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# DESIGN AND DEVELOPMENT OF ARM BASED EMBEDDED INTELLIGENT PUBLIC TRANSPORT VEHICLE POSITION SYSTEM

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**Abstract** - With ARM7 as the core, this paper discusses a kind of design of vehicle location system. The new mobile vehicle Positioning architecture and working theory of this system is integrated by a lot of hardware modules such as ARM microprocessor LPC2129 as a control unit to combinative with GPS LR9548 and GSM TC35 modules. By the hardware/software co-design, the new mobile vehicle Positioning system can be designed. It explores location solution, map matching and data compress associated with the positioning, shows a pro-gram flowchart and predicts the trend of the vehicle location system in the future and meets the traffic auditing department's needs about Mobile Vehicle Location. The set up consists of ARM7TDMI core, which is a 32-bit microprocessor, GSM & GPS serves as an important part as it is responsible for Positioning of the Vehicle. ARM7TDMI is an advanced version of microprocessors and forms the heart of the system. GSM operates through SMSs and is the link between ARM processor and centralized unit. This project is used to find the exact Location of the vehicle. GSM is used to inform the user about the exact Location of the vehicle. The information is given on user request in form of SMS. GSM modem can be controlled by standard set of AT (Attention) commands. These commands can be used to control majority of the functions of GSM modem.

**Keywords**- Mobile Vehicle Positioning, GPS Module TC35i, GPRS Module LR9548S, ARM embedded system.

## I. INTRODUCTION

With the ever increasing city holdings of cars, the huge number of cars raises problems of its own there are more and more car thefts, lost and violations of rules which are given serious attentions. There are more and more traffic jams, so requirements are that Transportation needs more improvement. The key technology Of Transportation is Vehicle positioning System, while the key of which is positioning System. Nowadays the most widely used positioning system is the Global Positioning System of America (GPS), which is a system consisting 24 satellites whose searching area embrace the globe. It can ensure that more than 4 satellites will be observed at one time, no matter what time it is or where you are, thus making sure that they can collect the longitude and latitude of the view point, and furthermore realizing the function of navigation, positioning, and time service. The design of this paper-Vehicle positioning System Based on ARM a combination of GPS and GSM can upload the information of the vehicle such as the position and speed to the Monitoring center in time, to make it convenient to control the traffic. Users can use the password to track vehicles, for security and anti-robbery, call Manual and check the vehicle position. The new intelligent mobile vehicle location system is designed to meet this need.

## II. HARDWARE DESIGN

### A. SYSTEM STRUCTURE AND PERIPHERAL EQUIPMENT

**Mobile vehicle positioning** system is composed of ARM7 microprocessor (LPC2129), peripheral equipment, **combinative with GPS** positioning module LR9548 and GSM wireless telecommunication module TC35. The circuit of ARM7 microprocessor and peripheral equipment includes an ARM7 chip, a clock circuit, are set circuit, a 32MB flash memory, a LCD. All of these make up the control and process core of the system. The block diagram of the terminal board is shown in Figure (A).

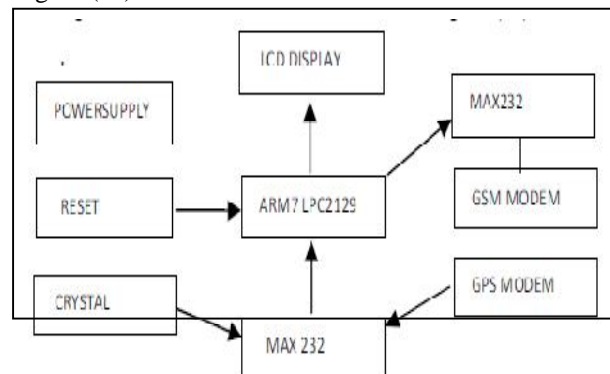


Figure (A) Structure of the system

## A. HARDWARE

The hardware structure of the system is dominated by ARM controller LPC2129, GPS module, GSM module, antenna, GPIO interface and power management unit and other components. The hardware structure is shown in Figure B.

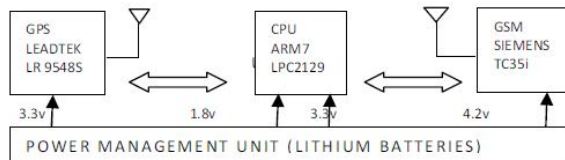


Figure (B) Hardware structure

## B. ARM CONTROLLER.

In Vehicle terminal, as a central processing unit of the system, ARM embedded system has a critical influence on overall performance. So introduced by Philips, the 16/32-bit ARM7 TDMI-S core LPC2129 microcontroller with real-time simulation and tracking support is used. It has 16K bytes of static RAM and 128k bytes of embedded high speed Flash memory. In the 64-pin package, 46 GPIO can be used. The Conversion Time of 4 10-bit A / D converter can be as few as 2.44us. It has Real-time clock and watchdog. A maximum operating frequency of 60MHz of the CPU can be achieved through the on-chip PL and the rich on-chip resources can meet the needs of general industrial control. LPC2129 not only works stably and faster, but also has dual serial, so is accessible to the plan.

## III. GLOBAL POSITIONING SYSTEM (GPS)

GPS Wireless communication module. This design adapts the current leading GPS technology and the integrated positioning chip LEADTEK LR9548S. Specifically Designed for OEM Applications, it is a GPS receiver module with high sensitivity, low power consumption, and 20 channels. Compared with other independent GPS solutions GPS9548 is able to help Users gain and continuously track GPS signals at a very low signal intensity, which means GPS9548 can be used in the environment where it has never been thought to be accessible, such as Buildings of the city building, dense forest, garage, and many indoor environment, with a positioning accuracy of less than 10 meters. With only an addition of relevant circuit at the periphery, positioning information including time, longitude, latitude, rate, moving direction, etc., can be output through the serial.

The GPS module can receive the data by connected to ARM7development-boardURAT0through RS232port. WhentheARM7chip sends the instruction AT to GPS module. The GPS module starts receiving the data and saves it into

memory. This instruction sends the region information with the vehicle license information to the support-server center through GSM net. Because the system is based on GPS data which is sent through GPRS net, it must be initialed at first. The initial instructions are following:

Reset

User settings initialized

Press +++++ to enter the setup mode...Done

Init command List: AT+ID= X CR AT+IP= X CR AT+PORT= X CR AT+HTH= X CR AT+BAUD= X CR AT+APN= X CR AT+AGREE= X CR AT+REST=X CR

AT+ID=X: this instruction is used to set the terminal address. Each device must be set the address which indicates its ID, the default ID is139XXXXXXXX. The default address is the SIM card mobile phone number which contains 11 numbers, the address can be changed as required. AT+ID=? This instruction is used to inquire the ID of the terminal. The instruction can be used to check whether the set of the device is correct.

AT+IP=X this instruction is used to set the IP address of these in surveillance center. The format of IP is X.X.X.X.AT+IP=? This instruction is used to inquire the IP address.

AT+PORT=X this instruction is used to set the port number of the application software in surveillance center server. AT+PORT=? This instruction is used to inquire the port number.

AT+HTH=X AT+HTH=? This instruction is used to set and inquire the time intervals of the GPS positioning information which the terminals send automatically. The unit of the time interval is second.

AT+BAUD=X AT+BAUD=? This instruction is used to set and inquire the initial baud rate. The default is 4800 and does not need changing usually.

AT+APN=X AT+APN=? This instruction is used to set and inquire the connect port of GPRS telecommunication. The default value is CMNET.

AT+AGREE=X AT+AGREE=? This instruction is used to set and inquire the net communication protocol. The default value is TCP protocol. The terminal on car supports the UDP and the TCP protocol. Users can change the protocol as needs.

## IV. ARM7TDMI MICROPROCESSOR

ARM7TDMI processor in our model due to its advanced features described below. 32-bit ARM processor is the contemporary general purpose microprocessor in the embedded market used in industrial level applications. ARM7 consists of a

number of peripherals interfaced to it. We use keypad matrix, LCD display, UARTS, GPIO and I<sup>2</sup>C protocol. ARM7 processor is a link between GPS and GSM modules for communication. The description of ARM7 is discussed in further sections.

**FEATURES:**

- 16/32-bit ARM7TDMI-S microcontroller is a 64 or 144 pin package.
- 16 KB on-chip Static RAM.
- 128/256 KB on-chip Flash Program Memory. 128-bit wide interface/accelerator enables high speed 60 MHz operation.
- In-System Programming (ISP) and In-Application Programming via on-chip boot-loader software. Flash programming takes 1ms per 512 byte line. Single sector or full chip erase takes 400 ms.
- B Two 32-bit timers (with 4 capture and 4 compare channels), PWM unit (6 outputs), Real Time Clock and Watchdog.
- Multiple serial interfaces including two UARTs (16C550), Fast I2C (400 Kbits/s) and two SPIs 60 MHz maximum CPU clock available from programmable on-chip Phase-Locked Loop.
- On-chip crystal oscillator with an operating range of 1 MHz to 30 MHz
- Two low power modes Idle and Power-down.
- Processor wake-up from Power-down mode via external interrupt

**V. GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM)**

GSM is the most widely used mobile technology using a simple Subscriber Identity Module (SIM) it has taken the world of mobile communication to new heights. It is based on a simple architecture. Even with the introduction of new technologies like CDMA, GSM has stood its strength due to its efficiency and simplicity. A GSM modem is a wireless modem that works with a GSM wireless network. Computers use AT commands to control modems. Both GSM modems and dial-up modems support a common set of standard AT commands. So we can use a GSM modem just 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. GSM is one of the most vital components in our set up since all the communication between the users and Centralized unit takes place through this modem. GSM Communicates with ARM through I<sup>2</sup>C bus.

GSM module TC35. Siemens TC35i wireless communication module is used. Having gained the domestic network card of Radio equipment, it operates in dual-band GSM900 and GSM1800, with power consumption of 2W and 1W respectively. The DC power supply ranges from 3.3v to 4.8V. The Current consumption is as below 3.5mA at sleep state, 25mA at leisure state 300m (Average) at launching state, and the maximum is 2.5A. Combining RF and baseband, this module provides users with a standard AT command interface and a fast, secure and reliable transmission of data, voice, SMS and fax. The Data input / output interface of TC35 is in effect a Serial Asynchronous Receiver Transmitter. It has fixed parameters and is in line with ITU-T RS232 interface standard 8 data bits and 1 stop bit, no parity. The baud rate is selectable between 300bps and 115kbps. The Command Interface of TC35 module Fully complies with specifications of GSM07.05 and GSM07.07. It sends standard AT commands through the serial port of a microprocessor LPC2129 to TC35i module serial port, to fulfill the Locator's function of sending and receiving text messages, therefore realizing the communication with mobile phone users outside.

A GSM modem can be an external device or a PC Card. Typically, an external GSM modem is connected to a computer through a serial cable or a USB cable. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate. The description of GSM is given below.

*AT Commands according to GSM 07.05*

The GSM 07.05 commands are for performing SMS and CBS related operations. SIM300 II supports both Text and PDU Modules

*Overview of AT Commands according to GSM 07.05*

AT+CMGD-DELETE MESSAGE

AT+CMGF-SELECT SMS MESSAGE FORMAT

AT+CMGL- LIST SMS MESSAGES FROM PREFERRED STORE

AT+CMGR-READ SMS MESSAGE

AT+CMGS-SEND SMS MESSAGE

AT+CMGW-WRITE SMS MESSAGE TO MEMORY

AT+CMSS- SEND SMS MESSAGE FROM STORAGE

AT+CMGC- SEND SMS COMMAND

## VI. SOFTWARE DESIGN

When using GPS to position, each satellite will send to the receiving terminal three key messages: Satellite number,

Satellite position and time. The receiving terminal store and use the received information, which is also used to fix the time on the GPS receiver. By comparing the difference of the time when each satellite signal is received and the time when the satellite is sent, The GPS receiver calculate the distance from each satellite to the receiver. When the receiver can contact enough satellites, it can use trigonometric formulas to calculate the location of the receiver. Three satellites can be able to operate 2D positioning (longitude and latitude), while four or more can be able to operate 3D positioning (longitude, latitude, and height). The key indicator of positioning is the accuracy. The horizontal position accuracy of most Civilian GPS receivers is about 5 to 10m. Using differential technique, cm-level even mm-level positioning accuracy can be achieved.

### TECHNICAL ALGORITHM

The current main error sources of positioning system include positioning error of the satellite itself, the refraction and diffraction error during transmission, and error of its hardware such as difference between the clocks receiving terminal. Given that positioning technologies have been identified, Location algorithm in position technology is the key to achieve the elimination of error and the realization of good positioning. The main three aspects are position resolution, map matching, and data compression / fusion, which is also the focus and hot spot of the current location technology at the same time.

(1) *POSITION RESOLUTION*. The first step of the vehicle location service is to solve the positioning coordinates of the vehicle. An excellent resolution of positioning coordinates can overcome a variety of errors like the multipath effect, the poor clock bell, etc. Currently the most widely used way of eliminating errors is the differential technique, the application of which provides a high precision of positioning. The differential technique is in effect the evaluation among observations of a station on two targets, observations of two stations on a target, or two times of observations of a station on one target. The aim is to remove the public entry, including public error and public parameters. The use of high precision carrier phase receiver can effectively improve the positioning accuracy.

(2) *MAP MATCHING*. The data source of Vehicle positioning System is mainly formed of Static data (electronic maps) and dynamic data (location data). The role of map matching in the vehicle positioning system is shown in figure C.

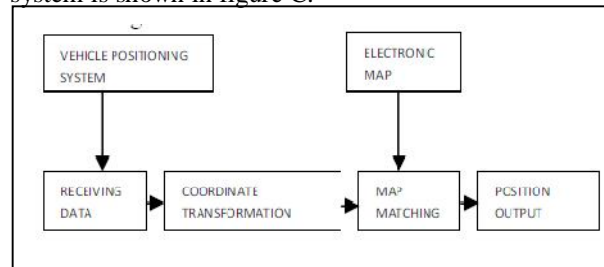


Figure (C) Map Matching

In practical application, the current civil positioning technique is far from the accuracy of the level of road width, so it is necessary to match with the electronic map to achieve good positioning and location service. The basic idea of map matching is that by matching the positioning coordinates of the vehicle trajectory with the factorized section of the object on the map, the road that vehicles currently exercise can be found, and the vehicle tab will be projected onto the road. That can be classified into two relatively independent processes: One is to find the road that vehicles currently exercise; the other is to project the vehicle tab onto the road. The map matching done at this stage is not perfect. The Vehicle Positioning System in practical application shows the phenomenon of serious zero drift or vehicle "driving" on both sides of the road on map. Therefore the improvement of Map Matching Algorithm is also the current research focus in vehicle positioning technology.

Data compression / fusion. First and foremost, a vehicle positioning system is an embedded system, which has some requirements of the size and real-time of the data processing. So it is necessary to compress the received data of the positioning system. It is also necessary to make the positioning data and digital map data into fusion.

### Program flow

Before running the main program, LPC2129 controller must initialize the runtime environment, which is, writing start code for ARM chips, including the exception vector table, stack initialization, the storage system initialization and target board initialization, usually written in assembly language. If you use the GPRS services developed on the basis of GSM while using the SMS service for delivery of positioning information, the program flow chart is shown in Figure D.



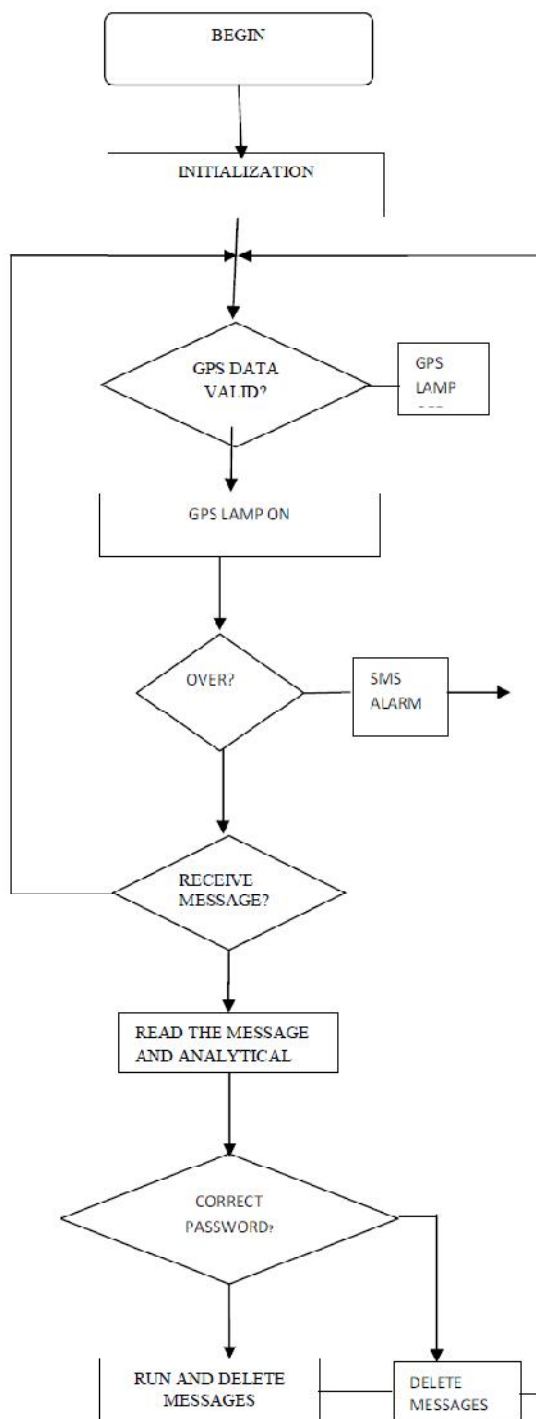


Figure (D) Program Flowchart

The key of software design is to write function Functions. Functions are realized by calling the corresponding function, which includes four parts: GPS data analysis and extraction, encoding and decoding PDU messages, sending and receiving text messages, and parsing and executing the command. After the first boot of the device, the locator is firstly initialized, including selecting pin function of the

controller LPC2129, setting the serial port work, initializing interrupt vectors and TC35i, and setting the working mode. Then the program enters the five links of loop command: 1) test valid GPS data. Wait until the GPS

Receiver module LR9548S has received valid data, at the same time the GPS light is lit. If the data is invalid, the GPS status indicator will always be off. 2) Verify overrun. If the vehicle is overrunning, the gauge instantly sends a SMS to predefined mobile phone users. 3) Check if you receive a new message. If you do not receive a new message, then return to 1). If you receive a new message, you have to read the new message where it is stored and decode the contents of the received SMS. 4) Verify the password. If the password is incorrect or non-command text, then delete the message and return to the article 1). If the password is the correct command, then start parsing the messages, and execute the corresponding subroutine command. 5) After the treatment, remove the message in order to avoid the situation that the full storage space cannot accept new messages.

## VII. FUTURE SCOPE & CONCLUSION

The future scope of this project is enhanced applications with the addition of the required features. One such application is to detect the longitude and latitude values. By using these values it can also be designed to detect the particular position of the vehicle by using Google earth software. In the same manner one can exactly predict the position in case of theft of the vehicle. The project is thus carried out using ARM7TDMI core with the help of GPS and GSM as wireless data communication platform .The vehicle position system has the advantages of small size, stable and reliable, with small delay, full- featured and powerful expansibility. The systems with little delay can effectively overcome the past disadvantages of poor real-time and high operating costs. Vehicle positioning systems is poised to achieve complexion of positioning technology, integration of positioning systems, and network of location-based services in the form of current client or server. The system is believed to have broad application prospects like fleet management, base services etc.

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