ÇUKUROVA UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES

MSc THESIS

Ersen PESEN

DESIGN AND CONSTRUCTION OF A DATA ACQUISITION SYSTEM FOR SENSORS USED IN AUTOMOTIVE INDUSTRIES OVER GPRS

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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ÇUKUROVA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ

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YÜKSEK LİSANS TEZİ
ELEKTRİK- ELEKTRONİK MÜHENDİSLİĞİ ANABİLİM DALI

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ÖZ

YÜKSEK LİSANS TEZİ

OTOMOTİV ENDÜSTRİSİNDE KULLANILAN SENSÖRLER İÇİN GPRS ÜZERİNDEN VERİ TOPLAMA SİSTEMİ TASARIMI VE UYGULAMASI

Ersen PESEN

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Danışman : Yrd. Doç. Dr. Murat AKSOY
Yıl: 2010, 116 Sayfa
Jüri : Doç. Dr. Ulus ÇEVİK
: Yrd. Doç. Dr. Mutlu AVCI

İş makinaları sektörü, günümüzde inşaat işleri, taş ve mermer ocakları, yol çalışmaları, ormancılık faaliyetleri gibi her türlü ağır iş alanında faaliyet göstermektedir. Özellikle yerleşim yeri dışında çalışan iş makinelerinin Bulunduğu çalışma ortamına göre performansının incelenmesi ve performans verilerinin kayıt altında tutulması, alınan verilere göre çıkan arızaları takip edebilme veya daha sonradan çıkabilecek arızaları önceden kontrol altına alınması, arızalanan araca daha erken müdahalede bulunmak ürün geliştirme yada yeni ürün tasarımında kayıt altına alınan bu bilgilerden yararlanılması kaybolmaya veya çalınmaya karşı konum bilgisi alınarak güvenlik uygulaması sayesinde daha kolay leasing alınması, iş makinaları saatle kiraya verildiği için aracın çalışma saatinde oynama yapılsa bile gerçek çalışma saatini kayıt altına alınması, için uzaktan izlenmesi çok önemlidir.

Bu tez çalışmasında, araçta kullanılan sensörlerden gelen bilgiler ve çalıştığı ortam bilgilerini öğrenmek için kullandığımız sıcaklık, nem ve mems titreşim sensörleri ile gps'ten gelen bilgiler gprs yardımıyla uzaktan izlenip verilerin kayıt altına alınması için yapılmıştır.

Anahtar Kelimeler: GPS, GPRS, Sensor, Veri Toplama, MEMS

ABSTRACT

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Year: 2010, 116 Pages
Jury : Assoc. Prof. Dr. Ulus ÇEVİK
: Asst. Prof. Dr. Mutlu AVCI

Construction machines are used in civil area, stone and marble sector, road works and forest studies. Especially construction machines are used outside of urban areas the following are of great importance: Inspection of performance due to the media and recording the performance, tracking construction machines and finding failures, early operations on the failed construction machines, using the recorded data during development, making the leasing easy by protecting the construction machines against theft, controlling the hour meter of the construction machines for borrowing

In this thesis, the sensors are used to measure position, temperature, humidity, vibration, etc. in vehicles and it is important to record these data from the sensors. This study aims use of sensors in vehicle, such as GPS **(**Global Positioning System) and MEMS **(**Micro -Electro- Mechanical Systems**)** vibration sensor and the vehicle data are gathering a DAQ (Data Acquisition System) and these are sent to a centre with GPRS.

Key Words: GPS, GPRS, SENSOR, DAQ, MEMS

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LIST OF ABBREVIATIONS

ABS : Anti-Lock Braking System
AC : Air Conditioning
ADC : Analog-to-Digital Converter
API : Application Programming Interface
ASP : Active Server Pages
AT : Attention Command
CAGR : Compound Annual Growth Rate
CSB : Selects the Chip on Multi-chip
CPU : Central Processing Unit
DAQ : Data Acquisition System
ECU : Engine Control Unit
ECG : Electrocardiography
ECM : Electronic Control Module
ECT : Engine Coolant Temperature
EGR : Exhaust Recirculation Gases
ECS : Electronic controller suspension
EPROM : Erasable Programmable Read Only Memory
ETSI : European Telecommunications Standard Institute
HAC : High Altitude Compensator
FOC : Full Operation Capability
HLR : Home Location Register
HTTP : Hypertext Transport Protocol
HVAC : Heating Ventilating & Air Conditioning
I²C : Inter-Integrated Circuit
IAT : Intake Air Temperature
IMEI : International Mobile Equipment Identity
I/O : Input/ Output
IP : Internet Protocol
GGA : Global Positioning System Fix Data

GGSN : Gateway GPRS Support Node
GIS : Geographical Information Systems
GLL : Geographic Position – Latitude/Longitude
GLONASS : Global Navigation Satellite System
GNSS : Any single or combined satellite navigation system
GSA : GNSS DOP and Active Satellites
GSV : GNSS Satellites in View.
GPS : Global Positioning System
GPRS : General Packet Radio Service
GSM : Global System for Mobile communication
GTP : Tunneling Protocol
LAN/ WAN : Local Area Network/ Wide Area Network
LPCVD : Liquid Phase Chemical Vapor Deposited
LVDT : Linear Variable Differential Transformer
MAF : Mass Air Flow
MAP : Temperature and Manifold Air Pressure
MEMS : Micro Electro- Mechanical Systems
MISO : Master In Slave Out.
MOSI : Master Out Slave In
NAVSTAR : Navigation System with Time And Ranging
NMEA : National Marine Electronics Association
NTC : Negative Resistance/Temperature Coefficient
OEM : Original Equipment Manufacturer
PCI : Peripheral Component Interconnect
PIN : Personal Identity Number
PHP : Personal Home Page / Hypertext Preprocessor
PSG : Phosphosilicate Glass
PSOC : Programmable System-on-Chip
QoS : Quality Of Service
PTC : Positive Resistance/ Temperature Coefficient
RTD : Resistance Temperature Devices

RLS : Recursive Least-Squares
RMC : Recommended Minimum Specific GPS/TRANSIT Data
SAE : Society of Automotive Engineers
SCK : Serial clock input
SIM : Subscriber Identity Module
SGSN : Serving GPRS Support Node
SMS : Short Message Service
SPI : Serial Peripheral Interface
TCP : Transmission Control Protocol
TTL : Transistor-to-Transistor Logic
UART : Universal Asynchronous Receiver Transmitter
USB : Universal Serial Bus
UTC : Coordinated Universal Time
VPS : Vapor Pressure Sensor
VSS : Vehicle Speed Sensor
VTG : Course Over Ground and Ground Speed

1. INTRODUCTION

The sensors are used to measure position, temperature, humidity, vibration, etc. in vehicles and it is important to record these data from the sensors. This study aims use of sensors in vehicle, such as GPS (Global Positioning System) and MEMS (Micro Electro- Mechanical Systems) vibration sensor and the vehicle data are gathering a DAQ (Data Acquisition System) and these are sent to a centre with GPRS(General Packet Radio Service).

Construction machines are used in civil area, stone and marble sector, road works and forest studies. Especially construction machines are used outside of urban areas the following are of great importance:

- Inspection of performance due to the media and recording the performance
- Tracking construction machines and finding failures
- Early operations on the failed construction machines
- Using the recorded data during development
- Making the leasing easy by protecting the construction machines against theft
- Controlling the hour meter of the construction machines for borrowing

On the other hand, the studies of this work will be able to be applied to other vehicles in the automotive industry hence being important.

Material and Method: Firstly, the s ensors and their technologies used in construction machines will be learned and the literature will be searched for the electrical properties of them. By using the data from the literature, a data acquisition card will be designed and prototyped for suitable connection of the sensors and GPS module and sending them using GPRS.

Outer medium information will be read with GPS and MEMS sensors.

- The real-time position, height and velocity information is read with GPS.
- The vibration of the machines will be read by MEMS sensors.

- Temperature and humidity will be read by temperature and humidity sensors.

The performance of the construction machines will be measured and recorded. The sensors used in machines:

- Fuel level sensor
- Engine water temperature
- Engine oil pressure
- Engine rpm
- Transmission oil temperature
- Transmission pressure

On the other hand, there are switch/sensors used in:

- Brake hydraulic level
- Fuel level
- Engine water temperature
- Engine oil pressure
- Hydraulic oil pressure
- Transmission oil temperature

which operates by warning of switching sensors.

Operation of the system is given following block diagram (Figure 1.1). The DAQ system gathers the data from sensors and GPS to send the computer with GPRS.

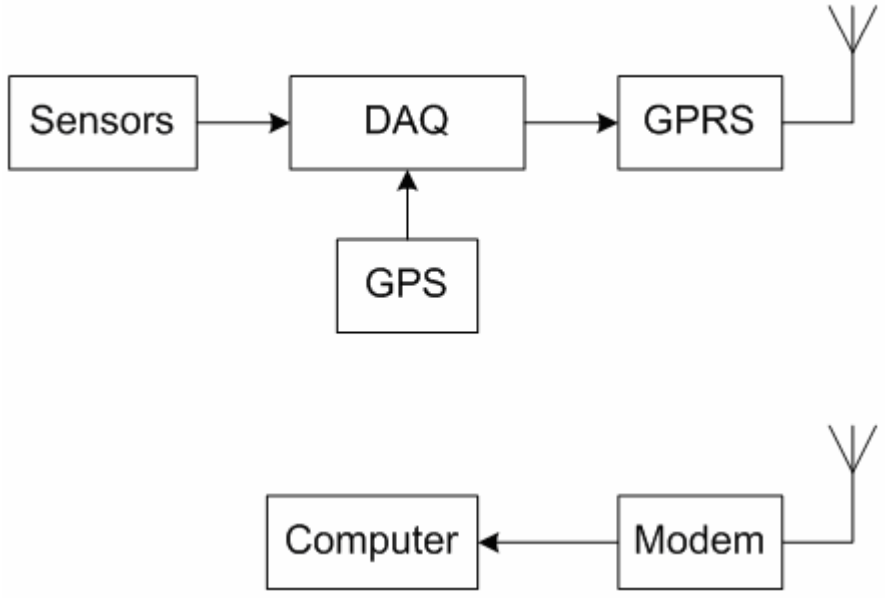


Figure 1.1. General diagram of system

2. PREVIOUS STUDIES

Demir (2006), informed that the aim of this study is remote reading of the information recorded by a digital meter by using the optical port of the meter and RS485 serial communication port with the intervention of GPRS modem. In this study, the details of Automatical Meter Reading technology, about which there is a little known and in which developments are experienced very fast, the positive and negative sides of this technology, preparation studies and the probable applications in our country is examined, a general aspect is constituted and a sample model is developed.

The remote meter reading system proposed in this study is a system which is developed with reference of Automatic Meter Reading system which is developed as a sample of international network system. The proposing system is a flexible and expansible one. With the assistance of the system the procedure of the subscribers can be done automatically by remote central control unit.

As a result, the remote meter reading process by using GPRS modem is done successfully and the importance and advantages of the study are stated.

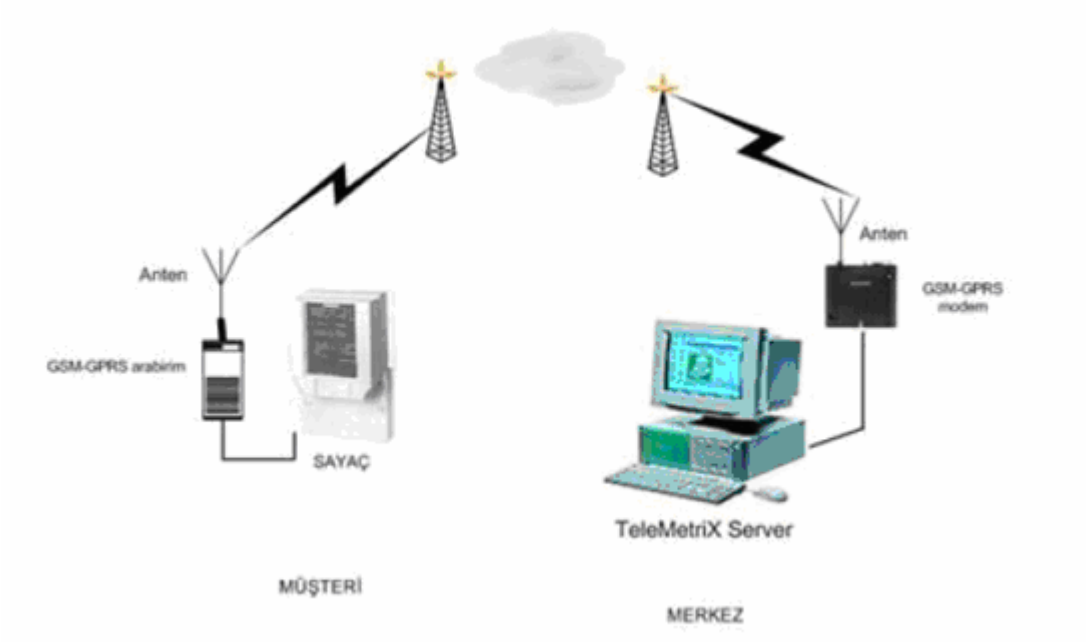


Figure 2.1. General diagram of a gprs system (Demir, 2006)

Çivril (2006), informed that A vehicle tracking system consists of mainly three components: A GPS receiver used to determine the position of the vehicle, a communication unit used to send the positioning data to the tracking centre, and a software package used to track the vehicle on digital maps and to carry out the positional analysis.For the system developed in this study, GPRS technology is choosen to send the positioning data determined by the GPS receiver. The communication cost of the system is low with this technology since the costs are determined by the amount of the data transmitted. Moreover, the communication costs can be reduced further by compressing the data before transmission.

In this study, a software was developed in Microsoft Visual C# .NET environment to display the digital maps prepared in MapInfo mif and gst formats on computer screen and track the vehicles on these maps.

Çınar (2005), in this master's thesis, a vehicle tracking system using GPS has been designed and built. In addition to this tracking ability, the destination coordinates can be sent to the vehicle and the driver can be directed to the destination with sound messages or written instructions. This adds a guidance capability to our system. Furhermore, in this master's thesis, GPS system structure and the details of SMS reception and transmission with mobile phones have been investigated and used in practice to navigate the user in an unknown territory. Studies have been completed on embedding several different softwares on the microcontroller without any conflicts at start up time. The softwares can be uploaded using the serial channel of the PC.Several I/O ports, an address bus and a data bus between external circuit elements and microcontroller processor have been designed and utilized.

Moreover, the achievability of concurrent operations in the absence of an operating system, i.e. multi-tasking, via timer interrupts, have also been studied. Beside these, the voice information is stored in EPROM and the necessary reconstruction conversions have also been performed.

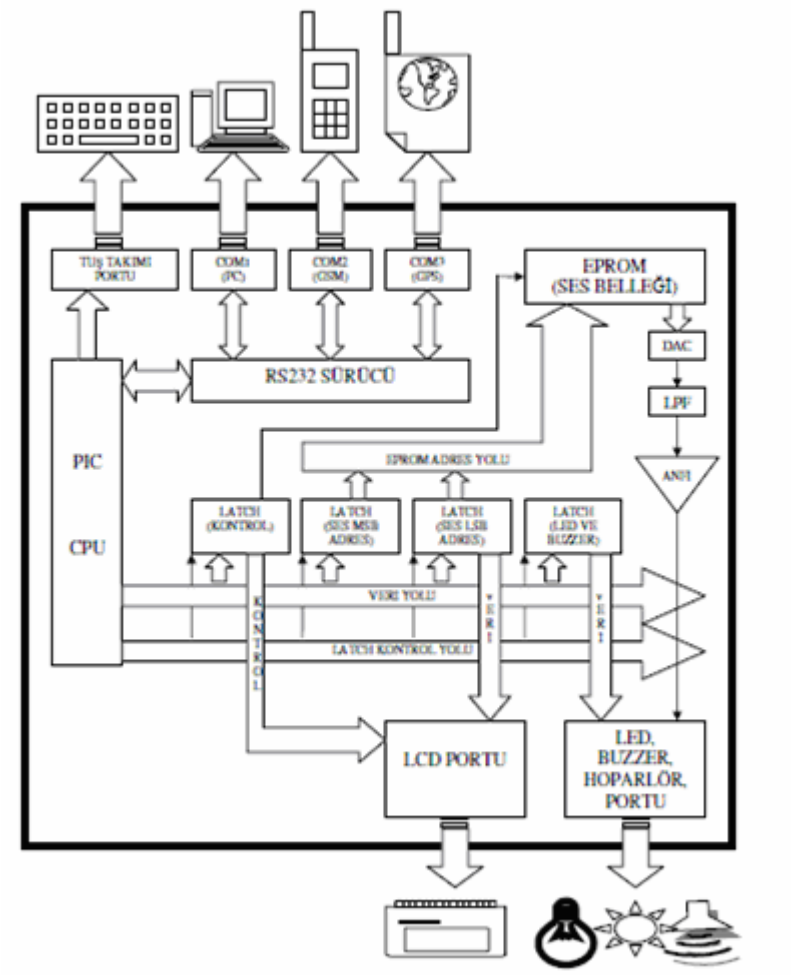


Figure 2.2. System architecture (Çınar, 2005)

Ryu and Gerdes (2004), informed that this paper demonstrates a method of estimating several key vehicle states – sideslip angle, longitudinal velocity, roll and grade – by combining automotive grade inertial sensors with a Global Positioning System (GPS) receiver. Kinematic Kalman filters that are independent of uncertain vehicle parameters integrate the inertial sensors with GPS to provide high update estimates of the vehicle states and the sensor biases. Using a two-antenna GPS system, the effects of pitch and roll on the measurements can be quantified and are demonstrated to be quite significant in sideslip angle estimation. Employing the same GPS system as an input to the estimator, this paper develops a method that compensates for roll and pitch effects to improve the accuracy of the vehicle state and sensor bias estimates. In addition, calibration procedures for the sensitivity and

cross-coupling of inertial sensors are provided to further reduce measurement error. The resulting state estimates compare well to the results from calibrated models and Kalman filter predictions and are clean enough to use in vehicle dynamics control systems without additional filtering.

Kinsey, Eustice and Whitecomb (2006), The paper surveys recent advances in underwater vehicle navigation and identifies future research challenges. Improvements in underwater navigation sensor technology and underwater navigation algorithms are enabling novel underwater vehicles and novel underwater vehicle missions. This paper first reviews advances in underwater navigation sensor technology. Second, advances in deterministic and stochastic underwater navigation methodologies and algorithms are reviewed. Finally, future challenges in underwater vehicle navigation are articulated, including near-bottom navigation, vehicle state estimation, optimal survey, environmental estimation, multiple-vehicle navigation, and mid-water navigation. Advances in vehicle navigation will enable new missions for underwater vehicle (commercial, scientific, and military) which were previously considered impractical or infeasible.

Medagama, Gamage, Wijesinghe, Leelaratna, Karunaratne and Dias (2008), informed that the paper presents the combined application of Geographical Information Systems (GIS), the Global Positioning System (GPS), the General Packet Radio Service (GPRS) and the Internet for tracking of vehicle fleets. It is one component of an enterprise solution that is designed to manage and track a large fleet. The key features of the system are an open-source GIS platform, real-time location information update, and a web-based user interface.

The system consists of GPS-based vehicle tracking devices, a communications server, a web-server, a database server, and a map server. The tracking devices mounted in the vehicles collect location information in real-time via the GPS. This information is transferred continuously through GPRS to a central database. The users are able to view the current location of each of the vehicles in the fleet via a web-based application, and thereby manage the fleet. The vehicle positions and other related information are displayed on a digital map, which is made available by a map server.

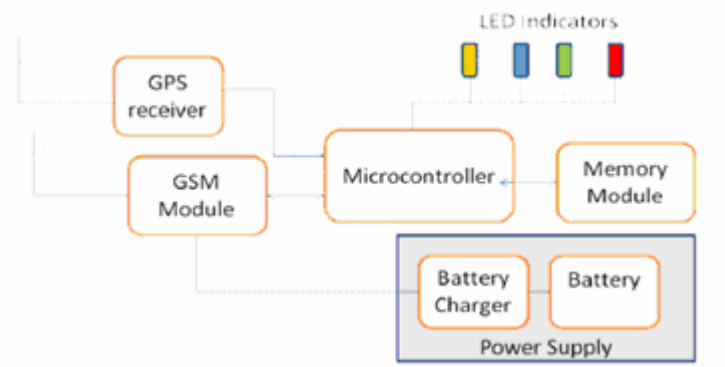


Figure 2.3. Block Diagram of the Tracking Unit (Medagama, 2008)

It is a typical example of how the advantages of ICTs may be leveraged for the efficient and effective management of a company's resources, particularly in the face of sky-rocketing fuel costs

Álvares (2006), stated that the application market for vehicular tracking and monitoring and patrimonial monitoring using monitoring systems, digital video processing, recording and transmission is nowadays considered one of the most promising in the security area. This paper presents the development of a computational system made of hardware and software with Linux embedded for vehicular monitoring, video processing, recording and transmission binded to a vehicular tracking and monitoring system based on GPS with tracking using Google Maps' API. This paper describes the development of the product, considering all the development parts, emphasizing the client interface and the hardware structure.

Hasan, Rahman, Haque, Rahman, Rahman and Rasheed (2009**),** informed that this paper proposes and implements a low cost object tracking system using GPS and GPRS. The system allows a user to view the present and the past positions recorded of a target object on Google Map through the internet. The system reads the current position of the object using GPS, the data is sent via GPRS service from the GSM network towards a web server using the POST method of the HTTP protocol. The object's position data is then stored in the database for live and past tracking. A web application is developed using PHP, JavaScript, Ajax and MySQL with the Google Map embedded. The existing live tracking systems that are available now a days use

SMS for the communication to the server which turned out to be expensive. (SMS are used for communication to device).

They have used the GPRS service which made our system a low cost tracking solution for localizing an object position and status. This system is very useful for car theft situations (alarm alert, engine starting, localizing), for adolescent drivers being watched and monitored by parents (speed limit exceeding, leaving a specific area), as well as for human and pet tracking**.**

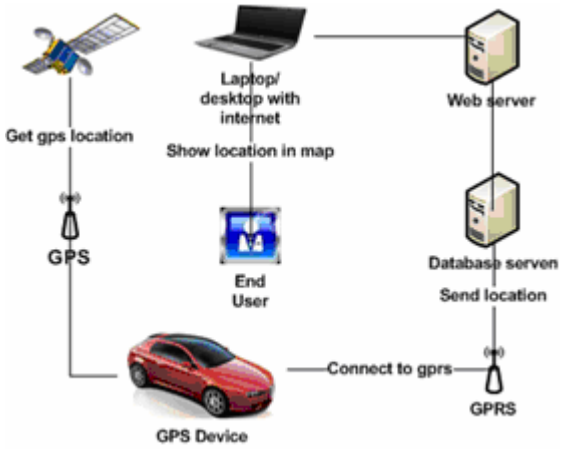


Figure 2.4. The n-tier Tracking System Diagram (Hasan, 2009)

Kishore, Vardhan, Narayana (2010), informed that in this paper, they present the principles of a low operational-cost but flexible Internet-based data-acquisition system. The maincore of the system is an embedded hardware running a scaleddown version of Linux: a popular choice of operating system for embedded applications. The embedded device communicates through General Packet Radio Service (GPRS),which makes it accessible from anywhere in the world through a web server built into the embedded device. In addition, GPRS provides a bidirectional real-time data transfer allowing interaction. The proposed system eliminates the need for server software and maintenance. A novel approach is introduced to minimize the operational costs while operating with a large amount of data.The system is demonstrated to be suitable for different embedded applications by attaching several real-time modules through appropriate interfaces.

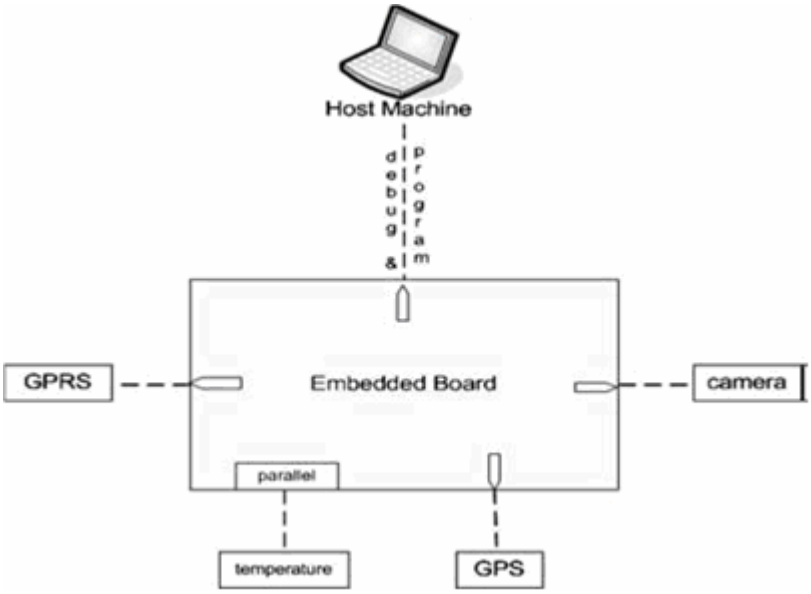


Figure 2.5. Block diagram of the embedded system with sample devices attached (Kishore, 2010)

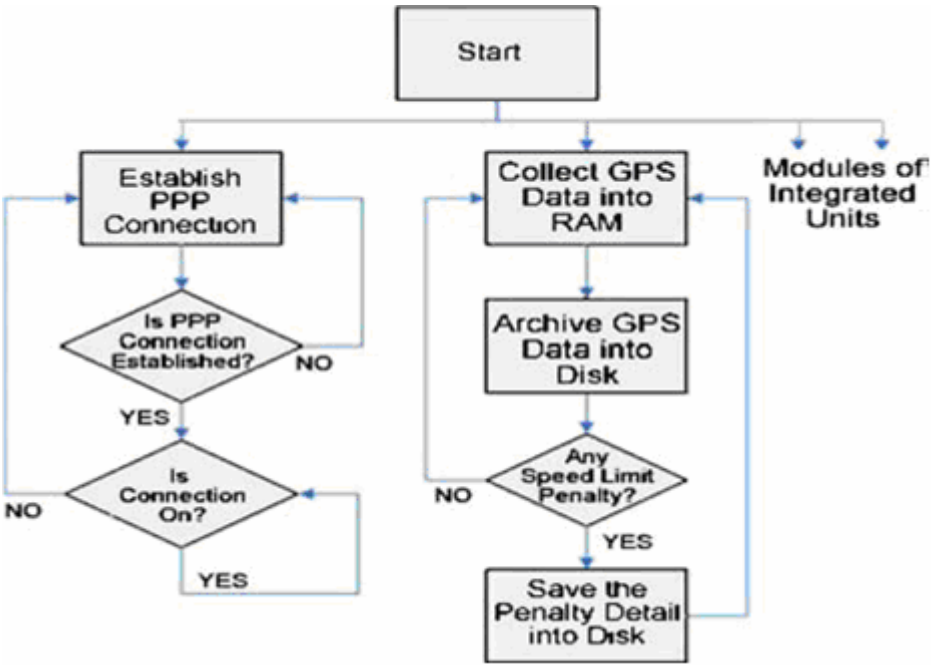


Figure 2.6. Manager code operational principles (Kishore, 2010)

Bayzan**,** Nowadays, traffic jams are becoming a bottleneck in especially big cities. This situation is getting worse as the number of new cars increases. Taking precautions about building new bridges and roads are not usually enough to ease

traffic problems in daily life. A solution could be employing navigation systems in cars. These systems help drivers chose the best and the shortest path between its current situation and destination as the one introduced in this paper. The proposed navigation system is simply based on GPRS and employs a new soft computing approach. In short, it is aimed to determine, by means of GPRS data, vehicle routes and alternative routes using soft computing algorithms and to test these routes by applying them to a geographical region.

Çaglar (2005)**,** informed that In this thesis he present a system offering inspection and management for the Emergency Medical Service (EMS) vehicles (ambulances). The system integrates several technologies including Geographic Information Systems (GIS), Global Positioning Systems (GPS) and RF wireless communication technologies. The aim of the system is to minimize ambulances' response time, make the management and inspection of the vehicles easier and improve the quality of health services.



Figure 2.7. General diagram of a gps and gprs system (Caglar, 2005)

Derelioğlu (2007), informed that the application developed will send information of on the situation to hospitals which are suitable and nearest to the location of the traffic accident. The system consists of a vehicle unit and a server unit. When an accident occured, the vehicle unit sends identification and medical information on the individuals and position information obtained form the GPS to the server unit using GPRS. The server unit creates an accident report and sends it to hospitals that are suitable and closet to the location of the accident. The results of this study show it is possible to reach traffic accident injuries in a much shorter time than is presently possible and with the efficiency provided with prior medical data.

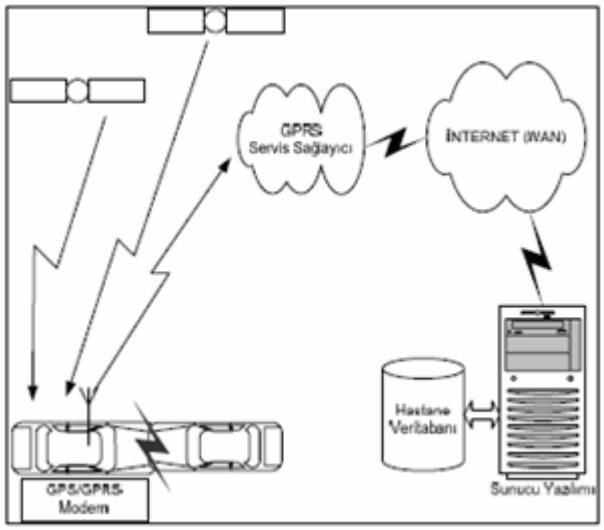


Figure 2.8 General diagram of a gprs system

Hernandez (2005), informed that in this paper, a sensor to measure the rollover angle of a car under performance tests is presented. Basically, the sensor consists of a dual-axis accelerometer, analog-electronic instrumentation stages, a data acquisition system and an adaptive filter based on a recursive least-squares (RLS) lattice algorithm. In short, the adaptive filter is used to improve the performance of the rollover sensor by carrying out an optimal prediction of the relevant signal coming from the sensor, which is buried in a broad-band noise background where they have little knowledge of the noise characteristics. The experimental results are satisfactory and show a significant improvement in the signal-to-noise ratio at the system output

Fleming (2001), explained that an up-to-date review paper on automotive sensors is presented. Attention is focused on sensors used in production automotive systems. The primary sensor technologies in use today are reviewed and are classified according to their three major areas ofautomotive systems application–powertrain, chassis, and body. This subject is extensive. As described in this paper, for use in automotive systems, there are six types of rotational motion sensors, four types of pressure sensors, five types of position sensors, and three types of temperature sensors. Additionally, two types of mass air flow sensors, five types of exhaust gas oxygen sensors, one type of engine knock sensor, four types of linear

acceleration sensors, four types of angular-rate sensors, four types of occupant comfort convenience sensors, two types of near-distance obstacle detection sensors, four types of far-distance obstacle detection sensors, and and ten types of emerging, state-of the-art, sensors technologies are identified.

Prosser (2001), explained that this paper will provide a review of past, present and future automotive sensors. Today's vehicles have become highly complex sophisticated electronic control systems and the majority of innovations have been solely achieved through electronics and the use of advanced sensors. A range of technologies have been used over the past twenty years including silicon microengineering, thick film, capacitive, variable reluctance, optical and radar. The automotive sensor market continues to grow with respect to vehicle production level in recognition of the transition to electronically controlled electrically actuated systems. The environment for these sensors continues to be increasingly challenging with respect to robustness, reliability, quality and cost

Hernandez (2007), explained that In this paper a survey on recent applications of optimal signal processing techniques to improve the performance of mechanical sensors is made. Here, a comparison between classical filters and optimal filters for automotive sensors is made, and the current state of the art of the application of robust and optimal control and signal processing techniques to the design of the intelligent (or smart) sensors that today's cars need is presented through several experimental results that show that the fusion of intelligent sensors and optimal signal processing techniques is the clear way to go. However, the switch between the traditional methods of designing automotive sensors and the new ones cannot be done overnight because there are some open research issues that have to be solved. This paper draws attention to one of the open research issues and tries to arouse researcher's interest in the fusion of intelligent sensors and optimal signal processing techniques.

Albarbar, Mekid, Starr and Pietruszkiewicz (2008), with increasing demands for wireless sensing nodes for assets control and condition monitoring; needs for alternatives to expensive conventional accelerometers in vibration measurements have been arisen. Micro-Electro Mechanical Systems (MEMS) accelerometer is one

of the available options. The performances of three of the MEMS accelerometers from different manufacturers are investigated in this paper and compared to a well calibrated commercial accelerometer used as a reference for MEMS sensors performance evaluation. Tests were performed on a real CNC machine in a typical industrial environmental workshop and the achieved results are presented.

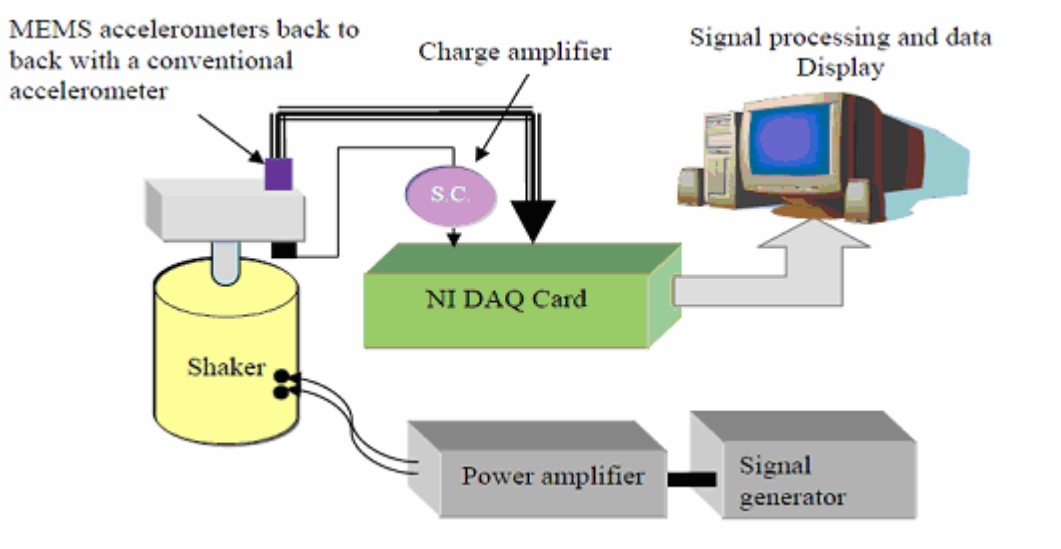


Figure 2.9. Test setup (Albarbar, 2008)

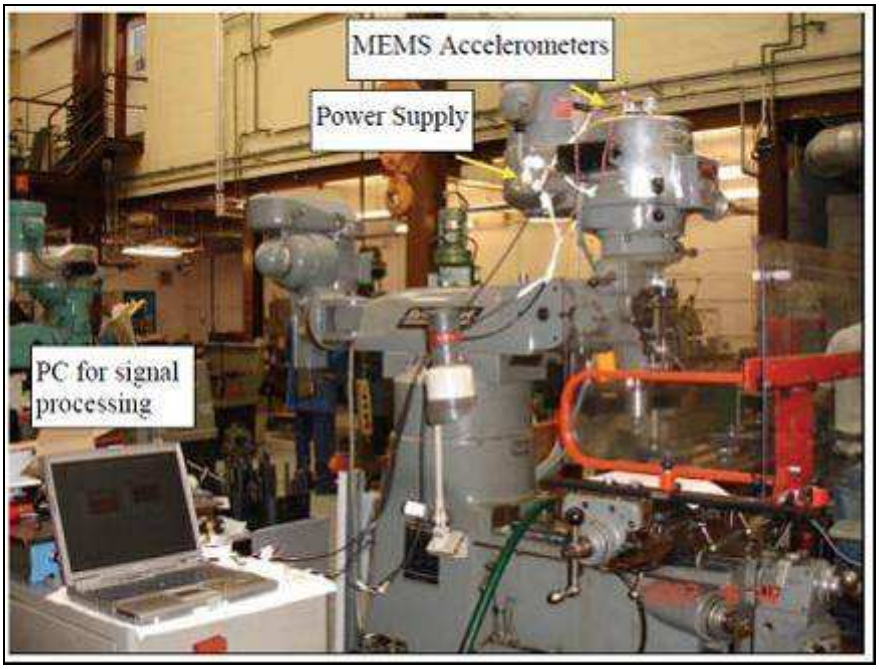


Figure 2.10 CNC machine vibration monitoring setup (Albarbar, 2008)

Yakut (2006), informed that the aim of this study is to supply know-how and experience for implementetion of humidity and gas sensing in oven and refrigerator .In the begining a literature research containing also hygrometry (thermophysical propertis of humunidity) for learning sensors and technologies for their applicability in refrigerator and/or oven has been completed.

By using the information obtained from literature, scope of studylimited with humidity sensing at buil-in electric oven and realized with the determined suitable thermal conductivity sensor (absolute humidity sensor) During this study the quantity of the food that placed in oven can be detected by humidity sensing. In addition it is possibleto predict the kind of food (i.e. beverage, meal or pizza) and sense whether the food is cookedor not.

At the last period of the study the innovative signal conditioning devices have been analyzed fort the processing of sensor outputs and excitation of sensors. Regarding mentioned issue two mixed-signal integrated circuits have been scrutinized with electronics engineering approach which areTEXAS INSTRUMENTS PGA309 and PSOC THE ICS performs the all needed process on sensor signals like as temperature drift compensation of offset and span amplifying filtering etc. General white goods applications of sensors have been simulated by the applications with both evaluation modules of PGA309 and PSOC for distinguish performances of devices. This document consists of humidity sensor integration especially with build-in electric oven,which is determined by research and several practices,including all periods including sensor plugging to the control systemof the devices.

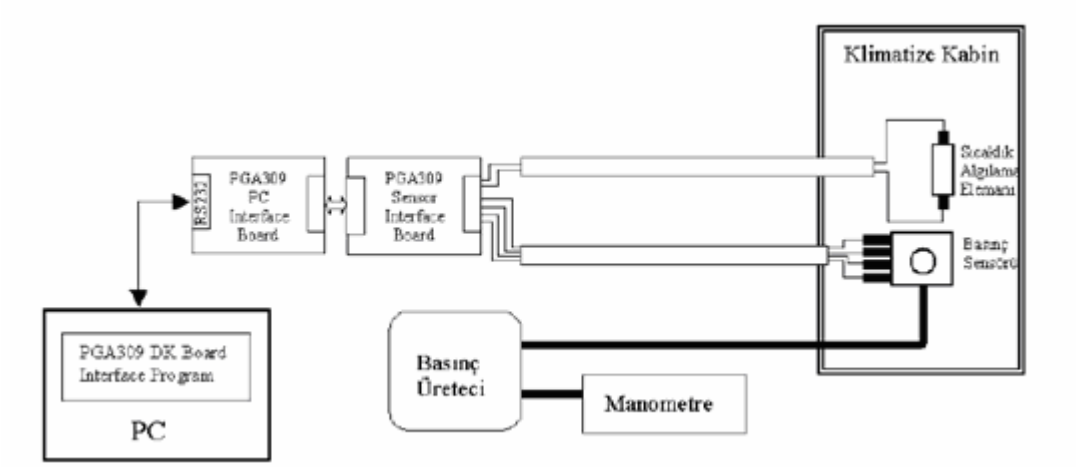


Figure 2.11. Sytem architecture (Yakut, 2006)

Sztaki (2001), explaine that the main objectives of the project are the elaboration of the theory and methods of intelligent supervision, control and communication systems installed on vehicles, and an associated information service system for fleet management. The development of the information service as part of the fleet management system that collects, analyses and evaluates data sent by individual vehicles extends the utility of the installed vehicle systems and represents a significant added value to its application.

This system integrates the capabilities of recent mobile telecommunication and the sensory and data measurement systems on the vehicle into a unified framework and has the feature of maintaining a permanent communication among the data acquisition and control modules allocated on the vehicles of transportation companies. It can also supervise and control the transportation processes, assist the driver in decision making, support the co-ordination of transport activities, and provides an information database for all participants possessing the particular unit on the vehicle. The main tasks in cargo transport systems are to monitor the technical conditions of the vehicle and schedule the maintenances, the fast and safe delivery of the cargo, to increase the driving safety of vehicles, to decrease the load of the vehicle by specifying the most suitable routes and by the dynamic modification of the routes planned, and to increase the efficiency of all activities related to the transportation.

The system to be developed will be coordinated among three main parties as it is illustrated in Figure 2.12. One of them is the vehicle whose states of motion and cargo, road or traffic information can be downloaded either off-line, either on-line, depending on the later use of the data. The second is the fleet management center that evaluates these data, communicates them to the owner and, if necessary, based on the confirmative action of the vehicle owners, supervises the vehicle control systems. The third party includes the users (fleet or vehicle owners) who are interested in having the information provided locally on-line about certain traffic situations or road conditions.

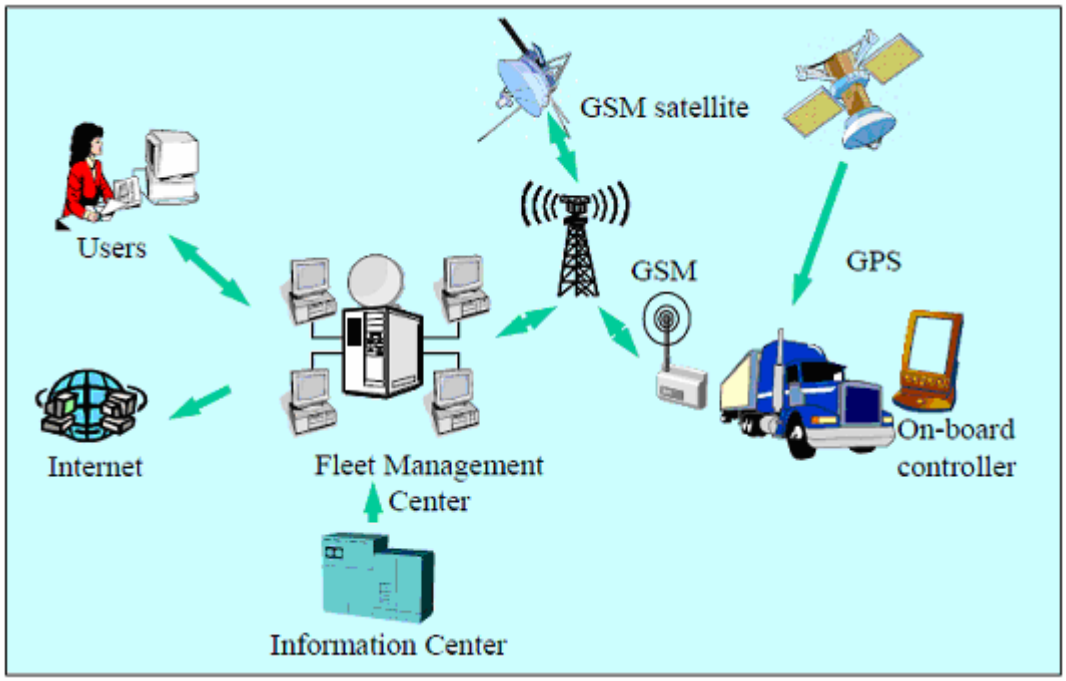


Figure 2.12. Illustration of the intelligent supervision, control and communication system (Sztaki, 2001)

Yazıcı, Gülçür (2005), informed that in this article, a hardware design for GRPS based mobile telemedicine sys tem is introduced. The need of effective and low cost personal and emergency monitoring telemedicine solutions are the main concern of this project. The elders, chronic patiences and ambulances are common examples of possible emergency cases.That project introduces continuous personal follow-ups especiallywhen the distance play critical role. One channel ECG and

0.5C0 resolution thermometer for body temperature measurement were chosen as bio-signals sources. Power consumtion and total volume for hardware were tried to be small and the usage of this device was faclitated by embedded software. The ECG data were digitized microcontroler in 10bit resolution and 500Hz sampling frequency and stored in EEPROM for 60s. Data is sent to a certain IP in internet via a personal mobile phone's GPRS modem. TCP/IP protocol and AT commad set is handled by embededly. Outgoing data is captured by a code (ASP) and then wrote in a database and then the data is converted in two dimentional form again. Design was copleted and sample data were stored and displayed on PC. The general architecture of the system make itself available to be data stored and accessible from everywhere.

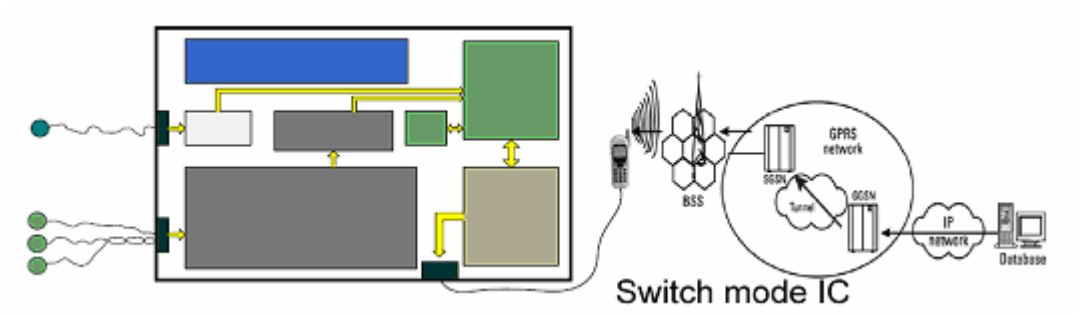


Figure 2.13. Sytem architecture (Yazıcı, 2005)

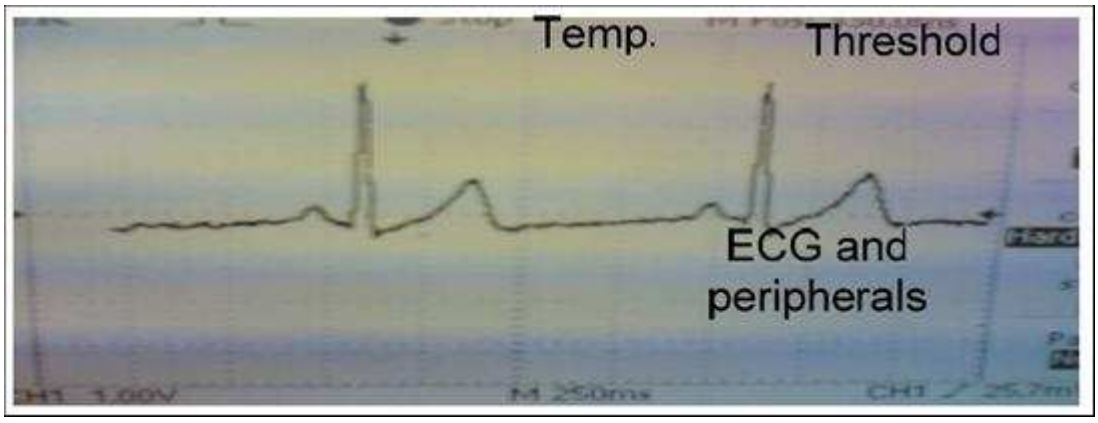


Figure 2.14. ECG Circuit (Yazıcı, 2005)

Ratcliffe, Heider, Crane, Krauthauser, Yoon and Gillespie Jr., When a structure is damaged there is often a concomitant localized change in structural

stiffness, which may affect the dynamic characteristicsof the structure. One characteristic that has proved suitable for damage identification and location is the operational curvature shape which exhibits changing features at locations of stiffness change. A method that finds theses features, SIDER, employs an algorithm that operates on broadband operational curvature shapes. To obtain data for SIDER, a small number of accelerometers, typically about four, is installed on the structure and the structure is then excited at a large array of test points using a ‘roving hammer’ technique. Frequency response functions are individually measured between each excitation point and the reference accelerometers, and the required operating curvature shapes are determined from the resulting array of frequency response functions. While setup of the experiment is reasonably quick, data acquisition can be time consuming and it is not easily amenable to automation. This paper investigates an alternative approach, which relies on the reciprocity theorem. An array of response transducers is installed on the structure, and then only a few locations are excited. There are significant benefits to this method, including the possibility of automation and remote sensing. The cost of hundreds of conventional accelerometers can be prohibitive, and therefore this project investigated using an array of low cost MEMS accelerometers. MEMS are also attractive in that they may be embedded into a composite structure during manufacture. In the study reported here the roving hammer and MEMS array methods are compared by testing a composite vertical stabilizer (tail plane) from an Airbus A320 aircraft. Despite the different test procedures, and the lower quality of the MEMS transducers, it is shown that an array of low cost MEMS transducers can determine results comparable with those obtained using high performance transducers.

3. MATERIAL AND METHODS

3.1. Material

3.1.1 Automotive Sensors: Past, Present and Future

Today's vehicles have kind of sensors supplying data for safety, performance and comfort functions. One of the first and most successful automotive applications were inlet manifold pressure measurement in early ignition and fuelling control systems. There are many other sensors including crankshaft position, knock, air mass flow, exhaust gas and temperature sensors which they have been used to enhance power train performance. After using electronically controlled electrically actuated systems on vehicles, new challenges and opportunities have created for sensor developers. Main sensors have completed with the addition of new sensors for new requirements, for example, long rage radar, tyre pressure monitoring and optical steering torque sensors. One of the important factor is sensor cost in the selection criteria of automotive system designers. In addition, sensor suppliers must provide quality demands of this automotive market. Figure 3.1. provides some example of sensors used on today's vehicles (Prosser, 2007).

3.1.1.1. Market Trends

During last twenty years, market studies have continued for increasing usage of sensors on automotive systems. Total world market value was $2.3b at 1991 and the market has grown to $10.1b in 2006 with an expect to take it to $15.8b in 2012.

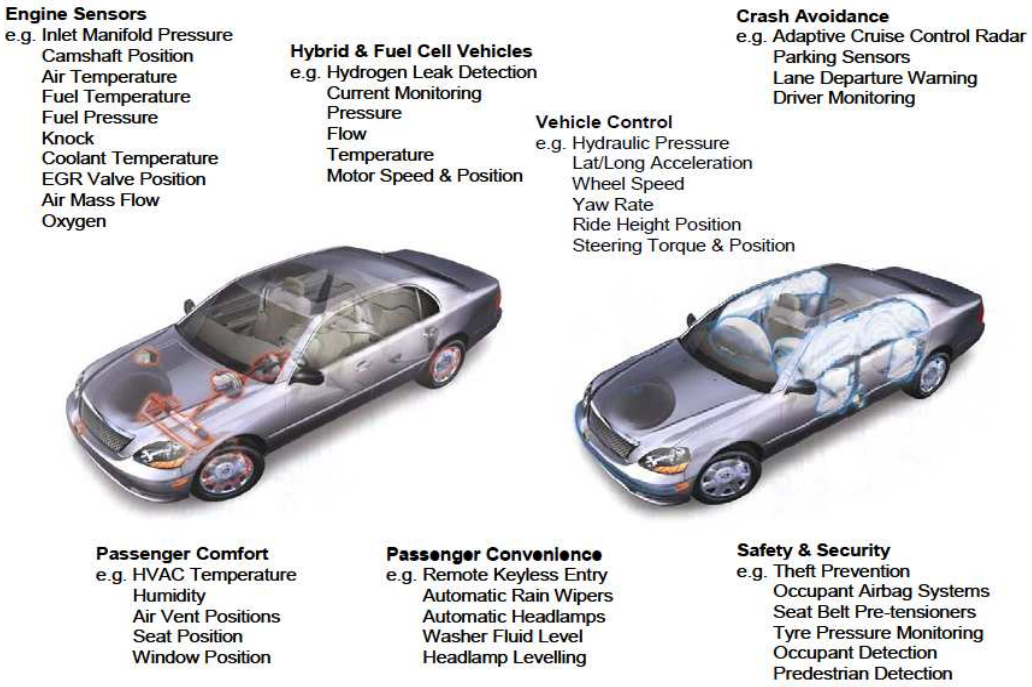


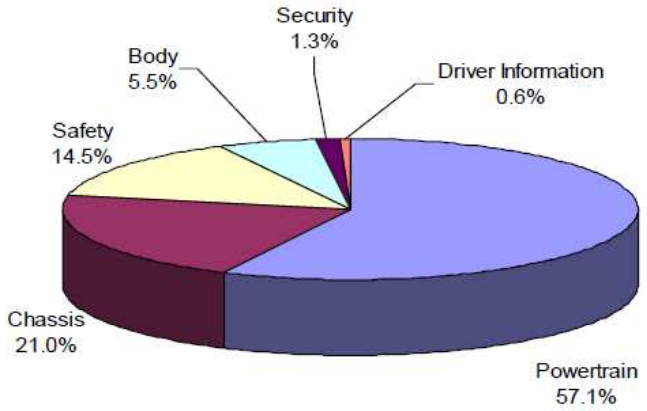
Figure 1. Examples of Automotive Sensor Applications

Figure 3.1. Examples of Automotive Sensor Applications (Prosser, 2007)

Although less than %4 growing expectation at passenger car production, automotive sensor revenues are expected to increase by 10.1% CAGR during the same period as a result of OEM's responding to increasing environmental and safety rule by presenting electronically controlled innovations. Big part of sensor demand depends on mature established applications, for example, engine emissions control, anti-locking braking systems and airbags.

Table 3.1. Total World sensors Market (Prosser, 2007)

Year	Market Value
1991	$2.3b
1995	$3.8b
1997	$4.7b
2000	$7.0b
2006	$10.1b
2012	$15.8b



ring systems in the US.

Figure 3.2. 2006 World market Value by Application (Prosser, 2007)

There is no service to consumer aftermarket in sensor business sector. The sensors are used by the vehicle manufacturer or tier one supplier who has system responsibility. The sensor supply chain can be grouped at below three categories:

1. System suppliers with in-house sensor design and manufacturing capabilities
2. Semiconductor companies who also possess an automotive sensor business
3. Sensor companies who target the automotive market

The automotive sensor market has still-expanding market characteristic depending on high production volumes, high reliability and low cost. Existing sensors will continue to find new application areas (Prosser, 2007).

3.1.1.2. Sensors & Their Applications

A simple vehicle includes over 30 electrical/electronic systems and more than 100 sensors. Although these are some sensor applications which have used for one specific technology like accelerometers and microengineering. Microengineered sensors (MEMS) have dominated the market with the applications of inlet manifold pressure sensor and airbag accelerometer. Pressure sensors have based on bulk and surface micromachining techniques using reliable batch processes and optimised thin film material properties (Prosser, 2007).

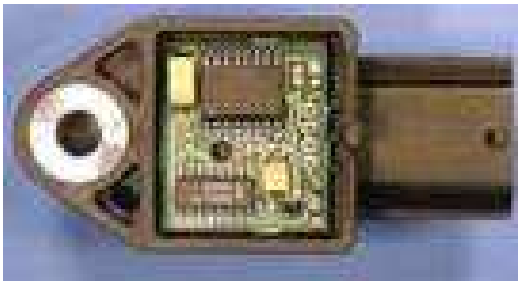


Figure 3.3. Airbag Accelerometer (Prosser, 2007)

The use of Hall Effect sensors and magnetoresistive devices have impacted the application of the traditional variable reluctance sensors for speed/position measurement, although there is a tradeoff between required functionality and cost.

The steering torque sensor which completes with a position sensor inside, is developed for electrically power assisted steering systems. Inductive and optical technologies have used torque sensing technologies. In the case of the optically-based sensor, the electronic control unit processes the pattern of light transmitted for determining both steering torque and position (Prosser, 2007).

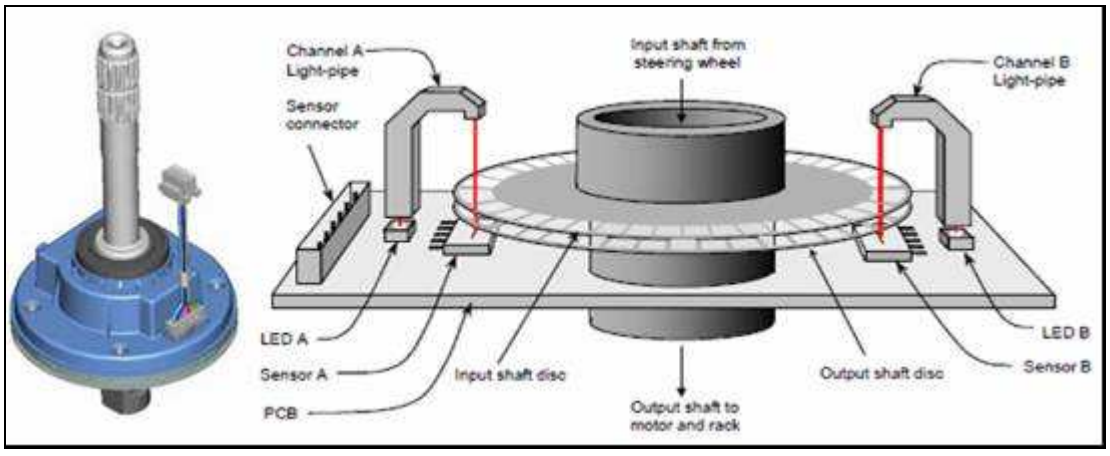


Figure 3.4. Optical Torque and Position Sensor. (Prosser, 2007)

An inertial sensor module, which includes a yaw rate sensor and one or two acceleration sensors, is used for vehicle stability control systems. The yaw sensor is used to measure vehicle rotation with a range of %75.The acceleration sensor is used to measure vehicle's longitudinal and lateral acceleration with a range of +/-1.5 g. (Prosser, 2007)



Figure 3.5. Slip Control System ECU with Integrated Inertial Sensors (Prosser, 2007)

The other sensor application for vehicles is long range radar sensor which is used as part of cruise control systems. Radar sensor has capability to scan at 77GHz operating frequency and at 150 metres distance. Vehicles can be operated upper speeds of 30 m/h by today's systems, but future systems will let us to operate vehicles down to zero speed through the use of short range radar.) (Prosser, 2007).

3.1.1.3. Future Sensor Opportunities

Future developmentt of safety systems will make vehicles more smart. They will recognize potentially dangerous situations and give support to the driver at pre-determined level. Also, parking assistance systems will adapt to vehicles as standard equipment in the near future. Ultrasonic sensors will use to measure the length and depth of a parking space for steering the vehicle safely with the manoeuvres that are required. Then the task will complete with a sound or visual instructions of driver (Prosser, 2007).

Sensor development engineers will need to take designer's opinion for fitting sensors functionally on vehicle. Electrical architectures will work on standardization and supply same sensor output range between vehicle systems. There will be successful electronic integration when mechanical systems replace by electronically controlled electrically actuated systems. Also that will be effective to develop new sensing technologies (Prosser, 2007).

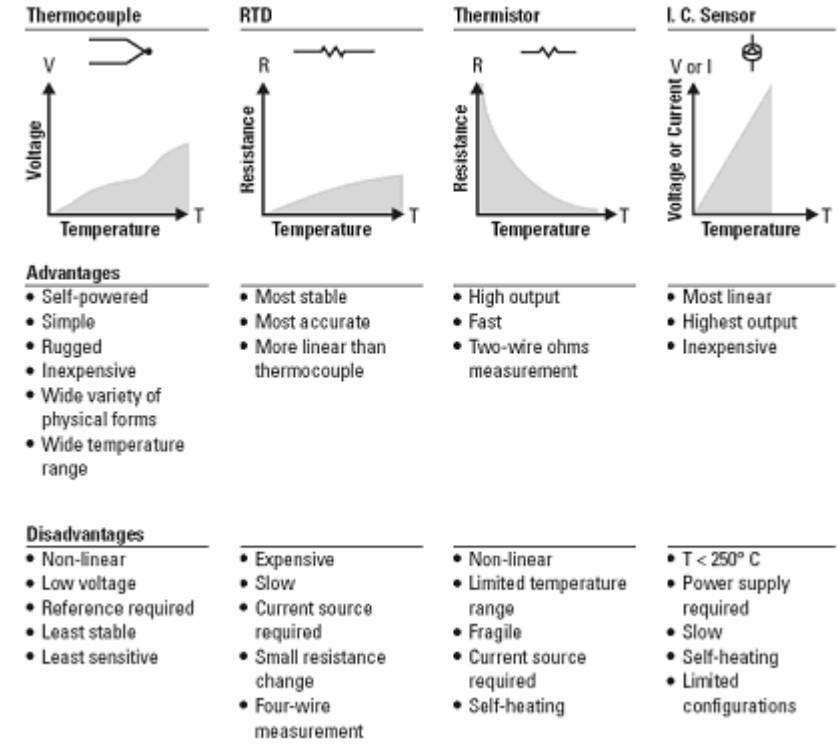
3.1.2. Automotive Applications for Temperature Sensors

Temperature sensors have been commonplace in a variety of automotive applications, enabling the enhancement of automotive systems. The ongoing trends to improve the system's performance and efficiencies, the driver convenience, and reduction of emissions continue to drive new temperature sensor applications. This section will discuss the (El-Awar, 1999).

Safety and envorinmental regulations have been stronger drivers for temperature sensor applications. In addition to mandates by external forces, technical advancements have had a great effect on the proliferation of temperature sensors. Also the needs of the customers have driven the need for electronics and sensors within the vehicle

There are a large number of technologies dedicated to the measurement of temperature, from thermocouples, thermistors, or resistance temperature detectors (RTDs) to solid-state technology (Table 3.2).

Table 3.2. Most popular types of temperature transducers and their compare (Agilent, 2008)



Existing Applications for Temperature Sensors: Temperature sensors provide a key parameter to the electronic control module (ECM) to enable feedback of the system's current state of operation. The two systems of the vehicle that are primary users of temperature sensors are the engine/powertrain management system and the HVAC system.

The most common applications for the automatic HVAC control are: outside air temperature sensor, inside/cabin temperature sensor, duct air temperature sensor. The outside air temperature sensor controls the temperature of the air external to the vehicle. The sensor interfaces with the HVAC control unit and/or display module to enable automatic HVAC control or outside temperature display. The inside/cabin temperature sensor provides the temperature within the passenger compartment of the vehicle. Duct sensors of the HVAC air delivery system are increasing due to temperature zoning within the cabin and further HVAC control system strategy refinements. These sensors further enhance the automotive HVAC system by providing additional measurement locations (El-Awar, 1999).

The engine/powertrain management system uses a number of temperature inputs to enhance the performance of the engine, control emissions, and optimize efficiency. (El-Awar, 1999). The most common applications are the:

- Coolant temperature sensor
- Intake air temperature sensor
- Transmission oil temperature sensor
- Cylinder head temperature sensor

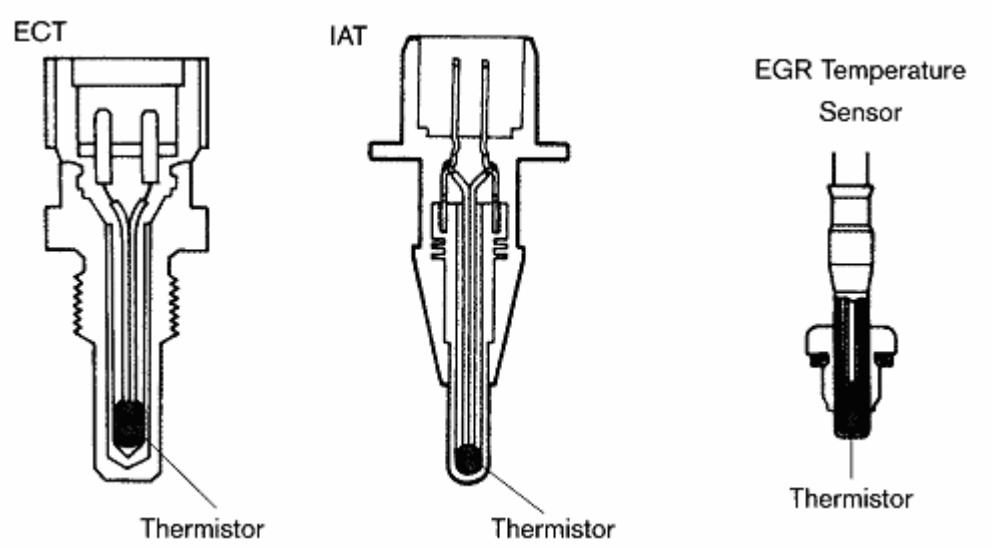


Figure 3.6. Temperature Sensor Types (Anonymous, 2008)

3.1.2.1. Engine Coolant Temperature (ECT) Sensor

The ECT is in a coolant passage just before the thermostat. It responds to change in Engine Coolant Temperature. The ECM learns the average temperature of the engine, by measuring ECT. The ECT sensor is very important for many ECM functions such as fuel injection, ignition timing, variable valve timing, transmission shifting, etc Always check to see if the engine is at operating temperature and that the ECT is accurately reporting the temperature to the ECM (Anonymous, 2008).

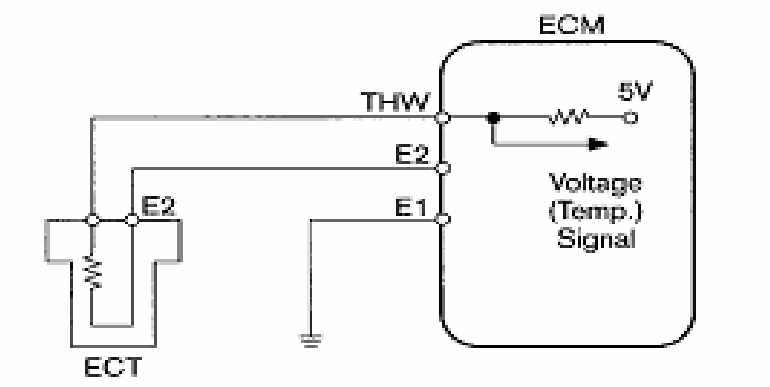


Figure 3.7. ECT Circuit (Anonymous, 2008)

3.1.2.2. Intake Air Temperature (IAT) Sensor

The IAT monitors the temperature of the incoming air stream. The IAT is connected to the THA terminal on the ECM and it is used for detecting ambient temperature on a cold start and intake air temperature when the engine heats up the incoming air (Anonymous, 2008).

3.1.2.3. Exhaust Gas Recirculation (EGR) Temperature Sensor

The EGR Temperature Sensor, measures the temperature of the exhaust gases is located in the EGR passage. The EGR Temp sensor is connected to the THG terminal. When the EGR valve opens, temperature increases. So, the ECM knows the EGR valve is open and that exhaust gases are flowing (Anonymous, 2008).

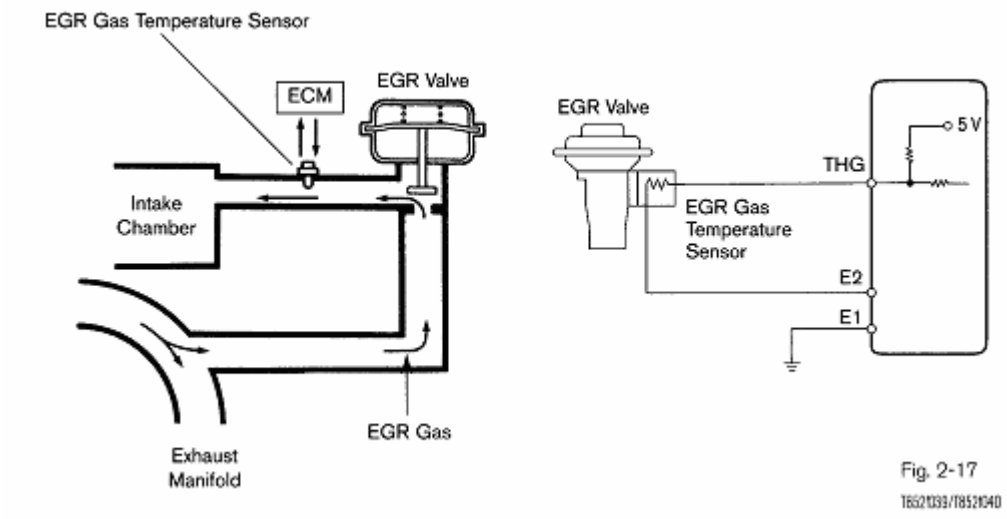


Figure 3.8. EGR Circuit (Anonymous, 2008)



Figure 3.9. NTC Thermistor

3.1.3. Automotive Applications for Pressure Sensors

Automotive requirements for pressure measurement range from the basic-oil pressure-to sophisticated -air pressure differential one side of the vehicle to the other.

This section elaborates on some kind of possibilities for the measurement of the pressure that may exist in the development, laboratory, or pilot phases of the vehicle, to actual volume production. Table 3.3. lists a number of potential pressure measurements versus vehicle system and provides an indication of the pressure range and type of measurement (Frank, 1999).

Table 3.3. Pressure sensing Requirements for Various Vehicle systems (Frank, 1999)

System	Parameter	Pressure range	Type
Engine control	Manifold absolute pressure	100 kPa	Absolute
	Turbo boost pressure	200 kPa	Absolute
	Barometric pressure (altitude)	100 kPa	Absolute
	EGR pressure	7.5 psi	Gage
	Fuel pressure	15 psi—450 kPa (13.5 MPa peak)	Gage
	Fuel vapor pressure	15 in H_2O	Gage
	Mass air flow	—	Differential
	Combustion pressure	100 Bar (16.7 MPa peak)	Differential
	Exhaust gas pressure	100 kPa	Gage
	Secondary air pressure	100 kPa	Gage
Elect transmission (continuously variable transmission)	Transmission oil pressure	80 psi	Gage
	Vacuum modulation	100 kPa	Absolute
Idle speed control	AC clutch sensor/switch	300–500 psi	Absolute*
	Power steering pressure	500 psi	Absolute*
Elect power steering (also elect assisted)	Hydraulic pressure	500 psi	Absolute*
Antiskid brakes/ traction control	Brake pressure	500 psi	Absolute*
	Fluid level	12 in H_2O	Gage
Air bags	Bag pressure	7.5 psi	Gage
Suspension	Pneumatic spring pressure	1 MPa	Absolute*
Security/keyless entry	Passenger compartment pressure	100 kPa	Absolute
HVAC (climate control)	Air flow (PC) Compressor pressure	300–500 psi	Absolute*
Driver information	Oil pressure	80 psi	Gage
	Fuel level	15 in H_2O	Gage
	Oil level	15 in H_2O	Gage
	Coolant pressure	200 kPa	Gage
	Coolant level	24 in H_2O	Gage
	Windshield washer level	12 in H_2O	Gage
	Transmission oil level	12 in H_2O	Gage
	Tire pressure	50 psi	Gage/absolute
	Battery fluid level	1–2 in below	Optical
Memory seat	Lumbar pressure	7.5 psi	Gage
Multiplex/diagnostics	Multiple usage of sensors	—	

3.1.3.1. Existing Applications for Pressure Sensors

A late twentieth century production vehicle may have a number of pressure for measurement. For example; atmospheric pressure, manifold pressure, engine oil pressure, tire pressure, vapor pressure in the fuel tank and other pressure measurements. Despite the difference of the location and changing measures, the operating principal are similar.

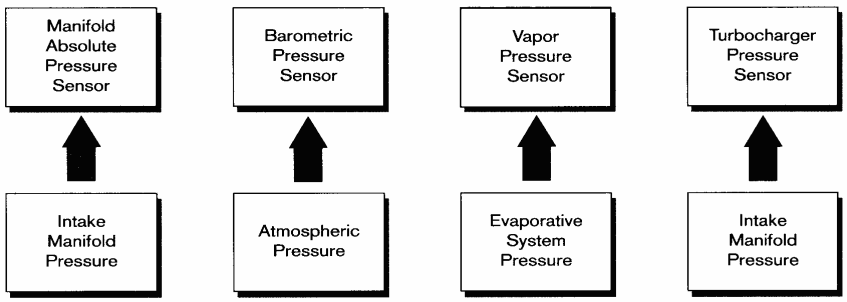


Figure 3.10. Applications for Pressure Sensors (Anonymous, 2008)

3.1.3.2. Manifold Absolute Pressure (MAP)

In the Manifold Absolute Pressure (MAP) sensor there is a silicon chip mounted inside a reference chamber. On one side of the chip is a reference pressure. On the other side is the pressure to be measured. The silicon chip changes its resistance with the changes in pressure. When the silicon chip flexes with the change in pressure, the electrical resistance of the chip changes. This change in resistance alters the voltage signal and any change in the voltage signal means there was a change in pressure (Anonymous, 2008).

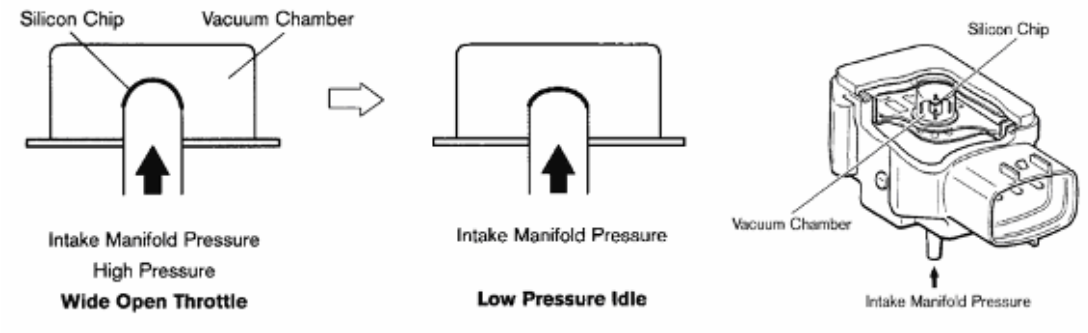


Figure 3.11. Manifold Absolute Pressure (Anonymous, 2008)

Intake manifold pressure is a directly related to engine load. The ECM needs to know intake manifold pressure to calculate how much fuel to inject, when to ignite the cylinder, and other functions. The MAP sensor is located either directly on the intake manifold or it is mounted high in the engine compartment and connected to the intake manifold with vacuum hose. It is critical the vacuum hose not have any kinks for proper operation (Anonymous, 2008).

The MAP sensor uses a perfect vacuum as a reference pressure. The difference in pressure between the vacuum pressure and intake manifold pressure changes the voltage signal. The MAP sensor converts the intake manifold pressure into a voltage signal (Anonymous, 2008).

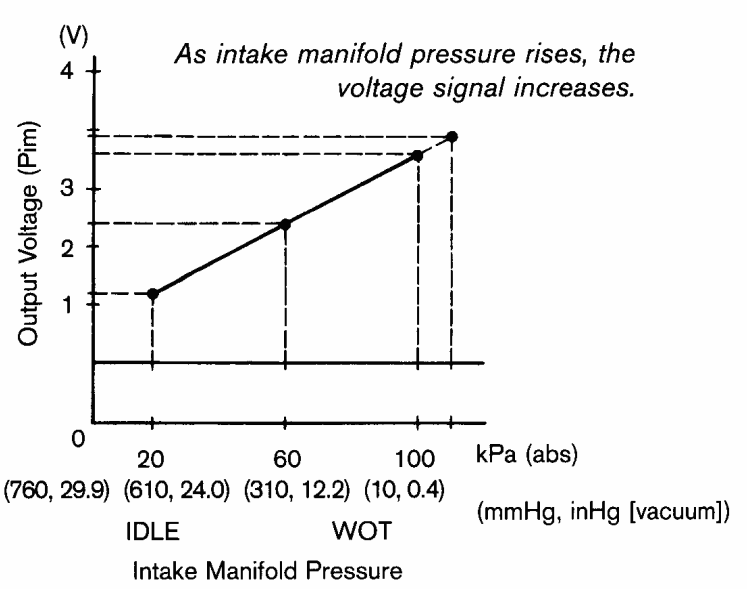


Figure 3.12. MAP voltage signal (Anonymous, 2008)

The MAP sensor voltage signal is highest when intake manifold pressure is highest (ignition key ON, engine off or when the throttle is suddenly opened). The MAP sensor voltage signal is lowest when intake manifold pressure is lowest on deceleration with throttle closed (Anonymous, 2008).

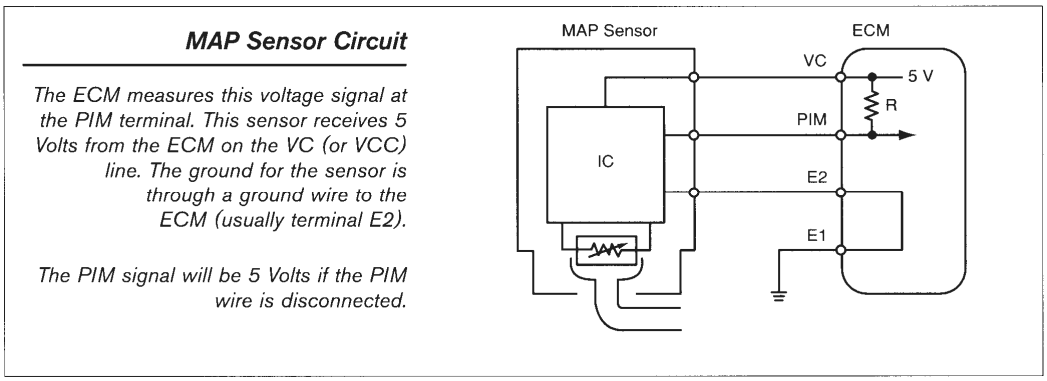


Figure 3.13. MAP sensor Circuit (Anonymous, 2008)

3.1.3.3. Barometric Pressure Sensor

The Barometric Pressure Sensor, sometimes called a High Altitude Compensator (HAC), measures the atmospheric pressure. Atmospheric pressure

varies with weather and altitude. This sensor operates the same as the MAP sensor except that it measures atmospheric pressure. It is located inside the ECM.

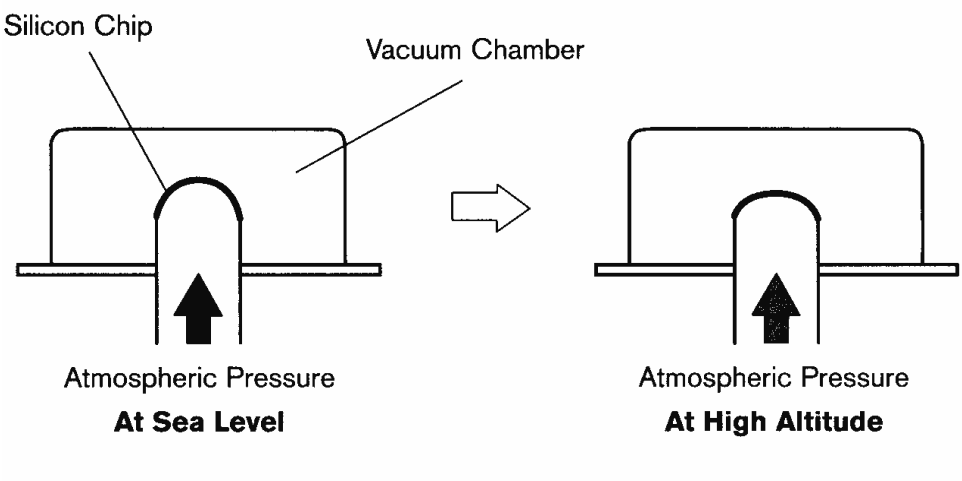


Figure 3.14. Barometric Pressure Sensor (Anonymous, 2008)

3.1.3.4. Turbocharging Pressure Sensor

The turbocharging pressure sensor operates identically to the MAP sensor and is used to measure intake manifold pressure. The only difference is that when there is boost pressure, the voltage signal goes higher than on a naturally aspirated engine (Anonymous, 2008).

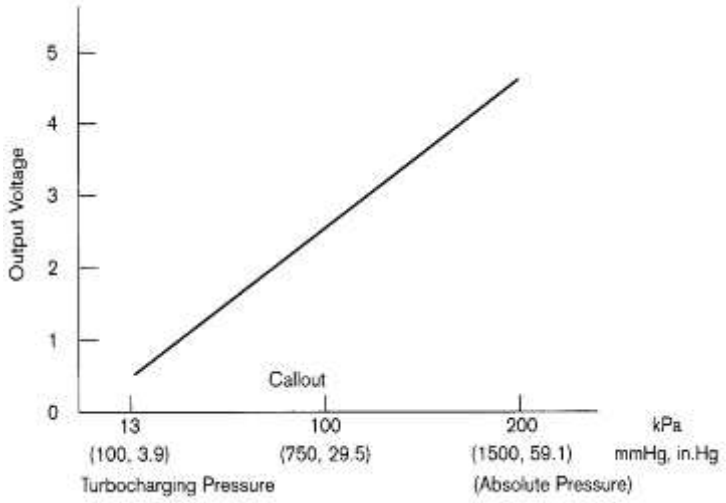


Figure 3.15. Turbocharging pressure sensor output voltage (Anonymous, 2008)

3.1.3.5. Vapor Pressure Sensor

The Vapor Pressure Sensor (VPS), measures the vapor pressure in the evaporative emission control system and it may be located on the fuel tank or in a remote control. This sensor uses a silicon chip mounted inside a reference chamber. On one side of the chip is a calibrated reference pressure. On the other side is thevapor pressure to be measured Changes in vapor pressure cause the chip to flex and vary the voltage signal to the ECM. The signal out depends on the difference between atmospheric pressure and vapor pressure. As vapor pressure increases the voltage signal increases. This sensor is sensitive to very small pressure changes (1.0 psi = 51.7 mmHg).(Anonymous, 2008).

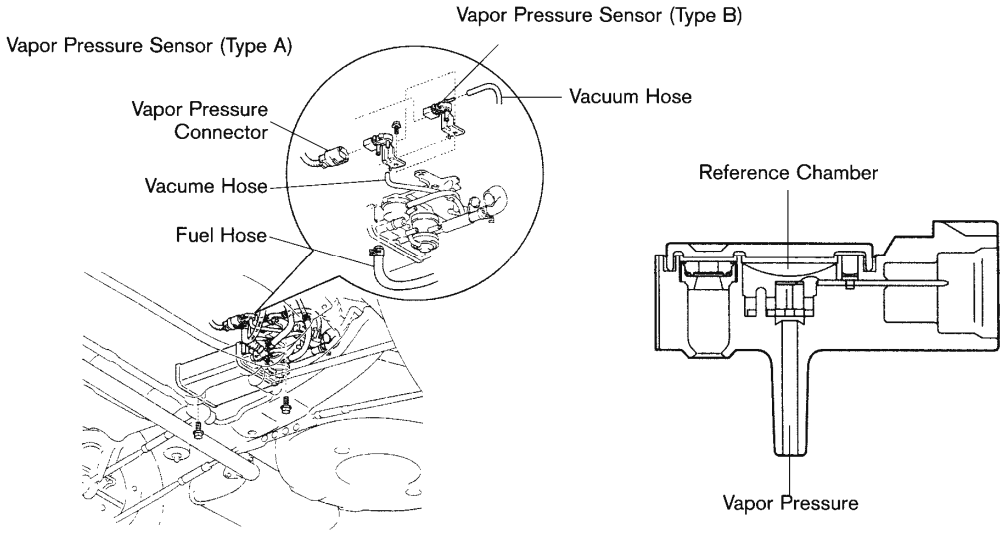


Figure 3.16. Vapor Pressure Sensor (Anonymous, 2008)

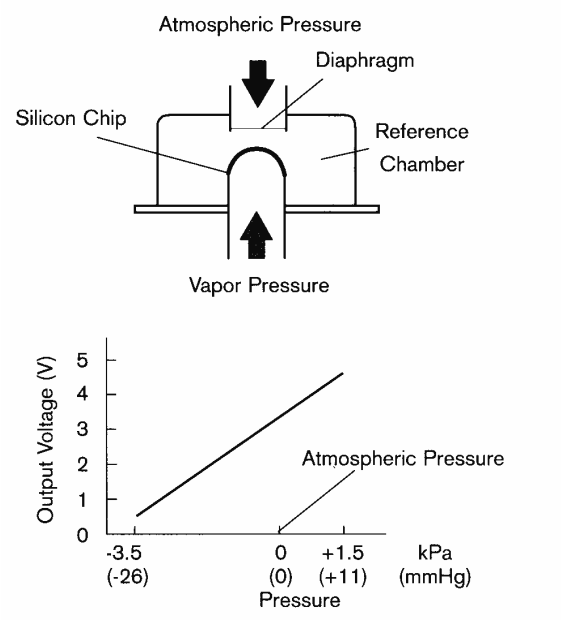


Figure 3.17. Vapor Pressure Sensor voltage output (Anonymous, 2008)

3.1.3.6. Engine and Transmission Oil Pressure

Oil pressure on automobiles and construction machines has traditionally been measured by deflection of a rubber diaphragm which closes a set of contacts (switches) providing a lamp indication with low oil pressure of moves a potentiometer to provide analog signal for a gage (Frank, 1999).



Figure 3.18. Engine Oil Pressure Sensor and Gauge

Transmission pressure is required as an input in ECU-controlled transmission shift points. This pressure can be measured with sensors similar to those developed for engine oil pressure.

3.1.3.7. Tire Pressure

The continuous monitoring of tire pressure offers increased fuel economy and safety to passenger cars or construction machines. Underinflated tires create excessive rolling friction and therefore devreased fuel economy. Available tire pressure system consist of a tire pressure sensor (or switch) at each wheel, wheel speed and indicator, temperature sensor, a radio frequency transmitter, electronic receiver/controller, and a display unit. The dashboard display provides an indication to the driver that the tires are improperly inflated. Tire pressure increases with temperature approximately 1.5 psi for 10 ºC of tire air temperature rise, so the system must provide correction for this effect. Aburpt increases in temperature and pressure can be sensed by these system and provide a warning of eminent tire failure providing an additional safety factor (Frank, 1999).

3.1.3.8. Other Pressure Measurements

Special construction machines truck measurements require pressure measurements that are quite different from those made on passenger cars. Accumulator-type fuel injection systems for direct injection diesel engines have fuel pressurized to 20 to 100 MPa in the accumulator by a high-pressure pump. The accumulator pressure is monitored in this approach to reduce particulates. Direct injection in spark ignition engines will extend these higher pres sures into passenger cars. Another method to reduce diesel particulates utilizes a ceramic fiber as a filter in a canister. A pressure sensor monitors the backpressure and allows the full filter to be regenerated by burning off the accumulated particulates in the filter. A heater element in the trap has power supplied from the power-switching module. A temperature approaching 1300 °F (700 °C) is reached inside the filter cartridge to incinerate the particles. Lumbar support systems utilize a pressurized system with a pressure sensor (<=7.5 psig) as the feedback element controlling the air pump to provide additional support to the driver's lower back in luxury vehicles. Pressure-sensitive grids have been used in the development process to automatically measure

up to 3600 contact points for visual display and weight distribution analyises (Frank, 1999).

3.1.3.9. Pressure Sensing Technology

There are two basic categories of analog pressure sensors **Force Collector Types** These types of electronic pressure sensors generally use a force collector (such a diaphragm, piston, bourdon tube, or bellows) to measure strain (or deflection) due to applied force (pressure) over an area (Anonymous, 2010b).

- Piezoresistive Strain Gage; Uses the piezoresistive effect of bonded or formed strain gages to detect strain due to applied pressure. Common technology types are Silicon (Monocrystalline), Polysilicon Thin Film, Bonded Metal Foil, Thick Film, and Sputtered Thin Film. Generally, the strain gauges are connected to form a Wheatstone bridge circuit to maximize the output of the sensor. This is the most commonly employed sensing technology for general purpose pressure measurement. Generally, these technologies are suited to measure absolute, gauge, vacuum, and differential pressures.
- Capacitive; Uses a diaphragm and pressure cavity to create a variable capacitor to detect strain due to applied pressure. Common technologies use metal, ceramic, and silicon diaphragms. Generally, these technologies are most applied to low pressures (Absolute, Differential and Gauge)
- Electromagnetic; Measures the displacement of a diaphragm by means of changes in inductance (reluctance), LVDT, Hall Effect, or by eddy current principal.
- Piezoelectric; Uses the piezoelectric effect in certain materials such as quartz to measure the strain upon the sensing mechanism due to pressure. This technology is commonly employed for the measurement of highly dynamic pressures.
- Optical; Uses the physical change of an optical fiber to detect strain due to applied pressure. A common example of this type utilizes Fiber Bragg

Gratings. This technology is employed in challenging applications where the measurement may be highly remote, under high temperature, or may benefit from technologies inherently immune to electromagnetic interference.

- Potentiometric; Uses the motion of a wiper along a resistive mechanism to detect the strain caused by applied pressure.

Other Types: These types of electronic pressure sensors use other properties (such as density) to infer pressure of a gas, or liquid (Anonymous, 2010b).

- **Resonant**; Uses the changes in resonant frequency in a sensing mechanism to measure stress, or changes in gas density, caused by applied pressure. This technology may be used in conjunction with a force collector, such as those in the category above. Alternatively, resonant technology may be employed by expose the resonating element itself to the media, whereby the resonant frequency is dependent upon the density of the media. Sensors have been made out of vibrating wire, vibrating cylinders, quartz, and silicon MEMS. Generally, this technology is considered to provide very stable readings over time.
- **Thermal**; Uses the changes in thermal conductivity of a gas due to density changes to measure pressure. A common example of this type is the Pirani gauge.
- **Ionization**; Measures the flow of charged gas particles (ions) which varies due to density changes to measure pressure. Common examples are the Hot and Cold Cathode gages.

3.1.4. Air Flow Sensors

3.1.4.1. Mass Air Flow (MAF) Sensors

The MAF sensor adjusts incoming air volume into the engine into a voltage signal for calculating engine load. This is important to determine how much fuel to inject at time of cylinder ignition and transmission shifting. The air flow sensor is mounted in the intake air stream for measuring incoming air easily. There are different different type of MAss Air Flow sensors in industry applications. More commons are Vane air flow meter and Karmen Vortex air flow meter (Anonymous, 2008).

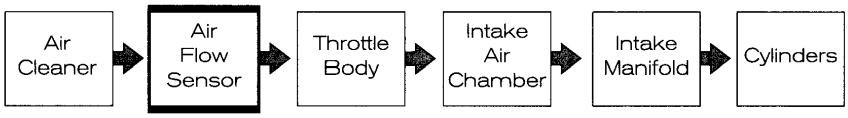


Figure 3.19. Air Flow Sensor (Anonymous, 2008)

Thermistor, platinum hot wire and electronic control circuit are main parts of MAF sensor. The thermistor measures air flow temperature with hot wire which is maintained a constant temperature by the electronic control circuit. The electronic control circuit gives a voltage signal when measures the current flow (Anonymous, 2008).

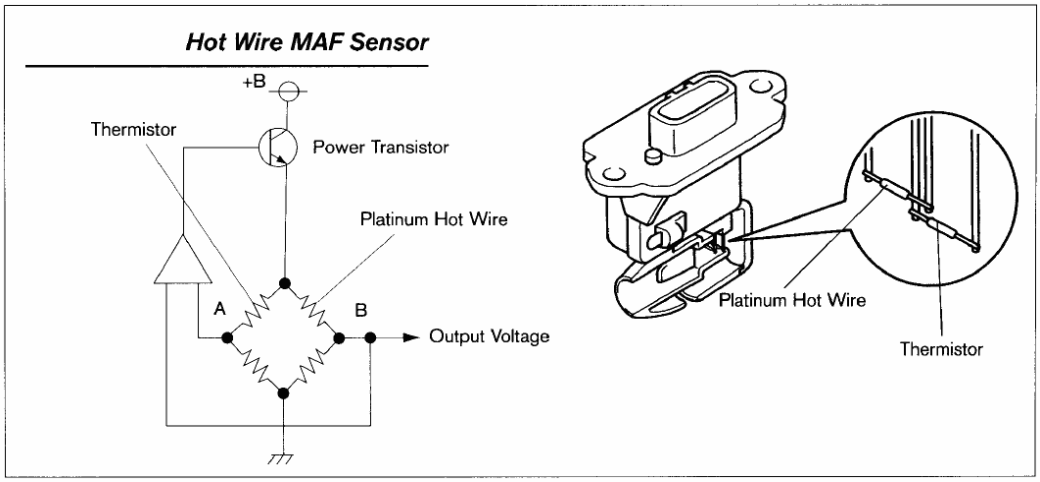


Figure 3.20. Hot Wire MAF Sensor (Anonymous, 2008)

3.1.4.2. Vane Air Flow Meter

The ECM is provided by the Vane Air Flow Meter with an accurate measure of the load placed for calculating basic injection duration and basic ignition advance angle. It occurs from below components:

- Measuring Plate.
- Compensation Plate.
- Return Spring.
- Potentiometer.
- Bypass Air Passage.
- Idle Adjusting Screw (factory adjusted).
- Fuel Pump Switch.
- Intake Air Temperature (IAT) Sensor.

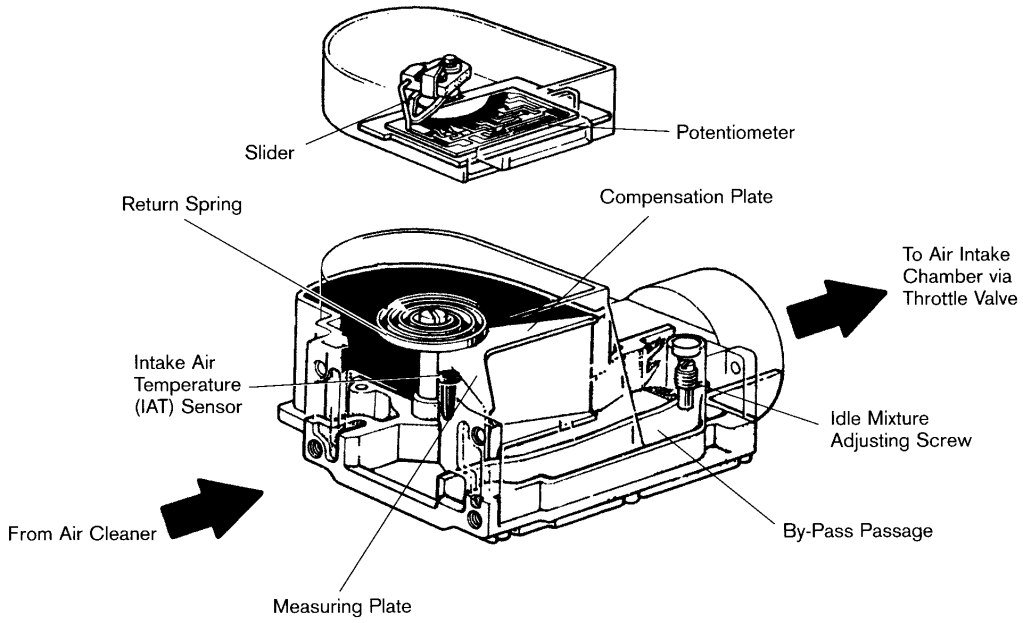


Figure 3.21. Vane Air Flow Meter (Anonymous, 2008)

3.1.4.3. Karmen Vortex Air Flow Meter

It supplies the same type of data with Vane Air Flow meter. It consists of the following components:

• Vortex Generator.

• Mirror (metal foil).

• Photo Coupler (LED and photo transistor).

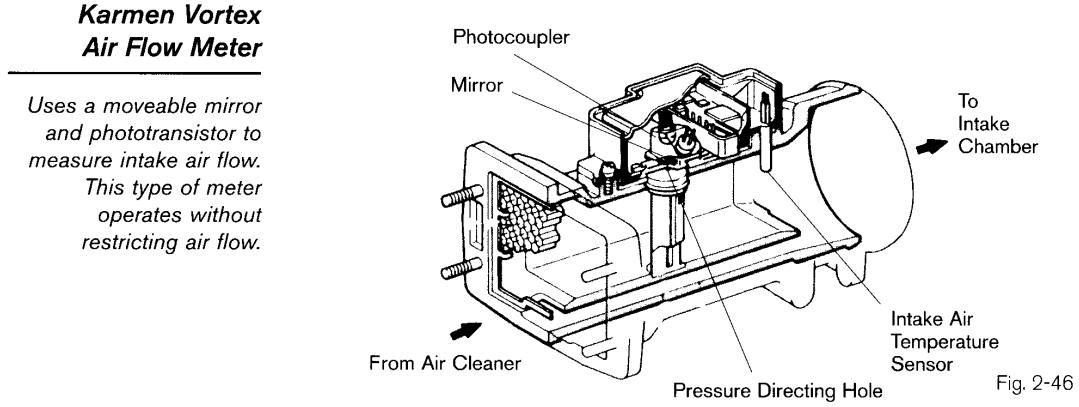


Figure 3.22. Karmen Vortex Air Flow Meter (Anonymous, 2008)

3.1.5. Position / Speed Sensor

The ECM takes data concerning the position of component, the speed of component and the change in speed of component from position/speed sensors.

The following sensors provide this data:

- Camshaft Position Sensor (also called G sensor).
- Crankshaft Position Sensor (also called NE sensor).
- Vehicle Speed Sensor.

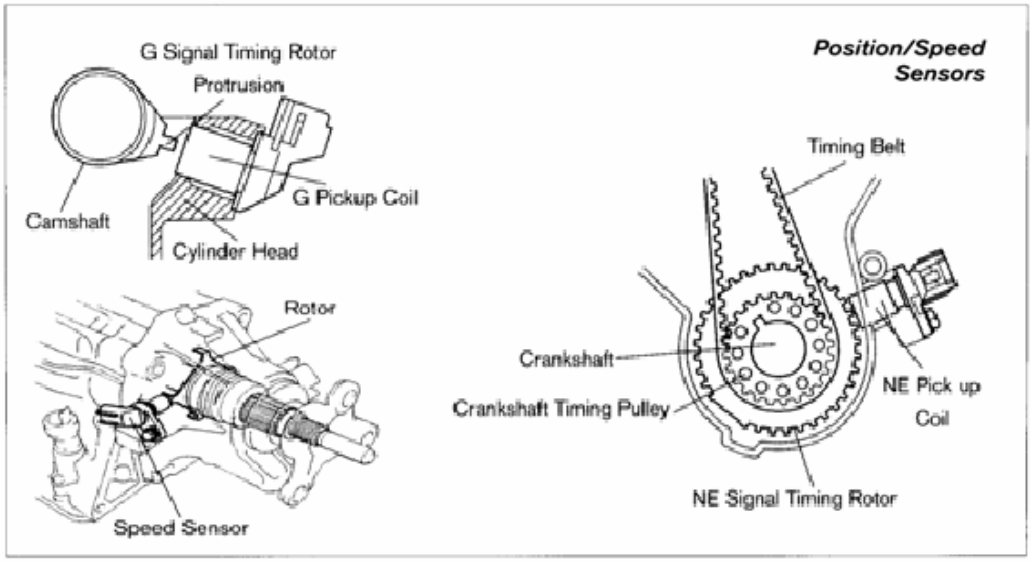


Figure 3.23. Position/Speed Sensors (Anonymous, 2008)

3.1.5.1. Pick-Up Coil (Variable Reluctance) Type Sensors

This sensor is used for generating camshafts speeds with an AC signal according to frequency increases. Also it can be used for V-type engines with variable timing. On distributor ignition systems, it is called as G sensor (Anonymous, 2008).

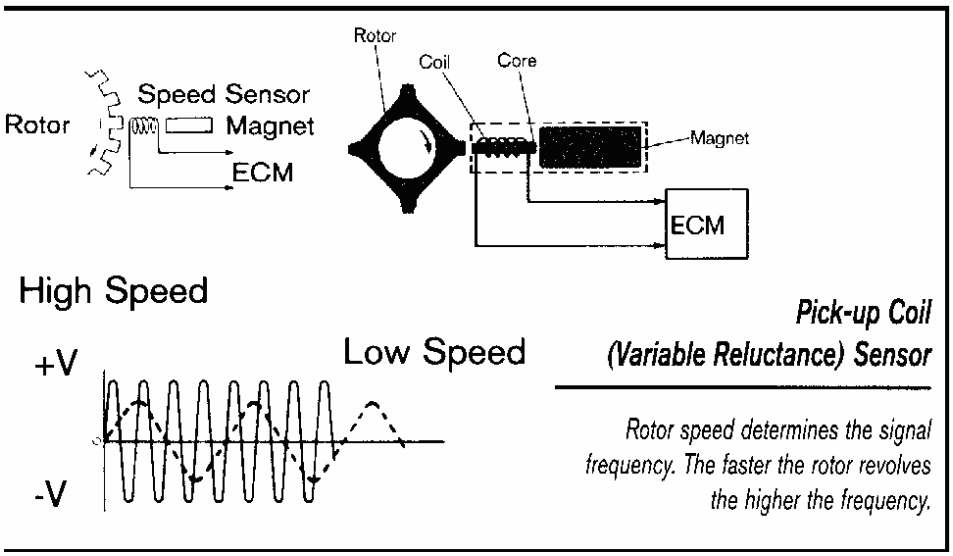


Figure 3.24. Pick-up Coil Sensor (Anonymous, 2008)

3.1.5.2. Camshaft Position Sensor (G Sensor)

The camshaft position sensor is a magnetic or hall effect sensor, this sensor reads information about the engine, camshafts and speed. It sends a signal to the computer relaying information about shaft speed, position and acceleration or deceleration. The function of the camshaft position sensor is important for the vehicle to run at its best, and maintaining a high level of performance and fuel economy (Anonymous, 2008).

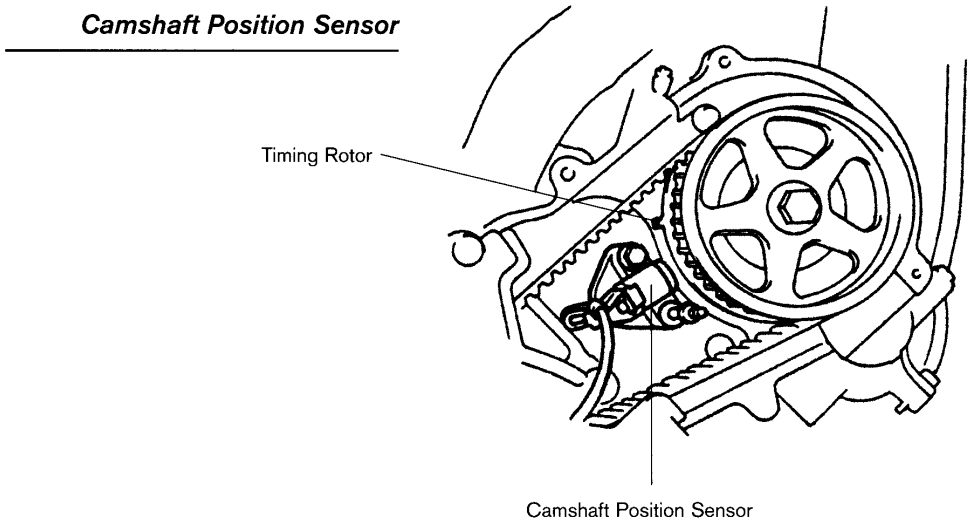


Figure 3.25. Camshaft Position Sensor (Anonymous, 2008)

3.1.5.3. Crankshaft Position Sensor (NE Sensor)

The crankshaft position signal, which combines with the G signal for displaying the compression on cylinder, is used by ECM to determine engine RPM, crankshaft position and engine misfire from its programming.

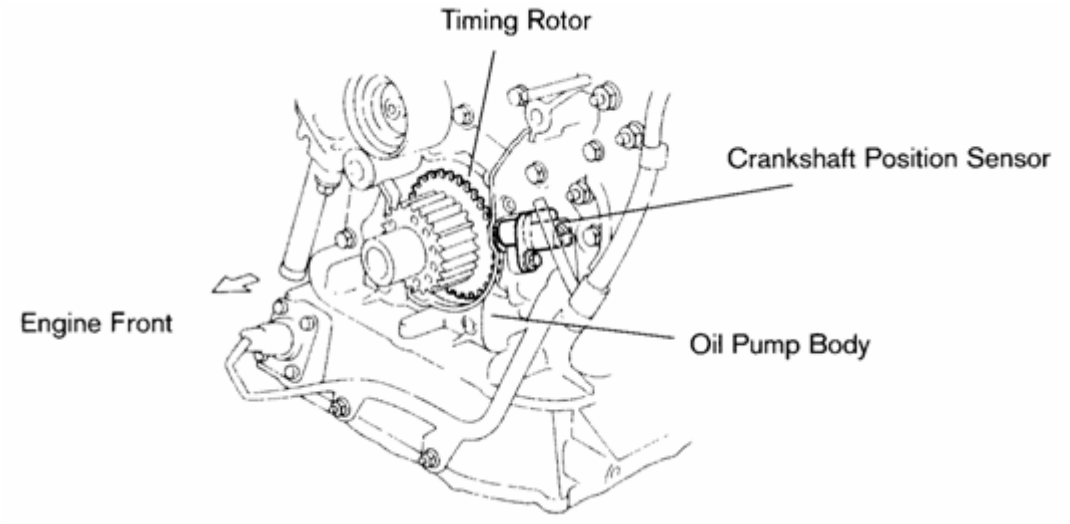


Figure 3.26. Camshaft Position Sensor (Anonymous, 2008)

3.1.5.4. Vehicle Speed Sensor (VSS)

The Vehicle Speed Sensor VSS signal, which occurs from transmission/transaxle output speed or wheel speed, is used by ECM to modify engine functions and begin diagnostic routines (Anonymous, 2008).

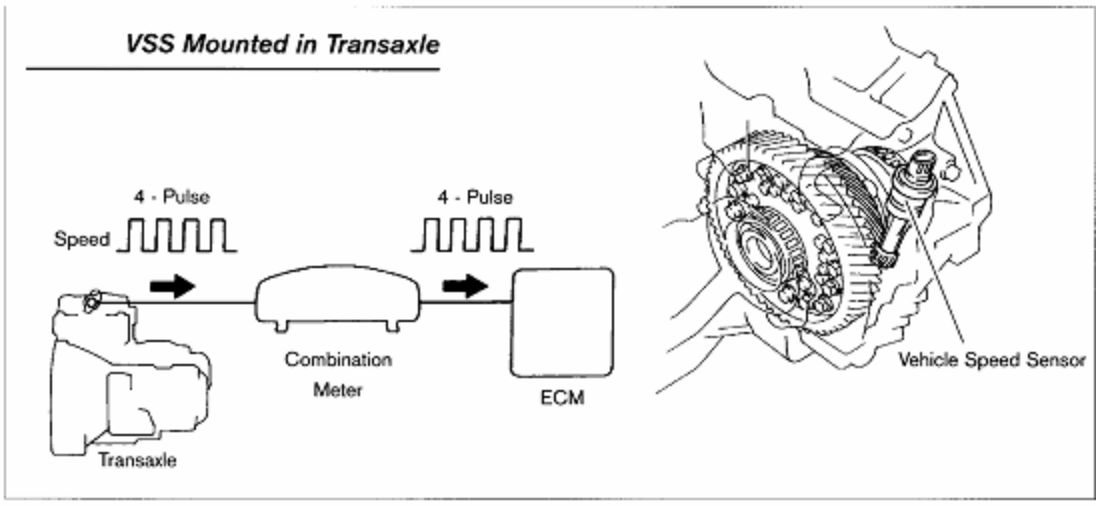


Figure 3.27. Vss mounted in transaxle (Anonymous, 2008)

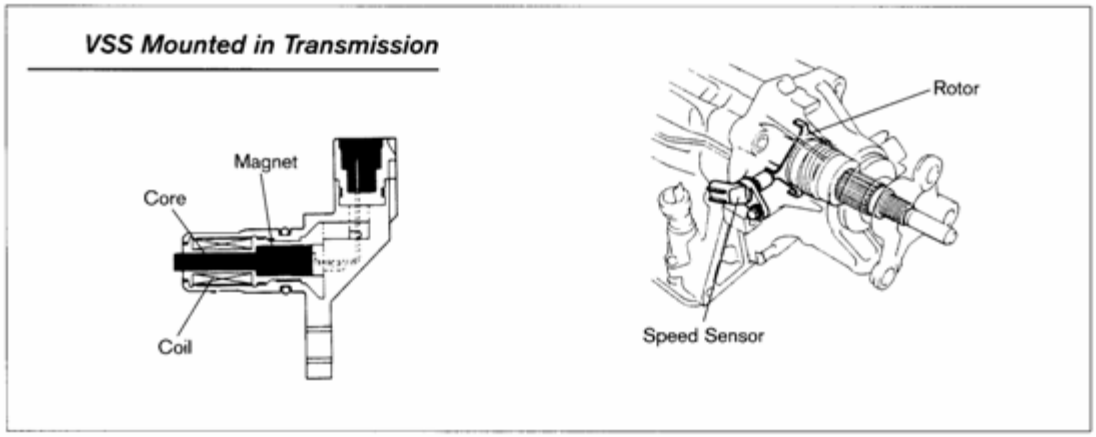


Figure 3.28. Vehicle Speed Sensor mounted in transmission (Anonymous, 2008)

3.1.6. Knock Sensors

The knock sensor is used for measuring engine knock which occurs within a specific frequency range.It sends a signal to ECM for controlling timing.

The knock sensor is mounted on engine block, cylinder head or intake manifold.

There is a piezoelectric element inside the knock sensor which generate a voltage when vibration is applied to them.The piezoelectric element is adjusted according to engine knock frequency (Anonymous, 2008).

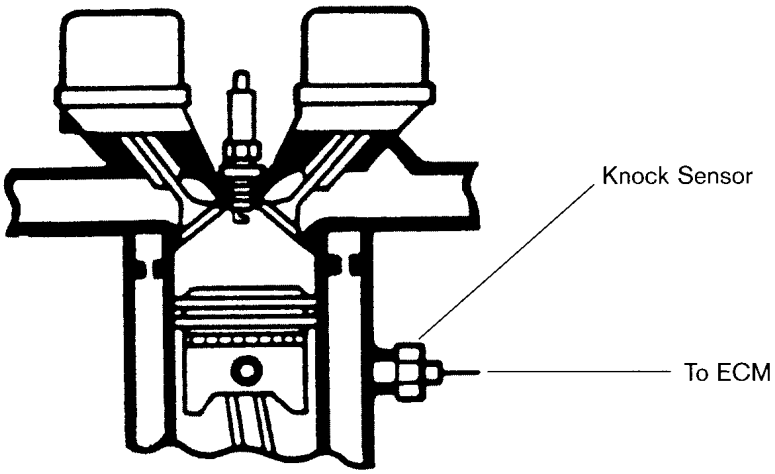


Figure 3.29. Knock Sensor Location (Anonymous, 2008)

3.1.7. MEMS Sensor

Microelectromechanical systems (MEMS) are small integrated devices or systems that combine electrical and mechanical components. They range in size from the sub micrometer (or sub micron) level to the millimeter level, and there can be any number, from a few to millions, in a particular system. MEMS extend the fabrication techniques developed for the integrated circuit industry to add mechanical elements such as beams, gears, diaphragms, and springs to devices.

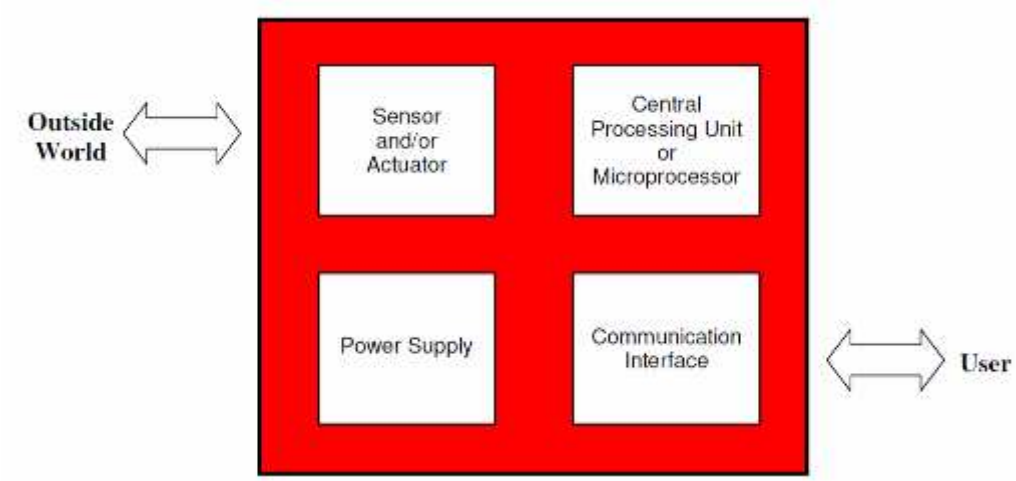


Figure 3.30. Components of MEMS (Castro, 2005)

Examples of MEMS device applications include inkjet-printer cartridges, accelerometers, miniature robots, microengines, locks, inertial sensors, microtransmissions, micromirrors, micro actuators, optical scanners, fluid pumps, transducers, and chemical, pressure and flow sensors. New applications are emerging as the existing technology is applied to the miniaturization and integration of conventional devices. These systems can sense, control, and activate mechanical processes on the micro scale, and function individually or in arrays to generate effects on the macro scale. The micro fabrication technology enables fabrication of large amount of devices, These devices can accomplish complicated functions. MEMS are not about any one application or device, nor are they defined by a single fabrication process or limited to a few materials. They are a fabrication approach that

conveys the advantages of miniaturization, multiple components, and microelectronics to the design and construction of integrated electromechanical systems (Vittorio, 2001).

Making cars cleaner and safer, not to mention more comfortable, has long been an attractive proposition for MEMS sensors suppliers. Today's vehicles have 100 different sensors, about 30 of which are MEMS. These sensors measure high and low g acceleration, turn rate and dead reckoning, pressure and flow in engine management and chassis control applications. Inclination sensors are also used for parking brakes and theft alarms vehicle dynamics control, and navigation; networked accelerometers for airbag deployment; and tire pressure monitoring, and infrared sensors offer night vision and regulate AC systems (Dixon, 2008).

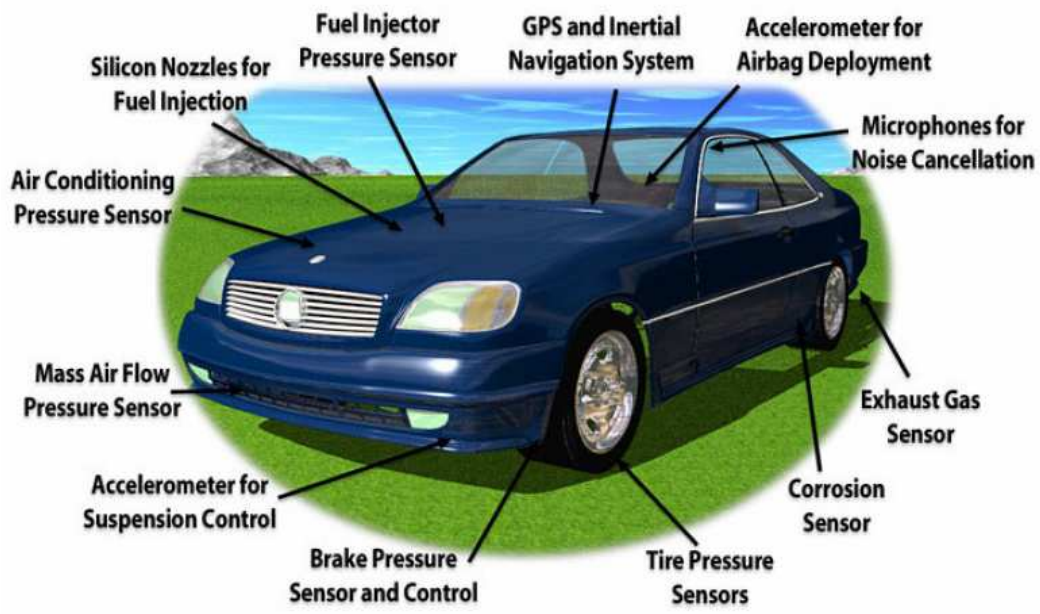


Figure 3.31. Automotive applications of Mems (Castro, 2005)

These applications exemplify trends for the future, including multi-sensor clusters with wireline communication to a central ECU and wireless microsystems (Monk, 2002).

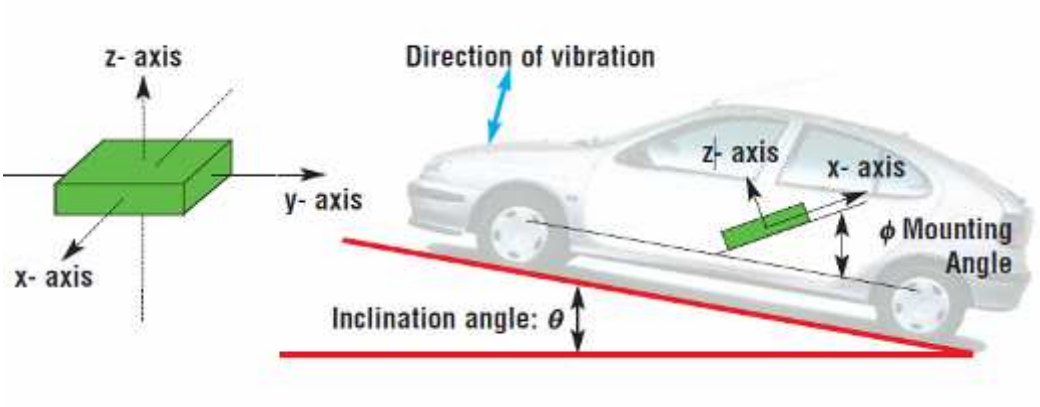


Figure 3.32. MEMS 3 axis accelerometers (Fijutsu,2010)

Acceleration: Acceleration measurement is used for airbag, active suspension systems, ride control systems and antilock brakes in cars. Airbag activation control is the most important application between them. Airbag systems are connected with crash sensors for providing a trigger signal over an electronic control unit that inflates the bag if a crash occurs. The crash sensors are positioned at differen points of the vehicle. It is important to see differences between crash sensors and accelerometers according to their utilization. Digital accelerometers are more sensitive when their output is active for upper limit level of acceleration (Canteli, 2005).

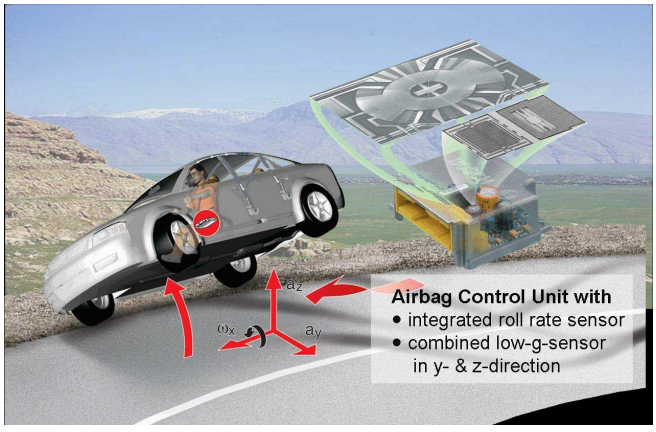


Figure 3.33. Modern airbag with rollover detection also rely on MEMS inertial sensors (gyroscopes and low-g accelerometers) (Bosch,2008)

3.1.8. Other Sensors

There are other sensor technologies for automotive applications which are limited in classical, electric cars or construction machines ;

1- Headlamp Leveling Control / Interior Lighting Controls / Infotainment Controls / Instrument Panel Dimming Controls / Traction Control / HVAC Controls / Airbag enable-disable / Tachograph Mode Switch / Navigation System Function Select
2- Mirror Memory
3- Door Position Sensor
4- Seat:
    - Seat heating control
    - Recliner position sensor
    - Head restraint position sensor
    - Lumbar position sensor
    - Seat memory position sensor (linear& rotary
5- Headlamp Leveling Sensor / Adaptive Front lighting
6- HVAC Air Flap Position Sensor
7- Steering Angle Position Sensor / Windshield Wiper Delay Control
8- Gear Select Position Sensor
9- Window Position Sensor
10- Pedal Position Sensor
11- Suspension & Chassis Height
12- Throttle Position / Air-intake Valve
13- Swirl System / EGR
14- Liquid Level Sensor
15- Power Sunroof Control / Convertible Hood Control
16- Rear-view Mirror Actuator Feedback Sensor
17- Anti-collision Radar
18- Anti-pinch Sensor / Aided Parking

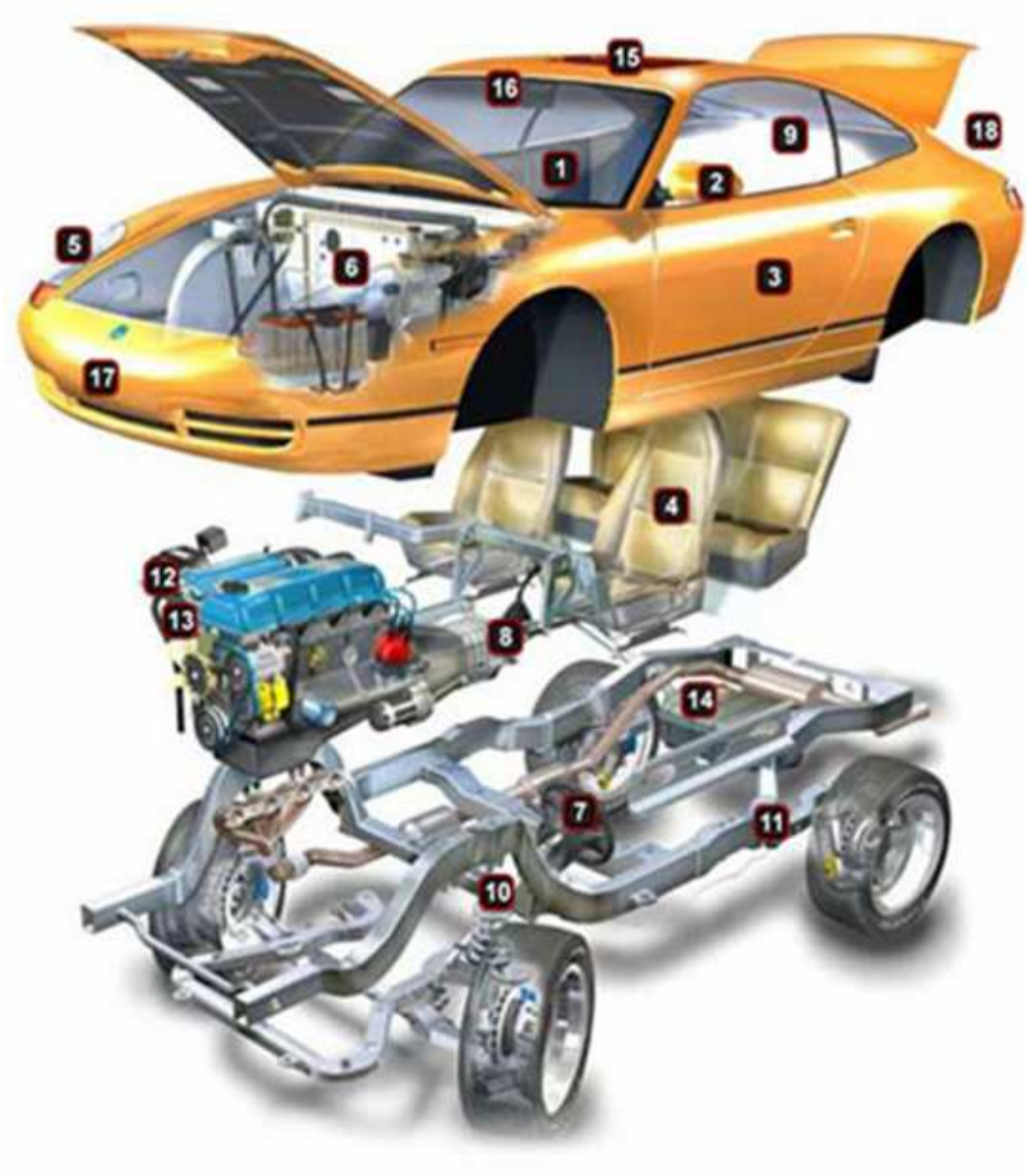


Figure 3.34. Automotive Sensors (Anonymous, 2009)

3.1.9. The Global Positioning System

The Global Positioning System (GPS) is a basic system to find ,search or locate human or devices. With this system correctly identify where it has been, is, and will be. The result of this struggle was to begin building maps. The earliest maps were simple mental pictures of the terrain around a group's camp or hunting area. The first maps produced date to more than 5,000 years ago, and are found on clay

tablets from the middle east. The Greeks and Romans began surveying for roads and new settlements using methods that differed little up to last century (Tennant, 2009).

Then, in the 18th century, the French began using triangulation to create maps of their country. Later, this was combined with trilateration to map entire continents and was referenced to stars. These maps were often hundreds of meters off even for the most painstaking surveys conducted (Tennant, 2009).

These problems of using line of sight surveying techniques were first addressed during and after WWII. The idea of using radio waves to locate and track ships was introduced in an attempt to coordinate forces during the war effort. This gave birth to the precursors of GPS, the OMEGA and LORAN systems, each of which had major problems. The main problem was that each of these systems were ground base, and to be used successfully, one needed direct line of sight with a transmitter (OMEGA does provide global coverage but with low accuracy and LORAN has accuracy of 450m but only covers 10% of the planet) (Tennant, 2009).

The next step was to take the above ideas into space. The first space based navigation system was called TRANSIT, it is still in use today. However, this system used Doppler shift to calculate position, and accuracy was only attainable if the receiver sat in one position for a couple of hours, and thus was only good for large-scale navigation (Tennant, 2009).

TRANSIT had some majors problems that GPS was specifically designed to overcome. These included the large gaps in coverage time due to TRANSIT only having 6 satellites in near circular polar orbits, which meant only a few minutes of coverage for every 90 minutes. Also, this earlier system did not give accurate measurements when the receiver only sat still for a few minutes, it needed much longer to calculate positions (Tennant, 2009).

Today, GPS is a fully functioning worldwide system used for everything from real-time navigation to mapping your hometown! To further appreciate the time and resources that built this system, let’s take a look at the specifications.

Actually, today’s GPS system grew out of two US military projects run during the 1970s. These resulted in the first generation of satellites being launched during the late 70s. The 1980s saw another wave of satellites being built and the US

government guaranteeing the ability of civilian use. The system reached Initial Operation Capability (IOC) in 1993 with 24 first generation (Block I) satellites deployed, and in 1995 reached Full Operation Capability (FOC) with 24 second generation (Block II) satellites deployed.

GPS is:

- A space based positioning system used for navigation, tracking and mapping
- It is designed and maintained by the US Military
- Truly global in scope
- Available every hour of every day all year long, and is cheap to use!

Now that we have a basic idea of what GPS is, and why it was developed, let's look at how it actually works. Basically, what are the actual components (human and machine) that allow this amazing utility to do what it does (Tennant, 2009).

3.1.9.1. The Science of GPS

GPS gives us, a unique set of coordinates for a point or location. These coordinates are usually referred to as GPS addressing. That means, for any point on the planet have a unique address, or a unique set of coordinates for locating. The possibilities are endless! GPS developed 5 basic parts, these are

1. Receiver uses triangulation based on signals from the satellites to figure positions.
2. To do this, the GPS calculates the distance from satellites by measuring travel time of a radio message.
3. To measure the travel time, the satellites use atomic clocks to accurately measure time.
4. Then, the travel time is used to calculate distance from the receiver, which gives the satellites position in space.
5. Techniques to compensate for time delay while radio signal travels through the atmosphere.

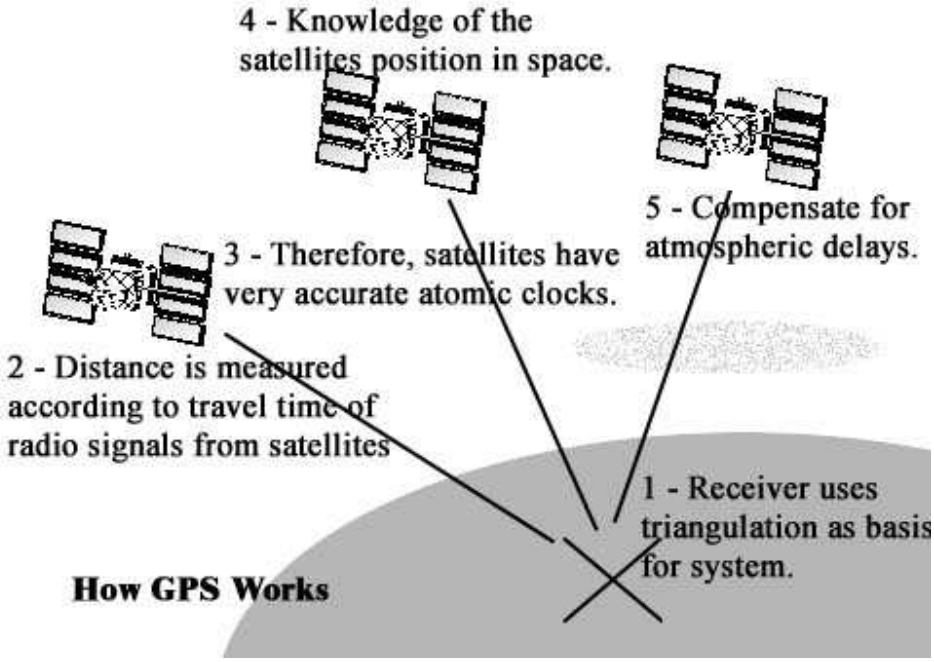


Figure 3.35. How GPS works (Tennant, 2009)

3.1.9.2. Satellite Ranging

The basic idea behind GPS is to measure our distance from a group of satellites in space, this is accomplished by simply measuring the amount of time that it takes for a radio signal to reach us. There are sizable complications in this system to work out, mainly compensating for errors caused by travel of the signals through the atmosphere, but we will explore this later. So, we know that we are 10,000km from a satellite. That means that we are somewhere on the surface of an imaginary sphere with a diameter of 10,000km surrounding the satellite. Now the receiver figures its distance from another satellite, and the resulting sphere will form a circle where it intersects the other sphere. We can do this with a third circle and it will narrow down the number of intersections to two points. These two points are technically all we need to know to accurately figure our place on the surface of the planet as only one of the points will be on the surface while the other point will be either out in space or outside of our current region (pre-set into the GPS unit when it is initialized). However, most receivers will just use the point formed from a forth

intersecting sphere to give us one point, and since trigonometry tells us that we need four ranges to unambiguously locate ourselves in three dimensions, it is best to take eadings with at least that many satellites. That's all, the receiver uses satellites as reference points for triangulating position. Now we can examine some of the problems that make this easy to understand process more complicated in the real world (Tennant, 2009).

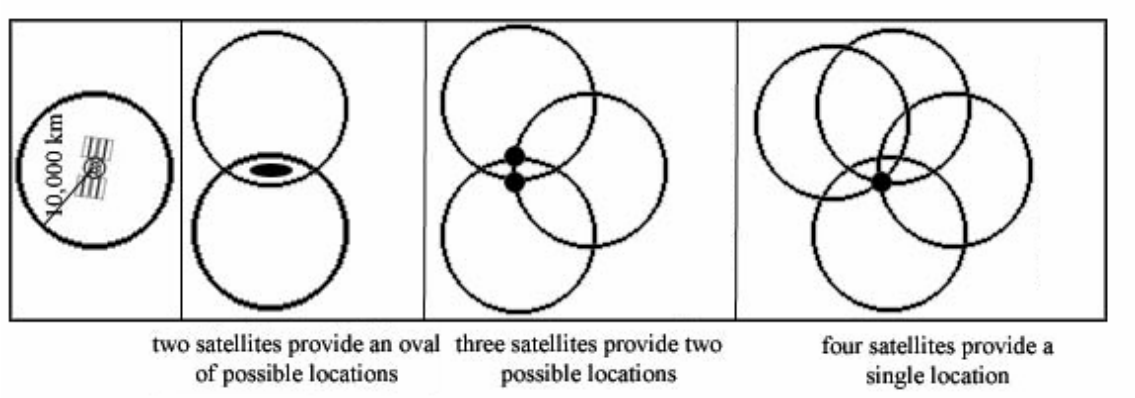


Figure 3.36. Satellites locations (Tennant, 2009)

3.1.9.3. Measuring Distance to a Satellite

However, when using this equation for calculating distance from satellites, two main considerations must be taken into account. Specifically, very accurate clocks must be used and a way to compensate for the distortion caused by the radio signals traveling through the atmosphere needs to be addressed (Tennant, 2009).

First, the problem of accurate clocks has been solved by the advent of other technologies (like your quartz wristwatch). The signal from a satellite directly overhead will reach a receiver in about 6/100ths of a second, and most GPS receivers available are able to measure time very accurately (often to a nanosecond, or .000000001 of a second). However, this still doesn't completely eliminate the possibilities of error. After all, if the satellite and receiver were out of sync by only 1/10th of a second, our distance measurement would be off by nearly 3,000 kilometers. The clocks on the satellites are incredibly accurate, each satellite has four

$100,000 atomic clocks onboard. Unfortunately, that puts the availability of having an atomic clock in our handheld units a little out of most people's reach.

There is a solution to the problem, and this is where trigonometry comes in. When we add a forth satellite, using a set of simple trigonometric equation (which is referred to as four equations to solve four variables) will eliminate any possible clock error that occurs, and each receiver that we use has this equation hardwired into it (Tennant, 2009).

In addition to measuring the distance accurately, we need to know where the satellite was when it sent the signal. This is accomplished by a complicated "pseudorandom" code that is generated by both the receiver and satellites. It is the same idea as if you stood at one end of a field and a friend stood at the other end, and then you both started counting. When you said "three," you might only then hear your friend say "one." This way, you could tell how long ago the number was said (or in the case of GPS, the signal left the satellite), and use that time-stamp to calculate the time difference, and use that to calculate the exact position. This is combined with another code that is constantly monitored by the US Department of Defense which has true location information encoded into it (Tennant, 2009).

The idea is simple, but the implementation of these theories is a bit complex. However, they have been well thought out, making GPS a wonderfully accurate utility for us to use in measuring distance (i.e. points on the Earth's surface).

3.1.9.4. Atmospheric Disturbances to the Signals

The radio signals that are transmitted by the satellites are not extremely powerful, for instance, they cannot penetrate buildings like FM signals. Also, the waves slow down ever so slightly when they pass through the atmosphere, which means that our distance equation (time x velocity = distance) may not accurately reveal the true distance (Tennant, 2009).

Now, we could try to predict the average delay caused by the changing atmosphere, but each day is obviously not average. The other way is to use a very sophisticated GPS unit that can compare the signals from two satellites to calculate

the variation caused by the upper atmosphere (the ionosphere), and some of the units tha twe use may very well have this capability (Tennant, 2009).

The resulting variation caused when the signal passes through weather is harder to correct, but it usually causes less that 2-3 meters of error. That amount of error is fine for mapping large areas (where is a city at) or general points (where is a car park). However, this amount of error is unsatisfactory for many types of data collection, and can be corrected using Differential Correction (Tennant, 2009).

3.1.9.5. Angles Matter

Another aspect of the GPS system that can cause errors is the angles of the satellites in relation to the horizon. The lower the angle, the more atmosphere the signal has to travel through, and the greater the error created. Telling the GPS unit to only use signals from satellites above a certain angle (usually 15 degrees or more) above the horizon is the normal method of compensating for this type of error. At the same time increasing this limit to narrow the scope of visible is also detrimental. It is better to use a wider array of satellites then a narrower cluster. The narrower the array of satellites used results in the signals traveling closer to parallel to each other rather than skewed. Intersecting skewed lines creates a point, while parallel lines create an ambiguous area (Tennant, 2009).

3.1.9.6. GPS Segments

GPS has 3 parts: the space segment, the user segment, and the control segment.

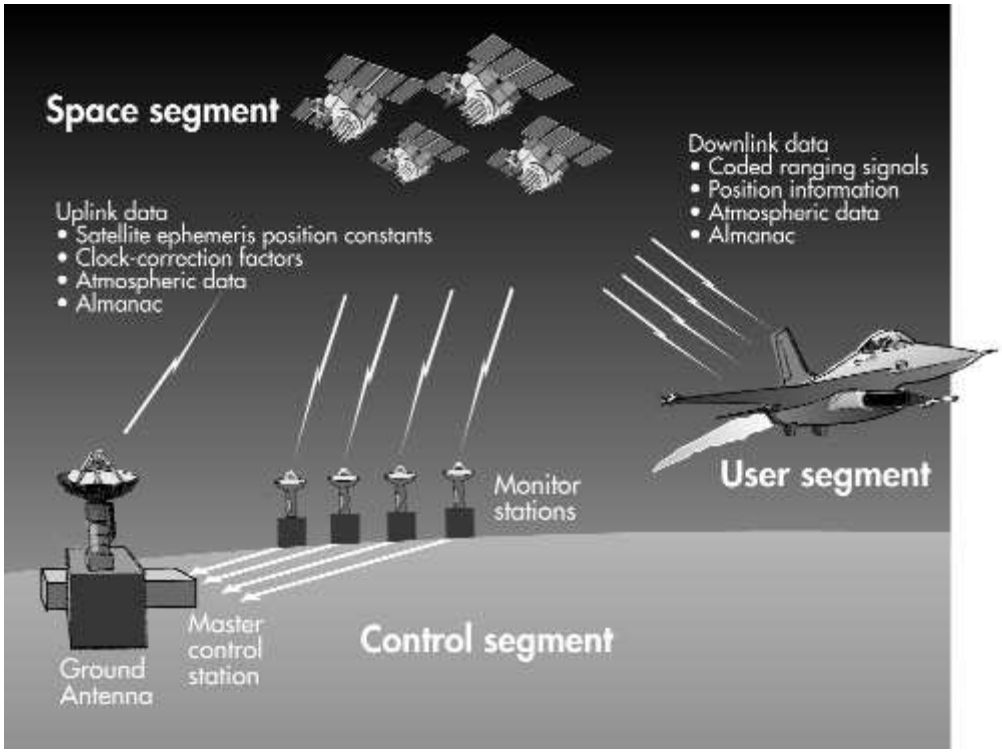


Figure 3.37. GPS consists of three major segments: the space segment, the user segment, and the control segment. (The Aerospace Corporation, 1997)

The Control Segment is that part of GPS that is ground based and monitors the satellites. It was constructed and is maintained by the US Department of Defense. It monitors the change in the satellites orbits (ephemeris) and transmits signals to correct for it. There is one master control base in Colorado Springs, Colorado, USA, and four monitoring stations located on the Pacific Ocean islands of Ascension Island, Diego Garcia, Kwajalein and Hawaii. An additional monitoring station is located in Cape Canaveral, Florida (Tennant, 2009).

The Space Segment is compo sed of the 24 satellites that orbit the planet at 55 degrees across the equator twice a day. The satellites are called NAVSTAR, were constructed by Rockwell International, have thrusters for course correction

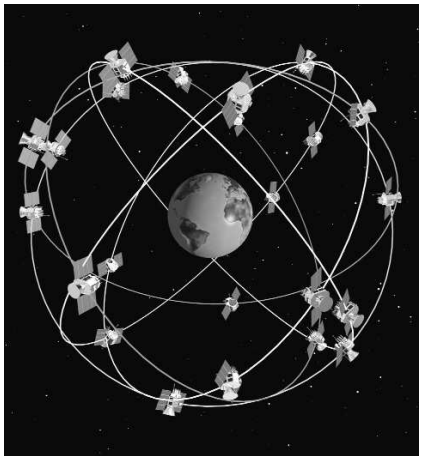


Figure 3.38. The 24-satellite constellation orbits 11,000 nautical miles above Earth. Each satellite completes its orbit every 12 hours (The Aerospace Corporation, 1997)

The final segment is the User Segment, that's us! Actually, its us and the US military. The fact that this system was designed for military applications has serious affects on its use. In the beginning, the US military introduced an artificial error into the signals, and this selective availability could throw measurements off by as much as 70 meters. However, this selective availability was turned off in 2000, and is only briefly turned on now when the US goes to war. Currently, the plan is to have selective availability turned off completely by 2006 (Tennant, 2009).

One trip around the Earth in space equals one orbit. The GPS satellites each take 12 hours to orbit the Earth. Each satellite is equipped with an accurate clock to let it broadcast signals coupled with a precise time message. The ground unit receives the satellite signal, which travels at the speed of light. Even at this speed, the signal takes a measurable amount of time to reach the receiver. The difference between the time the signal is sent and the time it is received, multiplied by the speed of light, enables the receiver to calculate the distance to the satellite. To measure precise latitude, longitude, and altitude, the receiver measures the time it took for the signals from four separate satellites to get to the receiver (The Aerospace Corporation, 1997).

3.1.10. General Packet Radio Service (GPRS)

GPRS (General Packet Radio Service) is a packet based communication service for mobile devices that allows data to be sent and received across a mobile telephone network. GPRS is a step towards 3G and is often referred to as 2.5G. (MorganDoyle Limited, 2004) Here are some key benefits of GPRS:

- **Speed ;** GPRS is packet switched. Higher connection speeds are attainable at around 56–118 kbps, a vast improvement on circuit switched networks of 9.6 kbps. By combining standard GSM time slots theoretical speeds of 171.2 kbps are attainable. However in the very short term, speeds of 20-50 kbps are more realistic.
- **Always on connectivity;** GPRS is an always-on service. There is no need to dial up like you have to on a home PC for instance. This feature is not unique to GPRS but is an important standard that will no doubt be a key feature for migration to 3G. It makes services instantaneously available to a device.
- **New and Better applications ;** Due to its high-speed connection and always-on connectivity GPRS enables full Internet applications and services such as video conferencing straight to your desktop or mobile device. Users are able to explore the Internet or their own corporate networks more efficiently than they could when using GSM. There is often no need to redevelop existing applications.
- **GSM operator Costs ;** GSM network providers do not have to start from scratch to deploy GPRS. GPRS is an upgrade to the existing network that sits along side the GSM network. This makes it easier to deploy, there is little or no downtime of the existing GSM network whilst implementation takes place, most updates are software so they can be administered remotely and it allows GSM providers to add value to their business at relatively small costs. The GSM network still provides voice and the GPRS network handles data, because of this voice and data can be sent and received at the same time.

3.1.10.1. Simple GPRS Technical Overview

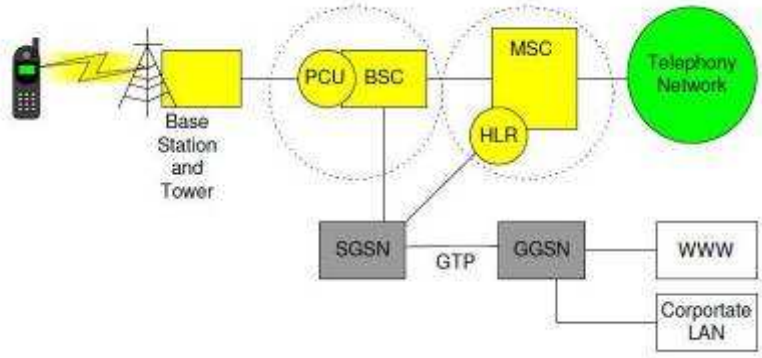


Figure 3.39. GPRS Architectural Components (MorganDoyle Limited, 2004)

As mentioned earlier GPRS is not a completely separate network to GSM. Many of the devices such as the base transceiver stations and base transceiver station controllers are still used. Often devices need to be upgraded be it software, hardware or both. When deploying GPRS many of the software changes can be made remotely. There are however two new functional elements which play a major role in how GPRS works. The Serving GPRS Support Node (SGSN) and the Gateway GPRS support node (GGSN). These 2 nodes are new to the network with the other changes being small if any. Before explaining what these 2 new members of our network do it is important to ask how does the network differentiate between GSM (circuit) and GPRS (packet)? In simple terms there are in practice two different networks working in parallel, GSM and GPRS. In any GSM network there will be several BSC's (Base Station Controllers). When implementing GPRS a software and hardware upgrade of this unit is required. The hardware upgrade consists of adding a Packet Control Unit (PCU). This extra piece of hardware differentiates data destined for the standard GSM network or Circuit Switched Data and data destined for the GPRS network or Packet Switched Data. In some cases a PCU can be a separate entity. From the upgraded BSC there is a fast frame relay connection that connects directly to the newly introduced SGSN (MorganDoyle Limited, 2004).

3.1.10.1.(1). SGSN

The Serving GPRS Support Node, or SGSN for short, takes care of some important tasks, including routing, handover and IP address assignment. The SGSN has a logical connection to the GPRS device. As an example, if you where in a car travelling up the M1 on a long journey and were browsing the Internet on a GPRS device, you will pass through many different cells. One job of the SGSN is to make sure the connection is not interrupted as you make your journey passing from cell to cell. The SGSN works out which BSC to "route" your connection through. If the user moves into a segment of the network that is managed by a different SGSN it will perform a handoff of to the new SGSN, this is done extremely quickly and generally the user will not notice this has happened. Any packets that are lost during this process are retransmitted. The SGSN converts mobile data into IP and is connected to the GGSN via a tunnelling protocol (Morgan Doyle Limited, 2004).

3.1.10.1.(2). GGSN

The Gateway GPRS Support Node is the "last port of call" in the GPRS network before a connection between an ISP or corporate network's router occurs. The GGSN is basically a gateway, router and firewall rolled into one. It also confirms user details with RADIUS servers for security, which are usually situated in the IP network and outside of the GPRS network (MorganDoyle Limited, 2004).

3.1.10.1.(3). Connectivity Between the SGSN & GGSN

The connection between the two GPRS Support Nodes is made with a protocol called GPRS Tunnelling Protocol (GTP). GTP sits on top of TCP/IP and is also responsible for the collection of mediation and billing information. GPRS is billed on per megabyte basis unlike GSM. In practice the two GSN devices may be a single unit (MorganDoyle Limited, 2004).

3.1.10.1.(4). HLR

The HLR or Home Location Register is a database that contains subscriber information, when a device connects to the network their MSISDN number is associated with services, account status information, preferences and sometimes IP addresses (MorganDoyle Limited, 2004).

3.1.10.2. IP Addressing

3.1.10.2.(1). Allocating Addresses

There are 3 different ways in which a device can be assigned an IP address.

1. The fist means of addressing is Fixed IP addressing. Fixed IP ddresses for mobile devices are not widely used due to shortages of Ipv4 addresses (Figure 3.40). This information is stored in the HLR.

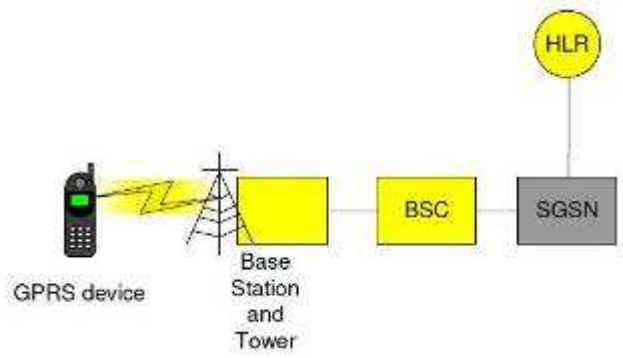


Figure 3.40. Fixed IP addressing (MorganDoyle Limited, 2004)

2. The second means of addressing is dynamic addressing. This is where a mobile device does not have its own IP address stored in the HLR. Instead the IP address is assigned to the GGSN domain.
3. The third method is also a type of dynamic IP addressing in which the IP address isassigned by RADIUS servers normally situated inside an IP

network outside the mobile network, an example of this being when you dial up to an ISP from your home PC.

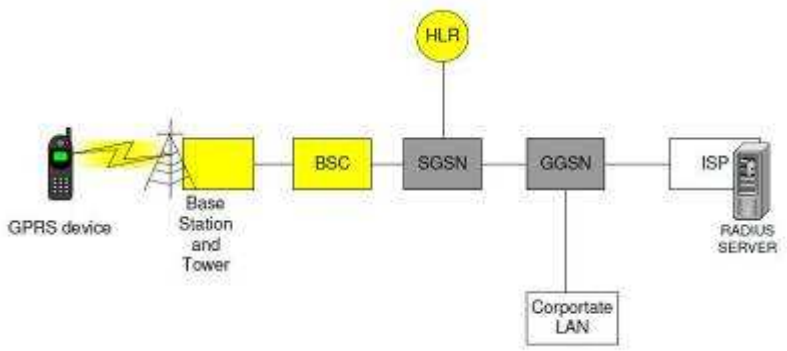


Figure 3.41. Dynamic IP addressing (MorganDoyle Limited, 2004)

3.1.10.2.(2). How Does the SGSN Know Which GGSN to Direct You To?

A mobile device is programmed with one or more Access Point Names which are commonly referred to as the APN's. An APN consists of a fully qualified DNS name e.g. ersenpesen.info. When a GPRS device wants to talk to ersenpesen.info's network, the SGSN does a DNS lookup and resolves the name to the correct GGSN. You could have multiple APN's programmed into your phone so you are not limited to a single service or GGSN (MorganDoyle Limited, 2004).

3.1.10.2.(3). IP Version 6

This new version of IP corrects unanticipated Ipv4 design issues that have come about because of the popularity of the Internet. In short we are running out of addresses.

IP version 4 is a 32-bit address that allows a maximum of around 4 billion IP addresses. It is estimated that by 2005 all the addresses in IP 4 will run out. Some say this will happen sooner - introduce millions of handheld devices all requiring IP addresses and suddenly there are none left.

To truly enable the Internet to such devices there has to be more addresses. This is where IP version 6 comes in. Instead of a 32-bit address, IP6 is 128 bit with a maximum number of:

340, 232, 366, 920, 938, 463, 463, 374, 607, 431, 768, 211, 456 possible IP addresses. This amount of address space is ample for future foreseeable growth.

At the moment there are around 1 billion addresses left for IP v 4 but many manufacturers of mobile devices especially in Asia are involving themselves heavily in IP v 6. This is mainly due to places like Japan having a fraction of the addresses allocated in comparison with other places like America.

3.1.10.3. GPRS Handset Classes

GPRS devices are not as straightforward as you may think. There are in fact 3 different classes of device (MorganDoyle Limited, 2004).

1. **Class A;** Class A terminals have 2 transceivers which allow them to send / receive data and voice at the same time. This class of device takes full advantage of GPRS and GSM. You can be taking a call and receiving data all at the same time.
2. **Class B;** Class B devices can send / receive data or voice but not both at the same time. Generally if you are using GPRS and you receive a voice call you will get an option to answer the call or carry on.
3. **Class C;** This device only allows one means of connectivity. An example would be a GPRS PCMCIA card in a laptop.

3.1.10.4. GPRS QoS

Just because GPRS uses many of the components of a standard GSM network it would be foolhardy to assume that the same standards should apply. Things to be taken into account include provider general network architecture, radio interface and throughput. Here are some of the key elements briefly explained (MorganDoyle Limited, 2004).

3.1.10.4.(1). Network Architecture

Provider networks have to be upgraded. As mentioned earlier the GSN's are new to the Standard GSM network. If GPRS is to stand-up to customer expectations network performance will be vital (MorganDoyle Limited, 2004).

3.1.10.4.(2). Radio Interface

The ETSI (European Telecommunications Standard Institute) has defined 3 new coding schemes for Radio Interface. When the GPRS device talks to the base station they can use 1 of the 4 schemes. The schemes are CS – 1 through CS – 3 where CS – 1 is the same as standard GSM. In simple terms CS – 1 is highly redundant but because of this is slow, 2 and 3 have less redundancy, whilst 4 has the least - removing all forward error control - but is capable of maximum throughput. If radio quality is bad then coding scheme 1 is used, as the quality improves less error control is needed (MorganDoyle Limited, 2004).

3.1.10.4.(3). Classes of GPRS services

Mobile devices can request different types of traffic to be prioritised in an attempt to give the user their desired level of connectivity. There are 4 types of class:

1. **Precedence Class;** An application can be assigned a Precedence Class 1, 2 or 3 If an application has a higher precedence (1) than another (3) then its traffic will be given a higher priority.
2. **Delay Class;** Applications can request predictive delay classes which guarantee an average and 95- percentile delay. There are 4 classes, 1 being the fastest.
3. **Reliability class;** Applications can request differing levels of reliability for its data depending on its tolerance to data loss.
4. **Throughput Class;** Applications can choose different profiles for throughput. There are 2 distinctions in class, peak and mean. Peak throughput

class is used mainly for bursty transmissions with a variable in octets per second describing the throughput required for burst of specified size. Mean is the average data transfer rate over a period of time measured in octets per hour. Other factors can affect QoS. Things like Radio quality, basic LAN / WAN and Internet congestion, faults on GSM and GPRS network' etc.

3.1.10.5. Problems With GPRS

Although GPRS has many benefits there have been a few problems. Connection speeds until the end of last year performed badly on some networks running at around 12Kbps, a far cry from the expected. This year however there do not seem to be as many problems, probably due to the fact that operators are improving due to trial and error. GPRS is after all a pretty new technology. Another problem sometimes encountered is customer expectation. Many companies have applications running on a 10 megabyte LAN and expect the same performance from their GPRS devices. Although the connection speeds these days are pretty good it still is not as fast as ISDN or Local Area Networks. To a certain extent operators have themselves to blame for this, since in the past their marketing has tended to promote the speed aspects of 2.5 and 3G. Today, they are working hard to reduce expectation in this respect. Earlier problems with things like mail servers not sending mail because of latency problems to GPRS devices have all been pretty much eradicated through optimization programs. People running Citrix Thin Client have also encountered problems with latency although a few Thin Client forums suggest that Citrix are addressing the issue. Deployment on some networks has been slow. There still is a major UK network provider who does not offer the service. GPRS roaming has not been implemented in many countries on a lot of networks as yet. This is where a user can use the GPRS service from any network operator. At the moment although your GSM mobile will work, GPRS may not work at all. Accesses by third party application providers are having a lot of difficulty obtaining an APN from providers to offer their own GPRS services. This somewhat limits services to that provided by the GPRS operator (MorganDoyle Limited, 2004).

3.2. Methods

The application that has been carried out, has been presented in a detailed way. Firstly, hardware and software and then server have been explained.

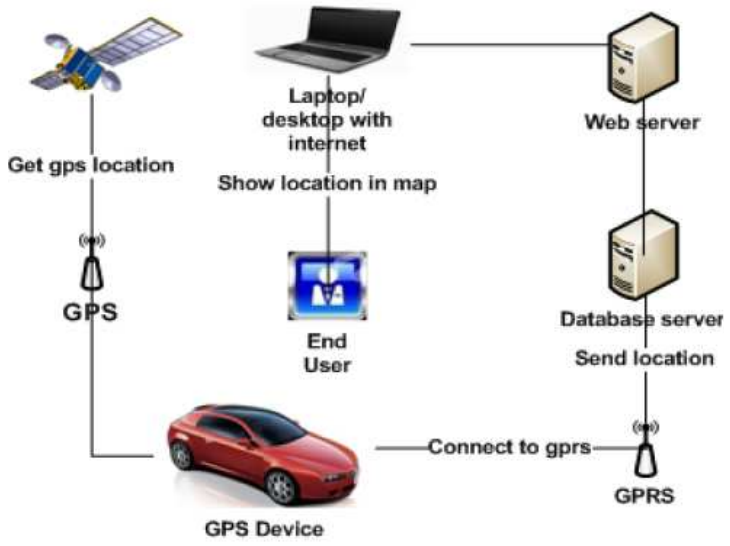


Figure 3.42. System diagram (Hasan, 2009)

3.2.1. General Specifications of Vehicle Unit

Vehicle Unit has been composed of sensors the brand TELIT EZ10-GPS GPS/GPRS modem and the brand Mikroelektronika easy arm development board.

The communication with the modem by the help of Easy arm development board is obtained with serial port RS232.It also supports data transmission whose speed is 300 bps – 115.200 bps It works with Modem AT command set. It includes GPS and GPRS modules. GPS module that it includes, functions as GPS receiver. GPS Location information can be supplied with AT commands. As for GSM/GPRS module, it provides GPRS connection. It collects the information coming from sensor by the help of the programme which has been developed in Easy arm development board. And the modem is controlled with AT commands. It sends GPS and sensor information to the remote server.

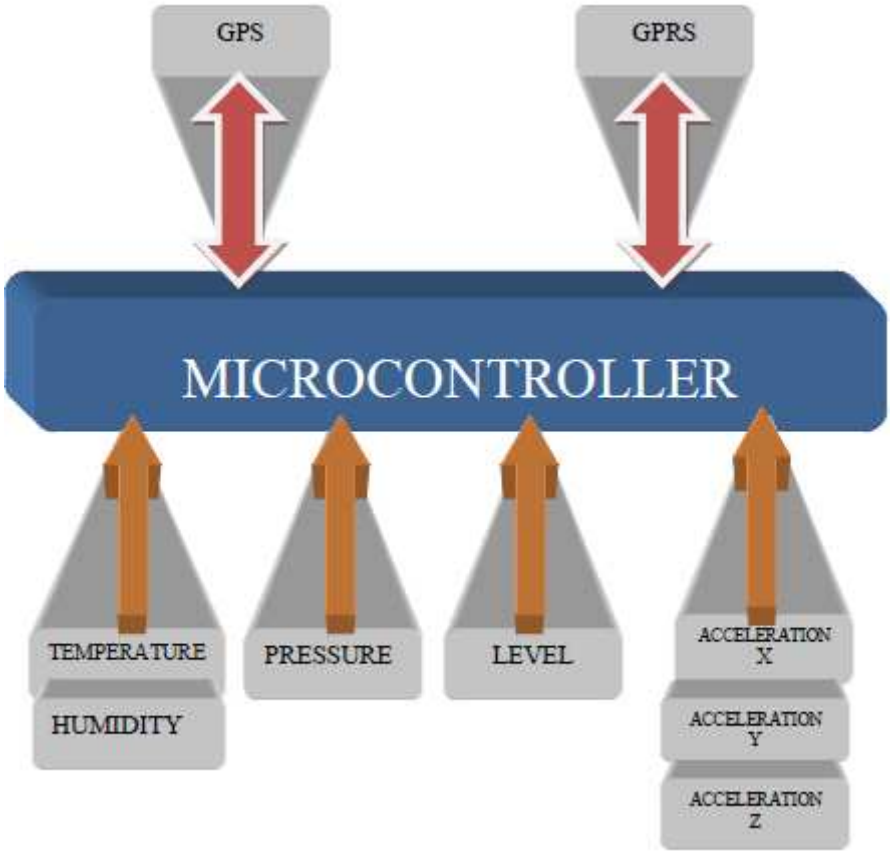


Figure 3.43. The block diagram of the vehicle unit

3.2.1.1 Operating The GPS/GPRS Modem

Some information has been obtained by examining the technical specifications of Telit brand gps/gprs modem. Then, AT commands have been searched and the commands which will be used in the system have been learnt. Firstly, modem has been connected to the computer from RS232 port and the computer has been checked with AT commands. GPS information has been read from the computer. By this way, the infrastructure of the programme of the system has been formed and data transfers for controlling the modem have been carried out.

3.2.1.1.(1). Product Features of Modem

- Quad-band EGSM 850 / 900 / 1800 / 1900 MHz
- Output Power
  Class 4 (2W) @ 850/900 MHz
  Class 1 (1W) @ 1800/1900 MHz
- Control via AT commands according to GSM 07.05, 07.07 and Telit enhancements
- Supply voltage range : 9 – 36 VDC
- TCP/IP stack Access via AT commands
- Extended temperature range: -20° / +70° C
- **GPS receiver**
  Support 20- channel GPS L1 1575,42 MHz
  Dedicated GPS AT commands
  GPS NMEA 0183 output format
- **GPRS Data**
  GPRS class 10
  Mobile station class B
  Embedded TCP/IP stack , including TCP,IP,UDP, SMTP and FTP protocols
- **Interfaces**
  D-Type 9 pin RS232 connector
  Baud rate: 300 – 115.200 bps
  Autobauding: 2.400 – 38.400 bps

3.2.1.1.(2). Read Acquired GPS Position

The GM862-GPS module is equipped with a SiRFStar III GPS receiver that is controllable by the GSM modem using a set of AT commands or dedicated NMEA sentences.

The NMEA 0183 is a specification created by the National Marine Electronics Association (NMEA) that defines the interface between other marine

electronic equipment. The access permits marine electronics to send information to computers and to other marine equipment. GPS receiver communication is defined within this specification.

The provided NMEA sentences are:

Table 3.4. NMEA sentences

GGA	Time, position and fix type data
GLL	Latitude, longitude, UTC time of position fix and status
GSA	GPS receiver operating mode, satellites used in the position solution and DOP values
GSV	The number of GPS satellites in view satellite ID numbers, elevation, azimuth and SNR values
VTG	Course and speed information relative to the ground
RMC	Time, date, position, course and speed data

Explanations of the above sentences (Table 3.4). We may read all these sentences at the same time, or we may get requested sentence or sentences at the same time. Picture (Figure 3.44.) related to reading of all data by connected to hyper terminal is following:

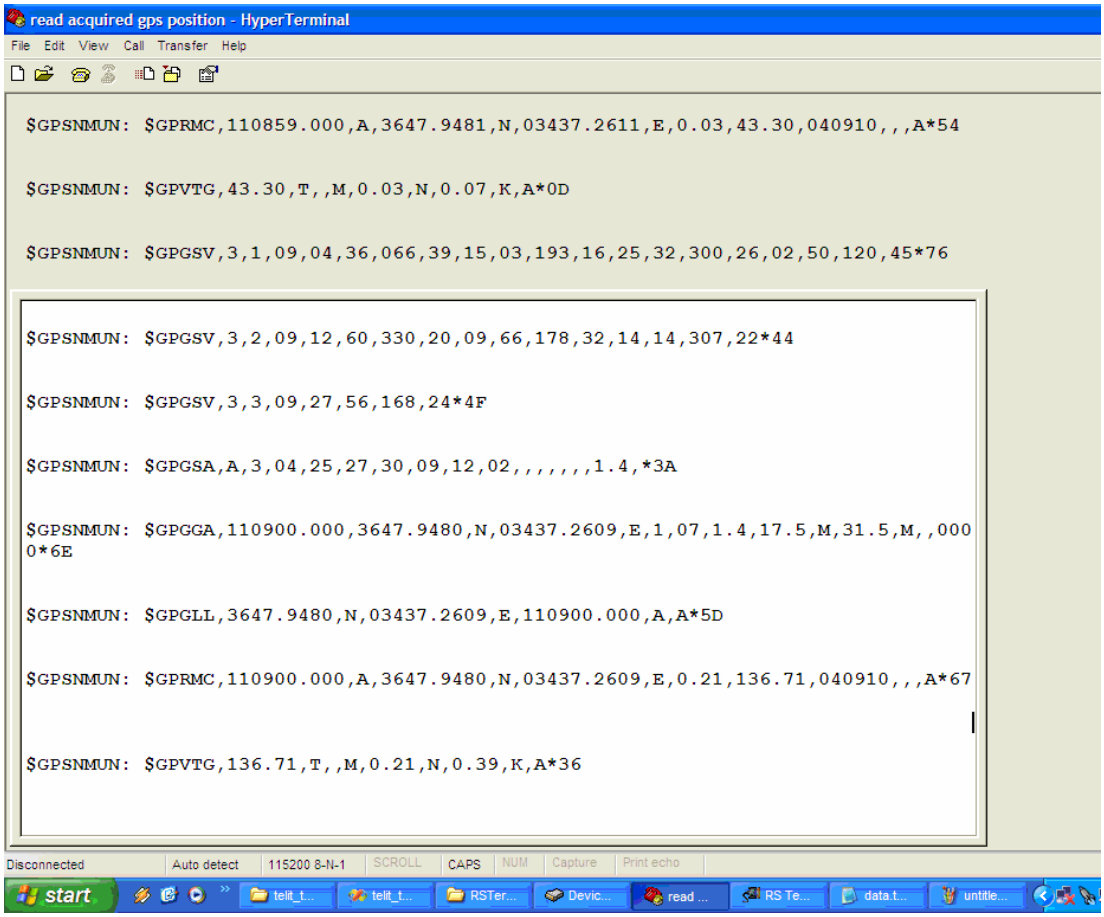


Figure 3.44. Example for NMAE sentences

We don't need to get all data for this project, it's enough to get needed data for us. We may get our needed data with AT$GPSACP command.

This command allows reading the acquired position of the GPS receiver

Syntax of the command:

T$GPSACP

The response sintax is:

$GPSACP:<UTC>,<latitude>,<longitude>,<hdop>,<altitude>,<fix>,<cog>,<spkm>, <spkn>,<date>,<nsat>

Table 3.5. contains the values access following example

Table 3.5. GPSACP data format

<UTC>:	(referred to GGA sentence)	
hhmmss	UTC of Position	
	values	hh (hour) 00 to 23
		mm (minutes) 00 to 59
		ss (seconds) 00 to 59
<latitude>:	(referred to GGA sentence)	
ddmm.mmmm N/S	value	dd (degrees) 00 to 90
		mm.mmmm (minutes) 00,0000 to 59.9999
		N/S: North / South
<longitude>:	(referred to GGA sentence)	
dddmm.mmmm E/W	valuess	ddd (degrees) 00 to 180
		mm.mmmm (minutes) 00,0000 to 59.9999
		E/W: East / West
<hdop>:	(referred to GGA sentence)	
x.x	Horizontal Diluition of Precision	
<altitude>:	(referred to GGA sentence)	
xxxx.x	mean-sea-level (geoid) meters	
<fix>:	0 – Invalid Fix	
	2 – 2D fix	
	3 – 3D fix	
<cog>:	(referred to VTG sentence)	
ddd.mm	Course over Ground (degrees, True)	
	values	ddd: 000 to 360 degrees
		mm 00 to 59 minutes
<spkm>	(referred toVTG sentence)	
xxxx.x	Speed over ground (Km/hr)	
<spkn>:	(referred toVTG sentence)	
xxxx.x	Speed over ground (knots)	
<date>:	(referred to RMC sentence)	
	values	dd (day) 01 to 31
		mm (month) 01 to 12
		yy (year) 00 to 99 (2000 to 2099)
<nsat> :	nn Number of satellites in Use (referred to GGA sentence)	
	00-12 (may be different from the number in view)	

On the project, sample (Figure 3.45) related to get necessary data for GPS informations and the definitions (Table 3.6) related to meanings of these data are following:

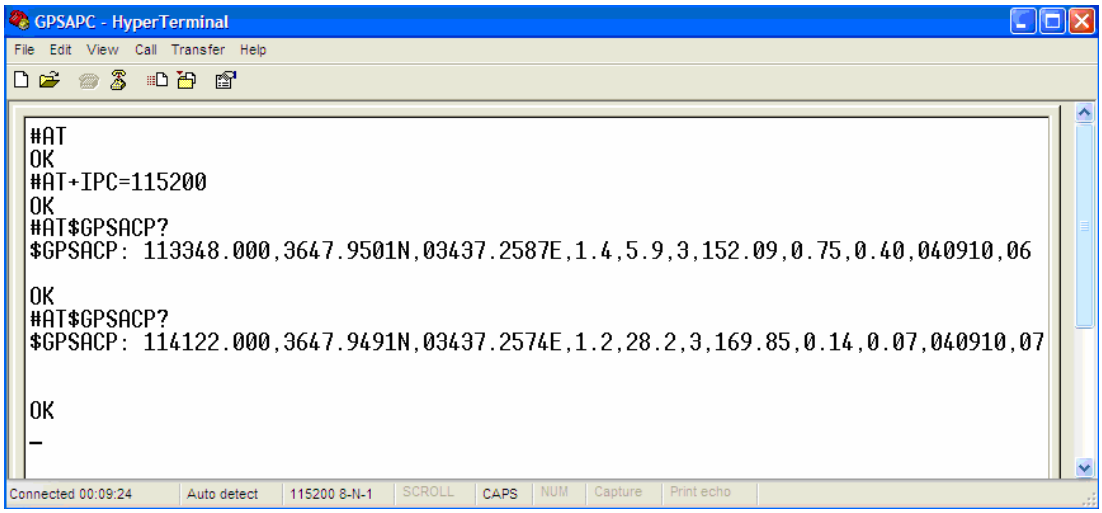


Figure 3.45. Read information from the GPS

Table 3.6. Definitions of the gps data samples

<UTC>	11:38:48
<latitude>	3647.9501N
<longitude>	3437.2587E
<hdop>	1,4
<altitude>	5,9 m
<fix>:	3
<cog>	152,09
<spkm>	0,75 km
<spkn>	0,40 knot
<date>	04.09.10
<nsat>	6

3.2.1.2. GPRS Connection

For GPRS connection ,it needs IP address ,port number of the connection and socket protocol type (TCP/UDP). These parameters have entered to the unit with AT commands. In this application 88.249.68.153 used as IP address, 31261 as port

number and TCP as protocol type. For GPRS connections TURKCELL SIM CARD has been used.

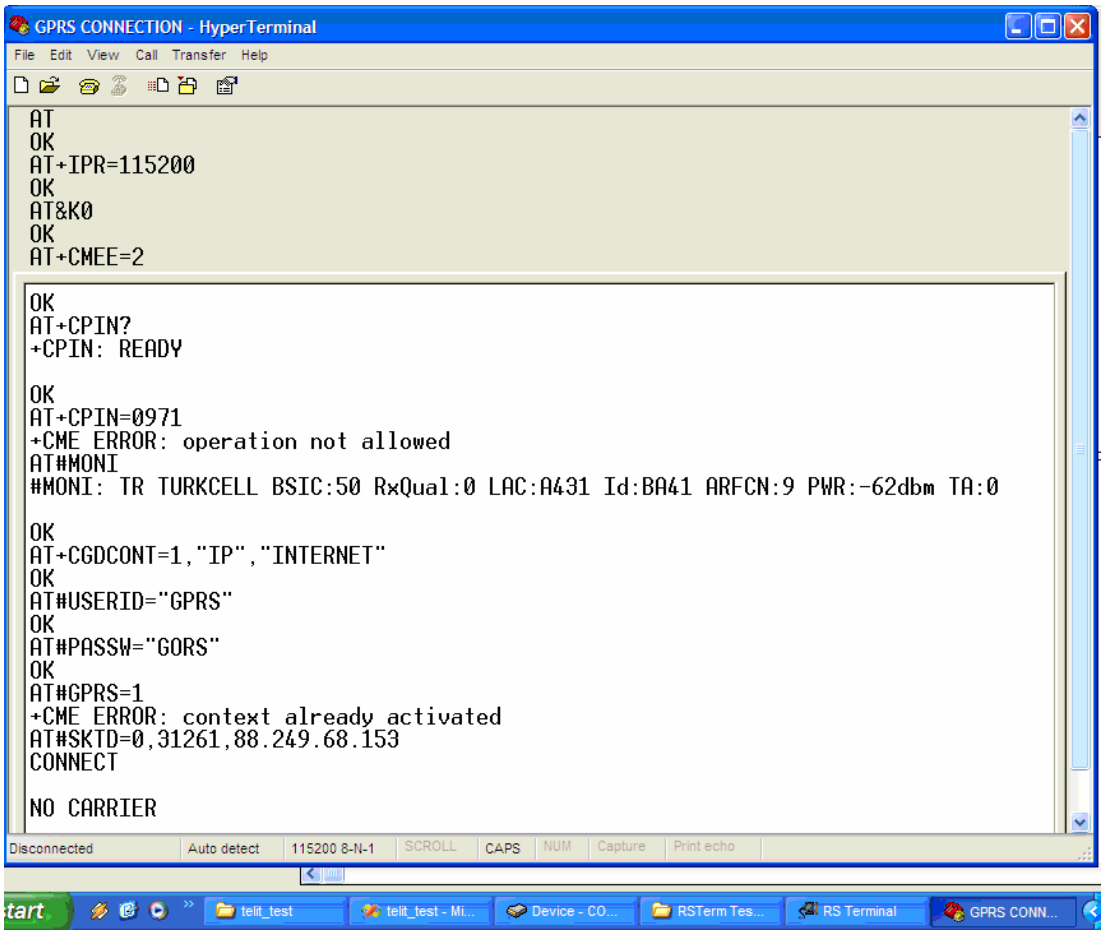


Figure 3.46. GPRS connection

At startup it is necessary to send an AT command to access device set the right speed and character format of the serial port. When this is done the device responds with OK. If no response is received within the timeout period of 200 ms retry.

- Send command AT
- Wait for OK response

After this initial command, it is advisable to fix the port rate, in order to eliminate possible errors in detecting the serial speed rate:

- Send command AT+IPR=<rate>

- Wait for OK response

where rate is the port speed and can be 0, 300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200 bps.

After autobauding the first thing to check is the SIM presence and PIN code insertion, this can be done with the following commands:

Enable the Extended error result codes

- send command AT+CMEE=1
- wait for OK response

or if you prefer the verbose format instead of the numerical format then:

- send command AT+CMEE=2
- wait for OK response

Query SIM presence and status

- send command AT+CPIN?
- wait for +CPIN: READY

Provide SIM PIN

- send command AT+CPIN=****

where **** stands access SIM PIN code (e.g. 1234)

- wait for OK response

After, enter t he PIN CODE of the SIM Card, then AT+CGDCONT command parameters are all the set of information to identify the internet entry point interface provided by the ISP. With these parameters the GPRS network identifies the ISP to be used to gain access to the internet and defines the value of the IP address of the GPRS device once connected.

Send command

AT+CGDCONT[=[<cid>[,<PDP_type>[,<APN>[,<PDP_addr>[,<d_comp>[,<h_comp>[,<pd1>[,…[,pdN]]]]]]]]]<cr>

wait for OK response:

Table 3.7. Parameters of AT+CGDCONT

<cid>	(PDP Context Identifier) numeric parameter which specifies a particular PDP context definition.
	1..max – where the value of max is returned by the Test command
<PDP_type>	(Packet Data Protocol type) a string parameter which specifies the type of packet data protocol
	“IP” – Internet Protocol
	“PPP” – Point to Point Protocol
<APN>	(Access Point Name) a string parameter that represents logical name used to select GGSN or external packet data network. If the value is null or omitted, then the subscription value will be requested.
<PDP_addr>	a string parameter that identifies the terminal in the address space applicable to the PDP. The allocated address may be read using the +CGPADDR command.
<d_comp>	numeric parameter that controls PDP data compression
	0 – off (default if value is omitted)
	1 – on
<h_comp>	numeric parameter that controls PDP header compression
	0 – off (default if value is omitted)
	1 – on
<pd1>, …, <pdN>	access N string parameters whose meanings are specific to the <PDP_type>

For Example ;

command:

AT+CGDCONT= 1,”IP”,”internet”

response

OK

The GPRS access configuration is done by setting: After access authentication parameters: User Name and Password

- send command AT#USERID=”GPRS”
- wait for OK response
- send command AT#PASSW =”GORS”
- wait for OK response

After an internet connection is provided , GPRS command must use, with the command #GPRS you can activate or deactivate a GPRS context INDEPENDENTLY from the TCP socket opening,

AT#GPRS=1 activates the context,

AT#GPRS=0 deactivates the context

Therefore with the AT#GPRS=1 command the module

- GPRS modem activates the context previously defined with AT+CGDCONT
- GPRS modem proceeds to the authentication
- Note that activating a context implies getting an IP address from the network and this will be maintained throughout the session.

The response code to the AT#GPRS=1 command reports the IP address obtained from the network, allowing the user to report it to his server or application.

With this command #SKTD (socket Dial) the TCP/UDP request to connect with the internet host starts:

- Eventually does the DNS query to resolve the IP address of the host name internet peer
- Gprs modem establishes a TCP/UDP (depending on the parameter request) connection with the given internet host
- Once the connection is up the module reports the code: CONNECT

AT#SKTD: <socket type>,<remote port>,<remote addr>,<closure type>,<local port>

Table 3.8. Parameters

<socket type>	socket protocol type
	0 – TCP (factory default)
	1 – UDP
<remote port>	remote host port to be opened
	0..65535 – port number (factory default is 0)
<remote addr>	address of the remote host, string type. This parameter can be either: any valid IP address in the format: xxx.xxx.xxx.xxx any host name to be solved with a DNS query in the format: **<hostname>**
<closure type>	socket closure behavior for TCP
	0 – local host closes immediately when remote host has closed (default)
	255 – local host closes after an escape sequence (+++) or after an abortive disconnect from remote.
<local port>	local host port to be used on UDP socket 0..65535 – port number

Example ;

AT#GPRS=1

AT#SKTD=0,31261,88.249.68.153

CONNECT

3.2.1.3. ARM Development Board

The data getting from the sensors can be read with the software which is developed by easy arm development kit. And these data, are sent to the server with AT command after GPS/GPRS modem is controlled.

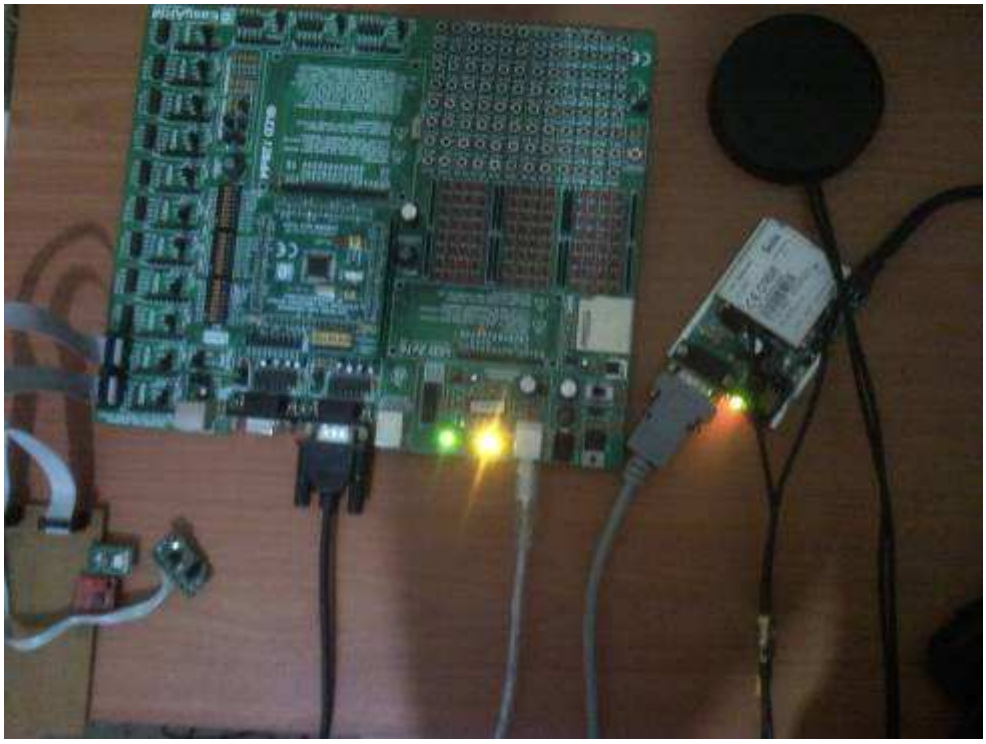


Figure 3.47. System setup

3.2.1.3.(1). Product Features of Arm Development Board

Easy Arm development system is a full-featured development board for Philips Arm LPC2148 microcontrollers.It has been designed to engineers to easily exercise and explore the capabilities of Arm microcontrollers. It allows Arm microcontrollers to be interfaced with external circuits and a board range of peripheral devices allowing the user concentrate on software development.

- Philips ARM7TDMI LPC2148 microcontroller (Single-chip 16-bit/32-bit microcontrollers; up to 512 kB flash with ISP/IAP, USB 2.0 full-speed device, 10-bit ADC and DAC)
- 12.0000 MHz crystal for maximum execution speed and standard serial bit rates
- On board USB 2.0 programmer.
- USB comm. connector for MCU with USB facilities.

- 2x RS-232 communication for connection with a PC or any other device with a DB9 connector.
- Switch between power supply thru USB or external power supply.
- JTAG connector
- 96 LEDs are provided.
- Pull up or Pull down port defining.
- Pull-up level selectable - 3.3V or 5V.
- 96 buttons are provided.
- All pins are taken out on IDC10 connectors to make them available for further connections.
- MMC\SD card slot - For MMC\SD memory cards.
- Graphic LCD 128x64 can be easily connected via the on-board connector. It is connected to MCU pins



Figure 3.48. Easy arm board

3.2.1.3.(2). Operating the Board –Read Information from the Sensors

After general information has been obtained ,USB driver has been set up to the computer in order to provide the communication between the board and computer. Development card The programmes have been developed by installing

Keil µ Vision in order to write a programme in C language and convert the written programme into hex format. Arm flash programmer has been set up to the computer in order to test by loading the written programmes to the development card. By this way, the programmes have been tested. The system has functioned free of problem.

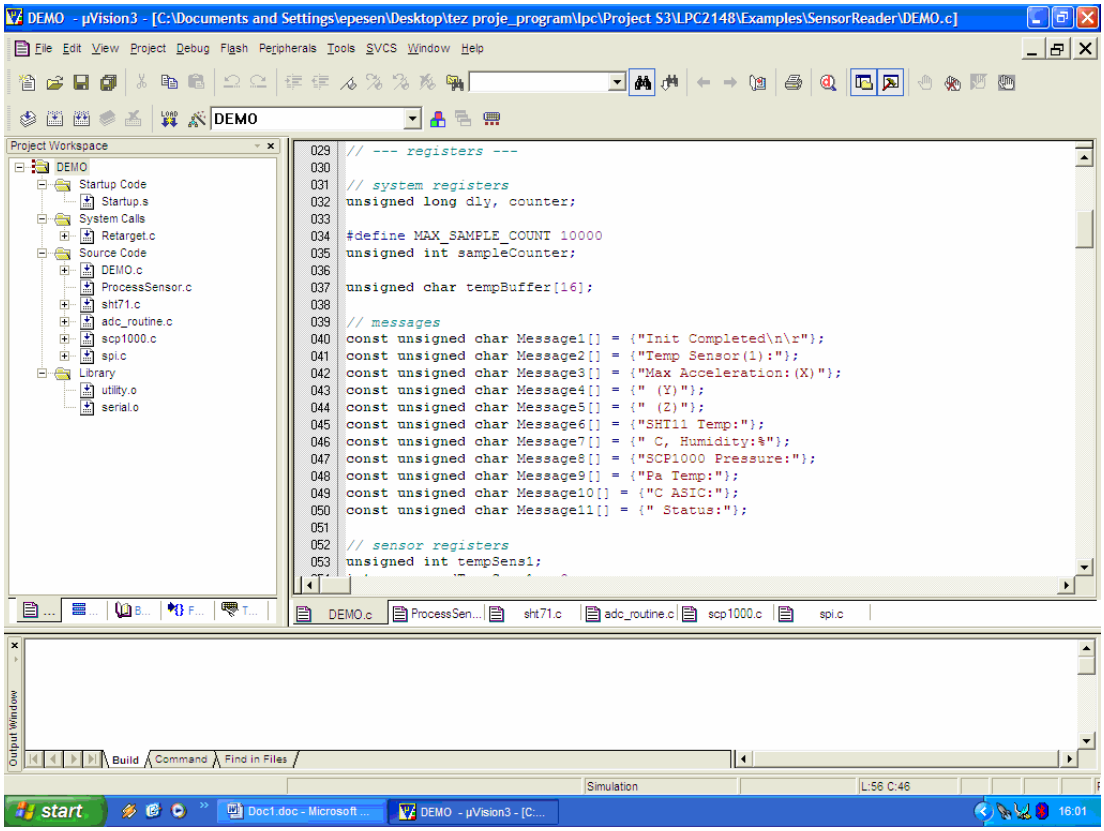


Figure 3.49. A sample for Keil µ Vision

3.2.1.3.(3). Read Data From Sensors

In this project three-axis accelerometer ADXL330 has been used. Some inquiries have been obtained about how to use ADXL330 .

3.2.1.3.(4). Three-axis Accelerometer

The three-axis accelerometer board features a small, thin, low-power, complete 3-axis accelerometer ADXL330 with signal conditioned voltage outputs,

all on a single monolithic IC. It measures acceleration with a minimum full-scale range of ±3 g and has 5V voltage level. It can measure static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock or vibration. ADXL330 is used in cost-sensitive, low-power, motion- and tilt-sensing applications such as: mobile devices, gaming systems, disk drive protection, image stabilization, sports and health devices (Analog devices, 2006).

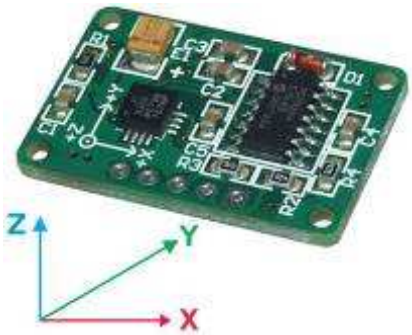


Figure 3.50. ADXL 330 accelerometer board

The board features an ADXL330. There is also a rail-to-rail Op Amp MCP6284 used for buffering.

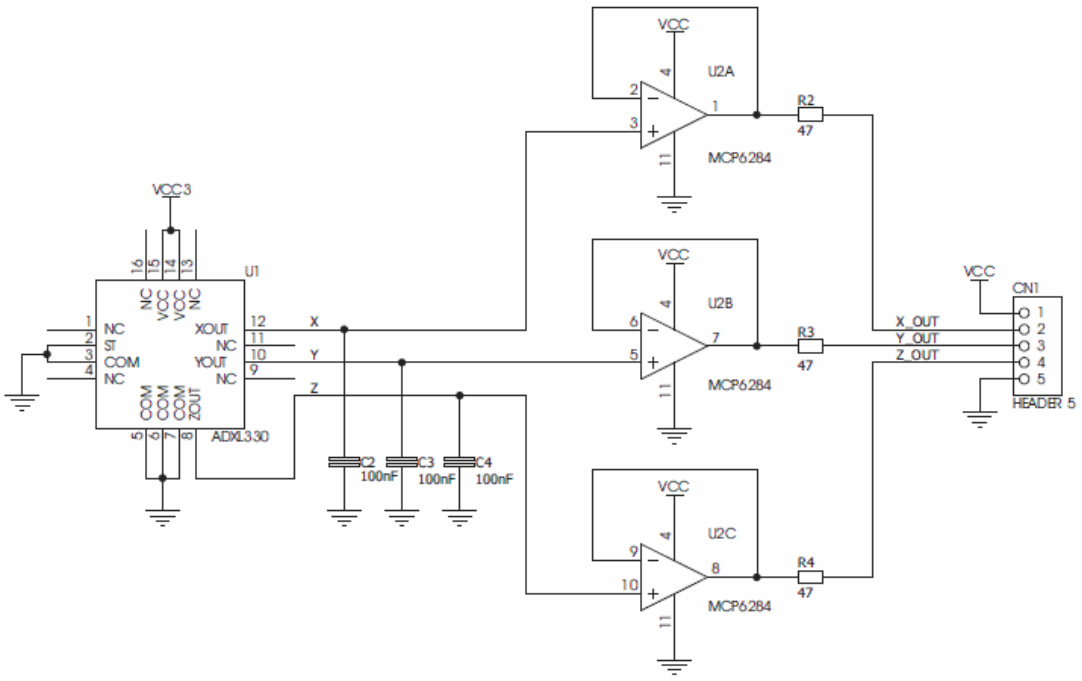


Figure 3.51. Accelerometer board circuit

A program was developed, in order to read the analog data getting from the probes. When program was developing, for comparing how much voltage for one g gets ,a transfer function must be calculated.

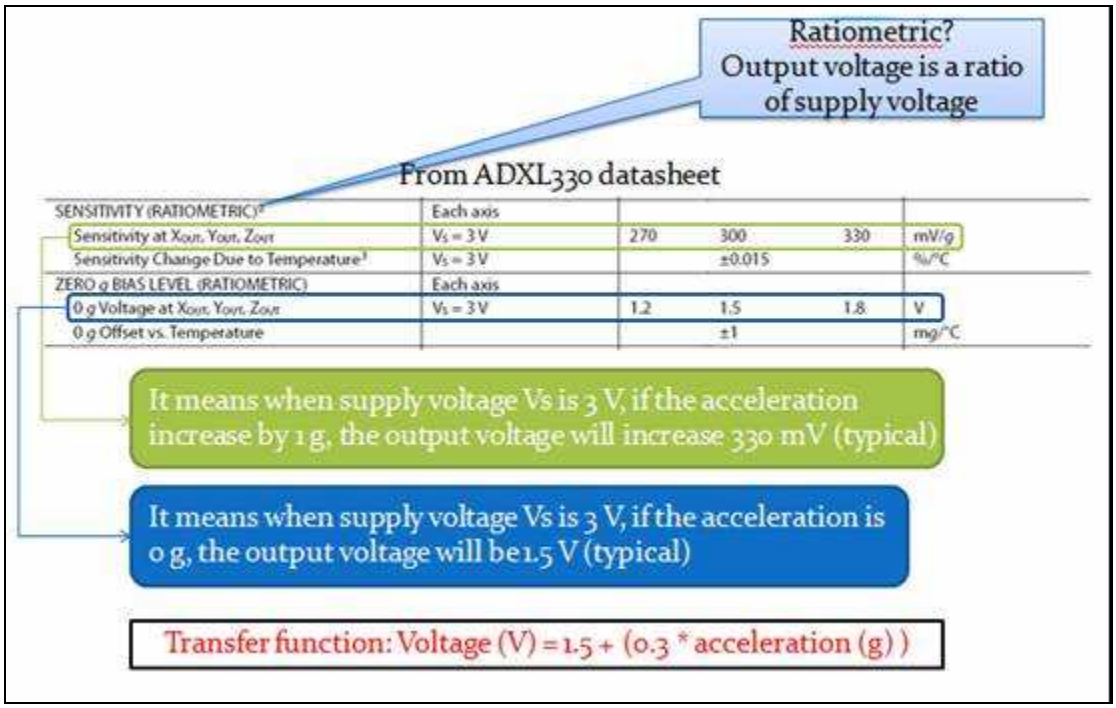


Figure 3.52. Transfer function of accelerometer board

An example for transfer function;

- Resolution: 12-bit
- Voltage reference

Vref+ = 2.5 V

Vref- = 0 V

- Conversion formula

N_{ADC} is the output number

$$N_{ADC} = (2^{n-bit} - 1) \times \left[\frac{Vin - V_{ref-}}{V_{ref+} - V_{ref-}} \right] \quad (3.2.1)$$

- For our setting

$$N_{ADC} = (4095) \times \left[\frac{Vin - 0}{2.5 - 0} \right] = (4095) \times \left[\frac{Vin}{2.5} \right] \quad (3.2.2)$$

Transfer function: V = 1.5 + (0.3 * g) (3.2.3)

- Conversion formula

$$N_{ADC} = (4095) \times \left[\frac{Vin - 0}{2.5 - 0} \right] = (4095) \times \left[\frac{Vin}{2.5} \right]$$

- When the acceleration is 0 g
  - V = 1.5
  - N_{ADC} = 2457
- When the acceleration is 1.5 g
  - V = 1.95
  - N_{ADC} = 3194

The Accelerometer board connection to the easy arm development is described below. A program was developed in order to read the data which connect to the computer from serial port. With developed software, the data are loaded to the computer and the results have been seen visually of a programme that has been written by VEE software. By this way, the programme which was written into the microcontroller, has been tested and it is seen that it is functioning quite well.

Acceleration X : AD0.1 - Port0. 8
Acceleration Y : AD0.2 - Port0. 9
Acceleration Z : AD0.3 - Port0.10

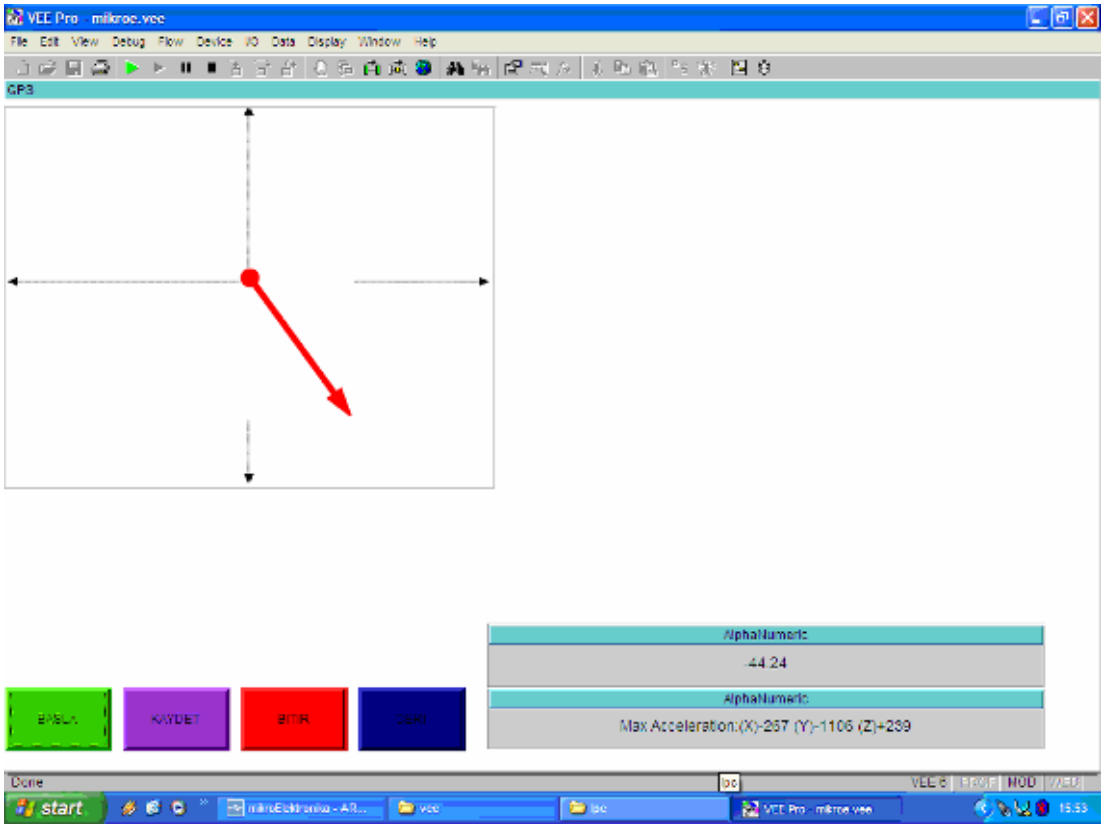


Figure 3.53. A sample for measurement of angle with ADXL 330 and read by computer

3.2.1.3.(5). SHT 11

The SHT1x / SHT7x is a single chip relative humidity and temperature multi sensor module comprising a calibrated digital output. Application of industrial CMOS processes with customized post processing (CMOSens technology) ensures highest reliability and excellent long term stability. The device includes two calibrated microsensors for relative humidity and temperature which are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit on the same chip. This results in superior signal quality, a fast response time and insensitivity to external disturbances (EMC) at a very competitive price. Applications are including automotive, instrumentation, medical equipment, heating, ventilation and air conditioning systems (HVAC), portable consumer electronics and battery-operated controllers (Sensirion, 2003).

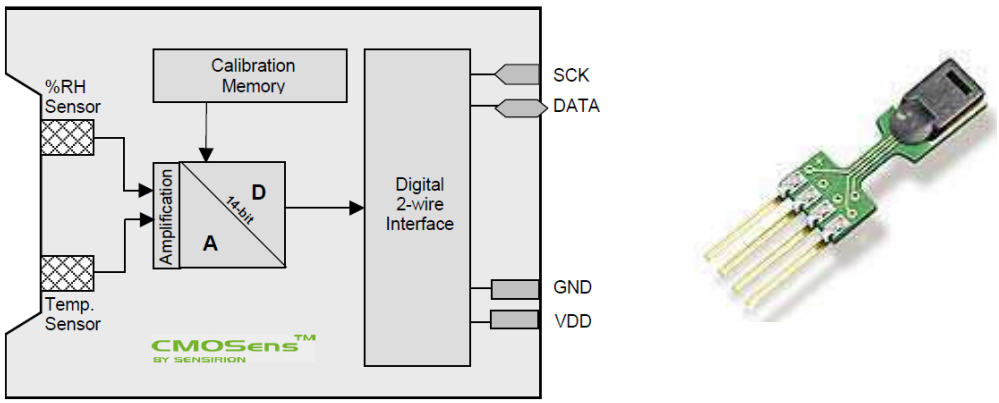


Figure 3.54. SHT11 and Internal block diagram of SHT11(Sensirion, 2003).

The bidirectional serial two- wire interface offered by the SHT sensor module is smilar to, but not directly compatible with , the I²C interface, the role of the master continuously switches from controller to sensor and back again.The SCK conection (serial clock input) serves to syncronise the sensor with the connected the microcontroller, while data are sent to and from the sensor using the DATA pin. The data pin is tristatable ; it cahanges son the falling edge of SCK and is validated by the rising edge.The data pin is provided with a pull-up resistor needed by the master (Figure 3.55).

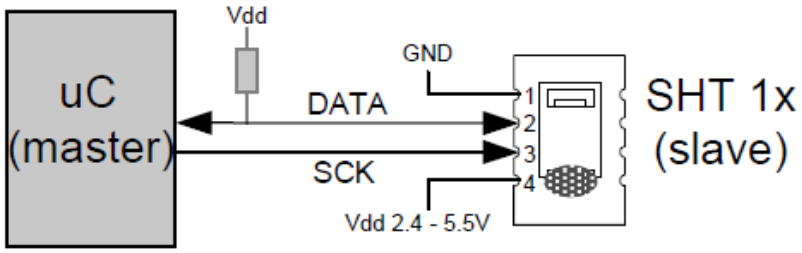


Figure 3.55. Typical application circuit (Sensirion, 2003).

The subsequent command which follows consists of three address bits and five instruction bits. At present address 000 is supported. The instruction bits for a temperature measurement are 00011, while those for a humidity measurement are 00101. The complete command set for the sensor is show in Table 3.9.

Table 3.9. Overview command

COMMAND	**CODE**	**DESCRIPTION**
Reserved	0000x	Reserved
Measure Temperature	11	Temperature Measure
Measure Humidity	101	Humidity Measure
Status Register Read	111	Read access to the status register (see application note)
Status Register Write	110	Write access to the status register (see application note)
Reserved	0101x1110x	Reserved
Soft Reset	11110	resets the chips, clears the status register to default values wait 11 ms before next command

After sending command the microcontroller must wait until the sensor completes the measurement. This takes 11 ms for an 8-bit measurement, 55 ms for a 12 bit measurement and 210 ms for a 14-bit measurement..The time varies with the speed of the internal oscillator and can be lower by up to ± %15. To signal the completion of a measurement, the SHT11 pulls data line low and enters Idle Mode (Sensirion, 2003).

From this point on it is just a matter of calculation; the sensor data have been transferred to the microcontroller and it is an easy job to convert these values into a temperature in ˚C and a relative humidity RH.

Since the temperature sensor is highly linear, it is very easy to convert the output value SO_{Temp} into the actual temperature values:

$$T = d1 + (d2x\ SOTemp) \quad (3.2.4)$$

With a 5 V power supply, d1 is -40˚C.For a 14 bit reading, d2 is 0.01˚C, for 12 bit reading 0.04˚C. Values for other voltages for conversion to the Fahrenheit scale appear in the data sheet.

A more complicated equation is needed to compensate for the non-linearity of the humidity sensor:

$$RH_{linear} = c1 + (c2 * SO_{RH}) + (c3 * SO_{RH}^2) \quad (3.2.5)$$

The constants c1,c2 and c3 are given in Table 3.10.

Table 3.10. Coefficients required to calculate humidity

SO_{RH}	c1	c2	c3
12 bit	-4	0,0405	$-2{,}8.10^{-6}$
8 bit	-4	0,648	$-7{,}2.10^{-4}$

At temperatures far from 25˚C the temperature coefficient of the humidity sensor needs to be taken into account:

$$RH_{comp} = (T\text{-}25^{\circ}C) * [0.01 + (t2 * SO_{RH})] + RH_{linear} \quad (3.2.6)$$

Coefficient t2 is 0.00008 for a 12-bit measuremt, and 0,00128 for an 8-bit measurement.

SHT11, connection to the easy arm development is described below. A program was developped in order to read the data which connect to the computer from serial port. With developed software, the data are loaded to the computer and the results have been seen visually of a programme that has been written by VEE software. By this way, the programme which was written into the microcontroller, has been tested and it is seen that it is functioning quite well.

SHT11 Data : P0.1

SHT11 Clk : P0.2

3.2.1.3.(6). Absolute Pressure Sensor

SCP1000-D01 digital absolute pressure sensors are intended for barometric pressure measurement and altimeter applications for 30kPa to 120kPa and -20C to 70C measuring ranges. The pressure and temperature output data is calibrated and compensated internally and the communication between the SCP1000 and its host micro-controller is realized using an SPI interface (VTI, 2007).

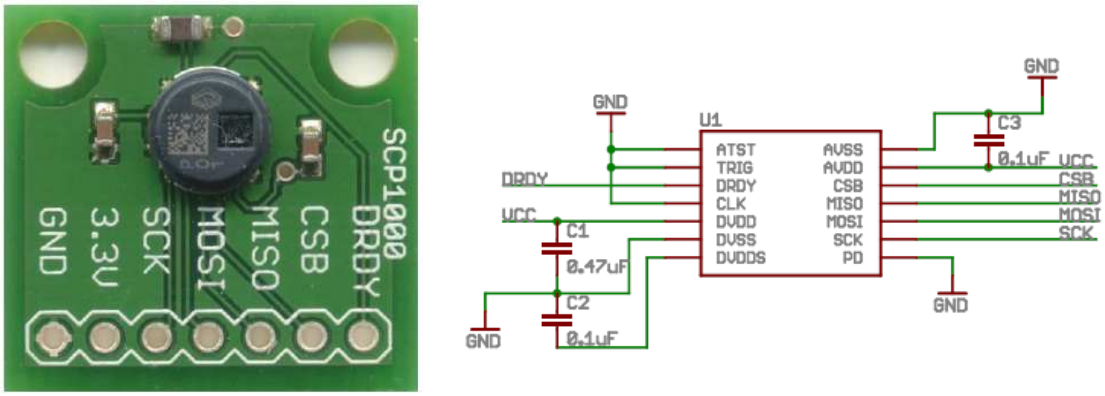


Figure 3.56. Pressure sensor and its ciruit

The SCP1000 pressure sensor has 4 measurement modes plus standby and power down mode. In all measurement modes, the pressure output word-length is 19 bits and the temperature output word-length is 14 bits. On this project, high resolution mode was used.

Table 3.11. The SCP1000 Pressure sensor has 4 normal operation modes plus power down mode (VTI, 2007)

Mode	Pressure measurement	Resolution	Output data refresh rate
High resolution	Continues	17 bits	1.8 Hz
High speed	Continues	15 bits	9 Hz
Ultra low power	Periodical	15 bits	Approximately 1 Hz
Low power	External trigger	17 bits or 15 bits	
Power Down	Activated through PD pin		

The SPI interface is a full duplex 4 wire serial interface. The connection between the microcontroller and SCP1000 is done using MOSI, MISO, SCK and

CSB. CSB selects the chip on multi-chip SPI bus, SCK is the serial data clock, MOSI is the data line from master to slave (Master Out Slave In) and MISO is data line from slave to master (Master In Slave Out). SCP1000 is configured to SPI slave mode (Figure 3.57).

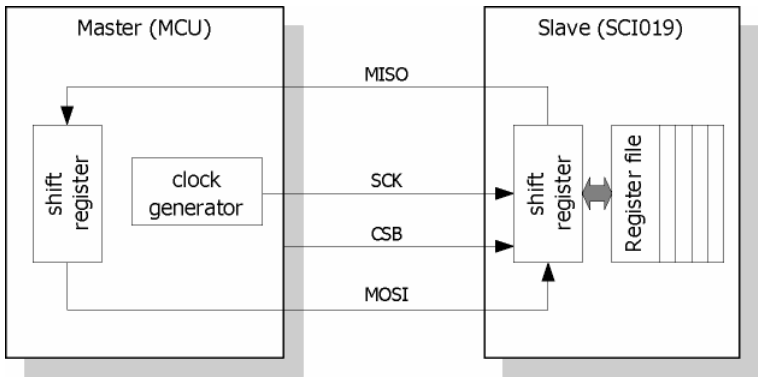


Figure 3.57. SPI master slave configuration (VTI, 2007)

The SCP1000 SPI frame format is presented in Figure 3.58. below.

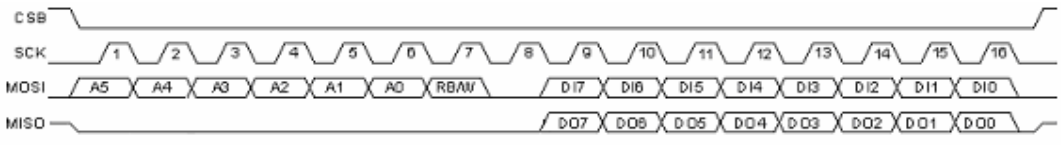


Figure 3.58. SPI frame format for two 8 bit words

Each SPI communication frame contains two or three 8 bit words: the first word defines the register address (6 bits wide, bits [A5:A0] in Figure 3.58.) followed by the type of access (‘0’ = Read or ‘1’ = Write) and one zero bit (bit 0, LSB). The following word(s) contain the data being read or written. The MSB of the words are sent first. Bits from MOSI line are sampled in on the rising edge of SCK and bits to MISO line are latched out on falling edge of SCK. The CSB line must stay low during the entire frame accesses, i.e. between the bytes. If the CSB line state changes to high, the access is terminated. The CSB has to be pulled up after each communication frame.

Examples SPI communication (8 and 16 bit read / write operations) are presented in Figure 3.59. below.

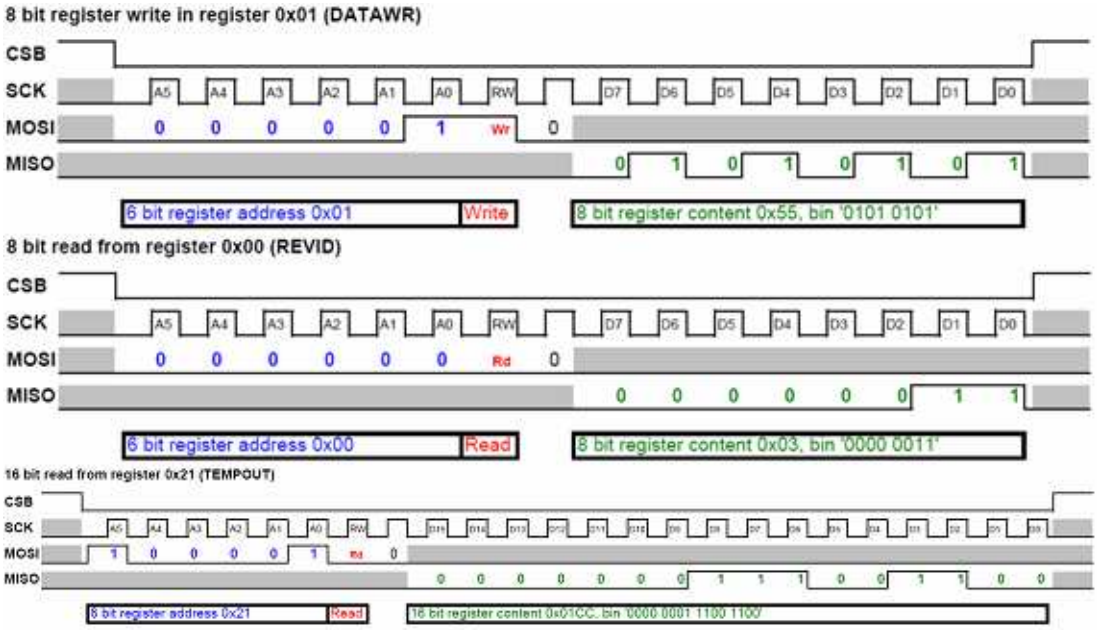


Figure 3.59. SPI communication examples (VTI, 2007)

SCP1000 D-01, connection to the easy arm development is described below. A program was developed in order to read the data which connect to the computer from serial port. With developed software, the data are loaded to the computer and the results have been seen visually of a programme that has been written by VEE software. By this way, the programme which was written into the microcontroller, has been tested and it is seen that it is functioning quite well.

SCP1000 MISO : P0.5

SCP1000 SCK : P0.4

SCP1000 SCB : P0.7

SCP1000 MOSI : P0.6

Picture of the interface program which read the data from the sht11, scp1000, float and acceleration sensors, is following. Accuracy of the read data was checked by measured with hand devices.

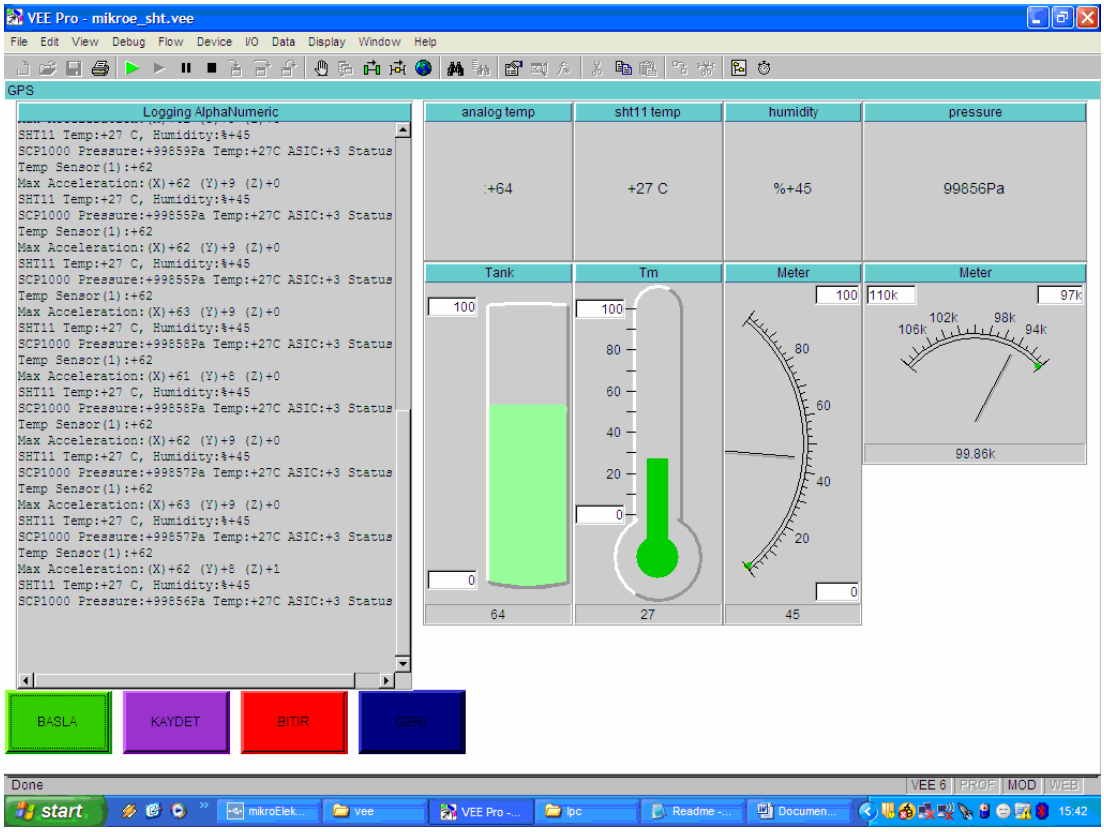


Figure 3.60. Read information from the sensors

3.2.1.4. Developed Software and its Flow Diagrams

The software which was developed by using C and C# a programs. The flow diagrams of the system were shown in Figure 3.61. and Figure 3.62.

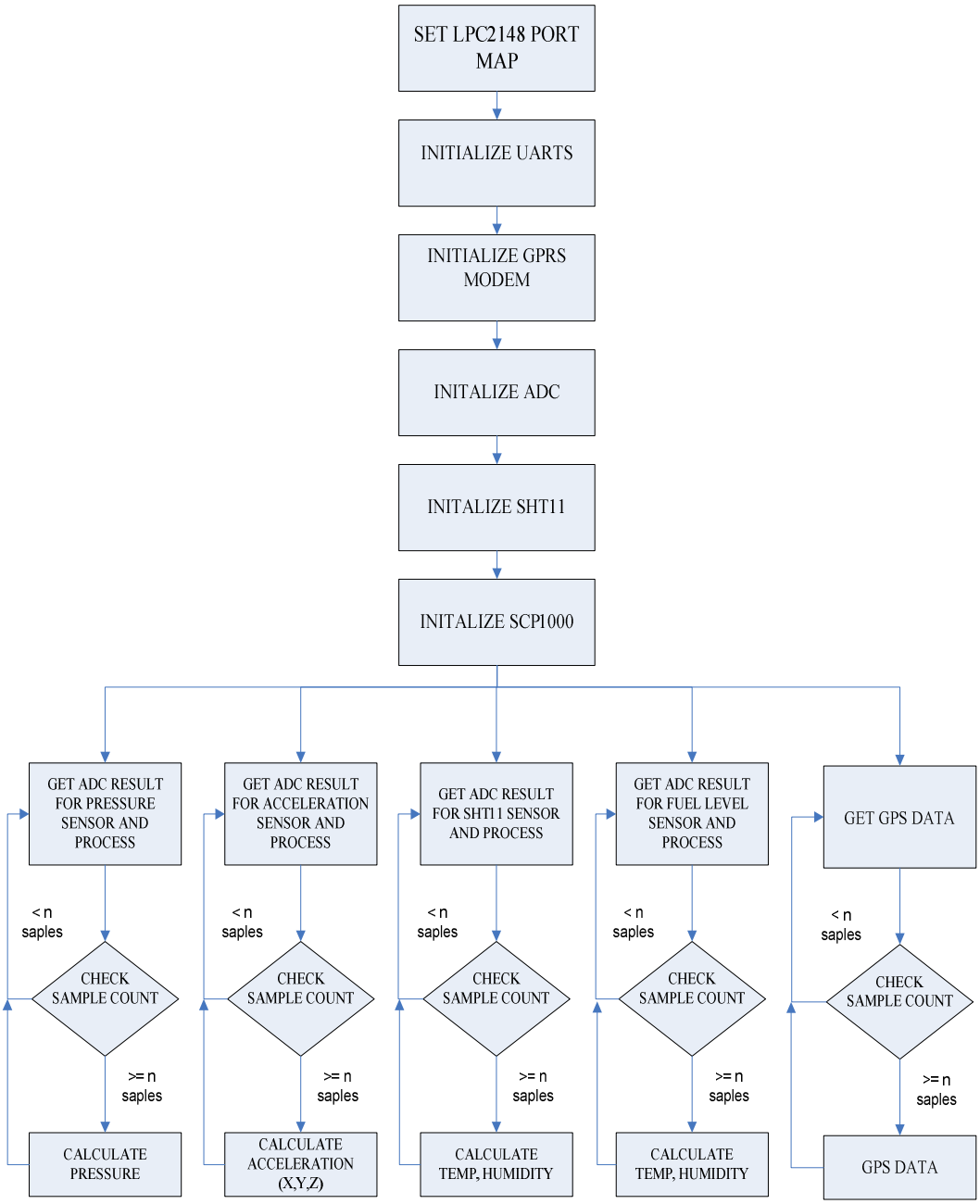


Figure 3.61. The Flow Chart; read data from sensor

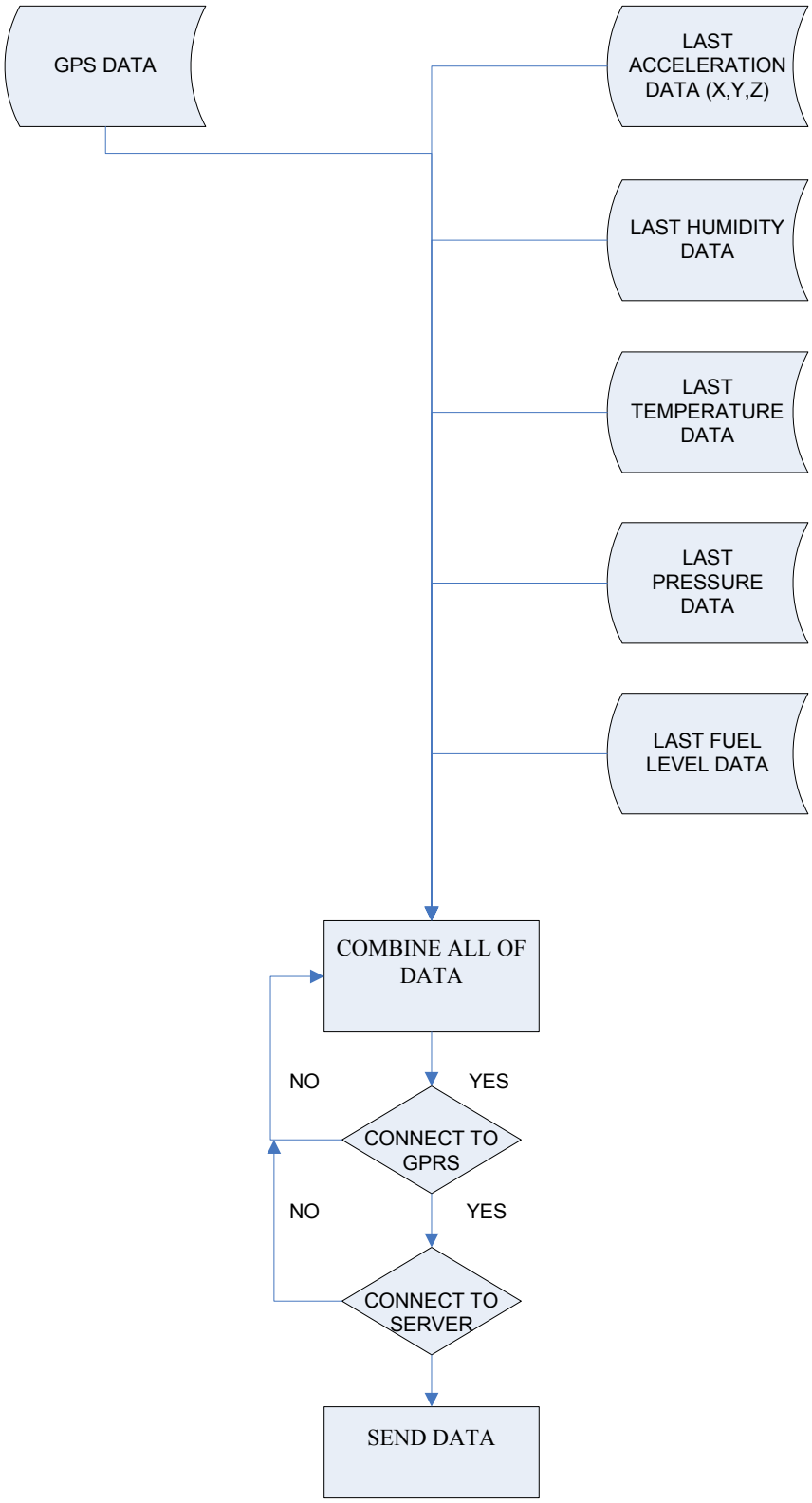


Figure 3.62. The Flow Chart; send data via GPRS modem

3.2.2. Application Server

Data coming from GPRS, is redirect to a pc on the local area network from 31261 language. This data send to MySql server on the internet that was rent before. This data show on an internet page that was configured with PHP language.

3.2.2.1. Port Forwarding

Configure router from NAT settings for port forwarding to TCP port 31261 on local network. (Figure 3.63)

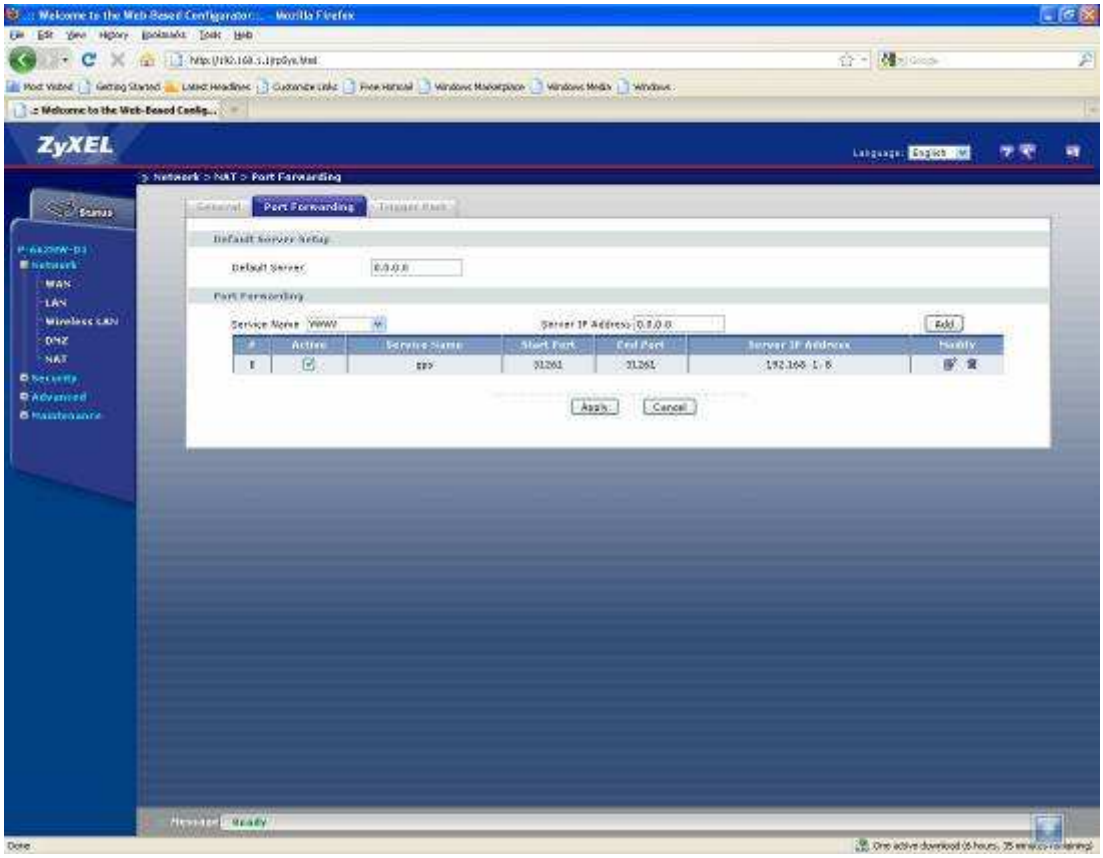


Figure 3.63. Modem setting

3.2.2.2. Send GPRS Data To MySql Server

Data push to MySql server with Delphi program (Figure 3.64).

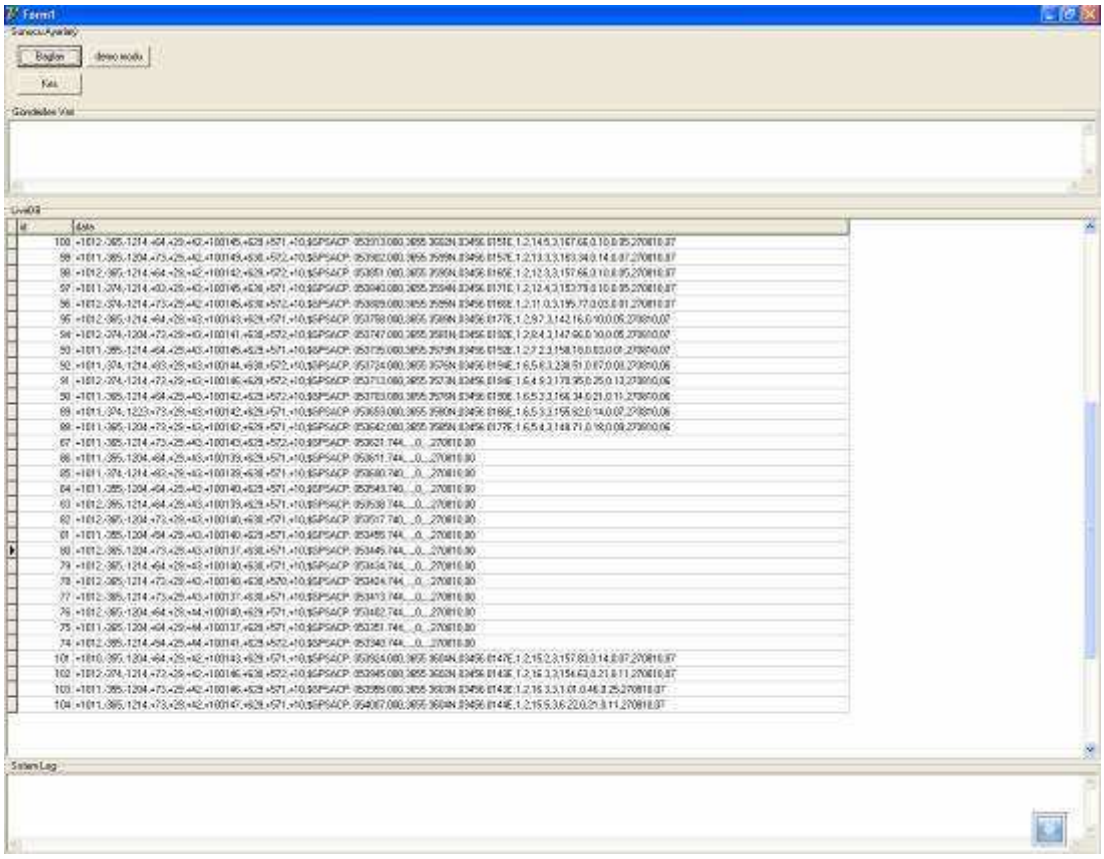


Figure 3.64. Delphi program

3.2.2.3. Internet Page

Data show on an internet page that was configured with PHP language. This data can visually see by web page (Figure 3.65).

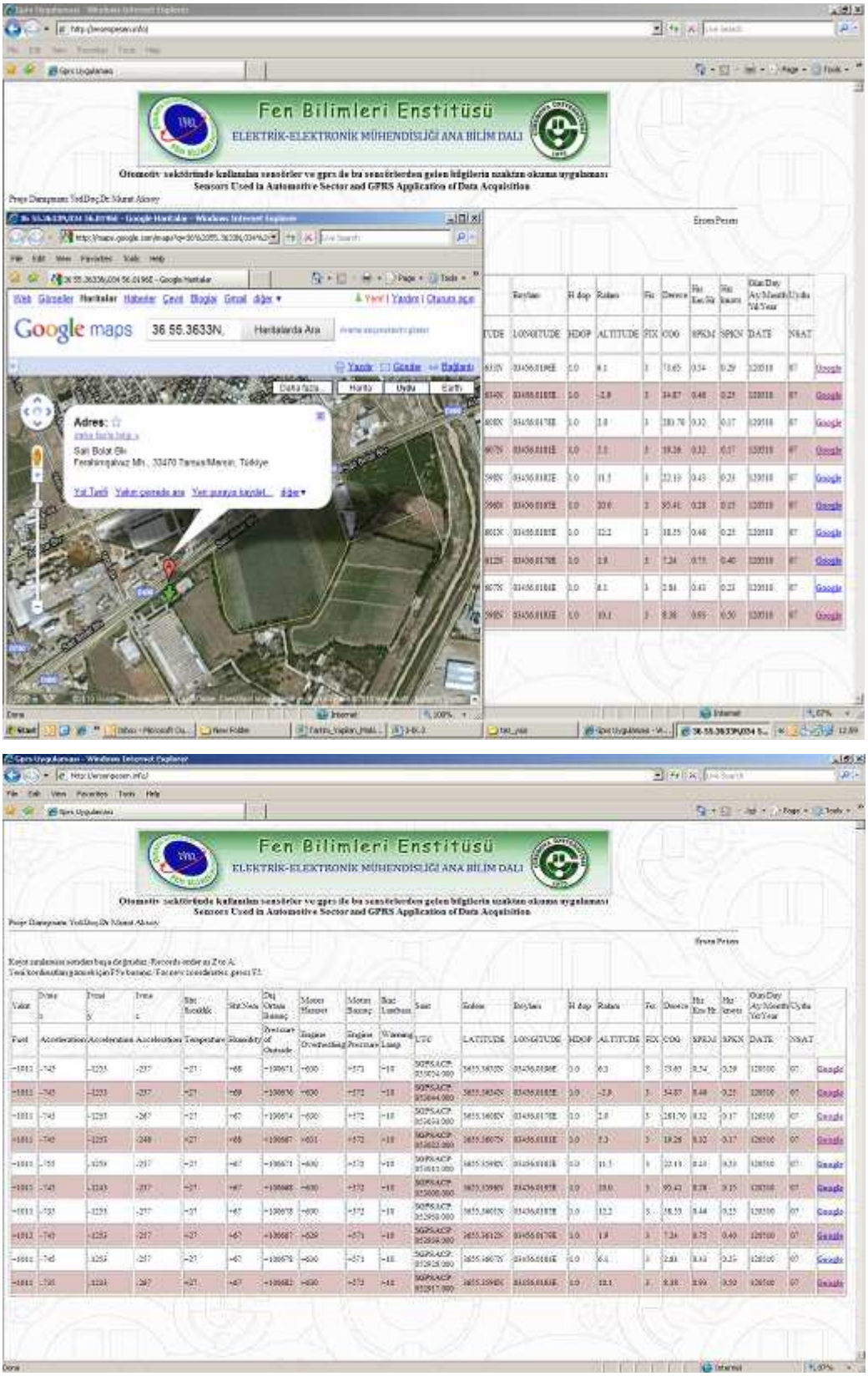


Figure 3.65. Web Pages

The software which was developed by using Delphi and PHP a programs

The flow diagrams of the system were shown in Figure 3.66.

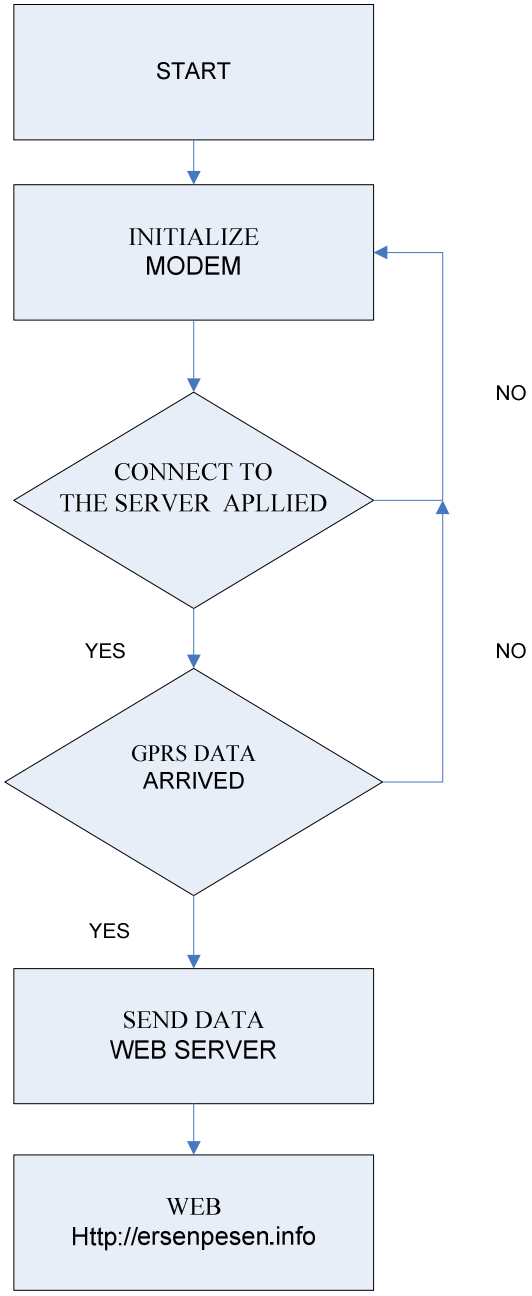


Figure 3.66. The flow chart for application server

4. RESULT AND DISCUSSION

Performed work on this thesis was obtained from seperate modules, seperate studies were performed and seperate programmes were written for each module, the system was run on microcontroller one by one, and to get the read datas, simulation programs were written on computer, calibration of the read datas are performed by checking and measuring with other devices. In the same way, it seemed that all modules run by checked the position informations obtained from GPS on google maps. Later, system was obtained by associating all modules.

With this study, information obtained related to sensors of the microcontrollers. Deatiled works have been done related to microcontroller architecture. AT commands have been learnt for the GPS/GPRS applications.

Received data from the meaurements by driving around the Çukurova University are following. (Table 4.1, Table 4.2, Figure 4.2 and Figure 4.3) Track path is shown on the following picture with blue lines (Figure 4.1).

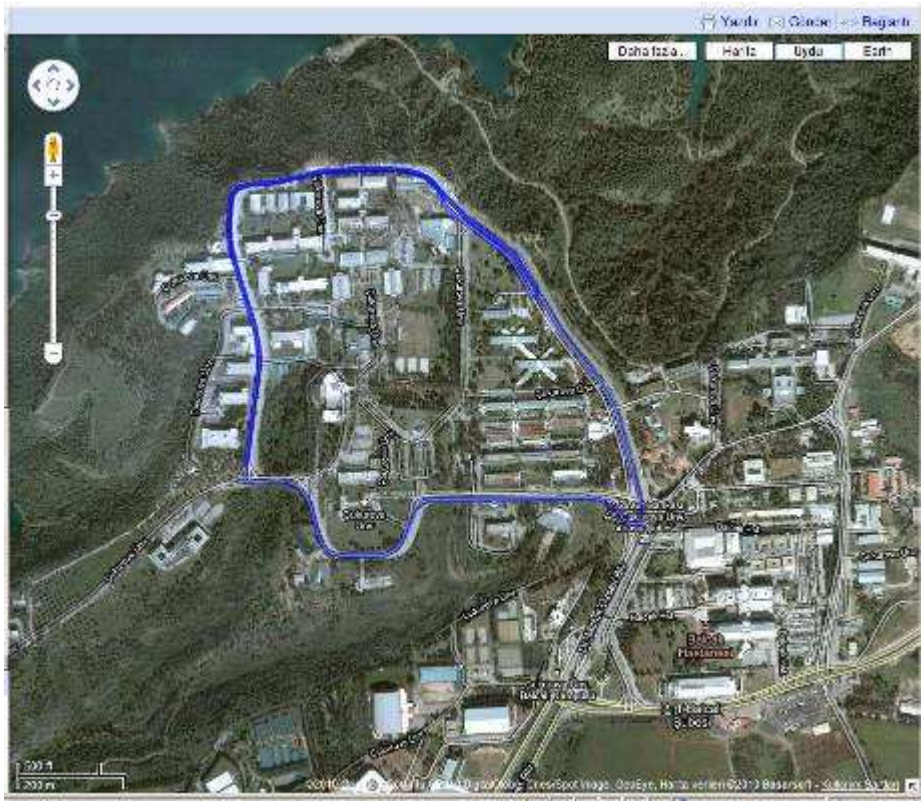


Figure 4.1. Track path

Table 4.1 Sample of measurement from sensor

Fuel	Acceleration/Angle (º)			Temprature	Humidity	Pressure
lt	X	Y	Z	º C	%	Pa
+28.6	-1.6	17	84.2	33	38	99204
+29.4	0.4	16	84.2	32	38	99063
+28.7	-1.6	16	84.2	34	34	99157
+28.6	-3.5	15	84.2	34	32	99132
+28.7	17	15	92	34	31	99041
+28.7	-1.6	16	84.2	34	34	99157
+28.6	-3.5	15	84.2	34	32	99132
+28.8	-3.5	14	91	34	32	99194
+28.6	-5.5	15	99.8	34	31	99126
+28.6	-3.5	15	84.2	34	32	99132
+28.8	-21.1	17	86.1	33	32	99194
+28.8	-11.3	14	99.8	34	32	99204
+28.6	-5.5	15	99.8	34	31	99126
+28.8	-21.1	17	86.1	33	32	99194
+28.8	-21.1	17	86.1	33	32	99194
+28.8	-21.1	17	86.1	33	32	99194
+28.8	-11.3	17	99.8	34	32	99204
+29.3	-11,2	17	82.2	32	38	99032
+28.8	-21.1	17	86.1	33	32	99194
+29.1	-1.6	17	91	33	37	99157
+29.2	-16.2	17	97.8	33	37	99156
+29.1	-2.6	17	89.1	33	34	99073
+29.1	-3.5	17	82.2	33	33	98992
+29.1	0.4	15	76.4	33	35	99119
+28.8	15	16	78.3	31	32	99087
+28.7	15	15	71.5	31	33	99147
+28.9	17	15	78.3	32	32	99185
+28.8	17	17	108.6	32	32	99227
+29.2	-8.4	17	75.4	32	32	99183
+29.3	-8,4	17	79.3	32	33	99190
+29.3	0,5	17	93	32	33	99183
+29.5	0.4	17	91	32	34	99174
+28.8	15	16	78.3	31	32	99087
+28.7	15	15	71.5	31	33	99147
+28.9	17	17	78.3	32	32	99185

Table 4.2. Read Acquired GPS Position

Utc	Latitude	Longgitude	Altitude	Cog	SPkm	Date	Nsat
13:02:21	3703.7081N	03521.1381E	154.9	113.46	0.14	17.09.2010	10
13:03:42	3703.7082N	03521.1378E	155.2	118.01	0.10	17.09.2010	10
13:03:55	3703.7085N	03521.1382E	157.4	117.04	0.14	17.09.2010	10
13:04:05	3703.7088N	03521.1385E	158.9	122.19	0.10	17.09.2010	10
13:04:16	3703.7089N	03521.1386E	159.5	83.99	0.14	17.09.2010	10
13:04:27	3703.7091N	03521.1389E	160.7	100.38	0.10	17.09.2010	10
13:04:38	3703.7092N	03521.1391E	161.4	102.86	0.14	17.09.2010	10
13:04:49	3703.7106N	03521.1397E	161.1	26.96	15.12	17.09.2010	10
13:05:03	3703.7447N	03521.1467E	159.6	26.91	18.46	17.09.2010	11
13:05:16	3703.7616N	03521.1844E	158.4	83.69	20.41	17.09.2010	11
13:05:16	3703.7616N	03521.1844E	158.4	83.69	20.41	17.09.2010	11
13:05:26	3703.7678N	03521.2201E	158.4	65.71	19.22	17.09.2010	11
13:05:37	3703.7761N	03521.2632E	157.1	83.11	25.95	17.09.2010	11
13:05:48	3703.7777N	03521.3185E	157.0	88.33	25.95	17.09.2010	10
13:05:59	3703.7767N	03521.3720E	157.5	101.13	25.38	17.09.2010	11
13:06:10	3703.7503N	03521.4096E	158.3	152.86	27.57	17.09.2010	10
13:06:21	3703.7154N	03521.4520E	157.3	125.83	31.93	17.09.2010	10
13:06:32	3703.6816N	03521.5024E	156.3	143.86	33.01	17.09.2010	10
13:06:43	3703.6200N	03521.5461E	152.1	148.30	48.52	17.09.2010	10
13:06:58	3703.5333N	03521.6241E	145.7	158.52	46.36	17.09.2010	10
13:06:58	3703.5333N	03521.6241E	145.7	158.52	46.36	17.09.2010	10
13:07:08	3703.4673N	03521.6458E	141.2	172.92	32.29	17.09.2010	10
13:07:38	3703.4457N	03521.4519E	138.9	267.85	48.42	17.09.2010	10
13:07:49	3703.4340N	03521.3702E	136.9	202.62	28.87	17.09.2010	10
13:08:00	3703.3942N	03521.3524E	135.3	216.74	24.15	17.09.2010	10
13:08:00	3703.3942N	03521.3524E	135.3	216.74	24.15	17.09.2010	10
13:08:11	3703.3840N	03521.3081E	134.7	268.14	23.22	17.09.2010	10
13:08:22	3703.3914N	03521.2638E	134.0	314.74	21.49	17.09.2010	10
13:08:33	3703.4201N	03521.2484E	134.1	343.08	22.39	17.09.2010	9
13:08:44	3703.4587N	03521.2308E	133.0	309.69	27.28	17.09.2010	9
13:08:55	3703.4671N	03521.1769E	127.6	296.96	22.46	17.09.2010	9
13:09:05	3703.5034N	03521.1678E	130.1	296.96	27.54	17.09.2010	9
13:09:16	3703.5481N	03521.1757E	136.1	359.95	26.20	17.09.2010	9
13:09:27	3703.5836N	03521.1796E	140.5	359.66	25.12	17.09.2010	8
13:09:39	3703.6266N	03521.1690E	142.8	343.83	23.29	17.09.2010	8
13:09:50	3703.6610N	03521.1550E	143.3	342.77	22.39	17.09.2010	9
13:10:01	3703.6959N	03521.1432E	146.8	348.56	22.00	17.09.2010	8
13:10:11	3703.7082N	03521.1365E	149.9	88.81	0.10	17.09.2010	9

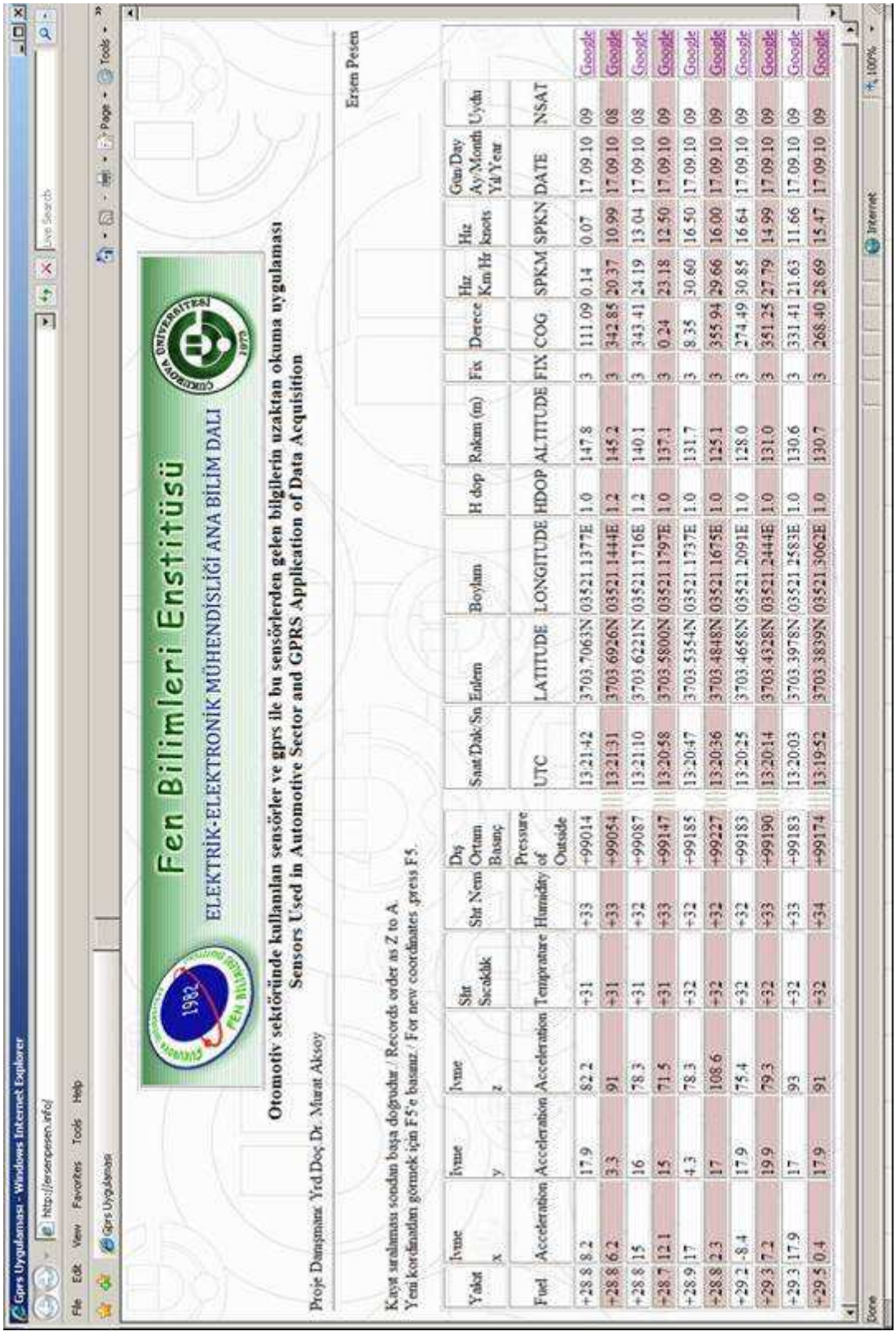


Figure 4.2. Web Page

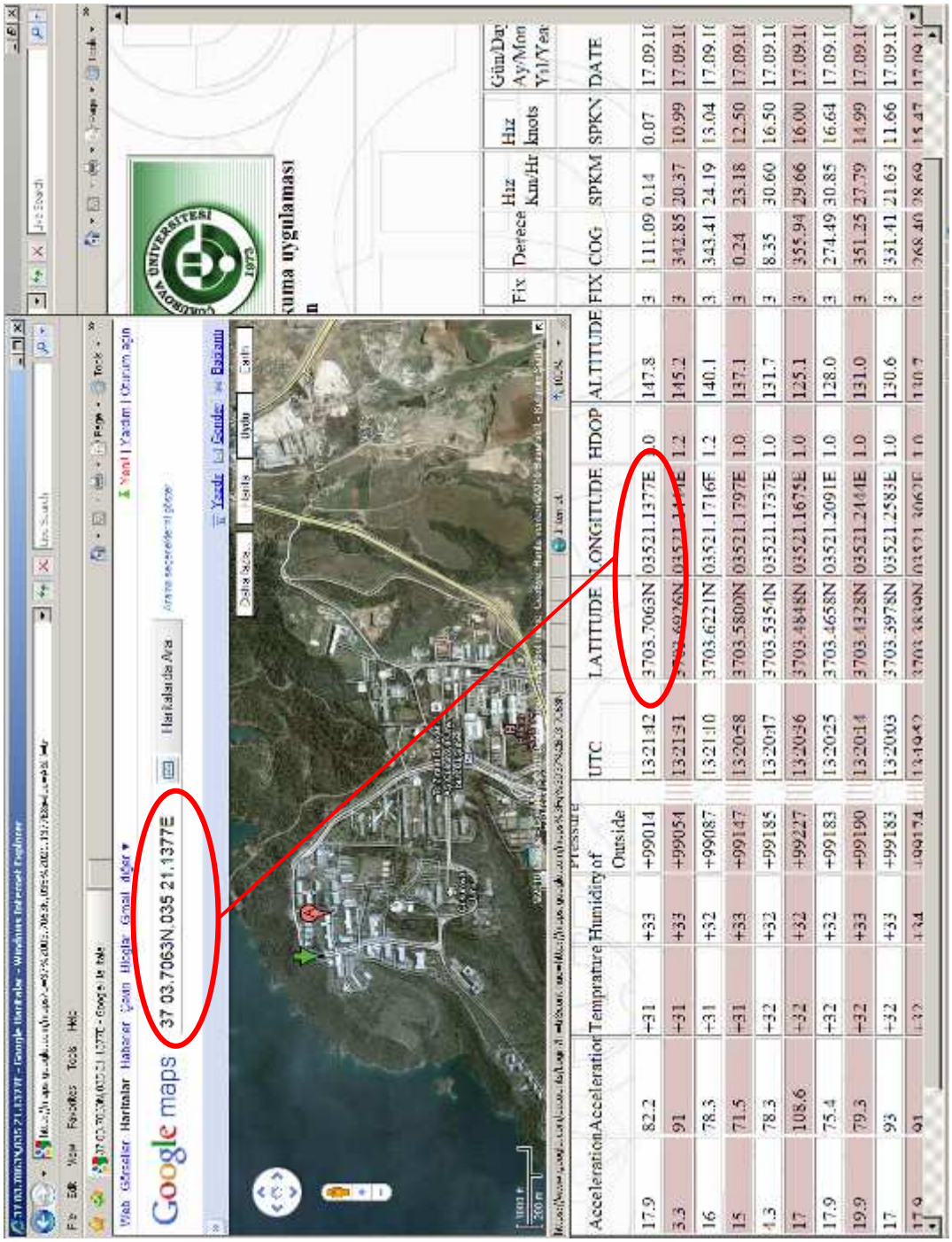


Figure 4.3. Web Page

According to the above data examples, the following processes have been seen

- Inspection of performance due to the media and recording the performance

- Tracking construction machines and finding failures
- Early operations on the failed construction machines
- Using the recorded data during development
- Making the leasing easy by protecting the construction machines against theft
- Controlling the hour meter of the construction machines for borrowing

5. CONCLUSION AND FUTURE WORK

On this work, the units which can be included by the structure of the gprs based remote data verification system, were analysed by considering the present technologies and tried to give the best answer to the question; “how should be the gprs based remote data verification systems” . At the end of this work, sample of the gprs based remote data verification system was composed by gathering the systems which are best harmonized with each other.

With this work, data and information from gps by the assistance of other hardware and software, and data collection systems from sensors used on vehicle were recorded by following remotely with a web page by an assistance of gprs. A practically applicable software was obtained by overcoming some issues and difficulties encountered during the improvement studies of the software with performed studies and solutions to be found. Obtained software was considered that it is a practically applicable software by testing with a sample of vehicle tracking system. The vehicle which device is mounted, was tracked succesfully on computer screen by the improved software, simultaneously.

To be able to use this improved system on vehicles effectively, it should be manufactured as reliable with a strong structure against the shocks and should be integrated to the vehicle. Used GSM operator should serve at used area to run the GPRS technology. There is a possibility for information transfer almost on everywhere with suggested wireless data transfer solutions System will be able to present to customers quick services and customer satisfaction will be able to be increased.

On the next steps of this study, it can be supplied that the driver on vehicle can monitor the path of the vehicle by using a graphic based screen on vehicle unit. Designed system can be used to obtain the road map of related region by providing plot of the vehicle path on computer environment (Command control unit). It shouldn’t be supposed that using the area of the software is restricted with these systems in spite of it’s improvement is based on the vehicle monitoring systems. Software can also be used on another area which required the numerical map

functionality, and instrument and components can be produced for software improvement. Also, the value of this study is pretty good, because it can be applied to the other vehicles in automotive sector with small changes, easily.

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BIOGRAPHY

I was born in Mersin, Turkey, on February 08th, 1975. I graduated from Gazi High School, Mersin, in 1992. I received my BS degree in Electronics and Communication Engineering Department from the Kocaeli University, Kocaeli, Turkey, in 1998. Then, I worked for Bis Company between 2001 and 2002 in İstanbul. I have been working at the Çukurova Company since 2002, in Mersin.

My areas of interest include automation systems, software development and instrumentation.

APPENDIX

Telit GM862-GPS modem

Telit wireless solutions

GSM | GPRS

GM862-GPS
Modem



- Telit Unified AT Command Set
- SiRF® Powered
- 20 Channel GPS Receiver
- Quad Band GPRS
- GPRS Class 10
- Pin to Pin Backward Compatible
- RoHS Compliant
- On Board SIM Holder
- PYTHON® Script Interpreter
- Embedded FTP and SMTP Client
- Extended Temperature Range
- Extended RF Sensitivity
- Embedded TCP/IP Stack

The new GM862-GPS module is at the cutting edge of the Telit product line. It combines superior performance in quad-band GSM/GPRS modem functionality with the latest 20-channel high sensitivity SiRFstarIII™ single-chip GPS receiver. Pin-to-pin compatibility to the previous GM862-GPS module enhances and extends the functionality of new and existing GPS applications.

With its ruggedized design, extended temperature range, integrated SIM card holder, and industrial-grade connectors, the Telit GM862-GPS is the ideal platform for mobile applications in areas such as telematics, fleet management, tracking, security, and vehicle navigation.

The new GPS receiver features low power consumption with position resolution accuracy of less than 2.5m, SBAS (WAAS and EGNOS) as well as high sensitivity for indoor fixes. These features combined with the available Python™ application development environment translate into a very cost effective and feature rich platform quite capable of becoming the total solution for the complete customer application. Additional features including jamming detection, integrated TCP/IP protocol stack, and Easy Scan® offer unmatched benefits to the application developer without adding cost.

As part of Telit's corporate policy of environmental protection, all products comply to the RoHS (Restriction of Hazardous Substances) directive of the European Union (EU Directive 2002/95/EG).

Product features

- Quad-band EGSM 850 / 900 / 1800 / 1900 MHz
- Output power
  - Class 4 (2W) @ 850 / 900 MHz
  - Class 1 (1W) @ 1800 / 1900 MHz
- Control via AT commands according to GSM 07.05, 07.07 and Telit enhancements
- Supply voltage range: 3.4 - 4.2 V DC (3.8 V DC recommended)
- GSM power consumption (typical values)
  - Power off: < 26 uA
  - Idle (registered, power saving): < 4 mA
  - Dedicated mode: 200 mA
  - GPRS cl.10: 370 mA
- Serial port multiplexer GSM 7.10
- SIM access profile
- Sensitivity:
  -107 dBm (typ.) @ 850 / 900 MHz
  -106 dBm (typ.) @ 1800 / 1900 MHz
- Dimensions: 43.9 x 43.9 x 6.9 mm
- Weight: 20 grams
- Extended temperature range
  -30°C to +80°C (operational)
  -40°C to +90°C (storage temperature)
- RoHS compliant
- TCP/IP stack access via AT commands

Making machines talk.®

GM862-GPS

Modem







actual size

Telit wireless solutions

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Fax +39 040 4192 289
E-Mail: wireless.solutions@telit.com
www.telit.com

Telit Wireless Solutions Inc.
3131 RDU Center Drive, Suite 135
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Fax +1 888 846 9774 or +1 919 840 0327
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Tel. +82 2 368 4600
Fax +82 2 368 4606
E-Mail: TelitAPAC@telit.com
www.telit.com

Distributed by:

GPS receiver

- GPS power consumption: Operating current: 75 mA, including 20 mA for the antenna LNA
- High sensitivity for indoor reception, up to -159 dBm (with active antenna)
- Accuracy < 2.5 m
- Extremely fast TTFF's at low signal levels
- Hot start < 3 s
- Warm start < 35 s
- Cold start < 35 s
- 200,000+ effective correlators
- Supports 20-channel GPS, L1 1575.42 MHz
- GPS NMEA 0183 output format
- Data WGS-84
- Dedicated GPS AT commands
- SBAS (WAAS and EGNOS) support
- Low power consumption

Interfaces

- 50-pin Molex connector
- 13 I/O ports maximum
- Analog audio (balanced and unbalanced)
- 1 A/D converter, buzzer output
- ITU-T V.24 serial link through UART:
  - CMOS level
  - Baud rate from 300 to 115,200 bps
  - Autobauding from 2,400 to 57,600 bps
- 50 Ohm MMCX antenna connector
- On board SIM card holder, 1.8V / 3V with real-time detection

Audio

- Telephony, emergency call
- Half rate, full rate, enhanced full rate and adaptive multi rate voice codecs (HR, FR, EFR, AMR)
- Superior echo cancellation & noise reduction
- Handset & hands-free operations
- DTMF

Approvals

- Fully type approved conforming with R&TTE
- CE, GCF, FCC, PTCRB, IC, Anatel

SMS

- Point-to-point mobile originated and mobile terminated SMS
- Concatenated SMS supported
- SMS cell broadcast
- Text and PDU mode

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Subject to changes in technology, design and availability.
* Copyright © 1991-1995 by Stichting Mathematisch Centrum, Amsterdam, The Netherlands. All Rights Reserved.
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Copyright © 2001-2008 Python Software Foundation. All Rights Reserved.
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Circuit switched data transmission

- Asynchronous transparent circuit switched data (CSD) up to 14.4 kbps
- Asynchronous non-transparent CSD up to 9.6 kbps
- V.110

GPRS data

- GPRS class 10
- Mobile station class B
- Coding scheme 1 to 4
- PBCCH support

Fax

- Group 3, class 1

GSM supplementary

- Call forwarding
- Call barring
- Call waiting & call hold
- Advice of charge
- Calling line identification presentation (CLIP)
- Calling line identification restriction (CLIR)
- Unstructured supplementary services mobile originated data (USSD)
- Closed user group

Additional features

- SIM phonebook
- Fixed dialing number (FDN)
- Real-time clock
- Alarm management
- Battery management
- Network LED support
- IRA character set
- Jamming detection & report
- Embedded TCP/IP stack, including TCP, IP, UDP, SMTP and FTP protocols

Python* application resources

- Python* script interpreter (module takes the application code directly in the Python* language)
- Memory: 3 MB of NV memory for the user scripts and 1.2 MB RAM for the Python* engine usage
- Over-the-air application SW update
- IIC Bus and SPI Bus controlled in Python*

python

Telit's EASY features

- EASY SCAN® automatic scan over GSM frequencies (with or without SIM card)

Order-No.

GM862-GPS 3 990 250 689