AUTOMATIC CAR NAVIGATION SYSTEM WITH KALMAN FILTER ALGORITHM

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PROJECT

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AUTOMATIC CAR NAVIGATION SYSTEM WITH KALMAN FILTER ALGORITHM

A Project

by

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Abstract

of

AUTOMATIC CAR NAVIGATION SYSTEM WITH KALMAN FILTER ALGORITHM

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Automatic Car Navigation System gives us knowledge about the vehicle moving system. It mainly, gives us information how DC motor is controlled, and how it behaves when connected with H-bridge. H-bridge is interfaced with both DC motor and microcontroller and the operation of vehicle depends on the programming of microcontroller. For microcontroller we selected evaluation board which supports our microcontroller (ATmega328). The H-bridge selected for interfacing was L293D which is Quadruple Half H-Driver. When interfaced with GPS, the car moves in the given direction. The initial location and the destination location were defined in the GPS module. The main aim was to drive the car from the initial location to final destination. The GPS module selected for this purpose was EM-408 from US GlobalSat Incorporation.

Also we implemented Kalman Filter Algorithm, to cancel out the noise and errors in the GPS signal. While retrieving the GPS signal, it is effected by noise and certain errors, and this algorithm helps us out to cancel this effect. It uses mathematical equations

in which initial vector and state estimate are defined. After doing the initial assignments, we obtain observation and control vector and by using Kalman filter we get the updated state estimate. This value that we receive is taken into account and microcontroller takes this value and gives direction to the vehicle according to that.

_________________________, Committee Chair
Jing Pang, Ph.D.

____
Date

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I would like to thank Dr. Preetham Kumar, my second project reader for reviewing my report. He provided me valuable suggestions and corrections that helped me to improve my project report.

I would like to thank my family members and friends for providing me all the support, strength and inspiration while working on this project and helped me to pass this critical phase of my graduation. Finally, I would like to thank all the faculty members of the Department of Electrical and Electronics Engineering at California State University, Sacramento, with their help, support and knowledge they made my graduation successful.

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Chapter 1

INTRODUCTION

1.1 Introduction to Car Navigation System

Automatic car navigation system is a very wide field, which helps us understand how a vehicle moves. Programming the microcontroller, and interfacing it with the H-bridge aids us to control the motor of a vehicle. Also, understanding various driving mechanism gives us a broad overview of car navigation system. Programming the microcontroller assists us for providing the desired movement and controlling of motors by switching them on and off for particular track following. Global Positioning System (GPS) is becoming more popular and advanced day by day. Its main aim is location tracking and providing us the best route to reach to that point. As we know, GPS signals are radio signals and they are affected by noise and certain factors. Filtering these signals by using mathematical algorithms makes it easier to remove certain noise and errors that gives us optimized signals. We make use of the Kalman filter algorithm for smoothing out GPS signal from noise and errors.

1.2 Purpose of the Project

The main purpose of the project was to make a Car Navigation System which moves in giving coordinates provided by GPS. Also, the interfacing of microcontroller and H-bridge and programming the microcontroller, play an important role in controlling the motor of the vehicle so that it can follow the path given by the GPS. Also to filter out the GPS signal or data by using Kalman filter algorithm provides a smooth signal for the vehicle.

1.3 Significance of the Project

The significance of this project is how to lower the noise and error signals that we receive while collecting the GPS data, also how to control the motor of the vehicle to provide a smooth driving mechanism and how to use h-bridge to controls the motor for providing a particular direction based on the microcontroller programming. As we know, all radio signals are being affected by some errors and noise signals, filtering them out to get the desired signal is significant for any project to work properly.

1.4 Organization of Report

Chapter two contains basic concepts of the Global Positioning System (GPS) which helps us understand how GPS interacts with the satellites revolving around the orbit and captures data for location tracking.

Chapter three gives information about Kalman filter algorithms that is used car navigation system for smoothing out the noise and various errors in the GPS data when it is receiving the data while moving.

Chapter four contains information about the microcontroller used in open source electronic board which helps us in interfacing it with the GPS module and H-bridge for motor controlling. Main programming is done in microcontroller to help control the DC motor with the GPS data and help driving the mobile platform to desired location.

Chapter five give us details how a mobile platform is made and what are the different type of driving mechanism can be used for a car to navigate. It also gives information about the DC motor, how it operates and general mechanism used inside it which is responsible for a vehicle to move.

Chapter six gives us details about H-bridge, how it is interface with the microcontroller and DC motor. It is H-bridge only which helps in rotating the motor in the given direction. It is the main control source for the driving the motor. Chapter seven gives us the designing of the project and how algorithms were used to control the vehicle movement. It also gives us the simulation graph which helps us understand the importance of Kalman filter algorithm. The program for simulation and motor control are provided in the attachment section. Chapter eight is the conclusion of the project, limitations and future work.

Chapter 2

GLOBAL POSITIONING SYSTEM

2.1 Introduction to GPS

The Global Positioning System (GPS) is a satellite based navigation system that provides reliable position and time information, which sends and receives radio signals. A radio navigation system formed from 24 satellites revolves around the Earth's orbit. The GPS satellite transmits signals to the receiver equipment on Earth and the GPS receivers acquire these signals to provide us necessary information. Every GPS operation must be accurate, so every satellite has an atomic clock on-board [1][2].

All GPS satellites synchronize their operation and indicate the current location and time. These signals travel at the speed of light and reaches to the receiver at different times. The receiver estimates the distance of the satellites from its location by the amount of time it takes to acquire the particular signal, thus calculating its position. It requires at least 4 satellites to calculate its position [4].

GPS technology consists of three segments:

1. Space Segment
2. Control Segment
3. User Segment

Control segment is responsible for maintaining the health and integrity of the satellite signals. It updates the satellite regularly for maximum user accuracy. The user segment consists of the GPS receivers, which in turn provide us the current location [3].

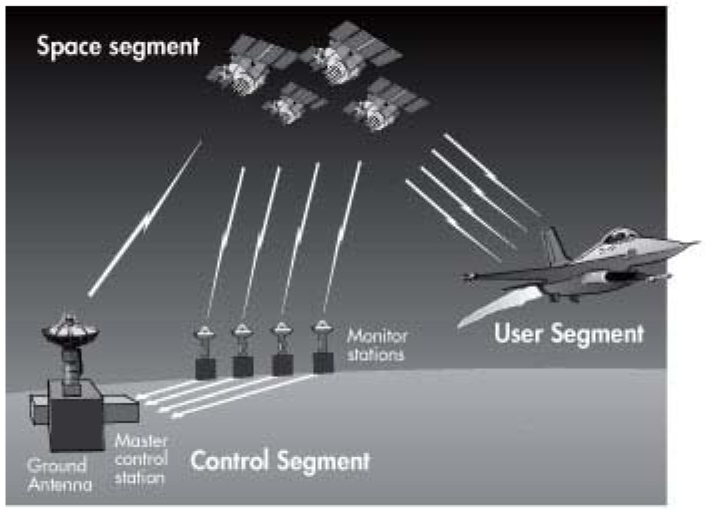


Figure 2.1. Basic GPS technology [3]

2.2 How GPS Works?

A GPS satellite signal contains following information:

1. About the satellite transmitting the signals.
2. Ephemeris data (Precise location of the satellite)
3. Working status of the satellite
4. Date and time of the signal transmitted.

As we know, control segment maintains health and integrity of the signals. In addition, it monitors GPS constellation. This information is uploaded to the satellites, which provides maximum user accuracy. The GPS receiver collects all information in the satellite. With different satellite signals, it can calculate its current location and time. With use of some algorithms, we can check various noise and error signals in GPS receiver to get precise location and time [4].

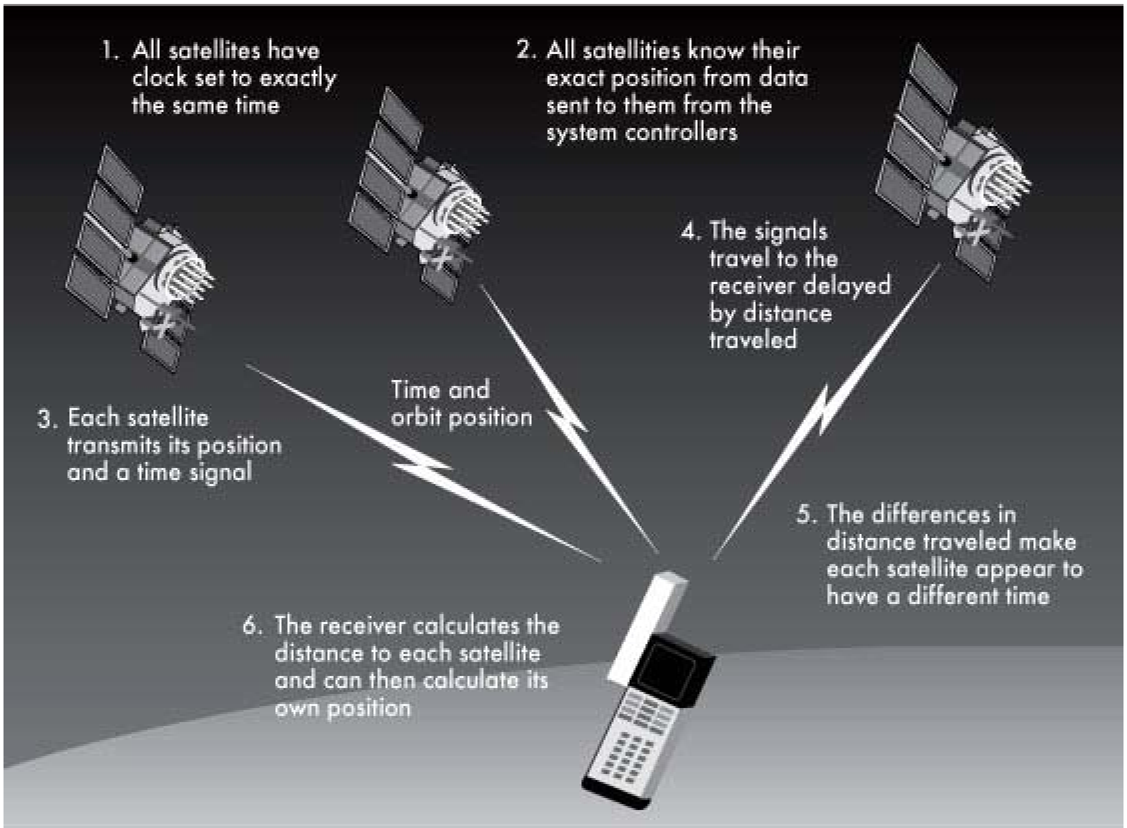


Figure 2.2. GPS Working [3]

2.3 GPS Receiver

For our project, we used the EM-408 GPS receiver. It maintains high reliability and accuracy. It has a built-in antenna but we can also connect an external antenna. It is a 20 channel receiver with extremely high sensitivity (-159dBm). It is compact in size and provides us very fast TTFF, that is, Time to First Fix at low signal levels. It has a 30' positional accuracy (about 10m). It is a 5-pin interface and they are [5]:

1. VCC: This is the main DC power supply (around 3.3V).
2. TX: Microcontroller receives information from this pin, as it is the main transmit channel.
3. RX: This pin captures information from the satellite, as it is the main receive channel.
4. GND: It is connected to ground.

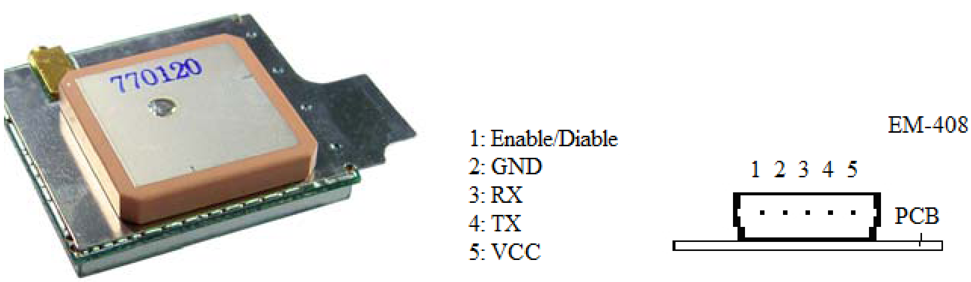


Figure 2.3. EM-408 GPS Receiver [5]

To plug the EM-408, we made use of evaluation board, which had ATmega328 microcontroller. It has 20 pin input/output channels and provides TX and RX connection for the GPS module [5].

Chapter 3

KALMAN FILTER

3.1 Introduction to Kalman Filter

Filtering is very essential in engineering and embedded systems. For example, radio communication signals can be corrupted by noise signals and interference. Filtering these signals, therefore provides us useful information and taking out the unnecessary disturbances. As we know, GPS is a satellite based navigation system, which helps us to point the exact location on the Earth. GPS system transmits and receives radio signals, which help us to determine the location and the velocity. However, certain factors interrupt GPS signals and can degrade the GPS position from few meters to tens of meters. These errors can be [6]:

1. Ionospheric
2. Atmospheric delays
3. Satellite and receiver clock Errors
4. Multipath
5. Dilution of precision
6. Selective Availability (S/A) and Anti-Spoofing (A-S)

These errors can be reduced and more accurate co-ordinates can be obtained by using recursive Kalman Filter. “The Kalman filter is a set of mathematical equations that provides an efficient computational (recursive) means to estimate the state of a process, in a way that minimizes the mean of the squared error”. The Kalman filter is a linear dynamic system in which disturbances are modeled by Gaussian random process. The Kalman filter produces both unbiased and minimum variance estimates of the state. Estimation with minimum variance means that the expected value of the squared error between the real and estimated states is minimized. The Kalman filter algorithm can be used for both discrete and continuous time model.

3.2 Analysis of Location Estimation

GPS is used for location tracking and relies on the radio signals from orbiting satellites. These radio signals are detected by the GPS receiver and calculate their location on the earth. Since these signals are affected by many errors, we use the Kalman filter and velocity estimation to reduce error in GPS signals and get better accuracy [7].

Consider the following equation [7].

$$S(k) = (X(k), Y(k), V_x(k), V_y(k))^T \quad \ldots\ldots (3.1)$$

Where X (k), Y (k) are coordinates (x and y) of GPS location at time k, V_x (k), V_y (k) are directional velocities of a GPS receiver at time k.

Kalman filter state model is given in equation 3.2 [7].

$$S(k) = AS(k) \quad \ldots\ldots (3.2)$$

$$A = \begin{bmatrix} 1 & 0 & d & 0 \\ 0 & 1 & 0 & d \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad \ldots\ldots (3.3)$$

Where A is transformation matrix between first and next measurement.

From both the equation, the Kalman filtering predicts and the minimum predicted Mean Square Error can be calculated and are given below. [7]

$$S(k|k-1) = AS(k-1|k-1) \qquad (3.4)$$

$$M(k|k-1) = AM(k-1|k-1)A^T + BQB^T \qquad (3.5)$$

$$B = \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ d & 0 \\ 0 & d \end{bmatrix} \qquad (3.6)$$

Where B is optional control input to current state, Q is dynamic noise.

Kalman gain is given in equation 3.7 [7].

$$K(k|k-1) = M(k|k-1)H^T . \{R + HM(k-1|k-1)H^T\}^{-1} \qquad (3.7)$$

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \qquad (3.8)$$

Where R is receiver noise

H is measurement sensitivity matrix

Finally, the estimate vectors are given as [7].

$$S(k|k) = AS(k|k-1) + K(k)\{L(k) - H(k)AS(k|k-1)\} \qquad (3.9)$$

$$L(k) = (l1(k), l2(k))^T \qquad (3.10)$$

Where l1 (k) and l2 (k) are coordinates of estimated GPS location.

3.3 The Discrete Kalman Filter Algorithm

The Kalman filter estimates the process by using a feedback control. It filter predicts the process state at some time and obtains a noisy measurement as feedback. Thus, the Kalman filter equation falls in two groups: time update and measurement update equations. Measurement update equations are used for feedback while time update equations are used for forwarding the next state. Time update equation can be considered as a predictor equation while measurement update as a corrector equation, thus forming predictor-corrector algorithm [9].

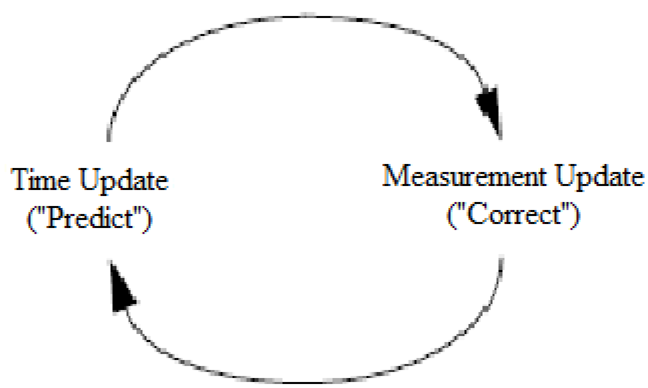


Figure 3.1. Discrete Kalman filter cycle [9]

Update time equation project the state and covariance steps forward form time k-1 to k. The equations are given below [9].

$\hat{x}_k^- = A\hat{x}_{k-1} + Bu_k$
$P_k^- = AP_{k-1}A^T + Q$

Table 3.1. Discrete Kalman filter time update equation [8] [9]

The measurement update equations are given below:

$K_k = P_k^- H^T (HP_k^- H^T + R)^{-1}$
$\hat{x}_k = \hat{x}_k^- + K_k(z_k - H\hat{x}_k^-)$
$P_k = (I - K_k H)P_k^-$

Table 3.2. Discrete Kalman filter measurement update equations [8] [9]

For the measurement update equation, the first task is to calculate the Kalman gain K_k. After calculating gain, the next step is to calculate z_k, and generate a posteriori state. The final equation then estimates the posteriori error covariance.

The process is repeated after each time and the pair of measurement updates with previous posteriori estimates is used to get the new priori estimates. This is known as the recursive nature of the Kalman filter. The following diagram shows all the operations of the filter.

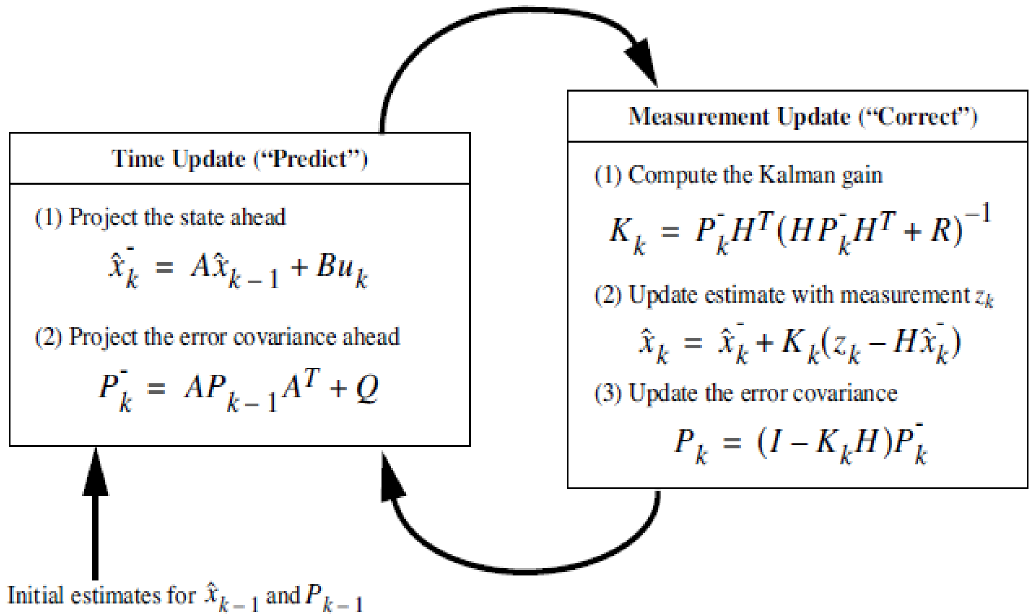


Figure 3.2. Discrete Kalman Filter Algorithm [8] [9]

Chapter 4

MICROCONTROLLER

Microcontroller is a computer-in-a-chip, consisting of a relatively simple CPU, clock, timer, I/O ports and memory, which control electronic devices. In contrast to microprocessors, they are designed for embedded applications. They are dedicated to one task and run one program at a time. They use ROM to store this program. They are also low power devices. It is a dedicated input device.

4.1 ATmega328 Microcontroller

For this project we used ATmega328 microcontroller. It is a low power CMOS 8-bit microcontroller. It has AVR enhanced RISC architecture. Since it executes instruction in single clock cycle, it achieves a throughput of 1 MIPS per Hz. Because of high throughput, we can optimize power consumption against processing speed [10].

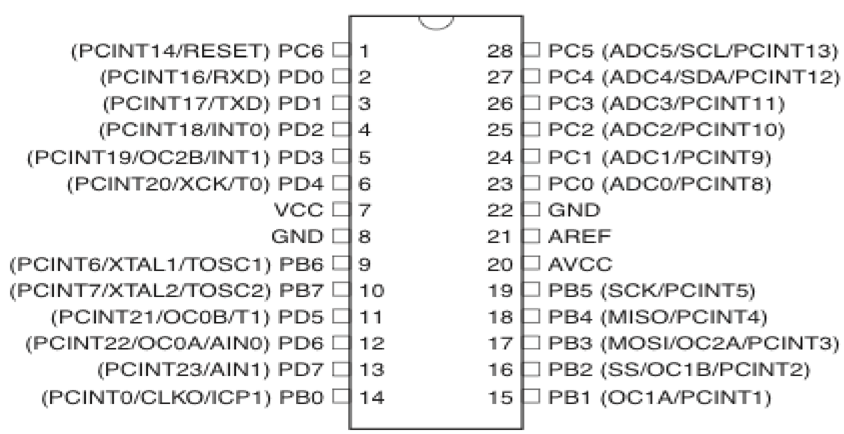


Figure 4.1. Pin diagram of ATmega328 [10]

ATmega328 contains AVR CPU. It is based on Reduced Instruction Set Architecture (RISC) and contains 32 general-purpose registers. They are directly connected to Algorithm logic unit (ALU), meaning that in one clock cycle, two independent registers can be accessed. It has Read-Write capabilities with 8Kbytes of In-System Programmable Flash. It has 1K bytes of EPROM and 2K bytes of SRAM [10].

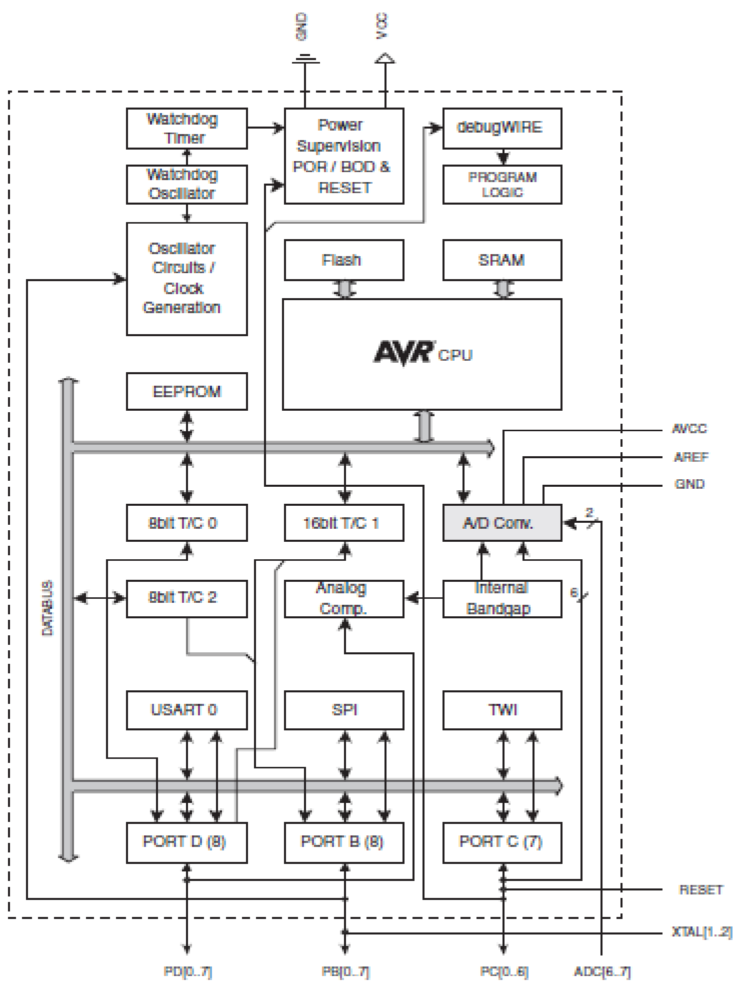


Figure 4.2. Block diagram of ATmega328 [11]

Comparison between different microcontrollers in the same group shows that they vary in memory size, boot loader support, and interrupt vector size.

Device	Flash	EEPROM	RAM	Interrupt Vector Size
ATmega48PA	4K Bytes	256 Bytes	512 Bytes	1 instruction word/vector
ATmega88PA	8K Bytes	512 Bytes	1K Bytes	1 instruction word/vector
ATmega168PA	16K Bytes	512 Bytes	1K Bytes	2 instruction words/vector
ATmega328P	32K Bytes	1K Bytes	2K Bytes	2 instruction words/vector

Table 4.1. Comparison between different Microcontrollers [10]

In order to connect the GPS module with the microcontroller, we need an evaluation board. For this, we used an electronic board for connecting them together. Based on the hardware and software it makes it easy to make use of these boards and we can design and create any working environment. The evaluation board is ATmega328 based microcontroller board. It has inbuilt 16 MHz oscillator, an USB connection, a power jack and a reset button. It has 20 pins out of which 14 can be used as digital input/output pins and 6 analog inputs. Out of 14 digital pins, 6 can be used as PWM outputs. It allows faster transfer rates.

Internal features of evaluation board are listed below.

1. Power: Atmel evaluation board can be powered by either external power supply or USB connector. The board operates between 6V and 12V. If less power is supplied the board will not work properly and irregular data will be given out. If more power is given, it can damage the board with overheating.

2. It has 4 different power pins VIN, GND, 5V, 3.3V
3. Memory: It has 2K bytes SRAM, 1K bytes EPROM and 32KB bytes Flash out of which 0.5KB is used as boot loader.
4. Input and Output Pins. It has 14 digital pins that can be used as either input and output. Out of which 6 can be used as PWM output. Operating voltage for each pin is 5V. In addition to this, it uses RX pin to receive and TX pin to transmit serial data.
5. Reset: It allows microcontroller to reset.

Chapter 5

MOBILE PLATFORM

After selecting the GPS module and microcontroller, we needed a mobile platform to implement both of them. Both GPS module and microcontroller were connected with each other. For the mobile platform, we made a moving car with four motors working on differential drive mechanism. We needed an H-bridge, which was to be connected with the car along with the evaluation electronic board.

5.1 Differential Drive Mechanism

When a vehicle is turning at the corners, its wheels rotate at different speed. Differential drive is a mechanism in which equal torque is provided to both wheels so that they can turn at different speeds. Vehicles without differential mechanism tend to damage its wheels as both tires rotate at the same speed. Differential drive mechanisms can be easily implemented both from a software and a hardware point of view. It divides the torque between the wheels so that it ensures balance by making them drive at different speeds.

When a motor encounters different loads on it, its speed varies and eventually the vehicle will turn even if it is adjusted to go straight. This means that motor velocity must be controlled dynamically, that is, to monitor and change the motor speed while it is running. One way of controlling this or providing dynamic motor control is by using

Feedback Control Loops. We can use either open loop control algorithm or closed loop algorithm. Pulse Width Modulation controlled motor is an example of open loop control scheme. For position control or true velocity algorithm, we use closed loop control scheme [11].

Differential drive mechanism is used in four-wheel drive pickups. It is usually a rear-wheel drive system. Transmission plays an important role and the front shaft turns the front axle while other turns the rear one. In four-wheel drive, the front driveshaft locks to the rear drive shaft so that axle receives equal torque from the engine. Both the front and the rear have open differential. It has two main drawbacks:

1. Because of locked phase, it is very difficult to use it on roads.
2. Since it applies equal torque between each of the two wheels, if anyone comes off the ground, torque applied drops down to zero. This means the other wheel also gets the equal torque, which is zero even it has plenty of traction. Therefore, no torque is applied.

Differential mechanism has three main tasks to perform:

1. It provides power to the wheels.
2. It slows down the rotational speed of the transmission by acting as a final gear reduction.
3. As the name appears, it transmits power to the wheels while they are rotating at different speed.

5.2 Synchro Drive Mechanism

In a synchro drive mechanism, all four wheels drive and steer together. All wheels are connected in such a way that all points in the same direction. To change direction, all wheels rotate simultaneously on the same axis. Thus, the car changes it direction but its whole body, that is, chassis points to the same direction. The synchro drive mechanism overcomes many problems that we face in differential drive mechanism [11].

5.3 DC Motor

An electric motor is one, which converts the electrical energy into mechanical energy. We have DC motors and AC motors, where AC motors are used for large machinery. DC motors are suitable for small jobs and thus we are using them in our mobile platform. DC motors usually provides high speed and low torque. In order to reverse it, we connect the motor shaft to the gear train, which causes motor to rotate slowly thus delivering more torque than before. A DC motor has two electrical terminals. The direction of rotation is controlled by applying voltage across the terminal. If positive voltage applied, the wheel rotates in one direction and by reversing the polarity of the voltage applied, the wheels rotate in opposite direction. Servomotor with two electrical terminals is one type of DC motor. It uses an integrated chip for position control, a potentiometer for position feedback and a gear train, which limits the shaft to turn. It uses the electric current to direct the motor to rotate into a particular direction [11] [12].

As we know, a motor converts electrical energy from a voltage source into mechanical energy, that is, rotation. When a current carrying wire is kept in a magnetic field, it experiences force on it. The force is directly proportional to the amount of current flowing in the wire, length of the wire and strength of the magnetic field [12].

Force = current * wire length * magnetic field…………………… (5.1)

The direction of the force is determined by the direction of the current flowing and direction of the magnetic field. It makes use of right hand rule to determine the direction of the force.

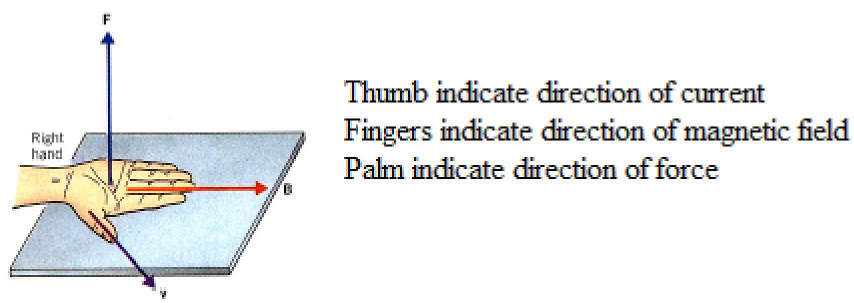


Figure 5.1. Right Hand Rule

The armature winding in the motor carries the motor current, also known as armature current. To develop constant torque as the rotor moves, armature coils are connected to dc circuit. The motor torque depends on the interaction between the magnetic field and armature current [12].

$T_e \alpha I_a$ .... (5.2)

The motor speed is dependent on the magnetic field developed across the armature conductor.

$$E_a \propto \omega_m \qquad (5.3)$$

Figure 5.2 shows a separately excited DC motor. The DC motor controls the magnetic field and the motor torque. It can be operated in two modes: constant torque operation and constant power operation as shown in figure 5.3.

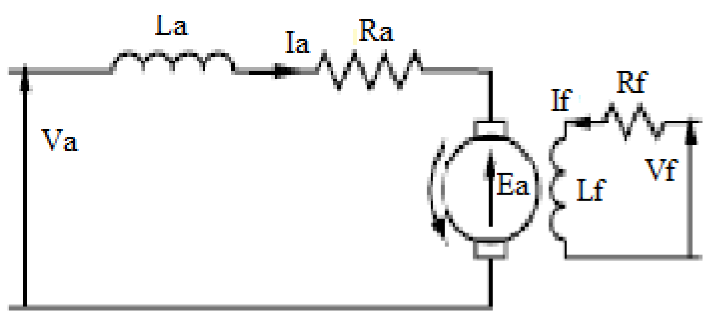


Figure 5.2. Separately excited DC motor [13]

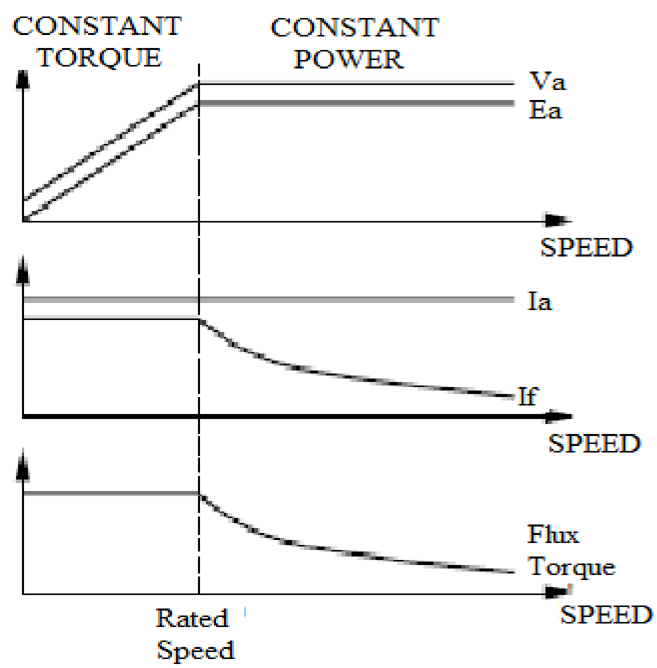


Figure 5.3. DC motor operating condition [13]

DC motor operation can be divided into four quadrants depending on the applied voltage polarity. In normal operating mode, both E_a and I_a are positive and are operating in first quadrant. The second quadrant is said to be breaking or regenerating mode. When reducing V_a ,E_a and making I_a negative, we can get the desired operation. By applying reverse polarity-voltage, third and fourth quadrant operations are achieved. Thus by controlling armature voltage and current polarities, all four quadrant operations can be achieved [13].

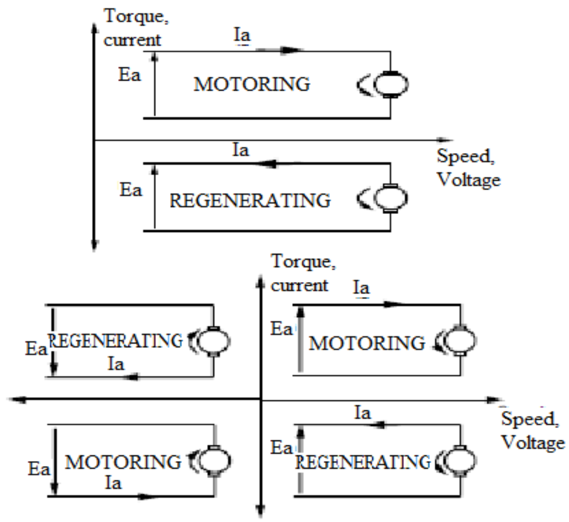


Figure 5.4. Torque speed characteristics for DC motor [13]

Chapter 6

H-BRIDGE

An H-bridge is an electronic circuit, containing four switching elements, which enables a voltage to be applied across a load in either direction, in an H like configuration. This circuit allows DC Motor to run clockwise or anti-clockwise. Basic structure of H-bridge is given below [14].

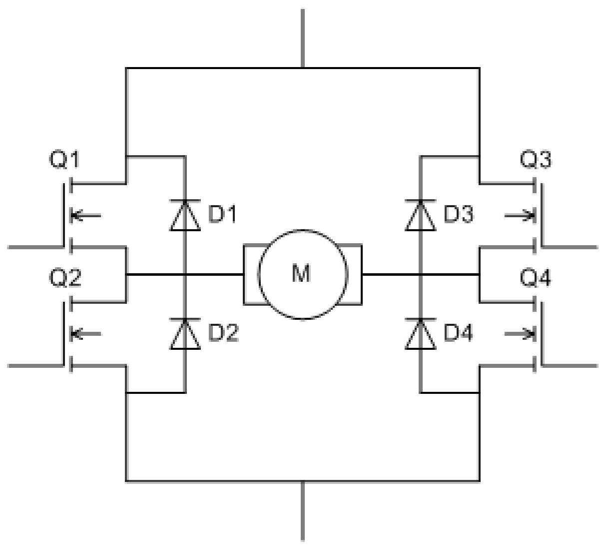


Figure 6.1. Basic structure of H-Bridge [14]

It contains four switching elements namely Q1, Q2, Q3, Q4 along with four diodes D1, D2, D3, D4 which are called Catch Diodes.

6.1 Construction

Typically, an H-bridge is constructed by using reverse polarity devices. The important factors to be taken into consideration are the operating current, the operating voltage and the switching frequency (PWM i.e. Pulse Width Modulation). Generally we can use PNP BJTs/ P-channel MOSFETs which are connected to the high side (VCC) and NPN BJTs/ N-channel MOSFETs which are connected to low side (GND). [14]

MOSFETs when working as a switch has two states. One in ON state and the other is in OFF state. MOSFETs with lower rdson, that is, the channel resistance is better. Higher value of rdson, higher are the losses, which dissipates more heat. Hence, lower rdson is better. [14]

N-channel MOSFET has lower rdson. Therefore, N-channel transistors are always used as switch is connected to ground, while the high side switch connected to VCC can be either N-type or P-type depending upon the operating conditions. For high frequency operation, P-channel MOSFETs are mainly used as high side switches where switching loss is significant. For lower frequency operation, high current operation N-channel MOSFETs are used where switching loss is not a problem. [14]

Catch diodes are not important in the design but they provide a low resistance path for collapse current to the motor to provide a reasonable voltage. When a switch is turned off, electromagnetic field generated in the motor winding, due to on-time condition, collapses but current still flows through it. Thus catch diodes provide a path for this collapse current which keeps a reasonable amount of voltage on the motor. The diodes should have short turn-on delay, thus Schottky-type diodes are generally used [14].

6.2 Operation

When Q2 and Q3 are turned on, the left lead of the motor is connected to ground and the right lead to the power supply. This energizes the motor which results in a clockwise rotation of the motor, that is, in forward direction and the shaft starts spinning. Similarly if Q1 and Q4 are turned on, the right lead is connected to ground and the left lead to power supply, energizes the motor in reverse direction, that is, anti-clockwise direction [14].

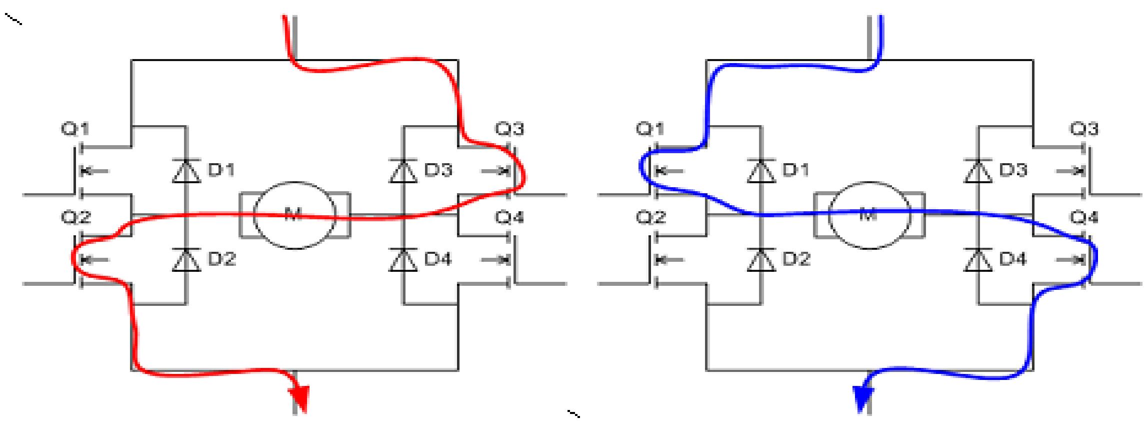


Figure 6.2. Current flow of H-bridge [14]

6.3 Drive Modes

When one high side and opposite low side switch are turned on, its shows the on-time behavior. The low side allows current to flow through the motor. For off-time behavior Q1 and Q2(or Q3 and Q4) should not be turned on at the same time. Thus providing three dfferent operating conditions; high level means Q1 or Q3 on, low level means Q2 or Q4 are on, mid level means none conducts. “It is important to note that actual drive voltage depend on the component selection (‘P’ or ‘N’-type high-side MOSFETs), and that two independent driving signals will have to be generated for two transistors” [14].

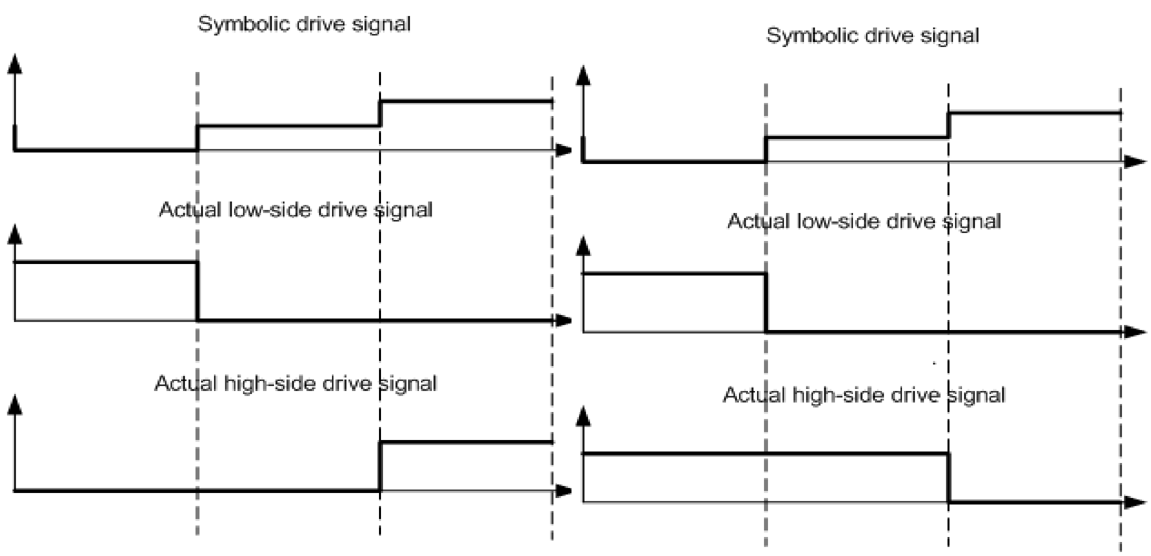


Figure 6.3. Symbolic and actual drive signals for both MOSFETS [14]

6.3.1 Sign/Magnitude Drive

It is the simplest drive mode in which one high-side and one opposite low-side switch are open. The remaining two are closed and the motor current increases during the period from 0 to its maximumvalue [14].

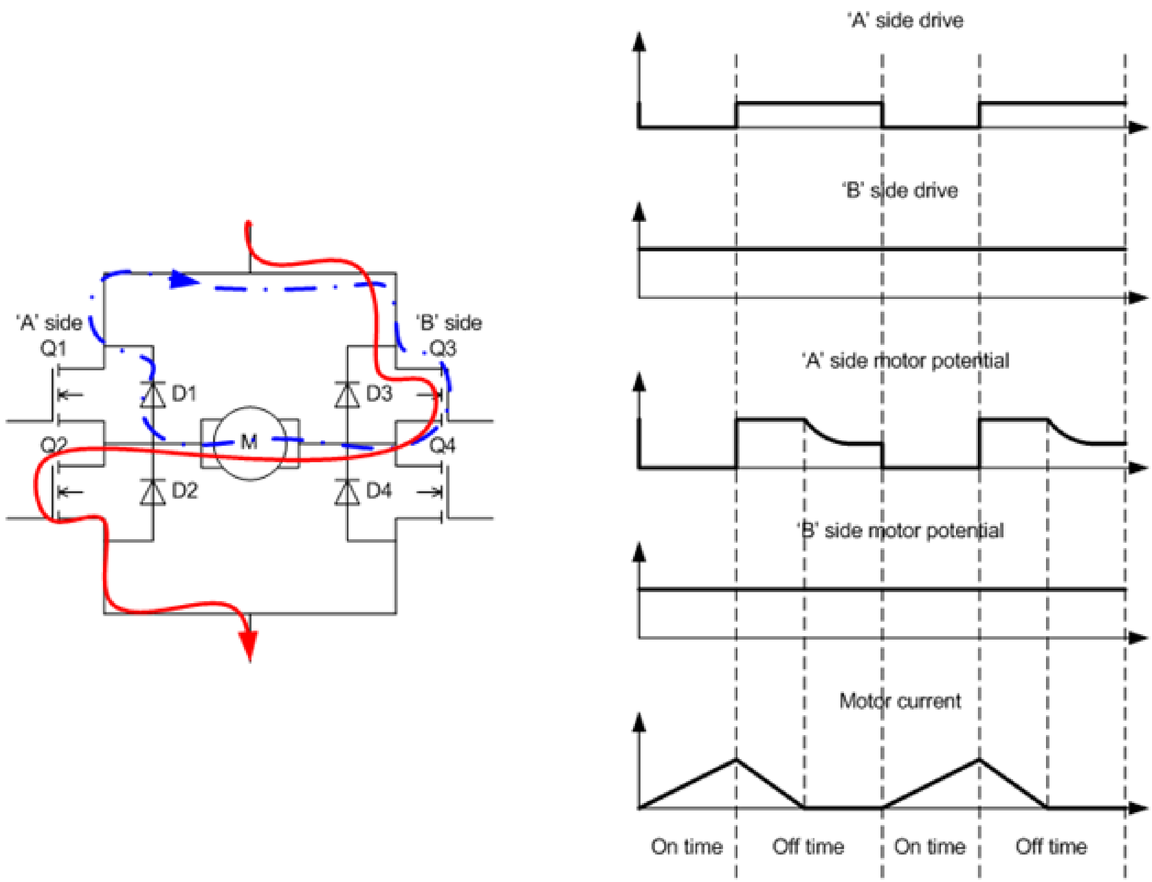


Figure 6.4. Sign/Magnitude Drive operation and waveform [14]

6.3.2 Lock Anti-Phase Drive

The on-time behavior is the same as the Sign/magnitude drive but during off-time motor is energized in reverse direction also. Thus it removes all the stress from the catch diodes. Q2 and Q3 conducts in on-phase while Q1 and Q4 conducts during off-time [14].

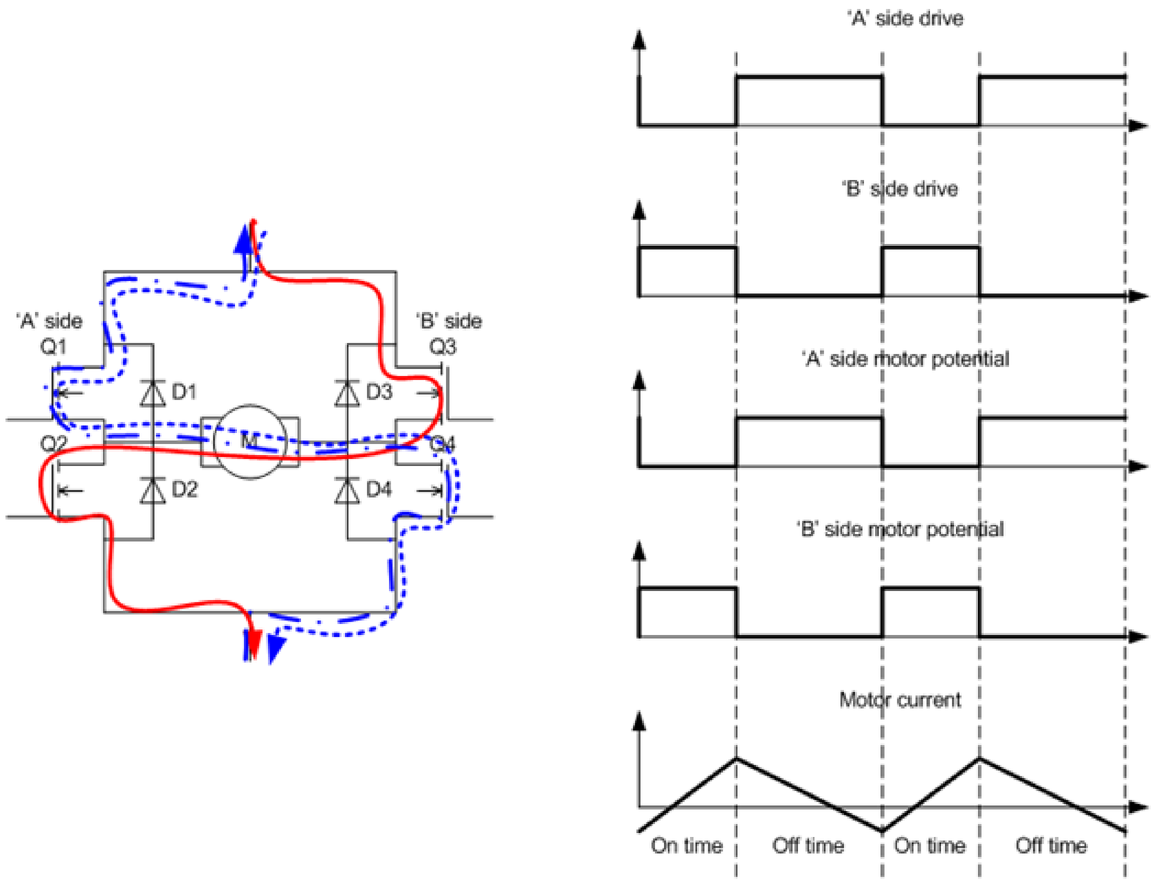


Figure 6.5. Lock anti-phase drive operation and waveform [14]

6.3.3 Active Field-Collapse Drive

It is the modification of lock anti-phase drive in which during the off-time, battery is connected to motor in the reverse direction, which provides a faster time for the diodes to collapse the field. The only thing taken into consideration is that the motor current should not be too negative [14].

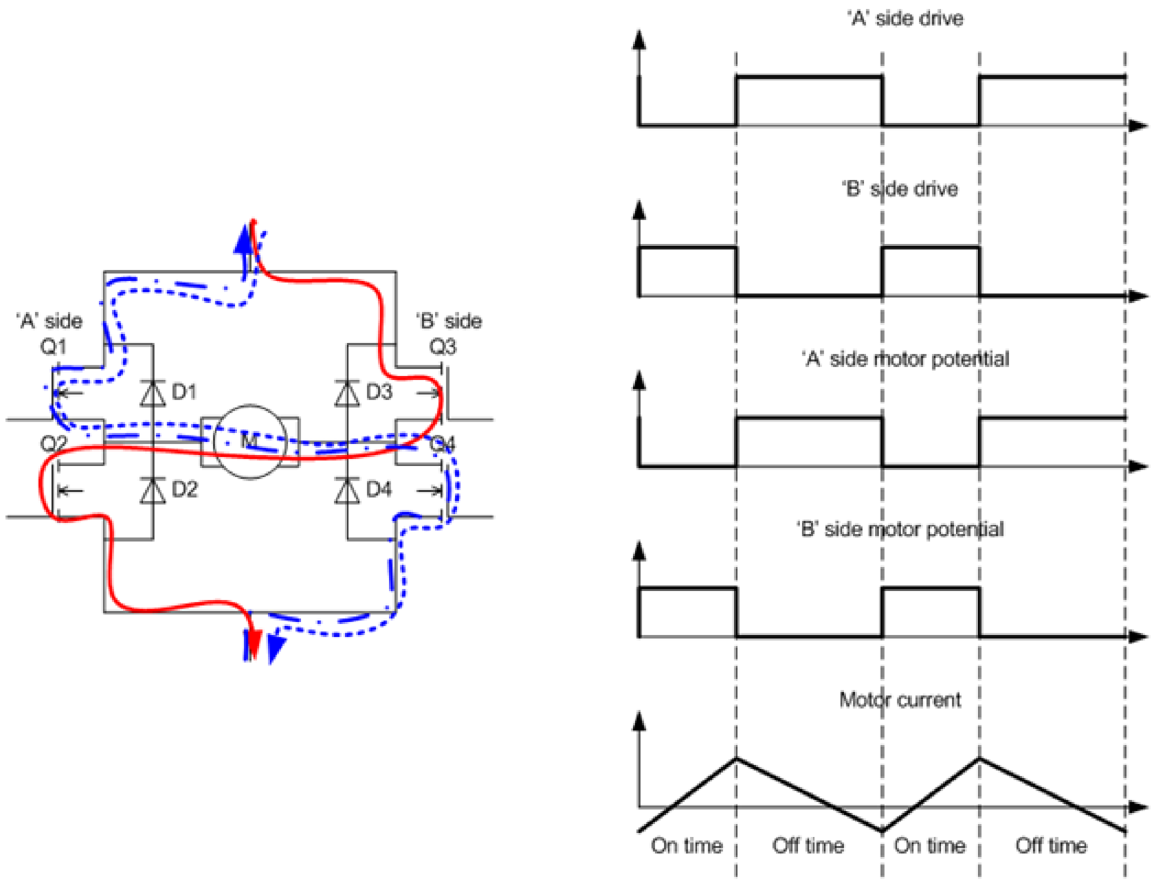
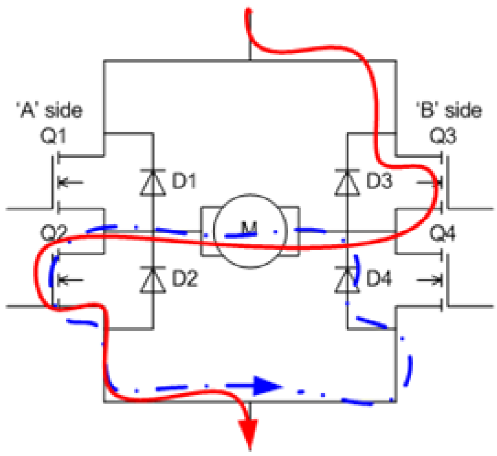


Figure 6.6. Active field-collapse drive operation and waveform [14]

6.3.4 Modified Active Field-Collapse Drive

As the name suggests it is the modification of the above drive. In this catch diode D3 does not conduct only D4 conducts and provides a faster collapse current to the motor. Also it dissipates siginificant less power than Sign/Magnitude drive [14].



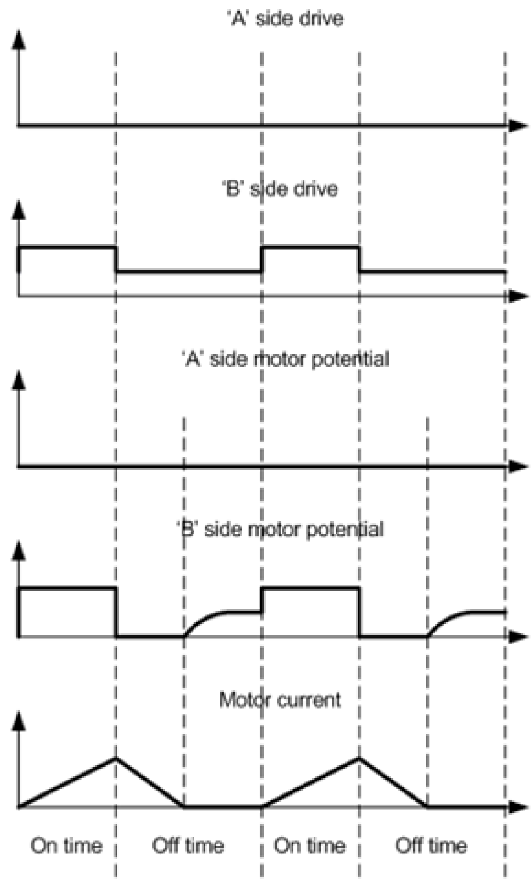


Figure 6.7. Modified active field-collapse drive operation and waveform [14]

6.4 L293D

For our project, we selected L293D as H-bridge integrated chip. It is a quadruple high current half H-bridge. It is similar to L293, the only difference is they provides different bidirectional drive current. L293 provides 1A of bidirectional drive current while L293D provides ~600mA from 4.5V to 36V. Both are designed to drive inductive loads, such as motors in our case. All inputs are compatible to TTL while all outputs are totem-pole drive circuits. Drivers are enabled and when they are high, ouputs are active and in phase with the inputs. And when enabled low, ouptuts are inactive and are in high impedance state. Pin diagram of L293D is given below [16].

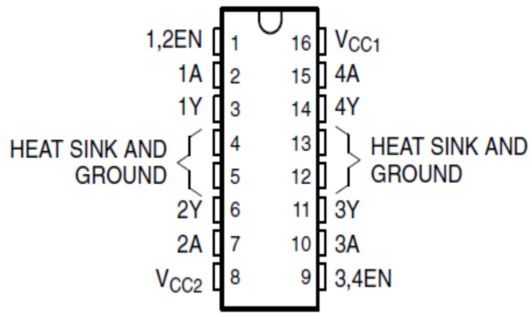


Figure 6.8. L293D pin diagram (NE Package) [16]

Drivers 1 and 2 are enabled by pin 1,2EN and drivers 3 for 4 by 3,4EN pin. With this we can form a full H bridge revesible drive which is suitable motor application.

It also has an internal ESD protection with wide voltage range from 4.5V to 36V. it also has separate input logic supply. Also it provides high niose immunity inputs. It provides thermal shutdown and also has ouput clamp diodes to provide Inductive Transient Suppression. Both VCC1 and VCC2 terminals are separated to minimize device power dissipation. The general block digram of L293D and its functional table for each driver are given below [16].

INPUTS†		OUTPUT
A	EN	Y
H	H	H
L	H	L
X	L	Z

Table 6.1. Function Table of L293D (each driver) [16]

Where

H: High-Level

L: Low-Level

X: Irrelvant State

Z: High Impedance State (off)

BLOCK DIAGRAM

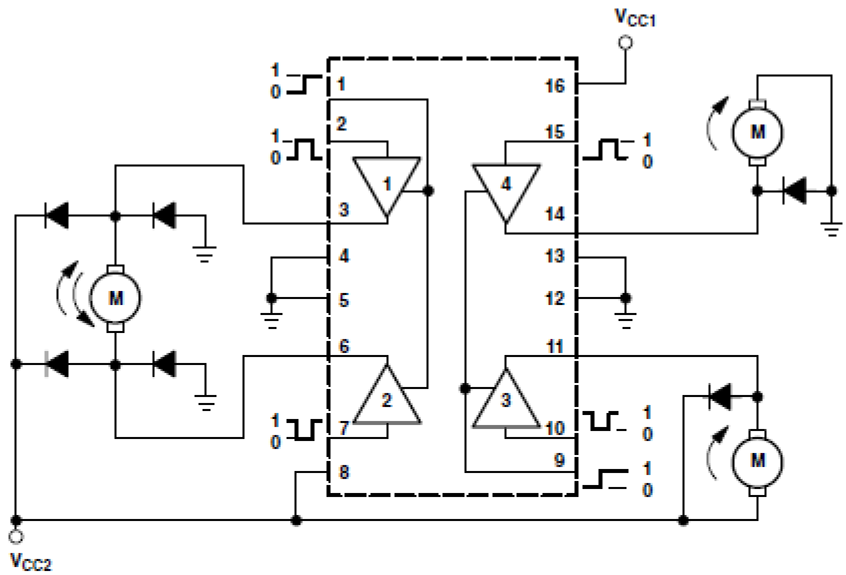


Figure 6.9. Block diagram for L293D [16]

We used circuitry in figure 6.9 for controlling the motor for our mobile platform. Since we need a differnetial drive mechanism and bidirectional DC motor control, programming the H-bridge provides us the given ouput.

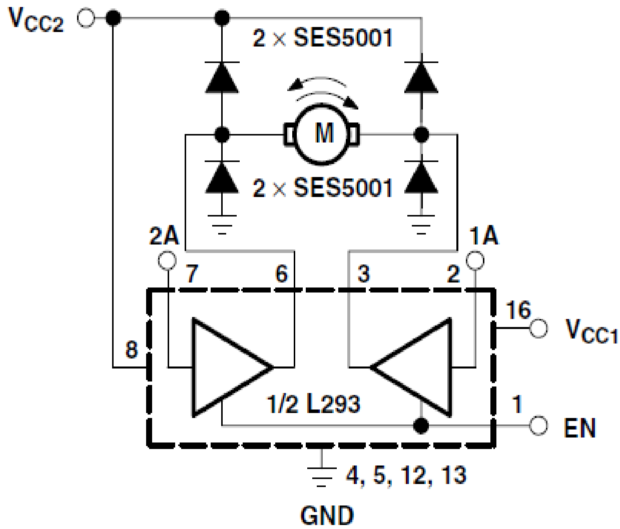


Figure 6.10. Bidirectional DC motor control. [16]

EN	1A	2A	FUNCTION
H	L	H	Turn right
H	H	L	Turn left
H	L	L	Fast motor stop
H	H	H	Fast motor stop
L	X	X	Fast motor stop

Table 6.2. Functional Table for Bidirectional DC Motor [16]

Interfacing H-bridge with the micrcontroller and programming it on the basis of the function table provide us the desired output. Since we are using evaluation board for the microcontroller, we interface our H-bridge with the elcronic board. Here is general connection of the H-bridge with the elctronic board for just one motor.

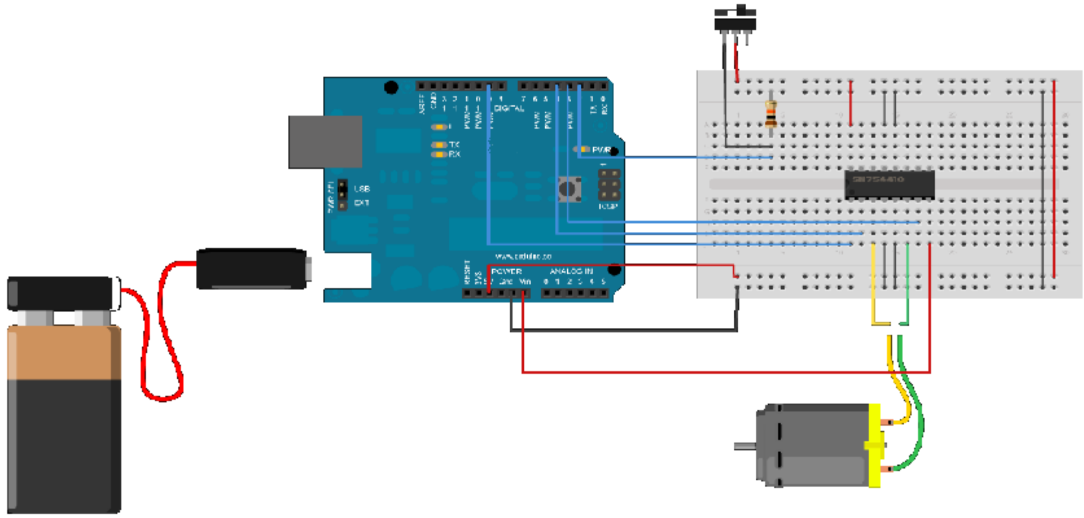


Figure 6.11. Interfacing of hardware

Pin 1 is gives PWM output from electrnoic board. (BLUE WIRE)

Pin 2 and 7 gives digital inputs form the electronic board. (BLUE WIRE)

Pin 3 and 6 are connected with the motor. (YELLOW AND GREEN WIRE)

Pin 4 and 5 are grounded. (BLACK WIRE)

Pin 8 is given as the voltage input. (RED WIRE)

Chapter 7

DESIGN AND SIMULATION

7.1 Microcontroller and H-bridge

After finally selecting the evaluation board for microcontroller and h-bridge and interfacing them together as shown in figure 6.11, we had to program the microcontroller for dc motor control. The programming of the microcontroller is done in C language. AVR studio uses its own library for C programming. We had to use those functions to implement our design. In our whole design we made use of new soft serial library. The microcontroller on the evaluation board comes with a bootloader which allows us to load a new code without using external harware programmer.

While programming the microcontroller for dc motor control, we used two main functions, digitalwrite for keeping the particular motor high or low and analogwrite for PWM (Pulse Width Modulation) signal. The PWM signal gave the duty cycle for the motor to run and its maximum value was 255, which is 100% duty cycle is obtained. Also evaluation board needed power through external power supply, battery of 9V and the motors were given a DC supply of 8V. Four pins were allocated to each motor in the H-bridge and driving the motor as needed. Table 6.2 gives the details regarding which motor should be kept high and low for particular direction control.

7.2 Kalman Filter Algorithm in Matlab

We make use of Kalman filter algorithm to get smoother values and to reduce the effect of noise and other factors. Discrete Kalman filter updates a system vector estimate based upon the information in a new observation. In chapter 3, I discussed about Kalman filter and derived various equations to achieve the desired result.

While driving our GPS based car on the given coordinates, we generated a log file which updates the GPS location, that is, latitude and logitude with direction and course after every second. We made use of this file and got the desired location at every second. With help of this file, I implemented the Kalman filter algorithm. I did the coding in MATLAB and generated the path of our system. Initial plot showed us a lot of variation in our GPS locations effected by certain factors. After passing those value through Kalman filter algorithm iterations, I got a smoother graph compared with previous plot. If we had sensor reading, the result would have been more accurate.

In MATLAB, we made use of various vectors and matrix multiplications to implement Kalman filter algorithm. Based on the formula we made use of certain vectors, are listed below.

s.x = state vector estimate

s.z = observation vector

s.u = input control vector

s.A = state transition matrix

s.P = covariance od state vector estimate s.B = input matrix

s.Q = process noise variance

s.R = measurement noise variance

s.H observation matrix

Initally, we defined all the state definition fields and the initial state estimates. After doing the initial assignments, we obtain observation and control vector. Then we used the filter design to obtain the updated state estimate and this process is repeated until the final value of the GPS log file used.

7.3 Simulation Result

After simulating the code, we got the following results.

Figure 7.1 shows the basic plot of GPS location. The vehicle starts at point A and moves to point B, then to point C and finally to the destination point D. The plot is drawn betwee latitude and longitude. The graph shows all the points that the vehicle travelled along its course.

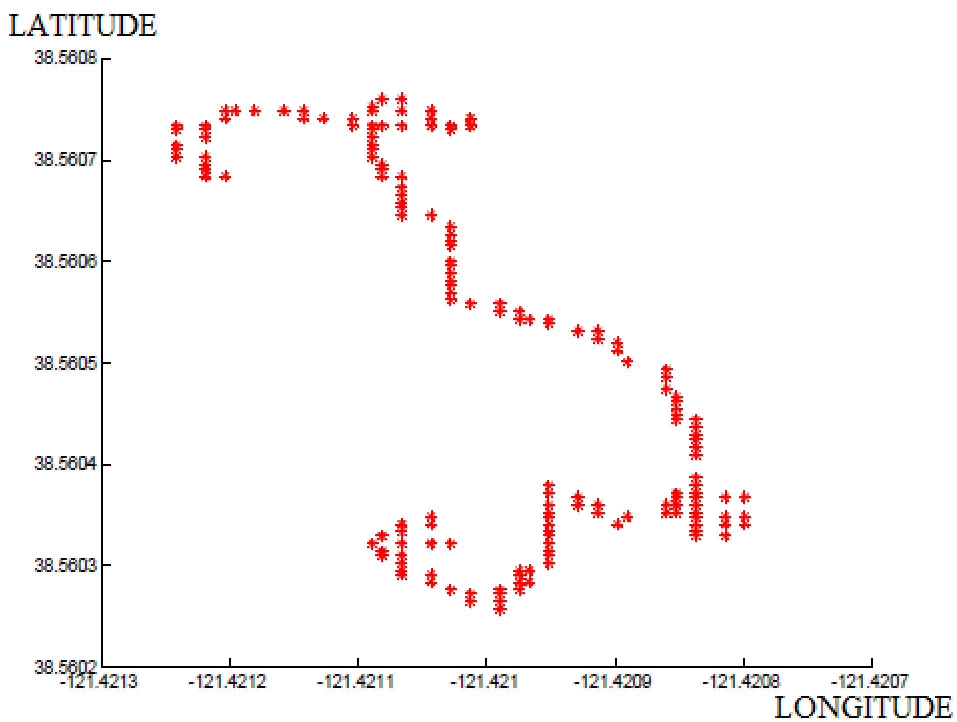


Figure 7.1. GPS location plot

Figure 7.2 shows the corrected Kalman filter plot. The kalman filter removes the unnecessary noise and signals from the GPS data and gives us a smoother graph with respect to GPS graph. The plot is drawn between corrected latitudes and longitudes.

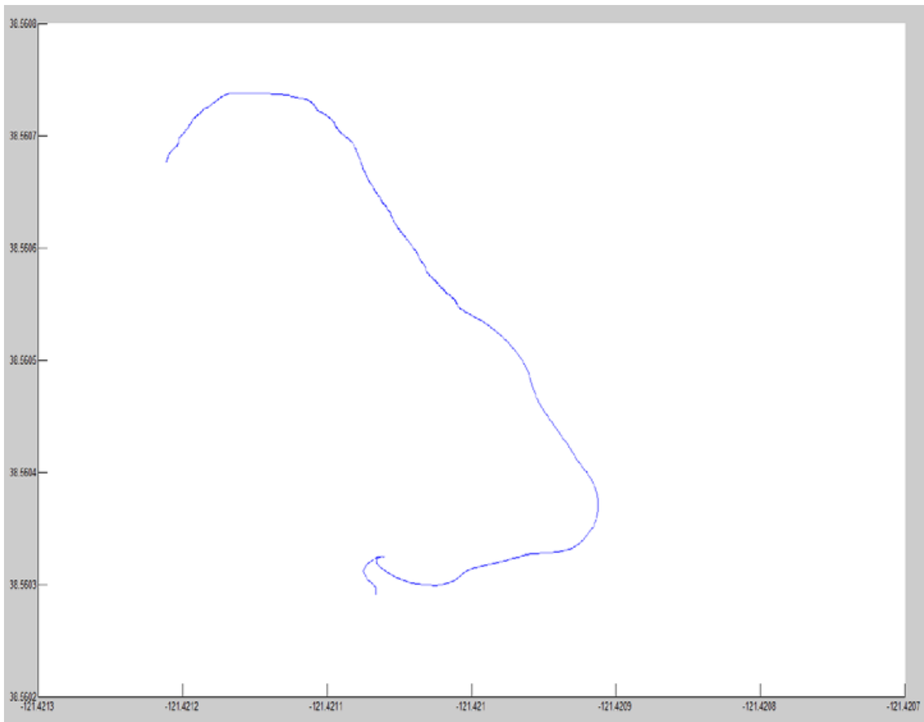


Figure 7.2. Kalman filter algorithm updated plot

Figure 7.3 shows the basic plot of the direction followed by the vehicle. The points in astriks are the GPS location plot derived from the GPS log file while the points connected by straight lines are the Kalman filter updated direction plot. The plot is drawn between the direction angle and observation.

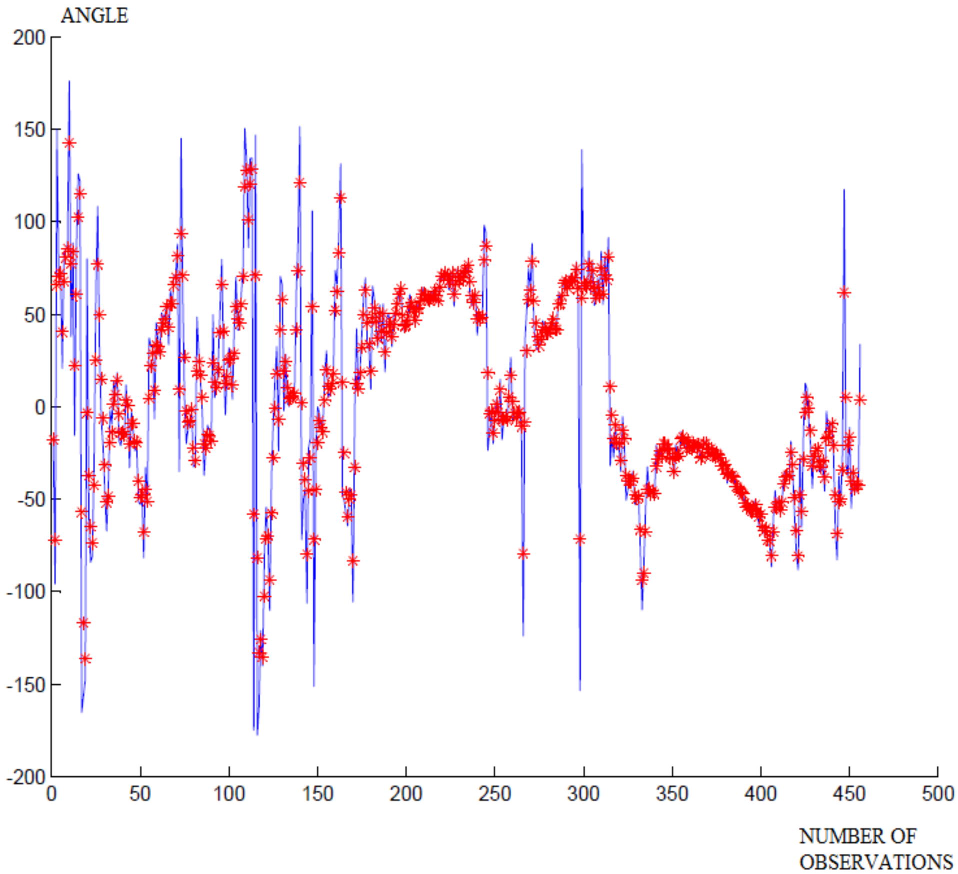


Figure 7.3. GPS direction plot and Kalman filter direction updated plot

Figure 7.4 shows the basic comparison between the GPS plot and Kalman filter plot. The plot shows the difference between the unfiltered GPS data and Kalman filter data and gives us a smoother graph for kalman filtered result compared to original GPS plot.

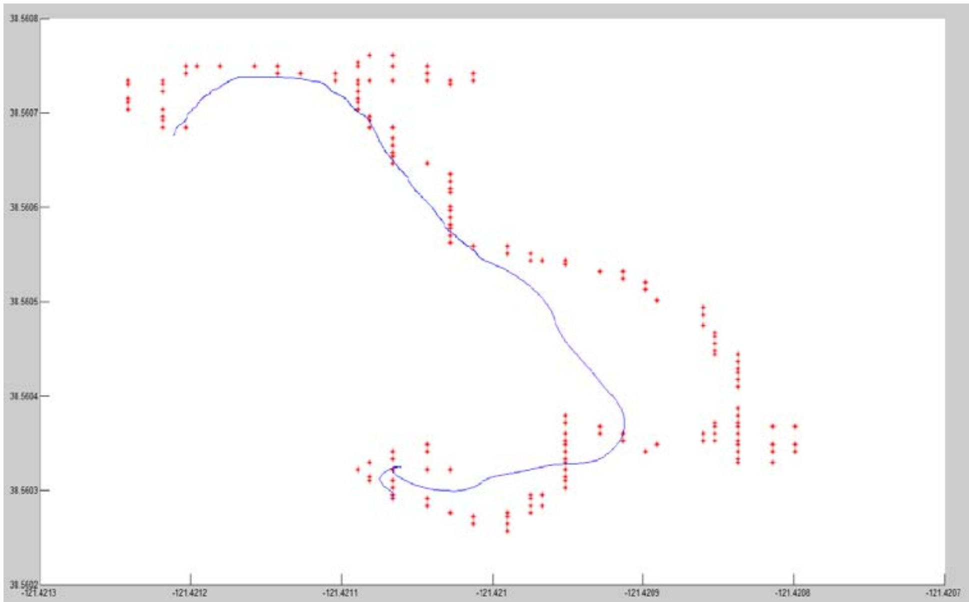


Figure 7.4. GPS plot vs Kalman Filter plot

Chapter 8

CONCLUSION

Automatic Car Navigation System with Kalman Filter Algorithm was successfully designed and implemented. Four different points of locations were provided by the GPS and the vehicle completed the whole path by tracking the GPS signal. Initially all four points were taken by using the GPS module and GPS was mounted on the mobile platform. With the help of microcontroller and h-bridge, the vehicle covered all four points and gave us the desired result. Also I successfully implemented the Kalman Filter Algorithm, which helped us to remove the unnecessary signal and noise from the GPS signal. It helped in smoothening our original track and direction provided by original GPS signal. Thus, filtering the GPS signal was achieved and gave us an optimized result.

Also further enhancement can be made in the project by giving a more powerful mobile platform. We can also implement collision detection by using sensors in the vehicle. We can also use the sensor data in Kalman filter algorithm, to give us more precise location tracking and hence gave us a very smooth track to follow without any noise and disturbance.

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