A

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on

Design and Development of Embedded System for Vehicle Telematics

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by

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CERTIFICATE

This is to certify that the dissertation titled "**Design and Development of Embedded System for Vehicle Telematics**" is a bonafide record of work done by **Yamuna SV, Roll No. 2K13/VLS/26** at **Delhi Technological University** for partial fulfilment of the requirements for the degree of Master of Technology in VLSI and Embedded System Design. This project was carried out under my supervision and has not been submitted elsewhere, either in part or full, for the award of any other degree or diploma to the best of my knowledge and belief.

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ABSTRACT

Telematics is the convergence of telecommunications and information processing. Nowadays the term Telematics mostly refers to automation in automobiles, such as the invention of the emergency warning system for vehicles, GPS navigation, integrated hands-free cell phones, wireless safety communications and automatic driving assistance systems. The main applications of vehicle Telematics are *Vehicle Tracking* and *Fleet management*.

This project is aimed to design and develop a state-of-art embedded system for vehicle Telematics which shall perform vehicle tracking and provide driver assistance mechanism like adaptive headlight control during night time. The project involves the up gradation of existing hardware design, firmware development, testing and simulation of vehicle Telematics system. The hardware consists of TIVA series ARM Cortex M4 Microcontroller as the main processing unit. The on-board embedded system has a GPS antenna, a GPRS module, a CMOS digital camera and few sensors to monitor vehicle parameters like temperature, fuel, energy, AC, door etc.

In this project, a hardware prototype unit is realized. This work involves the development of application software for receiving, framing and transmitting GPS data along with sensor data. The application is developed in ‘C’ language. The Telematic prototype unit is tested for its performance. Successful GPS and other sensor data are received at a Laptop that is configured as server. These raw data are decoded and displayed at the receiving station. Algorithm for night time vehicle headlight detection using Artificial Neural Network (ANN) classifier has been simulated in MATLAB and results tabulated. This Telematic design is versatile, reliable and meets the required specifications.

KEYWORDS: GPS, GPRS, GNSS, GSM, computer vision, ADAS, RFID, TCP/IP, ANN, Vedic Neuron, LPF, Adaptive Threshold, OSI Model, GTS, SoC, CCD

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ABBREVIATIONS

GPS	Global Positioning System
GSM	Global System for Mobile Communication
GPRS	General Packet Radio Service
GNSS	Global Navigational Satellite System
ADAS	Automatic Driver Assistance System
LIDAR	Light Detection and Ranging
RFID	Radio Frequency Identification
AC	Air Conditioning
CMOS	Complementary Metal Oxide Semiconductor
ARM	Advanced RISC Machine
TCP/IP	Transfer Control Protocol/ Internet protocol
OSI	Open Systems Interface
SVM	Support Vector Machine
LPF	Low Pass Filter
GTS	Global Telematic System
SoC	System on Chip
CCD	Charge Coupled Device
SMS	Short Messaging Service
IMEI	International Mobile Equipment Identification
PC	Personal Computer
RAM	Random Access Memory
EEPROM	Electrically Erasable Read only Memory
USB	Universal Serial Bus
DC	Direct Current
SPI	Serial Peripheral Interface
I2C	Inter Integrated Communication
EMI/EMC	Electro Magnetic Interference and Electro Magnetic Conduction
SIAM	Society of Indian Automobile Manufacturers

IR	Infra Red
RF	Radio Frequency
LDR	Light Dependent Resistor
JPEG	Joint Photographic Experts Group
MIL-STD	Military Standard
MIPS	Million Instructions per Second
MSPS	Mega Samples per Second
UART	Universal Asynchronous Receiver Transmitter
ADC	Analog to Digital Converter
ALU	Arithmetic Logic Unit
FPU	Floating Point Unit
LED	Light Emitting Diode
RTA	Real Time Application
FR	Functional Requirement

CHAPTER 1

1 INTRODUCTION

Intelligent vehicles rule the modern day automation industry as they play a vital role in the safety and convenience of drivers and passengers. A Smart vehicle is one which has various intelligent sensing devices and control algorithms to assess the vehicle's environment. These also assist the driver in various ways. Today's world is a world of automation in all fields, therefore there's an increase in shift towards automation in Industries. By means of automation, tedious work which was earlier done by man is carried out by machines and that too at a faster rate. Therefore there's tendency to develop an intelligent operation.

Telematics is two way communication for data and information transfer from a vehicle by converging technologies like wireless communication, GPS and on-board electronics. This system integrates the information technology with the automobile electronics. Telematics has automated several operations in the modern age vehicles. Telematics is used for safety, security, vehicle status, remote vehicle operation and information services depending on the type of user. These Telematics systems are expected to operate successfully nationwide [1].

In the new generation cars, an advanced feature known as Advanced Driver Assistance system (ADAS) has emerged. All these additional features are achieved with camera, light detection and range (LIDAR), radar, ultrasound based systems [2] etc. Automatic dippers are a part of this ADAS which is a tool that automatically identifies an approaching vehicle in the night and dips the headlight of the vehicle in which it is installed.

This project is aimed to design and develop an effective vehicle Telematics system with sensors for GPS, Auto Dipper, Ignition status, Fuel status, AC status, Door status etc to meet the given specifications. The Telematic system is mainly aimed to provide the real time vehicle tracking. The embedded hardware consists of Global Positioning System (GPS)/General System for Mobile Communication (GSM) for real time vehicle tracking and few additional features such as Radio Frequency Identification (RFID) reader, Fuel sensor, temperature sensor, motion sensor, ignition sensor etc. For integrating Auto Dipper with the Telematic system, a novel technology for image capturing and processing using embedded hardware is proposed and simulated in MATLAB.

1.1 Motivation

With day-to-day development in vehicle automation, vehicular Telematic systems are getting more and more sophisticated. The value proposition for Telematic system varies depending on the end users as given below.

- To consumers
  - Safety & security
  - Time savings (navigation)
  - Increased productivity (in vehicle)
- To fleet provider
  - Optimization of assets (asset tracking, performance monitoring)
- To business
  - Additional data from vehicles (warranty, usage)
  - Increased vehicle sales (or “price of survival”)
- To government
  - Improved infrastructure management (traffic, tolls)

Companies have started hiring vehicle fleet system and there is a demand for this fleet management. It becomes very difficult to manage a fleet of vehicles manually and also costs lot of manpower. Moreover certain features like real time vehicle tracking may not be possible manually at times. In order to circumvent all these issues, automatic vehicle Telematic systems emerged. The fleet hirer is interested in details about the vehicle location, amount of fuel, condition of Air Conditioning (AC), driver details etc, in real time. These real time data helps the fleet hirer to manage and control a particular vehicle from a centralized location. Also, this system aids in preventing any misuse of vehicles and avoids accidents at night time.

Studies have shown that the accident rate is double at night-time as compared to that at daytime. Reduction of driver errors can be attributed to the development of vehicle automation and thus the major contributory factor for accidents is reduced [3]. During the past 10 years, safety has become as much of a selling point in the automotive market as fuel economy and performance. Presently, in India vehicle headlight dipping is carried out manually, which can be the cause of several accidents. Evaluation reports of Indian transport authorities have been explored for this purpose and a novel design for dipping the vehicle headlight at night time automatically has been suggested to overcome the shortcomings.

This thesis has been motivated by the above facts like real time fleet management and to reduce night time accidents and improve night driving.

1.2 Objective

A state-of-art embedded system which can cater for all the vehicular Telematics functionalities like real time vehicle tracking and monitoring, Auto Dipper mechanism, remote vehicle operation, vehicle health status has to be developed. To meet the above said requirements, a GPS/GSM based embedded system is developed with provision to interface a camera for real time Auto Dipper application has been proposed. The main objective of the Telematics system is to acquire GPS data, frame it in the prescribed protocol along with other sensor data (if any) and transmit it using GSM communication.

The data is transmitted using Transfer Control Protocol/ Internet protocol (TCP/IP) protocol. This transmitted data shall be captured by the server configured with the designated IP address. The server then processes the received data for real time display to the user. This system shall aim to provide the Indian customers with all the latest functionalities of vehicular Telematics including Auto Dippers.

The major task for the Auto Dipper design are fast identification & processing of head light to dip the headlight before it glares the oncoming vehicle driver’s eyes. Identifying and distinguishing head light from tail lights, street lights and other nuisance lights is a challenging task.

The main objective of this work is

- To upgrade the existing hardware design
- To develop a small, portable and rugged embedded system that shall carry out the vehicle tracking and fleet management functionalities.
- To simulate the image processing algorithm using MATLAB for night time vehicle headlight detection for Auto Dipper functionality of the Telematic system.

1.3 Scope of Work

In this work, the processing unit consists of TIVA series ARM Cortex M4 Microcontroller. A CMOS camera (from Omni vision) for image capture is used for sensing the oncoming vehicle's headlight. The camera shall be located in the front windshield of the vehicle. The image data is converted into useful data and necessary information is extracted from that for decision making.

The on-board embedded system has GPS module interfaced to the Microcontroller. For transmission through GPRS, a GSM SIM with a modem is used. Other functionalities like temperature sensing, fuel sensing, energy monitoring, angle and distance tracking, AC monitoring and door monitoring are part of Telematic system. The embedded system has hardware capability to perform other functionalities in addition to the location based services. These applications are out of scope of this work.

This work is mainly concentrated for two applications as given below

1. To upgrade the existing hardware design and develop an application for location services. **The hardware design up gradation is confined to power supply module, communication module and camera module**. The application software shall frame the data packet and transmit using TCP/IP protocol.
2. To **simulate** the image processing algorithm **in MATLAB for headlight detection** during night time.

The image obtained from the camera is preprocessed and analyzed using an efficient algorithm. This algorithm shall aid in reducing the background noise, refining the image, reject the reflected lights and thus correctly zeroes down to vehicle headlight. This algorithm uses Artificial Neural Network (ANN) classifier to classify the detected image based on several features.

Therefore this thesis work is focused on the design up gradation and development of Telematic system. Hence the project would be limited to development of Telematic system and a robust sensing and classifying algorithm for headlight detection at night time.

1.4 Resources

1.4.1 Software

Windows 7 is used as the operating system. A laptop loaded with MATLAB R2013a is used for simulation of the image processing algorithm. Following tool boxes of MATLAB were used for simulation

(a) Image Processing Tool Box

(b) Image Acquisition Tool Box

(c) Neural Network Tool Box

Application development is carried out in “C” language and testing is carried out using Teraterm 4.84 and HyperTerminal software.

1.4.2 Hardware

(a) A laptop with the following configuration was used

(1) AMD Athlon Dual core processor 1.90 GHz

(2) 1.5 GB RAM

(b) A camera with USB streaming facility was used (Nikon camera)

(c) Prototype unit with ARM Cortex TM4C1231

(d) USB to serial Adaptor for connecting board to system

(e) 12 volts Adaptor for power supply

1.5 Organization of Report

The report is organized as follows

Chapter -1 gives overall view of the project work including introduction, motivation, scope of work and objective.

Chapter-2 gives the details of literature reviews carried out in connection with the thesis. This chapter introduces the concept of Telematics and Digital Image Processing. The basic idea for image detection, segmentation and classification are discussed upon. Introduction to Vedic Neuron is given in this chapter. Image classification and training using ANN are discussed.

Chapter-3 The Design methodology is briefed in this section. The hardware modules are explained in detail.

Chapter-4 Software design is explained in this chapter. The functional software requirements and its design are discussed in detail. The device configuration and protocol for data transmission is also given. The Auto Dipper application for vehicle headlight detection at night time is explained in detail.

Chapter-5 Functional test results of Telematic system are tabulated. The MATLAB simulation results for image detection and classification for Auto dippers are discussed.

Chapter-6 This chapter deals with the conclusion from the interpreted results and explores the future work for this technology.

CHAPTER 2

2 LITERATURE REVIEW

2.1 Overview of Telematics

Telematics is a fast growing subject in the field of automation. A large market is anticipated due to the developments in automotive Vehicle Telematics. In recent years, traffic congestion has become a significant problem. Drives are supported at various instances by the growing technology depending on the vehicle or circumstances. There are several passive safety areas in which provisions for improvements are available, such as safer vehicle drive system which has automatic headlights and wipers and anti-collision system and vehicle-to-vehicle compatibility. Automotive industry is becoming more and more competitive as enhanced services in vehicle prove to b a lead for success. Telematics in the global market is anticipated to increase exponentially year by year. Also, from survey the following points have emerged

- Telematic enabled vehicles in use will be 50% by 2020.
- By 2025 there shall be appx 104 million cars with wireless

Penetration of integrated Telematics is to be driven by the growing importance of smart phones and regulations for driver safety [2]. From [2] it is clear that the evolution of automotive Telematics shall have four versions i.e. Telematics 1.0, 2.0, 3.0 & 4.0. Vehicular Telematics has been of interest in the recent years due to the developments in the high end vehicles packaged with more and more advance technologies for various applications. There are several research activities in this field. Especially for the Advanced Driver Assistance System (ADAS), lots of requirements are emerging day to day. So to keep up with the requirements, the researchers are coming up with new technologies in this field.

Vehicle tracking refers to monitoring the location, movements, status and behavior of a vehicle or fleet of vehicles. This whole process of tracking is achieved through a combination of a Global Positioning System (GPS) and General Packet Radio System (GPRS). The GPS belongs to Global Navigational Satellite System (GNSS). Onboard embedded Telematic system consists of a GPS receiver and a Global System for Mobile communication (GSM) modem installed in each vehicle. This device communicates with the user, (to dispatch, emergency or co-coordinate unit) and PC or web-based software. The received data is converted into information by management reporting tools and then displayed with a visual display on computerized mapping software.

The conceptual block diagram of a basic Telematic system is shown in figure 2.1. It consists of three modules

- Moving vehicle (onboard embedded system)
- Wireless Interface (GPS, GSM)
- Back office Systems

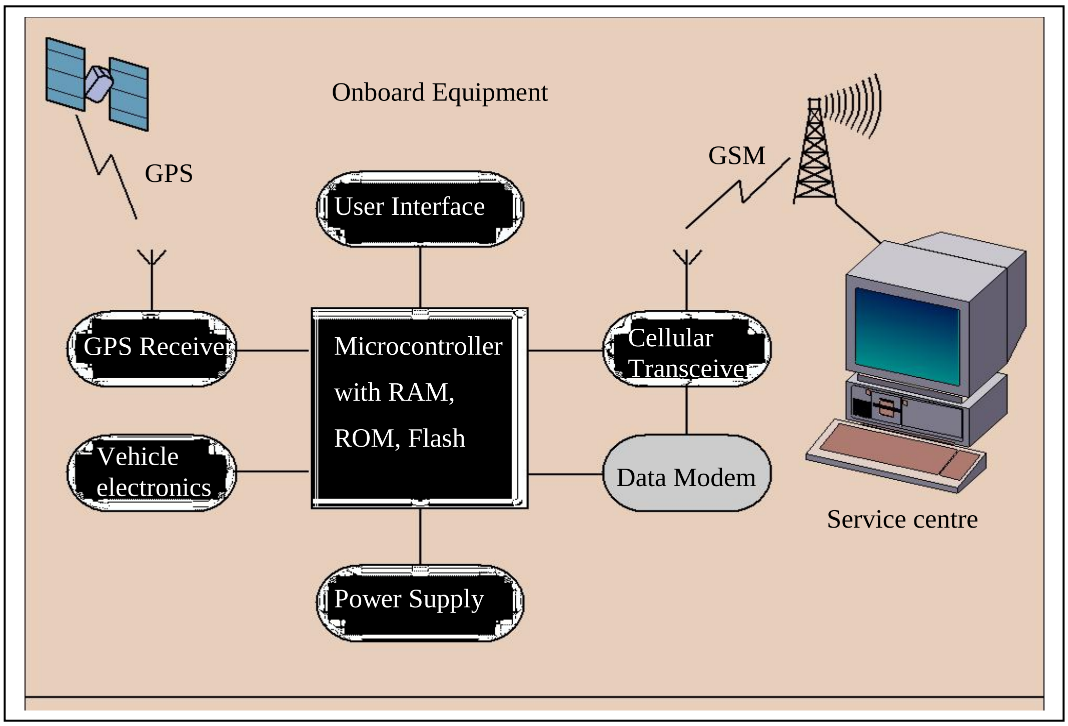

Fig. 2.1. Basic Telematic System [4]

The onboard embedded system communicates with GPS and Back office system (where a server station is located) through RF communication interface. It takes input from GPS through an inbuilt GPS receiver and packages it with other information from sensors and sends to service centre through GPRS communication via GSM mobile SIM. There may be various sensors in vehicle for monitor and health status of certain vehicle characteristics. The status information shall also be packaged into a single packet and sent to GSM module. A server at the back office shall receive this information and processes it.

2.1.1 Research in the field of Vehicle Telematics

In the article by "Yilin Zhao" titled "Telematics: Fun and Safe Driving", three standard Telematic protocols namely Application Communication Protocol (ACP), Global Automotive Telematics Standards (GATS) and the Motorola Emergency Messaging System (MEMS) are compared with respect to their performance parameters [4].

Integrated embedded system architecture for Vehicle Telematics (IVTIS) is proposed in [5], which concentrates on providing emergency call systems in addition to the standard existing Telematics operations like cruise control, antilock brake, climate control etc. The IVTIS provides infotainment in addition to the standard safety operations.

In this paper, the design consists of two modules, one is the communication interface and the other one is the onboard embedded system. The communication system is named as service and control station segment (SCS) which is a server equipped with wireless RF transceiver module. This module receives the data packets transmitted from the on-board embedded system. The onboard embedded system is known as mobile segment (MS), which is also equipped with wireless communication for receiving and transmitting packets through RF network. In general, all Telematic systems utilize TCP/IP network as shown in figure 2.2 for the on-board data transmission.

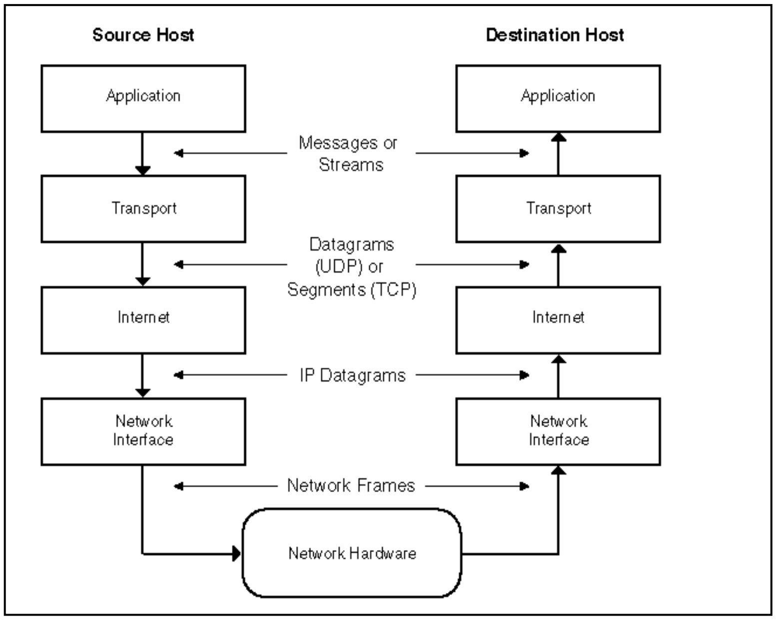

Fig. 2.2. TCP Layer for Communication

This paper proposes an embedded system built using a 32-bit MCU and uses Automatic Position Reporting System (APRS) for short range packet radio for a radius of 20km. This embedded system for Telematics has been proposed for surveillance applications with an inbuilt CCD camera. Though this design packaged more applications in a single device, the communication area was limited to 20km due to APRS packet radio.

In paper [6], a GPS/GSM based Vehicle tracking for Telematics has been proposed which can cater for long distance. A Global Positioning System module is used for giving the position information, navigation and providing timing information. It basically gives the following information such as

- Message transmission time
- Position at that instant of time.

A Global System for Mobile Communication (GSM) module is used for transmitting and receiving data through mobile network known as GPRS. General Packet Radio Service is a type of enhanced GSM wireless communication for higher data rates in 2G and 3G mobile communication. A typical GPS-GSM communication is shown in figure 2.3.

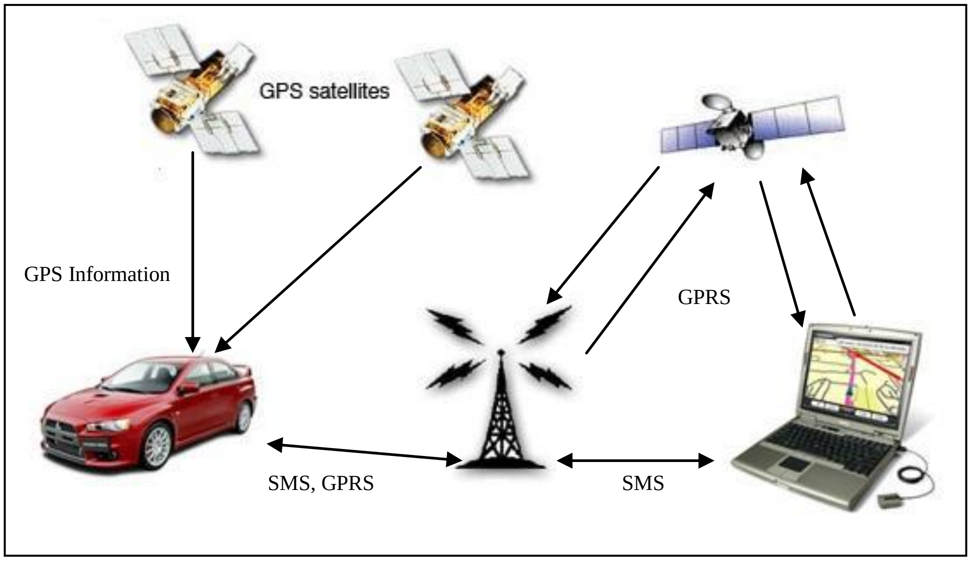

Fig. 2.3. Typical GPS-GSM Communication [8]

Several works on integrated GPS-GPRS Telematics have been reported in [7] [8] [9]. In the paper by El-Medany, W.; Al-Omary et al, the authors have proposed a real time tracking system which can provide accurate locations, speed and mileage of a vehicle. The main advantage of the system is its low cost. In this design GM862 cellular quad band is used for communication. A server to monitor is developed using Microsoft SQL Server 2003. For the users, a GUI (graphical user interface) is developed using ASP.net software for viewing the location information on a map.

In [8], a Telematic system based on GPS-GSM is proposed which is used for anti-theft alert system. The paper [9] by Le-Tien, T.; Vu Phung describes a Telematic system which is again based on the GPS-GSM. Apart from GPS data, the system utilizes compass sensor and Acceleration sensor for obtaining the moving direction of the vehicle. The system transmits information through SMS (Short Message Services) or GPRS service. The centralized server consists of a PC that supports GSM techniques-WMP100 from the Wavecom Company. The moving vehicle shall be traced on a google map in real time and displayed to user.

There are various researches in the field of Telematic RF communication protocol. In paper [10], a centralized open peer-to-peer framework Telematics has been proposed.

This architecture proposed a Global Telematics Protocol, by which an on-board embedded Telematic system can locate a Telematic service provider irrespective of its manufacturer. In this way, the architecture promises faster execution time and distributed load on a single server.

2.2 Overview to Auto Dippers

With the increasing technologies in advanced driver assistance system (ADAS), detection of vehicle headlight during night time has become simpler [11]. As mentioned in section 1.1, the rate of accidents is more during night time than in day time. From the statistics (carried out by Forbes) shown in figure 2.4, it can be seen that the road accident rate is more in India during 2013.

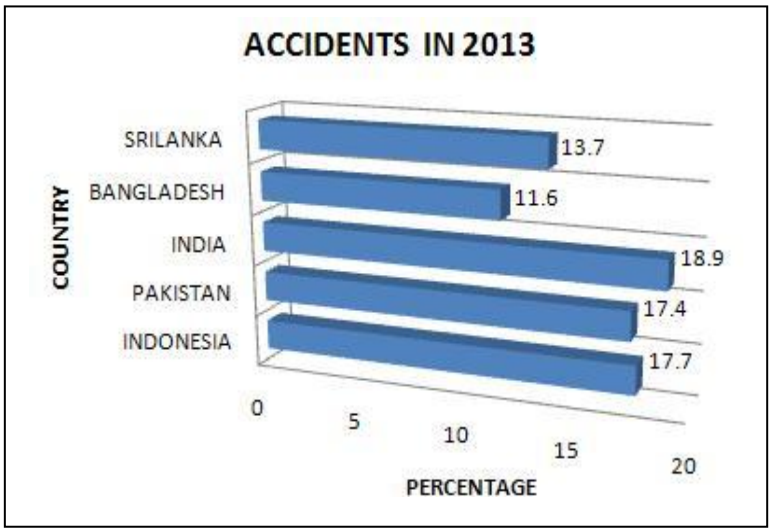

Fig. 2.4. Statistics for Night Time Road Accidents

This may be attributed to several reasons, the main being the driver's negligence. Most of the present day vehicle's come with a manual dipper scheme. The driver manually operates a lever to change from high beam to low beam. In case the driver doesn't dip the headlight, it may glare the eyes of the approaching vehicle driver and may cause accidents. Therefore, the best solution is to automate the dipper operation by sensing the oncoming vehicle at a particular distance.

Several automatic headlamp dimmer control systems have been proposed in various literatures but none of them are commercialized. Currently commercialized two important systems are:

- Vehicle lamp control developed by Gentex Corporation. It is a system for automatically controlling vehicle headlamps which includes an image sensor and a controller to generate headlamp control signals [12].
- Adaptive Headlight Control (AHC) developed by Mobileye. To perform AHC, Mobileye uses an image grabber and detailed analysis of light sources appearing in the image [13].

There are not many features at night time as compared to daytime scenario, which poses difficulty in identifying a vehicle. Moreover at night time only the vehicle's headlight or taillight are perceived and not the whole vehicle object. Only a camera based approach is more reliable in case of detection of oncoming and preceding vehicles. The main challenge of this approach is to distinguish these lights from reflections due to infrastructure elements, street lights, and other illuminated bodies in the road.

This work is aimed to propose an effective automatic control (auto dipper) of the vehicle head lights under night time which shall meet Indian road standards. A novel technology for image capturing and processing using camera based embedded hardware solution has been proposed.

2.2.1 Research in the field of Auto Dippers

Different countries transport department has laid down various regulations on the vehicle headlight emission intensity, which varies with the angle of incidence [14]. In India, the adaptation of Auto Dippers in commercial vehicles is not permitted as per the Central Motor Vehicle Rules in 1989 [15]. It was further confirmed after extensive study and demonstrations by Society of Indian Automobile Manufacturers (SIAM) in September 2001, which reported that the automatic dipping systems may not be safe [16]. The report from Department of Transportation (National Highway Traffic Safety Administration) [17] suggested that if manual dipping is not reliable then automatically dipping the headlight may be the best solution to avoid accidents and reduce glare due to headlight at night. National Research Development Corporation (NRDC), a Government of India Enterprise, has been evaluating Auto Dippers [18]. These reports considered the Indian road condition during that period when there were few four wheelers and the lighting conditions were different in rural and urban areas compared to other parts of the world and also the cost.

The main challenge in the design of an auto dipper is the vehicle detection technique. Headlight detection during night time is achieved using various algorithms. Most researchers have followed similar concepts for image preprocessing (thresholding) and detecting. Only the variations are in the classification part, to name a few like artificial neural network classifiers, ADA boost classifiers and Support Vector Machine (SVM) classifiers etc. These detection techniques have to be fast in order to enable real time decision making.

2.3 Overview of Digital Image Processing

The digital image processing comprises of basically two main steps [19] mentioned as follows

- Image Preprocessing
- Image Analysis

2.3.1 Image Preprocessing

Image Preprocessing is a first step in image processing which takes an image as input and gives an image output. It is done to remove unwanted noise present in the image. There are several types of preprocessing which are mentioned below

- Scaling
- Look Up Table
- Red Eye Reduction
- Image enhancement
    - Histogram equalization
    - Noise removal using a Weiner filter

    - Median Filtering
    - Unsharp mask filtering
    - Linear contrast adjustment
    - Decorrelation Stretch
    - Filtering with operators known as morphological operators
- Color Temperature
- Changing contrast
- Image Reduction

2.3.2 Image Analysis

This process takes an image as input and gives measurements as output. This is a data reduction process. Few image analysis process are given below

- Segmentation
- Simple Intensity thresholding
- Spot Detection
- Edge Detection
- Watershed Calculation

Image Segmentation is a process of grouping pixels which share certain common features. Before grouping a label is assigned to every pixel in an image. The pixels of a particular region shall be similar in certain characteristics such as texture, shape, intensity and color.

Image Thresholding is the simplest method of image segmentation. A gray scale image is converted into a binary image based on the threshold level that is fixed known as binarization. In thresholding, we have an object and a background so that all the pixels of the image fall either into the object category or background category based on the threshold value. Types of thresholding

- Global
- Local
- Adaptive/Dynamic

To understand the concept of thresholding, let us consider a function f(x,y).

- If T is a function of f(x,y) then it is Global Thresholding. The threshold value is held constant for the whole of the image. Represented as

$$g(x,y) = \begin{cases} 0 & f(x,y) < T \\ 1 & f(x,y) >= T \end{cases}$$

- If T is a function f(x,y) as well as p(x,y) where p(x,y) is some local properties function

  This is known as Local Thresholding

- If T is dependent on the co-ordinates of (x,y), then it is Adaptive/Dynamic thresholding.

  Adaptive thresholding is a form of image segmentation wherein the threshold value is not fixed as opposed to optimum thresholding where the threshold value is fixed. Optimum thresholding doesn't support advanced segmentation process. Several methods for adaptive thresholding are discussed in [20].

Few popular methods for thresholding are as follows

- Maximum Entropy method
- Otsu's Method
- K-means Clustering

Otsu Thresholding is a very old and simplest method of thresholding which is in use even now. Otsu proposed the selection of a threshold value that aims to minimize the variance within a group and maximize the inter group variance. But it is mainly applicable for uniformly illuminated images as it works on the histograms assuming that they are bimodal.

2.4 Vehicle Detection at night time

2.4.1 Light Source

There are two kinds of light source namely, the one that emits light and the other that reflects light. In case of automobiles both are combined together. In automobile the primary source is the filament of the electric lamp and the secondary source is the reflector. Present day headlights are outcome of a lot of research and development [21] [22] [23]. The light sources that are usually used in vehicle head lamps are as follows

- Tungsten lamps
- Halogen lamps
- HID- High Intensity Discharge lamps (xenon lamps)
- LED lamps

All these light sources differ in their intensities. The headlamp with HID light source produces between 2,800 and 3,500 lumens and doesn't use any filament. The headlamp with halogen bulbs uses filament and produces between 700 and 2,100 lumens [21]. Therefore, the HID headlamps have greater intensity than halogen headlamps and thus are becoming more common.

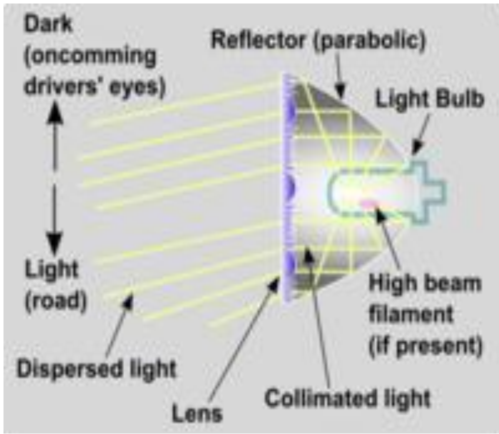

Fig. 2.5. Lens [21]

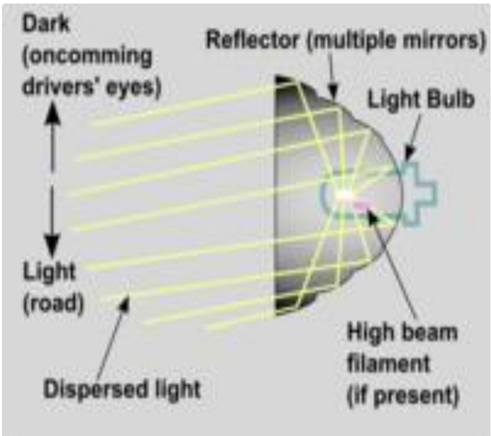

Fig. 2.6. Reflector Optics [21]

Main difficulty shall be in distinguishing the light emitted by other vehicles from reflections coming from infrastructure elements such as traffic signs, fences, poles etc. Light sense can be achieved by appearance and motion analysis using any of the following

1. IR sensor
2. Camera (monochrome)
3. Vision Sensor
4. CMOS Image Sensor
5. Light sensor
6. LDR (Light dependent resistor)
7. CCD Camera
8. Vision chips

Various research works have been carried out in the past to study the effect of glare due to oncoming vehicles [24]. Earlier work on headlight intensity control [25]-[28] focuses on the control system and the design of a smart controller using fuzzy logic. Some of the patents that reflect developments in this area are given in [29]-[31].

Once a light is sensed, the Auto Dipper system shall ascertain the source of light. Various factors affect in detection of vehicle lighting. Several algorithms were devised in determining the vehicle's headlight [32-41]. Few methods are

- Edge Detection algorithm using Neural Network [32]
- Thesholding [34]
- Adaptive Thresholding [35]
- Classifier based analysis[36],
- Real Adaboost Algorithm [36]
- Temporal coherence analysis [37]
- Mixture of sonar & vision information [38]
- Stereo Vision [39]
- Taillights used for computing an approximate trajectory [40]
- Morphological analysis [41]

In vehicles the high beam and low beam shall extend to a distance of 70m and 25m approximately as shown in figure 2.7.

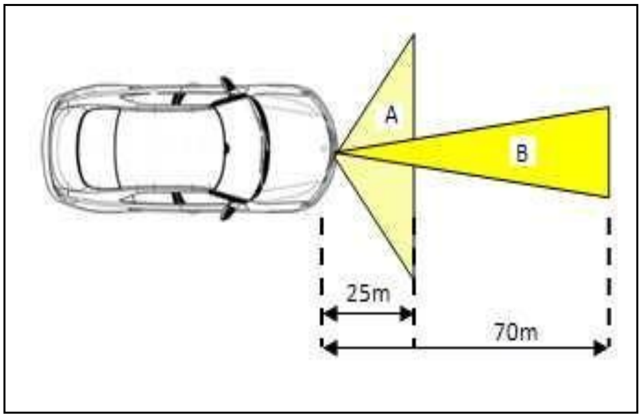

Fig. 2.7. High and Low Beam of Vehicle

2.5 Vehicle Classification using Vedic Neuron

2.5.1 Introduction to Vedic Neuron

Artificial neural networks (ANN) consist of massively parallel network and require parallel architecture for high speed operations in real time applications. The nonlinear (McCulloch) model of neuron is as shown in figure 2.8. The artificial neural networks are used for a number of applications including pattern recognition, classification, identification, GPS systems, speech, vision, and control systems.

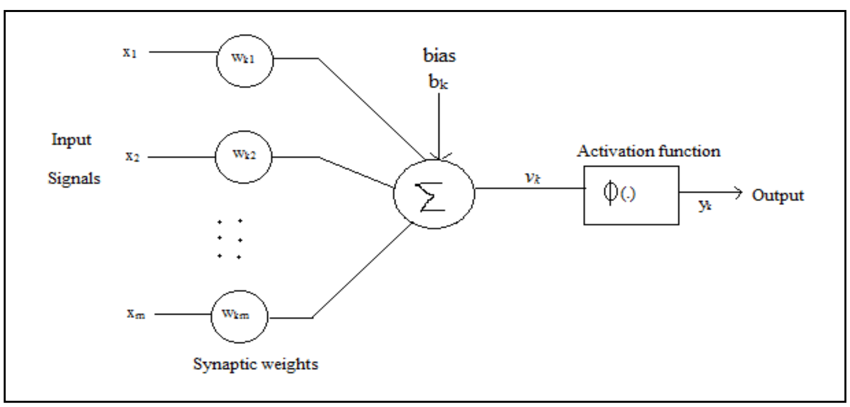

Fig. 2.8. Nonlinear model of Neuron

Vedic mathematics is a collection of arithmetic rules that allow more efficient speed implementation. The use of Vedic mathematics lies in the fact that it reduces the typical calculations in conventional mathematics into very simple one and reduces the computation time. This is because the Vedic formulae are claimed to be based on the natural principles on which the human mind works.

In [42], a novel scheme to combine these two technologies, namely ANN & Vedic maths, to achieve a high performance neuron has been proposed. The conventional multiplier which is used to multiply the input with weight in an ANN is replaced with Urdhva-Tiryagbhyam Vedic multiplier.

The neuron implemented using Vedic mathematics is known as **Vedic neuron**. In this paper, the speed of Vedic Neuron is compared with conventional Neuron and it was found that Vedic Neuron is 30% faster than its counterpart. A block diagram of the implemented Vedic Neuron is presented in figure 2.9.

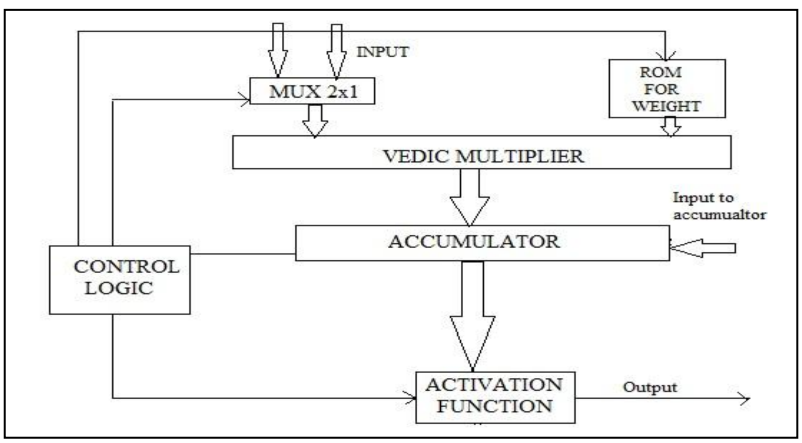

Fig. 2.9. Vedic Neuron Hardware Implementation [42]

ANN implemented using Vedic Neuron will classify objects at much faster rate compared to conventional ANN classifiers. A structure of ANN used for classification is shown in figure 2.8. It consists of the following

- Input layer
- Hidden layer
- Output layer

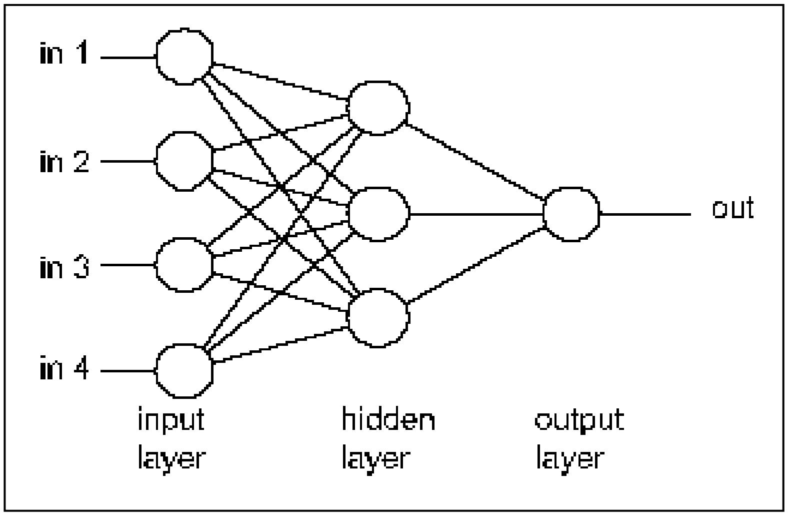

Fig. 2.10. Artificial Neural Network [45]

Input layer reads the input data, multiplies it with some weight vector. The weighted input is given to an activation function. The hidden layer gets data from the

input layer and provides data to the output layer. The output layer gives the final output of the network. There are several ANN architectures out of which the back propagation neural network is the most widely used [43]. Based on the structure, ANN is categorized into

- Multilayer feed forward (MLF) networks,
- Self organization feature map (SOFM), and
- Adaptive resonance theory (ART).

Out the above network, the MLF network is the most widely used network.

2.5.2 Image Classification using Vedic Neuron

The digital image classification consists of three steps as given below

- Training phase
- Classification phase
- Output phase

The main aim of classification is to sort observations into two or more classes that shall be labeled. Deriving a rule that can be used to optimally assign new objects to the labeled classes is the emphasis of classification. The given examples together with their classifications are known as the training set and future cases form the test set. There are two types of training techniques, namely supervised and unsupervised training.

In supervised training, the target output is known [44]. The ANN output is compared with desired target. If there's error between actual and desired output, then the correction is applied to the network's input as feedback to adjust its weight so as to come closer to the desired output. Several iterations are performed to match the actual output with the desired output. In unsupervised training, the target output is unknown [44]. Therefore, the ANN discovers features, patterns or categories by itself from the input data.

Several papers proposed the automatic dipping of headlight for instances when there's an oncoming vehicle or a tail light detected of the preceding vehicle as shown in figure 2.11.

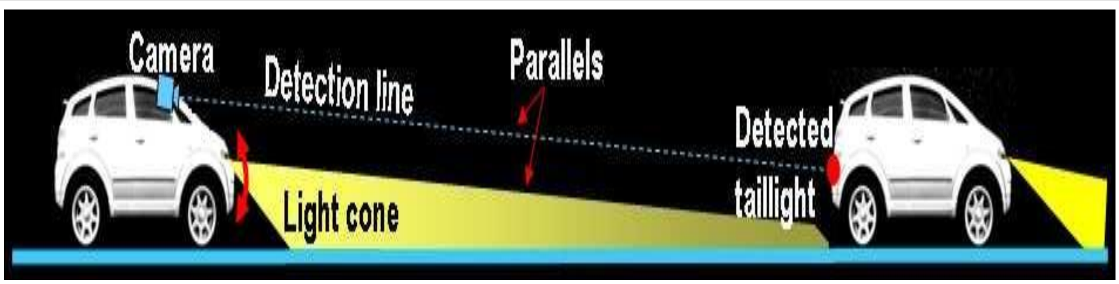

Fig. 2.11. Concept of Auto Dipper

In the paper by M. Daigavane, Preeti R. Bajaj, M.B. Daigavane [45], vehicle detection using segmentation, blob detection and classification (based on artificial neural network) is discussed. Back propagation algorithm with multilayer feed forward network is used for vehicle classification. But it has limitation in detection if traffic is high. A similar design approach for headlight detection is proposed but with a black and white camera for cost reduction and better results. Still this idea needs to be improved for accuracy.

2.6 Applications of Telematic System

Vehicle Telematics is used for the following

- Increase Productivity
- Reduce Labor Costs
- Control Fuel Costs
- Improve Customer Service
- Increase Fleet Safety and Security
- Reduce Operating Expenses
- Reduce Unauthorized Vehicle Use

Also known as GPS Fleet Telematics, the system is a way of monitoring the location, movements, behavior and status of a vehicle or fleet of vehicles. For fleet management, Telematics is used for the following

- Fleet Performance (Maintenance Management)
- Fleet Tracking (Assets Management, vehicle tracking, usage monitoring)
- Fleet Utilization (Customer processing, instant messaging, job dispatching)

This is achieved through a combination of an electronic GSM device and a GPS receiver installed in each vehicle, which then communicates with the user. Also this communicates with web-based software.

CHAPTER 3

3 DESIGN METHODOLOGY

The design methodology is aimed to meet the following

1. To upgrade the existing hardware design and develop an application for location services. The hardware design up gradation is confined to power supply module, communication module and camera module. The application software shall frame the data packet and transmit using TCP/IP protocol.
2. To simulate the image processing algorithm in MATLAB for headlight detection during night time.

To achieve the above two applications, the design is categorized as hardware design and software design. In the hardware design, the following modules are upgraded in the existing hardware design which consists of a main Microcontroller and other peripherals, whose design details are given in the following section.

- Power supply module
- Communication module
- Camera Module

In this project, a hardware prototype unit is realized. This work involves the development of application software for the following

- Power on built in self test (PBIT)
- Receiving, framing and transmitting GPS data along with few sensor data.

The application is developed in ‘C’ language. The Telematic prototype unit is tested for its performance. On power up, the unit shall execute the power on built in test which shall test the critical hardware components which are required for the proper execution for the Telematic application. Algorithm for night time vehicle headlight detection using Artificial Neural Network (ANN) classifier has been simulated in MATLAB and results tabulated.

3.1 Hardware Details

The system is powered from the voltage (12VDC) provided by the On-Board power supply of the vehicle. This 12VDC supply is stepped down using DC-DC converters with filter to power the digital circuits inside the unit. A 32-bit Microcontroller ARM TM4C1231 from Texas instrument is incorporated in the design as smart chip which will be interfaced with various peripherals to perform the task. An External Flash memory from Spansion of 1 GB shall be used for storing the packets and will be accessed when required. This external flash memory is interfaced with Microcontroller through serial communication bus i.e. Serial Peripheral Interface (SPI). A motion sensor is used to sense acceleration which is also interfaced with the Microcontroller. A block diagram of the Telematic system design is shown in figure 3.1

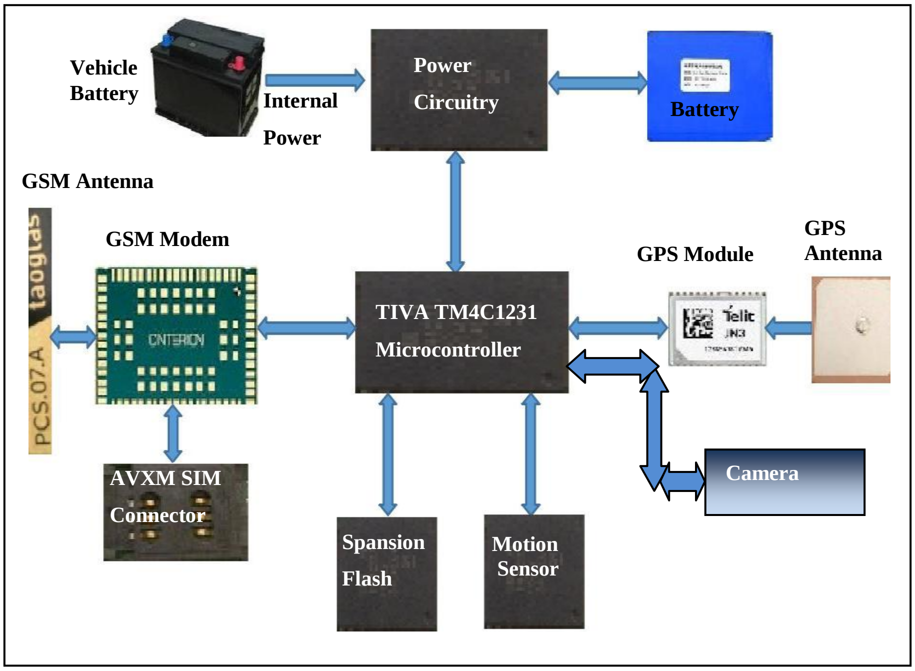

Fig. 3.1. Block diagram of Telematic System

The system has provision for taking analog, discrete and digital input and output signals. An infrared CMOS Serial JPEG Taxi Camera for Car system is interfaced with the Microcontroller through serial link. The camera has a resolution of 640*480 pixels. It uses the Omni vision OV528 high definition CMOS camera chip for image capture. The camera shall be mounted near the dashboard of the car.

3.2 Power Supply Design

This power supply module supplies power for MCU, Camera and Memory modules. The GPS and GPRS modules are sourced from a different power supply. The power-conditioning modules are capable of deriving the voltages required for proper functioning of the electronics from a single input of 12 V DC with 1.2 Amps to source power to MCU, Camera and Memory modules. The power requirements for the Telematic system are given in tables 3.1 and 3.2.

Description	**Input Voltage (V)**		**Output voltages (V)**	**Current (A)**
Requirements	12V (min)	15V (max)	5V, 3.3V	1A
Designed	12V (min)	30V (max)	5V, 3.3V (40mVpp ripple voltage)	2A (50mA ripple current)

Table 3.1 Voltage and Current Requirements

Description	**Power consumption(W) at 3.3V**		**Power consumption(W) at 5V**		**Power consumption (W) at 12V**		**Total Power (W)**	
	Min	Max	Min	Max	Min	Max	Min	Max
MCU, Camera, Memory	0	0.2	0.2	0.8	-	-	0.2	1

Table 3.2 Power Requirements

The power supply module complies with MIL-STD-461 specifications. The module also incorporates necessary EMI/EMC filters. DC to DC converters are used to derive the +5V and +3.3V voltages. The block diagram of the Power-conditioning Design is as shown in figure 3.2.

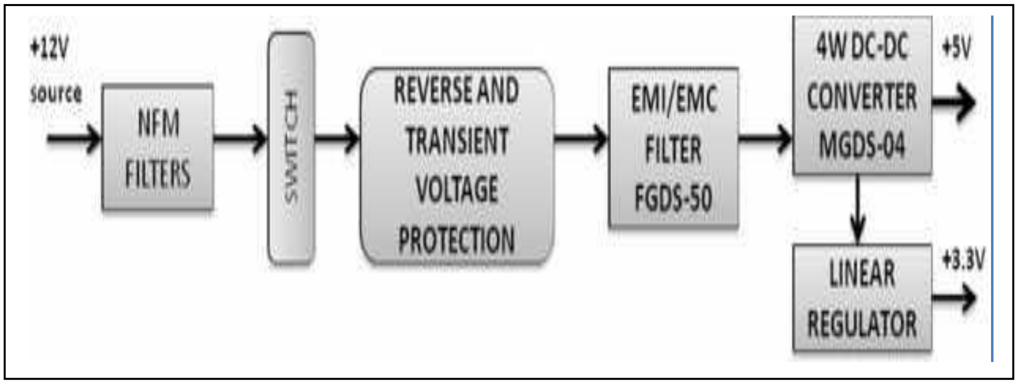

Fig. 3.2. Power Supply Module

The modules have the following capability

- soft-start
- permanent short circuit protection
- overvoltage protection for output voltage to ensure efficient module protections

The soft-start feature limits the inrush of currents during power up and also limits the current flow, thus protecting the further circuitry. The module is completely protected against short circuit of any duration by a shut-down and restores to normal when the overload is removed.

3.2.1 Input Filter Section

Power conditioning design incorporates NFM filter [46] as shown in figure 3.3 for Initial EMI/EMC filtering on supply lines. These filters protect the system from unwanted interference in the supply line that is generated from other devices at the initial level.

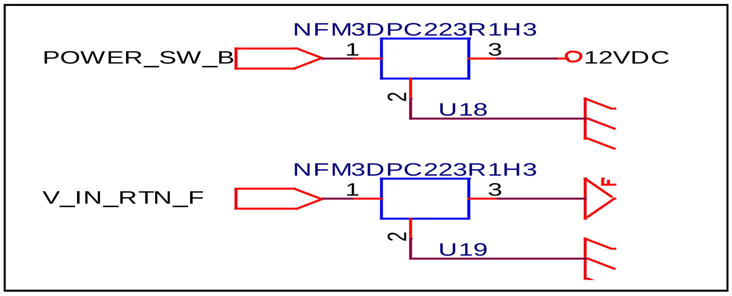

Fig. 3.3. Power supply Input Filter Schematic

3.2.2 DC –DC Converter Module

The datasheet of GAIA Converter filter module FGDS-2A-50V [48] details that the module has the capability to provide Electromagnetic Interferences (EMI) requirements. A Schottky diode is provided for reverse voltage protection and bidirectional transorb [47] type SMBJ45 is provided at the input for transient protection before connecting the source to a GAIA EMI/EMC filter module as shown in figure 3.4. A high performance and low profile DC/DC power modules MGDS-10 [49] is connected in series with FGDS-50 to derive 5V from 12V source input and supply a current of 2A. No external heat sink is required for the MGDS-10 series to supply 10W output power over the case temperature range of -40°C up to 105°C.

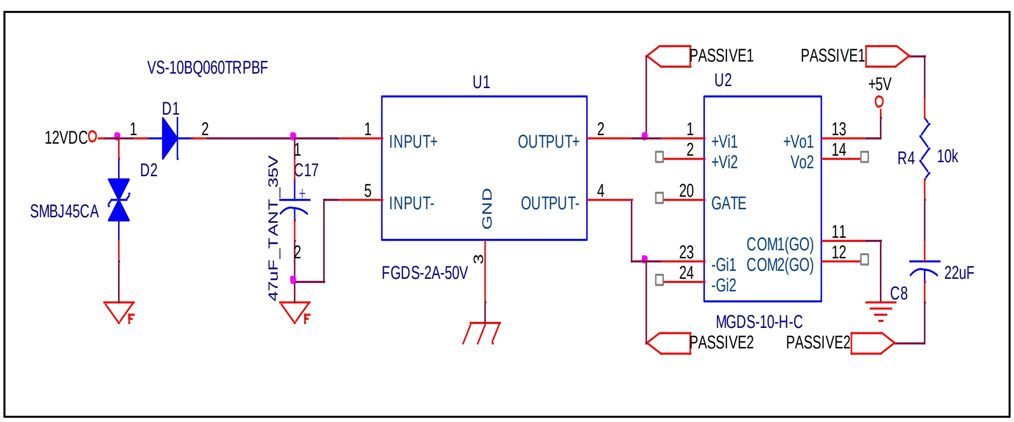

Fig. 3.4. DC-DC Converter Schematic

The 12VDC supply from the external DC supply is provided to the EMI Filter, which gives the filtered 12VDC output to the DC/DC module, with reduced input line reflected ripple current. The module is also compatible with an external reverse input polarity protection connected to its input to safeguard against any reversal for power supply connectors.

3.2.3 Regulator Module

For generation of +3.3 V supply from 5V, TC1262-3.3V regulator IC is used. Figure 3.5 shows the schematic for voltage down conversion.

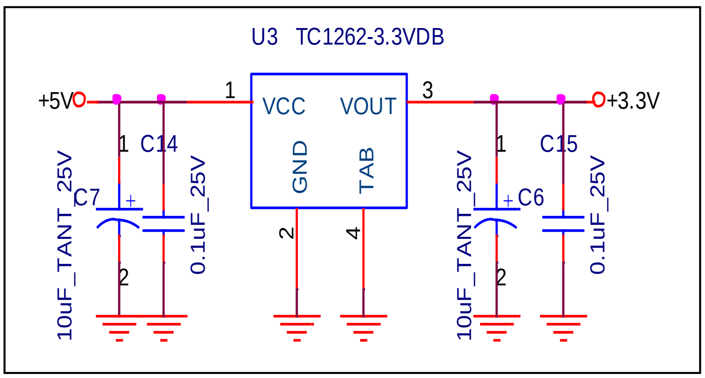

Fig. 3.5. Linear Regulator Schematic

3.3 IO Signals and Communication Interface Design

External sensors like temperature sensor, fuel sensor, image sensor are interfaced with the high performance 32-bit MCU TM4C1231 to carry out the processing of sensor data and execute the intended operation. Most of the interfaces are through serial communication with the Microcontroller.

3.3.1 Discrete Input Interface

Panic button switch and ignition switch discrete inputs are pulled up to 3.3V and these are interfaced to microcontroller through a optocoupler. When user presses the membrane switch, corresponding signals are connected to ground. Microcontroller processes the respective switch status and executes the required action.

3.3.2 Analog Input Interface

There is provision for a single analog input in the system. ADC is available as internal or external add-on peripheral to the microcontroller. DC voltages like 5V and 3.3V from the DC-DC converters are acquired continuously as analog input for monitoring the power supply status of the system. Voltage monitoring also aids the self test of the unit. These voltages are fed to the ADC inputs of the Microcontroller through ADC input port.

3.3.3 Communication Interface

To communicate with external systems, an RS232 interface supporting baud rate from 9600 to 115200 bits/sec is provided. RS-232 signals are routed from connector to Transceiver before interfacing as shown in figure 3.6 with microcontroller's UART. Optically isolated RS422 receiver supports data rates up to 10Mbps.

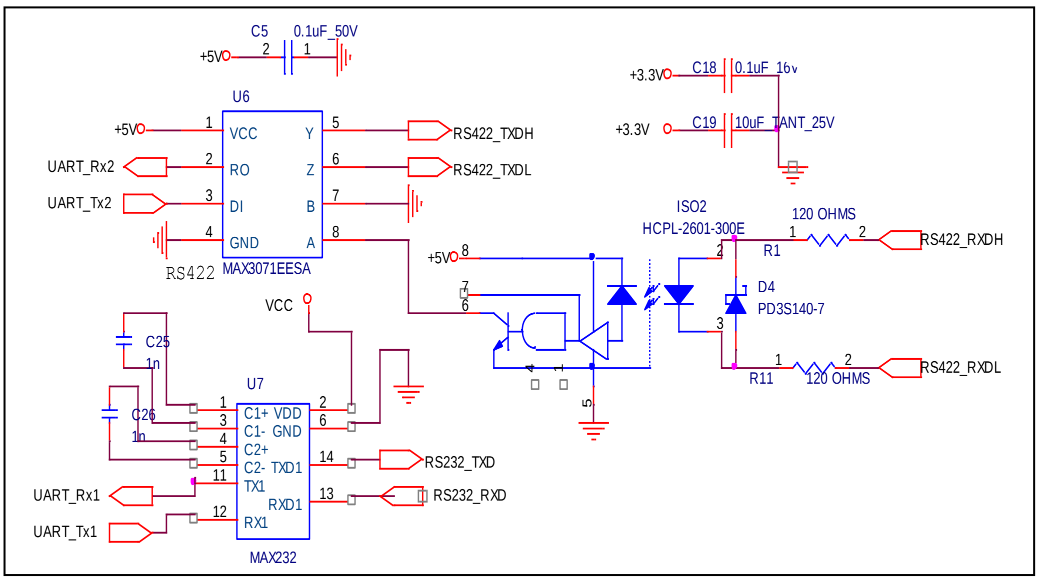

Fig. 3.6. UART Interface Schematic

3.4 Camera Interface Design

For the purpose of Auto Dipper, a serial bus camera system from Omni Vision (OV528) [51] is used. This single chip camera system performs as a video camera or a JPEG compressed still camera. The camera is interfaced to the MCU through serial communication interface. The Camera-to-Serial Bridge, is a low cost, single-chip & low-powered solution for high resolution serial bus. There is no additional DRAM required. The Serial Camera Control Bus is used to achieve greater flexibility in camera interface. A block diagram of the camera chip interface is shown in figure 3.7.

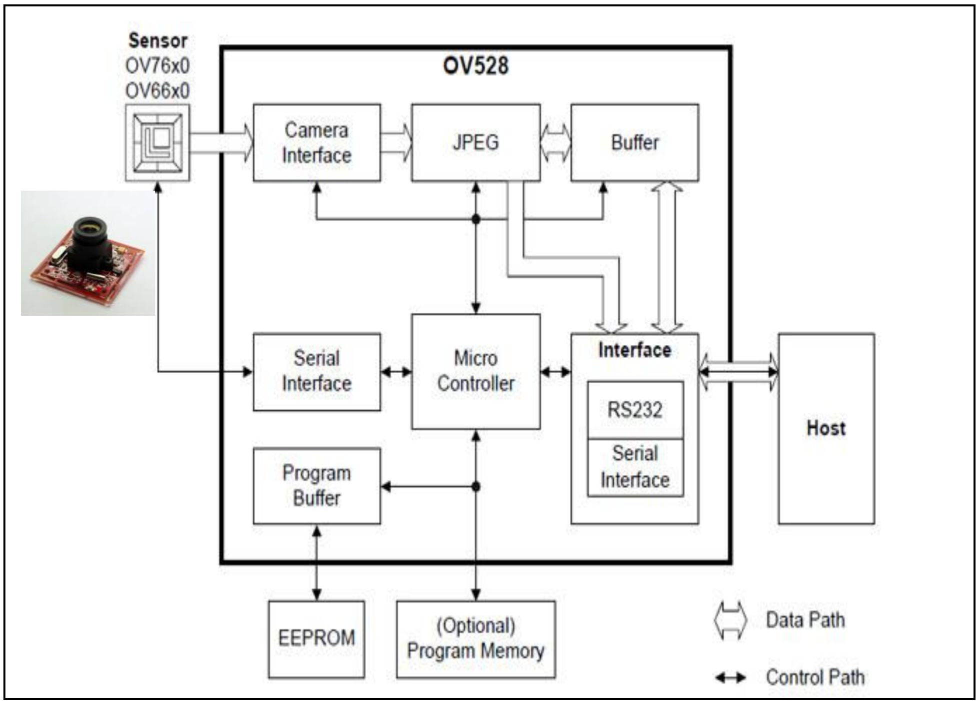

Fig. 3.7. Camera OV528 Chip Interface [51]

The OV528 takes 8-bit YC_bC_r 422 progressive video data from the OV7725 Camera Chip. The camera interface synchronizes with input video data. Then it performs operations such as down-sampling, clamping and windowing functions with desired resolution through serial bus host commands. The JPEG with the variable quality settings can achieve higher compression ratio & better image quality for various image resolutions. The circuit for Auto Dipper is shown in figure 3.8. & figure 3.9.shows the schematic diagram of the same.

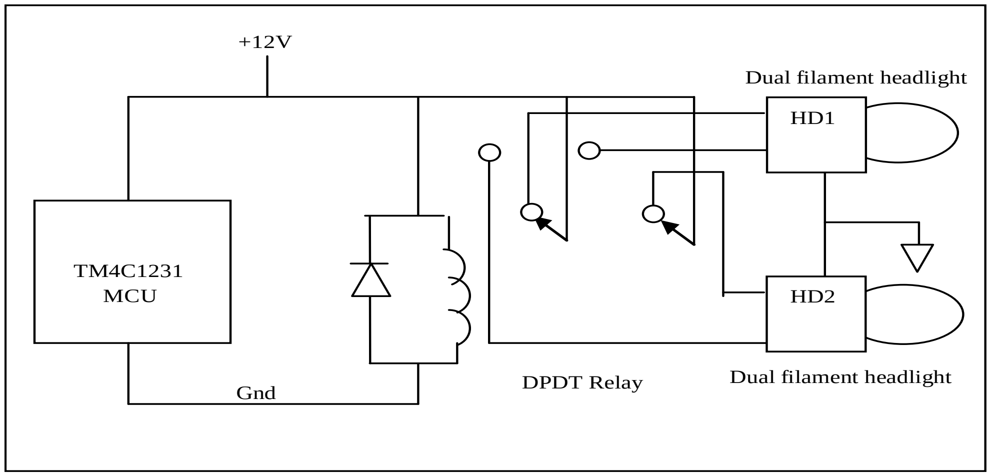

Fig.3.8. Auto Dipper Circuit

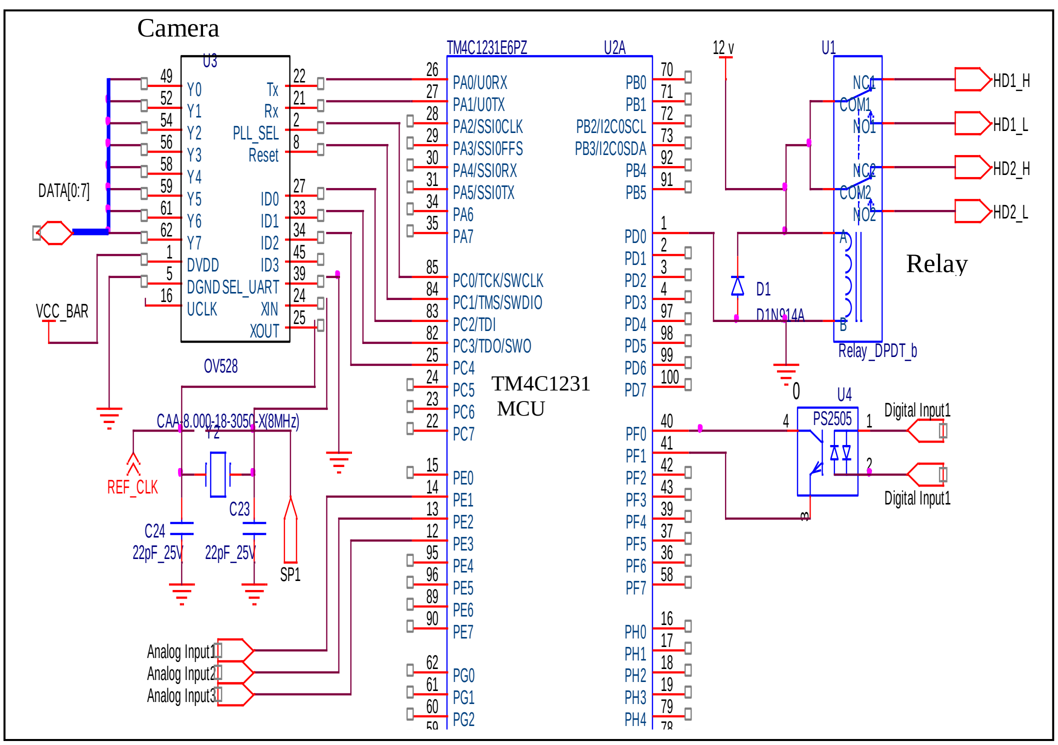

Fig. 3.9. Camera Interface Schematic

3.5 Existing Hardware Design

3.5.1 Microcontroller Design

The core of this embedded system is a high performance 32 bit ARM Microcontroller (TM4C1231) from Texas Instrument which is used for all the processing of input output signals. This MCU is selected because of the following reasons

- Specifically made to suit all the automotive industry applications.
- Supports mixed signal applications
- Supports wireless connectivity application making it suitable for GSM communication
- Low power
- Low cost
- Has 8 UARTs to interface GPS, GSM, camera and other sensor modules
- Provides free software package that includes graphics library, peripheral driver library and USB library.

Key highlights

- ARM Cortex-M4 with floating point
- CPU speed up to 80 MHz
- Up to 256-KB Flash
- 32KB single-cycle SRAM and 2KB EEPROM
- Two high-speed 12-bit ADCs up to1 MSPS
- Up to two CAN 2.0 A/B controllers
- Optional full-speed USB 2.0 OTG/Host/Device
- Up to 40 Pulse Width Modulator outputs
- Serial communication: UART – 8 channels, I2C – 6 channels, SPI-4channels
- Intelligent low-power design power consumption as low as 1.6 µA

The TM4C1231 MCUs provide a broad portfolio of connected Cortex M4 microcontrollers [50]. In figure 3.10, the internal architecture of TM4C1231 MCU is given. Further to the above mentioned advantages, the key highlights of MCU are listed below.

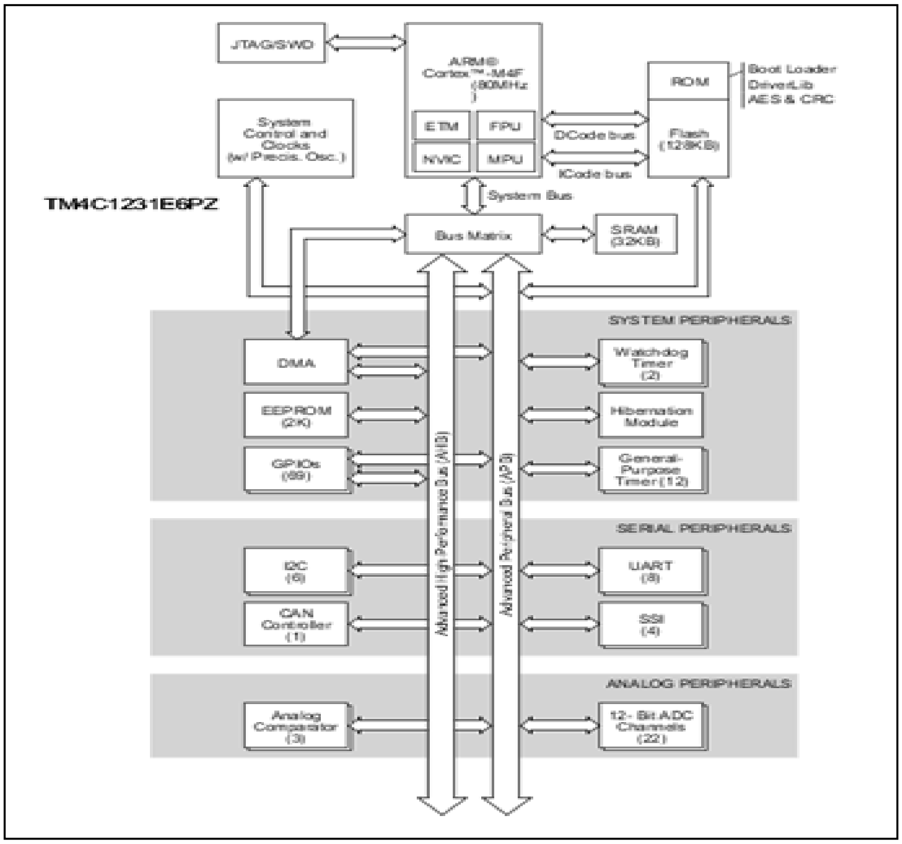

Fig. 3.10. Internal Architecture of Microcontroller TM4C1231 [50]

Texas TM4C1231 carries out the following functions

- Communicating on RS-232 Protocol with other external sensors
- Processing the data and transmit the data to GPRS communication
- Processing the user configurable features
- Implementing self test and monitor the health of all peripherals connected to it.
- Acquire and process the data and implement necessary algorithms for output.
- Communicate with Flash to store and retrieve data.

3.5.2 Memory Interface

Apart from the inbuilt memory of the Microcontroller, there's an external Flash memory. This flash memory is used to store the packet data in case of failure of GSM communication. Flash memory from Spansion [52] is a smart memory device that is divided into several blocks. These blocks can be erased independently. This enables to preserve valid data while old data is erased. The memory has inbuilt error correction codes which ensures data integrity. The internal block diagram of a NAND flash is as shown in figure 3.11.

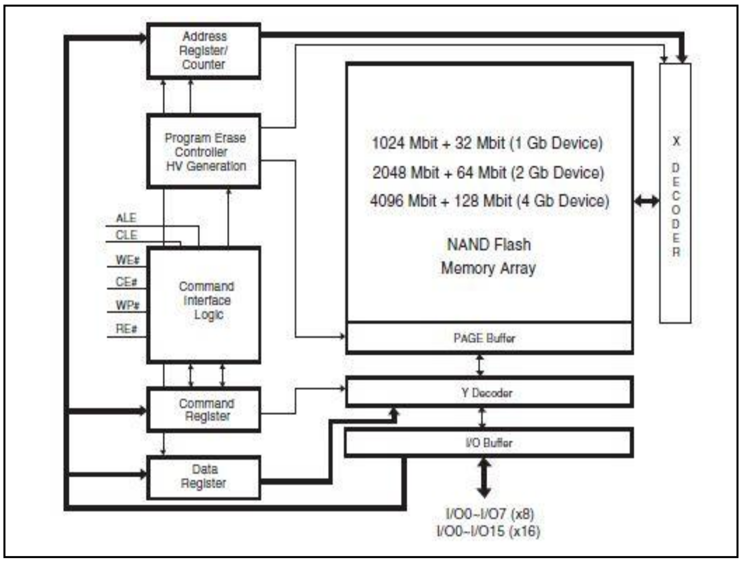

Fig. 3.11. NAND Flash Memory [52]

3.6 Connector

A single 14-pin D-sub connector is used for all input and output signals. Connector is compact and offers excellent strength to weight ratio as they are 50% lighter than typical metal connectors.

The connector pin orientation top view is shown in figure 3.12 and the numbers are shown in the side view of the connector figure 3.13.

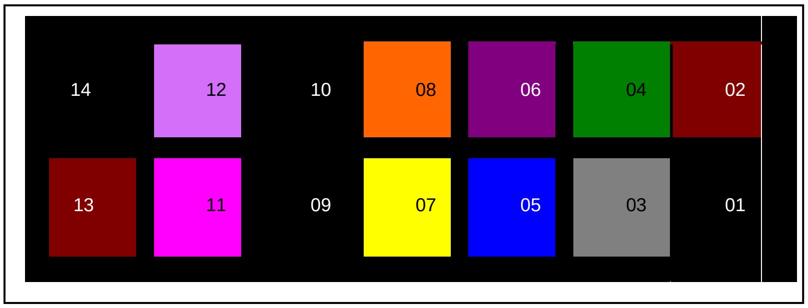

Fig. 3.12. Connector Pin Orientation - Top View

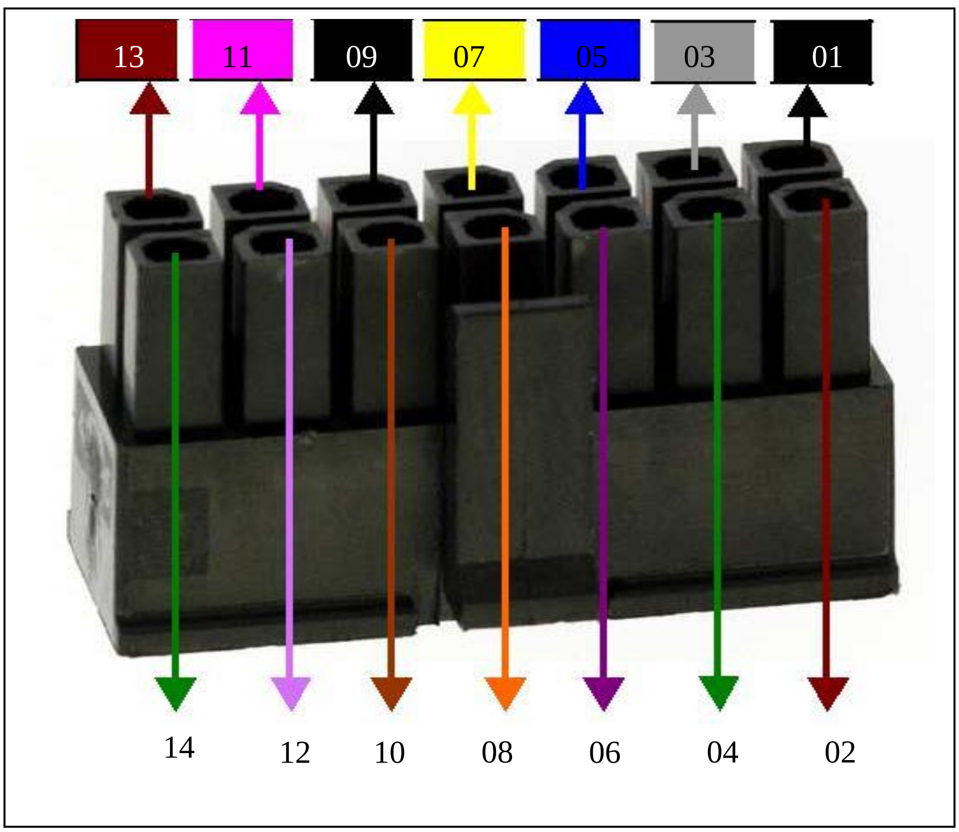

Fig. 3.13. Connector Pin Numbers

The connector pin details are tabulated in table 3.3.

Pin Number	Wire Color	Functionality
01	BLACK	BATTERY (-VE)
02	RED	BATTERY (+VE)
03	GREY	DIGITAL INPUT 1
04	GREEN	DIGITAL INPUT 2
05	BLUE	DIGITAL OUTPUT 2
06	VIOLET	DIGITAL OUTPUT 1
07	YELLOW	IGNITION
08	ORANGE	PULSE INPUT
09	BLACK	BATTERY (-VE)
10	BROWN	ANALOG INPUT 1
11	PINK	DIGITAL INPUT 3
12	PURPLE	DIGITAL INPUT 4
13	RED	RS-232 RX
14	GREEN	RS-232 TX

Table 3.3 Connector Pin Details

3.7 Grounding and shielding

- Grounding and shielding scheme are as per standards followed in commercial vehicles
- Chassis & shield grounds and signal grounds are brought separately to the main star.

3.8 Mechanical

The Telematic electronic is housed in a magnesium alloy box which is light weight and smaller.

Dimension details are given below in table 3.4.

Sl. No	Parameters	Dimension
1	Length	90mm
2	depth	65mm
3	Height	25mm
4	Weight	75g

Table 3.4 Mechanical Measurements

3.9 Features of Telematic System

- Compact and light weight
- Vibration and shock resistant
- Battery backup for 12 hours
- Four Digital inputs
- Two analog inputs
- RS232 serial port for communication
- In-built memory to log data
- Configuration through SMS/GPRS/Serial
- Configurable power down modes
- Various Alert systems like Over-speed, main power removal, geo-fence, harsh breaking, sudden acceleration
- Secured Device – access only through registered mobile number
- In-built surge protection
- Internal GPS/GSM antenna

CHAPTER 4

4 SOFTWARE DESIGN

4.1 System Requirements

The software is required to carry out the following functions at top level.

- Acquire GPS data
- Filter out required parameters
- Acquire sensor data through discrete inputs
- Process data for geofence
- Packet the filtered GPS data along with other processed sensor information as per the defined protocol
- Transmit the packeted data to GSM module for RF transmission at every 30 sec
- Acquire camera data through discrete input
- Action on vehicle headlight based on the camera module output

The system software requirements are tabulated as shown below table 4.1.

Target System	Windows 7 MATLAB R2013a Teraterm 4.84 Hyperterminal
Development Tool	‘C’ language Code Composer Studio IDE Image Processing Tool Box Image Acquisition Tool Box Video and Image processing Block

Table 4.1 System Requirements

4.2 Application Capability Requirements

In functional mode of operation the application software satisfies all the functional requirements. In addition to this, application software supports the Power on Built in Test (PBIT) and Initiated Built in Test (IBIT) capability. During the application start up time PBIT operation will take place. The IBIT test will be initiated by user if required.

4.2.1 Power on Built In Test (PBIT)

Once the application starts, PBIT will be carried out to ensure that the system is healthy. During the PBIT test operation Pass/Fail status of the test will be stored in Flash. Based on the PBIT test result, the application software has to decide the state (critical or non-critical) of system. Table 4.2 gives the details to define critical and non-critical state of Telematic system.

PBIT Test Cases	Test Case Result	System condition	Remarks
Microcontroller Test	PASS	NA	If Microcontroller fails then its total system failure
	FAIL	CRITICAL	
Flash Test	PASS	NA	
	FAIL	NON-CRITICAL	
SRAM Test	PASS	NA	
	FAIL	NON-CRTICAL	
EEPROM Test	PASS	NA	
	FAIL	NON-CRTICAL	
UART Test	PASS	NA	As most of the communication as through serial port, UART is important
	FAIL	CRITICAL	
Timer Test	PASS	NA	
	FAIL	NON-CRTICAL	
ADC Test	PASS	NA	
	FAIL	NON-CRITICAL	

Table 4.2 Criticality Matrix

After PBIT test, if the system is in non critical condition then the application software switches over to the functional mode. If the system is in critical condition then application software will stop its execution. PBIT capabilities description is tabulated in Table 4.3. PBIT has the following test cases:

4.2.1.1 Microcontroller Test

- Arithmetic and Logical Unit (ALU) test
- Floating Point Unit (FPU) test

4.2.1.2 Flash Test

- Flash Digital signature test
- Flash Checksum test

4.2.1.3 SRAM Test

- SRAM Digital Signature test
- SRAM Checksum test

4.2.1.4 EEPROM Test

- EEPROM Digital Signature test
- EEPROM Checksum test

4.2.1.5 Universal Asynchronous Receiver Transmitter (UART) Test

- Self loop back test

4.2.1.6 Timer Test

- Counter Test

4.2.1.7 ADC Test

- Power supply voltage reading

Capability Identification Number	Capability Identification Name	Description
TELE_RTA_FR_01	Microcontroller Test	To test ALU and Floating Point Unit (FPU).
TELE_RTA_FR_01_01	Arithmetic Unit Test	To test Arithmetic unit
TELE_RTA_FR_01_02	Logical Unit Test	To test Logical unit
TELE_RTA_FR_01_03	Floating point Unit	To test Floating point unit
TELE_RTA_FR_02	Flash Test	To test the user flash by verifying check sum and its digital signature.
TELE_RTA_FR_02_01	Flash Digital Signature	To verify digital signature in Flash
TELE_RTA_FR_02_02	Flash Checksum Test	To verify checksum in Flash
TELE_RTA_FR_03	SRAM Device Test	To test data bus and address bus and SRAM device test
TELE_RTA_FR_03_01	SRAM Data Bus Test	To perform data bus test for SRAM to find any shorts in the data bus.
TELE_RTA_FR_03_02	SRAM Address Bus Test	To perform the address bus test for SRAM to find the overlapping of addresses
TELE_RTA_FR_04	EEPROM Test	To test the EEPROM by verifying check sum and its digital signature.
TELE_RTA_FR_04_01	EEPROM Signature	To verify digital signature in EEPROM
TELE_RTA_FR_04_02	EEPROM Checksum	To verify checksum in EEPROM
TELE_RTA_FR_05	UART Test	To test the serial ports transmission and reception functionality of on-board UART devices through internal chip loop back
TELE_RTA_FR_06	Timer Test	To test the occurrence of Timer Interrupts
TELE_RTA_FR_07	ADC Test	To test the ADC by checking the power supply voltages

Table 4.3 PBIT Capability Requirements

4.2.2 Initiated Built In Test (IBIT)

In IBIT module, all the individual devices are tested based on application request. IBIT is initiated by an external input from the user. Therefore it is known as Initiated test. IBIT capabilities description is tabulated in Table 4.4

Capability Identification Number	Capability Identification Name	Description
TELE_RTA_FR_08	Microcontroller Test	To test ALU and Floating Point Unit (FPU).
TELE_RTA_FR_08_01	Arithmetic Unit Test	To test Arithmetic unit
TELE_RTA_FR_08_02	Logical Unit Test	To test Logical unit
TELE_RTA_FR_08_03	Floating point Unit	To test Floating point unit
TELE_RTA_FR_09	Flash Test	To test the user flash by verifying check sum and its digital signature.
TELE_RTA_FR_09_01	Flash Digital Signature	To verify digital signature in Flash
TELE_RTA_FR_09_02	Flash Checksum Test	To verify checksum in Flash
TELE_RTA_FR_10	SRAM Device Test	To test data bus and address bus and SRAM device test
TELE_RTA_FR_10_01	SRAM Data Bus Test	To perform SRAM test by finding any shorts in the data bus.
TELE_RTA_FR_10_02	SRAM Address Bus	To find the overlapping of addresses
TELE_RTA_FR_11	EEPROM Test	To test the EEPROM for check sum and its digital signature.
TELE_RTA_FR_11_01	EEPROM Signature	To verify digital signature in EEPROM
TELE_RTA_FR_11_02	EEPROM Checksum	To verify checksum in EEPROM

Table 4.4 IBIT Capability Requirements

IBIT- has the following test cases,

4.2.2.1 Microcontroller Test

- Arithmetic and Logical Unit (ALU) test
- Floating Point Unit (FPU) test

4.2.2.2 Flash Test

- Flash Digital signature test
- Flash Checksum test

4.2.2.3 SRAM Test

- SRAM Data bus test
- SRAM Address bus test

4.2.2.4 EEPROM Test

- EEPROM Digital Signature test
- EEPROM Checksum test

4.2.3 Functional Mode

1. On power up, a LED glows which gives indication of power to the system.
2. PBIT is initiated.
3. After successful completion of PBIT, the application software enters into the Functional mode.
4. In Functional mode, Telematic system is connected to external interfaces like GPS, GPRS, Camera, Fuel Sensor, and panic button.
5. There are five different tasks, namely,
    - GPS data framing task
    - Auto dipper task
    - Sensor task
    - Geofence task
    - Transmission task

6. In GPS framing task, the Telematic system tries to lock on to the GPS. This may take few seconds to minutes depending on the location.
7. An LED is designated for the purpose of GPS lock.
8. Once the lock is established, the LED glows brightly.
9. GPS data is read by the GPS module (GPS Antenna, Receiver) and sent to the Microcontroller through serial interface.
10. Microcontroller filters out the required data from GPS.
11. Filtered data is framed to be transmitted through GPRS using TCP protocol.
12. In Auto dipper task, Microcontroller reads the camera data through serial interface
13. The image processing algorithm is executed and a flag is set.
14. Based on the flag data, action is taken. If flag is high it means an approaching vehicle headlight is detected and low represents no vehicle.
15. If a vehicle is detected, then the headlight dipper relay in the vehicle shall be operated using the control signal generated by the Microcontroller.
16. In Sensor Task, the Microcontroller reads the sensor data like main power, ignition status, fuel status & panic button and frames it with other GPS data for transmission.
17. In Geofence Task, the Geofence module is executed. This module is used to extract the position information from GPS data to identify whether the vehicle is within a boundary or not.
18. In Transmission Task, the framed data is sent to the GPRS module at every 30sec for transmission.

    The detailed functional requirements are tabulated as in table 4.5

Capability Identification Number	Capability Identification Name	Description
TELE_RTA_FR_12	GPS framing Task	To read, filter & store GPS data as per protocol
TELE_RTA_FR_12_01	Read GPS data	To read data from GPS module
TELE_RTA_FR_12_02	Filter data	To filter latitude, longitude, velocity and altitude
TELE_RTA_FR_12_03	Store filtered data	To store the filtered GPS data in respective buffers
TELE_RTA_FR_13	Auto dipper Task	To detect the oncoming vehicle headlight and based on that operate the headlight supply relay.
TELE_RTA_FR_13_01	Read data from camera & execute Algorithm	To read the camera module data through serial link And to execute the image processing algorithm
TELE_RTA_FR_13_02	Operate Relay	To operate the headlight relay based on the RS232 input from camera
TELE_RTA_FR_14	Sensor Task	To acquire sensor data and take action accordingly
TELE_RTA_FR_14_01	Read main power sensor/fuel sensor /panic button/ignition sensor data	To read the sensor data at various update rates through discrete inputs
TELE_RTA_FR_14_02	Store sensor data	To store the read sensor information in respective buffers.
TELE_RTA_FR_15	Geofence Task	To read the GPS position information and calculate whether the vehicle is within or outside the designated boundary
TELE_RTA_FR_15_01	Extract position data	Read only the latitude and longitude information
TELE_RTA_FR_15_02	Check for boundary	Check whether the location is within or outside the designated boundary
TELE_RTA_FR_15_03	Store geofence information	To store the geofence status in a buffer
TELE_RTA_FR_16	Transmission Task	To frame packets and transmit the packets to GPRS module for RF transmission.
TELE_RTA_FR_16_01	Read buffered data	Read data from buffers such as geofence, ignition, main power, panic, fuel and GPS buffered data
TELE_RTA_FR_16_02	Frame Packets	Frame packets of the read buffered data as per the laid down protocol

Table 4.5 Application Functionality Requirements

4.3 Application Design

The overall application execution flow is given as flowchart in figure 4.1

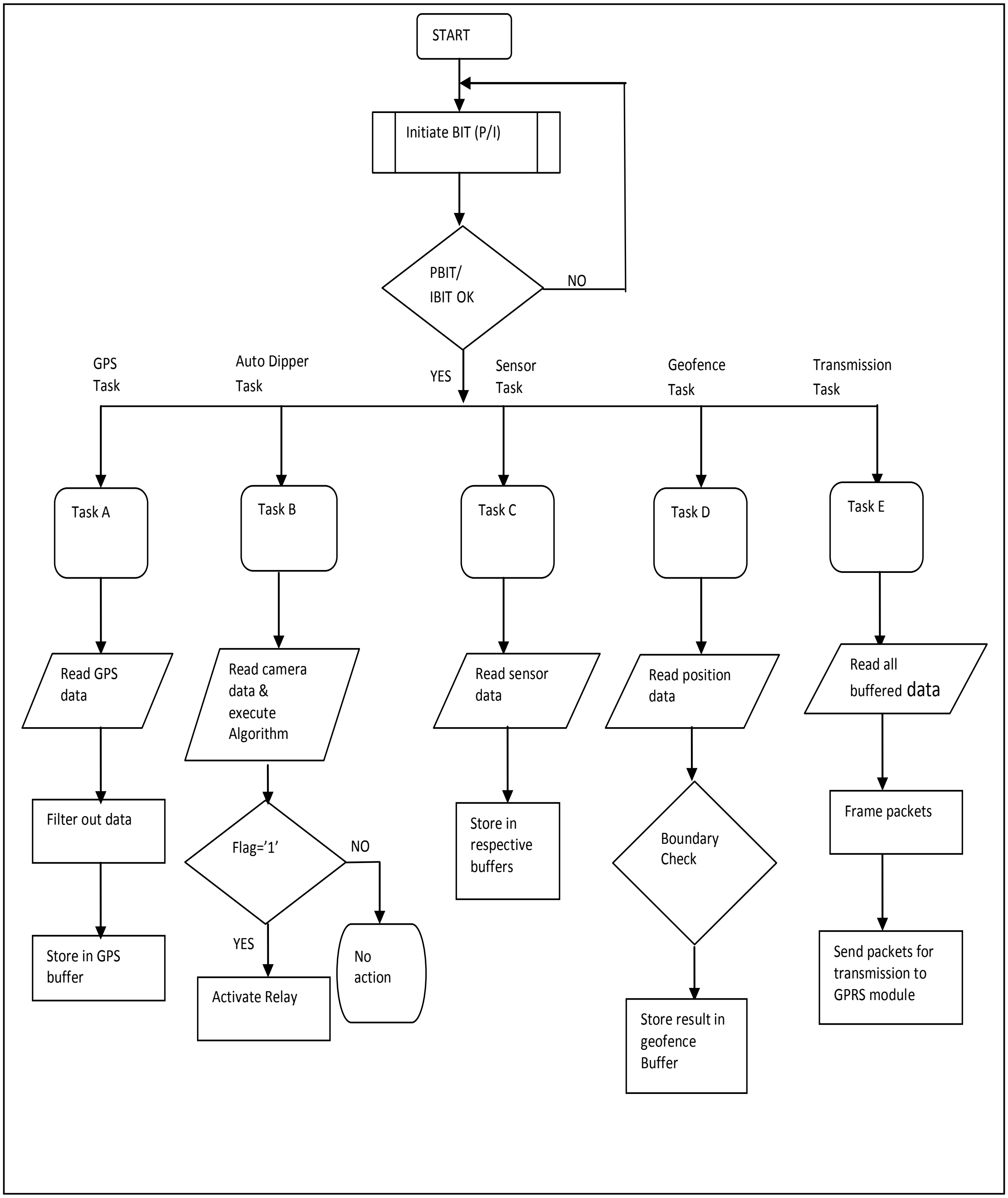

Fig 4.1. Application Software Flowchart

The design of application software for Telematic System is divided into three major modules. They are,

- PBIT (Power On Built In Test) Module
- IBIT (Initiated Built In Test) Module
- Functional Module

These modules are explained in detail in below section.

Design Algorithm:

BEGIN

1. Define each peripheral test status holding structure: S_PBIT_TEST_STATUS_FLAG. This structure contains the following two fields, Test Status Flag and Criticality Flag.
2. Define the PBIT status storage structure into Flash S_PBIT_STATUS_STORAGE_INTO_FLASH.
3. Create 7 global instances for S_PBIT_TEST_STATUS_FLAG. Each instance specifying the one peripheral test.
4. Initialize all the test status flag as OK and all the criticality flag as NOT_CRITICAL.
5. Define a global variable g_ApplicationMode and initialize it to PBIT_MODE.
6. Perform the processor test and update the processor test status flag and processor criticality flag based on the test result.
7. Perform the SRAM test and update the SRAM test status flag and SRAM criticality flag based on the test result.
8. Perform the FLASH test and update the Flash test status flag and Flash criticality flag.
9. Perform the UART test and update the UART test status flag and UART criticality flag.
10. Perform the timer test and update the Timer test status flag and Timer criticality flag.
11. Return to the main application.

END

4.3.1 PBIT Module Design

Design Identifier : TELE_RTA_FR_01

Specifications : Once the application starts, PBIT will be carried out to ensure that the Telematic system is healthy. During the PBIT test operation Pass/Fail status of the test will be stored in Flash memory. Based on the PBIT test result, the application software has to decide the Telematic system health condition. After PBIT test, application software switches to the functional mode. After successful completion of PBIT, a green LED glows. Table 4.6 gives the PBIT design components.

PBIT has the following test cases,

1. Processor Test
   - Arithmetic and Logical Unit (ALU) test
   - Floating Point Unit (FPU) test

2. Synchronous Random Access Memory (SRAM) Test
   - SRAM Data bus test
   - SRAM Address bus test
   - SRAM Device test

3. Flash Test
   - Flash Digital signature test
   - Flash Checksum test

4. EEPROM Test
   - Flash Digital signature test
   - Flash Checksum test

5. Universal Asynchronous Receiver Transmitter (UART) Test
6. Timer Test
7. ADC Test

Requirements Capability Identification Number	Design Capability Identification Number	Capability Identification Name
TELE_RTA_FR_01	TELE_RTA_DD_01	Processor test
TELE_RTA_FR_01_01	TELE_RTA_DD_01_01	Arithmetic unit test
TELE_RTA_FR_01_01	TELE_RTA_DD_01_02	Logical unit test
TELE_RTA_FR_01_02	TELE_RTA_DD_01_03	Floating point unit test
TELE_RTA_FR_02	TELE_RTA_DD_02	Flash test
TELE_RTA_FR_02_01	TELE_RTA_DD_02_01	Flash digital signature test
TELE_RTA_FR_02_02	TELE_RTA_DD_02_02	Flash checksum test
TELE_RTA_FR_03	TELE_RTA_DD_03	SRAM Device test
TELE_RTA_FR_03_01	TELE_RTA_DD_03_01	SRAM Data bus test
TELE_RTA_FR_03_02	TELE_RTA_DD_03_02	SRAM Address bus test
TELE_RTA_FR_04	TELE_RTA_DD_04	EEPROM Test
TELE_RTA_FR_04_01	TELE_RTA_DD_04_01	EEPROM Digital Signature Test
TELE_RTA_FR_04_02	TELE_RTA_DD_04_02	EEPROM Checksum Test
TELE_RTA_FR_05	TELE_RTA_DD_05	UART test
TELE_RTA_FR_06	TELE_RTA_DD_06	Timer test
TELE_RTA_FR_07	TELE_RTA_DD_07	ADC test

Table 4.6 PBIT Design Components

4.3.2 IBIT Module Design

Initiated built in Test is a subset of PBIT as it performs the same health check of the system but not only on power up but as and when there is a requirement to know the health. In this not all the tests as PBIT is carried out. Only processor, SRAM and Flash are tested. Table 4.7 gives the design components of IBIT

Capability Identification Number	Design Capability Identification Number	Capability Identification Name
TELE_RTA_FR_08	TELE_RTA_DD_08	Microcontroller Test
TELE_RTA_FR_08_01	TELE_RTA_DD_08_01	Arithmetic Unit Test
TELE_RTA_FR_08_02	TELE_RTA_DD_08_02	Logical Unit Test
TELE_RTA_FR_08_03	TELE_RTA_DD_08_03	Floating point Unit Test
TELE_RTA_FR_09	TELE_RTA_DD_09	Flash Test
TELE_RTA_FR_09_01	TELE_RTA_DD_09_01	Flash Digital Signature Test
TELE_RTA_FR_09_02	TELE_RTA_DD_09_02	Flash Checksum Test
TELE_RTA_FR_10	TELE_RTA_DD_10	SRAM Device Test
TELE_RTA_FR_10_01	TELE_RTA_DD_10_01	SRAM Data Bus Test
TELE_RTA_FR_10_02	TELE_RTA_DD_10_02	SRAM Address Bus Test
TELE_RTA_FR_11	TELE_RTA_DD_11	EEPROM Test
TELE_RTA_FR_11_01	TELE_RTA_DD_11_01	EEPROM Digital Signature Test
TELE_RTA_FR_11_02	TELE_RTA_DD_11_02	EEPROM Checksum Test

Table 4.7 IBIT Design Components

4.3.3 Functional Module Design

In this module, the unit enters into its actual intended functional mode. This module is executed after successful completion of PBIT. Table 4.8 gives the design components of functional module

Capability Identification Number	Capability Identification Name	Capability Identification Name
TELE_RTA_FR_12	TELE_RTA_DD_12	GPS framing Task
TELE_RTA_FR_12_01	TELE_RTA_DD_12_01	Read GPS data
TELE_RTA_FR_12_02	TELE_RTA_DD_12_02	Filter data
TELE_RTA_FR_12_03	TELE_RTA_DD_12_03	Store filtered data
TELE_RTA_FR_13	TELE_RTA_DD_13	Auto dipper Task
TELE_RTA_FR_13_01	TELE_RTA_DD_13_01	Read discrete input from camera module
TELE_RTA_FR_13_02	TELE_RTA_DD_13_02	Operate Relay
TELE_RTA_FR_14	TELE_RTA_DD_14	Sensor Task
TELE_RTA_FR_14_01	TELE_RTA_DD_14_01	Read main power sensor/fuel sensor/panic button/ignition sensor data
TELE_RTA_FR_14_02	TELE_RTA_DD_14_02	Store sensor data
TELE_RTA_FR_15	TELE_RTA_DD_15	Geofence Task
TELE_RTA_FR_15_01	TELE_RTA_DD_15_01	Extract position data
TELE_RTA_FR_15_02	TELE_RTA_DD_15_02	Check for boundary
TELE_RTA_FR_15_03	TELE_RTA_DD_15_03	Store geofence information
TELE_RTA_FR_16	TELE_RTA_DD_16	Transmission Task
TELE_RTA_FR_16_01	TELE_RTA_DD_16_01	Read buffered data
TELE_RTA_FR_16_02	TELE_RTA_DD_16_02	Frame Packets

Table 4.8 Functional Module Design Components

4.3.3.1 GPS framing Task

Design identifier : TELE_RTA_DD_12

Specifications : To read GPS data, filter out and frame it as per the protocol

Design Algorithm :

BEGIN

1. Initiate GPS Receiver.
2. Wait for GPS Lock is established
3. Read data from GPS module
4. Filter out only latitude, longitude, velocity and speed
5. Store filtered data in buffer
6. Return OK, if operation succeeds, otherwise return ERROR.

END

4.3.3.2 Auto Dipper Task

Design identifier : TELE_RTA_DD_13

Specifications : To detect the oncoming vehicle headlight and based on that operate the headlight supply relay.

Design Algorithm :

BEGIN

1. Initialize RS232 serial port as per the configuration (9600 baud rate)
2. Read the camera module image data through serial interface
3. Execute the image processing algorithm
4. Flag set based on the outcome of the algorithm
5. Relay activation based on the flag data
6. Return OK, if operation succeeds, otherwise return ERROR.

END

4.3.3.3 Sensor Task

Design identifier : TELE_RTA_DD_14

Specifications : To acquire sensor data and take action accordingly

Design Algorithm :

BEGIN

1. Initiate all I/O discrete lines
2. Read the sensor data through discrete inputs
3. Store the read sensor information in respective buffers.
4. Return OK, if operation succeeds, otherwise return ERROR.

END

4.3.3.4 Geofence Task

Design identifier : TELE_RTA_DD_15

Specifications : To read the GPS position information and calculate whether the vehicle is within or outside the designated boundary

Design Algorithm :

BEGIN

1. Read only the latitude and longitude information from GPS data.
2. Compare with the stored boundary values
3. Check whether the location is within or outside the designated boundary
4. Store the geofence status in buffer
5. Return OK, if operation succeeds, otherwise return ERROR.

END

4.3.3.5 Transmission Task

Design identifier : TELE_RTA_DD_16

Specifications : To frame packets and transmit the packets to GPRS module for RF transmission.

Design Algorithm :

BEGIN

1. Initiate GSM module
2. Read data from status buffers such as geofence, ignition, main power, panic, fuel and GPS buffered data
3. Frame packets of the read buffered data as per the laid down protocol
4. Return OK, if operation succeeds, otherwise return ERROR.

END

4.4 Device Configuration

The device can be configured either through SERIAL/USB/SMS. When used with USB interface the host terminal should use the "USB to serial driver" to communicate with device. Following are the HyperTerminal settings on a PC to control the device using serial communication.

- Baud Rate: 9600
- Data Bits: 8
- Parity: N
- Stop Bits: 1
- Flow control: None

4.4.1 Command Syntax

The device accepts one command at a time and each command is terminated by <CR> or <LF>.

Commands are usually followed by requested information and response that includes <CR><LF><response><CR><LF>

Steps to be followed while configuring the units

- Set the parameters using the commands
- Confirm the values by issuing show config new
- Issue the command save config
- Issue the command show config current to see the updated values

4.5 Protocol

The unit uses the TCP to send position and other information to the server. The protocol is shown in table 4.9 and the position information of all the data inside the packet is given in table 4.10. The parameters and values to the TCP operation is as below

4.5.1 Periodic (POS) Packet Format

^ID=unitid&POS=<VersionNo><Latitude><Longitude><Time><Date><Speed><Distance><Heading><No. Of Visible Satellites><Ignition Status><Over Speed><GSM Signalquality><Digital Input1><Digital Input2><Analog Input><Internal battery voltage><Vehicle battery voltage><GPS Odometereading><Main Power Status><Pulse Odometer Reading ><Validity><Stored Packet>

Example

^ID=PTTRK30(I/IS/E/ES*)(IMEI**)&POS=<3.0><1302.307><07854.921><122035><061010><18.5><42.2345><23.5><11.3><1><0><1><63><1><0><12.34><3.94><11.59><1.2><1><3.1><1><0>

** - IMEI: International Mobile Equipment Identification

*:
I : GPS Internal Antenna
E : GPS External Antenna
IS : GPS Internal Antenna with Serial Interface
ES : GPS External Antenna with Serial Interface

Panic Button (POS) Information

Panic button is mapped to DIGITAL INPUT 1. (GREEN color wire on the connector)

It is a positive triggered Input.

When the button is pressed a periodic packet is sent out with field Digital Input1 set to '1'

Pulse Odometer

Pulse Counting is mapped to ORANGE color wire on the connector

4.5.2 GeoFence(GEOF) Alert Packet Format

The geofence information will be part of the packet only when the device enters\exits one of the enabled fences.

^ID=unitid&GEOF=<Fence Number/Exit/Entry details><IgnitionStatus><Latitude><Longitude><Time><Date>

Example

^ID=PTTRK30(I/IS/E/ES)(IMEI)&GEOF=<1E,3X,5E><1><1302.307><07854.921>
<1=<Serial Device data>< Ignition Status><Latitude> <Longitude> <Time><Date>

GeoFence (GEOF) Information

This will contain the fence number and entry\exit status of corresponding fence.

Format <nE/X>

n -- Fence Number

E – Device entered inside the fence

X – Device came out of the fence

Example:

GEOF=<1E, 4X, 7E>

1E --- Device entered Fence 1

4X --- Device came out of Fence 4

7E --- Device entered Fence 7

4.5.3 Serial Message Out (SMO) Information

If any external device is connected to the serial interface, the data received from this device will be sent out as packet information. The bytes are sent out when it finds character '\n' from the serially received data.

Example:

SMO=<xxxxx>

xxxx --- Bytes received from the external device connected serially.

4.5.4 ALERTS Information

Device can send the alert packets in following conditions

1. In case of accidents
2. Harsh breaking
3. Sudden acceleration

All three can be independently enabled\disabled. The speed thresholds for all three are configurable.

Example1:

ALRT<1><Lat><long><Time><Date>

<1> --- Accident alert

Example2:

ALRT<1><Lat><long><Time><Date>

<2> --- Break alert

Example3:

ALRT<3><Lat><long><Time><Date>

<3> --- Acceleration alert

Parameter	Maximum Size (bytes)	Value
ID	24	The device identifier
POS	Position Information	Position detail of unit identified. Each parameter is separated by angle brackets(<>)
GEOF	Based on number of fences Entry/Exit	Contains the geofence number, Entry and Exit details
SMO	Serial Message Out data	Received bytes from serial interface
ALRT	Accident, Harsh breaking and sudden acceleration alerts	Alert number and position information

Table 4.9 Protocol for Telematic Data

S.No.	Paramter	No. of bytes	Value	Description
1	Version number	2	1	Version number of the packet structure
2	Latitude	12	1302.307	The position latitude
3	Longitude	12	07854.921	The position longitude
4	Time	6	122035	The GPS fix time in 24-hr time(hhmmss)
5	Date	6	061010	The GPS date ddmmyy format
6	Speed	6	18.5	Current speed of vehicle in nautical miles
7	Distance	8	42.2345	Distance traveled in kms from since update
8	Heading	6	23.5	Heading reading from GPS
9	No. of visible satellites	4	5	Number if visible satellites
10	Ignition status	1	1	0-unit battery 1-car battery
11	Over speed	1	0	0-No over speed since last update 1-Overspeed since last update
12	GSM Signal Quality	4	63	-63dbm (GSM signal strength)
13	Digital input1	1	1	0-Digital input1 is LOW 1-Digital input1 is HIGH
14	Digital input2	1	1	0-Digital input2 is LOW 1-Digital input2 is HIGH
15	Analog input	6	5	Holds analog input voltage value
16	Device internal battery voltage	6	5	Holds device internal battery voltage value
17	Vehicle internal battery voltage	6	5	Holds vehicle internal battery voltage value
18	GPS odometer reading	8	1.3	Holds the current GPS odometer reading
19	Main power	1	1	0 – Main power OFF 1– Main power ON
20	Pulse odometer reading	8	13	Holds the current Pulse odometer reading (Polled on Orange Color Wire)
21	Validity **	1	1	0– Invalid GPS data 1– Valid GPS data
22	Stored	1	0	0– Live Packet 1– Stored Packet

Table 4.10 Position Information of Telematic Data

4.6 Auto Dipper Application

The auto dipper application is based on image capture, image processing and analysis. A CMOS high resolution smart camera takes real time videos and sends it to the Microcontroller for processing. The video is converted to frames and then subjected to low level, intermediate level and high level processing. For the purpose of image processing color based segmentation is used for image analysis. The image is classified using ANN classifier. An overall flow of vision analytics is given in figure 4.2.

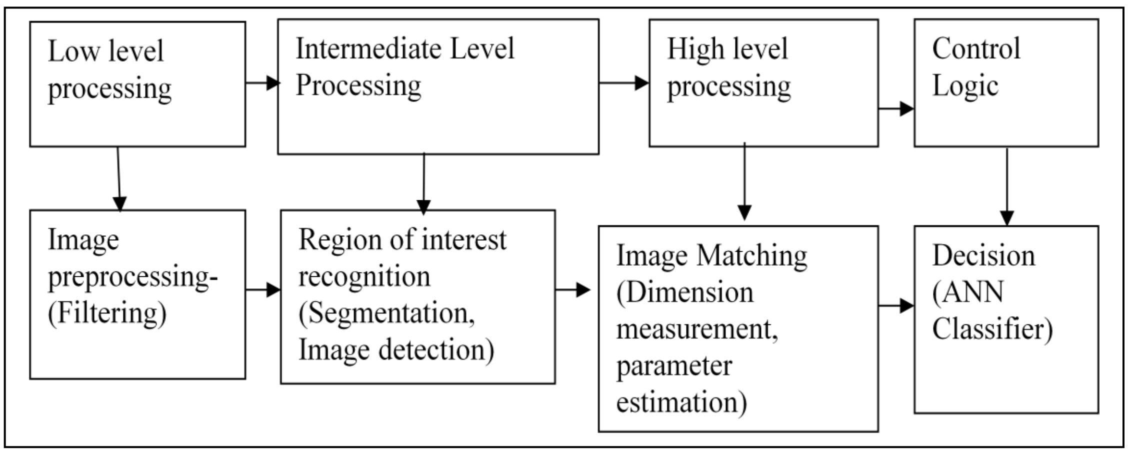

Fig. 4.2. Flow of Vision Analytics

The headlight of the vehicle shall dip automatically from high beam to low beam for the oncoming traffic with the following criteria. The scheme is as shown in figure 4.3.

- The oncoming vehicle is detected based on the visibility of the headlight (appx 200m).
- Speed of oncoming vehicles are assumed to be 60 kmph
- Headlight dips after successful detection of oncoming headlight (appx 100m)
- Continues dipping for 10sec (appx when the two vehicles are 5m apart)
- Resumes high beam after 10sec
- Within 100m, 450 frames are obtained with the camera (30fps) which is sufficient for headlight detection by the algorithm
- Each frame shall be processed within 40ms.

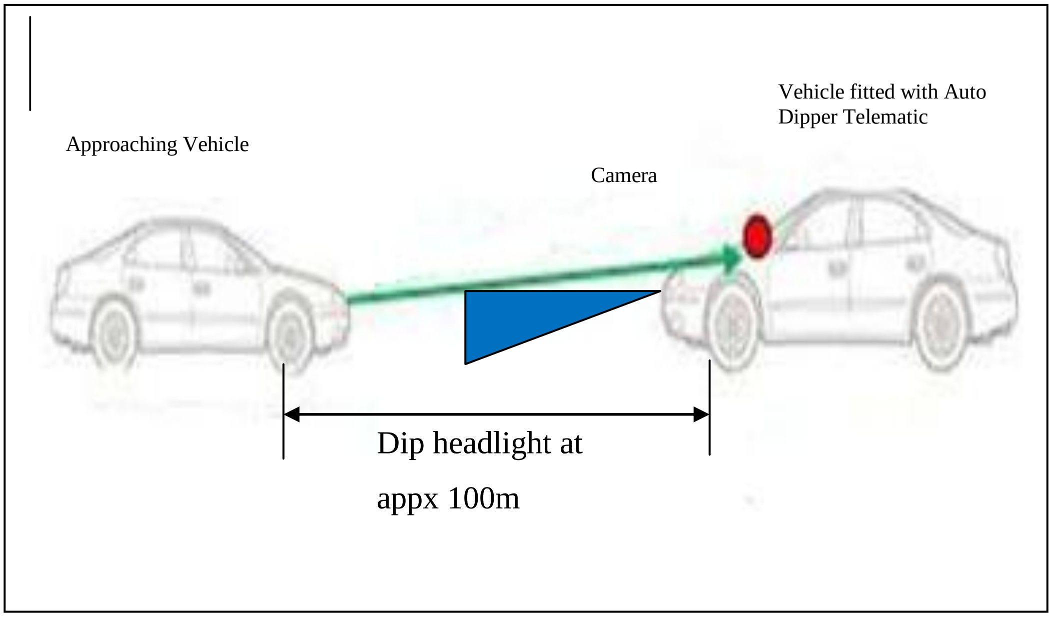

Fig. 4.3. Scheme for Auto Dipper Telematic

4.6.1 Algorithm

A CMOS image sensor mounted behind the windscreen inside the camera-assisted vehicle is used to obtain the input images. The videos are converted to frames which are processed. First of all, the image is preprocessed to remove unwanted noise from unevenly illuminated road using Gaussian low pass filter. Then a segmentation method is applied to detect bright objects known as blobs. This may detect all the bright objects including the headlight. This is known as blob detection. Therefore, a color based adaptive threshold method is applied to extract only the oncoming vehicle's headlight.

Instead of using a fixed threshold, an adaptive threshold based on color which is obtained from the image itself is utilized for this purpose. As the vehicle headlight is of white color in general, a method which would detect the maximum white color in the detected blobs. Few morphological operations like opening and closing are applied to remove nuisance lights. Once the headlight is detected, feature extraction is carried out. Based on the features extracted, the objects are classified using ANN classifier.
An overall view of the image processing algorithm is given in figure 4.4.

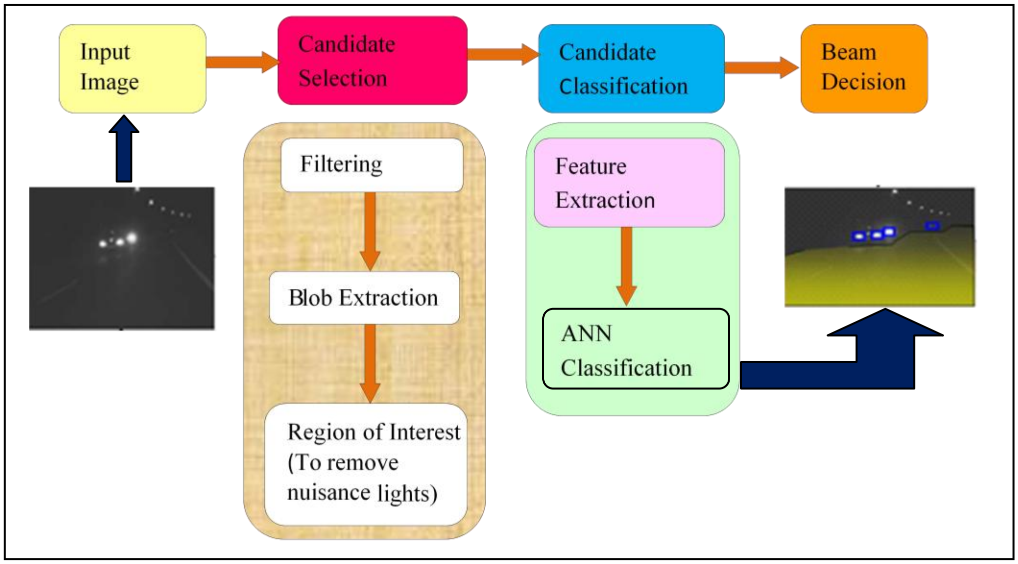

Fig. 4.4. Algorithm for Vehicle Headlight Detection

Assumptions

Speed of the vehicle	: 60 kmph (30m/s)
Vehicle detection distance	: 200 m
Vehicle headlights dip at	: 100 m
Vehicle high beam at	: 5m
With OV7670 (30fps)	: 450 frames in 15sec

Frame Extraction time within a distance of 100 m i.e. 15 s

4.6.1.1 Preprocessing

The first step in any image processing application is preprocessing which takes image as input and gives an image output. In this step, noise removal, irrelevant information can be removed. Here, the image is captured using vision system i.e. CMOS high definition camera mounted behind the windshield inside the car. A typical night time road scene taken using the still camera is shown in figure 4.5.

In the figure, an oncoming vehicle, a preceding vehicle and few street lights are present. Even the oncoming vehicle's headlight reflection is also seen. Our interest is to detect only the oncoming vehicle's headlight. Generally the oncoming vehicle's headlight is the brightest blob in the whole image. Therefore all other lights are considered as nuisance lights which need to be removed. A Gaussian Low Pass Filter (LPF) is used to accomplish this task. It removes noise from unevenly illuminated road.

Fig. 4.5. Typical Road Scene at Night time

4.6.1.2 Blob Detection (Candidate selection)

There are several methods for bright object segmentation. Here a color based adaptive thresholding is proposed for the purpose of blob detection. The original RGB image is converted to an indexed image with color map using the command "rgb2ind". The color map matches colors in RGB image with the nearest color in the color map. Also, no dither option is used so that each color in the original image is mapped to the closest color in the new map. The new indexed image is in form of a matrix with three rows for red, green and blue respectively. This matrix gives the information about the color pixel values. Maximum number of red pixels in the image occupies the first row. Similarly, maximum number of green pixels occupies the second and maximum number of blue pixels in third row.

The next step is to get the maximum intensity of each color (R, G, B) from the first, second and third row using the command "max (map (:,1). This step is done to obtain the

Region of Interest (ROI). In this case, the ROI is the vehicle's headlight which is bright white. In images, a bright white light is identified where all the three colors i.e. RGB have high pixel values.

The aim is to find out the regions which have all the pixels with high values and thereby remove other nuisance lights. This is done using the command "roicolor", which selects a ROI within an indexed image and returns a binary image. In this step itself the vehicle's headlight gets detected.

4.6.1.3 Candidate Classification (ANN Classifier)

In this step, feature extraction and feature classification are carried out using ANN (implemented using Vedic Neuron) classifier. ANN classifier is complex but gives very accurate results. In this work, a three layer MLF with activation function (sigmoid transfer) is used.

4.6.1.3.1 Feature extraction

This process is carried out on the extracted blobs. In this algorithm, the ANN model is trained to identify three different blob types which are mentioned as follows

- Head light
- Tail light
- Street light

Features are grouped in 6 categories to identify the above given types of blobs as given in table 4.11. The design architecture shall be a 3 layered model with 512 input neurons, 10 hidden neurons and one output neuron which shall classify any vehicle into head light or tail light. Each layer has one bias unit which has a fixed '1' as its input value.

S.No.	Feature	Description
1.	Position	The gravitational centroid of the blob is found out using the coordinates – x and y. By doing this we eliminate the other nuisance light such as street light. Generally the street lights are located at different spatial locations in the obtained image.
2.	Brightness	This is useful in distinguishing headlight and taillight using the intuition that the close by things is brighter than the far away thing as well as reflected object. Brightness is the average and variance of all the pixels in the detected blob.
3.	Shape	This feature is useful in categorizing headlight, taillight and streetlight from other lights. In general the headlight, tail light and street light are round in shape whereas the other lights are irregular in shape. Using this intuition we can group the light sources among the blobs.
4.	Spatial Relation	The headlight as well as tail lights of vehicle appear in pairs whereas street lights appear in a straight line mostly. This fact is used to distinguish vehicle lights from street lights.
5.	Color	This feature is useful in differentiating headlight and tail light. Mostly headlights are bright white color and taillights are reddish in color. With this intuition each blob can be categorized based on color
6.	Motion	Motion features like moving forward and moving away can be utilized for classification. These features describe the trajectory of blobs from frame to frame.

Table 4.11 Features of a Blob

4.6.1.3.2 Feature Classification

This process classifies an unknown blob using the trained model. Based on the extracted features which are also known as training features, a particular blob can be classified using ANN Classifier. So for a given image, three types of blobs are identified. From this only the line of sight blobs are extracted so that street lights and other nuisance lights are removed. Based on color and intensity, headlights and taillights can be differentiated. This algorithm is aimed to detect the vehicle's headlight, therefore from the classification output, the required oncoming vehicle headlight presence is known.

4.6.1.4 Output

A discrete signal is the output from the algorithm which shall set a flag. The MCU reads the flag and if it is set takes action accordingly. The power supply to the vehicle's headlight is routed through electro mechanical relays operated by MCU. If the flag is set, then MCU operates the dipper relay through ground line.

CHAPTER 5

5 SIMULATION RESULTS

Telematic Prototype unit is as shown in figure 5.1. The Telematic system has two types of test – Acceptance test and functional test.

Fig. 5.1. Telematic Prototype Unit

5.1 Functional Test and Results

5.1.1 Equipments required for Functional Test Procedure (FTP)

The following items are required to conduct the FTP Test:

Telematic unit: Hardware Part No.: SUN100, Sl. No.: Prototype,

Software Version: 1.0.

12V, 1Amp, DC Power supply unit.

PC Based Monitor/ Simulator: Pentium-IV PC/Laptop with Windows XP OS.

Power Supply cables

Power Supply Interface Cable – (J1)

5.1.2 Test Setup

The Telematic unit Test Setup for functional tests is as shown in Fig.5.2. The Test Setup consists of the following

Telematic Unit

Pentium-IV PC/Laptop.

12V/1Amp DC Power Supply unit.

Interfacing Cables as listed at section 3.6.

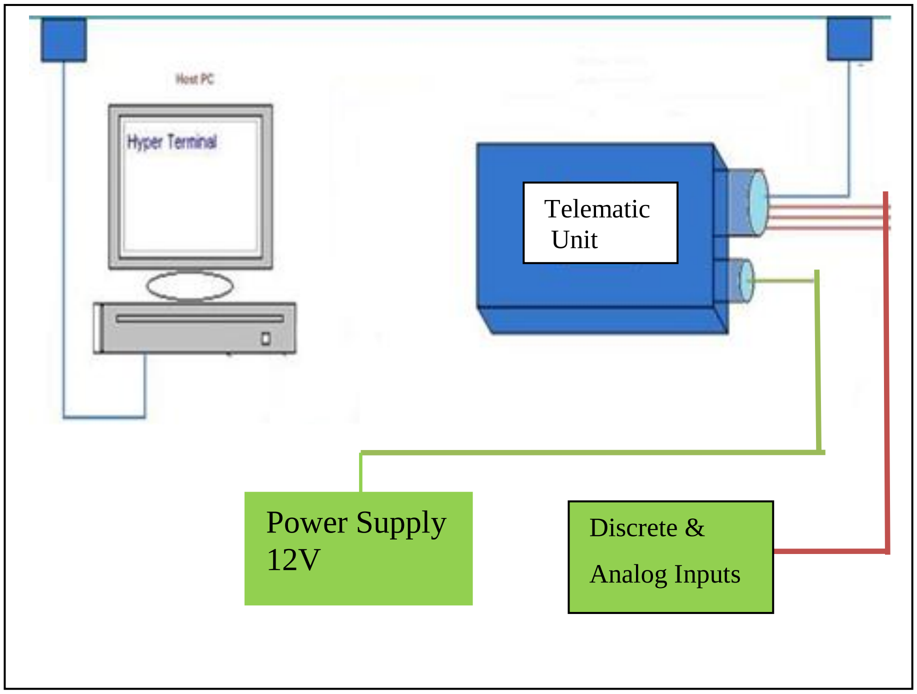

Fig. 5.2. Functional Test Setup for Telematic Unit

The test Equipment for testing Telematic unit is built around a PC/Laptop with necessary DC power supplies. The hardware setup is as shown in Fig.5.3. A PC/Laptop with teraterm software serves as a server with 9600 baud. The configuration settings for the Telematic unit are as shown in figure 5.4.

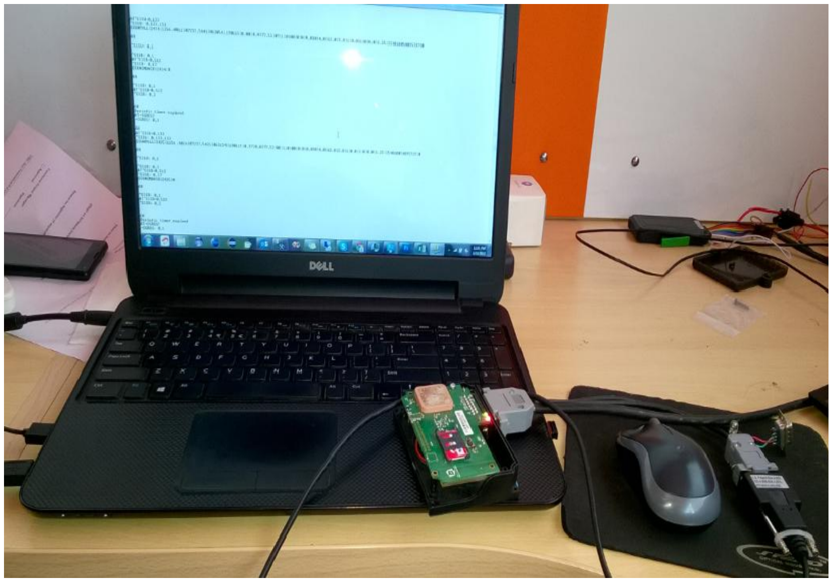

Fig. 5.3. Telematic Prototype Unit Testing

ID: 354868054895737
URL: suntelematics.co.in
IP: 202.138.98.172
PORT: 8880
APN: AIRTELGPRS.COM
SVer: 1.18

OK

show func

UpDateRate: 30
GPS Odo: 0.0
PANIC: ENABLE
SMO: DISABLE
GSM: OK
GPS: OK
HVer: 1.01

Fig. 5.4. Snap shot of Configuration Settings for server

5.1.3 Functional Test Procedure

The unit is powered on with 12 V DC supply. There are two LED's one for GSM – green color and the other for GPS – Red color. Both the LED's keep blinking till there's a positive GPS/GSM lock. Once a positive lock is established the LED's become stable. The unit transmits packets at every 30sec to server and gets an acknowledgement from the server if the packet is received properly. Basically the unit gets data from GPS and keeps transmitting to the server. The data is viewed either using Teraterm software in the server. Figure 5.5 shows the functional test of the prototype unit.

Fig. 5.5. Functional Test

5.1.4 Functional Test Results

The first data received by the server is always "SUNSTART" followed by general packets which start with "SUNPOLL". The acknowledgement packet from the server starts with "SUNACK" for every received packet. The test result for the prototype unit is shown in figure. 5.6. The table 5.1 shows the test resultant packet obtained.

At the server end, asp.net software is used to take this raw data and processes. The location of a particular vehicle is shown on a google map and also tracked live. A live vehicle track using Telematic system is shown in figure 5.7.

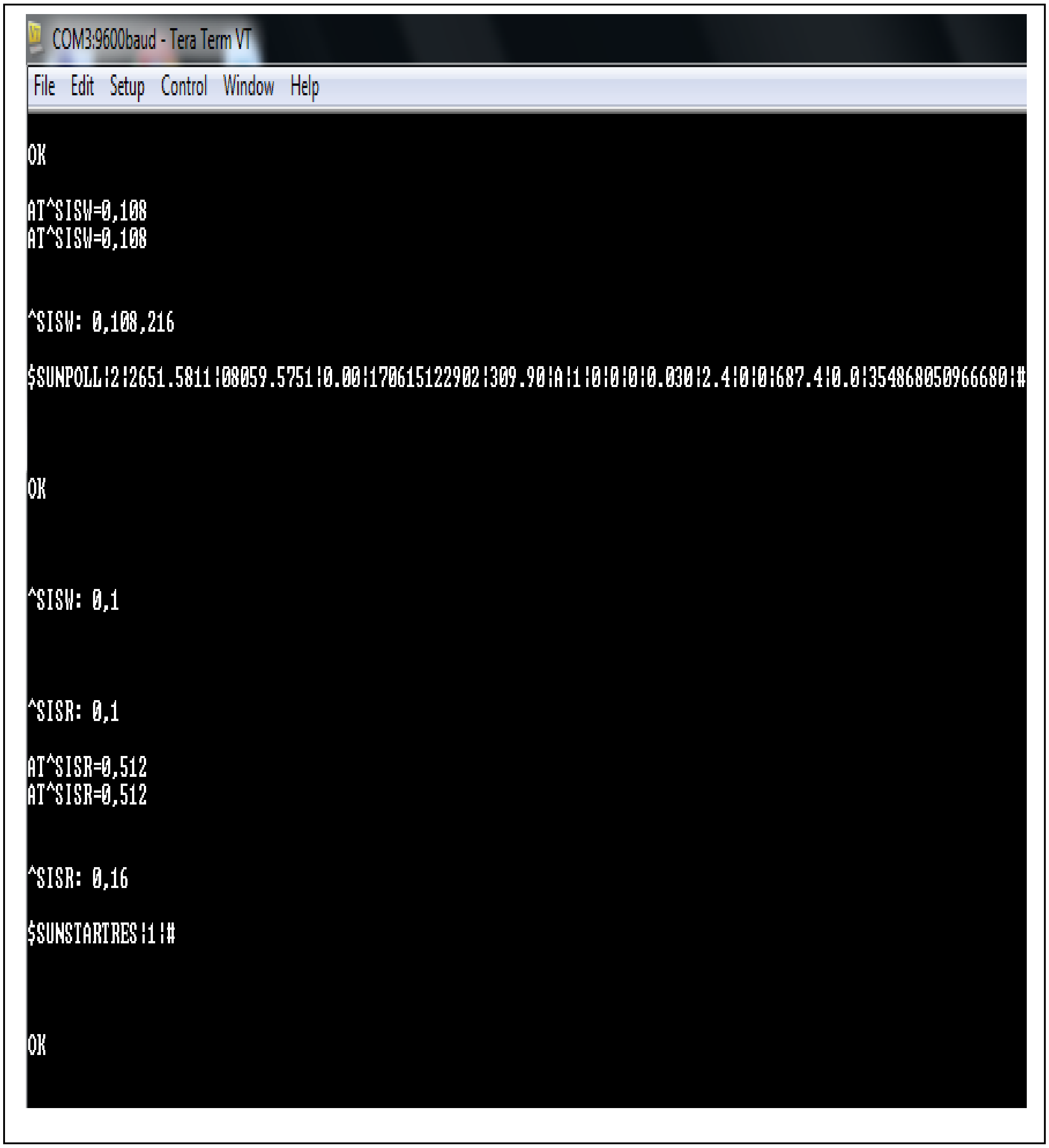

Fig. 5.6. Data received at Server

Test Frame received at the server laptop

$sunpoll|8475|12.9401|77.6257|12:08:22|15-06-15|0.23|0.0|312.90|06 |
1|0|00|0|0|0.014|4.0|11.9|2.4|1|0.0|1|0|0.0|1.25|354868054895737|#

5.1.4.1 Test Result

Byte Number	Data	Description
	$sunpoll	Header
1.	8475	Unique Identification Number
2.	12.9401	Latitude
3.	77.6257	Longitude
4.	12:08:22	GPS time
5.	15-06-15	GPS date
6.	0.23	GPS speed
7.	312.90	GPS Direction
8.	06	Number of satellite
9.	1	Ignition Status (Digital on or off)
10.	0	Over speed status
11.	00	GSM Signal Quality
12.	0	Digital input one
13.	0	Digital input two
14.	0.014	Analog input one
15.	4.0	Device battery voltage
16.	11.9	Vehicle battery voltage
17.	2.4	GPS odometer value
18.	1	Power source (1 - running main power, 0 - running battery power)
19.	0.0	Pulse Odometer
20.	1	GPS Status (1 – Valid 0- Invalid)
21.	0	Packet type (1 - stored packet, 0 - normal packet)
22.	0.0	Extra data(future use)
23.	1.25	Device firmware version
24.	354868054895737	Device IMEI number
25.	#	Ender

Table 5.1 Received Frame Data

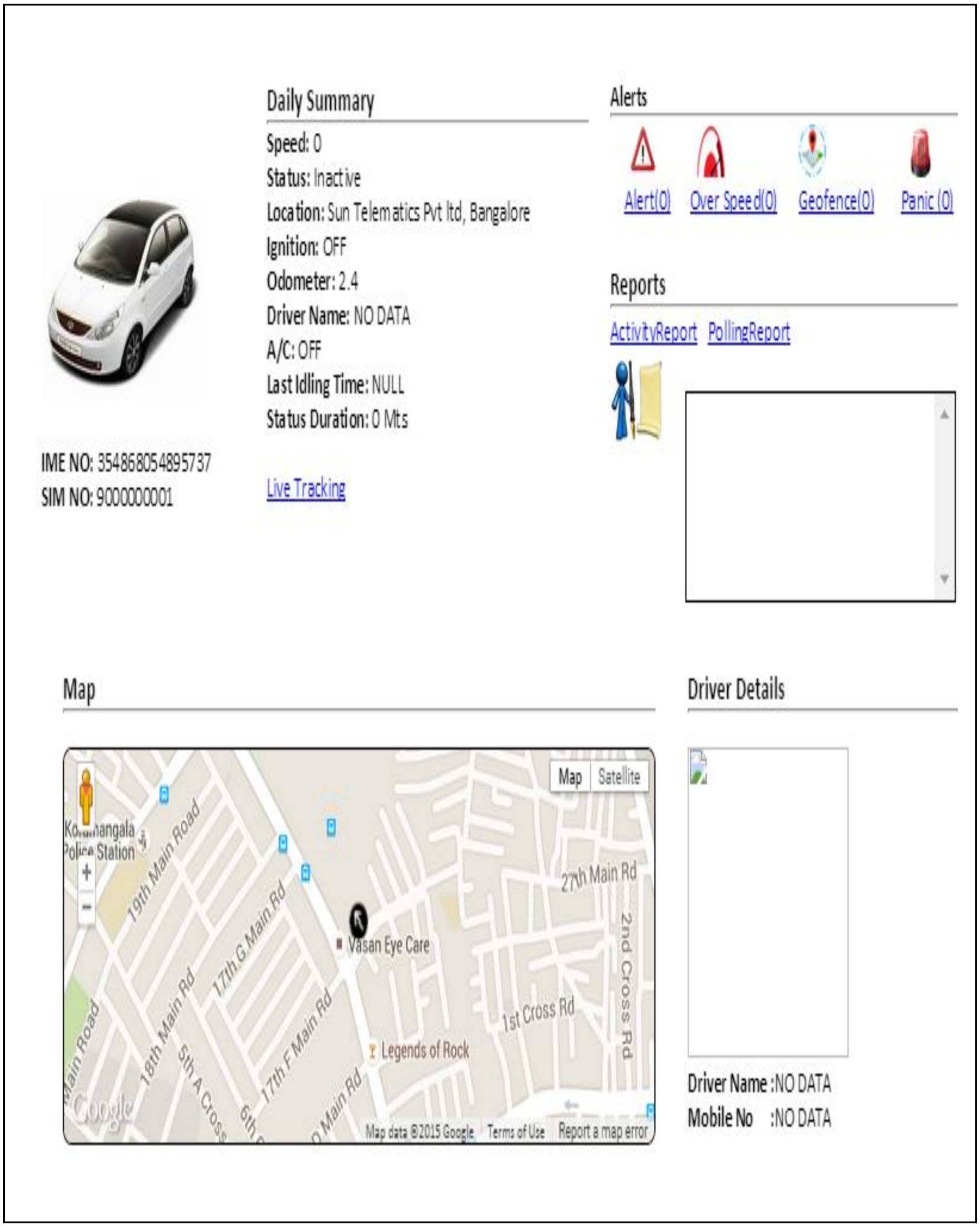

Fig. 5.7. Vehicle Located in Map

5.2 MATLAB Simulation Results

For detecting a vehicle headlight during night time, a novel algorithm using ANN (implemented with Vedic Neurons) classifier is proposed. The algorithm is simulated in MATLAB with few night time videos.

Fig. 5.8. Original Input Image

Fig. 5.9. Indexed Image

Figure 5.8 shows an original image which is taken using a color CMOS digital camera with a resolution of 16M pixel from Nikon. This original image is too big for processing, so it is resized to bring it down to 640 x 480 pixels. All further processing is done on this resized image.

Figure 5.9 shows an oncoming car with street light and some reflections. The target here is only the vehicle headlight and the nuisance lights are street light and reflected light which needs to be removed.

Figure 5.9 shows the indexed image of the original image. Here color mapping is carried out where red, green and blue color pixels are grouped together with their maximum pixel value.

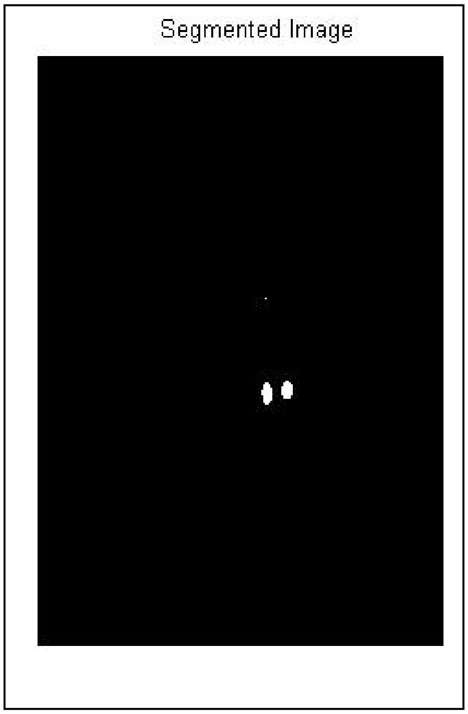

Fig. 5.10. Segmented Image

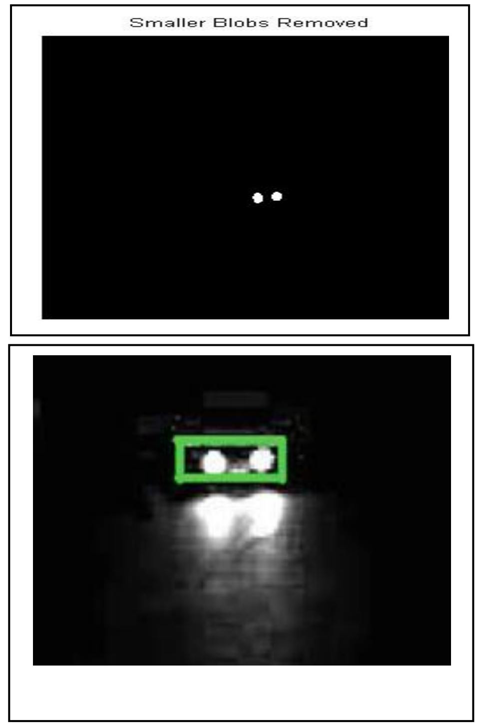

Fig. 5.11. Headlight Detected

Figure 5.10 is the segmented image of the original image. Color based Segmentation is carried out with adaptive thresholding to detect blobs. There are three blobs detected. Two are the vehicles headlight and one is the street light which is very small. This street light blob needs to be removed by cropping only the line of sight area.

Figure 5.11 shows a classified image. This image shows only the vehicles headlight detected.

CHAPTER 6

6 CONCLUSION

6.1 Conclusion

This era is an era of automation. The world is rapidly moving towards a wireless information age. Therefore, to cope up the vehicles have stated depending more on wireless technology for efficient and safe travel. Telematics uses embedded systems to acquire, process, store and distribute the information through wireless communication. Automatic Driver Assistance System (ADAS) has emerged rapidly to enhance the features of vehicles. Most of the Telematic systems were used initially to provide a user with the location, but slowly the application area of Telematic has widened and as of today it plays a very major role in vehicle and fleet management.

In this work, a robust Telematic system is designed and developed using the state of art technology. It provides location based services. The design is capable of providing several other services like status of ignition, AC, door, alert system, fuel, driver details etc. This work was mainly concentrated in acquiring GPS data and sending it to the server to find the location of vehicle. The other features are for future enhancement. The Microcontroller and IO selection has been done keeping in mind the future expansion of the system.

For the Auto Dipper application, a camera interface has been provided to take input from an external camera mounted in the windshield. A novel image processing algorithm has been proposed for this purpose. MATLAB simulations were carried out for vehicle headlight detection at night time using the proposed algorithm and found satisfactory.

A prototype unit has been designed and tested successfully for the functionality. The obtained data was plotted on a real time Google map.

6.2 Future Work

The Telematic unit can be minimized by using a single System-on-Chip (SoC), so that it can be fitted on the dashboard of any vehicle without occupying much area. This SoC shall embed all the requirements in a single chip thereby avoiding external ADC's, sensors, DSP modules etc.

Few future enhancement in the Telematic services are envisaged and listed below

- Data services
  - Software downloads
  - Content downloads
- Enhanced vehicle diagnosis & repair
- Expansion into other dimensions of vehicle lifecycle (manufacturing, vehicle development, design)
- Communications bandwidth
- Coverage (wireless)
- Vehicle penetration
- Vehicle integration (messaging)
- Reduced costs (hardware, service)
- Standards (Bluetooth, vehicle messaging)

Also, in place of the standard camera, a vision chip can be replaced which can directly compute the image and process it, thereby reducing the load on the Microcontroller.

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