quad Drive Motor

1. INTRODUCTION

Satellite Imaging for Rail Navigation (SIMRAN) is a real time train tracking system that is meant to help passengers to know the exact position and speed of a train by sending SMS queries utilizing Global Position System (GPS) and digital mapping of stations..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 traveling. Driverless 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 [1]. 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. 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 [1]. 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. This overrides the speed setting from the server. 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). CAN is a networking protocol widely used in automotive applications to interconnect different parts of the vehicle. 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 [2].

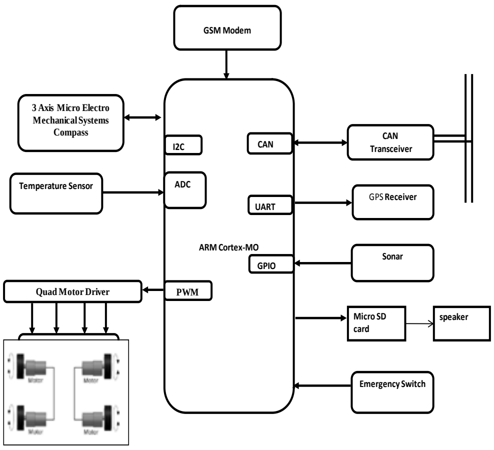

Fig. 1.Block Diagram

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. Emergency push button is to stop the train in critical situation.

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[5].

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 MicroSD 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 [2]. 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. COMPONENTS

A) ARM Cortex M0

The LPC1313 is an ARM Cortex-M0 based, low-cost 32-bit MCU family,designed for 8/16-bitmicrocontroller applications, offering performance,low power, simple instruction set and memoryaddressing together with reduced code size comparedto existing 8/16-bit architectures. This operates atCPU frequencies of up to 50 MHz. The peripheralcomplement includes up to 32 kB of flash memory,up to 8 kB of data memory, one C_CAN controller,one Fast-mode Plus I2C-bus interface, one RS-485/EIA-485 UART, up to two SPI interfaces withSSP features, four general purpose timers, a 10-bitADC, and up to 42 general purpose I/O Pins. On-chip C_CAN drivers and flash In-System Programming tools via C_CAN are included.

Features:

- 32-bit RISC Architecture based on ARMv6-M
- Efficient 3-stage processor pipeline
- 1.62 CoreMark/MHz - 0.9 DMIPS/MHz
- Integrated Interrupt Controller (NVIC)
- Thumb-2 code density
- CoreSight debug support
- Wakeup Interrupt Controller (WIC)

AMBA AHB-lite Interface Bus Architecture

The Cortex-M0 processor is an entry-level32-bit ARM Cortex processor designed for a broadrange of embedded applications.

The controller has 48 General purpose input/ output pins for connecting inputs and outputs. All thepins are inputs as default. A keypad can be connectedto this system using this GPIO pins. The ABS, ESCand GSM systems can be activated whenever needed.

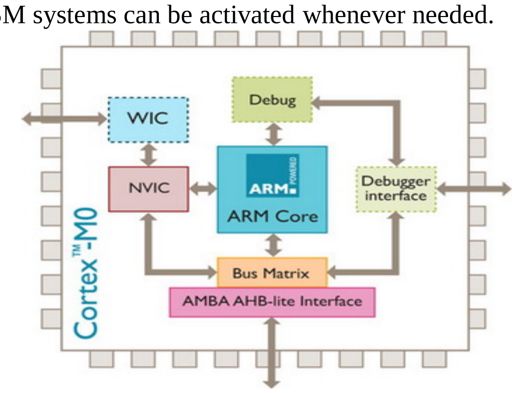

Fig.2ARM CORTEX M0

B) Can Controller -MPC2515

The three electronic control units which arepresent in dashboard, front and rear wheel arecommunicated through CAN protocol. This CANprotocol is basically an automotive protocol which iswidely used in automobile industry. It is an eventdriven protocol and this is very reliable in automobileindustry. Here CAN controller MPC2515 is used.The main features of this CAN controller are it implements CAN V2.0B at 1 Mb/s (0 – 8 byte lengthin the data field, Standard and extended data and remote frames), high speed SPI interface It is capableof transmitting and receiving both standard andextended data and remote frames. The MPC2515 interfaces with microcontrollers (MCUs) via anindustry standard Serial Peripheral Interface (SPI).The communication between the processor and CANis done through CAN_TX and CAN_RX pins[6].

C) Graphics LCD – PCD8544

This system uses a graphics LCD to displaythe values of acceleration, braking force, steering angle, direction of the vehicle and time to which thevehicle travelled in particular direction. This systemuses PCD8544 as its display unit. It is a single chipcontroller/ driver which use 48 rows, 84 columnoutputs. All necessary functions for the display areprovided in a single chip, including on-chipgeneration of LCD supply and bias voltages, resulting in a minimum of external components and low power consumption[11]. The PCD8544 interfaces tomicrocontrollers through a serial bus interface.

D) MEMS Sensor – LSM303DLHC

Here Micro Electro Mechanical system isused to sense vehicle position. It is a 6-Axis MEMSDigital compass is an accurate tilt compensateddirection sensor that provides the 360 degreedirection by sensing the earth magnetic fieldorientation. Vehicle dynamics is sensed using this 6DOF digital MEMS compass module that integrates a3-axis magnetometer and 3-axis MEMSaccelerometer[2]. This system uses LSM303DLHC tosense vehicle dynamics. It is a System-in-linepackaging featuring a 3D digital linear accelerationsensor and a 3D digital magnetic sensor.LSM303DLHC has linear acceleration full-scales of
$\pm 2g$ / $\pm 4g$ / $\pm 8g$ / $\pm 16g$ and a magnetic field full-scaleof ±1.3 / ±1.9 / ±2.5 / ±4.0 / ±4.7 / ±5.6 / ±8.1 gauss.All full-scales available are fully selectable by theuser. LSM303DLHC includes an I2C serial businterface that supports standard and fast mode 100 kHz and 400 kHz[12]. The system can be configured togenerate interrupt signals by inertial wakeup/free-fall events as well as by the position of the device itself.Thresholds and timing of interrupt generators areprogrammable by the end user on the fly. Magneticand accelerometer parts can be enabled or put intopower-down mode separately. The LSM303DLHCfeatures two data-ready signals (RDY) which indicatewhen a new set of measured acceleration data andmagnetic data are available, therefore simplifying data synchronization in the digital system that usesthe device[9].

E.Temperature Sensor

When the temperature changes beyond the specified limits, the MCP9800/1/2/3 outputs an alert signal. The user has the option of setting the alert output signal polarity as an active-low or active-high comparator output for thermostat operation, or as temperature event interrupt output for microprocessor-based systems [10].

Fig.3 Temperature sensor

F.UART

UART stands for the Universal Asynchronous Receiver/Transmitter. In asynchronous transmitting, teletype-style UARTs send a "start" bit, five to eight data bits, least-significant-bit first, an optional "parity" bit, and then one, one and a half, or two "stop" bits. The start bit is the opposite polarity of the data-line's idle state. The stop bit is the data-line's idle state, and provides a delay before the next character can start.

G. Ubiquitous Vehicle Tracking:

GPS and GSM technologies enable the vehicle owners to track and monitor the vehicle with cell phone at anytime from anywhere. The important enhancement in this feature is its ability to inform the vehicle position even during a GPS outage using dead reckoning method, as in [2]. This is achieved with the help of Inertial Navigation Sensors that consists of a 3-axis MEMS Magnetometer and a 3-axis MEMS Accelerometer that will act as a tilt compensated compass module. The 3-axis digital MEMS accelerometer detects 3-axis acceleration and acts as a vibration sensor to find the accident scenario. The Features are SIM900D from SIMCOM,Very powerful single-chip processor integrating ARM926EJ-S core, Ideal for M2M applications,Quad-Band 850/ 900/ 1800/ 1900 MHz,Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands),SMS cell broadcast,Inbuilt Antenna ,AT cellular command interface

Fig. 4 GSM module.

H. SONAR

Sound Navigation and Ranging is a technique that uses Sound propagation to detect the object. It produces the ultrasonic waves. Trigger and echo pulse is obtained from this. These pulses are used to detect the obstacles. There are two types of

SONAR. They are Passive and Active. Passive sonar is essentially listening for the sound made by vessels; active sonar is emitting pulses of sounds and listening for echoes. Sonar may be used as a means of acoustic location and of measurement of the echo characteristics of target.

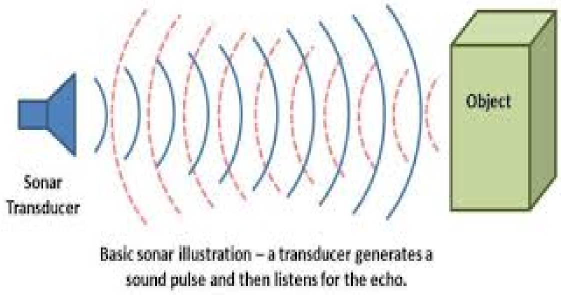

Fig. 5 SONAR

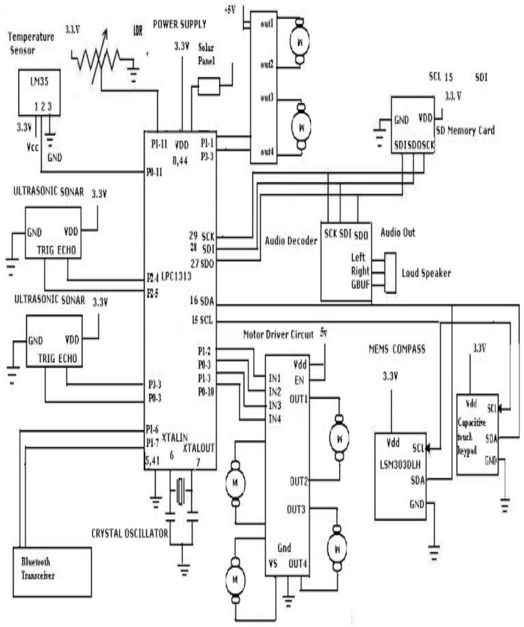

Fig. 6Circuit diagram

H. DC Servo motor

Four wheel Robot run with the help of Pulse width modulation. The PWM will adjust the speed of the Motor. In case of half cycle, the speed of the motor is slow and for full cycle the speed of the motor is increased[11].Differential drive wheelsL293D high current motor driver, High torque DC motors, 6V / 12V operation, Supportsupto 1Amp peak current, Strong Chassis to carry loads.

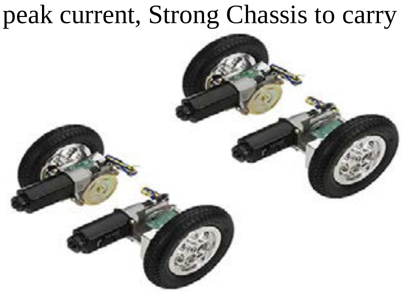

Fig.7 Servo Motor

3. WORKING

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 traveling.Driverless 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. 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.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. 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. This overrides the speed setting from the server. 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). CAN is a networking protocol widely used in automotive applications to interconnect different parts of the vehicle. 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. Emergency push button to stop the train in critical situation. 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. 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 MicroSD 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.

IV.Software Tool Used – LPCXpresso IDE

The LPC11Cx2/Cx4 are an ARM Cortex-M0 based, low-cost 32-bit MCU family, designed for 8/16-bit microcontroller applications, offering performance, low power, simple instruction set and memory addressing together with reduced code size compared to existing 8/16-bit architectures.

The LPC11Cx2/Cx4 operate at CPU frequencies of up to 50 MHz. The peripheral complement of the LPC11Cx2/Cx4 includes 16/32 kB of flash memory, 8 kB of data memory, one C_CAN controller, one Fast-mode Plus I2C-bus interface, one RS-485/EIA-485 UART, two SPI interfaces with SSP features, four general purpose counter/timers, a 10-bit ADC, and up to 40 general purpose I/O pins.

On-chip C_CAN drivers and flash In-System Programming tools via C_CAN are included. In addition, the LPC11C22 and LPC11C24 parts include an on-chip, high-speed CAN transceiver.There is syntaxcoloring, source formatting, function folding, on- andoffline help, and extensive project managementautomation.

- LPCXpresso is a complete toolchain for LPC1000 series of Cortex-M microcontrollers.
- Eclipse based IDE.
- GNU Compiler, Linker and Libraries
- Enhanced GDB Debugger
- Supports LPC-Link Programmer and Debugger
- Developed by NxP Semiconductors and CodeRedTechnologies.
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5. SYNTHESIS SCREEN SHOTS

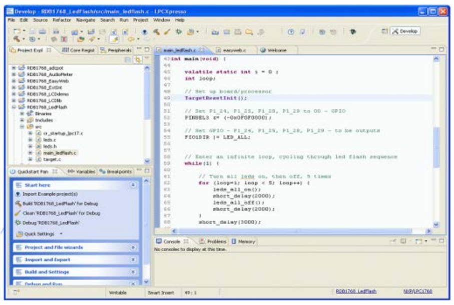

Fig.8 LPCXpresso IDE

6. ADVANTAGES

- This is a fully automated robotic solution that removes the need for human driver, removes human error and allows the government authority to increase the much needed frequency of operation. It also increases the operational efficiency of railways for example providing late night service outside usual hours means no extra cost.
- Significant cost-savings is achieved via labor reduction. This is particularly advantageous to metros in smaller cities that don't have access to massive budgets. This could bring mass transit to Tier-2 metropolitan cities.
- Real time train tracking dropped by Indian Railways is now being resurrected added with vital new features.
- Accuracy of GPS location is very high. The GPS module has a resolution of upto 3m.
- Unmanned railway crossing incidents will be reduced.
- All the trains are centrally controlled by a route server which eliminates complexity of a distributed control system.
- Passengers are informed with station names which are useful for illiterates and aged people.
- A high speed highly noise tolerant protocol such as CAN meets the requirement of a information exchange at real-time without any data loss.
- ARM Cortex-M0 architecture provides a next generation hardware platform, ideal when low power and high performance is needed.

7. CONCLUSION

Driverless train control system with real time train tracking facility based on satellite imaging for rail navigation and onboard disaster prevention network. It will run the train autonomously without any human operators. This will avoid train to train collisions, over speeding problem, signaling 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. 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.

ACKNOWLEGEMENT

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