PC - BASED GPS TRACKING WITH IMMOBILIZATION CAPABILITY THROUGH SMS

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A Design Report Submitted to the School of Electrical Engineering, Electronics Engineering, and Computer Engineering in fulfilment of the Requirements for the Degree

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APPROVAL SHEET

Mapua Institute of Technology
School of EECE

This is to certify that we have supervised the preparation of and read the design report prepared by **Aldous C. Eugenio, Kelvin Kristian M. Manalo, Jessiedaniel B. Maribojoc, Albert Joseph A. Pasion, and John Paolo V. Ranara** entitled **PC – Based GPS tracking with Immobilization Capability through SMS** and that the said report has been submitted for final examination by the Oral Examination Committee.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

GPS tracking in a vehicle with immobilization capability through SMS is a server based device attached to the vehicle ignition wire. The device can support tracking and immobilization to the vehicle when a SMS code is received by the server. For tracking, the server sends a command to the device to request for the GPS coordinates and sends it back to the server via SMS. The SMS is parsed to get the X and Y coordinates and compared it to the database. After comparison, the server sends the exact location of the vehicle to the one requesting. In case the location is outside NCR, the server will send a message to the on requesting that the vehicle is out of coverage. For immobilization, the program uses a SMS code to turn on and off the relay board which is connected to the ignition wire. The request code changes the value of the EEPROM to save its last state to avoid reset on the relay board. When the system boots up, the first thing that the PIC will do is to check for the value of EEPROM. For engine on request, the relay is turned on and the value of the EEPROM is 1 and for engine off, request the value of the EEPROM changes to 0. Rebooting the system will not affect the current state of the relay board not unless a SMS code for engine off or engine on is sent.

KEYWORDS: (Short Message Service, Global Positioning System, EEPROM, Server, NCR)

Chapter 1

DESIGN BACKGROUND AND INTRODUCTION

This chapter contains the background of the design project, its basic components, the history of the topic and its different features.

Background

Nowadays, technology is now offering the widest and powerful tools to track or to locate a person, vehicle, roads and even the directions when navigating the sea with the use of Global Positioning System (GPS) but this doesn’t come with cheaper price. With the use of the free service of the 26 GPS satellites made by the US Air Force, a device with GPS capability can track anyone, anywhere with the use of the technology. Gadgets like cell phones, PDA’s and computers are now capable of acquiring access to the 26 satellites of the US Air Force but acquiring those gadgets would cost a lot. Tracking the vehicle is not just the concern of the owner but also its security. The proponents design a device that can track a vehicle with a device attached to it in which tracking is done by sending a SMS message to the device and verifies the code by the microcontroller to validate and perform its requested operation. The device can also control the vehicles engine to turn off or on.

The design is intended to be used as a tracking system to vehicle carrying the device. It is designed to track the vehicle with the use of a cell phone and a PC and to secure the vehicle if it is tracked by sending a message to disable the engine. The car can be turned on again when a requested engine on is received by the device. The design is mainly composed of a GPS module, GSM module, PC, relay and microcontroller. GPS module is used as a receiver to access the GPS satellite and transmit the information gathered. Microcontroller is used to verify the sent message received by the GSM module and parse it to check the kind of operation to be done.

The feature of this design is tracking of vehicles from a cell phone to computer by sending a SMS message to the computer and then to car and when it is received and verified by the tracker unit, the GSM module will send the location of the vehicle by its longitudinal and latitudinal position by SMS to the computer. The computer will compare the coordinates received and display the exact location of the vehicle through a map. The computer now sends a message to the sender's cell phone on the exact location of the car. When engine off is requested, the relay will automatically open to cut the electricity supply to the car. Engine on request will automatically close the relay.

Statement of the Problem

Vehicle tracking using modern devices available in the market doesn't include immobilization on the vehicle. It is only capable to track the exact location of the vehicle by sending its exact location on the GPS receiver and through the owner.

In this scenario, the proponents introduced a way to track the vehicle on its current location using a SMS triggered GPS tracking device that can track and immobilize the vehicle where ever the owner's location is by sending a SMS message to the device attached to the car. Immobilizing the car is by cutting off engine power with a SMS code decoded by the microcontroller to instruct the relay connected to the ignition wire to open.

Objectives of this Design

The general objective of the design is to design a tracking and security system to be implemented on a vehicle with the use of a computer and GSM module that supports GPS for locating the target through SMS message and implementing security by cutting the power source of the car using relay.

The following are the specific objectives of the design:

a.) To interface the device using ignition wire.

b.) To immobilize the vehicle by automatically disabling the car's engine through SMS.

c.) To locate the vehicle travelling within NCR region remotely using a cellular phone.

d.) To create a database for tracking using mySQL containing locations in NCR region.

Significance and Impact of the Design

Most of the existing vehicle tracking devices in the market does not support immobilization. This design is intended to improve the existing vehicle tracking system to perform vehicle immobility. The applied technology in the design is based on the current and existing technology and still evolving depending on its application. Car owners can use the design that travels within the vicinity of National Capital Region (NCR). Car owners can not only track their cars but they can also immobilize them. The design can give ideas to other designers to improve and use the GPS tracking and immobility to its maximum potential.

The impact of this design will open the local community in developing more reliable tracking and security system for their vehicles. The design can lighten up the work of the authorities that are searching for stolen vehicles equipped with the tracking device. Globally, the design will contribute to maximize the use of GPS and enhance existing design to perform more accurately.

Scope and Delimitation

The design can only perform those that are listed below and the components that are presented in the design. Scopes of the design are as follows:

a.) The design uses a GPS module in the device.

b.) A GSM module is used for both the device and to the computer terminal.

c.) A SIM card is used for both of the GSM modules.

d.) Request codes through SMS messages that are recognized by the microcontrollers are pre defined by the programmers in who it will validate and decide on what operation to be done.

e.) A SMS starting with <GPSREQ> format is used for vehicle tracking.

f.) A SMS starting with <ONENG> format is used to turn on the relay board.

g.) A SMS starting with <OFFENG> format is used to turn off the relay board.

h.) A Visual Basic.NET program installed in the computer is used to compare the received coordinates, get its exact locations and send message to the one requesting via SMS.

i.) Coordinates (longitudinal and latitudinal) are the output signal coming from the GPS module that will be sent by the GSM module to the computer.

j.) The input to be fed to the device in the vehicle is a SMS message following a code depending on the request to be done.

k.) NCR map is attached in the software for viewing the vehicle's location.

l.) The engine cannot be started when the relay is open (not energized).

The design's delimitations are the things or conditions that it cannot perform or function. Delimitations of the design are as follows:

a.) The computer cannot display the exact location of the vehicle outside the NCR map.

b.) The target vehicle to be tracked when positioned in dead spot of the GPS satellites is impossible to locate. (Example of dead spots are tunnels, basement parking, and underwater)

c.) The displayed map in the computer for tracking will not be in real-time.

d.) GSM module can only accommodate 160 characters, it will only receive the message if the number goes beyond, but it cannot decode the data sent.

e.) One out of two SMS sent simultaneously will be processed.

Definition of Terms

1.) Differential GPS (DGPS) – is a technique for reducing the error in GPS-derived positions by using additional data from a reference GPS.

Source: "Marine Differential GPS". Satellite Navigation. Trinity House.

2.) DTMF – Dual Tone Multi Frequency, signalling is used for telecommunication signalling over analog telephone lines in the voice-frequency band between telephone handsets and other communications devices and the switching center.

Source: IEEE Transactions on Consumer Electronics, Vol. 50, No.4 November 2004

3.) GNSS – Global Navigation Satellite Systems, is the standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage

Source: "A Beginner's Guide to GNSS in Europe" by IFATCA.

4.) GPS – Global Positioning System (GPS) is part of a satellite-based navigation system developed by the United States Department of Defense under its NAVSTAR satellite program.

Source: GPS Overview from the NAVSTAR Joint Program Office. Retrieved December 15, 2006

5.) GPS orbit – fully operational GPS includes 24 or more (28 in March 2006) active satellites approximately uniformly dispersed around circular orbits with four or more satellites each.

Source: GPS Overview from the NAVSTAR Joint Program Office. Retrieved December 15, 2006

6.) GPS signals – each GPS satellite carries a cesium and/or rubidium atomic clock to provide timing information for the signal transmitted by the satellites.

Source: GPS Overview from the NAVSTAR Joint Program Office. Retrieved December 15, 2006

7.) ITS – Intelligent Transport System, are those utilizing synergistic technologies and systems engineering concepts used to develop and improve transportation systems of all kinds.

Sources: Monahan, Torin. 2007. "War Rooms" of the Street: Surveillance Practices in Transportation Control Centers

8.) Radio Navigation – relies on radio frequency sources with known locations.

Sources: Global Positioning Systems, Inertial Navigation, and Integration

Mohinder S. Grewal, Lawrence R. Weill, and Argus P. Andrews

9.) Microcontroller - is a small computer on a single integrated circuit consisting of a relatively simple CPU combined with support functions such as a crystal oscillator, timers, watchdog, serial and analog I/O etc.

Source : Jack Ganssle and Mike Barr ,"Embedded Systems Dictionary".

10.) SMS – Short Message Service, is a communication service standardized in the GSM mobile communication system, using standardized communications protocols and allowing the interchange of short text messages between mobile telephone devices

Source: IEEE Transactions on Consumer Electronics, Vol. 50, No.4 November 2004

11.) Transceiver – is a device that can transmit and receive analog or digital signals.

Source: A. J. Kloneck, "Simultaneous sending and receiving system ”

12.) Ignition key - is the key used in a motor vehicle to turn the switch that connects the battery to the ignition system and other electrical devices.

Source: Michael Bowler, “The Great Book of Automobiles”.

13.) Relay - is a simple electromechanical switch made up of an electromagnet and a set of contacts.

Source: I. Sinclair, J. Dunton, ”Practical Electronics Handbook 6th Edition”

14.) UART – also known as Universal Asynchronous Receiver Transmitter, is a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232. Source: Dario J. Toncich, "Data Communication and Networking application for Manufacturing Industries".

15.) Serial Port - is a serial communication physical interface through which information transfers in or out one bit at a time.

Source: I. Sinclair, J. Dunton, "Practical Electronics Handbook 6th Edition"

Chapter 2

REVIEW OF RELATED LITERATURE AND RELATED STUDIES

The main concept of this design was established with the help of some existing designs, studies, and principles while conducting this design. This organized and synthesized collection of citations of related studies and principles helps in achieving the design objectives.

Part of this idea came from the three companies in Singapore, namely Comfort Transportation Pte Ltd., with its subsidiary Yellow-Top Cab, Trans-Island Bus Services, and CityCab Pte Ltd. that implemented their taxi dispatching using satellite-based Dispatch System. This technology implemented introduced the Automatic Vehicle Location and Dispatch Systems or AVLDS. This new satellite-based AVLDS comprises different features, like the interactive voice responses (IVR), and computerized dispatch system (CDS) which are not included in the proponents' design, since the objective is to track and disable the vehicle's engine when it is carnapped from the owner. Another is the differential global positioning system (DGPS) which is a wireless data communications (WDC). According to the article written by Ziqi Liao, an author of a book published in IEEE Transactions on Engineering Management, "GPS dispatch systems will play an increasingly important role in the further improvement of their operations and services. The findings of this study should have practical implications to the development of sophisticated public transport system. Future studies can be conducted to explore the implementation of on-board vehicle navigation systems in different environments."

Another idea came from the design of A. Alheraish, named, Design and Implementation of Home automation System. The design used GSM cellular communication network and integrated it to a microcontroller and a GSM module for wide range of applications. The microcontroller acted like a brain in of the system. It is used to communicate with the modules when there is a need to access in sending or receiving data. GSM module acted as an interface between the microcontroller and the GSM network

Nowadays, the mode of transmitting data by cellular networks is the GSM or the Global system for mobile communication. One option in the GSM network for transmitting data is the SMS or the Short Message Service. The designers chose the SMS as a mode of transmitting the data. The designer also used a microcontroller that acted as an interface between the GSM module and the Personal Computer and GPS module and the automobile. The controller takes the data from the GPS module and translates it to AT commands or the Attention commands so the module can understand it. GSM module takes the AT commands from the microcontroller. Figure below shows a GSM module circuit. The module is composed of a SIM card holder, which holds the SIM to be used in the module, GSM transmitter/receiver which transmits and receives the SMS message and a GSM module that is connected to a microcontroller. GSM module can be easily connected to any ports of a microcontroller and doesn't need any interface circuit for it to function normally.

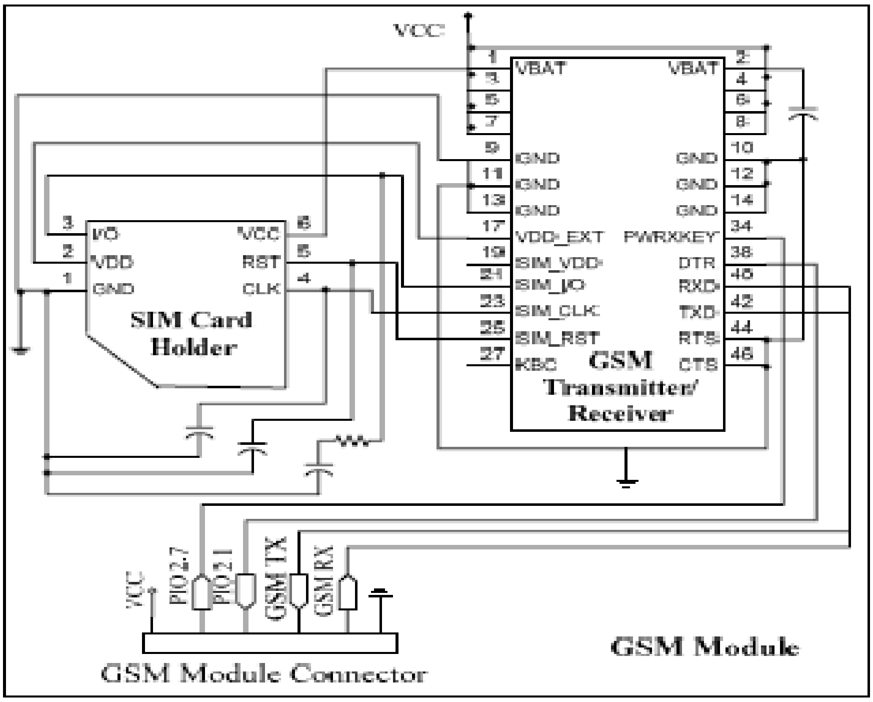


Figure 2.1 GSM Module Circuit

SMS Security System is a design made by some Mapuans where a controller is used to control a cellular phone attached to a receiver box so that it can send a message to the cellular phone carried by the owner when the connected alarm security device is triggered. AT commands are used to control the built-in modem in a cellular phone. AT is the abbreviation of attention. AT commands are instructions used to control a modem. Every command line starts with "AT", a good reason why modem commands are called AT commands.

Some of the AT commands used are: ATD (to dial), ATA (answer), AT+CMGS (send message), AT+CMSS (send message from storage) and AT+CMGR (read SMS messages). There are very large numbers of AT commands but the designers chose to use a few commands and these are: AT+CMGR for checking and reading the message and AT+CMGD to delete the message. With these commands, the designers will know the location of the vehicle being tracked. As for this design project, it aims to interface a GSM module in the car system. The GSM module will send a SMS message that contains information about the present location of the car. Table 2.2 below shows a typical AT commands that are supported by some of the known GSM modem manufacturers.

AT COMMAND	DESCRIPTION	SYNTAX
AT	Most common AT commands is used to check if the GSM modem is communicating with the PC.	AT<CR>
AT+CMGS	AT command is used to send a message.	AT+CMGS = "Receivers number" <CR> Message <Ctrl-Z>
AT+CMGL	AT command is used to read messages.	AT+CMGL="ALL"<CR> Note: Shows all messages.
	AT command is used to	AT+CMGD="ALL"<CR>

AT+CMGD	delete messages.	Note: Delete all messages.
AT+CGMI	AT command is used to know the modems manufacturer.	AT+CGMI<CR>
AT+CGMM	AT command is used to know the modems model.	AT+CGMM<CR>

Table 2.1 AT Commands

Table 2.1 only shows some of the AT commands that are available on most of the modems available in the market. AT commands of GSM modems vary depending on the manufacturer but there are still AT commands that are common to every manufacturer.

Another prototype named SMS Commander Car Alarm System, made by Kroby, was a good example to base our design project. It used a PIC32 microcontroller installed in the car system. It has a control on/off function via SMS, where one can query the alarm system's on/off status anytime. The position of the car can be known by simply texting the car using a coded message, and then the coordinates of its present location will be sent to the owner's cellular phone. The car movement can be followed on-line using GPRS and a compatible software. The group's design can be based on how the SMS Commander enables text messages to be read and analyzed by the car. Other commands such as stop or lock can be easily done by the car if they will be able to make the car understand SMS messages.

The system in the article entitled, Real Time Tracking Management System using GPS, GPRS and Google earth is composed of a GPS module, Goo-Tracking firmware, Goo-Tracking server. The GPS module that the designers used in their system is based on 8-bit AVR RISC microcontroller which is low power MCU with 32k ROM and 2k RAM and has several peripherals such as UART, SPI, I2C to connect GPS/GPRS module, MMC module and GPIO control module.

The GPS module has two functions, the GPS locates the device position and the GPRS transmits the device location to the server. The I2C interface is connected to GPIO Control module which an I/O interface to control external device such as car alarm or Electronic Control Unit (ECU) for vehicle immobilization.

The Goo-Tracking firmware is the firmware that performs three phases, the initialization, the GPS position reading, and the GPS data formatted and transmitted to Goo-Tracking server via GPRS networks. The initialization phase prepares the module for reading and transmitting location information. It is composed of three functions. The first function is to initialize parameters on AVR microprocessor for UART, SPI, GPIO and timer for GPS reading. The second function is to initialize GPRS/GPS module to set up parameters to warm up GPS engine, to make a connection to a GPRS network and to connect to the server via TCP/IP socket. The third function is to initialize MMC module into SPI mode for data read/write. In the GPS position reading phase, the MCU sends a series of AT commands to GPRS/GPS module via the UART port. To acquire the current location of the device, they issue the AT+WGPSPOS command to get the data in NMEA standard format. This is an example of a circuit interface of microcontroller to the GPS module.

Figure 2.2 RS-232 Driver Circuit

In Figure 2.2, the circuit includes a serial port female to be connected to any serial port device and to interface it to the UART of microcontroller, you need to put a MAX232 IC which is a Multichannel Driver/Buffer. In this way, interfacing PIC or any MCU to the serial port is possible.

In the GPS data formatted and transmitted phase, the NMEA-formatted data is then parsed and convert to designed format. The format includes the device ID, session ID, time in UTC format, flags, latitude, longitude, speed, date, and reserved (Rsv) fields. Each line ended with the symbol (^) represents one sample of data from a GPS Tracking module in one session or fleet. Samples are bundled together, ended with the character \n, and transmitted to the Goo-server.

Once the GPS Tracking Module is connected to GPRS networks, it transmits position information to Goo-Tracking Server which is a commodity personal computer running a Linux operating system with an open source software such as Apache web server, PHP, and MySQL program. The server has three functions to receive the information, to store information in a database, and to display the information. The receiving function opens a non-blocking socket to receive data from multiple GPS Tracking Modules simultaneously. The storing function; formats the receiving data into our database that is designed to provide real-time query response for real time tracks and to provide search query response for the post analysis of vehicle tracks.

Chapter 3

DESIGN PROCEDURES

This chapter contains the design procedures in making the system, block diagram, and schematic design. It shows how the system works and how each parts of the system is connected to the other parts.

Block Diagram:

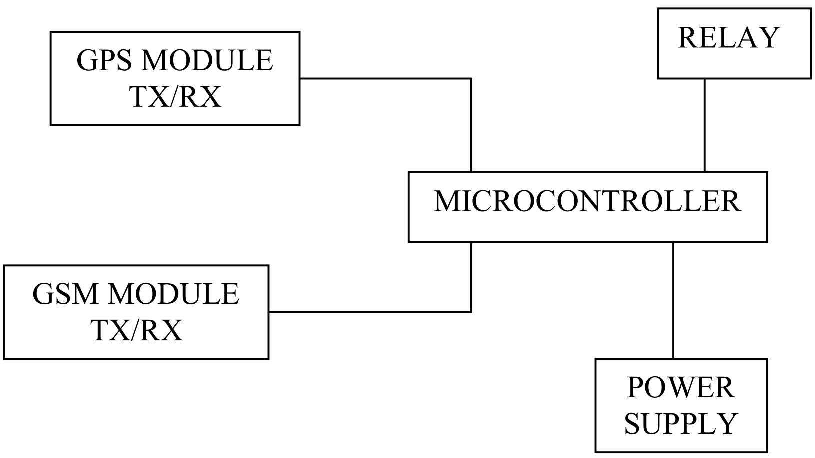


Figure 3.1 GPS/GSM Tracker Unit

Figure 3.1 shows the hardware block diagram of the system. The hardware part is mainly the parts that are interconnected to each other by interfacing the PIC to GPS module using Level Converter. Major hardware components are the PIC microcontroller, GPS module, GSM module, relay and a personal computer. GPS module is connected to the microcontroller via MAX232 while GSM module is directly connected to PIC. These are the parts attached to the vehicle. Each of this part is designed to perform specific task especially for the microcontroller to get the GPS coordinates received by the GPS module. The software includes are the programs stored in the microcontroller and the software in the computer. The codes in the microcontroller are lines of codes that perform parsing of the received SMS message and commanding the GSM module to send GPS coordinates. Codes for PIC are written in Basic using Proton. AT commands are for codes used in the GSM module while NMEA command format are used for the GPS control. Power supply is the source of the power for the hardware components. This can be coming from the car's battery or from the cigarette lighter of the car.

Computer Server:

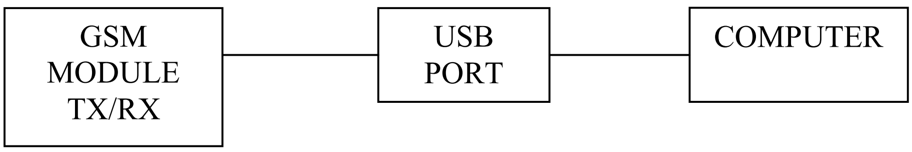


Figure 3.2 PC Server

The computer server which is shown in Figure 3.2 allows the GPS tracker unit to communicate to each other. The server sends commands to the tracker unit attached to the vehicle but it can only receive reply from the GPS tracker unit if the code sent by the server is correct. In the computer server part, the software used is written in Visual Basic.NET that can compare the received coordinates sent by the device to locate the vehicle's exact location. The software provides a graphical view of a map of the National Capital Region (NCR). After locating the exact location, the computer now sends the request from the sender of the commands by sending the exact location of the vehicle. Immobilization of the car is also through the PC server to the GPS tracker unit.

Data Gathering

The proponents gathered data on how to interface the microcontroller to GPS and GSM modules. Knowing how to interface both of these modules can eliminate the possibility of having a larger circuitry. Using the data acquired from IEEE journals, the proponents learned that GPS is interfaced to the microcontroller by means of a level converter (MAX232). The idea of interfacing the modules to the microcontroller using a multichannel RS-232 driver/buffer to adjust the voltage level of UART pins of the microcontroller came from the IEEE Journal entitled "Real time Tracking Management System using GPS, GPRS and Google Earth". Microcontroller UART's doesn't recognize 2.8V as a logic high compared to other TTL pins of the microcontroller. It is because the UART pins of the microcontroller use Schmitt trigger. The proponents also gathered data in programming and configuring the GSM modules and the GPS module. The GPS module can be configured directly to the computer by a software that supports NMEA data protocol. Acquisition of location can be directly acquired only if there are a minimum of 3 open satellites for the module to use. Less than 3 satellites open for the module will result with no output. The outputs of the GPS modules are the longitudinal and latitudinal coordinates of the module which cannot be directly used to software to show its location. The proponents need to convert the raw data gathered to exactly locate the target using a map that contains the location together with a direction.

Design Procedure

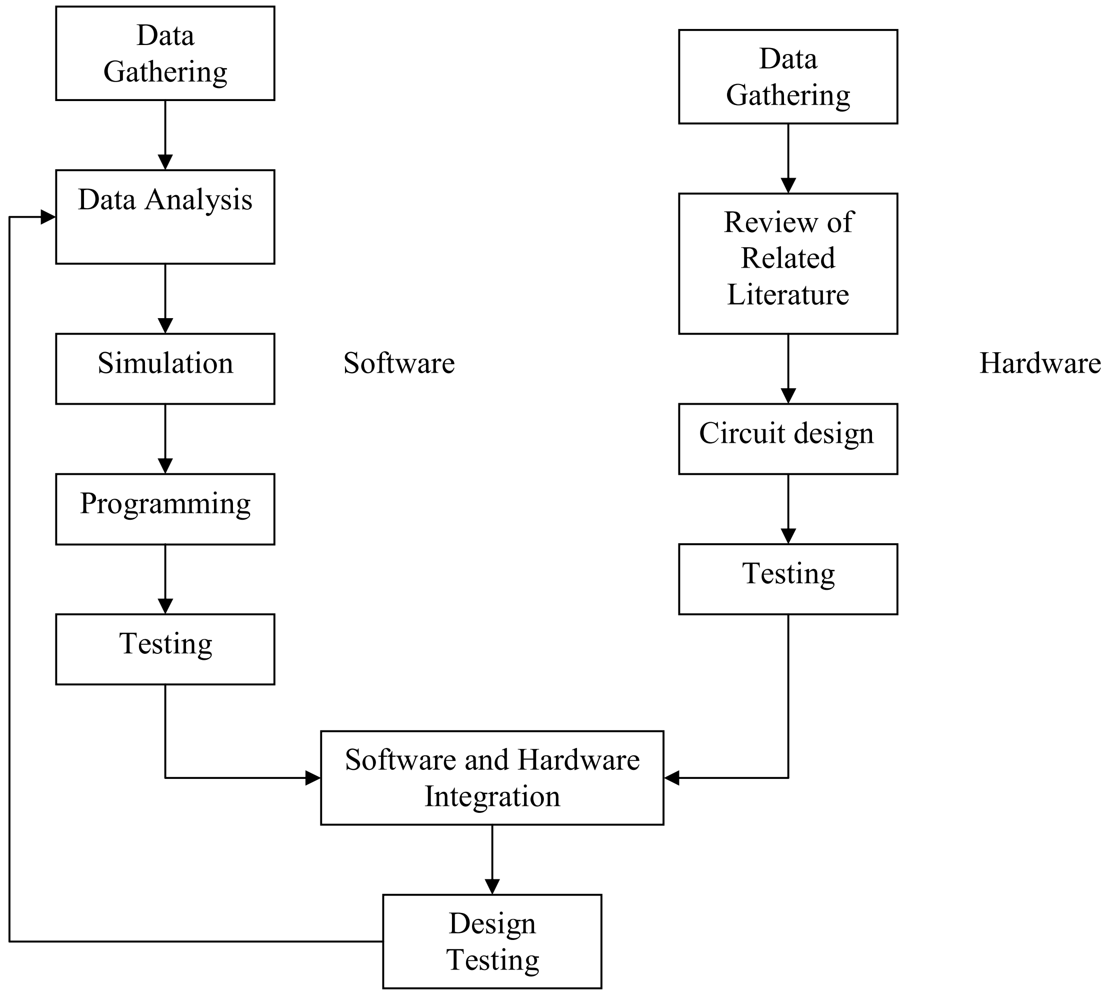


Figure 3.3 Design Procedure Flow Chart

Figure 3.3 shows the graphical view of the design procedure used by the proponents. In order to systematically create the proposed topic, the proponents designed a procedure to follow. The procedure is divided into two parts, the hardware, and the software.

A. Software

a. Data Gathering

The software part starts from the gathering of required data including the hardware specifications of the modules to be used for programming purpose. In this way, the proponents can decide on what programming language is best to use in developing the software part.

b. Data Analysis

Data analysis is done to evaluate and verify the hardware specifications to identify and finalize the programming language to use. This is also done when testing the finished prototype. Gathered data are analyzed and verified if the output of the system is correct.

c. Simulation

Simulation of algorithms or routines in the software is done especially in the microcontroller programming which uses routines like decoding SMS message and conversion of the GPS received coordinates to decimal degrees. This will reduce errors in programming the hardware components.

d. Programming

Programming of the whole system is done after the simulation of routines or algorithms are verified and tested to be correct. Programming of the whole system includes the programming part in the server and microcontroller. Microcontroller contains codes written in basic and Visual Basic.NET for the server. The proponents used EEPROM of the PIC to save the status of the relay board. The status of the EEPROM will only change if <ONENG> and <OFFENG> are sent for request.

e. Testing

Testing of the software is done after the hardware part is finished. Testing of the software in the microcontroller is done by sending a SMS message request code in the GSM module. Software testing in the computer server is done by sending a SMS coordinates to the GSM module to verify its output by using Google Earth.

B. Hardware

a. Data Gathering

This is the process of acquiring information about the hardware components to be used. Information includes hardware specifications, interfaces, configuration, and needed power supply.

b. Review of Related Literature

Reviewing related literature will form a foundation for the proponents in designing the circuit diagram. The proponents can gather information on the interfaces of the hardware components, programming language applicable, problems encountered in designing the circuit diagram and the expected output from each of the components in the diagram. A review on the AT commands is also done.

c. Circuit Design

After performing the procedures before circuit designing, the proponents have already gathered vital information regarding the design of the circuit diagram. The schematic diagram is composed of GPS module, GSM module, PIC16F877A Microcontroller, voltage regulator (78L05, RT9163), Level Converter (MAX232) and a relay. The supply voltage of the circuit is 12V which is fed to the voltage regulator to regulate the output to 5V for the microcontroller and the level converter. Another voltage regulator (RT9163) which voltage output is 3.3V is used for the supply of the GPS module. The module needs 3.3V of supply voltage to operate. A LED is connected to the GPIO pin of the GPS module to indicate if the module had acquired a signal to the satellites. A blinking LED means the module is updating its location while a steady LED means its not updating. High Speed diode is connected forward biased to the GPS pin 21 (Real Time Clock and backup SRAM). A Level Converter (MAX232) is used to convert voltage signal (TTL/CMOS to RS-232) from the GPS module to be read by the microcontroller's UART pin.

Microcontroller uses 4Mhz of crystal oscillator for clock. Clock is needed for the execution of programs in the microcontroller. A crystal oscillator is precise compared to RC oscillator/resonator. 2 parallel 33pF capacitor connected to the crystal oscillator to limit its frequency to 4MHz. The receiver pin of port c is connected to RS-232 output of the MAX-232 and the transmitter pin of the GPS module is connected to the transmitter input of the MAX 232 level converter. The GSM module is directly connected to RD7 and RD6 pin of Port D of the PIC. Relay board is composed of a 12VDC 30A Normally open SPST relay, 870 ohm resistor, PNP transistor, LED and a diode. The resistor connected in series with the base of the transistor that limits the current passing from the microcontroller to the transistor. A led is connected to the coil of the relay to indicate if the contacts of the relay are open or close. The diode is used as a protection diode to the circuit. It blocks current coming from the coil of the relay when the coil de-energized when power supply is turned off. This protects other components from sudden burst of current. Transistor is used as a switch in the relay board. It is configured as a common-emitter configuration. In this way, it can have high current output to provide the coil in energizing.

d. Testing

Testing of the circuit can be done part by part or as a whole. GPS module and GSM module can be tested first in a personal computer using hyperterminal. Testing the whole system can be done after all major components are tested to be working correctly and have been transferred to PCB.

C. Integration of Hardware and Software

After the software and hardware are tested, integration comes next to test the system as a whole.

D. Design Testing

This is the last method to be followed. Required output of the system must be obtained to validate the system's performance. Output of the system is analyzed to verify its reliability and accuracy. Verification of the systems output can be checked using Google Earth to verify the x and y coordinates received by GPS module. Steps after data analysis are done if bugs or errors occurred during the testing.

System Flowchart:

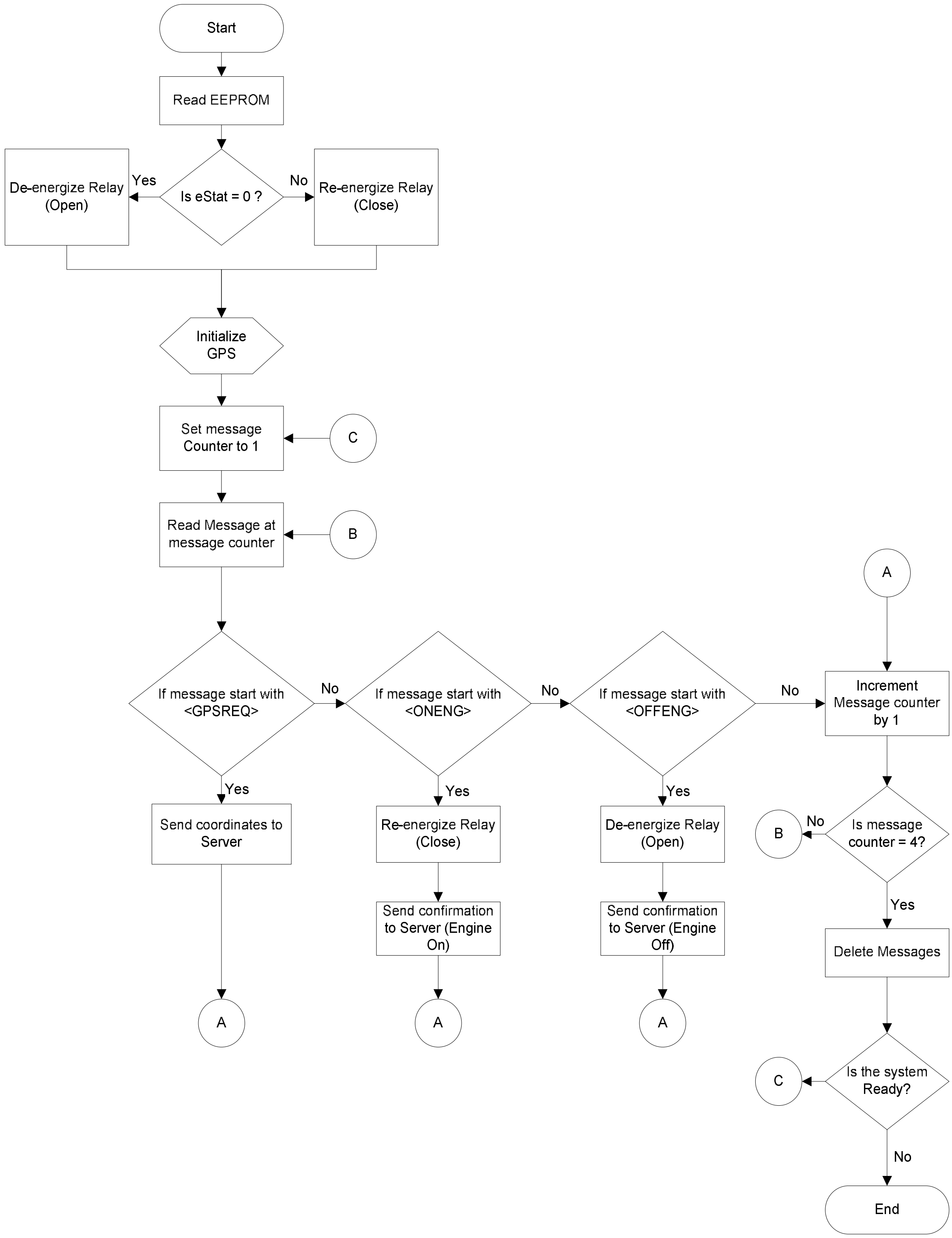


Figure 3.4 GPS/GSM tracking unit flow chart

Figure 3.4 shows the system flowchart of the GPS tracker unit attached to the vehicle. The system starts with reading the EEPROM status, a value of 1 to EEPROM of the microcontroller will close (re-energized) the relay and a value of 0 will open (de-energized). The value of the EEPROM will only change by valid Off and On engine request (Value of 1 for ONENG, 0 for OFFENG). After reading the EEPROM, the system initializes the GPS module. If the GPS is initialized, it will set mCtr for reading the message from the SIM inbox. Reading of SMS message starts from mCtr = 1 and parse the message for possible request code. A SMS starting with <GPSREQ> allows the GSM module to send a SMS message to the server containing the GPS coordinates. SMS starting with <ONENG> activates the relay by supplying the coil of the relay. SMS starting with <OFFENG> de-energized the coil of the relay disconnecting the contacts of the relay to the coil thus, making the relay in open state. A SMS that doesn't start with any pre defined codes by the system will be deleted. After verifying SMS message, mCtr will increase by one and check it again for possible request code until it reaches to mCtr = 3. Reaching mCtr = 4 will delete the messages in the inbox then go back to mCtr = 1. If the GPS module is not initialized or the switch is turned off, the flow of the system will end.

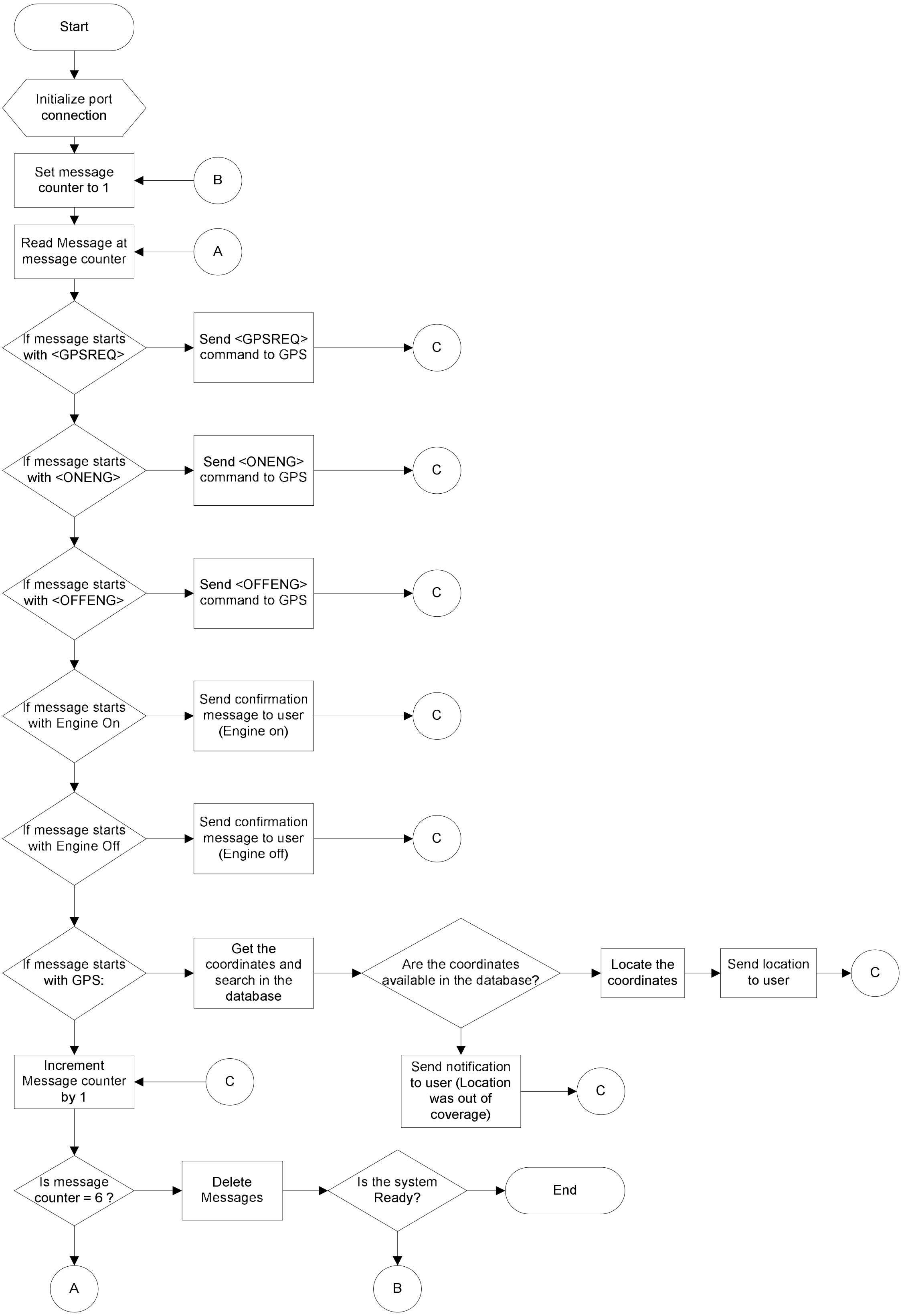


Figure 3.5 GPS/GSM – PC server flow chart

Figure 3.5 is the PC server flow chart of the system. The software in the server starts with initializing the port of the GSM module which is connected to USB port. After initializing, the software will check if the on button is pressed or not. Pressing the ON button will start the program to read and delete messages and setting mCtr to 0. Starting from mCtr = 0(which is the index of the message in the SIM inbox), checks for possible request code. A SMS starting with <GPSREQ> commands the server to send a SMS message to the GPS tracker unit containing "<GPSREQ>" and saves the mobile number of the one requesting. SMS starting with <ONENG> will also send a SMS message to GPS tracker unit containing "<ONENG> and will also send a SMS message to GPS tracker unit then save the mobile number of the sender. Likewise SMS starts with <OFFENG> but will send a SMS to GPS tracker unit with <OFFENG>. SMS containing GPS: is a SMS coming from the GPS tracker unit with GPS coordinates. The message will be parsed and extract the longitudinal and latitudinal coordinates. It will then be compared to the database stored in the server. Depending on the result of comparison, a match result in the database will show the exact location of the vehicle and then sends the exact location to the one requesting, non-matching result will display to the server "The GPS location is out of range or currently not available on the database". After verifying the SMS message, the mCtr will increase by 1 until it reaches mCtr = 4. when mCtr = 4, the system starts to delete the messages stored in the inbox then reads messages again starting from mCtr = 0.

Circuit Diagram:

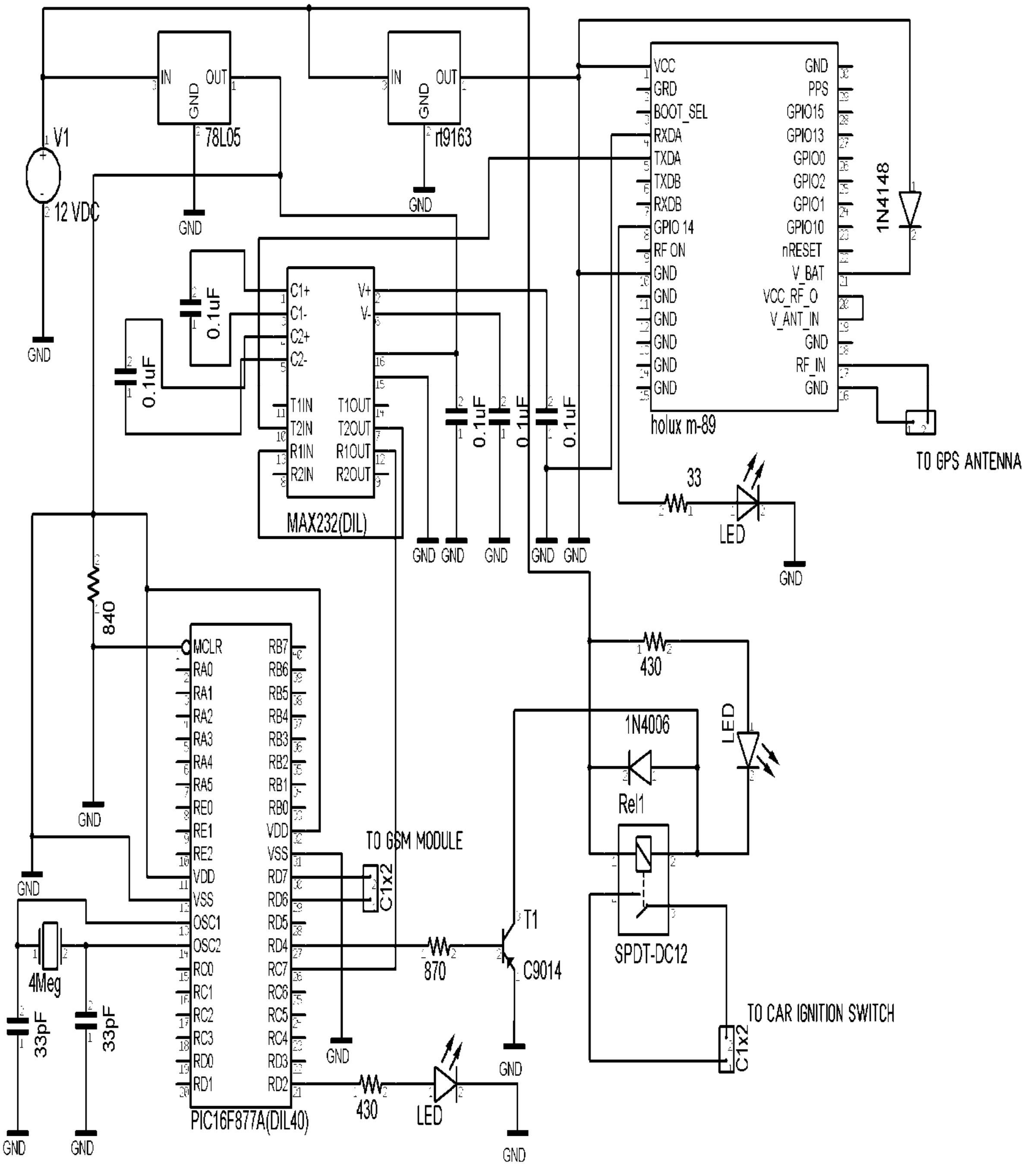


Figure 3.6 Complete Circuit Diagram

Figure 3.6 shows the schematic diagram of the whole system. It is mainly composed of PIC16F877A, GPS module, GSM module, MAX232 and relay board. GPS module, PIC16F877A and MAX232 are supplied by 5VDC using a 7805 voltage regulator. The circuit needs 12VDC of supply voltage to function. It is connected to the input pin of the 7805 voltage regulator to lower it to 5VDC. Capacitors from the MAX232 connected from C1 +/-, C2 +/-, V+ and V- are specified by the manufacturer together with their values (0.1uF) because the capacitors are impossible to be solved due to incomplete circuit presentation from the datasheet. GPS module uses RT9163 as a voltage source because it needs 3.6VDC of voltage source.

A high speed diode (1N4148) is connected forward biased from the output of the RT9163 voltage regulator to the real time clock and SRAM backup pin of the GPS module. A LED with 33 ohms resistor is connected in GPIO pin of GPS module to indicate that the module is updating its location. The antenna of the GPS is connected to the RF_IN and ground of the module. The transmitter pin of the GPS module is connected to TTL/CMOS input of the MAX232 (T2IN). The output of the level converter (T2OUT) is then again set as input in RS-232 input pin (R1IN) and then converted it to TTL/CMOS level (R1OUT). This is done to convert the voltage level of the GPS module from TTL/CMOS level to RS-232 and then to RS-232 to TTL/CMOS. The output pin of the MAX232 (R1OUT) can now be connected to UART pin of the microcontroller which is port RC7. MCLR pin of the PIC16F877A is connected to 5VDC together with a 840 resistor to disable the pin because it is an active low pin. Vss of the microcontroller is connected to ground and Vdd is connected to 5V. A 4MHz crystal oscillator is used to PIC16F877A as clock input for instruction cycle. The 2 33pF capacitors are connected parallel to the oscillator to trim the oscillating frequency down to 4MHz. GSM module is directly connected to port RD7 and RD6 without any interface. The relay board is connected to RD4. A LED in series with 430 ohms resistor connected to RD2 indicates the reading of the GSM module.

The relay board circuit is controlled by the microcontroller because it is connected to RD4 of the microcontroller. Whenever RD4 is in low state, emitter of the transistor connected in ground is open and the supply voltage of the relay is 12V thus, making it in open state. Whenever RD4 is high, emitter is close thus, voltage supply of the relay changes to 12V-0V allowing the coil of the relay to energize. A wire connected in output pin of the relay cuts the connection of the ignition wire. The diode acts a protection to components that may be damaged when the coil de-energized when supply is cut off. The PNP transistor is used as (a switch that also has a high current gain due to its common emitter configuration. LED indicates the status of the relay).

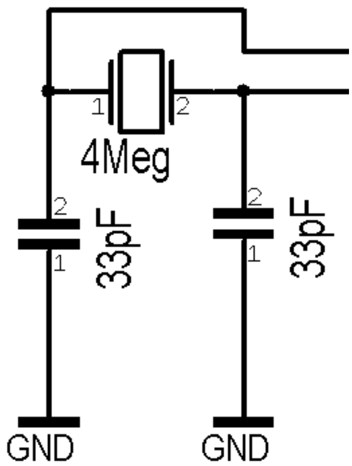


Figure 3.7 4 Mhz Crystal Oscillator Circuit

Figure 3.7 shows the 4Mhz crystal oscillator connected to the microcontroller. The crystal oscillator needs 2 parallel capacitors to trim the clock resonance to desired clock frequency. Without oscillator capacitors, the clock frequency can be higher than 4 Mhz. Load capacitance is usually given in the datasheet of the crystal oscillator. The circuit only needs 4 Mhz of clock frequency for the operation of the microcontroller that's why the proponents need to compute for the oscillator capacitors. The formula for the capacitors is

C1=C2=(2 X Cload) – (Cparasitic – Cinput)

Where:

C1 & C2 – are the parallel capacitors in the oscillator.

Cload – is the capacitance load given by the crystal manufacturer.

Cparasitic – is the Capacitance parasitic, usually 5pF for computation.

Cinput – is the Capacitance input.

The crystal oscillator datasheet requires 19pF of capacitance load and a 5pf capacitance parasitic. Since there is no capacitance input, the value for it is 0. Substituting the values to the formula given above indicates that:

C1 = C2 = (2 X 19pF) – (5pf – 0)

C1 = C2 = 38pF – 5pF

C1 = C2 = 33 pF

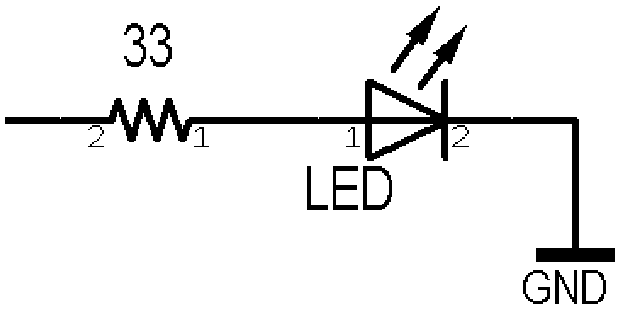


Figure 3.8 Limiting Resistor for LED (RED)

Limiting resistor for LED is very important when using an LED in a circuit. This resistor limits the current that will flow from the power source to the LED. Connecting LED directly to power source may destroy the LED for it will exceed its peak current especially for high voltage source. For Standard Red LED, the maximum value of the Voltage Load is 2V. Computing for the required limiting resistor for Standard Green LED is

R = (Vs – Vl) / I

Where:

Vs – Voltage source.

Vl – Voltage load usually given in the LED datasheet.

I – Current from source.

R – limiting resistor

The power source of GPS LED is 3.3V and the forward current for standard red LED is 40mA based from its datasheet. Substituting to the equation will result to

R = (3.3V – 2V) / 40mA

R = 32.5 ohms

Since the 32.5 ohms value for resistor is not available in the market, the proponents used the nearest higher value which is 33 ohms.

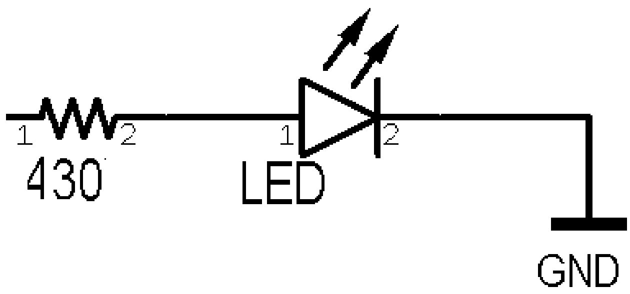


Figure 3.9 Limiting Resistor for LED (GREEN)

Figure 3.9 uses the same formula in Figure 3.8 to compute for the value of limiting resistor from port RD2. The voltage source comes from the port pin RD2 of the microcontroller which is 4.3V. Maximum Voltage load for standard green LED is 2.6V. The output current for RD2 is 4mA as shown in the datasheet. Substituting the value

R = (Vs – Vl) / I

R = (4.3V – 2.6V) / 4mA

R = 425 ohms

Since there is no 425 ohms value for resistor in the market, the proponents used 430 ohm resistor.

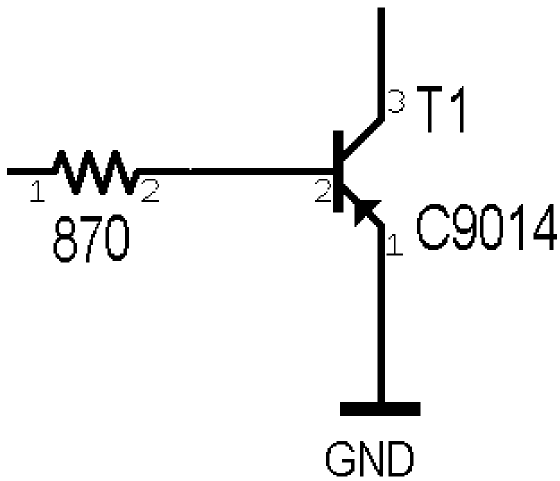


Figure 3.10 Transistor Base Resistor

The transistor base is connected in series with a resistor to limit the current that will pass the base of the transistor when power is supplied. When the current passes through the base of the transistor and if exceeds the maximum allowable current for the transistor, the transistor will be damaged that's why a resistor is connected to the base of the transistor. To compute for the value of base resistor, the formula is

Rb = (Vin – Vbe) / Ib

Where:

Rb – Base resistor

Vin – Voltage input

Vbe – forward voltage from base to emitter

Ib – Base current

The output voltage of port RD4 is 4.3V and the maximum forward voltage for silicon transistor is 0.85V and base current is 4mA that comes from port RD4, substituting the values in the formula shows that:

Rb = (Vin – Vbe) / Ib

Rb = (4.3V – 0.85) / 4mA

Rb = 862.5 ohms

Since there is no 862.5 ohm resistor in the market, the proponents considered the highest next value which is 870 ohms.

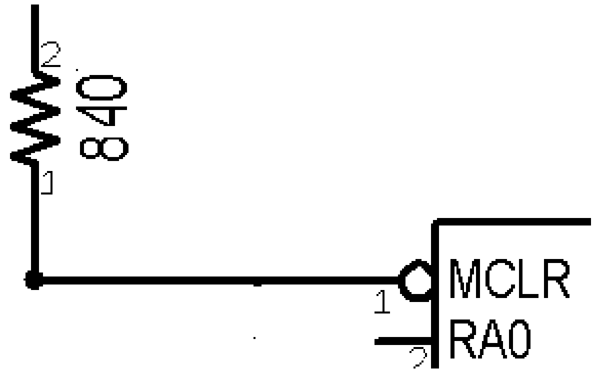


Figure 3.11 Pull - Up Resistor in PIC16F877A

PIC16F877A uses pull-up resistor connected to MCLR to avoid the microcontroller from resetting. Since MCLR pin of PIC16F877A is inverted, hanging the pin without connection or simply making the input signal to 0 will put the microcontroller to unable state. This resistor pulls up the MCLR pin to almost ground level. Base from the datasheet of the microcontroller, the value of pull-up resistor must be less than 40k ohms. The voltage source 5V comes from the output voltage of the 7805 regulator and the output current is 6mA. Computing for the value of pull-up resistor is given by Ohms Law.

R = V / I

Where:

R – Resistor value

V – Voltage source

I – Current passing to device

R = 5V / 6mA

R = 833.33 ohms

Since there is no 833.33 ohm resistor in the market, the proponents used 840 ohm resistor.

PCB Layout:

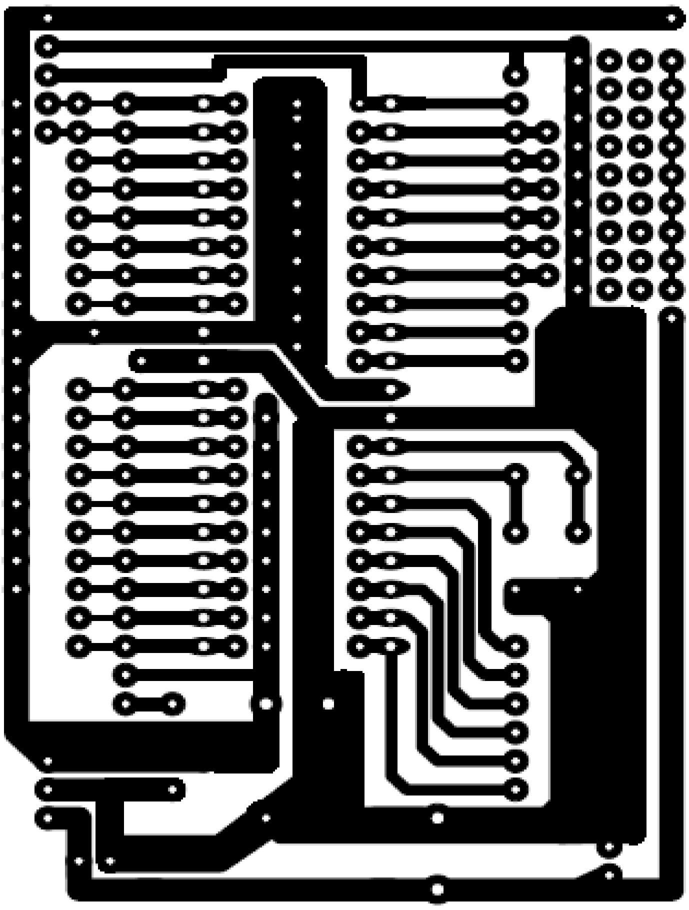


Figure 3.12 PIC16F877A PCB Layout

GPS Module:

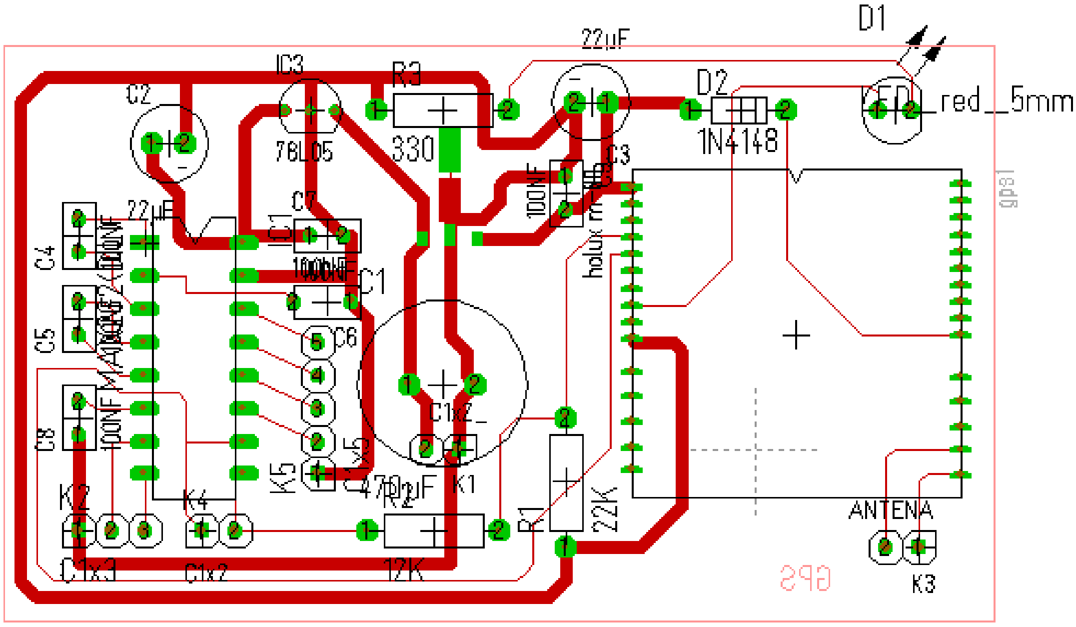


Figure 3.13 GPS Module PCB Layout

Relay Board:

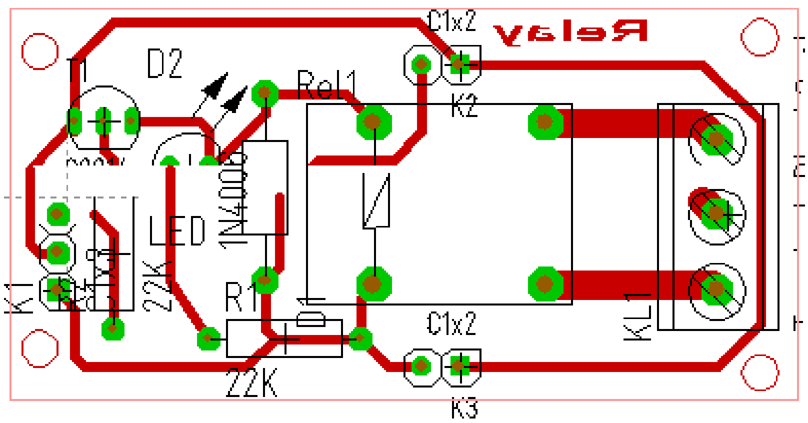


Figure 3.14 SPDT Relay Board PCB Layout

Chapter 4

TESTING, PRESENTATION AND INTERPRETATION OF DATA

This chapter shows how the design is tested, presented, and interpreted the gathered data from the prototype. This chapter also includes the validity and the reliability of the designed prototype.

Testing the Whole System

Testing the GPS module is the part of the system to be tested first. Reliability and accuracy of the module depends on the brand of the module. Holux M-89 warm start at the average of 33 seconds and an average of 36 seconds cold start with less than 1 sec reacquisition time. Accuracy of the module is a +/- 2 meters. Testing the module is required to verify if the module can access at least 3 satellites. Failure to access at least 3 satellites will make the module to standby. An initial testing for the GPS module is done through a PC connected via serial port. Hyperterminal 7.0 (Windows Vista Version) is used to see the information gathered by the GPS module. Once powered up and connected to the serial port, continuous receiving of streams of data is acquired by the module. Acquisition of the X and Y coordinates of the module starts when the LED in the GPS module starts to blink. Blinking of the LED indicates that the module is updating its location. A 2-row Serial LCD is used to show the output of the GPS module. The default or raw data that a GPS module receives are continuous streams of data ($GPGGA,161229.487,3723.2475,N,12158.3416,W,1,0,9,0,M,,,,0000*18) which includes different information (altitude, velocity, position, time, number of satellites used, etc.) in 1 stream of lines starting with a '$' sign. The only data that the proponents need is the longitudinal and latitudinal coordinates in a $GPGGA format which is the number that is before the letter 'N' or 'S' and after 'W' or 'E'. A routine in the PIC program that parses the streams of data is needed to extract the needed information regarding the GPS location. After extracting the required information, it is now converted to decimal degrees value of longitudinal and latitudinal format. The converted values can now be used as the GPS position of the module and can be verified using Google Earth or Google Maps. Below is a table that shows the testing of the GPS module in different locations.

Vehicle Exact Location	**Coordinates Received N and E**		**GPS response time**	**Server response time**	**Server result location**
Mapua Institute of Techonlogy, Manila Point 1 (Near IEEE)	14.5907	121.9779	62 seconds	3 seconds	Mapua Institute of Technoloy, Muralla Street (Manila City)
Mapua Institute of Techonlogy, Manila Point 1 (Near IEEE)	14.5907	121.9779	42 seconds	4 seconds	Mapua Institute of Technoloy, Muralla Street (Manila City)
Mapua Institute of					Mapua

Techonlogy, Manila Point 2 (Open Parking Near Basketball Court)	14.5905	121.9783	38 seconds	5 seconds	Institute of Technoloy, Muralla Street (Manila City)
Mapua Institute of Techonlogy, Manila Point 2 (Open Parking Near Basketball Court)	14.5904	121.9784	54 seconds	3 seconds	Mapua Institute of Technoloy, Muralla Street (Manila City)
Mapua Institute of Techonlogy, Manila Point 3 (Along Muralla Street)	14.5909	121.9785	80 seconds	3 seconds	Mapua Institute of Technoloy, Muralla Street (Manila City)
Mapua Institute of Techonlogy, Manila Point 3 (Along Muralla Street)	14.591	121.9784	56 seconds	4 seconds	Muralla Street Intramuros near Mapua Institute of Technology (Manila City)
Jollibee along Marcos Highway, Antipolo City	14.6216	121.1084	45 seconds	3 seconds	Marcos Highway near Sta. Lucia (Marikina City)
Jollibee along Marcos Highway, Antipolo City	14.6215	121.1084	85 seconds	3 seconds	Marcos Highway near Sta. Lucia (Marikina City)
Jollibee along Marcos Highway, Antipolo City	14.6215	121.1084	40 seconds	3 seconds	Marcos Highway near Sta. Lucia (Marikina City)
Jollibee along Marcos Highway, Antipolo City	14.6216	121.1083	47 seconds	4 seconds	Marcos Highway near Sta. Lucia (Marikina City)
Jollibee along Marcos Highway, Antipolo City	14.6215	121.1084	54 seconds	5 seconds	Marcos Highway near Sta. Lucia

					(Marikina City)
Ayala Boulevard corner San Marcelino, Manila City	14.5889	120.9846	30 seconds	5 seconds	Ayala Boulevard corner San Marcelino near SM City Manila (Manila City)
Ayala Boulevard corner San Marcelino, Manila City	14.5889	120.9847	67 seconds	5 seconds	Ayala Boulevard corner San Marcelino near SM City Manila (Manila City)
Ayala Boulevard corner San Marcelino, Manila City	14.5889	120.9847	55 seconds	3 seconds	Ayala Boulevard corner San Marcelino near SM City Manila (Manila City)
Ayala Boulevard corner San Marcelino, Manila City	14.5888	120.9847	48 seconds	3 seconds	Ayala Boulevard corner San Marcelino near SM City Manila (Manila City)
Ayala Boulevard corner San Marcelino, Manila City	14.5889	120.9846	50 seconds	4 seconds	Ayala Boulevard corner San Marcelino near SM City Manila (Manila City)
Aurora Boulevard near SM City Centerpoint, Quezon City	14.6064	121.0195	94 seconds	4 seconds	Aurora Boulevard near SM Sta Mesa. (Manila City)
Aurora Boulevard near SM City					Aurora Boulevard

Centerpoint, Quezon City	14.6064	121.0195	56 seconds	3 seconds	near SM Sta Mesa. (Manila City)
Aurora Boulevard near SM City Centerpoint, Quezon City	14.6064	121.0197	67 seconds	3 seconds	Aurora Boulevard near SM Sta Mesa. (Manila City)
Aurora Boulevard near SM City Centerpoint, Quezon City	14.6065	121.0198	53 seconds	3 seconds	Aurora Boulevard near SM Sta Mesa. (Manila City)
Aurora Boulevard near SM City Centerpoint, Quezon City	14.6065	121.0195	55 seconds	4 seconds	Aurora Boulevard near SM Sta Mesa. (Manila City)
Santolan Road corner EDSA, San Juan Metro Manila	14.6108	121.0547	89 seconds	5 seconds	EDSA near Camp Krame, San Juan Metro Manila
Santolan Road corner EDSA, San Juan Metro Manila	14.611	121.0557	45 seconds	4 seconds	EDSA near Camp Krame, San Juan Metro Manila
Santolan Road corner EDSA, San Juan Metro Manila	14.6111	121.0556	69 seconds	3 seconds	EDSA near Camp Krame, San Juan Metro Manila
Santolan Road corner EDSA, San Juan Metro Manila	14.6109	121.0556	57 seconds	3 seconds	EDSA near Camp Krame, San Juan Metro Manila
Santolan Road corner EDSA, San Juan Metro Manila	14.6108	121.0556	34 seconds	3 seconds	EDSA near Camp Krame, San Juan Metro Manila
E.Rodriguez Avenue corner Katipunan Avenue, Pasig City	14.6145	121.0708	35 seconds	3 seconds	E. Rodriguez Avenue cor Katipunan Near Petron (Pasig City)
E.Rodriguez					E. Rodriguez

Avenue corner Katipunan Avenue, Pasig City	14.6145	121.0714	45 seconds	3 seconds	Avenue cor Katipunan Near Petron (Pasig City)
E.Rodriguez Avenue corner Katipunan Avenue, Pasig City	14.6146	121.0714	110 seconds	4 seconds	E. Rodriguez Avenue cor Katipunan Near Petron (Pasig City)
E.Rodriguez Avenue corner Katipunan Avenue, Pasig City	14.6146	121.0716	68 seconds	4 seconds	E. Rodriguez Avenue cor Katipunan Near Petron (Pasig City)
E.Rodriguez Avenue corner Katipunan Avenue, Pasig City	14.6146	121.0714	51 seconds	3 seconds	E. Rodriguez Avenue cor Katipunan Near Petron (Pasig City)
Marcos Highway corner Sumulong Highway, Antipolo City	14.6253	121.1255	34 seconds	3 seconds	E. Rodriguez Avenue cor Katipunan Near Petron (Pasig City)
Marcos Highway corner Sumulong Highway, Antipolo City	14.6255	121.1256	71 seconds	4 seconds	Out of Map Coverage
Marcos Highway corner Sumulong Highway, Antipolo City	14.6255	121.1255	58 seconds	3 seconds	Out of Map Coverage
Marcos Highway corner Sumulong Highway, Antipolo City	14.6254	121.1257	62 seconds	4 seconds	Out of Map Coverage
Marcos Highway corner Sumulong Highway, Antipolo City	14.6251	121.127	51 seconds	3 seconds	Out of Map Coverage
Peace Village, Antipolo City	14.6151	121.1915	62 seconds	3 seconds	Out of Map Coverage
Peace Village, Antipolo City	14.6151	121.1915	53 seconds	5 seconds	Out of Map Coverage

Peace Village, Antipolo City	14.615	121.1915	74 seconds	5 seconds	Out of Map Coverage
Peace Village, Antipolo City	14.6153	121.1913	66 seconds	4 seconds	Out of Map Coverage
Peace Village, Antipolo City	14.6153	121.1915	42 seconds	5 seconds	Out of Map Coverage

Table 4.1 System Testing

Table 4.1 shows different location acquired by the GPS. The tests are performed in different locations with the server located at Antipolo, Rizal. Each of the location is tested five times and gathered its GPS coordinates together with the server response time to the request and GPS response time. GPS response time corresponds to the time taken for the GPS device to reply to the server while the server response time is the time taken for the server to reply to the requesting party. In different locations, there are different GPS and server response time. It depends on where the location of the vehicle is (open or closed area), GPS response time takes longer when the vehicle is in a closed area and faster when it is in an open area. The average time it takes to reply to the servers is 57.4seconds. The server response time takes longer when the network is having traffic but in normal operation, the server response time takes only about 4.2 seconds. Adding both responses time will give the total time it takes to receive the tracking request from the time a request is sent. Tests done in locations listed above are tested in one spot. The table shows that there is a difference between the coordinates that are tested in same location. This is due to the GPS accuracy +/- 2m which is equivalent to a 0.0001 decimal in the GPS coordinates.

Testing of GSM module

Another major part of the system is the GSM module. This module can also be tested in a PC using serial port and a Hyperterminal 7.0 (Vista Version). First way to test GSM module is to use a hyperterminal and use AT commands if it is supported. If the said module is supported by a certain command, it will output an "OK" to a certain AT command sent to the module. Table below shows an example of AT command testing.

AT Command	Reply of the hyper terminal
AT	OK
AT+CMGS=?	OK
AT+CMGF=?	OK
AT+CMGD=?	OK
AT+CMGR=?	OK

Table 4.2 AT commands reply table

The given AT commands in Table 4.2 are the basic commands that are needed to send, receive, and delete messages. The reply "OK" of the computer only means that the computer is communicating to the GSM module. The proponents used AT+CMGS = "09272872312" <CR> hello <ctrl+ Z>. for testing the module in sending a SMS message. The recipient 09272872312 received the text message “hello” after commanding the GSM module in the hyperterminal. The command “AT” with a reply of “OK” means that the PC and the GSM module are communicating to each other. AT+CMGF is a command that sets the GSM module reading format. AT+CMGR is an AT command that shows the message in a specified index. The proponents tested the GSM module by typing in the hyperterminal AT+CMGR=0 and reply of “OK” is received. This means that, there is no message saved located in index 0 of the sim card inbox. AT+CMGD is a command that deletes a message depending on the specified index in the sim card. AT+CMGD=0 deletes a message in index 0 of the sim card. The testing shown above is also used in testing GLOBE Tattoo for using it as a GSM module.

Testing Engine Off/On Request

The system is also tested using the Engine Off/On capability. For safety purposes, the test is done in a stationary vehicle in which the vehicle is turned on. The proponents decided to perform this kind of test to prevent accident. Even if the vehicle is stationary, the immobilization is still applicable. Below is a table that shows the time it takes for the server to send a confirmation message to the requesting party when Off/On engine is requested.

Request Code	Vehicle Exact Location	GPS response time	Server response time	SMS message sent as confirmation
<OFFENG>	Mapua Institute of Techonlogy, Manila Point 1 (Near IEEE)	62 seconds	4 seconds	Your vehicle is now immobilized.
<ONENG>	Mapua Institute of Techonlogy, Manila Point 1 (Near IEEE)	79 seconds	5 seconds	Your vehicle is back to normal.
<OFFENG>	Mapua Institute of Techonlogy, Manila Point 2 (Open Parking Near Basketball Court)	54 seconds	3 seconds	Your vehicle is now immobilized.
<OFFENG>	E.Rodriguez Avenue corner Katipunan Avenue, Pasig City	40 seconds	5 seconds	Your vehicle is now immobilized.
<ONENG>	E.Rodriguez Avenue corner Katipunan Avenue, Pasig	58 seconds	4 seconds	Your vehicle is back to normal.

	City			
<OFFENG>	E.Rodriguez Avenue corner Katipunan Avenue, Pasig City	110 seconds	5 seconds	Your vehicle is now immobilized.
<OFFENG>	Jollibee along Marcos Highway, Antipolo City	85 seconds	3 seconds	Your vehicle is now immobilized.
<ONENG>	Jollibee along Marcos Highway, Antipolo City	40 seconds	3 seconds	Your vehicle is back to normal.
<OFFENG>	Jollibee along Marcos Highway, Antipolo City	47 seconds	3 seconds	Your vehicle is now immobilized.

Table 4.3 Engine Off/On Testing

Table 4.3 shows the testing in Engine Off/On request. The tests are done together with the GPS request code. Parts of the GPS test are done with Engine Off/On request. The proponents first tested the GPS request code and after recording the data, some places are also tested for Engine Off/On request. The GPS response time is the time taken by the GPS tracker unit to reply to the server while server response time is the time taken by the server to send the confirmation message to the requesting party. Adding both of the response time is the time taken by the whole system to relay the confirmation message to the requesting party. The average time for the GPS response time is 64 seconds while the average for the server response time is 4 seconds. The time taken for these tests are dependent on the delay of the system in reading the SMS and the delay caused by the network.

Requesting correct format for turning on the engine is the same as the conditions in requesting the exact location and in turning off the engine.

Partial correct format is also the same for the correct format. Requesting incorrect format to the server will not trigger the server to request to the GPS tracker unit

Chapter 5

CONCLUSION AND RECOMMENDATION

This chapter contains the overall conclusion regarding the design. This chapter also includes the recommendation for the design to improve its function, reliability, and accuracy.

Conclusion

The design, after several testing, has conformed to the stated objectives that include the reliability, accuracy of the GPS module and security by means of immobilization of the vehicle. The general objective is also met by the design. The design can track vehicle using GPS module by sending a SMS message to the GSM module. The immobilization of the vehicle is also met by cutting of the electrical power to the engine by interfacing the design to the ignition wire. The database made for the design is almost complete for NCR regions. The design is also tested in different scenarios; still it performs its task. Accuracy of the design in tracking is almost the same as the output of Google Earth which is taken from the satellite which is very accurate. Overall the functionality of the design can greatly contribute to resolving problems on carnapping in the country. Sooner or later, the design will be introduced to the market as a reliable product for tracking and security purpose for automotives.

Recommendations

The proponents recommend to individuals interested to the design to greatly improve the tracking functionality as well as the security functions. Tracking of the vehicle as recommended by the proponents must be broader than NCR to increase the reliability of the system within Luzon. In this way, outside the NCR will not be considered to be a dead spot by the computer server. For better and faster way to track the vehicle, the proponents also recommend that the tracking must be done in real time. Furthermore, they encourage that all interested researchers should find a way to minimize the overlapping of messages when simultaneous testing is done. The proponents also recommend that the interface between the design and the car must be done using the ECU of the car. But this method is much complicated, costly, and affect – dangerous – that – might the – cars - performance.

BIBLIOGRAPHY

"Marine Differential GPS". Satellite Navigation. Trinity House.

IEEE Transactions on Consumer Electronics, Vol. 50, No.4 November 2004

"A Beginner's Guide to GNSS in Europe" by IFATCA.

GPS Overview from the NAVSTAR Joint Program Office. Retrieved December 15, 2006

Monahan, Torin. 2007. "War Rooms" of the Street: Surveillance Practices in Transportation Control Centers

Global Positioning Systems, Inertial Navigation, and Integration

Mohinder S. Grewal, Lawrence R. Weill, and Argus P. Andrews

"Embedded Systems Dictionary" by Jack Ganssle and Mike Barr

IEEE Transactions on Consumer Electronics, Vol. 50, No.4 November 2004

A. J. Kloneck, "Simultaneous sending and receiving system"

APPENDIX A

LIST OF MATERIALS

Quantity	Component Name	Price per piece	Total
1	SMS module	PHP 4,500.00	PHP 4,500.00
1	HOLUX GR-89 GPS module	PHP 4,500.00	PHP 4,500.00
1	MAX232 IC	PHP 50.00	PHP 50.00
1	PIC16F877A	PHP 175.00	PHP 175.00
8	0.1 uF Ceramic Capacitor	PHP 2.00	PHP 16.00
3	35V – 22uF Electrolytic Capacitor	PHP 5.00	PHP 15.00
2	78L05 Voltage Regulator	PHP 15.00	PHP 30.00
3	LED	PHP 2.50	PHP 7.50
1	16V – 47uF Electrolytic Capacitor	PHP 5.00	PHP 5.00
4	2 pin female connector	PHP 5.00	PHP 20.00
1	8 pin female connector	PHP 22.00	PHP 22.00
2	¼W 1k Resistor	PHP 1.00	PHP 1.00
1	40 pin IC socket	PHP 15.00	PHP 15.00
1	4Mhz Crystal Oscillator	PHP 20.00	PHP 20.00
2	33pF Ceramic Capacitor	PHP 2.00	PHP 4.00
1	16V – 470uF Electrolytic Capacitor	PHP 5.00	PHP 5.00

1	¼W 22k Resistor	PHP 1.00	PHP 1.00
1	½W 2.7K Resistor	PHP 1.50	PHP 1.50
1	Black Casing	PHP 175.00	PHP 175.00
1	Relay Board	PHP 150.00	PHP 150.00
		TOTAL:	PHP 9,713.00

APPENDIX B

PIC PROGRAM

```
    Device 16F877A

    Declare XTAL 4

    DECLARE WATCHDOG = OFF

    DECLARE FSR_CONTEXT_SAVE = ON

    ALL_DIGITAL=TRUE

REMARKS ON

Declare    LCD_DTPIN        PORTC.0

Declare    LCD_RSPIN        PORTD.0

Declare    LCD_ENPIN        PORTD.1

Declare LCD_LINES           2

Declare LCD_INTERFACE       4


    HSERIAL_BAUD = 4800

    HSERIAL_RCSTA = %10010000

    HSERIAL_TXSTA = %00100100

    HSERIAL_CLEAR = On


    DECLARE SERIAL_DATA 8

    Symbol T9600 = 84 NO_LIST

    Symbol T4800 = 188      NO_LIST
```

```
dim ctr as byte, alertCtr as byte,UTC as byte

dim latWhole as word,latDec as word,latN as float

dim latI as byte

dim longWhole as word,longDec as word,longN as float

dim longI as byte

dim pfi as byte

dim RQCtr as byte

dim myMsg[80] as byte

dim mCtr as byte

dim idx as byte

dim mMode as byte

dim eStat as byte


TRISA=$FF

TRISB=$7F

TRISC=$80

TRISD=$A8


PORTB.7=0

PORTD.2=0

eStat=EREAD 0
```

```
if eStat=1 then

  PORTD.4=1
else
  PORTD.4=0
endif
 cls
Print At 1,1,"INITIALIZING"
Print At 2,1,"DEVICE..."
delayms 8000

PROG_MAIN:
cls
Print at 1,1, "GPS:Initializing"
pfi="0"
while pfi="0"
        HSerIn [Wait("$GPGGA,"),UTC, Wait(","), DEC4 latWhole, DEC5 latDec,
latI, Wait(","), DEC5 longWhole, DEC5 longDec ,longI,Wait(","),pfi]

wend
```

```
cls
Print at 1,1, "GPS: Init OK"
delayms 2000

while 1
        gosub smsRead
wend

smsRead:
for mCtr=1 to 3
        for ctr=0 to 79
                myMsg[ctr]=32

        next ctr
        cls
        Print at 1,1,"READING MSG ",DEC mCtr

        msgGR:
        PORTD.2=1
        SEROUT PORTD.6, T9600,["AT+CMGR=",DEC mCtr,13]
        SERIN PORTD.7,
T9600,3000,msgOE,[Wait(34),Wait(34),Wait(34),Wait("<GPSREQ>")]
```

```
            cls
            Print at 1,1,"GPS REQ MSG ",DEC mCtr
            delayms 2000
            mMode=1
            gosub WriteData
            gosub smsSend
            goto delSMS

      msgOE:
           SEROUT PORTD.6, T9600,["AT+CMGR=",DEC mCtr,13]
        SERIN PORTD.7,
T9600,3000,msgNE,[Wait(34),Wait(34),Wait(34),Wait("<ONENG>")]
             cls
            Print at 1,1,"ON REQ MSG ",DEC mCtr
            eStat=1
            EWRITE 0,[eStat]
            PORTD.4=1
            delayms 2000
            mMode=2
            gosub WriteData
```

```
            gosub smsSend
            goto delSMS

    msgNE:
            SEROUT PORTD.6, T9600,["AT+CMGR=",DEC mCtr,13]
       SERIN PORTD.7,
T9600,3000,msgTO,[Wait(34),Wait(34),Wait(34),Wait("<OFFENG>")]
            cls
            Print at 1,1,"OFF REQ MSG ",DEC mCtr
            eStat=0
            EWRITE 0,[eStat]
            PORTD.4=0
            delayms 2000
            mMode=3
            gosub WriteData
            gosub smsSend
            goto delSMS

    msgTO:
    cls
    Print at 1,1,"NO REQ MSG at"
    Print at 2,1,"MSG ",DEC mCtr
```

```
        delayms 3000

        PORTD.2=0

        delSMS:

        SEROUT PORTD.6, T9600,["AT+CMGD=",DEC mCtr,13]

        delayms 3000
        next mCtr
return

smsSend:
RQCtr=1
PORTB.7=1
delayms 3000
PORTB.7=0

startSending:
cls
Print at 1,1, "SENDING ALERT #", DEC RQCtr
SEROUT PORTD.6 , T9600,  ["AT+CMGS=",34,"09052777430",34,13]
```

```
delayms 1000
if mMode=1 then
SEROUT PORTD.6 , T9600,  ["GPS: ",latI,": ",DEC4 latN,", ",longI, ": ", DEC4
longN]

elseif mMode=2 then

SEROUT PORTD.6 , T9600,  ["Engine ON"]
else
SEROUT PORTD.6 , T9600,  ["Engine OFF"]

endif
delayms 1000
SEROUT PORTD.6 , T9600,  [26]
delayms 10000

'if RQCtr>1 then
'   goto smsOut
'else
'        RQCtr=RQCtr+1
'        goto startSending
```

```
'endif

smsOut:

delayms 1000

return

WriteData:

          HSerIn [Wait("$GPGGA,"),UTC, Wait(","), DEC4 latWhole, DEC5
latDec, latI, Wait(","), DEC5 longWhole, DEC5 longDec ,longI,Wait(","),pfi]

          cls
          Print at 1,1, latI,": ",DEC4 latWhole,".",DEC4 latDec
          Print at 2,1, longI, ": ", DEC5 longWhole, ".",DEC4 longDec
          latN=latWhole//100

          latN=latN + latDec/10000

          latN=latN /60
```

```
latWhole=latWhole/100

latN=latWhole+latN

longN=longwhole//100

longN=longN + longDec/10000

longN=longN /60

longWhole=longWhole/100

longN=longWhole+longN


cls

Print at 1,1, latI,": ",DEC4 latN

Print at 2,1, longI, ": ", DEC4 longN



Return

End
```

APPENDIX C

SERVER SOURCE CODE

```
Imports System.IO.Ports
Imports MySql.Data.MySqlClient
'============================NOTES
'                          MESSAGE DELETING
Public Class Main
    Dim mobile_no(4) As String
    Dim message(4) As String
    Dim messagelocation As Integer
    Dim default_mobile_no As String = "09062884499"
    Dim gps_mobile_no As String = "09396592140"
    Dim nameloc As String = ""
    Dim command As String
    Dim MainSwitch As Boolean = False
    Dim usbport As String = "COM3"
    Private Sub Main_Load(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles MyBase.Load
        MainStatusLabel.Text = "Initializing...."
        Timer_Initial.Start()

    End Sub

    Private Sub btnSwitch_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnSwitch.Click
        If MainSwitch Then
            btnSwitch.Text = "ON"
            ManualModeToolStripMenuItem_Click(sender, e)
            MainSwitch = False
        Else
            btnSwitch.Text = "OFF"
            AutomaticModeToolStripMenuItem_Click(sender, e)
            MainSwitch = True
        End If
    End Sub

    Private Sub Timer_Initial_Tick(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Timer_Initial.Tick
        init_mes()
        Timer_Initial.Stop()
```

```
        MainStatusLabel.Text = "Initializing.... Done"


    End Sub

    Private Sub ExitToolStripMenuItem_Click(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles ExitToolStripMenuItem.Click
        Me.Close()
    End Sub

    Private Sub ManualModeToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
ManualModeToolStripMenuItem.Click
        MainSwitch = False
        ManualModeToolStripMenuItem.Checked = True
        AutomaticModeToolStripMenuItem.Checked = False
        Label2.Enabled = True
        Label3.Enabled = True
        txtGPSE.Enabled = True
        txtGPSN.Enabled = True
        btnUp.Enabled = True
        btnDown.Enabled = True
        btnLeft.Enabled = True
        btnRight.Enabled = True
        btnLocate.Enabled = True
        Timer_AutomaticMode.Stop()
        MainStatusLabel.Text = "System is off"

    End Sub

    Private Sub AutomaticModeToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
AutomaticModeToolStripMenuItem.Click
        MainStatusLabel.Text = "Starting automatic mode.."


        MainSwitch = True
        ManualModeToolStripMenuItem.Checked = False
        AutomaticModeToolStripMenuItem.Checked = True
        Label2.Enabled = False
        Label3.Enabled = False
        txtGPSE.Enabled = False
        txtGPSN.Enabled = False
        btnUp.Enabled = False
```

```
        btnDown.Enabled = False
        btnLeft.Enabled = False
        btnRight.Enabled = False
        btnLocate.Enabled = False
        Timer_AutomaticMode.Start()
    End Sub

    Private Sub AddCoordinatesToolStripMenuItem_Click(ByVal sender As
System.Object, ByVal e As System.EventArgs) Handles
AddCoordinatesToolStripMenuItem.Click
        Coordinates_Management.ShowDialog()
        Coordinates_Management.Dispose()
    End Sub

    Private Sub init_mes()
        Dim SMSPort As New SerialPort
        Dim portdata As String
        Dim msgctr As Integer = 0
        Dim startCMGR As Integer
        With SMSPort
            .PortName = usbport
            .BaudRate = 115200
            .Parity = Parity.None
            .DataBits = 8
            .StopBits = StopBits.One
            .Handshake = Handshake.None
            .DtrEnable = False
            .RtsEnable = False
            .NewLine = vbCrLf
        End With
        SMSPort.Open()
        SMSPort.WriteLine("AT+CMGF=1")
        Threading.Thread.Sleep(100)
        SMSPort.WriteLine("AT+CMGR=" & msgctr)
        Threading.Thread.Sleep(100)
        portdata = SMSPort.ReadExisting
        startCMGR = portdata.LastIndexOf("+CMGR:")
        SMSPort.Close()
        msgctr = msgctr + 1
    End Sub

    Private Sub read_sms()
        Dim startCMGR As Integer
        Dim messagectr As Integer = 0
```

```
        Dim portdata As String
        Dim SMSPort As New SerialPort
        With SMSPort
            .PortName = usbport
            .BaudRate = 115200
            .Parity = Parity.None
            .DataBits = 8
            .StopBits = StopBits.One
            .Handshake = Handshake.None
            .DtrEnable = True
            .RtsEnable = True
            .NewLine = vbCrLf
        End With


        For index As Integer = 0 To 4
            SMSPort.Open()
            SMSPort.WriteLine("AT+CMGF=1")
            'should delay
            Threading.Thread.Sleep(100)
            SMSPort.WriteLine("AT+CMGR=" & messagectr)
            'should delay
            Threading.Thread.Sleep(100)
            portdata = SMSPort.ReadExisting

            startCMGR = portdata.LastIndexOf("+CMGR:")
            If startCMGR > 0 Then
                'THERE IS A MESSAGE ON THE SELECTED SLOT
                portdata = portdata.Remove(0, startCMGR + 19)
                mobile_no(messagectr) = portdata.Remove(portdata.IndexOf(""","))
                message(messagectr) =
portdata.Substring(portdata.LastIndexOf("""") + 3)
                message(messagectr) =
message(messagectr).Remove(message(messagectr).LastIndexOf("OK"))
            Else
                'THERE are no message

            End If

            SMSPort.Close()
            messagectr = messagectr + 1
            If messagectr = 5 Then
                messagectr = 0
            End If
```

```
        Next


    End Sub

    Private Sub delete_sms()
        Dim messagectr As Integer = 0
        Dim SMSPort As New SerialPort
        With SMSPort
            .PortName = usbport
            .BaudRate = 115200
            .Parity = Parity.None
            .DataBits = 8
            .StopBits = StopBits.One
            .Handshake = Handshake.None
            .DtrEnable = True
            .RtsEnable = True
            .NewLine = vbCrLf
        End With


        For index As Integer = 0 To 4
            SMSPort.Open()
            SMSPort.WriteLine("AT+CMGF=1")
            Threading.Thread.Sleep(100)
            SMSPort.WriteLine("AT+CMGD=" & messagectr)
            Threading.Thread.Sleep(100)
            SMSPort.Close()
            messagectr = messagectr + 1
            If messagectr = 5 Then
                messagectr = 0
            End If
        Next


    End Sub

    Private Sub Timer_AutomaticMode_Tick(ByVal sender As System.Object, ByVal
e As System.EventArgs) Handles Timer_AutomaticMode.Tick
        Timer_AutomaticMode.Stop()
        clear_messages()
        MainStatusLabel.Text = "Reading SMS...."

        Timer_ReadMes.Start()
```

```
    End Sub

    Private Sub Timer_ReadMes_Tick(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Timer_ReadMes.Tick
        Timer_ReadMes.Stop()
        init_mes()
        MainStatusLabel.Text = "Reading SMS.... Done"

        read_sms()
        delete_sms()
        MainStatusLabel.Text = "Checking SMS...."




        'CHECK FOR TRIGERRING MESSAGE
        For index As Integer = 0 To 4

            If message(index) = String.Empty Then

            ElseIf message(index).StartsWith("<GPS>") Then
                'This is a gps request
                'Send a appropriate sms signal to the device
                default_mobile_no = mobile_no(index)
                command = "<GPSREQ>"
                Timer_SendingCommand.Start()
                Exit Sub
            ElseIf message(index).StartsWith("<ON>") Then
                'This is a engine off request
                'Send a appropriate sms signal to the device
                default_mobile_no = mobile_no(index)
                command = "<ONENG>"
                Timer_SendingCommand.Start()
                Exit Sub
            ElseIf message(index).StartsWith("<OFF>") Then
                'This is a engine off request
                'Send a appropriate sms signal to the device
                default_mobile_no = mobile_no(index)
                command = "<OFFENG>"
                Timer_SendingCommand.Start()
                Exit Sub
            ElseIf message(index).StartsWith("GPS:") Then
                'Locate this location
                'This is a reply message, send to proper requesting number
```

```
            messagelocation = index
            Timer_Locate.Start()
            Timer_SendingMes.Start()
            Exit Sub
        End If

    Next
    MainStatusLabel.Text = "No Command/Request found."

    If MainSwitch Then
        Timer_AutomaticMode.Start()
    End If
End Sub

Private Sub Timer_Locate_Tick(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles Timer_Locate.Tick
    Timer_Locate.Stop()
    MainStatusLabel.Text = "GPS Coordinate found..... locating"

    Dim gpsN As Double
    Dim gpsE As Double
    gpsN = Val(message(messagelocation).Substring(8, 7))
    gpsE = Val(message(messagelocation).Substring(20, 8))
    locate(gpsN, gpsE)
End Sub

Private Sub locate(ByVal gpsN As Double, ByVal gpsE As Double)
    Dim myConn As New MySqlConnection
    Dim myCommand As New MySqlCommand
    Dim myData As MySqlDataReader
    Dim xloc As Integer
    Dim yloc As Integer
    myCommand.Connection = myConn
    myConn.ConnectionString = "server=localhost; user id=root;
password=dan; database=gps"

    Try
        myConn.Open()
    Catch ex As MySqlException
        MessageBox.Show("Error in opening database")
    End Try

    myCommand.CommandText = "select * from mapindex where gpsn=" &
gpsN & " and gpse=" & gpsE
```

```
        myData = myCommand.ExecuteReader
        If myData.HasRows = False Then
            myConn.Close()
            MessageBox.Show("The GPS location is out of range or currently not
available on the database.", "GPS Error", MessageBoxButtons.OK,
MessageBoxIcon.Error)
            nameloc = "Your vehicle location is out of coverage or not on the
database"
            Exit Sub
        Else
            MainStatusLabel.Text = "Location Found"

            myData.Read()
            LocationToolTip.ToolTipTitle = "N: " & myData(0).ToString & ", E: " &
myData(1).ToString
            xloc = myData(2)
            yloc = myData(3)
            nameloc = myData(4)
            myConn.Close()
            draw_point(xloc, yloc, nameloc)
        End If
    End Sub

    Private Sub draw_point(ByVal x As Integer, ByVal y As Integer, ByVal desc As
String)
        Dim coor As New Point(x, y)

        Dim mappage As Integer = 1
        Dim mapx, mapy As Integer

        mapx = Math.Truncate(x / 785)
        mapy = Math.Truncate(y / 526)


        If (mapx = 0 And mapy = 0) Then
            PictureBox1.Image =
Global.GPS_Tracking_and_Security.My.Resources._1
        ElseIf (mapx = 0 And mapy = 1) Then
            PictureBox1.Image =
Global.GPS_Tracking_and_Security.My.Resources._2
        ElseIf (mapx = 0 And mapy = 2) Then
            PictureBox1.Image =
Global.GPS_Tracking_and_Security.My.Resources._3
        ElseIf (mapx = 0 And mapy = 3) Then
```

```
            PictureBox1.Image =
Global.GPS_Tracking_and_Security.My.Resources._4
        ElseIf (mapx = 0 And mapy = 4) Then
            PictureBox1.Image =
Global.GPS_Tracking_and_Security.My.Resources._5
        ElseIf (mapx = 0 And mapy = 5) Then
            PictureBox1.Image =
Global.GPS_Tracking_and_Security.My.Resources._6


        End If
        'convert x and y back to minimal values

        x = x - (mapx * 785)
        y = y - (mapy * 526)

        coor = New Point(x, y)

        If x = 0 And y = 0 Then
            MessageBox.Show("Your vehicle is at " + desc + ". But it is outside the
map area!", "Information", MessageBoxButtons.OK,
MessageBoxIcon.Information)
        Else
            LocationToolTip.Show("Your vehicle is at " + desc, PictureBox1, coor)
            LocationToolTip.Show("Your vehicle is at " + desc, PictureBox1, coor)
        End If
    End Sub

    Private Sub btnLocate_Click(ByVal sender As System.Object, ByVal e As
System.EventArgs) Handles btnLocate.Click
        locate(Val(txtGPSN.Text), Val(txtGPSE.Text))
    End Sub

    Private Sub Timer_SendingMes_Tick(ByVal sender As System.Object, ByVal e
As System.EventArgs) Handles Timer_SendingMes.Tick
        Timer_SendingMes.Stop()
        MainStatusLabel.Text = "Sending Location to " + default_mobile_no
        Dim SMSPort As New SerialPort
        With SMSPort
            .PortName = usbport
            .BaudRate = 115200
            .Parity = Parity.None
            .DataBits = 8
            .StopBits = StopBits.One
```

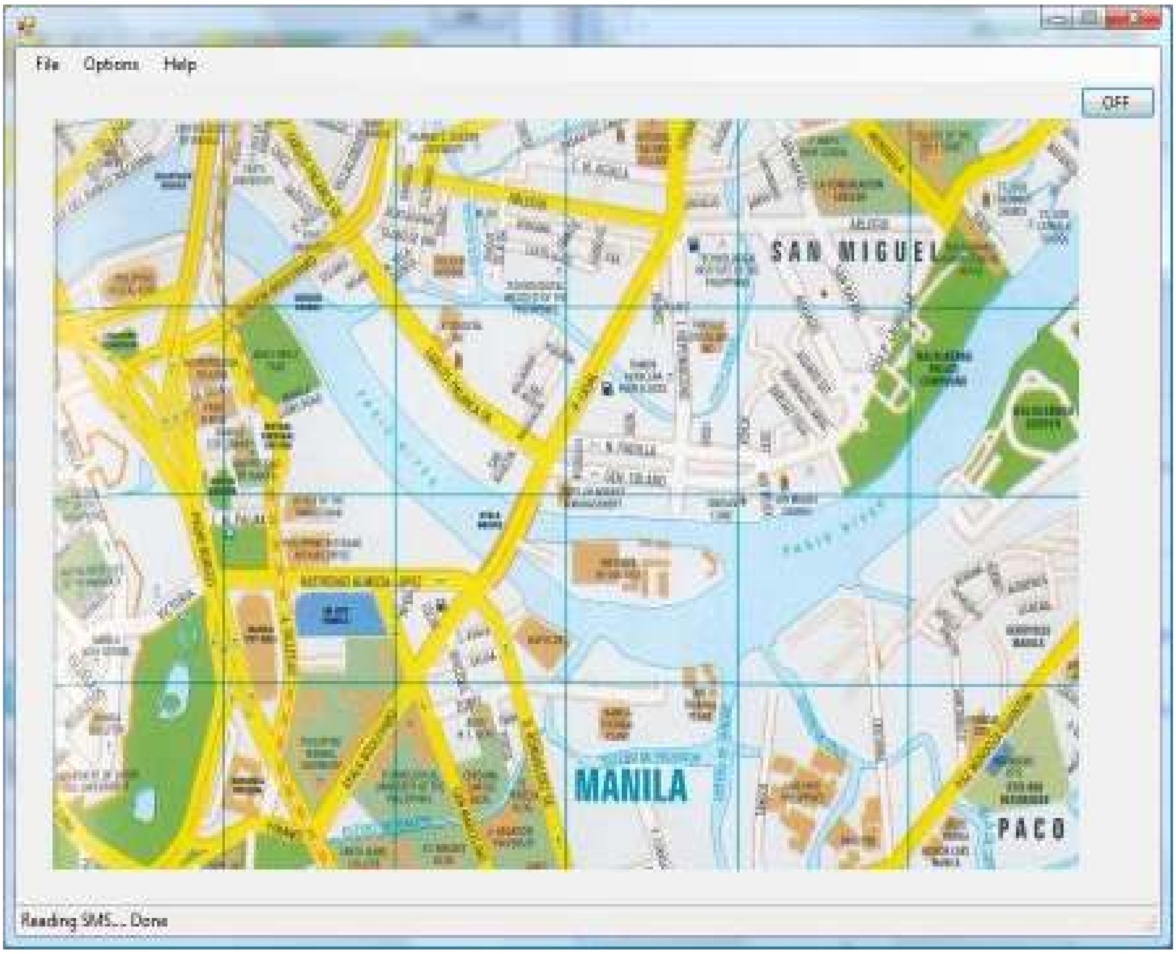
```
            .Handshake = Handshake.None
            .DtrEnable = False
            .RtsEnable = False
            .NewLine = vbCrLf
        End With
        SMSPort.Open()
        SMSPort.WriteLine("AT+CMGF=1")
        Threading.Thread.Sleep(100)
        SMSPort.WriteLine("AT+CMGS=""" & default_mobile_no & """")
        SMSPort.WriteLine("Your vehicle is at " & nameloc & "." & Chr(26))
        Threading.Thread.Sleep(100)
        SMSPort.Close()
        MainStatusLabel.Text = "Message sent."

        If MainSwitch Then
            Timer_AutomaticMode.Start()
        End If

    End Sub

    Private Sub Timer_SendingCommand_Tick(ByVal sender As System.Object,
ByVal e As System.EventArgs) Handles Timer_SendingCommand.Tick
        Timer_SendingCommand.Stop()
        MainStatusLabel.Text = "Sending commands to device..."

        Dim SMSPort As New SerialPort
        With SMSPort
            .PortName = usbport
            .BaudRate = 115200
            .Parity = Parity.None
            .DataBits = 8
            .StopBits = StopBits.One
            .Handshake = Handshake.None
            .DtrEnable = False
            .RtsEnable = False
            .NewLine = vbCrLf
        End With
        SMSPort.Open()
        SMSPort.WriteLine("AT+CMGF=1")
        Threading.Thread.Sleep(100)
        SMSPort.WriteLine("AT+CMGS=""" & gps_mobile_no & """")
        SMSPort.WriteLine(command & Chr(26))
        Threading.Thread.Sleep(100)
        SMSPort.Close()
```

```
        MainStatusLabel.Text = "Command Message Sent."

        If MainSwitch Then
            Timer_AutomaticMode.Start()
        End If
    End Sub

    Private Sub clear_messages()

        For index As Integer = 0 To 4
            message(index) = String.Empty
            mobile_no(index) = String.Empty
        Next

    End Sub
End Class
```

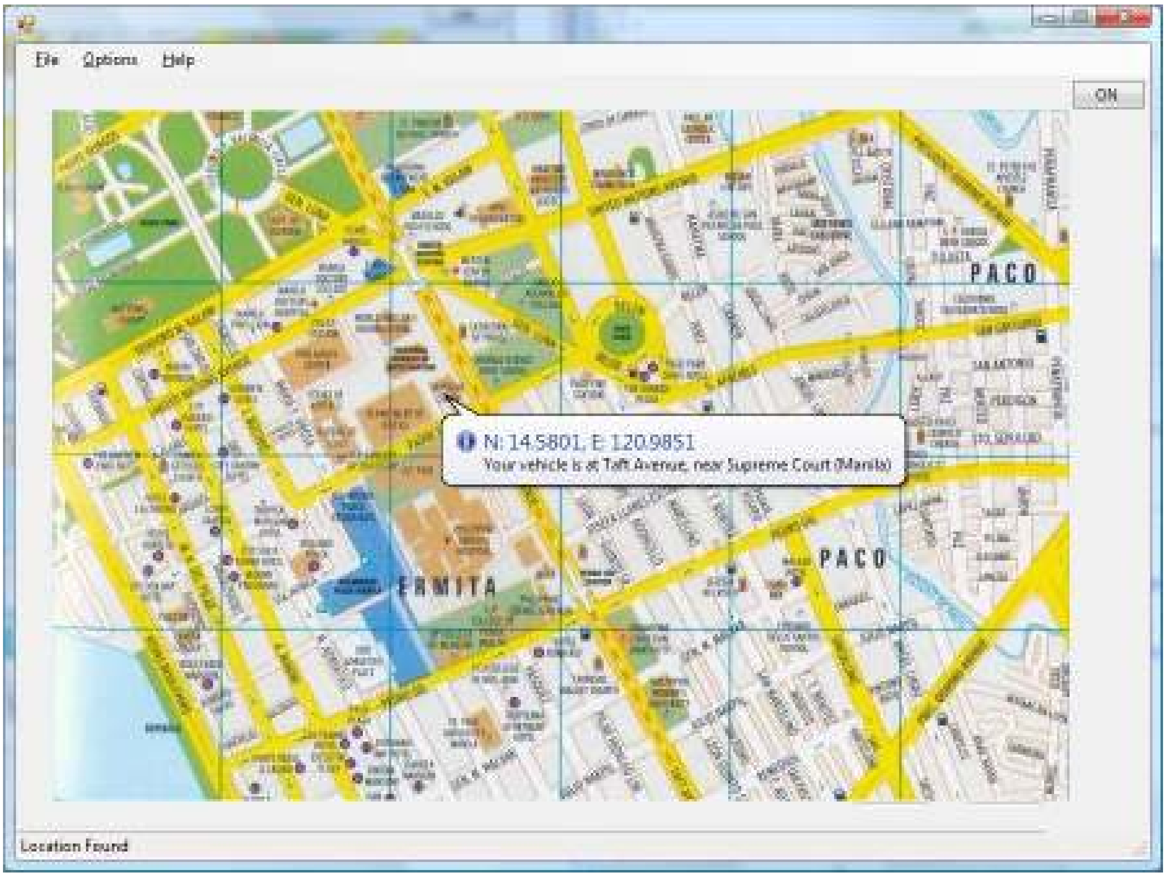
APPENDIX D

SERVER SOFTWARE SCREENSHOTS

Server waiting for request:



GPS Request:


File Options Help
ON
PACO
ERMITA
PACO
N: 14.5801, E: 120.9851
Your vehicle is at Taft Avenue, near Supreme Court (Manila)
Location Found

APPENDIX E

PROTOTYPE PICTURES

Front View:

Top View:

APPENDIX F
SYSTEM REQUIREMENTS

System Requirements:

OS - Windows XP or Windows Vista

Processor – 1.0 GHz or faster (XP) or 2.0 GHz or faster (Vista)

Memory - 1.0 GB RAM (XP) or 2 GB RAM (Vista)

Hard Drive – 20MB free space

Microsoft .Net Framework 3 or higher

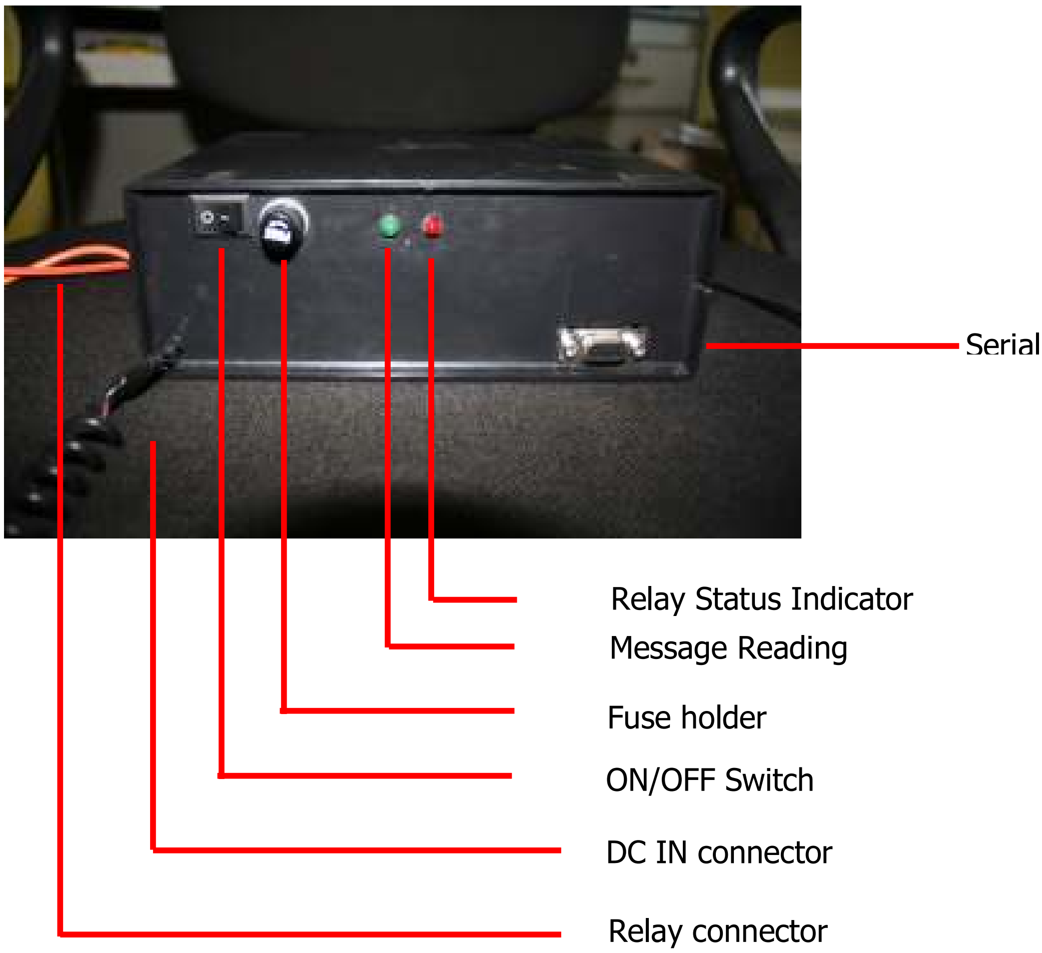
Mysql version 6.0 or higher

Usb 2.0 port

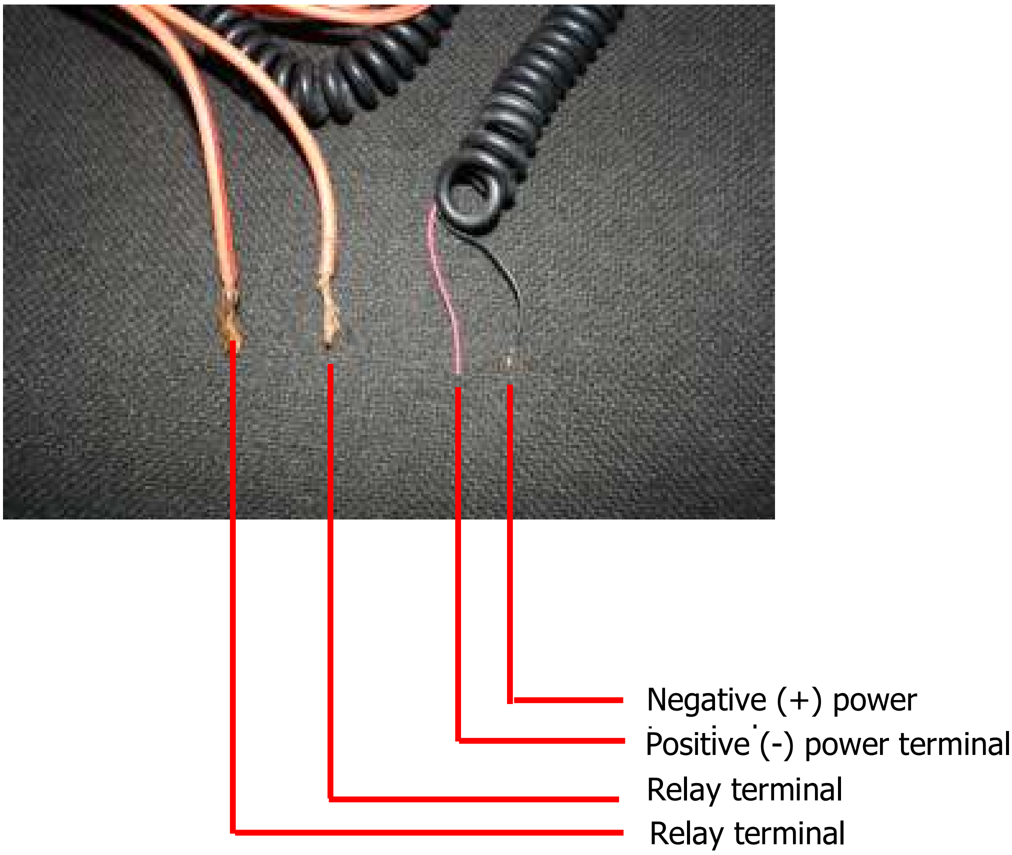
Globe Tattoo GSM

APPENDIX G
USER'S MANUAL AND INSTALLATION GUIDE

Part Names
System front



System wiring

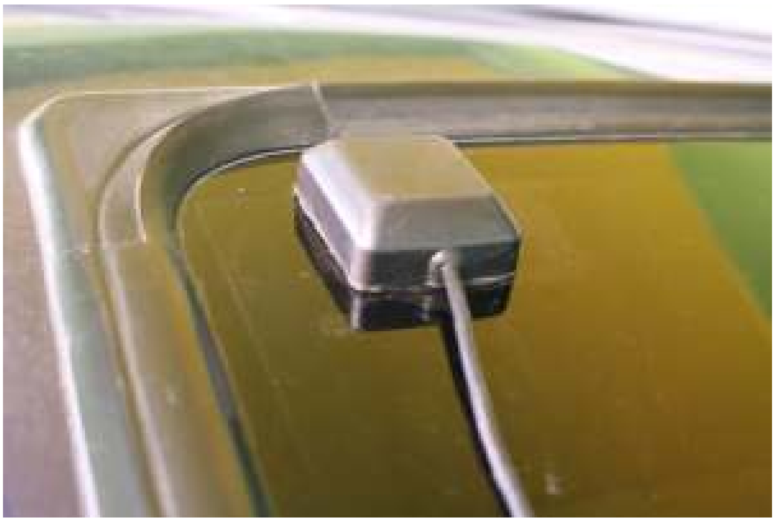


Installation

1. Find a secured place in the vehicle where the device can be mounted.
2. Located the device wiring as shown above.
3. Connect the Positive (+) terminal to the vehicle's positive power supply that is directly connected to the vehicle's battery.
4. Connect the Negative (-) terminal to any part of vehicle's body. (Example: bolts, screws, etc.)
5. Cut off the ignition wire of the vehicle that is coming to the ignition switch.
6. Connect the other end of the ignition wire to a single relay terminal and connect the other end to the remaining relay terminal.

Caution: Ask for a help to an authorize auto-electrician for locating the wire needed to be cut off. Incorrect wiring connection could damage the vehicle electrical operation.

System Antenna



Note: System antenna must be connected outside the vehicle's body and must always be facing towards the sky.

Getting Started

1. Turn on the system switch.
2. The relay status indicator will tell where the system is at ON or OFF state.
3. Wait for about 1-2 minutes for GPS initialization.
4. When the device is ready the reading message indicator will lit up every 3-5 seconds.
5. The system is now ready for any operation

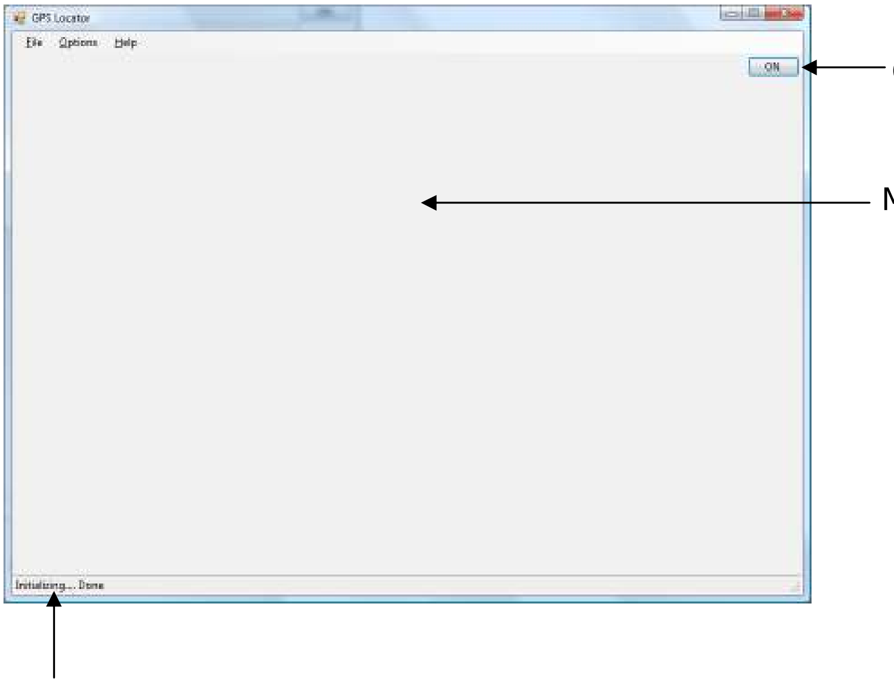
Software Installation

System Requirements:
OS- Windows XP or Windows Vista
Processor – 1.0 GHz or faster (XP) or 2.0 GHz or faster (Vista)
Memory - 1.0 GB RAM (XP) or 2 GB RAM (Vista)
Hard Drive – 20MB free space
Microsoft .Net Framework 3 or higher
Mysql version 6.0 or higher
Usb 2.0 port
Globe Tattoo GSM

Preparing your computer

1. Insert your Globe Tattoo GSM to any available USB port.
2. Extract the file GPS.zip to C:\ of the computer that will be used as a server.
3. Run windows command prompt and input "mysql –u root –p C:\GPS\gpsdata.sql and press enter.
4. Input a password if applicable.
5. Open the location C:\GPS\GPSstart.exe
6. The GPS locator program will now run.

Getting Started
User Interface



ON/OFF Button

Map display

Status indicator

1. Click the On/OFF button.
2. The status indicator will display whether the system is on or off.
3. Once the system is on, the system will continuously read message from the SIM inside the Globe Tattoo GSM.

Note: It is normal that map display is empty upon running the program for the first time. Map will be display if the system recognizes the coordinate being read.
Note: The server's texting number will be same as the SIM card number inserting into the Globe Tattoo GSM.

System Functions

GPS Request

Send a message to the server starting with <GPSREQ> to request for the vehicle location.
A reply message indicating the vehicle's exact location will be reply to the requestor.

Engine OFF

Send a message to the server starting with <OFFENG> to request for a vehicle engine off function.
A reply message indicating the vehicle's engine off confirmation will be reply to the requestor.

Engine ON

Send a message to the server staring with <ONENG> to request for a vehicle engine on function.
A reply message indicating the vehicle's engine on confirmation will be reply to the requestor.

Note: Command messages can be only send if the program is on. Otherwise it will not trigger any action.

APPENDIX H
DATASHEETS

FAIRCHILD
SEMICONDUCTOR®

May 2009

1N4001 - 1N4007
General Purpose Rectifiers

Features
- Low forward voltage drop.
- High surge current capability.

DO-41
COLOR BAND DENOTES CATHODE

Absolute Maximum Ratings * $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Value							Units
		4001	4002	4003	4004	4005	4006	4007	
V_{RRM}	Peak Repetitive Reverse Voltage	50	100	200	400	600	800	1000	V
$I_{F(AV)}$	Average Rectified Forward Current .375 " lead length @ $T_A = 75°C$	1.0							A
I_{FSM}	Non-Repetitive Peak Forward Surge Current 8.3ms Single Half-Sine-Wave	30							A
I^2t	Rating for Fusing (t<8.3ms)	3.7							A^2sec
T_{STG}	Storage Temperature Range	-55 to +175							°C
T_J	Operating Junction Temperature	-55 to +175							°C

* These ratings are limiting values above which the serviceability of any semiconductor device may by impaired.

Thermal Characteristics

Symbol	Parameter	Value	Units
P_D	Power Dissipation	3.0	W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	50	°C/W

Electrical Characteristics $T_A = 25°C$ unless otherwise noted

Symbol	Parameter	Value	Units
V_F	Forward Voltage @ 1.0A	1.1	V
I_{rr}	Maximum Full Load Reverse Current, Full Cycle $T_A = 75°C$	30	μA
I_R	Reverse Current @ Rated V_R $T_A = 25°C$ $T_A = 100°C$	5.0 50	μA μA
C_T	Total Capacitance $V_R = 4.0V$, f = 1.0MHz	15	pF

Typical Performance Characteristics

Figure 1. Forward Current Derating Curve

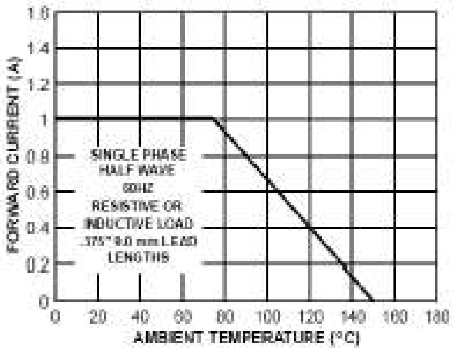


Figure 2. Forward Characteristics

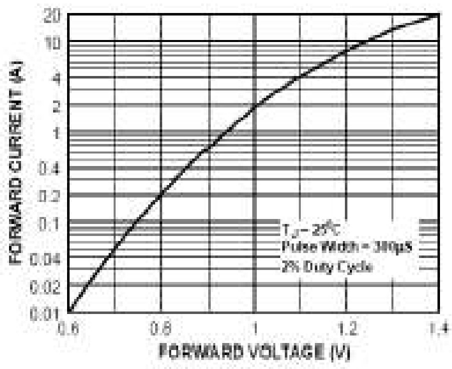


Figure 3. Non-Repetitive Surge Current

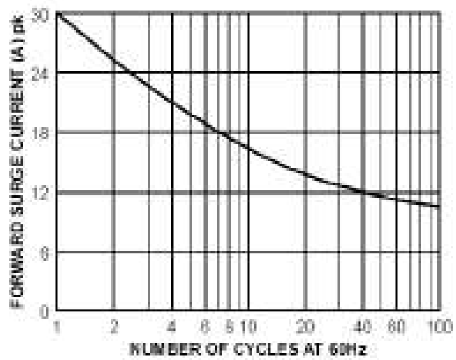
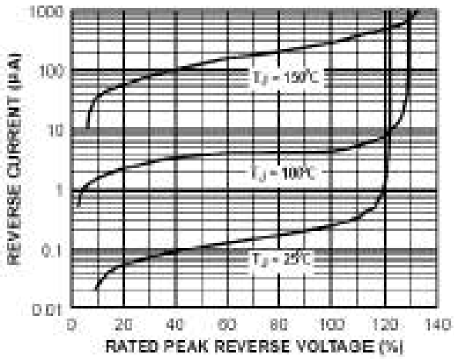
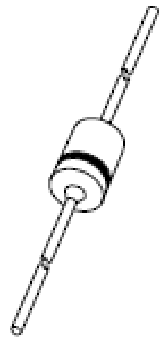


Figure 4. Reverse Characteristics



DATA SHEET



1N4148; 1N4448
High-speed diodes

Product specification 2002 Jan 23
Supersedes data of 1999 May 25

Philips
Semiconductors

PHILIPS

High-speed diodes 1N4148; 1N4448

FEATURES

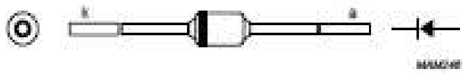
- Hermetically sealed leaded glass SOD27 (DO-35) package
- High switching speed: max. 4 ns
- General application
- Continuous reverse voltage: max. 75 V
- Repetitive peak reverse voltage: max. 100 V
- Repetitive peak forward current: max. 450 mA.

APPLICATIONS

- High-speed switching.

DESCRIPTION

The 1N4148 and 1N4448 are high-speed switching diodes fabricated in planar technology, and encapsulated in hermetically sealed leaded glass SOD27 (DO-35) packages.



The diodes are type branded.

Fig.1 Simplified outline (SOD27; DO-35) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{RRM}	repetitive peak reverse voltage		–	100	V
V_R	continuous reverse voltage		–	75	V
I_F	continuous forward current	see Fig.2; note 1	–	200	mA
I_{FRM}	repetitive peak forward current		–	450	mA
I_{FSM}	non-repetitive peak forward current	square wave; T_j = 25 °C prior to surge; see Fig.4			
		t = 1 µs	–	4	A
		t = 1 ms	–	1	A
		t = 1 s	–	0.5	A
P_{tot}	total power dissipation	T_{amb} = 25 °C; note 1	–	500	mW
T_{stg}	storage temperature		−65	+200	°C
T_j	junction temperature		–	200	°C

Note

1. Device mounted on an FR4 printed circuit-board; lead length 10 mm.

High-speed diodes 1N4148; 1N4448

ELECTRICAL CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_F	forward voltage	see Fig.3			
	1N4148	I_F = 10 mA	–	1	V
	1N4448	I_F = 5 mA	0.62	0.72	V
		I_F = 100 mA	–	1	V
I_R	reverse current	V_R = 20 V; see Fig.5		25	nA
		V_R = 20 V; T_j = 150 °C; see Fig.5	–	50	µA
I_R	reverse current; 1N4448	V_R = 20 V; T_j = 100 °C; see Fig.5	–	3	µA
C_d	diode capacitance	f = 1 MHz; V_R = 0; see Fig.6	–	4	pF
t_{rr}	reverse recovery time	when switched from I_F = 10 mA to I_R = 60 mA; R_L = 100 Ω; measured at I_R = 1 mA; see Fig.7	–	4	ns
V_{fr}	forward recovery voltage	when switched from I_F = 50 mA; t_r = 20 ns; see Fig.8	–	2.5	V

THERMAL CHARACTERISTICS

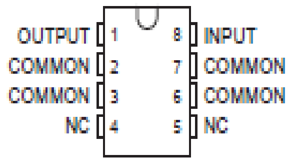
SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j\text{-}tp}$	thermal resistance from junction to tie-point	lead length 10 mm	240	K/W
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	lead length 10 mm; note 1	350	K/W

Note

1. Device mounted on a printed circuit-board without metallization pad.

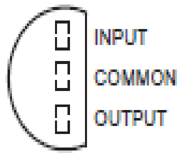
- 3-Terminal Regulators
- Output Current up to 100 mA
- No External Components
- Internal Thermal-Overload Protection
- Internal Short-Circuit Current Limiting
- Direct Replacements for Fairchild µA78L00 Series

D PACKAGE
(TOP VIEW)



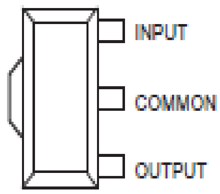
NC – No internal connection

LP PACKAGE
(TOP VIEW)



TO–226AA

PK PACKAGE
(TOP VIEW)



description

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used with power-pass elements to make high-current voltage regulators. One of these regulators can deliver up to 100 mA of output current. The internal limiting and thermal-shutdown features of these regulators make them essentially immune to overload. When used as a replacement for a zener diode-resistor combination, an effective improvement in output impedance can be obtained, together with lower bias current.

The µA78L00C series is characterized for operation over the virtual junction temperature range of 0°C to 125°C.

AVAILABLE OPTIONS

T_J	$V_{O(NOM)}$ (V)	PACKAGED DEVICES						CHIP FORM (Y)
		SMALL OUTLINE (D)		PLASTIC CYLINDRICAL (LP)		SOT-89 (PK)		
		OUTPUT VOLTAGE TOLERANCE						
		5%	10%	5%	10%	5%	10%	
0°C to 125°C	2.6	µA78L02ACD	–	µA78L02ACLP	µA78L02CLP	µA78L02ACPK	µA78L02CPK	µA78L02Y
	5	µA78L05ACD	µA78L05CD	µA78L05ACLP	µA78L05CLP	µA78L05ACPK	µA78L05CPK	µA78L05Y
	6.2	µA78L06ACD	µA78L06CD	µA78L06ACLP	µA78L06CLP	µA78L06ACPK	µA78L06CPK	µA78L06Y
	8	µA78L08ACD	µA78L08CD	µA78L08ACLP	µA78L08CLP	µA78L08ACPK	µA78L08CPK	µA78L08Y
	9	µA78L09ACD	µA78L09CD	µA78L09ACLP	µA78L09CLP	µA78L09ACPK	µA78L09CPK	µA78L09Y
	10	µA78L10ACD	–	µA78L10ACLP	µA78L10CLP	µA78L10ACPK	µA78L10CPK	µA78L10Y
	12	µA78L12ACD	µA78L12CD	µA78L12ACLP	µA78L12CLP	µA78L12ACPK	µA78L12CPK	µA78L12Y
	15	µA78L15ACD	µA78L15CD	µA78L15ACLP	µA78L15CLP	µA78L15ACPK	µA78L15CPK	µA78L15Y

D and LP packages are available taped and reeled. Add the suffix R to the device type (e.g., µA78L05ACDR). The PK package is only available taped and reeled (e.g., µA78L02ACPKR). Chip forms are tested at T_A = 25°C.

electrical characteristics at specified virtual junction temperature, V_I = 9 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA78L02C MIN	µA78L02C TYP	µA78L02C MAX	UNIT
Output voltage	V_I = 4.75 V to 20 V, I_O = 1 mA to 40 mA	25°C	2.5	2.6	2.7	V
		0°C to 125°C	2.45		2.75	
	I_O = 1 mA to 70 mA	0°C to 125°C	2.45		2.75	
Input voltage regulation	V_I = 4.75 V to 20 V	25°C		20	100	mV
	V_I = 5 V to 20 V			16	75	
Ripple rejection	V_I = 6 V to 20 V, f = 120 Hz	25°C	43	51		dB
Output voltage regulation	I_O = 1 mA to 100 mA	25°C		12	50	mV
	I_O = 1 mA to 40 mA			6	25	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		30		µV
Dropout voltage		25°C		1.7		V
Bias current		25°C		3.6	6	mA
		125°C			5.5	
Bias current change	V_I = 5 V to 20 V	0°C to 125°C			2.5	mA
	I_O = 1 mA to 40 mA				0.1	

† Pulse-testing techniques maintain T_J as close to T_A as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.

electrical characteristics at specified virtual junction temperature, V_I = 10 V, I_O = 40 mA (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T_J†	µA78L05C MIN	µA78L05C TYP	µA78L05C MAX	µA78L05AC MIN	µA78L05AC TYP	µA78L05AC MAX	UNIT
Output voltage	V_I = 7 V to 20 V, I_O = 1 mA to 40 mA	25°C	4.6	5	5.4	4.8	5	5.2	V
		0°C to 125°C	4.5		5.5	4.75		5.25	
	I_O = 1 mA to 70 mA	0°C to 125°C	4.5		5.5	4.75		5.25	
Input voltage regulation	V_I = 7 V to 20 V	25°C		32	200		32	150	mV
	V_I = 8 V to 20 V			26	150		26	100	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	25°C	40	49		41	49		dB
Output voltage regulation	I_O = 1 mA to 100 mA	25°C		15	60		15	60	mV
	I_O = 1 mA to 40 mA			8	30		8	30	
Output noise voltage	f = 10 Hz to 100 kHz	25°C		42			42		µV
Dropout voltage		25°C		1.7			1.7		V
Bias current		25°C		3.8	6		3.8	6	mA
		125°C			5.5			5.5	
Bias current change	V_I = 8 V to 20 V	0°C to 125°C			1.5			1.5	mA
	I_O = 1 mA to 40 mA				0.2			0.1	

† Pulse-testing techniques maintain T_J as close to T_A as possible. Thermal effects must be taken into account separately. All characteristics are measured with a 0.33-µF capacitor across the input and a 0.1-µF capacitor across the output.

19-4323; Rev 11; 2/03

MAXIM

+5V-Powered, Multichannel RS-232 Drivers/Receivers

MAX220–MAX249

General Description

The MAX220–MAX249 family of line drivers/receivers is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where ±12V is not available.

These parts are especially useful in battery-powered systems, since their low-power shutdown mode reduces power dissipation to less than 5μW. The MAX225, MAX233, MAX235, and MAX245/MAX246/MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multidrop RS-232 Networks

Features

Superior to Bipolar

- ♦ Operate from Single +5V Power Supply (+5V and +12V—MAX231/MAX239)
- ♦ Low-Power Receive Mode in Shutdown (MAX223/MAX242)
- ♦ Meet All EIA/TIA-232E and V.28 Specifications
- ♦ Multiple Drivers and Receivers
- ♦ 3-State Driver and Receiver Outputs
- ♦ Open-Line Detection (MAX243)

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220EJE	-40°C to +85°C	16 CERDIP
MAX220MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.

*Contact factory for dice specifications.

Selection Table

Part Number	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (μF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
MAX220	+5	2/2	4	0.1	No	—	120	Ultra-low-power, industry-standard pinout
MAX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
MAX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✔	120	MAX241 and receivers active in shutdown
MAX225	+5	5/5	0	—	Yes	✔	120	Available in SO
MAX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
MAX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
MAX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
MAX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
MAX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
MAX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
MAX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
MAX236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
MAX237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
MAX238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
MAX240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
MAX241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
MAX242	+5	2/2	4	0.1	Yes	✔	200	Separate shutdown and enable
MAX243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
MAX244	+5	8/10	4	1.0	No	—	120	High slew rate
MAX245	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, two shutdown modes
MAX246	+5	8/10	0	—	Yes	✔	120	High slew rate, int. caps, three shutdown modes
MAX247	+5	8/9	0	—	Yes	✔	120	High slew rate, int. caps, nine operating modes
MAX248	+5	8/8	4	1.0	Yes	✔	120	High slew rate, selective half-chip enables
MAX249	+5	6/10	4	1.0	Yes	✔	120	Available in quad flatpack package

+5V-Powered, Multichannel RS-232 Drivers/Receivers

ABSOLUTE MAXIMUM RATINGS—MAX220/222/232A/233A/242/243

Supply Voltage (V_{CC}) ....-0.3V to +6V
Input Voltages
T_{IN}..-0.3V to (V_{CC} - 0.3V)
R_{IN} (Except MAX220) ....±30V
R_{IN} (MAX220)..±25V
T_{OUT} (Except MAX220) (Note 1) ....±15V
T_{OUT} (MAX220)...±13.2V
Output Voltages
T_{OUT}..±15V
R_{OUT}...................................-0.3V to (V_{CC} + 0.3V)
Driver/Receiver Output Short Circuited to GND........Continuous
Continuous Power Dissipation (T_A = +70°C)
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C)....842mW
18-Pin Plastic DIP (derate 11.11mW/°C above +70°C)....889mW
20-Pin Plastic DIP (derate 8.00mW/°C above +70°C) ..440mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C) ...696mW
16-Pin Wide SO (derate 9.52mW/°C above +70°C)......762mW
18-Pin Wide SO (derate 9.52mW/°C above +70°C)......762mW
20-Pin Wide SO (derate 10.00mW/°C above +70°C)....800mW
20-Pin SSOP (derate 8.00mW/°C above +70°C) 640mW
16-Pin CERDIP (derate 10.00mW/°C above +70°C).....800mW
18-Pin CERDIP (derate 10.53mW/°C above +70°C).....842mW
Operating Temperature Ranges
MAX2_ _AC_ _, MAX2_ _C_ _..............................0°C to +70°C
MAX2_ _AE_ _, MAX2_ _E_ _ ....-40°C to +85°C
MAX2_ _AM_ _, MAX2_ _M_ _ ....-55°C to +125°C
Storage Temperature Range.............................-65°C to +160°C
Lead Temperature (soldering, 10s) ....+300°C

Note 1: Input voltage measured with T_{OUT} in high-impedance state, $\overline{SHDN}$ or V_{CC} = 0V.
Note 2: For the MAX220, V+ and V- can have a maximum magnitude of 7V, but their absolute difference cannot exceed 13V.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243

(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

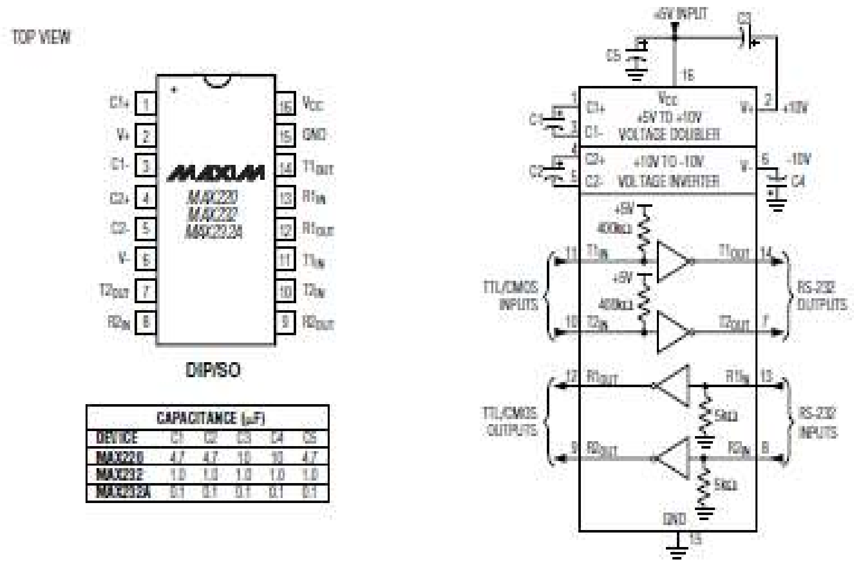
PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±8		V
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High	All devices except MAX220		2	1.4		V
	MAX220: V_{CC} = 5.0V		2.4			
Logic Pull-Up/Input Current	All except MAX220, normal operation			5	40	µA
	$\overline{SHDN}$ = 0V, MAX222/242, shutdown, MAX220			±0.01	±1	
Output Leakage Current	V_{CC} = 5.5V, $\overline{SHDN}$ = 0V, V_{OUT} = ±15V, MAX222/242			±0.01	±10	µA
	V_{CC} = $\overline{SHDN}$ = 0V, V_{OUT} = ±15V			±0.01	±10	
Data Rate				200	116	kbps
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V		±7	±22		mA
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±30	V
RS-232 Input Threshold Low	V_{CC} = 5V	All except MAX243 $R2_{IN}$	0.8	1.3		V
		MAX243 $R2_{IN}$ (Note 2)	-3			
RS-232 Input Threshold High	V_{CC} = 5V	All except MAX243 $R2_{IN}$		1.8	2.4	V
		MAX243 $R2_{IN}$ (Note 2)		-0.5	-0.1	
RS-232 Input Hysteresis	All except MAX243, V_{CC} = 5V, no hysteresis in shdn.		0.2	0.5	1	V
	MAX243			1		
RS-232 Input Resistance			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC} - 0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Shrinking V_{OUT} = V_{CC}		10	30		

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243 (continued)

(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
TTL/CMOS Output Leakage Current	$\overline{SHDN}$ = V_{CC} or $\overline{EN}$ = V_{CC} ($\overline{SHDN}$ = 0V for MAX222), 0V ≤ V_{OUT} ≤ V_{CC}			±0.05	±10	µA
$\overline{EN}$ Input Threshold Low	MAX242			1.4	0.8	V
$\overline{EN}$ Input Threshold High	MAX242		2.0	1.4		V
Operating Supply Voltage			4.5		5.5	V
V_{CC} Supply Current ($\overline{SHDN}$ = V_{CC}), Figures 5, 6, 11, 19	No load	MAX220		0.5	2	mA
		MAX222/232A/233A/242/243		4	10	
	3kΩ load both inputs	MAX220		12		
		MAX222/232A/233A/242/243		15		
Shutdown Supply Current	MAX222/242	T_A = +25°C		0.1	10	µA
		T_A = 0°C to +70°C		2	50	
		T_A = -40°C to +85°C		2	50	
		T_A = -55°C to +125°C		35	100	
$\overline{SHDN}$ Input Leakage Current	MAX222/242				±1	µA
$\overline{SHDN}$ Threshold Low	MAX222/242			1.4	0.8	V
$\overline{SHDN}$ Threshold High	MAX222/242		2.0	1.4		V
Transition Slew Rate	C_L = 50pF to 2500pF, R_L = 3kΩ to 7kΩ, V_{CC} = 5V, T_A = +25°C, measured from +3V to -3V or -3V to +3V	MAX222/232A/233A/242/243	6	12	30	V/µs
		MAX220	1.5	3	30	
Transmitter Propagation Delay TLL to RS-232 (Normal Operation), Figure 1	t_{PHLT}	MAX222/232A/233A/242/243		1.3	3.5	µs
		MAX220		4	10	
	t_{PLHT}	MAX222/232A/233A/242/243		1.5	3.5	
		MAX220		5	10	
Receiver Propagation Delay RS-232 to TLL (Normal Operation), Figure 2	t_{PHLR}	MAX222/232A/233A/242/243		0.5	1	µs
		MAX220		0.6	3	
	t_{PLHR}	MAX222/232A/233A/242/243		0.6	1	
		MAX220		0.8	3	
Receiver Propagation Delay RS-232 to TLL (Shutdown), Figure 2	t_{PHLS}	MAX242		0.5	10	µs
	t_{PLHS}	MAX242		2.5	10	
Receiver-Output Enable Time, Figure 3	t_{ER}	MAX242		125	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}	MAX242		160	500	ns
Transmitter-Output Enable Time ($\overline{SHDN}$ Goes High), Figure 4	t_{ET}	MAX222/242, 0.1µF caps (includes charge-pump start-up)		250		µs
Transmitter-Output Disable Time ($\overline{SHDN}$ Goes Low), Figure 4	t_{DT}	MAX222/242, 0.1µF caps		600		ns
Transmitter + to - Propagation Delay Difference (Normal Operation)	t_{PHLT} - t_{PLHT}	MAX222/232A/233A/242/243		300		ns
		MAX220		2000		
Receiver + to - Propagation Delay Difference (Normal Operation)	t_{PHLR} - t_{PLHR}	MAX222/232A/233A/242/243		100		ns
		MAX220		225		

Note 3: MAX243 $R2_{OUT}$ is guaranteed to be low when $R2_{IN}$ is ≥ 0V or is floating.



CAPACITANCE (µF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	4.7	4.7	10	10	4.7
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

Figure 5. MAX220/MAX232/MAX232A Pin Configuration and Typical Operating Circuit

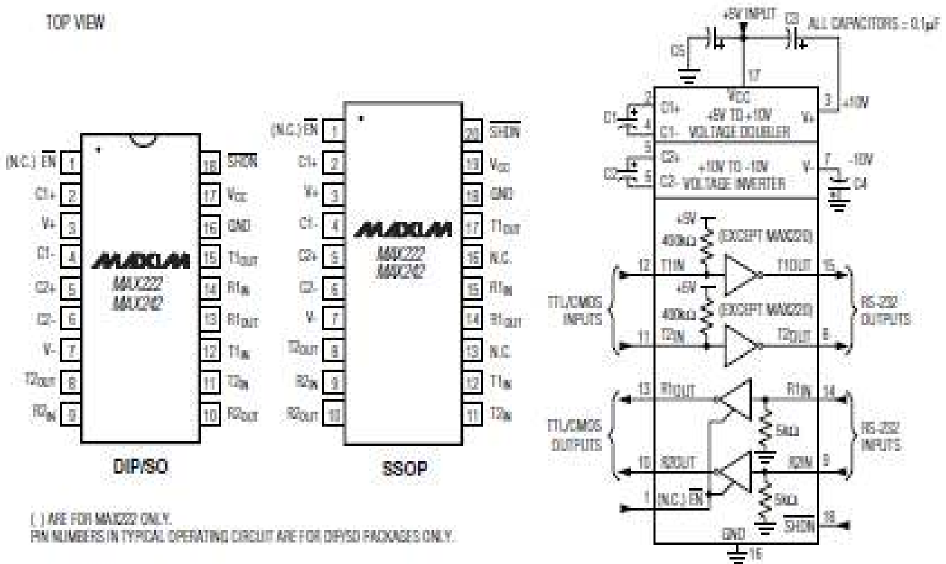


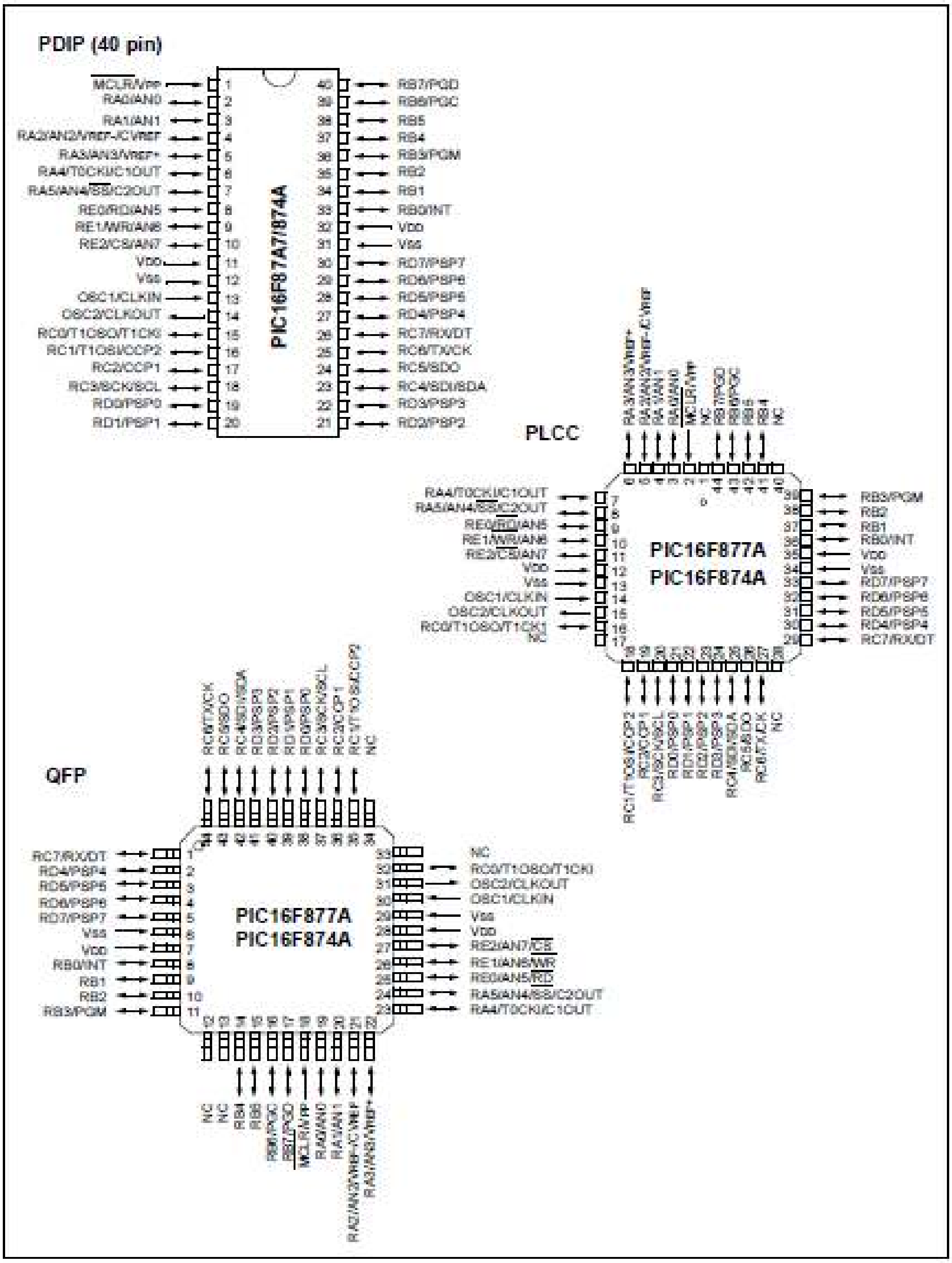
Figure 6. MAX222/MAX242 Pin Configurations and Typical Operating Circuit

PIC16F87XA
Data Sheet

28/40/44-Pin Enhanced Flash Microcontrollers

DS39582B

Pin Diagram


PDIP (40 pin)
PIC16F877A/874A
PLCC
PIC16F877A
PIC16F874A
QFP
PIC16F877A
PIC16F874A

17.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Ambient temperature under bias .... -55 to +125°C

Storage temperature .... -65°C to +150°C

Voltage on any pin with respect to V_{SS} (except V_{DD}, $\overline{MCLR}$, and RA4) .... -0.3V to (V_{DD} + 0.3V)

Voltage on V_{DD} with respect to V_{SS} .... -0.3 to +7.5V

Voltage on $\overline{MCLR}$ with respect to V_{SS} **(Note 2)** .... 0 to +14V

Voltage on RA4 with respect to V_{SS} .... 0 to +8.5V

Total power dissipation **(Note 1)** 1.0W

Maximum current out of V_{SS} pin .... 300 mA

Maximum current into V_{DD} pin .... 250 mA

Input clamp current, I_{IK} ($V_I < 0$ or $V_I > V_{DD}$) .... ± 20 mA

Output clamp current, I_{OK} ($V_O < 0$ or $V_O > V_{DD}$) .... ± 20 mA

Maximum output current sunk by any I/O pin .... 25 mA

Maximum output current sourced by any I/O pin .... 25 mA

Maximum current sunk by PORTA, PORTB and PORTE (combined) **(Note 3)** .... 200 mA

Maximum current sourced by PORTA, PORTB and PORTE (combined) **(Note 3)** .... 200 mA

Maximum current sunk by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Maximum current sourced by PORTC and PORTD (combined) **(Note 3)** .... 200 mA

Note 1: Power dissipation is calculated as follows: $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum(V_{OI} \times I_{OL})$

2: Voltage spikes below V_{SS} at the $\overline{MCLR}$ pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}$ pin rather than pulling this pin directly to V_{SS}.

3: PORTD and PORTE are not implemented on PIC16F873A/876A devices.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

17.1 DC Characteristics: PIC16F873A/874A/876A/877A (Industrial, Extended) PIC16LF873A/874A/876A/877A (Industrial)

PIC16LF873A/874A/876A/877A (Industrial)	**Standard Operating Conditions (unless otherwise stated)** Operating temperature $-40°C \le T_A \le +85°C$ for industrial
PIC16F873A/874A/876A/877A (Industrial, Extended)	**Standard Operating Conditions (unless otherwise stated)** Operating temperature $-40°C \le T_A \le +85°C$ for industrial $-40°C \le T_A \le +125°C$ for extended

Param No.	Symbol	Characteristic/ Device	Min	Typ†	Max	Units	Conditions
	VDD	**Supply Voltage**					
D001		16LF87XA	2.0	—	5.5	V	All configurations (DC to 10 MHz)
D001		16F87XA	4.0	—	5.5	V	All configurations
D001A			VBOR		5.5	V	BOR enabled, FMAX = 14 MHz[7]
D002	VDR	**RAM Data Retention Voltage**[1]	—	1.5	—	V	
D003	VPOR	**VDD Start Voltage** to ensure internal Power-on Reset signal	—	VSS	—	V	See **Section 14.5 "Power-on Reset (POR)"** for details
D004	SVDD	**VDD Rise Rate** to ensure internal Power-on Reset signal	0.05	—	—	V/ms	See **Section 14.5 "Power-on Reset (POR)"** for details
D005	VBOR	**Brown-out Reset Voltage**	3.65	4.0	4.35	V	BODEN bit in configuration word enabled

Legend: Rows with standard voltage device data only are shaded for improved readability.

† Data in "Typ" column is at 5V, 25°C, unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: This is the limit to which VDD can be lowered without losing RAM data.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors, such as I/O pin loading, switching rate, oscillator type, internal code execution pattern and temperature, also have an impact on the current consumption.
The test conditions for all IDD measurements in active operation mode are:
OSC1 = external square wave, from rail-to-rail; all I/O pins tri-stated, pulled to VDD;
MCLR = VDD; WDT enabled/disabled as specified.

3: The power-down current in Sleep mode does not depend on the oscillator type. Power-down current is measured with the part in Sleep mode, with all I/O pins in high-impedance state and tied to VDD and VSS.

4: For RC osc configuration, current through REXT is not included. The current through the resistor can be estimated by the formula Ir = VDD/2REXT (mA) with REXT in kΩ.

5: Timer1 oscillator (when enabled) adds approximately 20 μA to the specification. This value is from characterization and is for design guidance only. This is not tested.

6: The Δ current is the additional current consumed when this peripheral is enabled. This current should be added to the base IDD or IPD measurement.

7: When BOR is enabled, the device will operate correctly until the VBOR voltage trip point is reached.

17.1 DC Characteristics: PIC16F873A/874A/876A/877A (Industrial, Extended) PIC16LF873A/874A/876A/877A (Industrial) (Continued)

PIC16LF873A/874A/876A/877A (Industrial)			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial				
PIC16F873A/874A/876A/877A (Industrial, Extended)			**Standard Operating Conditions (unless otherwise stated)** Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended				
Param No.	**Symbol**	**Characteristic/ Device**	**Min**	**Typ†**	**Max**	**Units**	**Conditions**
	IDD	**Supply Current**(2,5)					
D010		16LF87XA	—	0.6	2.0	mA	XT, RC osc configurations, FOSC = 4 MHz, VDD = 3.0V
D010		16F87XA	—	1.6	4	mA	XT, RC osc configurations, FOSC = 4 MHz, VDD = 5.5V
D010A		16LF87XA	—	20	35	µA	LP osc configuration, FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D013		16F87XA	—	7	15	mA	HS osc configuration, FOSC = 20 MHz, VDD = 5.5V
D015	ΔIBOR	**Brown-out Reset Current**(6)	—	85	200	µA	BOR enabled, VDD = 5.0V

Legend: Rows with standard voltage device data only are shaded for improved readability.

† Data in "Typ" column is at 5V, 25°C, unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: This is the limit to which VDD can be lowered without losing RAM data.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors, such as I/O pin loading, switching rate, oscillator type, internal code execution pattern and temperature, also have an impact on the current consumption.
The test conditions for all IDD measurements in active operation mode are:
OSC1 = external square wave, from rail-to-rail; all I/O pins tri-stated, pulled to VDD;
$\overline{MCLR}$ = VDD; WDT enabled/disabled as specified.

3: The power-down current in Sleep mode does not depend on the oscillator type. Power-down current is measured with the part in Sleep mode, with all I/O pins in high-impedance state and tied to VDD and VSS.

4: For RC osc configuration, current through REXT is not included. The current through the resistor can be estimated by the formula Ir = VDD/2REXT (mA) with REXT in kΩ.

5: Timer1 oscillator (when enabled) adds approximately 20 µA to the specification. This value is from characterization and is for design guidance only. This is not tested.

6: The Δ current is the additional current consumed when this peripheral is enabled. This current should be added to the base IDD or IPD measurement.

7: When BOR is enabled, the device will operate correctly until the VBOR voltage trip point is reached.

17.2 DC Characteristics: PIC16F873A/874A/876A/877A (Industrial, Extended) PIC16LF873A/874A/876A/877A (Industrial)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended Operating voltage VDD range as described in DC specification (Section 17.1)				
Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	VIL	Input Low Voltage					
		I/O ports:					
D030		with TTL buffer	Vss	—	0.15 VDD	V	For entire VDD range
D030A			Vss	—	0.8V	V	4.5V ≤ VDD ≤ 5.5V
D031		with Schmitt Trigger buffer	Vss	—	0.2 VDD	V	
D032		MCLR, OSC1 (in RC mode)	Vss	—	0.2 VDD	V	
D033		OSC1 (in XT and LP modes)	Vss	—	0.3V	V	(Note 1)
		OSC1 (in HS mode)	Vss	—	0.3 VDD	V	
		Ports RC3 and RC4:		—			
D034		with Schmitt Trigger buffer	Vss	—	0.3 VDD	V	For entire VDD range
D034A		with SMBus	-0.5	—	0.6	V	For VDD = 4.5 to 5.5V
	VIH	Input High Voltage					
		I/O ports:		—			
D040		with TTL buffer	2.0	—	VDD	V	4.5V ≤ VDD ≤ 5.5V
D040A			0.25 VDD + 0.8V	—	VDD	V	For entire VDD range
D041		with Schmitt Trigger buffer	0.8 VDD	—	VDD	V	For entire VDD range
D042		MCLR	0.8 VDD	—	VDD	V	
D042A		OSC1 (in XT and LP modes)	1.6V	—	VDD	V	(Note 1)
		OSC1 (in HS mode)	0.7 VDD	—	VDD	V	
D043		OSC1 (in RC mode)	0.9 VDD	—	VDD	V	
		Ports RC3 and RC4:					
D044		with Schmitt Trigger buffer	0.7 VDD	—	VDD	V	For entire VDD range
D044A		with SMBus	1.4	—	5.5	V	For VDD = 4.5 to 5.5V
D070	IPURB	PORTB Weak Pull-up Current	50	250	400	μA	VDD = 5V, VPIN = VSS, -40°C TO +85°C
	IIL	Input Leakage Current(2, 3)					
D060		I/O ports	—	—	±1	μA	VSS ≤ VPIN ≤ VDD, pin at high-impedance
D061		MCLR, RA4/T0CKI	—	—	±5	μA	VSS ≤ VPIN ≤ VDD
D063		OSC1	—	—	±5	μA	VSS ≤ VPIN ≤ VDD, XT, HS and LP osc configuration

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: In RC oscillator configuration, the OSC1/CLKI pin is a Schmitt Trigger input. It is not recommended that the PIC16F87XA be driven with external clock in RC mode.

2: The leakage current on the MCLR pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

3: Negative current is defined as current sourced by the pin.

17.2 DC Characteristics: PIC16F873A/874A/876A/877A (Industrial, Extended) PIC16LF873A/874A/876A/877A (Industrial) (Continued)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended Operating voltage VDD range as described in DC specification (Section 17.1)				
Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	VOL	**Output Low Voltage**					
D080		I/O ports	—	—	0.6	V	IOL = 8.5 mA, VDD = 4.5V, -40°C to +85°C
D083		OSC2/CLKO (RC osc config)	—	—	0.6	V	IOL = 1.6 mA, VDD = 4.5V, -40°C to +85°C
	VOH	**Output High Voltage**					
D090		I/O ports(3)	VDD – 0.7	—	—	V	IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C
D092		OSC2/CLKO (RC osc config)	VDD – 0.7	—	—	V	IOH = -1.3 mA, VDD = 4.5V, -40°C to +85°C
D150*	VOD	**Open-Drain High Voltage**	—	—	8.5	V	RA4 pin
		Capacitive Loading Specs on Output Pins					
D100	COSC2	OSC2 pin	—	—	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1
D101	CIO	All I/O pins and OSC2 (RC mode)	—	—	50	pF	
D102	CB	SCL, SDA (I^2C mode)	—	—	400	pF	
		Data EEPROM Memory					
D120	ED	Endurance	100K	1M	—	E/W	-40°C to +85°C
D121	VDRW	VDD for read/write	VMIN	—	5.5	V	Using EECON to read/write, VMIN = min. operating voltage
D122	TDEW	Erase/write cycle time	—	4	8	ms	
		Program Flash Memory					
D130	EP	Endurance	10K	100K	—	E/W	-40°C to +85°C
D131	VPR	VDD for read	VMIN	—	5.5	V	VMIN = min. operating voltage
D132A		VDD for erase/write	VMIN	—	5.5	V	Using EECON to read/write, VMIN = min. operating voltage
D133	TPEW	Erase/Write cycle time	—	4	8	ms	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: In RC oscillator configuration, the OSC1/CLKI pin is a Schmitt Trigger input. It is not recommended that the PIC16F87XA be driven with external clock in RC mode.

2: The leakage current on the $\overline{MCLR}$ pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

3: Negative current is defined as current sourced by the pin.

500mA Low Dropout Positive Voltage Regulator

General Description

The RT9163 is a positive low dropout regulator designed for applications requiring low dropout performance at full rated current. The device is available in fixed output voltage of 3.3V, 3.5V, and 5.0V. The RT9163 provides excellent regulation over line, load, and temperature variations.

The other features include low dropout performance at a maximum of 1.4V at 500mA, fast transient response, internal current limiting, and thermal shutdown protection of the output devices. The RT9163 is a three-terminal regulator available in surface mount SOT-89, SOT-223, and TO-252 packages.

Ordering Information

RT9163-□□ □ □

Package Type
ZL : TO-92 (L-Type)
X : SOT-89
XL : SOT-89 (L-Type)
L : TO-252
G : SOT-223 (Type-I)
GL : SOT-223 (Type-II)
GT : SOT-223 Type-III)
GF : SOT-223 (Type-IV)

Operating Temperature Range
P : Pb Free with Commercial Standard
G : Green (Halogen Free with Commercial Standard)

Output Voltage
33 : 3.3V
35 : 3.5V
50 : 5.0V

Note :
RichTek Pb-free and Green products are :
- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.
- Suitable for use in SnPb or Pb-free soldering processes.
- 100%matte tin (Sn) plating.

Marking Information

For marking information, contact our sales representative directly or through a RichTek distributor located in your area, otherwise visit our website for detail.

Features

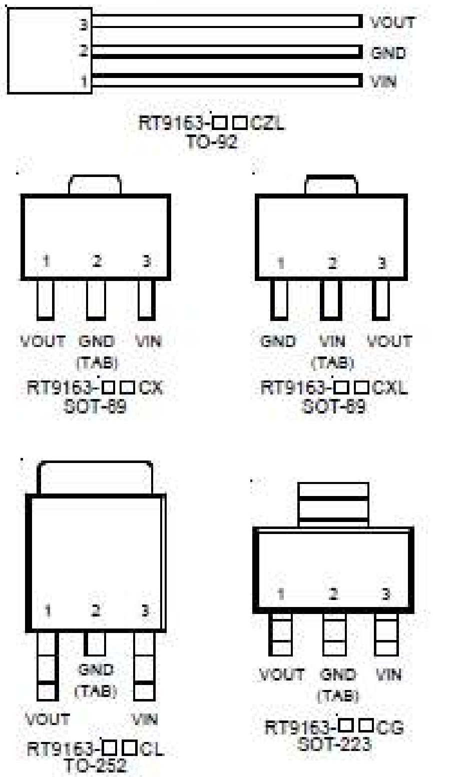
- Low Dropout, Maximum 1.4V at 500mA
- Fast Transient Response
- ± 2% Total Output Regulation
- 0.4% Line Regulation
- 0.4% Load Regulation
- TO-92, SOT-89, SOT-223, and TO-252 Packages
- RoHS Compliant and 100% Lead (Pb)-Free

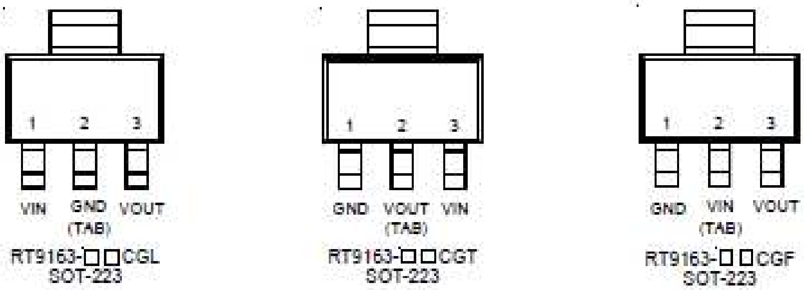
Applications

- 5V to 3.3V Linear Regulator
- Low Voltage Microcontroller, DSP,.... etc. Power Supply
- Linear Regulator for LAN Card and CD-ROM

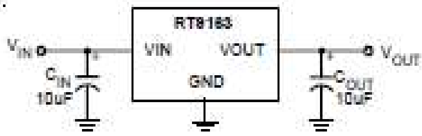
Pin Configurations

(TOP VIEW)

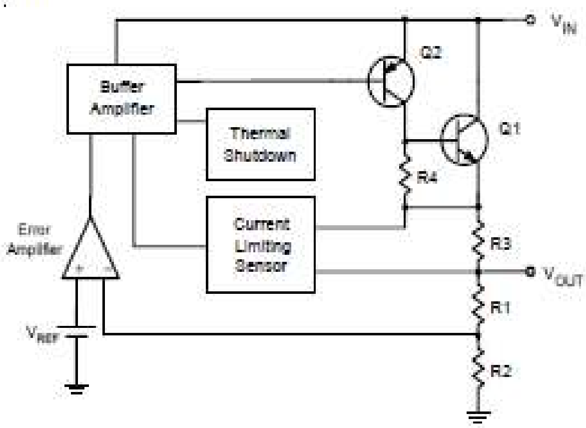




Typical Application Circuit



Function Block Diagram



Functional Pin Description

Pin Name	Pin Function
VOUT	Output Voltage
GND	Ground
VIN	Power Input

Absolute Maximum Ratings

- Input Voltage ---------- 15V
- Power Dissipation, P_D @ T_A = 25°C
  - TO-92 ---------- 0.625W
  - SOT-89 ---------- 0.571W
  - SOT-223 ---------- 0.740W
  - TO-252 ---------- 1.471W
- Package Thermal Resistance (Note 4)
  - TO-92, θ_{JA} ---------- 160°C/W
  - SOT-89, θ_{JC} ---------- 48°C/W
  - SOT-89, θ_{JA} ---------- 175°C/W
  - SOT-223, θ_{JC} ---------- 19°C/W
  - SOT-223, θ_{JA} ---------- 135°C/W
  - TO-252, θ_{JC} ---------- 7.5°C/W
  - TO-252, θ_{JA} ---------- 68°C/W
- Operating Junction Temperature Range ---------- −40°C to 125°C
- Storage Temperature Range ---------- −65°C to 150°C

Electrical Characteristics

(V_{IN} = 5V, T_A = 25°C, unless otherwise specified)

Parameter		Symbol	Test Conditions	Min	Typ	Max	Units
Output Voltage (Note 1)	RT9163-33	V_{OUT}		3.235	3.300	3.365	V
	RT9163-35			3.430	3.500	3.570	
	RT9163-50		V_{IN} = 7V	4.900	5.000	5.100	
Line Regulation (Note 1)	RT9163-33 RT9163-35	ΔV_{LINE}	V_{IN} = 5V ~ 15V	--	0.1	0.4	%
	RT9163-50		V_{IN} = 7V ~ 15V	--	0.1	0.4	
Load Regulation (Note 1)		ΔV_{LOAD}	I_L = 0 ~ 500mA	--	0.2	0.4	%
Dropout Voltage (Note 2)		V_{DROP}	ΔV_{OUT} = 1%	--	1.3	1.4	V
Current Limit		I_{LIM}	Load = 1Ω	550	--	--	mA
Quiescent Current		I_Q		--	4.5	8	mA
Temperature Coefficient		T_C		--	0.005	--	%/°C
Temperature Stability		T_S		--	0.5	--	%
RMS Output Noise (Note 3)				--	0.003	--	%/V_{OUT}

Note 1. Low duty cycle pulse tested with Kelvin connections.

Note 2. The dropout voltage is defined as V_{IN} -V_{OUT}, which is measured when V_{OUT} is $V_{OUT(NORMAL)}$ − 100mV.

Note 3. Bandwidth of 10 Hz to 10 kHz.

Note 4. θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective thermal conductivity test board of JEDEC 51-3 thermal measurement standard. The case point of θ_{JC} is on the center of the exposed pad.

AUK Semiconductor

STC9014N

NPN Silicon Transistor

Description

- General purpose application
- Switching application

Features

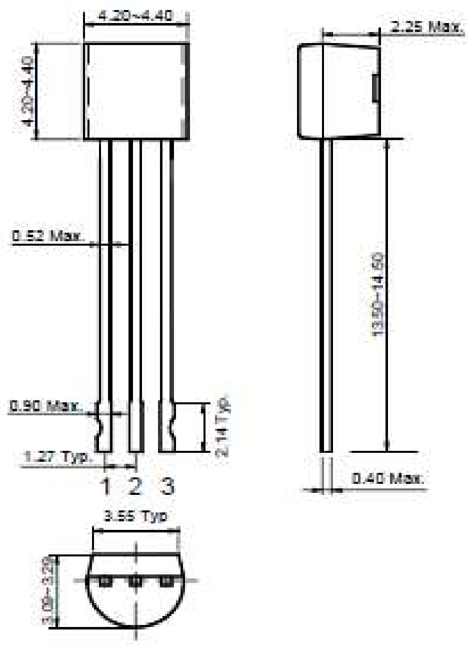
- Excellent h_{FE} linearity : $h_{FE}(I_C=0.1\ mA)\ /\ h_{FE}(I_C=2\ mA) = 0.95$(Typ.)
- Complementary pair with STA9015N

Ordering Information

Type NO.	Marking	Package Code
STC9014N	STC9014	TO-92N

Outline Dimensions

unit : mm



PIN Connections
1. Emitter
2. Base
3. Collector

Absolute Maximum Ratings

(Ta=25°C)

Characteristic	Symbol	Rating	Unit
Collector-base voltage	V_{CBO}	60	V
Collector-emitter voltage	V_{CEO}	50	V
Emitter-base voltage	V_{EBO}	5	V
Collector current	I_C	150	mA
Collector power dissipation	P_C	500	mW
Junction temperature	T_J	150	°C
Storage temperature range	T_{stg}	-55~150	°C

Electrical Characteristics

(Ta=25°C)

Characteristic	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Collector-emitter breakdown voltage	BV_{CEO}	I_C=1mA, I_B=0	50	-	-	V
Collector cut-off current	I_{CBO}	V_{CB}=60V, I_E=0	-	-	50	nA
Emitter cut-off current	I_{EBO}	V_{EB}=5V, I_C=0	-	-	100	nA
DC current gain	h_{FE}*	V_{CE}=5V, I_C=1mA	100	-	1000	-
Collector-emitter saturation voltage	$V_{CE(sat)}$	I_C=100mA, I_B=10mA	-	0.1	0.25	V
Base-emitter voltage	V_{BE}	V_{CE}=5V, I_C=1mA	-	0.65	0.85	V
Transition frequency	f_T	V_{CE}=10V, I_C=10mA	-	200	-	MHz
Collector output capacitance	C_{ob}	V_{CB}=10V, I_E=0, f=1MHz	-	2	-	pF

* : h_{FE} rank / B : 100 ~ 300, C : 200 ~ 600, D : 400 ~ 1000.

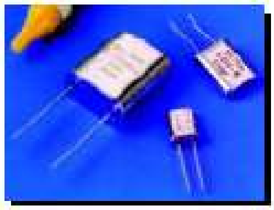
RALTRON

MICROPROCESSOR CRYSTAL UNITS

SERIES A, B, C
HC-49/U, HC-51/U, AND UM-1

FEATURES

- EXCELLENT CLOCK SIGNAL GENERATOR FOR CPU's
- WIDE FREQUENCY RANGE
- INDUSTRY STANDARD PACKAGES



SPECIFICATIONS

FREQUENCY RANGE		100.00 KHz TO 300.00 MHz
HOLDER TYPES	A: HC-49/U	1.00 MHz TO 300.00 MHz
	B: HC-51/U	100.00 KHz TO 4.00 MHz
	C: UM-1	8.00 MHz TO 300.00 MHz
FREQUENCY TOLERANCE AT 25 °C		±30 PPM TYPICAL ±50 PPM MAXIMUM
FREQUENCY STABILITY OVER TEMPERATURE		±50 PPM TYPICAL ±100 PPM MAXIMUM
OPERATING TEMPERATURE RANGE		-20 °C TO +70 °C STANDARD
		-40° C TO +85 °C EXTENDED
STORAGE TEMPERATURE RANGE		-55 °C TO +125 °C
AGING		±5 PPM PER YEAR MAXIMUM
LOAD CAPACITANCE		10 TO 32 pF OR SERIES
SHUNT CAPACITANCE		7 pF MAXIMUM
EQUIVALENT SERIES RESISTANCE (ESR)		SEE PAGE 11
DRIVE LEVEL		0.1 mW TYPICAL 1 mW MAXIMUM
SHOCK RESISTANCE		±5 PPM MAXIMUM 75 cm DROP TEST IN 3 AXES ONTO A HARD SURFACE OR 1000 g's x 0.5 ms x ½ SINEWAVE IN 3 AXES

FREQUENCY RANGE AND MODE OF OSCILLATION BY HOLDER TYPE

HOLDER TYPE	FUNDAMENTAL (FUND)	THIRD OVERTONE (3OT)	FIFTH OVERTONE (5OT)	SEVENTH OVERTONE (7OT)	NINTH OVERTONE (9OT)
TYPE A: HC-49/U	1.00 MHz TO 65.00 MHz	20.00 MHz TO 90.00 MHz	50.00 MHz TO 130.00 MHz	125.00 MHz TO 200.00 MHz	180.00 MHz TO 300.00 MHz
TYPE B: HC-51/U	100.00 KHz TO 4.00 MHz				
TYPE C: UM-1	8.00 MHz TO 65.00 MHz	25.00 MHz TO 90.00 MHz	50.00 MHz TO 130.00 MHz	125.00 MHz TO 200.00 MHz	180.00 MHz TO 300.00 MHz

PART NUMBERING SYSTEM

HOLDER TYPE			FREQUENCY		LOAD CAPACITANCE		MODE			EXTENDED TEMPERATURE
A B C	HC-49/U HC-51/U UM-1	-	IN MHz	-	10 TO 32pF FOR PARALLEL S FOR SERIES	-	FUND 3OT 5OT 7OT 9OT	FUNDAMENTAL THIRD OVERTONE FIFTH OVERTONE SEVENTH OVERTONE NINTH OVERTONE	-	EXT

MECHANICAL OPTIONS								TAPE AND REEL
THREE PIN BASE	-	THIRD LEAD (TOP OF HOUSING)	-	SPACER	-	SLEEVE	-	TR
3PIN		3RD		SP		SL		

GPS Engine Board

M-89
SPECIFICATION

HOLUX
THE PRO NAME IN GPS

新竹市科學園區研發二路 號 樓

Website: www.gzxintucom

1. Introduction

1.1 General introductions

M-89 is an ultra miniature 25.4 * 25.4 * 3 mm GPS engine board designed by low power consumption MTK GPS solution. It provides superior sensitivity up to -159dBm and fast Time-To-First-Fix in navigation application. The stable performance of M-89 is your best choice to be embedded in your portable device design, like PDA、PND、mobile phone、Digital Camera for GPS service.

1.2 Key Features

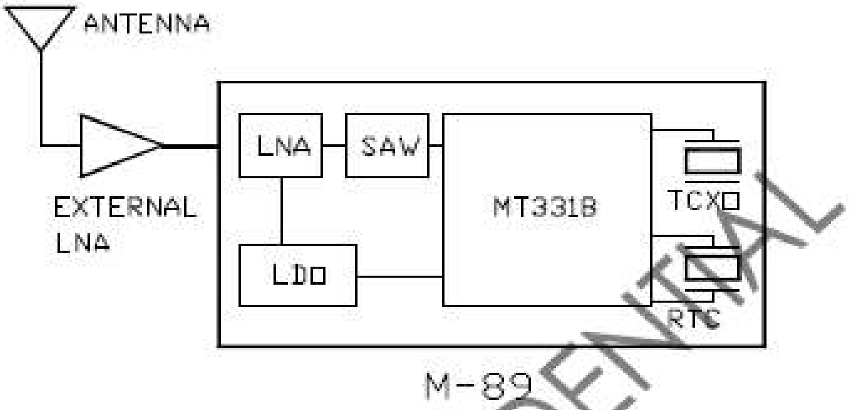
- small form factor: 25.4 * 25.4 * 3 mm
- RoHS /WEEE compliant
- High sensitivity -159dBm
- Searching up to 32 Channel of satellites
- Fast Position Fix
- Low power consumption
- RTCM-in ready.
- Built-in WAAS/EGNOS/MSAS Demodulator.
- Support NMEA0183 V 3.01 data protocol.
- Real time navigation for location based services.
- For Car Navigation, Marine Navigation, Fleet Management, AVL and Location-Based Services, Auto Pilot, Personal Navigation or touring devices, Tracking devices/systems and Mapping devices application

1.3 Applications

- Automotive and Marine Navigation
- Automotive Navigator Tracking
- Emergency Locator
- Geographic Surveying
- Personal Positioning
- Sporting and Recreation
- Embedded applications:
- Smart phone, UMPC, PND, MP

2 Technical Description

2.1 Block Diagram



2.2Pin Definition

Pin	Pin Name	Type	Function description
1	*VCC_IN*	I	3.3 ~ 5 V supply input
2	*GND*	G	Ground
3	*NC*	I	NC
4	*RXDA*	I	Serial Data input A
5	*TXDA*	O	Serial Data Output A
6	*TXDB*	O	Serial Data Output B
7	*RXDB*	I	Serial Data input B
8	*GPIO0*	I/O	General purpose I/O. flash at 1Hz when position is fixed.
9	*INT1*	I/O	General purpose I/O
10	*GND*	G	Ground
11	*GND*	G	Ground
12	*GND*	G	Ground

13	*GND*	G	Ground
14	*GND*	G	Ground
15	*GND*	G	Ground
16	*GND*	G	Ground
17	*RF_IN*	I	GPS signal input
18	*GND*	I	Ground
19	*V_ANT_IN*	I	Antenna power supply input,3V
20	*VCC_RF_O*	O	Antenna power supply, 2.8V
21	*V_BAT*	I	RTC and backup SRAM power, 2.6 ~ 3.6 VDC.
22	*HRST*	I	Reset, active low
23	*GPIO1*	I/O	General purpose I/O
24	*GPIO2*	I/O	General purpose I/O
25	*GPIO3*	I/O	General purpose I/O
26	*GPIO4*	I/O	General purpose I/O
27	*GPIO5*	I/O	General purpose I/O
28	*GPIO6*	I/O	General purpose I/O
29	*PPS*	O	1 PPS output, synchronized with GPS time. TIME_MARK 1 PPS output, 1us/s
30	*GND*	G	Ground

2.3Specification

General	
GPS technology	MTK GPS chipset
Frequency	L1,1575.42MHZ
C/A Code	1.023MHZ chip rate
Channels	32 channels all in view searching
Sensitivity	Batter than -159dBm
Receiver Accuracy	
Position	Without aid:3.0 M 2D-RMS DGPS(WAAS, EGNOS, MSAS, RTCM):2.5 M
Velocity	Without aid:0.1 M/sec
Time	0.1 microsecond. Sync GPS time
Datum	
Datum	WGS84(Default) total 219 datum's
Time to First Fix	(Follow MTK chip specification)
Hot start	1 sec average

Warm start	33 sec average
Cold start	36 sec average
Reacquisition	<1sec
Protocol	
GPS Output Data	NMEA0183(v3.1)- GGA,GLL,GSA,GSV,RMC,VTG Support Baud rate 4800/9600/…./57600 bps (default 4800), Data bit:8,Stop bit:1
Update Rata	1Hz(default)
Protocol Support	NMEA-0183
1PPS	Enable(1Hz pulse 10% duty cycle)
Limitations	
Acceleration Limit	<4G
Altitude Limit	<18000 meters
Velocity Limit	<515 M/sec
Jerk Limit	20 M/sec^3
Power	
Operation Current	Acquisition:65 mA@3.3V
Operation Current	Tracking:<35mA@3.3V
DC Input Range	VCC 3.0~5.0V VBAT 3.0~5.0V
Processing Core	
Processor Type	ARM7EJ-S
Processor Speeds	48 MHz
Integrated program Flash	4 MHz
Interface	CMOS 2.8 V Level
Tempture	
Opertaing Temperature	-40℃ to +85℃.
Storage Temperature	-40℃ to +125℃.
Operating Humidity	5% to 95,No condensing
Physical	
Dimension	25.4 * 25.4 * 3 mm.
Weight	3g.

4 User Interface

M-89 provides 2-wire digital UART port for communication of GPS position data using NMEA protocol or MTK extension protocol. UART port is capable of 4800 to 115200 baud rate.

4.1 Protocol

M-89 is default to support standard NMEA-0183 protocol. In addition, a series of MTK extensions (PMTK messages) have been developed that can be used to provide extended capabilities common to many applications.

4.1.1 NMEA Protocol

M-89 is capable of supporting following NMEA formats:

NMEA RECORD	Description
GGA	GPS fix data
GLL	Geographic
GSA	GNSS DOP and active satellite
GSV	GNSS Satellites in view
RMC	Recommended minimum specific GNSS data
VTG	Course Over Ground and Ground Speed
ZDA	Time&Data

4.1.2 MTK NMEA Packet Format

Preamble	TalkerID	PktType	Datafield	*	CHK1	CHK2	CR	LF

Maximum packet length is restricted to 255 bytes

Field	Length	Type	D
Preamble	1 byte	Character	"$"
TalkerID	4 byte	Character string	"PMTK"
PktType	3 byte	Character string	"000" to "999" , an identifier used to tell the decoder how to decode the packet
DataField	Variable		"," must be inserted ahead each data filed to help the decoder process the Data Field
*	1 byte	Character	The star symbol is used to mark the end of Data Field
CHK1 CHK2	2 byte	Character string	checksum of the data between Preamble "," and "*"
CR, LF	2 byte	Binary data	used to identify the end of a packet