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Design And Development Of A Modern Vigilance Control System To Enhance The Rail Passenger Safety Using GSM And GPS Technology

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Abstract

This paper is proposed to prevent train accidents (due to un-alertness of engine drivers) by designing engines with a new emergency braking system— Modern VCD (Vigilance Control Device), a microcontroller based safety device which will enhance passenger's safety by cyclically generating warnings and by automatically stopping the train if the driver is incapacitated or dead or fast asleep. This paper also informs the position of the loco crew to the higher authorities and tracks the position of the train where it is stopped by using Global System for Mobile communication (GSM) and Global Positioning System (GPS) technologies. If the driver does not perform a regular task such as accelerating or braking for a stipulated period of time a message will be send to the signal inspector through GSM. After the train is stopped automatically, its position is tracked by GPS and a message will be send to the signal inspector.

Index Terms: *Driver, Control, GPS, GSM, Loco, Vigilance, Warnings*

1. Introduction

In Indian Railways, major accidents have been caused due to failure of Railway staff. Higher incidence of human failures surface as technical safeguards and backups do not always replace the human effort. Though an accident occurs only when both fail but it usually gets logged as 'human error' with a tendency of glossing over technical failure. Under optimum field conditions and with the best of intentions, a human being is likely to commit a mistake from time to time. This is the reason why operating rules included many redundancies in safety procedures and operating practices involve number of checks and balances. More and more automation is resorted to prevent human errors. This paper provides a method to safety of the passengers in trains by alerting the driver cyclically. Vigilance control device plays a major role to reduce the accidents that are caused by the pilot of the train. Vigilance Control Device (VCD) is a microcontroller based safety device which will automatically apply penalty brakes in case the driver is incapacitated or dead. Similar operation is available in older locomotives in the form of Dead man's Lever. "The dead man's lever is a knob that has to be kept pressed at all times to keep the train running. This system was introduced to prevent accidents, even if the driver died at his controls, hence the name. Unless a certain amount of pressure is maintained on the lever, brakes get automatically activated and the train slows down and comes to a stop. Another form of driver safety system is "Dead Man System" which detects a continuous input from the driver, e.g. by application of force to a pedal or handle[1]. In this system there is no facility to inform the action of the driver and the position of the train to higher authorities to take any responsible decision. So in order to overcome this disadvantage and to make the driver in alertness and to ensure safety to passengers the new system is proposed called modern vigilance control device. In this paper we are using AT89S52 microcontroller, the heart of the system and JHD 16x2A LCD for displaying the actions and we are using GSM modem of SIM 300 for messaging the information to the higher authorities and GPS system for tracking the position of the train after the penalty brake is applied.

The rest of the paper is as follow. In Section 2, we explain the proposed setup of the system i.e., the block diagram and its description. Section 3 explains the working of the proposed system. We conclude the paper in Section 4 describing our accomplishments.

2. Block Diagram and its Description

The block diagram consists of different components interfacing to a microcontroller. The block diagram is shown in Fig.1.

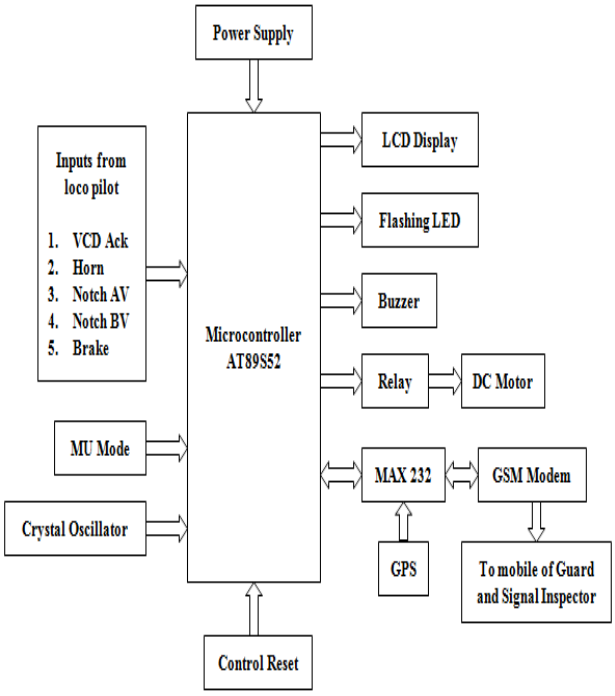


Fig.1: Block Diagram

The various components in the block diagram are mentioned below:

1. AT89S52 Microcontroller
2. Power Supply
3. Crystal Oscillator
4. Inputs from Loco
5. MU Mode
6. Control Reset
7. 16x2 Liquid Crystal Display(LCD)
8. LED
9. Buzzer
10. Relay
11. DC Motor
12. MAX 232
13. GSM Modem
14. GPS Module

2.1 Microcontroller Unit

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 and 80C52 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

Features of the microcontroller:

1. It is a 8-bit microcontroller.
2. 8K Bytes of In-System Programmable (ISP) Flash Memory.
    a. -Endurance: 1000 Write/Erase Cycles
3. Fully Static Operation: 0 Hz to 33 MHz
4. 256 x 8-bit Internal RAM.
5. 32 Programmable I/O Lines.
6. Three 16-bit Timer/Counters.
7. Eight Interrupt Sources.
8. Full Duplex UART Serial Channel.

2.2 Power Supply

The input to the circuit is applied from the regulated power supply. The microcontroller voltage is of 5V. The A.C. input i.e., 230V from the mains supply is step down by the transformer to 12V and is fed to a rectifier. The output obtained from the rectifier is a pulsating D.C voltage. So in order to get a pure D.C voltage, the output voltage from the rectifier is fed to a filter to remove any A.C components present even after rectification. Now, this voltage is given to a voltage regulator to obtain a pure constant dc voltage. We are using an IC 7805 as voltage regulator to get a 5V output Voltage.

2.3 Crystal Oscillator

A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wrist watches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, so oscillator circuits designed around them became known as "crystal oscillators". This block provides necessary frequency sine wave to the micro controller. This frequency is converted to square wave within the micro controller.

2.4 Inputs from Loco

These are the inputs given by the driver while driving to the microcontroller. The inputs are VCD Acknowledgement (VCD Ack), Horn, Notch AV, Notch BV, and Brake.

2.5 MU Mode

Mu mode is multiple unit mode to support the efficiency of the second engine.

2.6 Control Reset

Control reset is to execute the entire VCD cycle from beginning.

2.7 Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this JHD 16x2A LCD each character is displayed in 5x7 pixel matrix. The schematic diagram of 16x2 LCD is shown in Fig.2. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Some of the LCD command codes are listed in Table 1.

Fig.2: Schematic diagram of 16×2 LCD

Features:

1. Interface with either 4-bit or 8-bit microprocessor.
2. Display data RAM.
3. 80x8 bits (80 characters).
4. Character generator ROM and RAM.
5. 160 different 5x7 dot-matrix character patterns.
6. 8 different users programmed 5x7 dot-matrix patterns.
7. Numerous instructions.

8. Clear Display, Cursor Home, Display ON/OFF, Cursor.
9. ON/OFF, Blink Character, Cursor Shift, Display Shift.
10. Built-in reset circuit is triggered at power ON.

Table 1: LCD Command Codes

Code(Hex)	Command to LCD Instruction Register
01	Clear display of the screen
06	Automatic increment
38	2 line 5x7 Matrix
0F	Display is on and the cursor blinks
80	Force Cursor to begin from 1st line
C0	Force Cursor to begin from 2nd line

The LCD display is connected to the output port of micro controller to display the cyclic operations of vigilance control device.

2.8 Flashing LED

Light-emitting diodes are elements for light signalization in electronics. They are manufactured in different shapes, colors and sizes. For their low price, low consumption and simple use, they have almost completely pushed aside other light sources- bulbs at first place. They perform similar to common diodes with the difference that they emit light when current flows through them. Light emitting diodes (LEDs) are semiconductor light sources.

Based on semiconductor diode, LEDs emit photons when electrons recombine with holes on forward biasing. The forward voltage of LED (1.7V-2.2V) is lower than the voltage supplied (5V) to drive it in a circuit. Using an LED as such would burn it because a high current would destroy its p-n gate. Therefore a current limiting resistor is used in series with LED. The LED is interfaced to the output port of micro controller as the first indication to alert the driver.

2.9 Buzzer

Buzzer is an audio signaling device, which may be mechanical, electro-mechanical or electronic that sounds a warning of continuous or intermittent sound. It is compact and produces high sound pressure levels with minimal power consumption. The range of operating voltages is from 1 to 30V whilst sound output may be as high as 75 dB at 1m. Normally, buzzers operate a buzzing noise in the frequency range 300 to 500 Hz. This is used to alert the driver. The buzzer is connected to output port as a second indication to driver.

2.10 Relay

A relay is an electrically controllable switch widely used in industrial controls, automobiles and appliances. A relay is able to control an output circuit of higher power than the input circuit. Relays are devices which allow low power circuits to switch a relatively high Current/Voltage ON/OFF. For a relay to operate a suitable pull-in & holding current should be passed through its coil. Generally relay coils are designed to operate from a particular voltage often its 5V or 12V. The relay used is 5-pin relay to drive motor as an indication for movement of train.

2.11 DC Motor

DC (direct current) motors convert electrical pulses to mechanical movement. Maximum speed of DC motor is indicated in RPM. The RPM is reduced when moving a load and it decreases as the load increases.

The permanent magnet DC motor can be modeled as a device that produces torque proportional to the current flowing through it. It also produced a voltage proportional to the rotational velocity. The RPM of a motor is proportional to the voltage across its terminals. The motor will spin up in speed until the generator portion of the motor model matches the supply voltage. At that point no more current will flow into the motor and it will produce zero torque. Of course, there is some amount of friction, so there will be some amount of torque required to spin the motor, thus some amount of current needed. This current causes a voltage drop across the small series resistance in motor model. This voltage drop takes away from supply voltage and causes the motor to spin a bit slower than the supply voltage would indicate.

Specifications of DC Motor are:
1. Output RPM: 500 rpm
2. Input Voltage: 12 V
3. Current: 500 - 600 Ma
4. Shaft length RF

2.12 MAX232

The microcontroller can communicate with the serial devices using its single serial port. The logic levels at which this serial port operates is TTL logics. But some of the serial devices operate at RS 232 logic levels. So in order to communicate the microcontroller with modem, a mismatch between the logic levels occurs. In order to avoid this mismatch, in other words to match the Logic levels, a serial driver is used. A MAX232 is a serial line driver used to establish communication between modem and microcontroller. The interfacing of GSM modem with microcontroller using MAX 232 as a serial line driver is shown in Fig.3. The voltage levels of Max 232 are given in Table 2.

Table 2: Voltage levels of Max 232

RS232 Line Type & Logic Level	RS232 Voltage	TTL Voltage to/from MAX232
Data Transmission (Rx/Tx) Logic 0	+3 V to +15 V	0V
Data Transmission (Rx/Tx) Logic 1	-3 V to -15 V	5V
Control Signals (RTS/CTS/DTR/DSR) Logic 0	-3 V to -15 V	5V

Control Signals (RTS/CTS/DTR/DSR) Logic 1	+3 V to +15 V	0V

2.13 Global System for Mobile communication (GSM)

A GSM modem is a wireless modem that works with a GSM wireless network. A wireless modem behaves like a dial-up modem. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves. It operates at either the 900MHz or 1800MHz frequency band. It supports voice calls and data transfer speeds of up to 9.6kbits/s, together with the transmission of SMS (Short Message Service). The GSM Modem comes with a serial interface which the modem can be controlled using AT command interface. The interfacing of GSM modem with the microcontroller is shown in Fig.3.

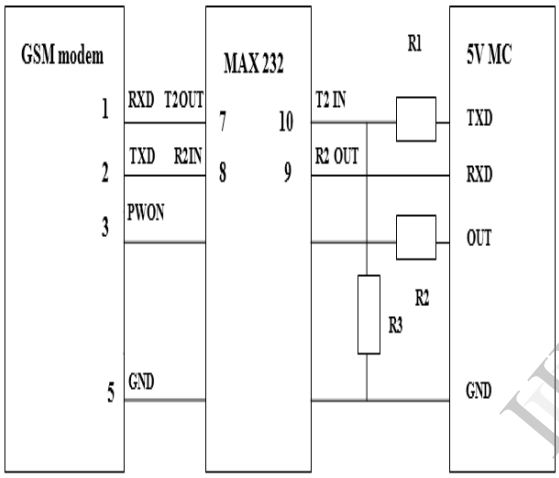
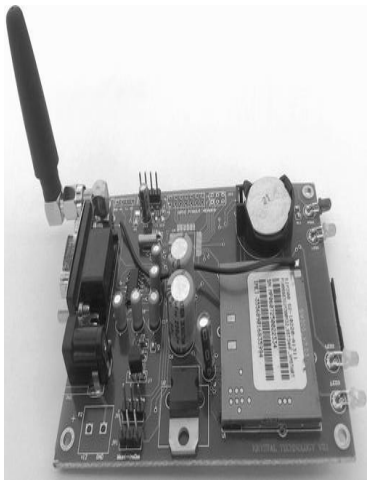


Fig.3: Interfacing of GSM modem with microcontroller

Here a GSM modem SIMCOM made SIM300 V 7.03 interfaced with the microcontroller operates in 900MHz frequency and is operated at voltage levels of 3.5 to 5V. The modem is provided with network status indication LED lamp. It is also provided with buzzer to indicate incoming call. The GSM modem is shown in Fig.4.



.4: GSM Modem Prototype

The working of GSM modem is based on commands, the commands always start with AT (which means ATtention) and finish with a <CR> character. AT commands are used to control the MODEMs. Since one of the main objective for this application is to show how to send the message, only a subset of the AT command set needs to be implemented. The AT commands are given to the GSM modem with the help of PC or controller. Some of the AT commands used are listed in Table 3.

Table 3: AT Command Set

Command	Description
AT	Check communication between the module and the computer
AT+CMGF	Set the SMS mode (Either text or protocol data unit mode)
AT+CMGW	Store message in the SIM
AT+CMGS	Send message to a given phone number
ATD	Dial or Call a number
ATA	Answer a Call
ATH	Disconnect remote user link with the GSM module

2.14 Global Positioning System (GPS)

The Global Positioning System (GPS) is a satellite based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and provides the user with information. Using GPS technology one can determine location, velocity and time, 24 hours a day, in any weather conditions anywhere in the world for free. GPS was formally known as the NAVSTAR (Navigation Satellite Timing and Ranging). The basis of the GPS technology is a set of 24 satellites that are continuously orbiting the earth. These satellites are equipped with atomic clocks and sent out radio signals as to the exact time and location. These radio signals from the satellites are picked up by the GPS receiver. Once the GPS receiver locks on to four or more of these satellites, it can triangulate its location from the known positions of the satellites. It is a higher performance, low power satellite based model. It is a cost effective and portable system which accurately detects the location. The GPS receiver used here is Sky Traq Venus 6 GPS module ST22 which is having TTL logics and also RS232 as option. The GPS receiver is shown in Fig.5. This GPS is used to track the position of the train after the emergency brake is applied in order to avoid the accidents. This application is used only after the train is stopped

GPS Receiver Specifications:

1. 65 channels-1Hz Update rate
2. Hot Start- 1sec
3. Baud rate- 9600bits/s
4. Operating Voltage-5Volts dc

5. O/P Format-NMEA 0183-RS232
6. Operating Temperature: -40 to +85^{o}C
7. Sensitivity- Tracking: -160 dBm
   Reacquisition: -158 dBm
   Cold Start (Autonomous): -148 dBm

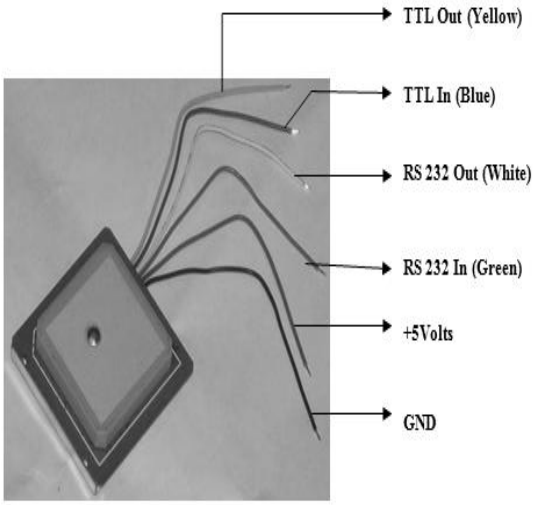


Fig.5: GPS Receiver

3. WORKING

VCD is microcontroller based equipment designed and manufactured to enhance the safety of the locomotive operation by ensuring the alertness of the crew all the time. The system is resetting type and operates in a fail-safe manner. VCD will give cyclic warnings to the driver. Based on the drivers reaction to these warnings (in terms of pre-defined set of actions to be done by the driver), the system will automatically reset the alerting cycle.

The locomotive driver operates controls for increasing and decreasing locomotive power application or releasing the breaks or operating the horn of the locomotive. The VCD monitors whether these controls have been operated by the driver in a 60-second time period. In case the driver has not operated any controls, the VCD gives a visual warning by activating a flashing light for 8 seconds. If acknowledgement is not received, an additional audio alarm is given for 8 sec. If driver further fails to acknowledge the alarm, a message is send to guard and to signal inspector through GSM modem as "DRIVER IS NOT ALERT", here guard is provided with break to control the VCD. If guard is not applying break within 10 sec then message is sent to signal inspector as "DRIVER AND GUARD NOT ALERT" and VCD will initiate the automatic application of brakes and it informs the position of the train where it is stopped in the form of latitude and longitude through GSM by using GPS module.

MU mode is the multiple unit used when the efficiency of the one engine is not sufficient for pulling the trains in hilly areas then it is provided for utilizing the efficiency of the second engine it is required to operate in mu mode. When VCD is operated in MU mode the above operation of the VCD cycle should not be activated in the second engine that is the driver is provided only in one cabin so it is programmed that when VCD operates in MU mode the entire VCD cycle at second engine should not activate.

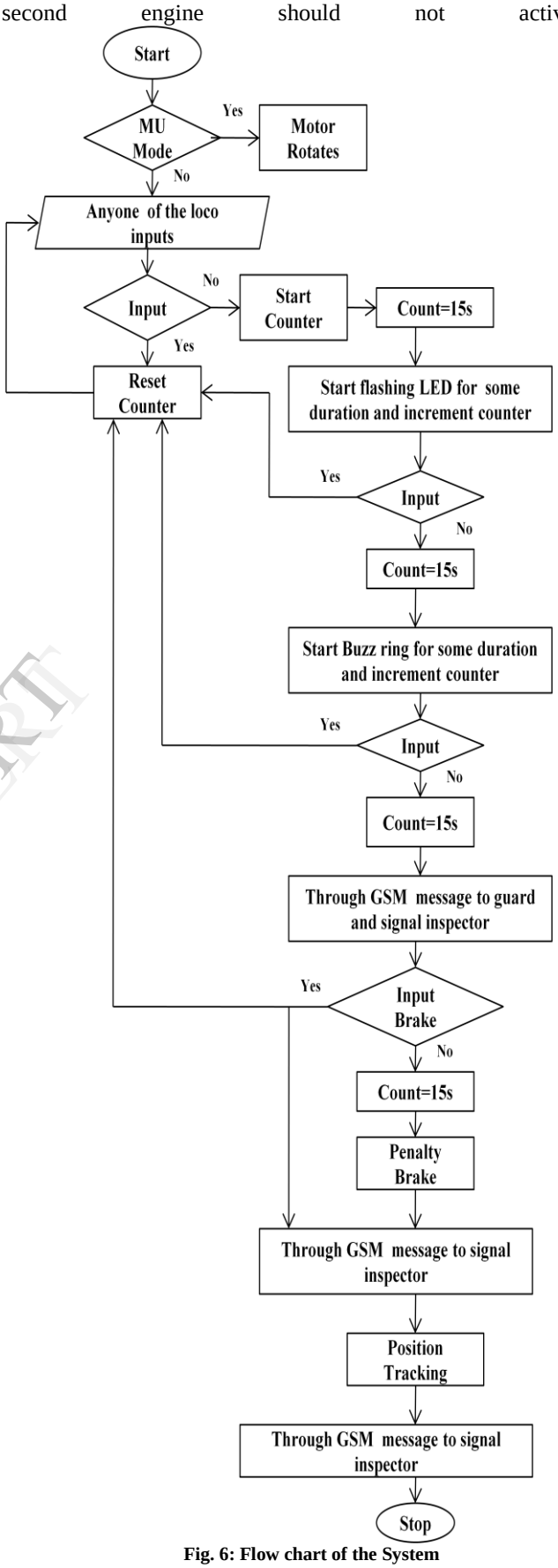


Fig. 6: Flow chart of the System

The flow chart shown in Fig.6 gives the clear explanation of the working of the modern vigilance control device. By using this flow chart the source code is developed. The source code is written in embedded C language.

4. CONCLUSION

Many people travel in trains and the number of people travelling is more when compared to any other like buses etc. In this paper the modern vigilance control device improves vigilance and provides warning and brake application signals in a predefined manner. So with the use of this device we can ensure safety to passengers. With this device we can analyze that whether the accident is due to loco pilot i.e., engine driver or due to failure of locomotive. By using this device we can inform the action of the driver to the higher authorities if he fails to respond the cyclic warnings and the position of the train can also be tracked to avoid the accidents. The high priority is given to the lives of people. Hence this paper provides a feasible solution to reduce accidents due to human failure.

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