International Journal of Electronics, Communication & Soft Computing Science and Engineering (IJECSCSE)
Volume 1, Issue 1

Design and Development of Fully Automatic AT89C52 Based Low Cost Embedded System for Rail Tracking

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***Abstract*— A real time low cost, low power and fully automatic an embedded system for tracking and positioning of rail by using RFID, global positioning system (GPS) and global system for mobile communication (GSM) is suggested. The current design is an embedded application, which will continuously monitor a rail from its source to destination and report the status of rail as and when required. For doing so a low cost AT89S52 microcontroller is interfaced with RFID, GSM Modem and GPS Receiver. A relevant about current position of a particular rail can be send to any destination station as well as mobile users on demand.**

***Key Words* — GPS, GSM, RFID, RS 232 Serial Interface**

I. INTRODUCTION

In today's scenario, where railway itinerary is getting busier and railway network spreading its wings wider, there is a need for a low cost, low power system which can efficiently track and monitor the functioning of Indian railways. The already existing system in India requires lot of man power which is not completely reliable.

During the last decade, a large collection of formal methods has been implemented for specifying, designing, and analyzing real-time systems. Tracking objects in real time is a difficult but useful concept in today's industry[2]. However, there is not a cost effective method for tracking objects that the industry can take advantage of. New methodologies are needed to increase the accuracy and speed of tracking objects. One of such real time system is Tracking Railway position. There have been many technologies to track the position of a train in the middle of its journey. Global Positioning System is one such technology that is used to locate the train's coordinates[6]. There are other real time locating systems available for the same purpose.

There is Advanced Radio Based train control system (ATCS), the systems involved the use of radio, satellite and radar communications[3]. Following the lengthy appraisal of this technology, it entered operational service with San Francisco's Bay Area Rapid Transit System (BART) in 2001. Further, the Indian railways has been evaluating a radio-based ATC system designed by Siemens but similar to the system being introduced by BART.

Especially in a country like India where trains are invariably late for more than one reason it becomes imperative that we install an automatic railway monitoring system. In India mainly manual methods are used to monitor the position of the train. Manually activated signals are operated by level crossing and railway staff, on instructions transmitted by telephone or telegraph signal from the nearest station. The information to the public waiting on the platform or at home about the arrival of a train is completely dependent on manual process. Due to complete manual process there is always a chance for dereliction of the duty and delay in the information traversing. Also the present scenario creates a situation where the passengers have to wait and the platform authorities keep them waiting for indefinite time interval.

II. ABOUT RFID SYSTEM

An RFID reader is a device that is used to interrogate an RFID tag. The reader has an antenna that emits radio waves; the tag responds by sending back its data. A number of factors can affect the distance at which a tag can be read (the read range). The frequency used for identification, the antenna gain, the orientation and polarization of the reader antenna and the transponder antenna, as well as the placement of the tag on the object to be identified will all have an impact on the RFID system's read range[1].

A. Active Tag

An RFID tag is an active tag when it is equipped with a battery that can be used as a partial or complete source of power for the tag's circuitry and antenna. Some active tags contain replaceable batteries for years of use; others are sealed units.

Active RFID tags may have all or some of the following features:

1. Longest communication range of any tag.
2. Capability to perform independent monitoring and control.
3. Capability of initiating communications.
4. Capability of performing diagnostics.
5. The highest data bandwidth
6. Active RFID tags may even be equipped with autonomous networking; the tags autonomously determine the best communication path.

A. The problems and disadvantages of an active RFID tag are:

1. The tag cannot function without battery power, which limits the lifetime of the tag.
2. The tag is typically more expensive
3. The tag is physically larger, which may limit applications.
4. The long-term maintenance costs for an active RFID tag can be greater than those of a passive tag if the batteries are replaced.
5. An RFID transponder is a special kind of radio transmitter and receiver. It is activated when it receives a signal of a specific kind. RFID transponders are

present in smart cards and Radio Frequency Identification tags.

B. Common Problems with RFID

Some common problems with RFID are reader collision and tag collision. Reader collision occurs when the signals from two or more readers overlap[8]. The tag is unable to respond to simultaneous queries. Systems must be carefully set up to avoid this problem. Tag collision occurs when many tags are present in a small area; but since the read time is very fast, it is easier for vendors to develop systems that ensure that tags respond one at a time

C. Design Considerations

The RFID (Radio Frequency Identification-13.56MHz RFID system) essentially consists of an RFID Reader/Writer (Transceiver), an HF Tag and a Processor unit interfacing to various peripherals as shown in figure-1.

1. HF Tags

A wide range of HF tags are available. Physical form factor and processing requirements of the HF Tag are the primary factors that help decide which tag to use. In addition, the amount, type and security level of the information which needs to be stored on the card determine the appropriate tag. Memory sizes up to 2kBit with different security levels are available.

2. RFID Reader/Writer (Transceiver)

The RFID Transceiver represents the core of the RFID reader. Besides the interface to the reader's antenna, a parallel or serial communication can be used between the Processor and the Transceiver unit. Various programming options make RFID Transceiver suitable for a wide range of proximity (communication distance to Transceiver - Tag: <10cm) and vicinity (communication distance to Transceiver - Tag: >50cm) RFID applications.

ISO15693, IOS14443-A bit rates ranging from 106kbps to 848kbps, ISO18000-3 and Tag-it RFID communication protocols are supported. Included with the on chip data coding/encoding is the automatic generation of SOF (Start of Frame), EOF (End of Frame), CRC and/or parity bits. The transceiver unit supports data communication levels to the MCU/I/O Interface ranging from 1.8V to 5.5V while also providing a data synchronous clock.

3. Processor

For both, the Fixed and Mobile RFID Reader, the power consumption of the Processor is an important care about. The broad product portfolio of the Ultra low power MSP430 family makes it an ideal processor choice for this application[1]. Their high level of system integration also simplifies the design and reduces system cost.

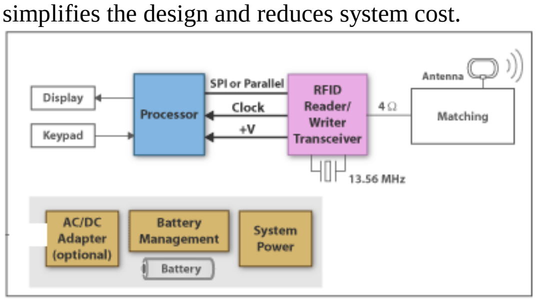

Figure-1. Block diagram of RFID system.

III. About GPS System

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS.

A. How it works?

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map[10].

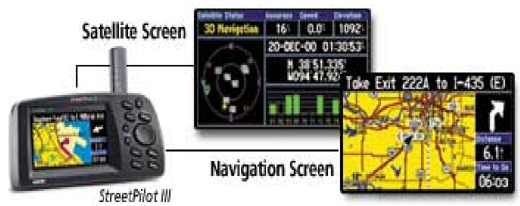

Figure-2. Global Positioning System (GPS)

A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

Here's how GPS works in six logical steps:

1. The basis of GPS is "triangulation" from satellites.
2. To "triangulate," a GPS receiver measures distance using the travel time of radio signals.
3. To measure travel time, GPS needs very accurate timing which it achieves with some tricks.
4. Along with distance, you need to know exactly where the satellites are in space. High orbits and careful monitoring are the secret.
5. You must correct for any delays the signal experiences as it travels through the atmosphere.
6. Finally (for us), you can now obtain the precise time from the GPS satellites [11].

B. What's the signal?

GPS satellites transmit two low power radio signals, designated L1 and L2. Civilian GPS uses the L1 frequency of 1575.42 MHz in the UHF band. The signals travel by line of sight, meaning they will pass through clouds, glass and plastic but will not go through most solid objects such as buildings and mountains. A GPS signal contains three different bits of information - a pseudorandom code, ephemeris data and almanac data. The pseudorandom code is simply an I.D. code that identifies which satellite is transmitting information [10]. You can view this number on your Garmin GPS unit's satellite page, as it identifies which satellites it's receiving. Ephemeris data, which is constantly transmitted by each satellite, contains important information about the status of the satellite (healthy or unhealthy), current date and time. This part of the signal is essential for determining a position. The almanac data tells the GPS receiver where each GPS satellite should be at any time throughout the day. Each satellite transmits almanac data showing the orbital information for that satellite and for every other satellite in the system.

IV. About GSM System

GSM networks consist of thee major systems: SS, which is known to be The Switching System; BSS, which is also called The Base Station; and the Operation and Support System for GSM networks as shown in figure-3.

A. The Switching System

The Switching system is very operative system in which many crucial operations are conducted, SS systems holds five databases with in it which performs different functions. If we talk about major tasks of SS system it performs call processing and subscriber related functions. These five databases from SS systems are HLR, MSC, VLR, AUC and EIR[7].

B. MSC- Mobile Services Switching Center:

MSC is also important part of SS, it handles technical end of telephony. It is build to perform switching functionality of the entire system. It's most important task is to control the calls to and from other telephones, which means it controls calls from same networks and calls from other networks. Toll ticketing, common channel signaling, network interfacing etc are other tasks which MSC is responsible for.

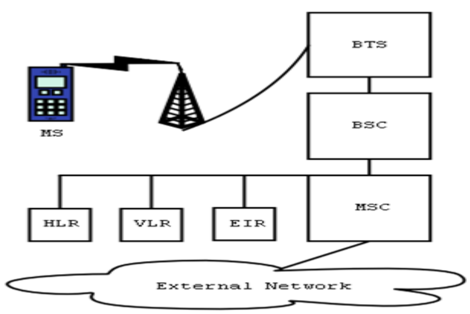

Figure-3. GSM Architecture and Working of GSM Networks

C. The Base Station System (BSS)

The base station system have very important role in mobile communication. BSS are basically outdoor units which consist of iron rods and are usually of high length. BSS are responsible for connecting subscribers (MS) to mobile networks. All the communication is made in Radio transmission. The Base station System is further divided in two systems. These two systems, they are BSC, and BTS [12].

D. BSC – The Base Station Controller:

The Base Station normally controls many cells, it registers subscribers, responsible for MS handovers etc. It creates physical link between subscriber (MS) and BTS , then manage and controls functions of it. It performs the function of high quality switch by handover over the MS to next BSC when MS goes out of the current range of BTS, it helps in connecting to next in range BTS to keep the connection alive within the network. It also performs functions like cell configuration data, control radio frequency in BTS. Data moves to MSC-Mobile switching center after BSC done processing it. MSC is switching center which acts as bridge between different mobile networks.

E. BTS – The Base Transceiver Station:

Subscriber, MS (Mobile Station) or mobile phone connects to mobile network through BTS; it handles communication using radio transmission with mobile station. As name suggests, Base transceiver Station is the radio equipment which receive and transmit voice data at the same time. BSC control group of BTSs.

F. The Operation and Support System (OSS)

OMC- Operations and maintenance center is designed to connect to equipment of MSC- Mobile Switching Center and BSC-Base Station Controller. The implementation of OMC is called OSS-The Operations and Support System.OSS helps in mobile networks to monitor and control the complex systems. The basic reason for developing operation and support system is to provide customers a cost effective support and solutions. It helps in managing, centralizing, local and regional operational activities required for GMS networks.

V. Proposed Rail Tracking System

The system consists of a transmitter module and a receiver module. The RFID tag will be placed on the train engine and the RFID transponder will be hanging at a set position on destination station. The necessary information like train name, number, current time, date etc will be sensed and transmitted using GSM network to the receiver module and the information will be displayed for public notice.GSM modem is used to send the position (Latitude and Longitude) of the vehicle from a remote place. The GPS modem will continuously give the data i.e. the latitude and longitude indicating the position of the vehicle. The GPS modem gives many parameters as the output, but only the relevant data coming out is read and displayed on to the LCD. The same data is sent to the mobile at the other end from where the position of the vehicle is demanded. A real time clock (RTC) is used to transmit real time and date along with other relevant rail information. The hardware interfaces to microcontroller are RFID system, GSM modem, GPS receiver, RTC and LCD display as depicted in figure-4. The design uses RS-232 protocol for serial communication between the modems and the microcontroller. A serial driver IC is used for converting TTL voltage levels to RS-232 voltage levels. When the request by user is sent to the number at the modem, the system automatically sends a return reply to that mobile indicating the position of the vehicle in terms of latitude and longitude and other necessary information.

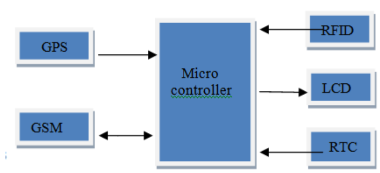

Figure-4. Interfacing of Peripherals with Microcontroller

A. GSM Modem

GSM modem provides full functional capability to serial devices to send SMS and data over GSM Network. The TC35i GSM engine operating in the GSM 900 MHz and GSM 1800 MHz frequency band is an extremely compact and super slim communication module especially designed for elementary, telemetric and telephony such as: metering, fleet management, security systems, POS terminals or vending machines. It is compatible with the predecessor engine TC35 and offers additional features such as SIM application tool kit and extended AT commands for the industrial environment[12]. Block diagram of GSM TC35i is shown in figure-5.

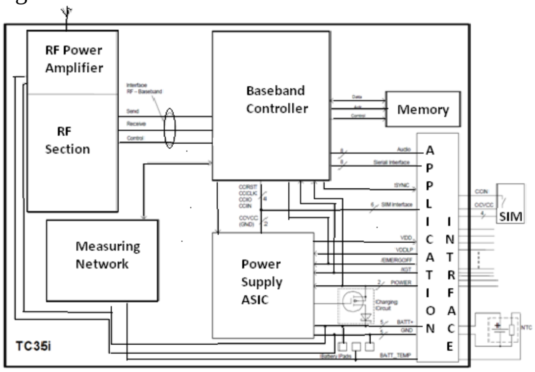

Figure-5. Block diagram of GSM TC35i

The upper voltage limit has been changed from 5.5V to 4.8V. The physical interface to the cellular application is made through a ZIF connector. It consists of 40 pins, required for controlling the unit, transferring data and audio signals and providing power supply lines. The cellular device application forms the Man-Machine Interface (MMI). The serial interface allows for access to the GSM engine. For battery powered applications, TC35i features a charging control which can be used to charge a Li-Ion battery.

B. GSM Modem Interfacing With AT89c5Microcontroller

GSM modem interfacing with microcontroller 8051 for SMS control of a rail tracking system. The SMS can be sent and received for the data sharing and situation information and control. The sending SMS through GSM modem when interfaced with microcontroller or PC is much simpler as compared with sending SMS through Modem in PDU Mode. Text message may be sent through the modem by interfacing only three signals of the serial interface of modem with microcontroller i.e. TxD, RxD and GND [9]. In the proposed scheme RTS and CTS signals of serial port interface of GSM Modem are connected with each other. The transmit signal of serial port of microcontroller is connected with transmit signal (TxD) of the serial interface of GSM Modem while receive signal of microcontroller serial port is connected with receive signal (RxD) of serial interface of GSM Modem. The COMPIM Serial Port Model shown in the schematic diagram (Figure-5) developed in Proteus VSM is equivalent to the serial interface of GSM Modem.

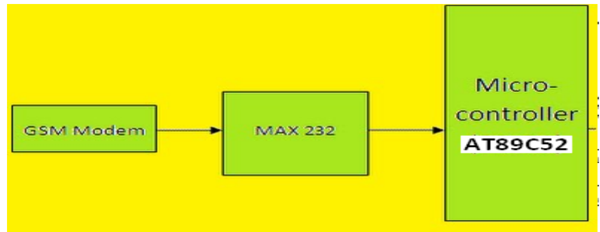

Figure-5. Interfacing of GSM with AT 89c52 through Max232

C. AT Commands

The following are the AT Commands and sequence of events performed for sending text message to a mobile phone through GSM modem interfaced with microcontroller.

1. First select the text mode for SMS by sending the following AT Command to GSM Modem: AT+CMGF = 1. This command configures the GSM modem in text mode.
2. Send the following AT Command for sending SMS message in text mode along with mobile number to the GSM Modem : AT+CMGS =+919422926175. This command sends the mobile number of the recipient mobile to the GSM modem.
3. Send the text message string ("Train No-17038,BknSec Exp,Date-1/12/2011,Time-7.39PM,AT-Shegaon") to the GSM Modem This is a test message from UART.
4. Send ASCII code for CTRL+Z i.e., 0x1A to GSM Modem to transmit the message to mobile phone. Every AT command is followed by i.e. carriage return and line feed

The SMS message in text mode can contain only 140 characters at the most. It depends upon the amount of information collected from GPS Engine that you need at the base so it depends upon how much you need to pack in 140 characters of SMS in text mode. The program segment for generation of AT commands and GSM modem initialization is as follows-

```
INI_GSM:
        MOV     DPTR,#GSM_AT
        LCALL   TRANSMIT
        LCALL DELAY
        MOV     DPTR,#GSM_CMGF
        LCALL   TRANSMIT
        LCALL DELAY
        MOV     DPTR,#GSM_CMGS
        LCALL   TRANSMIT
        LCALL DELAY
        MOV     DPTR,#MESSAGE
        LCALL   TRANSMIT
        LCALL DELAY
        MOV     DPTR,#CTRL_Z
        LCALL   TRANSMIT
        LCALL DELAY
        RET

            ORG 3000H
GSM_AT:   DB "AT",0DH,0AH,0
GSM_CMGF: DB "AT+CMGF=1",0DH,0AH,0
GSM_CMGS: DB
"AT+CMGS=+919422926175",0DH,0AH,0
```

MESSAGE: DB " Train No-17038,BknSec Exp,Date-1/12/2011,Time-7.39PM,AT-Shegaon ",0DH,0AH,0 ; 0D-carrage return ,0A -line feed
CTRL_Z: DB "1A"

D. RFID and GPS Receiver System

The major components of the RFID and GPS receiver system are the tag, reader and the interface as shown in Figure-6. Tag is a memory device, usually EEPROM, programmed with a series of bits. All automatic identification technologies require a medium to store information that will subsequently be retrieved by various applications for processing. RFID uses tags to electronically encode information [4].

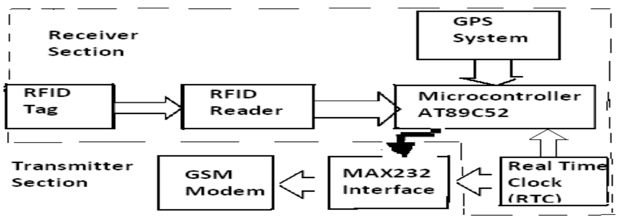

Figure- 6. Typical RFID rail tracking system a) RFID and GPS based receiver section b) GSM based Transmitter Section

These tags come in a variety of sizes and designs and there are numerous types, each tailored to meet specific application requirements. All tags have two key components an integrated circuit (IC) chip and an antenna. Information is stored on the chip and transmitted to the outside world via antenna. The chip and antenna can be laminated on plastic cards, encapsulated in protective housings or embedded in label stock. The amount of information that can be stored varies by chip design. RFID tags are typically categorized according to: Power source, Frequency, Encoding Method and Readers. GPS Receiver is used to capture the rail position (Latitude and Longitude) from a remote place. RFID tag will be read by the reader so find out train arrival at particular station[1]. So GPS and RFID information can be send through GSM modem using AT commands to the destination station as well as mobile user on demand..

VI. Circuit Operation

In this rail positioning and navigation system we can locate the rail around the globe with AT89S52 micro controller, GPS receiver, GSM modem, MAX 232, EEPROM. Microcontroller used is AT89S52. The code is written in the internal memory of microcontroller i.e. ROM. with help of instruction set, it processes the instructions and it acts as interface between GSM and GPS with help of serial communication of 8052. GPS always transmits the data and GSM transmits and receive the data. GPS pin TX is connected to microcontroller via MAX232. GSM pins TX and RX are connected to microcontroller serial ports. The overall circuit connections are depicted in figure.7. Microcontroller communicates with the help of serial communication. First it takes the data from the GPS receiver and then sends the information to the owner in the form of SMS with help of GSM modem. GPS receiver works on 9600 baud rate is used to receive the data from space Segment (from Satellites), the GPS values of different satellites are sent to microcontroller AT89S52, where these are processed and forwarded to GSM [4]. Inbuilt Timer of AT89S52 is used in auto reloading mode to set the 9600 baud rate. The program segment for this is as follows.

```
INI_SEC_COMM:
        MOV TMOD, #20H   ;T1 in mode 2
        MOV TH1, #-3     ;9600 baud
        MOV SCON, #50H   ;8b, 1start, 1stop
        ANL PCON, #07fh  ;To make SMOD =0
        SETB TR1         ;start T1
        RET
```

At the time of processing GPS receives $GPRMC values only. From these values microcontroller takes only latitude and longitude values excluding time, altitude, name of the satellite, authentication etc. E.g. LAT: 1728:2470 LOG: 7843.3089 GSM modem with a baud rate 9600.GSM is a global system for mobile communication in this project it acts as a SMS Receiver and SMS sender. EEPROM is used to store the mobile number. The power is supplied to components like GSM, GPS and Micro control circuitry using a 12V/3.2A battery .GSM requires 12v,GPS and microcontroller requires 5v .with the help of regulators we regulate the power between three components[3].

VII. Results

The suggested rail tracking system produced excellent results and rail can actually be tracked with minor modification and experimentation. On a commercial foresight the system, once installed, will be able to completely track rail effectively. System is designed and developed on Proteus VSM 7.2 platform and also tested in real time hardware platform. System showing excellent coordination of GPS, GSM modem, RTC and RFID. On top of all this there is no limit to the number of rails that may be tracked.

VIII. Conclusion

An attempt is made to integrate the two most widely used technologies namely GPS and GSM for developing navigator called G_2I system. It is found that, it is possible to integrate GPS with GSM modem for reliable rail position information and to ascertain the coverage area. In this paper, we have presented a low cost low power design of a fully automatic rail tracking system. The performance of the proposed implementations is evaluated using Proteus VSM 7.2 and required hardware. The suggested designs show enhancement in terms of speed and functionality. As rail has RFID tags, in future it is possible to achieve automatic man-less opening-closing of gate at railway crossing. Pc can be easily interfaced with mention daily logs. Also the related information can directly be displayed on moving message display at platforms.

Acknowledgment

The authors would like to sincerely thank Sant Gajanan Invention and Advance Research Centre (SGIARC), S. S. G. M. College of Engineering, Shegaon for their valuable support and help.

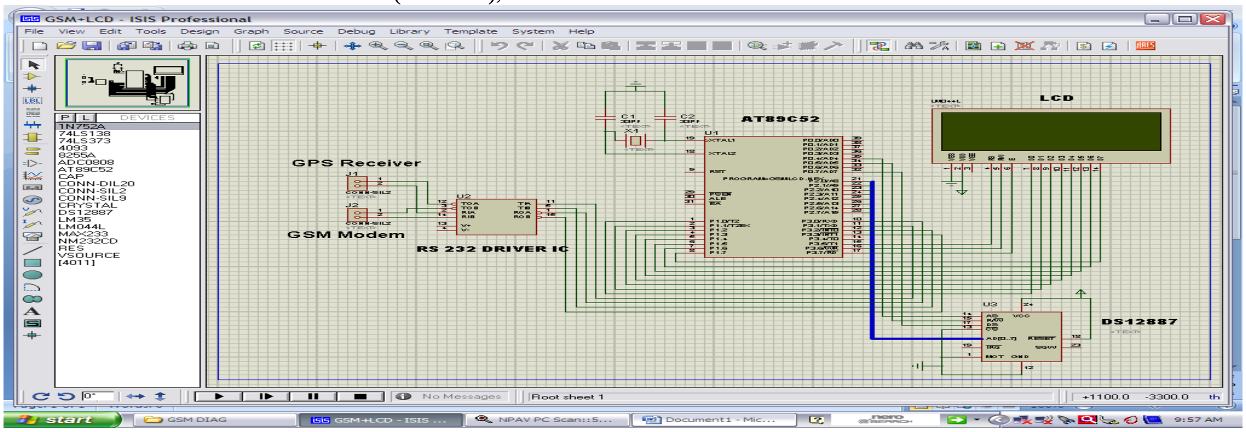

Figure-7. Typical connections between AT89S52 and Peripherals for proposed System.

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He completed the post graduate diploma in computer from BTE, Bombay in 1999. He is pursuing Ph.D degree in VLSI domain related to Telecommunication engineering. He was part of a team –winner of first ever national level design contest conducted by Cadence Design Systems (I) Pvt. Ltd., Bangalaore, INDIA that first prize and reorganization at national level at CDNLive! India 2006, part of Cadence's global series of technical conferences, organized on October 12, 2006 in Bangalore, INDIA. He is life member of ISTE and published many papers in national and international conferences. He is currently working as a lecturer in Electronics & Telecommunication Department of SSGM College of Engineering. Shegaon, INDIA. He is also working as a incharge of VLSI & Embedded Design Centre in a SGIARC (Research Centre), Shegaon, INDIA. His current research interest includes VLSI & Embedded systems, System programming using C, C++, VeriLog, Assembly languages.

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