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Train Positioning and Crack Detecting System

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ABSTRACT

With the development of Satellite Communication Technology and RF Technology it is easy to identify the train's position, its status and cracks on the railway track. A leading share to the Indian economy is contributed by the commercial transport railway network. So, any problems of crack detection in railway network when unexpectedly faced may be dealt with a powerful and cost effective solution else, there may be a proportionate decrease in the nation's economy. Train positioning system has brought this technology to day-to-day life of the common person. The GPS-GSM Based System is one of the most prominent systems, which integrate both GSM and GPS technologies. In this proposed work we will present a train positioning system that employs a GPS module and a GSM modem to find the location of a train and offers an advanced feature of railway crack detection and collision avoidance. To complete the design successfully, a GPS unit, a GSM unit, a relay, LCD, two MCU units, RF Transmitter, RF Receiver, an electronic device buzzer and vibration meter are used. The objective of this project is to remotely track a train's location and to remotely detect cracks on railway track.

Keywords: Tracking, positioning, GSM, GPS, Google Map, Train Positioning, RF TX, RF RX, VIBRATION METER, VIBRATION METER.

I. INTRODUCTION

Smart train positioning system is an electronic device that tracks the train's location. Primarily tracking system uses GPS module to detect the train's location. Earlier GNSS/INS is used for determining trains position and status [1].

Many applications of navigation systems have high commands on consistency and robustness of the navigation solutions. Integrated GPS/INS systems make use of the complementary properties of different sensors and reach an accurate short and long term solution [2]. Here we also concentrate towards the problem of accidents in railways happening due to cracks and due to derailment. The survey comments that 60% accidents occurred in railways are due to derailments and 90% due to crack problems. Hence, this problem of cracks on railways became a crucial problem, which has to be dealt with paramount importance and attention, as the frequency of usage of Indian railways is high. This problem of cracks which is in major proportion, contributes for major train accidents will go unnoticed. To deal with this problem microwave antennas are used for crack detection [10], is investigated in research. Another important technique for crack detection is IR photodiode sensing [11], which seemed to more suitable but later it became inaccurate. To improve accuracy and for gathering real time positioning information of trains and also for determining cracks on railway tracks we introduce ''Smart train positioning system".

With this system the position of the train is identified using Global Positioning system (GPS) and Global system mobile communication (GSM). This system not only constantly watch moving trains and reporting the status on demand but also senses vibrations arises on the railway track due to moving train, if vibrations are not detected by installed vibration meter on the side of tracks then identify the problem of cracks and alert the driver by an emergency alarm. These systems allows crack detection, provide real-time information such as location, expected arrival and departure time of train in a concise and easy-to-read format.

This project attempts to provide a viable solution by discussing the technical details and design aspects. The discussion continues with the explanation of different criteria involved in choosing simple components like GPS module, GSM module, LCD, two microcontroller units (ATMEL), RF TX, RF RX, relay, an electronic device, and vibration meter for effective implementation in train. There are three features introduced in this project. For example if user sends call request to the track ID number of the system and system responds to the user's request by comparing the number stored in the library of MCU. Those entire users registered in IR CTC are authorized user and only their numbers were stored in the library of MCU. After viable verification MCU will get the location from the GPS module as GPS module takes NMEA data from satellite and sends these data to the MCU and reply back to the user with the location coordinates (i.e. longitude and latitude). These coordinates can be used to view the location of a vehicle on Google maps.

The train positioning systems are mainly used to view the location of a train. This system comprises of a cost effective position tracking technology and special crack detection technology. It facilitates the anti-collision avoidance features when two trains moving on same track by displaying the location of other train on same path thus tracking the position of train from a distance of 100 meter hence avoiding collision. It performs railway crack detection by detecting vibration of metal from a distance of 1 kilometre via vibration meter as metal has the probability to vibrate if no vibration occur then alert driver by using RF and relay based control concept. Buzzer can be turned on and off in order to alert driver about the flaws/cracks on railway track. This is basic overview about the proposed work. This system is user friendly, easily installable, easily accessible and can be used for various other purposes.

II. METHODS AND MATERIAL

A. Background Research

In [1] Deeply integrated GNSS/INS strategy for train positioning based on vector tracking loop was proposed, and the mathematical model for GNSS/INS integrated system was established. GNSS/INS could be classified into loosely coupled integration and deeply coupled integration. Compared to LI, DI is performed better to track the receiver in low carrier noise ratio condition caused by signal attenuation or due to radio frequency interference. It employs a Vector Tracking Loop (VTL) for train locating information. VTL tracking control input which is generated from pseudo-range and range rate that are estimated from navigation results, while the navigation results are calculated from channel tracking results. This method can track temporarily attenuated or blocked signals.

In [2].Deeply coupled GPS/INS navigation system based on INS-VDLL integration was proposed. The tracking via the C/A code phase and the carrier frequency is actually replaced by direct tracking via the position and velocity solution, respectively. For the code tracking a Vector Delay Lock Loop is used, which uses the position estimation to feed the Numerically Controlled Oscillators of each DLL. For carrier tracking two methods are proposed. The VFLL works similar to VDLL while a stabilized PLL method uses single channels for tracking.

In [3] Comparison of the performance of a Non-Coherent Deeply Integrated Navigation Algorithm and a Tightly Coupled Navigation Algorithm was proposed. In this paper the author compare the performance of a tightly coupled and a Deeply Integrated (DI) navigation algorithm at low carrier to noise power density ratios (C/N0). The purpose of the comparison is to ensure the relative improvement in tracking ability from the DI architecture. In order to make a valid side by side comparison, the algorithm both use the same discriminator functions, signal amplitude estimation techniques, and noise power estimation techniques. The only major difference between the two algorithms is the manner in which central Extended Kalman Filters are updated with GPS measurements.

In [4] GNSS Receiver with Vector Based FLL-Assisted PLL Carrier Tracking Loop was proposed.

In this paper a vector receiver is chained with a FLL-assisted PLL for carrier phase tracking. The output of the VFLL receiver is used to replace the traditional FLL discriminator used in a FLL-assisted PLL. This combines the robustness of carrier tracking from a vector receiver with the carrier phase tracking ability of a PLL. Partial GPS satellite signal outages are bridged using the vector tracking capability with position and velocity information from remaining satellites. With instantaneous re-acquisition, carrier phase lock can be achieved. Even in weak signal environment the vector based FLL-assisted PLL has an increased robustness regarding carrier phase tracking in comparison to traditional FLL- assisted PLL carrier tracking loops

In [5] Deep integration of navigation solution and signal processing was proposed. The paper discusses the deep coupling scheme. It offers three main benefits of the vector loop over conventional DLL/FLL: increased availability, Doppler/pseudo range accuracy assessment from signal processing and less computational load in the software receiver. The navigation processor controls the signal processing unit of a GNSS receiver in various ways. In this mode tracking loops become obsolete and the navigation solution is calculated from code and frequency discriminator output.

In [6] an Interference benefit of a Vector Delay Lock Loop was proposed. This paper compares the interference benefits performance equations for three types of GPS receivers, a VDLL receiver, an ultra-tight (UTC) or deep integration (DI) receiver and VDLL embedded in a UTC or DI receiver. The basic theme used in this paper is to determine the measurement equations and then characterize the measurement errors. The pseudo range measurement is determined from the time difference between the time code is received by the receiver and the time it was sent by the Space Vehicle. It offers additional benefits include: no additional hardware, no increase in power consumption, no increase in weight and no increase in reliability.

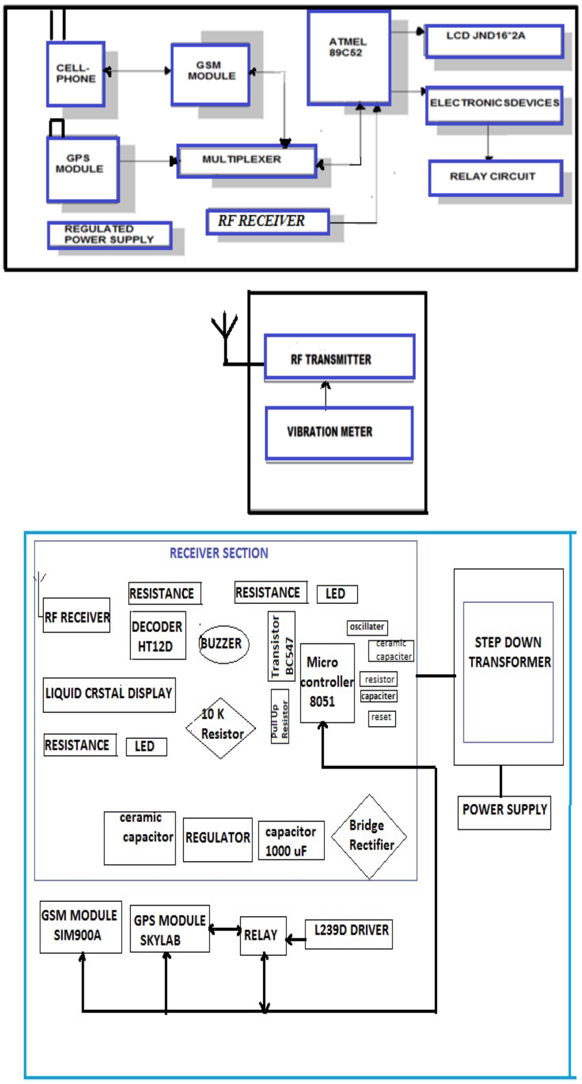
In [7] Analysis of discriminator based vector tracking algorithms was proposed. In this paper, a realization of the vector delay lock loop concept was introduced. The VDLL architecture uses a single Extended Kalman Filter to predict the satellite PRN code phase and track the user's position velocity, and clock states. Vector Delay Lock Loop (VDLL) combines the tracking of the different satellite PRN signals into a single algorithm. The VDLL uses calculated user's position to generate the replica PRN sequences. The error signals generated after each integration interval are then used to estimate the user's position and clock bias. An EKF is used to track user's navigation states (position, velocity and clock bias). VDLL offer advantages over traditional DLL. The VDLL can reacquire the blocked signals when they reappeared however traditional method did not reacquire the blocked signals once they reappeared.

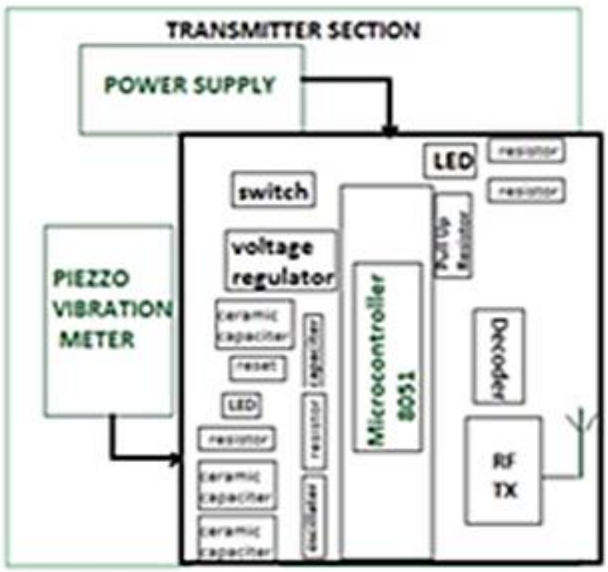
B. Proposed Methodology

In this proposed work, an advanced technique of train positioning is used to track the location of train by employing GPS and GSM technology. This smart system is equipped with anti-collision features. If both trains moving on same path GPS gets the location coordinate from satellite and transmits the location coordinate to the MCU, LCD displays the location coordinates. Thus alerting the driver, this way the system minimizes collision.

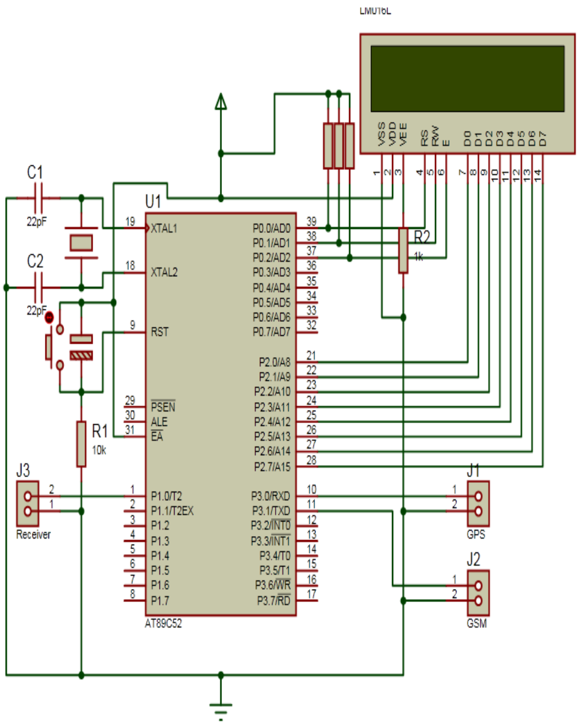
1. Block Diagram

The Block Diagram of smart train positioning system based on GSM and GPS technology is shown in figure1. It consists of a power supply section, Relay, decoder, encoder a GSM module, a GPS module, RF TX, RF 434MHz RX, Vibration Meter a MCU (ATMEL) and a LCD.





2. Circuit Diagram



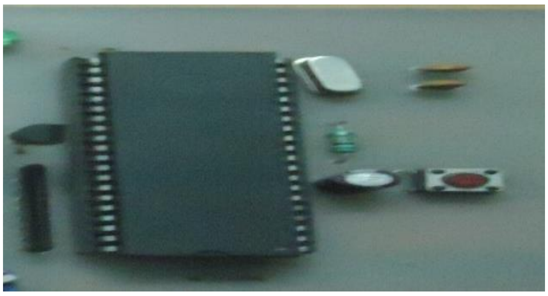
3. The GPS

The Global Positioning System (GPS) is a satellite-based navigation system consists of a network of 24 satellites located into orbit. GPS works in any weather circumstances at anywhere in the world. Normally no subscription fees or system charges to utilize GPS. A GPS receiver must be locked on to the signal of at least three satellites to estimate 2D position (latitude and longitude) and track movement. With four or more satellites in sight, the receiver can determine the train's position coordinates (latitude, longitude). Here SKYLAB GPS receiver is used which is very compact to detect the train location and provide information to authorized person in easy to read format that is in the form of position coordinates and possible to display the received data on Google maps. Features: Ultra High Sensitivity and Low Power GPS Receiver Module, Extremely fast, high accuracy, NMEA Output：GGA, GSA, GSV Advanced Features: Always Locate; AIC and lead free.

4. GSM Modem

A GSM modem used in this project is SIM900A The GSM modem is a specialized type of modem that accepts a SIM card operates on a subscriber's mobile number over a network just like a cellular phone. It is a cell phone without display. Modern sim900A is a dual-band GSM device. SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900A can fit almost all the space requirements in your applications, especially for slim and compact demand of design.

5. The MCU Unit



AT89C52 MCU from 8051 family is used. Features of MCU: low-power, high performance C-MOS 8 bit MCU, 8K bytes in system programmable flash memory, four input/output port, one port for serial communication. It is an 8bit microcontroller. 8bit accumulator, 8bit Register and 8bit ALU. On chip RAM 128 bites (data memory).On chip ROM 4 Kbytes (program memory).Two 16bit counter/ timer. A 16 bit dptr (data pointer). Two levels of interrupt priority.4 byte bi-directional input/ output port. Power saving mode (on some derivatives).16bit address bus:-it can access 2^16 memory locations:-64kb (65536) each of RAM and ROM. It is an inclusion of Boolean processing system, have an ability to allow logic operations to be carried out on registers and RAM. 8bit data bus:-it can access 8bit of data in one operation. UART (this serial communication port makes chip to use simply as a serial communication interface). It has four separate Register set. (Each contains 8 Registers (R0 to R7).

6. Liquid Crystal Display (LCD)

LCD 16*2 (16 Char and 2 rows) is used. It displays the location in terms of coordinates and the SMS sent or received by the GSM modem. The two rows of the LCD are used to show the north and east coordinates. The Pin 2 is connected to VCC and pin 1 with Ground. Pin no 3 is connected with resistor value of 10 K. Variable Resistor that is used for the contrast colour of the LCD, Pin no 4 (RS), 5(R/W), 6(EN) are attached with P2.5, P2.6, P2.7 of the MCU respectively. Resets of the 8 pins are attached to port 0 of MCU.

III. RESULTS AND DISCUSSION

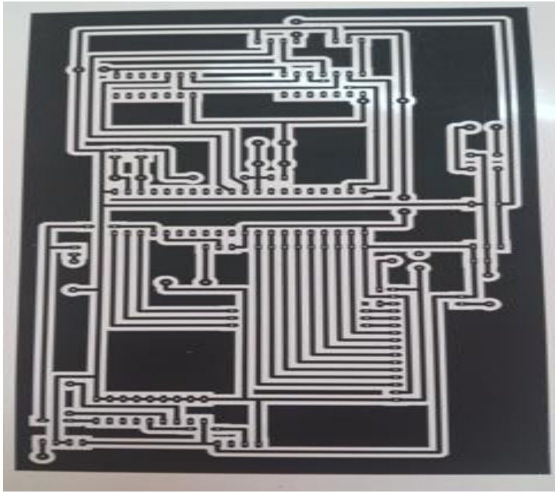
A. Simulation of Design

Although there are varieties of software packages, which can be used to simulate the circuit; the most commonly used are the circuit wizard and the PCB wizard. In order to test circuit, I have used the Proteus design suite (software). For the electronic circuit simulation, the schematic capture and the PCB wizard is used for printed circuit board (PCB) layout design. The software program has written in assembly language and compiled using Keil software. After compiling operation, the hex code generated and stored in the computer. The hex code of the program should be loaded into the AT89C52 by using ISP programmer.

B. Hardware Assembling And Testing

First step, we need to make single side PCB layout for the given circuit diagram. After made the PCB the following process is required to complete the project.

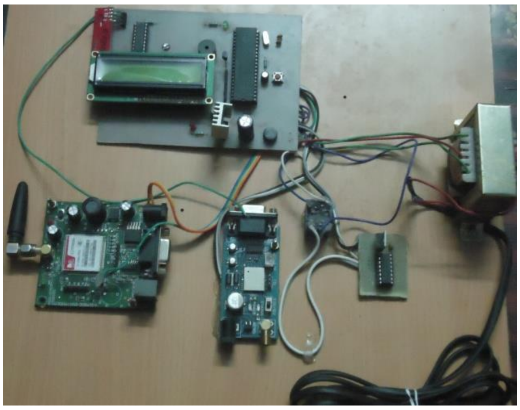
1. Assemble all the components on the PCB based on circuit diagram; insert a valid SIM in the GSM modem. Here we use L239D driver to run relay



2. Connect the GPS module according to circuit diagram.
3. System initialize when power supply is on Led indicates now if user call to System number implemented in train. GSM crop number display on LCD and send to microcontroller.
4. Microcontroller checks the number with already stored number if correctly matches, controller enables relay to activate GSM. Relay activate GPS to take reading and thus coordinate is send to user via GSM.
5. To drive relay l239d is used.

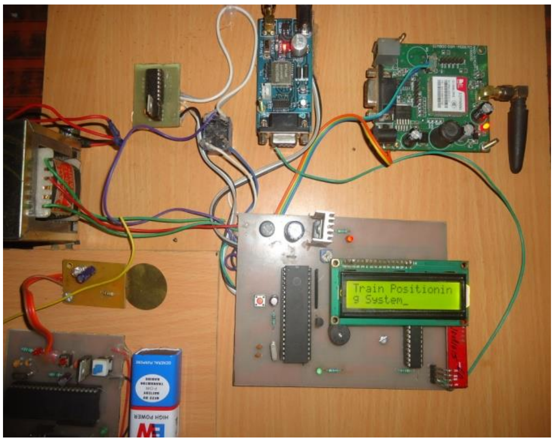
6. Vibration meter senses the vibration occurs due to effective movement of train from a distance of more than 1 meter as it is a prototype. For real implementation this senses from a range of more than 1Km.
7. If vibration is detected on track effectively then it indicates no cracks but if the vibration were not senses during movement from a distance then microcontroller sends data to encoder, it converts the parallel data to serial for transmission through a RF TX, when TE pin is active low. On the hand RF Rx receives signal and sends to decoder, it decodes about path break and activate transistor to activate buzzer to on. Thus this system alerts driver about cracks and helps in avoiding accident.
8. These projects implemented and tested successfully by us.
9. This system is very useful for obtaining real time positioning information.

Receiver Section



Transmitter Section

Complete system



IV. CONCLUSION

In this paper, we have proposed an innovative method of train positioning systems used to track the positioning information of train by using GPS and GSM technology with an accuracy of less than 3 meter for prototype and for large trains its around 3Km and also including vibration meter, RF interfacing with Decoder/Encoder to detect cracks. The positioning is done in the form of latitude and longitude along with the exact location of the place, by making use of Google maps. The system tracks the location of a particular train on the user's request and responds to the user via SMS. The received SMS contains longitude and latitude that is used to locate the train on the Google maps. Here with the introduction of vibration sensor and RF technology now it is possible to detect cracks to avoid accidents due to derailing or cracks. In this method, driver easily tracks the location of other train following same route by just calling to number allotted to train2 following same route to prevent collision and to minimize delay. Wide changes were made as compared to base paper system. First is the introduction of GPS instead of GNSS that avoid usage of mathematical model for positioning estimation. Earlier to calculate coordinates we need to going through various complex mathematical calculations now GPS reduces complexity and increases accuracy. Second it simultaneously detects for cracks too. Nowadays major accident in railways occurs due to derailment or cracks there are so many manual techniques are used to check for cracks but here we introduced smart technique that detects cracks via sensing vibration. There we set vibration of certain range as threshold vibration by examining the vibration of actual moving train for real implementation .Here it's just a prototype we create vibration by knocking on pizzo sensor through nails. When vibration is made continuously indicate no cracks and if not indicates about cracks.

V. ACKNOWLEDGEMENT

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