A FINAL YEAR PROJECT REPORT ON VEHICLE OVER SPEED DETECTION AND RECOGNITION

Thesis · August 2014

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A FINAL YEAR PROJECT REPORT ON VEHICLE OVER SPEED DETECTION AND RECOGNITION

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A PROJECT WAS SUBMITTED TO THE DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING IN PARTIAL FULLFILLMENT OF THE REQUIREMENT FOR THE BACHELORS DEGREE IN ELECTRONICS & COMMUNICATION ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMPUTER ENGINEERING

LALITPUR, NEPAL

August 28, 2014

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PAGE OF APPROVAL

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INSTITUTE OF ENGINEERING

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The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a project report entitled "Vehicle over speed detection and recognition “submitted by Prashnna K. Gyawali, Robin Chatatut, Shailesh Acharya, Sizen Neupane in partial fulfillment of the requirements for the Bachelor’s degree in Electronics & Communication / Computer Engineering.

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DATE OF APPROVAL: 24 AUG 2014

ACKNOWLEDGEMENT

We would like to express our gratitude and appreciation to all those who gave us the possibility to complete this report. We express our sincere thanks to the Dr. Diwakar Raj Pant, Head of Department, Department of Electronics and Computer Engineering, and Dr. Nanda Bikram Adhikari, Deputy Head of Department, Department of Electronics and Computer Engineering for extending their support for our project idea.

We would also like to thank our supervisor Mr. Anil Verma for his guidance and supervision.

We are thankful to Mr. Bal Krishna Bal for his valuable suggestion on image processing and character recognition. We would also thank our institution and our faculty members without whom this project would not have been possible. We also extend our heartfelt thanks to our friends, elder brothers and well-wishers.

I would also like to acknowledge with much appreciation the crucial role of the staff of Electronics and Computer Engineering Department, who gave the permission to use all required equipments and the necessary resources to complete the project.

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ABSTRACT

Road accidents have been very common in the present world with the prime cause being the careless driving. The necessity to check this has been very essential and different methods have been used so far. However with the advancement in the technology, different governing bodies are demanding some sort of computerized technology to control this problem of over speed driving.

At this scenario, we are proposing a system to detect the vehicle which are being driven above the given maximum speed limit that the respective roads or highway limits.

The overall project is divided in three categories; speed detection, image acquisition and transfer and image processing. Speed detecting device works on the principle of Doppler Effect using microwave Doppler radar sensor. The speed is compared with the preset threshold and camera is triggered if the speed limit exceeds. Acquisition and transfer of image is done by a HD camera interfaced with raspberry pi. Raspberry pi is connected to the server via internet. The server runs an Image processing program which isolates the license plate from picture frame. The characters in the number plate is digitized and sent to the authority residing in the next station where the vehicle is heading.

Keywords: Doppler Radar, Doppler Effect, Image Processing, Acquisition and Transfer

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ANPR	Automatic Number Plate Recognition
ARM	Acron RISC Machine
AVR	Advanced Virtual RISC
CPU	Central Processing Unit
CRS	Computer Recognition System
DRO	Dielectric Resonant Oscillation
EEPROM	Electrically Erasable Programmable Read-Only Memory
EGAD	Electronic Ground Automatic Destruct
GFLOPS	Giga Floating Point operation per Second
GND	Ground
GPIO	General Purpose Input/Output
GPU	Graphics Processing Unit
HD	High Definition
HDML	Handheld Device Markup Language
HPBW	Half Power Beam Width
IC	Integrated Circuit
IDE/IDLE	Integrated Development Program
IOE	Institute of Engineering
LCD	Liquid Crystal Display

LAN	Local Area Network
LED	Light Emitting Diode
LPR	License Plate Recognition
MIPI	Mobile Industry Processor Interface
MMC	Multi Media Card
NPN	Negative-Positive-Negative
PAL	Phase Alternating Line
PCB	Printed Circuit Board
PNP	Positive-Negative-Positive
PIC	Peripheral Interface Controller
RAM	Random Access Memory
RISC	Reduced Instruction Set Computer
RS	Resistor Select
SCP	Service Control Point
SD	Secure Digital
SDIO	Secure Digital Input/output
SPI	Serial Peripheral Interface
SPICE	Simulation Program with Integrated Circuit Emphasis
SRAM	Static Random Access Memory
SSH	Secure Shell
TTL	Transistor - Transistor Logic

UART	Universal Asynchronous Receiver/Transmitter
USART	Universal Synchronous/Asynchronous Receiver/Transmitter
UK	United Kingdom
USB	Universal Serial Bus
VCC	Voltage Constant Current
VDC	Voltage Direct Current
VGA	Video Graphics Array
VLP	Vehicle License Plate
VNC	Virtual Network Connection
VOUT	Output Voltage
VSM	Value Stream Mapping
VTMR	Vehicle Transport and Management Rule

1.INTRODUCTION

Over speeding vehicles are major issues for road safety and needs proper addressing to minimize the accidents. Excessive Speed is a factor in one third of all fatal crashes.

Vehicle speed detection is based on the use of Dopplar Radar to find the speed of the moving vehicles. Dopplar effect can be exploited to measure the speed of vehicles and identify those crossing speed limit. The shift in frequency between the transmitted and reflected high frequency wave is the key factor used to calculate speed. The dopplar radar based speed detector can be interfaced to a microprocessor based system for measurement and comparison. HD camera attached to the system can be used to provide a real time view of the road. The system can be connected to the server via internet and the images from the road can be transmitted to the server for processing.

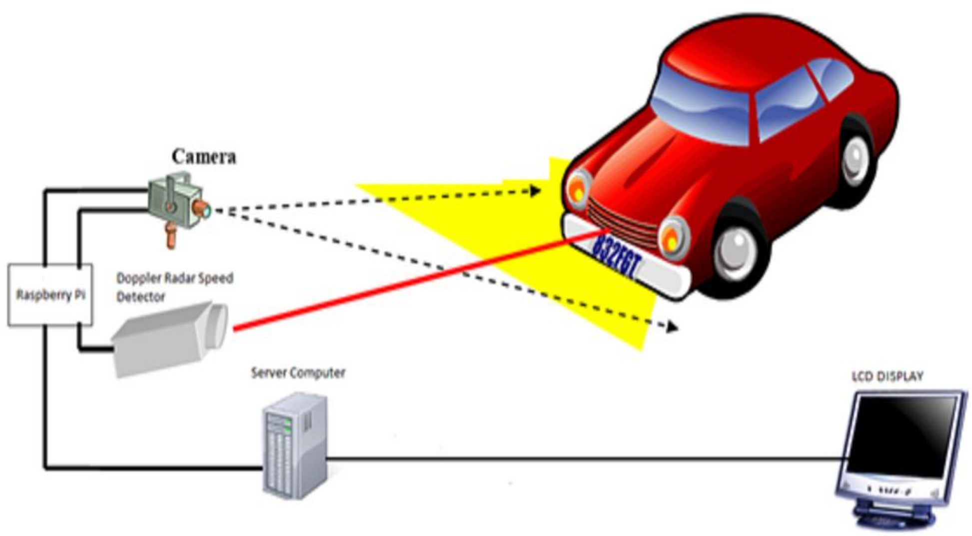


Figure 1.1 Vehicle over speed detection and recognition

Automatic number plate recognition is an image processing technology that uses number plate to identify the vehicle. The objective is to isolate the number plate of the vehicle from the image and use optical character recognition to identify the characters of the number plate. Moreover, the digitize number plate will be transmitted to the next station where it will be displayed in LCD panel.

1.1 National statistical trends in road accident

Road accidents are increasing in Nepal due to increased vehicle speed. This has become a serious problem which killed more than 1734 people's life and injury of more than 11000 people in year 2009/10. The estimated annual national loss from road accidents is more than £ 9 million. Considering the heavy loss of lives and wealth in road accidents the concerned road and traffic management agencies have started to incorporate road safety issues in their program but it seems inadequate as the losses of life and property from road accidents is increasing. Trend of road accidents and losses of life and property is increasing in recent year. However, the figures do not give the full accident picture. Experience shows that a fairly large number of accidents are never reported to the police, mainly because the involved parties want to settle the matter between them. This under-representation is assumed to be less pronounced for severe accidents.[1]

Various causes of road accidents show drivers negligence 3,037 times, passengers negligence 18 times, overtake 100, speed 386, drink driving 208, technical problem 295, animals 1, road condition 9, weather condition 1 and other problems.

Year	Accidents	Fatalities	Serious Injuries	Slight Injuries	Injury/ fatal ratio	Fatality per 10,000 Vehicles
2001-02	3,823	879	458	4,138	5.23	66.2
2002-03	3,864	682	785	4,442	7.66	48.38
2003-04	5,430	802	1,659	3,925	6.96	52.04
2004-05	5,532	808	1,795	4,039	7.22	49.42
2005-06	3,894	825	1,866	3,655	6.69	47.64
2006-07	4,546	953	2,583	5,331	8.30	50.17
2007-08	6,821	1,131	2,663	5,245	6.99	54.9
2008-09	8353	1356	3609	6457	7.42	60.21
2009-10	11747	1734	4130	7383	6.64	67.13
Sum	54,010	9,170	19,548	44,615	7.00	

Table 1.1 National statistical trends in road accident[1]

1.2 Statement of problem

Number of ways are being implemented to check and identify the over speeding vehicle. But no automatic system has been developed so far that can perform the task of speed detection and vehicle identification without human assistance. The major issues seen at the present context are :

- Road accidents are increasing day by day with prime cause being the over speeding of the vehicle.
- The use of human resources to check this issue can be very tedious and time consuming and sometimes become irrelevant.
- Commercially available automatic LPR systems are very costly and difficult to implement for the Nepali license number plate due to its character being in Devanagari script (mostly).

1.3Objectives

The objective of our project is to address the issues discussed above. The objectives are as follows:

- To design an automatic and versatile system that addresses the issues of over speeding without use of human resources.
- To detect the speed of the over speeding vehicle and digitize number plate using image processing.
- To establish the networking between different systems to exchange the information among them.

1.4Scope

1. **Road safety:** The timely checking of the over speeding vehicle will reduce high percentage of road accidents.
2. **Automation in law enforcement:** The system being completely automatic, reduces the number of traffic police officers needed to deploy in the real field for checking speeding vehicles.

   With very few enhancements in the proposed system new features can be easily incorporated such as:

   - **Vehicle security:** The lost out cases of the vehicle are increasing day by day, the stolen vehicle can be easily detected by comparing with the registered entry of stolen vehicles.
   - **Parking:** The vehicles can be easily registered using automatic system with this system in the parking lounge or similar purpose complexes.
   - **Visitor management:** This system can be effectively used to assist visitor management systems in recognizing guest vehicles.

2.LITERATURE REVIEW

Many projects addressing similar problems have been done in international level. One such approach has been discussed in the research paper by Leo Cetinski and David Dawson. [13] Use of speed gun for speed detection and LPR software for vehicle recognition has been explained in the paper.

A number of different approaches have been used by many researchers to detect speed of moving vehicle. One of the most popular ways of speed detection is based on LASER crossing. Two LASER lights placed on the path of a moving vehicle can be used to determine the speed by measuring the time difference between the crossings.

However this approach is now less frequently used for speed detection after the advent of Doppler radar guns. Speed detection using Doppler sensor is based on the principle of Doppler Effect. [17, 30] Commercially available speed guns are based on this approach of speed detection and provide high degree of accuracy.

The history of automatic vehicle number detection dates back to mid 1970s. In 1976, the Police Scientific Development Branch in the UK first invented this system. Systems were working by 1979, and contracts were let to produce industrial systems, first at EMI Electronics, and then at Computer Recognition Systems (CRS) in Wokingham, UK. Early trial systems were deployed on the A1 road and at the Dartford Tunnel. However it did not become widely used until new developments in cheaper and easier to use software was pioneered during the 1990s.

The issue of Number Plate Detection is still not solved completely because the accuracy in Number Plate digitization achieved so far is not satisfiable. Different approaches for LPR have been developed but the research still continues for the best result. Initial approaches were based on boundary line properties. Gradient filters were used to enrich boundary lines. Algorithm such as Hough transform was then used to detect boundary lines.two sets of lines parallel to each other were then considered as boundary of the plate. [29]

Another approach focused on some properties of plate images such as their position, dimension ratio, brightness, symmetry, angles, etc.[28] Morphological processings were done to detect similar properties in the image so as to locate the position of number plate. Another approach was by using statistical properties of the characters in the plate. This approach is based on finding the regions for Number Plate character based on the the variance of gray level, number of edges, edge densities in the region.[28] This method is very accurate if the number of characters on the plate is fixed.. The research and upgrading of these algorithms continue with many researchers working on the project over a long time.

In the case of our country, very few works have been done in this field in the past. One such project on Digitization of Nepali Number Plate was done by the students of IOE, Pulchowk campus.[9] The paper[9] explains the use of neural network in digitization of characters of Nepali Number Plate and the accuracy achieved in Digitization of each character

Similar uses have been implemented in many more developed countries so far with the success rate being low. However, in the underdeveloped countries like Nepal; the overall system that we are proposing is not even in the discussion.

3.BACKGROUND THEORY

3.1HB100 sensor

HB100 Miniature Microwave Sensor is a X-Band Bi-Static Doppler transceiver module. Its built-in Dielectric Resonator Oscillator (DRO) and a pair of Microstrip patch antenna array, make it ideal for use in motion and speed detection. [2]

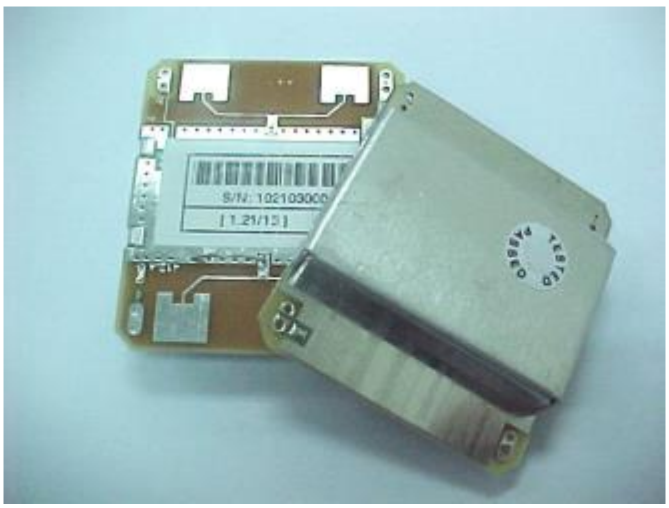


Figure 3.1 HB100 Sensor[2]

Features:

•Low current consumption

•Simplicity in interfacing

• Continuous Wave or Pulse operation

• Detection range of 10m

•Application in motion detection and speed measurement

3.1.1Why Hb100 sensor for speed detection?

Modern speed detectors like speed gun use radar sensor built in to their circuit. It is difficult to hack one of them to use the sensor part for our purpose. As a separate unit, very few sensors are available in market that works on the principle of Doppler effect for speed detection. HB100 is one such sensor which meets most of our requirement and is a low cost device. There are other sensors like Xb100 with range of upto 100m but are expensive for use in this project.

3.1.2Operation

The sensor woks on the principle of Doppler Effect.

3.1.2.1 Doppler Effect

Doppler Effect was proposed by Australian physicist Christian Doppler in 1842. Doppler effect is the difference between the observed frequency and emitted frequency of a wave for an observer moving relative to the source of waves. The most commonly seen example of Doppler effect is the change in frequency of the sound heard when a vehicle with siren is approaching and passes by. This variation in frequency depends on the relative direction and velocity of wave between the source and the observer. It is maximum when the source is moving directly toward or away from the observer and diminishes with increasing angle between the direction of motion and the direction of the waves, until when the source is moving at right angles to the observer, there is no shift.

When a stationary source projects wave of certain frequency towards a moving object the frequency of the reflected wave changes. The reflected wave has a frequency slightly higher if the object is moving towards the source and it is slightly lower if the object is moving away relative to the source. The shift in frequency between the emitted wave and the reflected wave is the factor that determines the speed of the object. This phenomenon is exploited in Doppler radar sensors to measure the speed of vehicles or any other object.

3.1.2.2Frequency Variation

If c be the velocity of light v the target velocity then the shifted frequency (f_r) can be expressed as a function of the original frequency (f_t)[3] :

$$f_r = f_t \left(\frac{1 + v/c}{1 - v/c} \right)$$

Assuming the direction of the source and the direction of motion of the target is perfectly aligned, Change in the frequency between the transmitted and reflected wave, (Doppler frequency) (f_d), is thus:

$$f_d = f_r - f_t = 2v \frac{f_t}{(c - v)}$$

Since for most practical applications of radar, $v \ll c$, so $(c - v) \rightarrow c$. We can then write:

$$f_d \approx 2v \frac{f_t}{c}$$

If the direction of the moving object makes a certain angle with the source direction, Doppler frequency is reduced by a value equal to the cosine of the angle between source and target's direction.

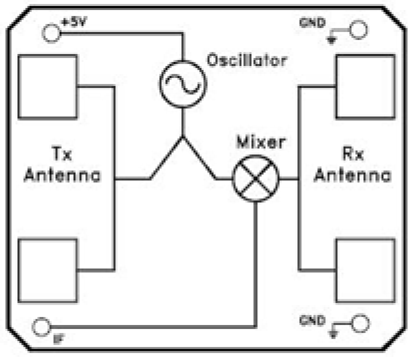


Figure 3.2 Block diagram and connection[2]

The sensor circuit consists of a Dielectric Resonator Oscillator, microwave Mixer and patch antenna. The transmit frequency and power of the module is set by factory. There is no user adjustable part in this device. The module is a low power radio device (LPRD) or intended radiator. The Oscillator produces a sinusoidal wave of frequency 10.525 Ghz. The patch antenna connected to the oscillator radiate the wave towards the target. The reflected wave is received by another set of patch antenna built in the circuit. The microwave mixer mixes these two signals to generate a sinusoidal wave with frequency equal to the difference between the two.

3.1.2.3 Radiation Pattern

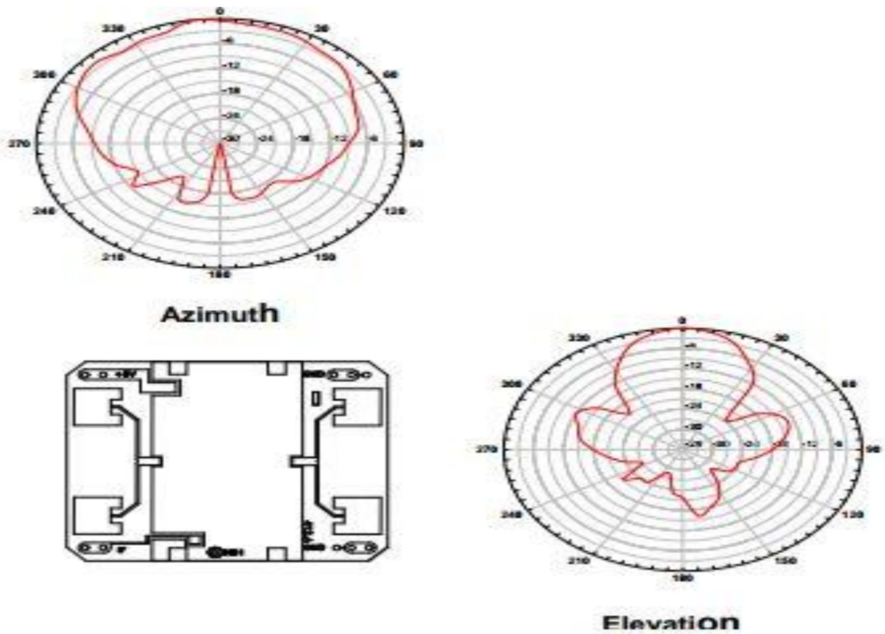


Figure 3.3 Radiation pattern of sensor[2]

The radiation patterns of the antenna and their half power beam width (HPBW) are as shown in the diagram. The module should be mounted with the antenna patches facing to the desired detection zone. The orientation of the module can be changed to get the best coverage.

3.1.3Output of the sensor

The magnitude of the Doppler Shift is proportional to reflection of transmitted energy and is in the range of few mill volts. A high gain low frequency amplifier is usually connected to the IF terminal in order to amplify the Doppler shift to a processable level. Frequency of Doppler shift is proportional to velocity of motion. The Received Signal Strength (RSS) is the voltage measured of the Doppler shift at the IF output. It can be used to predict the distance between the source and the target. Target closer to the source produce a hifh level of RSS. But the exact value may vary greatly depending on the type of the surface and reflection coefficient of the target.

Noises are of major concern when designing an amplifier. Noise may be the result of the internal circuitry of the sensor and amplifier or due to fluctuation in the power supply. High frequency noise from power supply may affect the output significantly.

3.2Amplifier

Wide ranges of amplifiers are available for use in the circuit and the one that best fits the system requirement needs to be used. . The amplifier IC used for this purpose is the LM324 Quad op amp. This IC has four operational amplifiers.

The LM324-N series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than −0.3 VDC (at 25°C). An input clamp diode with a resistor to the IC input terminal can be used.

To reduce the power supply drain, the amplifiers have a class A output stage for small signal levels which converts to class B in a large signal mode. This allows the amplifiers to both source and sink large output currents. Therefore both NPN and PNP external current boost transistors can be used to extend the power capability of the basic amplifiers. The output voltage needs to raise approximately 1 diode drop above ground to bias the on-chip vertical PNP transistor for output current sinking applications. For ac applications, where the load is capacitively coupled to the output of the amplifier, a resistor should be used, from the output of the amplifier to ground to increase the class A bias current and prevent crossover distortion.

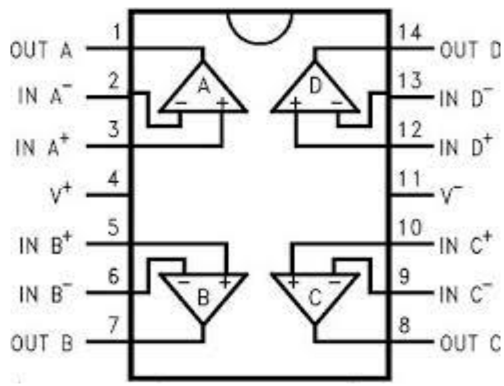


Figure 3.4 LM324 block diagram[4]

3.2.1Features

•Internally frequency compensated for unity gain

• Large DC Voltage Gain 100 dB

• Wide Bandwidth (Unity Gain) 1 MHz (Temperature Compensated)

• Low Input Biasing Current 45 nA (Temperature compensated)

• Wide Power Supply Range:

- Single Supply 3V to 32V
- Dual Supplies ±1.5V to ±16V

• Very Low Supply Current Drain (700 µA) (Essentially Independent of Supply voltage)

• Low Input Offset Voltage 2 mV and Offset Current: 5 nA

• Input Common-Mode Voltage Range Includes ground

• Differential Input Voltage Range Equal to the power supply voltages

• Large Output Voltage Swing 0V to $V^+ - 1.5V$

3.2.2Advantages

• Eliminates Need for Dual Supplies

• Four Internally Compensated Op Amps in a Single Package

• Allows Directly Sensing Near GND and VOUT

(Temperature Compensated) also Goes to GND

• Compatible with All Forms of Logic

• Power Drain Suitable for Battery Operation

3.2.3Operational Amplifier

An operational amplifier (op-amp) is a high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output. In this configuration, an op-amp produces an output potential (relative to circuit ground) that is typically hundreds of thousands of times larger than the potential difference between its input terminals. The op-amp is one type of differential amplifier. Other types of differential amplifier are made by using one or more op-amps.

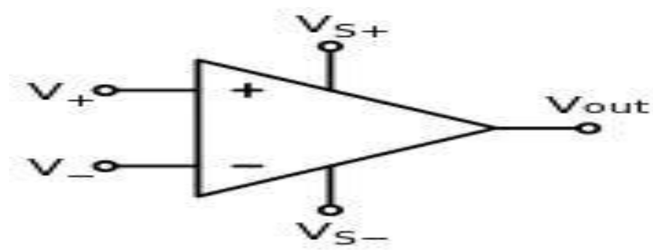


Figure 3.5 op-amp representation

The amplifier's differential inputs consist of a non-inverting input (+) with voltage V_+ and an inverting input (–) with voltage $V_–$; ideally the op-amp amplifies only the difference in voltage between the two, which is called the *differential input voltage*. The output voltage of the op-amp V_{out} is given by the equation:

$$V_{\text{out}} = A_{\text{OL}}\,(V_+ - V_-)$$

where A_{OL} is the open-loop gain of the amplifier (the term "open-loop" refers to the absence of a feedback loop from the output to the input).

3.2.3.1 Open loop

The open loop gain of the amplifier(A_{OL}) is very high in the order of 100,000. Small difference between V^+ and V^- drives the amplifier output nearly to supplyvoltage. This operation where the output is set to the max value(that is equal to the supply voltage) is called saturation. So it is not practical to use open loop configuration for amplification purpose. Without feedback network the amplifier can act as a comparator. . If the inverting input is held at ground (0 V) directly or by a resistor R_g, and the input voltage V_{in} applied to the non-inverting input is positive, the output will be maximum positive; if V_{in} is negative, the output will be maximum negative.The circuit's gain is just the A_{OL} of the op-amp.

3.2.3.2Closed loop

For practical purposes feedback loops are used to control the performance of the amplifier. Generally negative feedback is used, by applying a portion of the output voltage to the inverting input. This controls the overall gain and response of the circuit which is determined mostly by the feedback network, rather than by the op-amp characteristics. If the feedback network is made of components with values small relative to the op amp's input impedance, the value of the op-amp's open loop response A_{OL} does not seriously affect the circuit's performance. Transfer functions are used to characterize the response of the op-amp with its input output and feedback circuit.

Generally op-amps are used in one of the two configurations inverting configurarion and Non inverting configuration.

3.2.4Non Inverting Configuration

In the Non-inverting configuration, input signal is applied to the non-inverting terminal(V^+) and the feedback is given to the inverting terminal V^-.

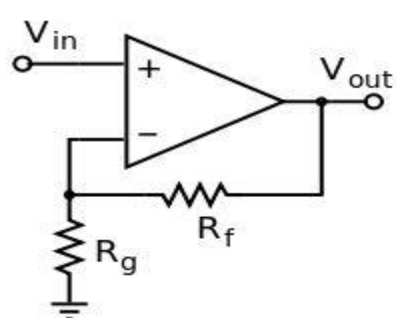


Figure 3.6 Inverting op-amp

The presence of negative feedback via the voltage divider R_f, R_g determines the closed-loop gain $A_{CL} = V_{out} / V_{in}$. The voltage gain of this configuration is given as $1 + R_f/R_g$. There is no reversal of phase between the input and the output.

3.2.5Inverting Configuration and low pass filter

In the inverting configuration of op-amp input is applied to the inverting terminal V_- via a resistor R_1. Feedback from output is fed to the inverting terminal via a resistor R_2 and the non-inverting terminal is connected to ground. The overall gain of the inverting terminal with this configuration is given by the ratio of the feedback resistance to the input resistance. Gain=R_2/R_1 .

Designing a low pass filter requires an additional capacitive reactance to be connected in the feedback path in this configuration.

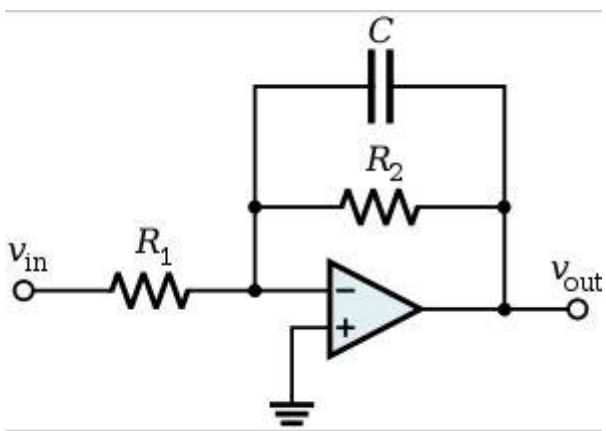


Figure 3.7 Inverting amplifier with low pass filter

The above circuit represents a first order active low pass filter. The cut off frequency of the circuit is defined as the threshold value of frequency above which all frequency components are attenuated.

In the operational amplifier circuit shown in the figure, the cutoff frequency (in hertz) is defined as:

$$f_c = \frac{1}{2\pi R_2 C}$$

or equivalently (in radians per second):

$$\omega_c = \frac{1}{R_2 C}$$

The gain in the passband is $-R_2/R1$ and all frequency above f_c value is attenuated.

The gain of the op-amp can be increased to sufficiently high value so that it operates in the saturation region. The output at such case is a near digital pulse than can be fed into the digital I/O pin of any TTL device.

The frequency of the output signal from the amplifier can be measured using the digital pin of microcontroller. Microcontroller can be used to measure frequency, calculate the speed and make necessary comparisons. The output is displayed on the display device interfaced with the microcontroller.

3.3Arduino platform for atmega 328

Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins, as well as 14 digital I/O pins which allow the user to attach various extension boards. It comes with a simple integrated development environment (IDE) that runs on regular personal computers and allows users to write programs for Arduino using C or C++.

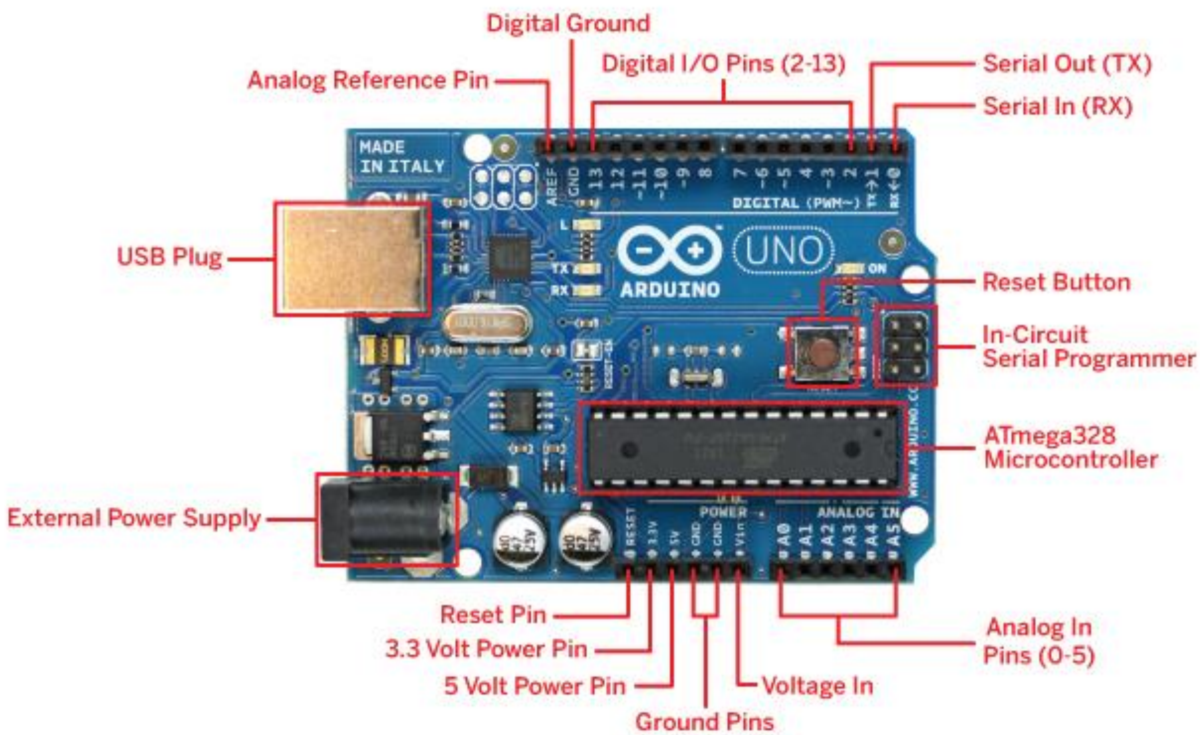


Figure 3.8 Arduino Uno[5]

Arduino Uno is a development board with an on-board atmega 328 microcontroller. The input output pins of the microcontroller are mapped to different sets of digital and analog I/O pins on the board. The five analog pins are capable of sensing analog voltage down to 4mv. The digital pins 2-13 can be used as input or output. Pins 0 and 1 are dedicated for serial data transmission. Arduino works with a supply voltage of +5 volts and ground. The power supply can be given via a USB cable connected to USB plug or by using an external adapter. The processor runs on a 16Mhz crystal soldered to the board.

3.3.1Features

-Easy to interface sensors and display devices

-Debugging and testing is easy with Arduino IDE

- Easy to program in the target circuit using USB cable

-Open source project

-Wide range of libraries available in the repository for interfacing commonly used peripherals

3.3.2Atmega 328

Atmega 328 is the microcontroller unit attached to the board and performs all the processing. The high-performance Atmel 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts,serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter. programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

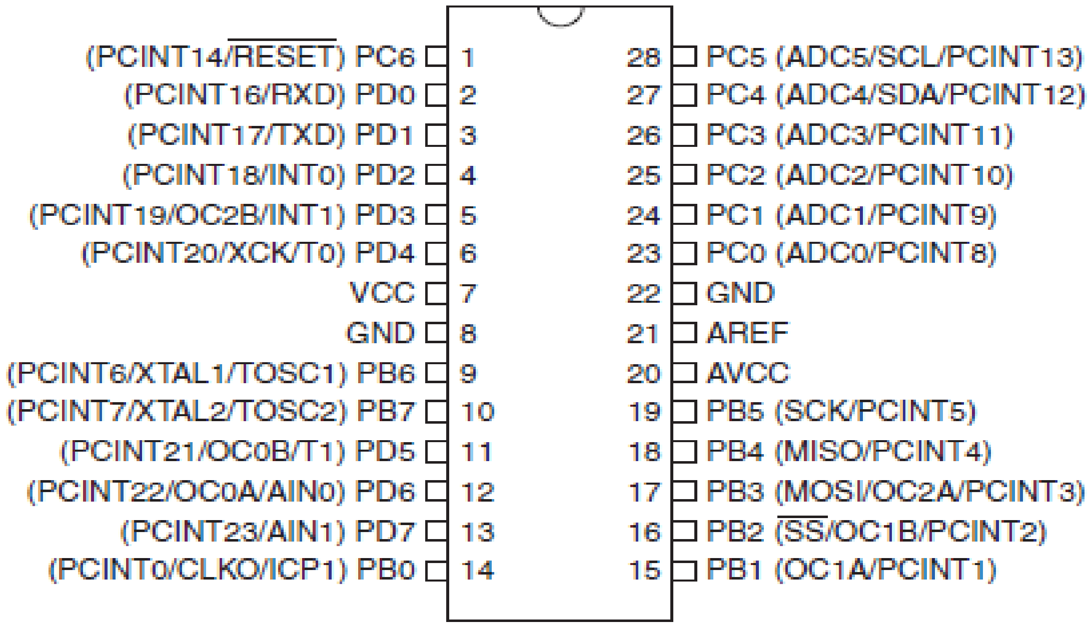


Figure 3.9 Atmega 328 pin diagram

The digital output pin of the microcontroller is used to signal the raspberry Pi board to trigger the camera.

3.4Raspberry pi

The Raspberry Pi is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer science in schools.

The secret sauce that makes this computer so small and powerful is the Broadcom BCM2835, a System-on-Chip that contains an ARM1176JZFS with floating point, running at 700 MHz, and a Video core 4 GPU. The GPU provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode and is capable of 1Gpixel/s, 1.5Gtexel/s or 24 GFLOPs of general purpose computer. It comes with both model A and model B .If you want a Raspberry Pi for general use, then you should buy a model B, revision 2(the latest). With twice as much memory, it will cope with most tasks much better than the model A. If, on the other hand, you are embedding a Raspberry Pi in a project for a single purpose, then using a model A will be better option.

Model	RAM	USB sockets	Ethernet Ports
A	256 MB	1	No
B(rev 1)	512MB	2	Yes
B(rev 2)	256MB	2	Yes

Table 3.1 Comparison between model A and model B:

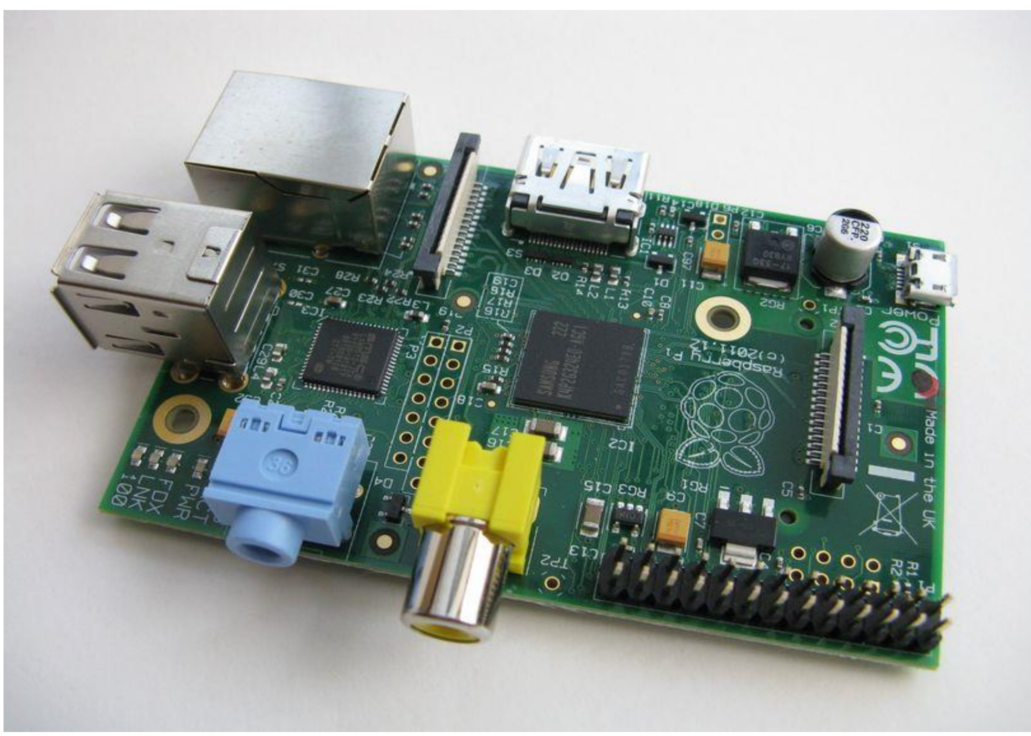


Figure 3.10 Raspberry pi [6]

3.4.1Hardware

It does not come with a real time clock so the operating system must use network time.

3.4.1.1 RAM

On the older boards 128 MB RAM was allocated by default leaving 128 MB for CPU. Later 256 MB RAM raspberry pi was released which was sufficient for 1080p decoding, or for simple 3D. 224 MB was for Linux only, with just a 1080p frame buffer, and was likely to fail for any video or 3D. 128 MB was for heavy 3D, possibly also with video decoding .For the new model B with 512 MB RAM initially there were new standard memory split files released(arm256_start.elf, arm384_start.elf, arm496_start.elf) for 256 MB, 384 MB and 496 MB CPU RAM (and 256 MB, 128 MB and 16 MB video RAM).

Processor:

Broadcom SoC is used is raspberry pi. It operated at 700Mhz default which is equal to 0,041 GFLOPS. On a computer level it is similar to 700 MHz Pentium II computer. It does not require heat sink or some sort of cooling.

3.4.1.2 Networking

The Model A does not have an RJ45 Ethernet port, it can connect to a network by using an external user-supplied USB Ethernet or Wi-Fi adapter. On the model B the Ethernet port is provided by a built-in USB Ethernet adapter.

3.4.1.3 Peripherals

Generic USB keyboards and mice are compatible with the Raspberry Pi.

3.4.2Model B Features

- Dimensions**:** 85.60mm x 56mm x 21mm
- Broadcom BCM2835 SoC
- 700 MHz ARM1176JZF-S core CPU
- Broadcom VideoCore IV GPU
- 512 MB RAM
- 2 x USB2.0 Ports
- Video Out via Composite (PAL and NTSC), HDMI or Raw LCD (DSI)
- Audio Out via 3.5mm Jack or Audio over HDMI
- Storage: SD/MMC/SDIO
- 10/100 Ethernet (RJ45)
- Low-Level Peripherals:
    - 8 x GPIO
    - UART
    - I2C bus
    - SPI bus with two chip selects
    - +3.3V
    - +5VGround

- Power Requirements: 5V @ 700 mA via MicroUSB or GPIO Header
- Supports Debian GNU/Linux, Fedora, Arch Linux, RISC OS and More!

3.4.3 Why raspberry pi?

- The biggest advantage of raspberry pi is its small size as credit card. it works as if a normal computer at a relatively low price.
- One of other advantage of raspberry pi is usually speeding: problems can be solved in ‘hardware’ rather than in software, make use of parallelization.
- Lower power consumption. By replacing linear regulators with switching ones power consumption is reduced by between 0.5W and 1W.

3.4.4Setting up Raspberry pi

The Raspberry Pi is not generally supplied with an operating system. To setup raspberry pi Download an iso disk image for the from raspberry site then extract the folder contained in the zip file to some convenient location. Eject any external hard disks or USB flash drives and insert the SD card then use the Fedora ARM Installer to put it onto an SD card. Run fedora-arm-installer.exe as a user who has administrator rights.

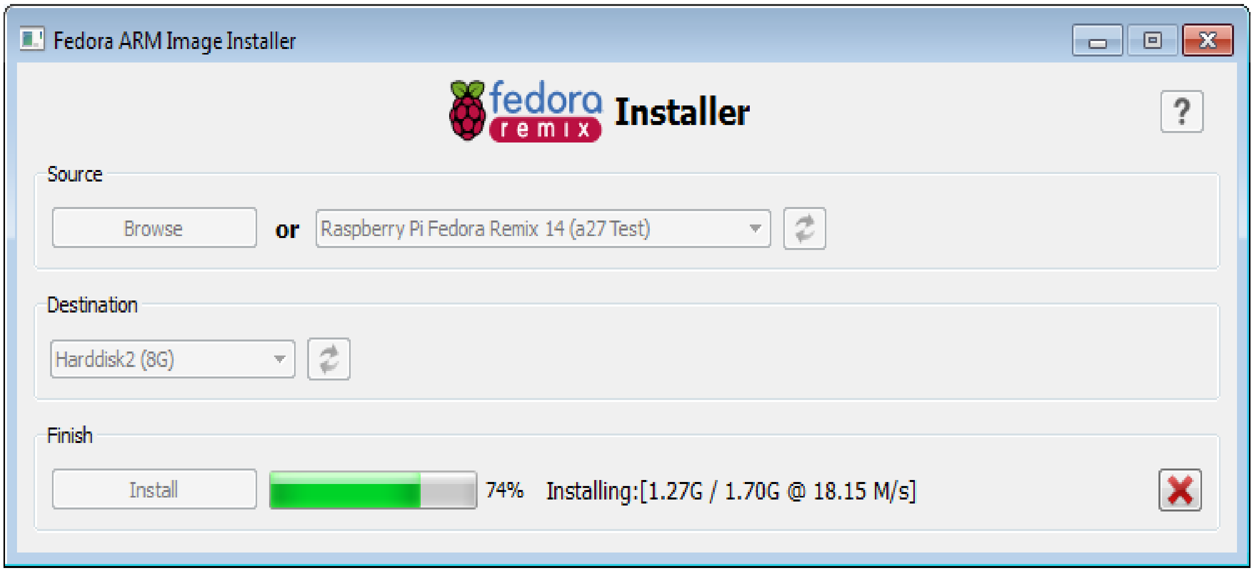


Figure 3.11 Fedora ARM Image installer

Login from the widows computer network requires putty to start an SSH session. Computer should be connected to the network where raspberry pi is connected. For a graphical environment to control pi remotely VNC can also be used . To run VNC run the following commands

$ sudo apt-get update

$ sudo apt-get install tightvncserver

Having installed the VNC server, run it using the command:

$ vncserver :1

The first time you run this, you will be prompted to create a new password, so anyone connecting remotely has to enter the password before being granted access to the Pi. To connect to the Pi from a remote computer, you will need to install a VNC client.

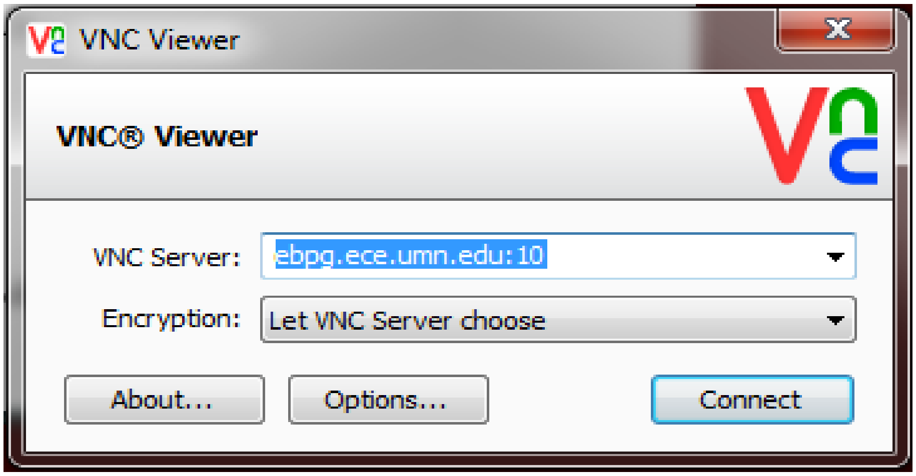


Figure 3.12 VNC viewer login

3.4.5Python Programs with IDLE in raspberry pi

The common Raspberry Pi distributions come with the IDLE Python development tool. In both the Python and Python 3 versions. If you are using Raspbian or Occidentalis. You will find shortcuts to both versions of IDLE on your Raspberry Pi desktop. We have used python programming to transfer captured image of vehicle which has crossed speed limits.

3.4.6Raspberry pi Camera

RPI CAMERA BOARD plugs directly into the CSI connector on the Raspberry Pi. It's able to deliver a crystal clear 5MP resolution image or 1080p HD video recording at 30fps with latest v1.3. Board features a 5MP (2592 × 1944 pixels) Omni vision 5647 sensor in a fixed focus module. The module attaches to Raspberry Pi, by way of a 15 pin Ribbon Cable, to the dedicated 15 pin MIPI Camera Serial Interface (CSI), which was designed especially for interfacing to cameras. The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor.

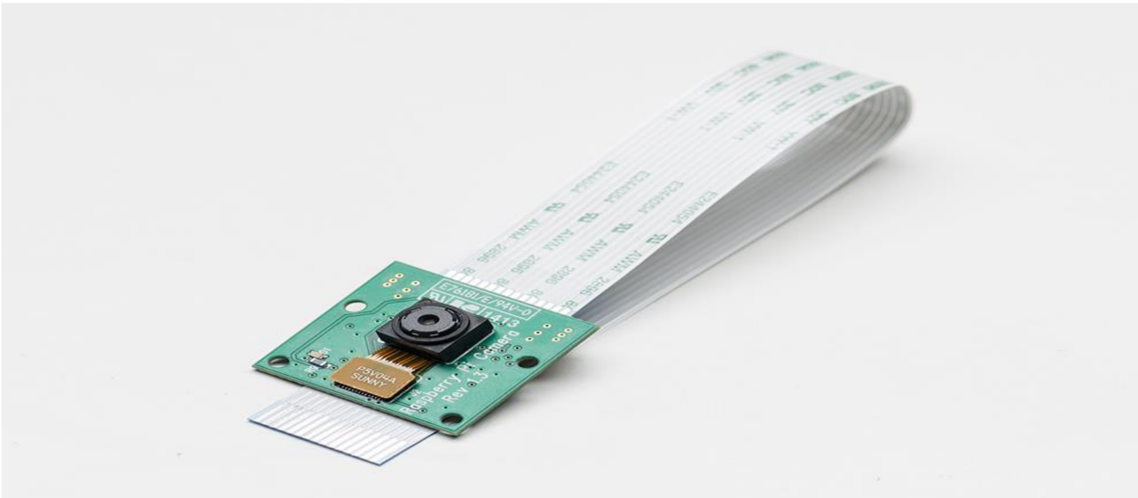


Figure 3.13 Raspberry pi camera [6]

Features

- Fully compatible with both the Model A and Model B Raspberry Pi
- 5MP Omni vision 5647 camera module
- Still picture resolution of 2592 x 1944
- Video supports 1080p at 30fps, 720p at 60fps and 640x480p 60/90 recording
- 15 pin MIPI camera serial interface plugs directly into the Raspberry Pi Board
- Size is 20mm x 25mm x 9mm
- Weight of 3g

3.4.6.1 Installing camera module

The Raspberry Pi camera module is attached to a Raspberry Pi by a ribbon cable. This cable attaches to a special connector just behind the Ethernet socket. To fit it, pull up the levers on either side of the connector, so that they unlock, and then press the cable into the slot with the connector pads of the cable facing away from the Ethernet socket. Press the two levers of the connector back down to lock the cable in place. The camera module also requires some software configuration. For that run the following command in terminal session:

$ sudo raspi-config

Then from the options there select camera option and enable it. Two commands are available for capturing still images and videos: raspiStill and raspivid. To capture a single still image, use the raspiStill command as shown here:

$ raspistill -o image1.jpg

A preview screen displays for about five seconds and then takes a photograph and stores it in the file image1.jpg in the current directory.

To capture video, use the command raspivid:

$ raspivid -o video.h264 -t 10000

The number on the end is the recording duration in milliseconds in this case, 10
seconds.

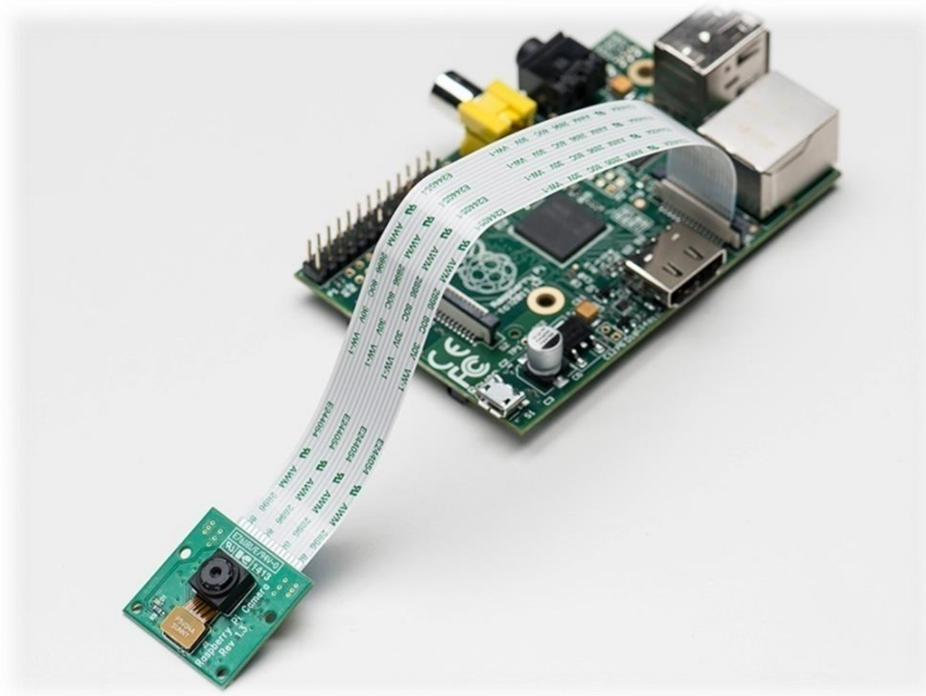


Figure 3.14 Raspberry Pi with camera module fitted [6]

3.5LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments) animations and so on.

A **16x2 LCD** means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

1. 16 Characters x 2 Lines
2. Built-in HD44780 Equivalent LCD Controller

3. Works directly with ATMEGA, ARDUINO, PIC amd many other microcontroller/kits.
4. 4 or 8 bit data I/O interface
5. Low power consumption

Figure 3.15 LCD JHD162A

We will be using this LCD to display speed and frequency given by HB100 microwave dopplar radar speed sensor. It has 3 control pins RS(register select), E(Enable) and RW(read/write). The LCD have basic two operating modes Instruction mode and Character mode depending upon the status of the pin, the data on the 8 data pins (D0-D7) is either treated as instruction or character data. The enable pin has a simple function. It is just a clock input for the LCD. It is just held at VCC by a pull up resistor. The instruction or the character data at the data pins (D0-D7) is processed by the LCD on the falling edge of this pin. Generally we always use LCD to display something but in some cases we need to read from LCD in that case R/W pin is used

Pin configuration for LCD JHD162A:

PIN No	Name	Function
1	VSS	Ground voltage
2	VCC	+5V
3	VEE	Contrast voltage
4	RS	Register Select 0 = Instruction Register 1 = Data Register
5	R/W	Read/ Write, to choose write or read mode 0 = write mode 1 = read mode
6	E	Enable 0 = start to latch data to LCD character 1= disable
7	DB0	Data bit 0 (LSB)
8	DB1	Data bit 1
9	DB2	Data bit 2
10	DB3	Data bit 3
11	DB4	Data bit 4
12	DB5	Data bit 5
13	DB6	Data bit 6
14	DB7	Data bit 7 (MSB)
15	BPL	Back Plane Light +5V or lower (Optional)
16	GND	Ground voltage (Optional)

Table 3.2 Pin configuration of LCD JHD162A [7]

3.6Number plate recognition

After detection of speed of the vehicle, the system checks for the over speed according to the threshold set and if crossed it will trigger to capture the moment of the event. The positioning of the camera will be structured previously to get the image of back part of over speeding vehicle. The image thus captured will be send to the sever to detect and recognize the license plate of the vehicle.

3.6.1 Nepali Vehicle License Plate

License plate is the identification plate where unique numbers for each vehicle is printed. The registration number of the vehicle is binded with the chasis number of the vehicle. The VLP (Vehicle License Plate), issued by the by the zonal level Transport Management Office, a government agency under the Ministry of Transportation. The VLP must be placed on both front and back side of the vehicle. The plates are required to be either in Devanagari or Latin script. In practice, the registration plates of Nepal are bilingual. The Traffic Police Division issued the guidelines that the plate must not be reflective and digitally printed.

For the purpose of vehicle registration Vehicle & Transport Management Act, 2049 (1992) and Vehicle & Transport Management Rule, 2054 (1997) of Nepal, classifies vehicles into the following 5 main categories on the basis of size and capacity [8]:

- Heavy and medium-sized vehicle: This includes bus, truck, dozer, dumper, loader, crane, Fire engine, tanker, roller, pick-up, van, mini bus, mini truck, minivan etc. having the capacity to carry more than 14 people (for passenger vehicle) or more than 4 tons (for cargo vehicle).
- Light vehicle: This includes car, jeep, van, pick-up, micro bus, etc. having the capacity to carry less than 24 people or less than 4 tons.

- Two-wheeler: This includes vehicle having two wheels like motor cycle, scooter etc.
- Tractor and power-trailer:
- Three-wheeler: This includes vehicle having three wheels like tempo, auto-rickshaw etc.

The above mentioned each categories are further divided into 5 sub categories on the basis of ownership and service-type which are as follows:

Type of vehicle	Heavy size	Middle size	Motorcycle, scooter
Government	ग	झ	ब
Private	क	च	प, त
Local	ख	ज	थ
Tourist	य	य	
Government Organization/ Institution	घ	ञ	
Diplomatic	सिडी	सिडी	सिडी
Constitutional		झ	

Table 3.3 Major Categories of Vehicle [9]

- Private vehicle: The vehicles which are for entirely personal purpose and uses a red license plate with the letters written in white.
- Public vehicle: The vehicles which are for public purpose and use black license plate with the letters written in white or white license plate with the letters written in black.
- Government vehicle: The vehicles owned by the government agencies and constitutional bodies such as ministries, departments, directorates, along with police, military etc. falls under this category which uses white plate with the letters written in red.
- National Corporation vehicle: The vehicles which are registered under the name of public corporations fully or partially owned by the government fall under this category. These vehicles use yellow plate with the letters written in blue.
- Tourist vehicle: The special vehicles to make proper transportation arrangement for internal and external tourists in the nation.

The vehicles are provided with the letter as shown in the Table 3.3 with these being major categories of the vehicle so that the visual distinction can be made. Every development region in Nepal follows the same trend for vehicle classification except the region has own identifier described below.

The 4 identifiers are:

The license plate of Nepal is more detailed in comparison with other countries. The current license plate format for vehicles in Nepal consists of 4 parts composed of letters and digits in the LL NN LL NNNN format:

Figure 3.16 Vehicle Identifier

The identifier of the vehicle shown in Figure 3.16 is described as:

1) the zone code, signifying the zone in which the vehicle is registered.
2) the set number which is prefixed when the four digit number runs out from the last part.
3) the type of vehicle like private, public, governmental, national corporation, tourist etc. as well as the class of vehicle like two-wheeler, light vehicle, heavy and medium-sized vehicle etc.
4) the last part signifies four digits running in sequence.

And the color of the background and foreground represent the owned type of vehicle like public, private, government, diplomatic vehicle, etc.

All 14 zones of Nepal have their own abbreviated code for reference purpose. These codes are normally single letter in Nepali and two letters (sometimes three letters also, but the third letter 'a' can be omitted) in English which are shown in the Figure 3.16.

The two physical form of VLP are:

The physical standard of the VLP is determined by Ministry of Transport. As per the Vehicle and Transport Management Rule (VTMR), the two physical form are shown in the Figure 3.16(a) & Figure 3.16(b)

I. TheVLP present in the 4:3 ratio.

Figure 3.16(a) Vehicle identifier

II. VLP present in 4:1 ratio

Figure 3.16(b) Vehicle identifier

According the VMTR, the character and number are written inside the number plate by leaving ½ inch of space around the border for heavy and middle size four wheeler as for two wheeler bikes, scooter the space are made at ¼ inch. The distance between the number and the character must be ¼ inch and the distance between upper line and lower line of character must be ½ inch [9].

3.6.2Image Processing and Recognition

The steps involved in the overall image processing is represented by the flowdiagram shown in figure 3.6.2

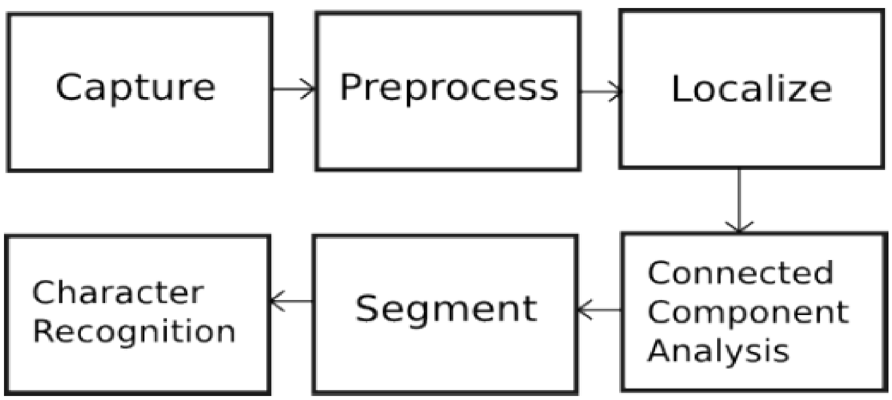


Figure 3.17 Image Processing and Recognition [10]

3.6.2.1Image Acquisition

Image acquisition is done by the raspberry pi camera which captures the image when it is triggered. The positioning of the camera will be structured previously to get the image of back part of over speeding vehicle. The feature of the image and properties of the camera is discussed in 3.4.6 Raspberry pi camera. A better choice is an HD Infrared (IR) camera.

3.6.2.2Preprocessing

After digital image has been obtained, and send to the server system next step is to deal with pre-processing of the image. The main purpose of the pre-processing is to increase the efficiency of other processes. Preprocessing is the set algorithms applied on the images to enhance the quality. It is an important and common phase in any computer vision system. For the present system preprocessing involves two processes:

Size Modification – The image size from the camera might be large and can drive the system slow. It is to be resized to a feasible aspect ratio.

Conversion of Color Space – Images captured using IR or photographic cameras will be either in raw format or encoded into some multimedia standards. Normally, these images will be in RGB mode, with three channels (viz. red, green and blue). Number of channels defines the amount color information available on the image. Thus, the image has to be converted to grayscale to make it appropriate for further processing.

3.6.2.3 Localization of the numbers

The image of the back part of the vehicle is captured. At such the image will contain other parts of the vehicle and surrounding along with the interested VLP. The license plate needs to be localized from the noise. The localization is the process of making the binary image, localization is done by an image processing technique called Thresholding. The pixels of the image are truncated to two values depending upon the value of threshold. This is an easy and convenient way to perform image segmentation based on different intensities or colors in the foreground and background part of an image. Not all images can be segmented successfully into foreground and background using simple thresholding. Its accuracy depends on the distribution of the intensity histogram. If the intensity distribution of foreground objects is quite distinct from the intensity distribution of background, it will be clear to apply thresholding for image segmentation. In this case, we expect to see distinct peaks in the histogram corresponding to numbers in VLP, so that threshold values can be picked to isolate those peaks accordingly. If such a peak does not exist, it is unlikely that simple thresholding can achieve a good segmentation.

Morphological image processing is a collection of non-linear operations related to the shape or morphology of features in an image. According to Wikipedia, morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grayscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest.

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood.

A morphological operation on a binary image creates a new binary image in which the pixel has a non-zero value only if the test is successful at that location in the input image.

Binary dilation is performed to the source binary image using different shaped structural elements.

3.6.2.4Connected Component algorithm

After localization of the image, connected component algorithm is applied to eliminate undesired areas of the image. This connected-component labeling is alternatively referred as connected-component analysis, blob extraction, region labeling, blob discovery, or region extraction is an algorithmic where subsets of connected components are uniquely labeled based on a given heuristic. This algorithm is used in computer vision to detect connected regions in binary digital images, although color images and data with higher dimensionality can also be processed. When integrated into an image recognition system or human-computer interaction interface, connected component labeling can operate on a variety of information. In this case blob extraction is performed on the resulting binary image from a thresholding step. Blobs may be counted, filtered, and tracked. Here, each of the connected components (blobs) is labeled and extracted.

3.6.2.5Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics. Example of image segmentation is shown in the figure below

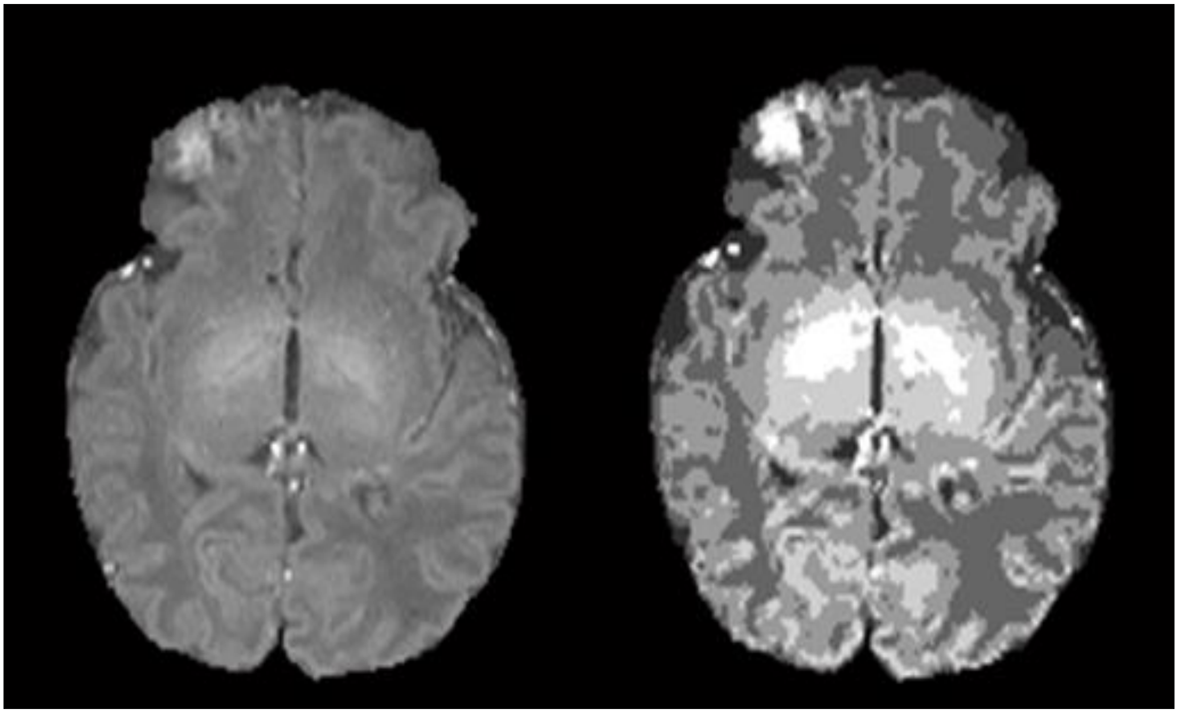


Figure 3.18 Segmentation [11]

The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (see edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Scissoring algorithm is used which performs by scanning the image vertically and cropping out white versions in the image. This technique is fast and efficient than compared to other predefined image cropping techniques. . Segmentation phase also involves classification of the collected blobs and recording only the essential ones. Undesirable blobs occur even after segmentation. These are removed by two methods:

1) Aspect ratio based elimination.
2) Pixel coordinate based selection.

Aspect ratio based elimination: The aspect ratio (row/column) of each blob is calculated and recorded. A binarized candidate is sure of containing more characters than unwanted blobs.

The mean of the aspect ratios are calculated and compared to all the blobs in turn. If anyone of them has a larger deviation, that blob is removed from the candidate.

Pixel coordinate based selection: This algorithm thrives on the fact that license numbers are occurring in the plate in a single set of rows. Effectively, we can detect the edge of the license plate, and select the blobs coming between the minimum and maximum row coordinates. This can reduce the amount of unwanted blobs and make the system more accurate. However, in our case, as we are capturing the back part of the vehicle numbers are in two rows, this algorithm is not used.

3.6.2.6Character Recognition

After the blob region has been selected, the blobs are tested to recognize the character associated with it. Template matching is a technique in digital image processing for finding small parts of an image which match a template image. It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot or as a way to detect edges in images.

Feature based approach

If the template image has strong features, a feature-based approach may be considered; the approach may prove further useful if the match in the search image might be transformed in some fashion. Since this approach does not consider the entirety of the template image, it can be more computationally efficient when working with source images of larger resolution, as the alternative approach, template-based, may require searching potentially large amounts of points in order to determine the best matching location.

Template Approach

For templates without strong features, or for when the bulk of the template image constitutes the matching image, a template-based approach may be effective. As aforementioned, since template-based template matching may potentially require sampling of a large number of points, it is possible to reduce the number of sampling points by reducing the resolution of the search and template images by the same factor and performing the operation on the resultant downsized images (multi resolution, or pyramid, image processing), providing a search window of data points within the search image so that the template does not have to search every viable data point, or a combination of both.

Algorithm

- Correlation of the input image with every image in the template for the best matching. Image correlation is an optical method that employs tracking and image registration techniques for accurate 2D and 3D measurements of changes in images.[12]
- Record the value of correlation for each template's character.
- Find the index which corresponds to the highest matched character.

4.SOFTWARE AND TOOLS USED

4.1Tools used for circuit design

4.1.1KiCAD

KiCAD is an open source software suite for electronic design automation. It facilitates the design of schematics for electronic circuits and their conversion to PCB designs. KiCAD uses an integrated environment for all of the stages of the design process schematic capture, PCB layout, Gerber file generation/visualization and library editing. KiCAD has a built-in basic auto router. Tools exist within the package to create artwork and 3D view of the PCB. KiCAD is also across platform.

4.1.2PCB Wizard

The PCB Wizard is a powerful and a highly innovative package for designing single side and double side PCBs. It provides a comprehensive range of tools covering all the traditional steps in PCB production, including schematic drawing, schematic capture, component placement, automatic routing. Circuit diagrams are drawn using circuit symbol components connected with wires. Components are simply dragged, dropped and arranged in the working window and necessary connections are made between the component terminals.

4.2Tools Used for Simulation

4.2.1Proteus VSM

The Proteus VSM combines mixed mode SPICE circuit simulation, animated components and microcontroller models to facilitate co-simulation of complete microcontroller based design. It is possible to develop and test such designs before a physical prototype is constructed. This is possible because interaction with the design is possible using circuit indicators like LED, display panels, actuators etc. It also provides extensive debugging facility by employing breakpoints, single stepping and variable display of both assembly code and high level language source code.

4.3Software used

4.3.1PuTTY

PuTTY is a free and open-source terminal emulator, serial console and network file transfer application. It supports several network protocols, including SCP, SSH, Telnet, rlogin, and raw socket connection.

Some features of PuTTY are:

- The storing of hosts and preferences for later use.
- Control over the SSH encryption key and protocol version.
- Public key authentication support.
- Support local serial port connection.
- Self-contained executables required mo installation.

4.3.2Real VNC

It is a company that provides remote access software. The software consists of a server and client application for the Virtual Network Computing (VNC) protocol to control another computer's screen remotely. RealVNC clients using can vncviewer run in full-screen mode they use the F8 function-key as the default key for bringing up an options menu. The server component of RealVNC allows a computer to be remotely controlled by another computer. The software can be installed for legitimate purposes, but it can also be installed from a remote location by an attacker with malicious intent.

4.3.3Arduino IDE

The Arduino development environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. It has many built in libraries along with libraries for LCD display. We can also install third party library in the latest IDE of Arduino.

4.3.4Python (programming language)

Python is a widely used general purpose high level programming language which emphasizes program readability and reduces complexity in coding. Its syntax allows programmers to express concepts in fewer lines of code than would be possible in other languages. The language provides constructs intended to enable clear programs on both a small and large scale. It supports multiple programming including object oriented, imperative and functional programming. It has feature like automatic memory management and has a large library.

Python uses dynamic typing and a combination of reference counting and a cycle-detecting garbage collector for memory management. An important feature of Python is dynamic name resolution (late binding), which binds method and variable names during program execution.

Features of python programming language:

- Simple ,easy to learn, free and open source
- Interpreted
- Object Oriented
- Extensible.

Python is indeed an exciting and powerful language. It has the right combination of performance and features that make writing programs in Python both fun and easy.

4.3.5MATLAB

MATLAB is a high level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computation. It can be used in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology.

MATLAB was used to test the algorithms and then to model the system. MATLAB has a variety of toolboxes for different purposes. In this case Image Processing toolbox is used.

5.METHODOLOGY

5.1System Block diagram

The overall system has a number of components, with specific tasks, working together. Connection of the different components is as shown in the block diagram Figure 5.1

5.1.1Diagram Description

Firstly, the HB100 sensor is a major part of the system. It senses the moving vehicle and produces output sinusoidal signal. The output signal is amplified by a very high gain amplifier. The output of the amplifier is fed to the digital pin of Arduino. The microcontroller measures the frequency of the input signal and calculates the speed of the vehicle from the value of frequency. The value of speed is displayed on the LCD panel. It also checks if the speed limit is exceeded and signals raspberry pi if the speed limit is crossed. The raspberry pi triggers the camera attached to the board. The image is then sent to the server via internet connection. The server processes the image to extract the characters in the License plate. The extracted character is then sent to the next station.

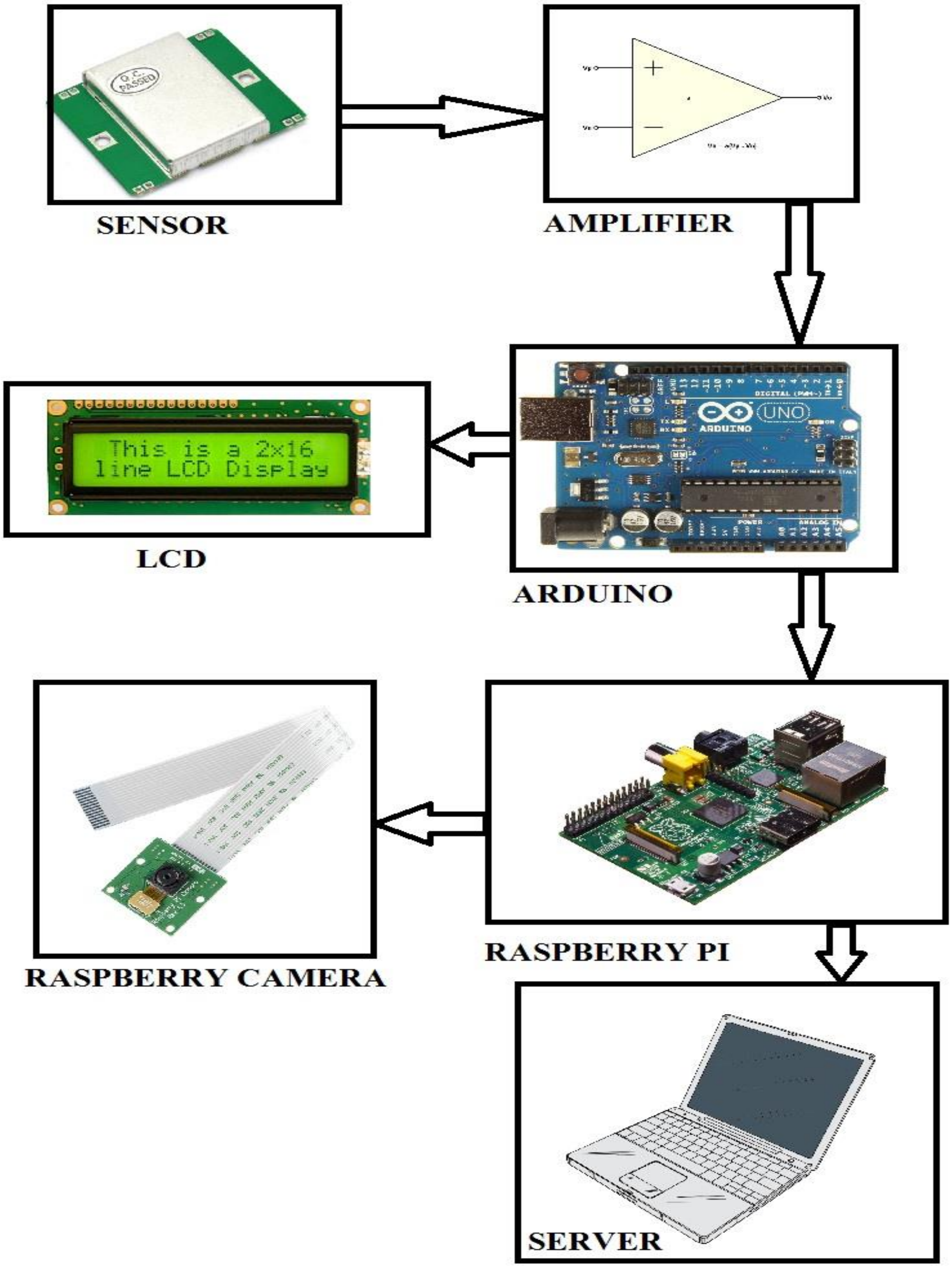


Figure 5.1 Block diagram of the system

5.2Flow chart

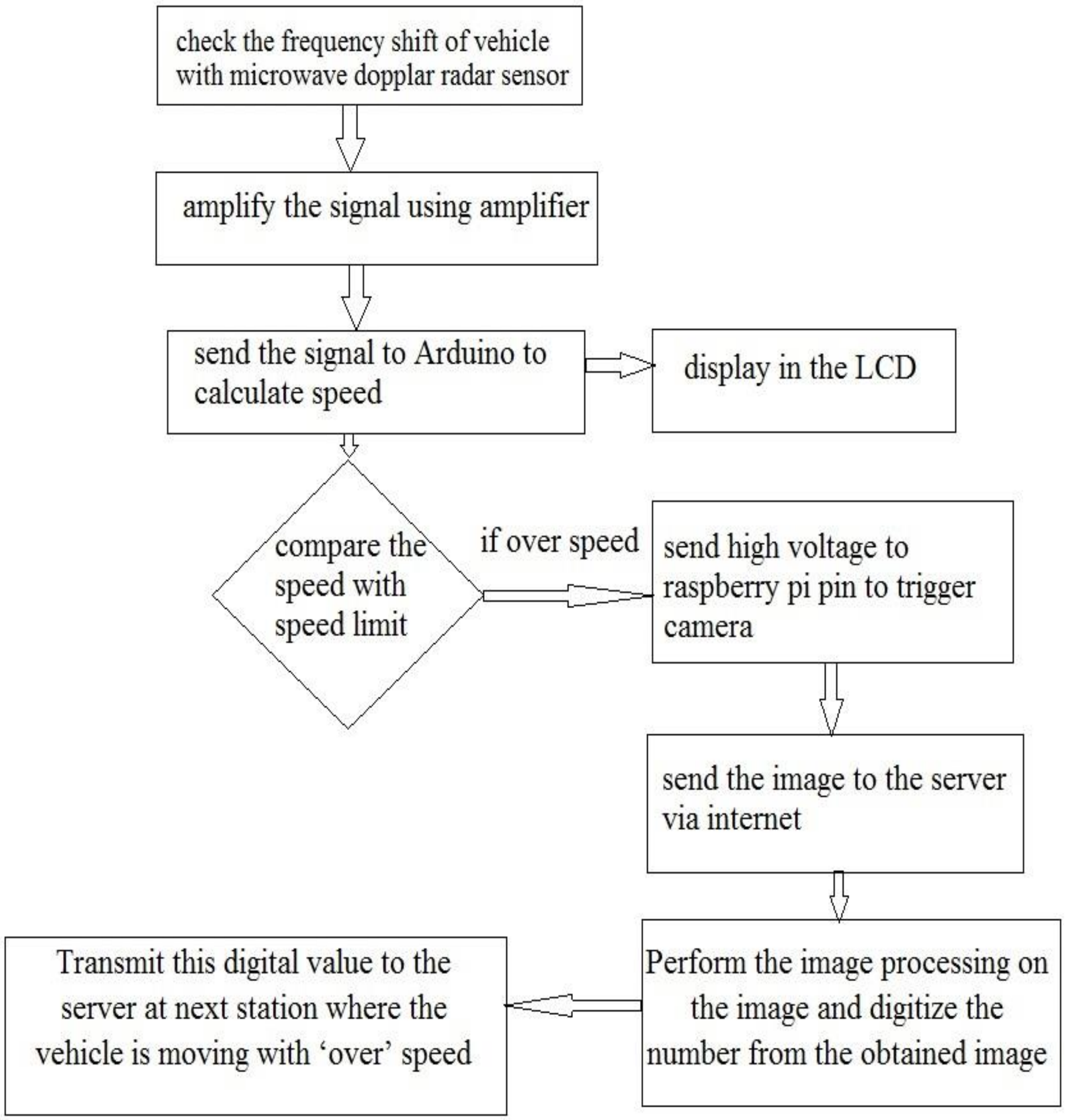


Figure 5.2 System flow diagram

The overall system can be broadly divided into three parts.

5.3Speed Detection

Radar sensor was used to detect the speed of the vehicles. Among the various methods researched for speed detection, radar detection seemed to be the most accurate way of detecting speed of vehicles. It is widely used in the commercial speedgun used by Traffic Police for checking on speeding vehicle. The radar sensor has a built in oscillator and mixer. The oscillator outputs a sinusoidal signal of frequency 10.525 Ghz and radiates the signal to a direction using microstrip patch antenna. The signal strikes the moving vehicle and reflected back to the sensor with shift in frequency according to Doppler principle. The mixer generates a signal that is the difference between the transmitted and the received signal and the frequency of the output signal is proportional to the speed of vehicle. The output is a low amplitude frequency signal in audio range.

The sensor is a 3 pin circuit. Vcc, Gnd and output pin. +5 volt is supplied between Vcc and Gnd and the output is taken from the output pin and Gnd.

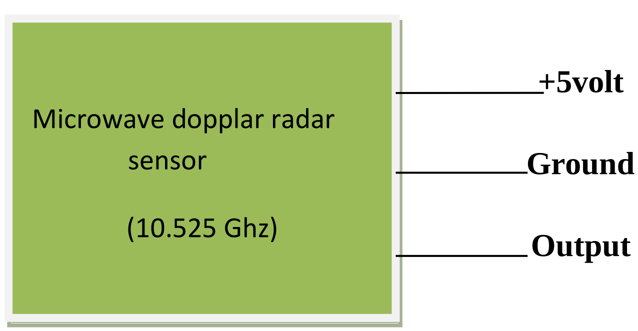


Figure 5.3 Simplified diagram speed detection

Using the dopplar shift equation to calculate the relation between the shift in frequency and velocity of the moving object.

fd =2*cosA* f * v/c

Where fd= shift in frequency in Hz (i.e. frequency of the output signal from radar)

v=velocity of moving object

c=velocity of electromagnetic wave in vacuum

f=frequency of transmitted wave from the sensor (10.525 Ghz)

Assuming the object is directly ahead so that the value of angle cosA=1, the expression for velocity of the object reduces to :

v= fd/19.49074 km/hour

For v=0, fd=0

For speed limit of 60 Km/hr, i.e. v=60 Km/hr, output frequency fd=1169.428Hz.

If the output signal of the sensor has frequency exceeding 1169.444Hz, the vehicle exceeds the speed limit of 60 km/hr.

5.4Amplification of signal

The output of the sensor is sinusoidal wave with very small amplitude and needs to be amplified before further processing. The output of sensor is in the audio frequency range. However we are concerned with the frequency below the speed limit. i.e nearly 1.1 Khz. So an audio amplifier with low pass active filter is desired for the design. The amplifier IC used for this purpose is the LM324 Quad op amp. This IC has four operational amplifiers

The output signal from the radar is in the range of few millivolt. So high gain of the amplifier is needed to shift the voltage level to the point that is able to drive a TTL logic. The amplification is achieved in two stages to minimize the effect of noise. The complete diagram of the amplifier circuit used is as shown below.

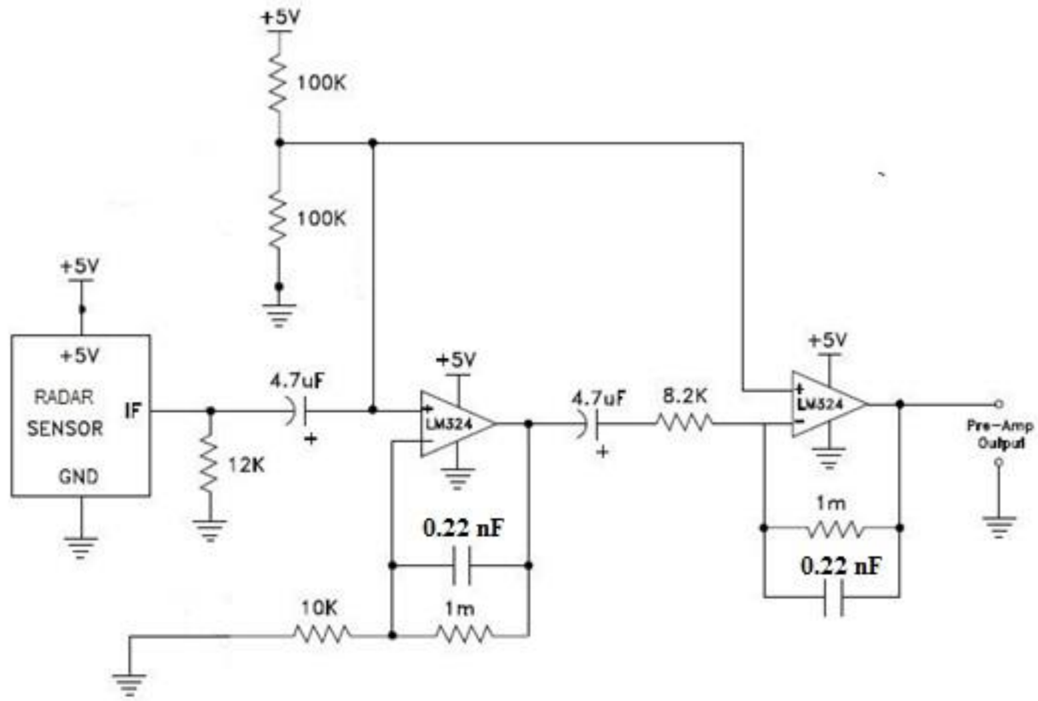


Figure 5.4 Amplifier Design

Amplification of the radar output is achieved using two of the four stages of LM324 IC.

5.4.1Non-Inverting stage

The first stage is configured as Non-inverting amplifier. The output of the sensor has a small dc value (0.01 to 0.2 Vdc)and so AC coupling of the output is necessary. The input is supplied to the non inverting terminal via a capacitor(4.7 µF) and a resistor(12K) is connected to the ground. Dc offset of nearly 2.5 volts is generated using a resistive divider network. Two resistors of 100K are connected between +5 volt and Ground to generate 2.5volt at the centre.

The gain of the first stage is given by the values of the resistor in the feedback path(1M) and the resistor from the inverting terminal to ground(10k). The gain in the non inverting amplifier is

Gain= (1+1M/10K) = 100

5.4.2Inverting stage

The output of first stage is a sinusoidal signal with a small dc offset. The dc component at the output is filtered by the capacitor at the output terminal. The second stage is a op-amp configured as inverting amplifier. The signal is applied to the inverting terminal via 8.2K resistor and dc offset of 2.5 volt is supplied to the non-inverting terminal. The gain for this stage is given by the values of the feedback resistor (1M) and the resistor at the inverting input terminal (8.2 K). The gain in this stage is given by the equation

Gain= -1M/8.2K =122

The 2.2nF capacitor in the feedback path of the amplifier makes this configuration an active low pass filter. The high frequency noises are filtered and the accuracy of the system is improved.

The two stages are cascaded to achieve the overall gain of the amplifier. The overall gain is given by the product of the gain in individual stages.

Overall gain of amplifier= 100 * 122 =12,200

The gain of the amplifier is so high that the op-amp in the second stage reaches saturation. Since we are concerned only with the frequency of the signal and not the shape of the wave form, the output is driven to saturation point with very high gain. The second stage acts as a comparator and the output produced is a digital waveform that can be sensed by the digital pin of a microcontroller.

5.5Measurement of frequency

Frequency of the signal is the factor representing the speed of the moving object. So the next stage is the measurement of the frequency of the incoming pulse from the amplifier. Output from the amplifier is connected to the external interrupt pin of atmega 328 .The corresponding pin in arduino Uno is digital pin 8. Counter of atmega328 is used for the measurement of the frequency of input signal. External interrupt pin of atmega328 can be programmed to work with either rising edge or falling edge. So, Interrupt pin can be used to detect rising edge in the input signal. The rising edge of the input signal provides interrupt to the microcontroller. The interrupt subroutine starts the counter. On the next rising edge the counter stops. The frequency of the input signal can be obtained from counted value and the clock of the counter. A number of such measurements can be taken and averaged for better accuracy.

5.5.1Algorithm for measuring frequency

1) Enable external interrupt and check for rising edge in the input signal

2) At rising edge, start counter

3) Wait for next rising edge

4) At next rising edge, stop counter

5) Divide clock frequency of counter by output of counter

6) Repeat steps 1-5 for a number of times and take average

The microcontroller is run with a 16 Mhz crystal. So if the counter inside it counts ‘n’ between two successive rising edges of the input signal then the frequency of the input signal is 16/n Mhz. This approach of measuring frequency is accurate when the frequency of the input signal is very small compared to the clock of microcontroller.

5.6Display

The value of the speed calculated from the frequency was displayed on a 2*16 LCD display. The LCD was interfaced to the microcontroller as per the instruction provided in the datasheet.

Pin No.	Symbol	Function	Remarks
1	Vss	GND	Connected to Ground
2	Vdd	+3V or +5V	Connected to +5 volt
3	Vo	Contrast Adjustment	Connected to ground for constant contrast.
4	RS	H/L Register Select Signal	Digital pin 12 of Arduino
5	R/W	H/L Read/Write Signa	Connected to ground (Always read)
6	E	H → L Enable Signal	Digital pin 11
7	DB0	H/L Data Bus Line	Not connected
8	DB1	H/L Data Bus Line	Not connected
9	DB2	H/L Data Bus Line	Not connected
10	DB3	H/L Data Bus Line	Not connected
11	DB4	H/L Data Bus Line	Digital pin 5
12	DB5	H/L Data Bus Line	Digital pin 4
13	DB6	H/L Data Bus Line	Digital pin 3
14	DB7	H/L Data Bus Line	Digital pin 2
15	A/Vee	+ 4.2V for backlight LED	Connected to Vcc with 570 ohm resistor
16	K	Power Supply for B/L (OV)	GND

Table 5.6 Display

The Arduino board not only calculates and displays speed but also compares it with a preset threshold. The threshold for our design is 60 km/hr. When it detects overspeed, Digital Pin 8 is set high for a short instance. Output pin of microcontroller is connected to raspberry Pi to signal the Pi to trigger the camera whenever speed limit is crossed. Direct connection between atmega328 and raspberry Pi cannot be made due to difference of logic level for the two processors. So a resistive voltage divider network is used to shift voltage level of 5V at output pin to 3.3V. The output pin of atmega is connected to ground via two resistors 270 ohm and 470 ohm in series. Voltage across 470 ohm resistor and ground is fed as input to raspberry Pi's digital pin. Digital pin 23 of raspberry Pi is configured as input pin. When the digital pin in raspberry pi goes high it triggers its HD camera and captures image of the approaching vehicle.

5.7Socket programming in python:

Raspberry pi comes with a Linux based operating system and python is the official programming language supported. The board needs to communicate to the server to transfer the image file for further processing. Each time a vehicle crosses the speed limit the Pi board captures the image, connects to the server and sends it. The connection between server and the pi board is via internet. The Pi has a LAN interface and is capable of connecting to the internet directly through LAN cable. The server on the other side continually monitors for any incoming request and handles it. Both the client and server are programmed in python.

- The server creates a socket and listens for any incoming connection in the designated port.
- The client program running on the Pi board continuously checks for High signal in its input pin.
- When high, it triggers the camera and saves the image in its memory.
- The client then requests for a connection with the server.
- The server accepts the connection.

- The Client then sends the image to the server and disconnects the socket.
- The client again starts monitoring its input pin.
- The server saves the image along with the current date and time.
- The server again starts listening for any incoming connection

5.8Number Plate recognition

Initially using MATLAB platform the image processing was performed which include following steps.

5.8.1Number plate extraction

- Take a image
- Resize the image keeping the aspect ratio same
- Convert to gray scale
- Apply median filtering to remove noise

Figure 5.5 Number plate extraction

- Find the structural element
- Dialating the gray image with the structural element
- Eroding the gray image with structural element
- Morphological Gradient for Edge enhancement
- Converting the class to double

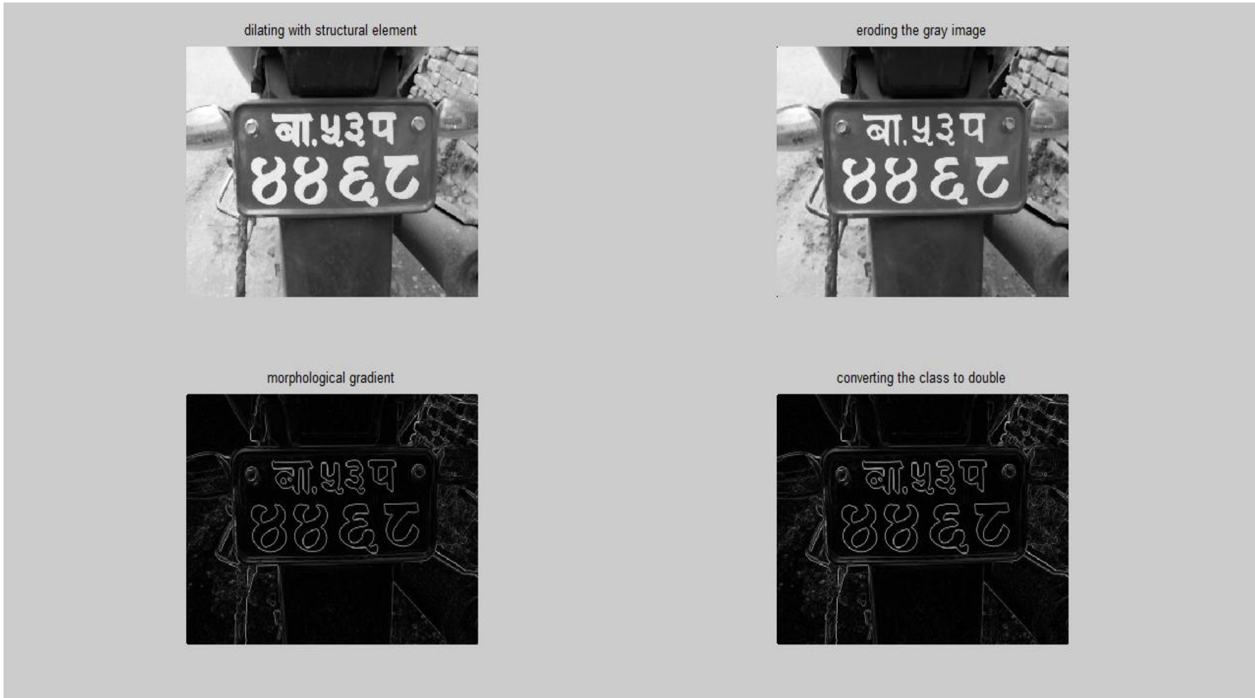


Figure 5.5(a) Number plate extraction

- Convolution of the double image for brightening the edges
- Intensity scaling between the range 0 to 1
- Conversion of the class from double to binary
- Eliminating the possible horizontal lines from the output image of region grow that could be the edges of a license plate

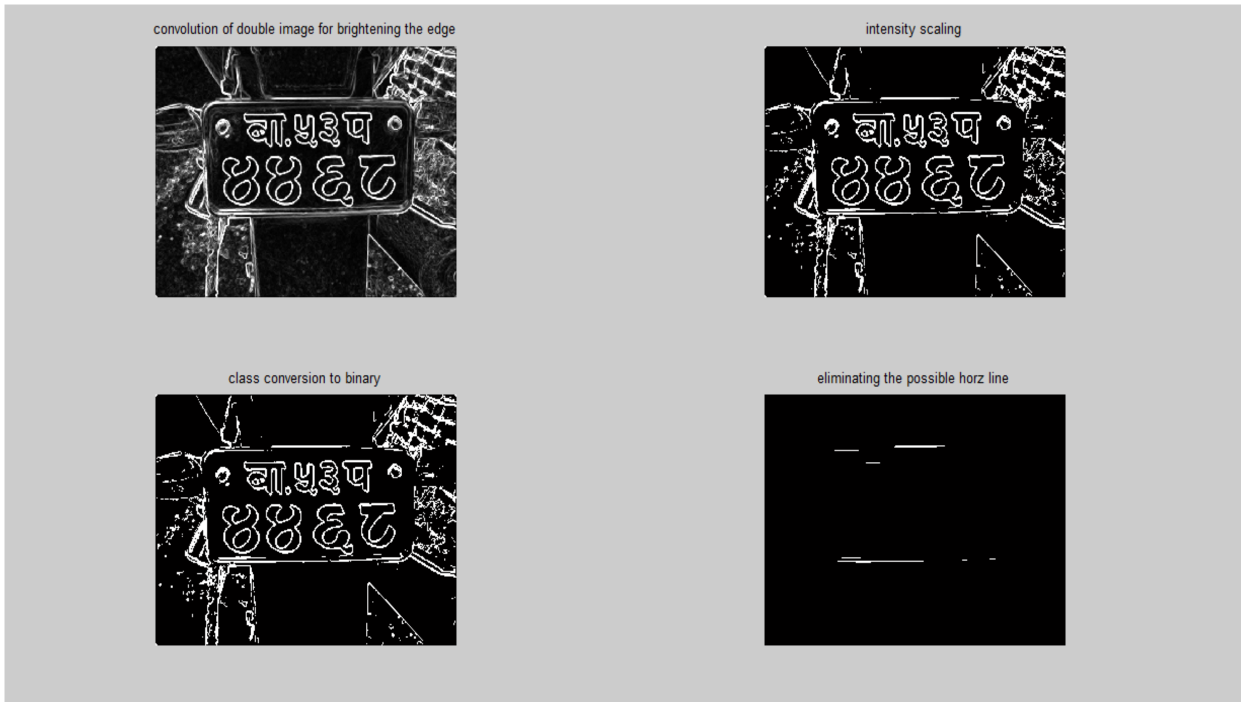


Figure 5.5(b) Number plate extraction

- Subtracting the recent image from binary image
- Filling all the regions of the image
- Thinning the image to ensure character isolation
- Selecting all the regions that are of pixel area more than 100

Figure 5.5(c) Number plate extraction

6.EXPERIMENTAL RESULTS

6.1Accuracy in frequency measurement

The accuracy of the system in frequency measurement was tested using a function generator and an oscilloscope. The input to the amplifier was connected to the output of the function generator and an oscilloscope was connected for reference. Small sinusoidal signal was applied to the circuit and the frequency varied. The table below summarizes the result obtained from the test.

Applied frequency	Measured Frequency
50.12 Hz	50.05 Hz
101.31 Hz	101.25 hz
200.88 Hz	200.65 Hz
300.08Hz	299.90 Hz
400.60 hz	399.85 Hz
600.32 Hz	600.45Hz
800.62 Hz	798.48 hz
1000.98 Hz	999.15 hz

Table 6.1 Applied frequency vs measured frequency

The test showed very high degree of accuracy in measurement of frequency of input signal. However, in actual system with sensor as source of frequency noises in various forms are present. So a slightly higher degree of inaccuracy than the data shown in above table can be expected.

6.2Calculation of speed

If ‘f’ be the value of frequency measured by the microcontroller, then the corresponding speed in Km/hr is obtained by dividing it with a factor 19.49. Some of the values of frequency and their corresponding speed are presented in the table below.

Frequency	Speed
0 Hz	0 .00 Km/hr
100 Hz	5.13 Km/hr
400 Hz	20.52 Km/hr
800 Hz	41.04 Km/hr
1200 Hz	61.57 Km/hr

Table 6.2 Calculation of speed

6.3Accuracy in speed measurement

Testing accuracy of the sensor and the overall system in speed measurement required a standard calibrated device such as a speed gun for determining speed of moving vehicles. But due to lack of such resources available for testing, the accuracy of system could not be exactly determined. Attempts were made to test the system output against the speedometer of vehicle and despite the complexity in observation some data were produced to check the accuracy of system.

Reading from vehicle speedometer	Reading shown by our system
0 (km/hr)	3 (km/hr)
10 (km/hr)	14 (km/hr)
20 (km/hr)	26 (km/hr)
30 (km/hr)	28 (km/hr)

Table 6.3 Accuracy in speed measurement

The accuracy of the system was observer to be very low. This may be due to the number of factors:

- The direction between the motorbike and the sensor was not perfectly aligned (i.e. angle A not equal to 0).
- The table is based on the observation made by the motor bike rider and the observer looking at the LCD display .It was hard to synchronize the readings taken by two observers. Furthermore the readings from the analog spectrometer of the bike could not be observed precisely.
- The output was affected by number of objects moving in the surrounding.

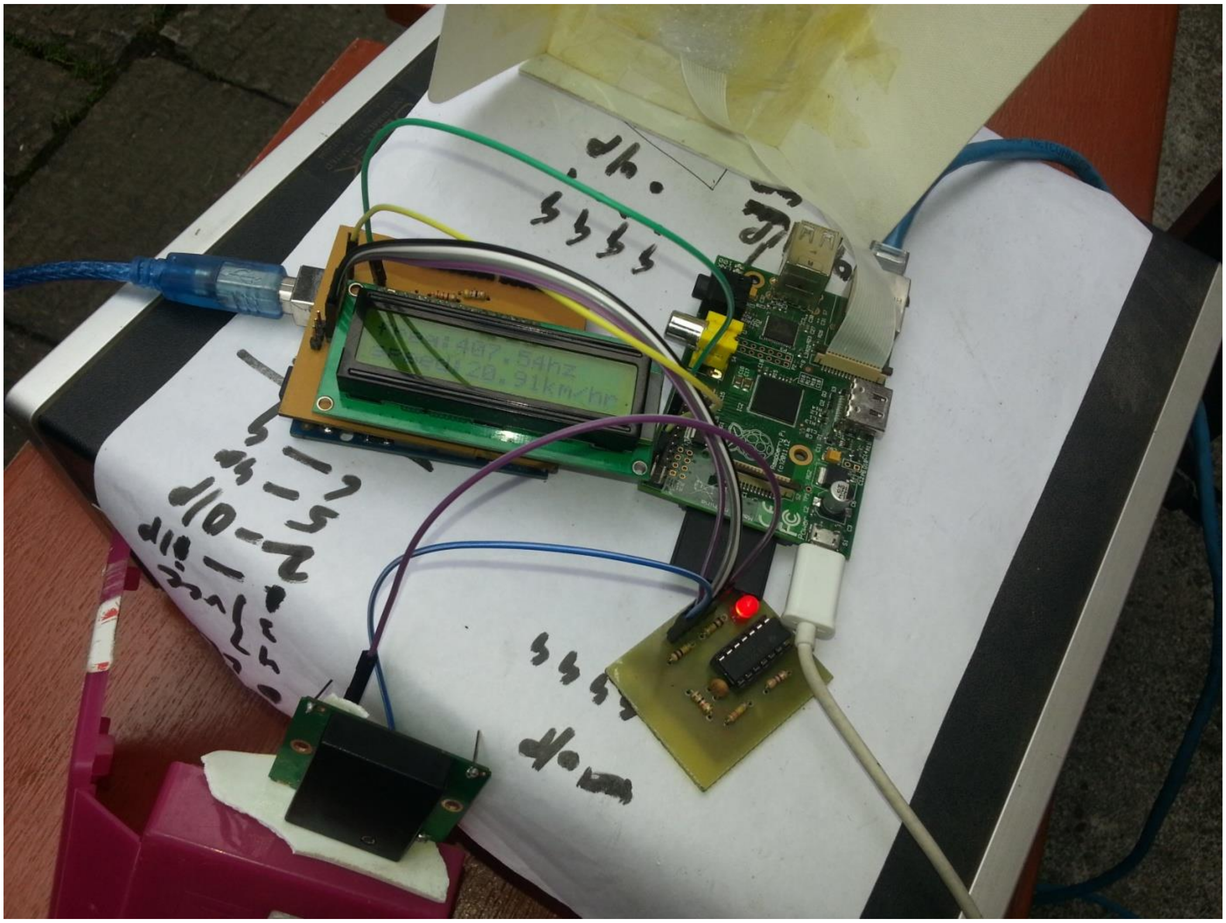


Figure 6.1 Experimental Setup

6.4Connected component analysis

For this we measure the properties of image regions. Regionprops, a function inside Image Processing Toolbox of MATLAB, is used. It measures a set of properties for each connected component (object) in the binary image. The selected blob looks like

This is the region extracted from the processed image:

Figure 6.2 Region Extraction

At this, to extract the component of our interest we analyze through the histogram method:

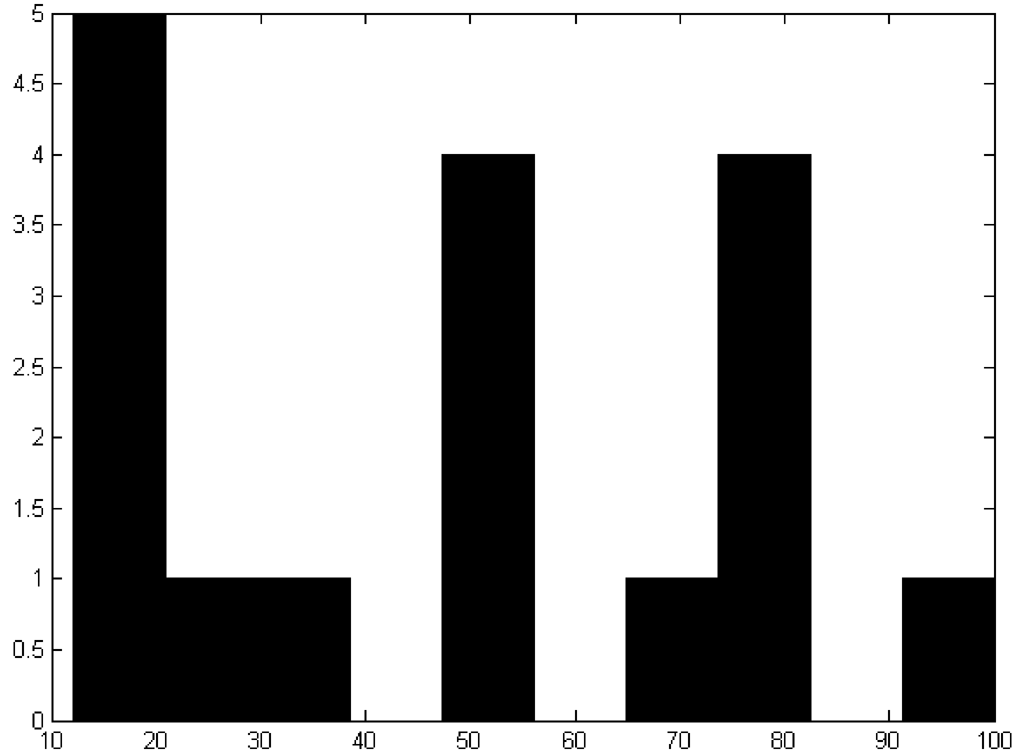
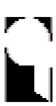


Figure 6.3 Analysis through histogram

Here we have 2 bars that are with the value of 4 and we extract using these bar. Since we are getting the image of the backside of the vehicle, the numbers in the plates are in two rows with 4 characters. We emphasize on obtaining the indices of bounding boxes whose width along the y-dimension is nearly same. If the approach of y-width doesn't work then Bounding Boxes with nearly same y-coordinates are obtained.

Then, the obtained components are tested with list of templates which are prepared from manually extracting the characters from the processed image which are as:




6.COST ESTIMATION

S.NO	Item	Specification	Rate (Rs.)	Quantity	Total (Rs.)
1	Raspberry pi	model B	6500	1	6500
2	camera	rev1.3	3000	1	3000
3	Arduino	UNO	3500	1	3500
4	Sensor	HB100	3000	2	6000
5	Microcontroller	atmega328	450	2	900
6	Resistors	pack	80	2	160
7	Capacitors	pack	10	15	150
8	Crystal	16MHZ	30	2	60
9	PCB board	12*12	800	2	1600
10	memory card	micro SD	500	1	500
11	Bread Board		150	2	300
12	Matrix board		100	2	200
13	Male female header		1	100	100
14	Connectors	Female-Female	12	50	600
15	IC base	14 pin	30	2	60
16	IC base	Lm324	50	2	100
17	drill bit	1mm	80	4	320
18	soldering Rod	40 watt	1	550	550
19	soldering materials	Wire,paste&stand		500	500
20	LCD	16*2	400	1	400
21	power supply	7805 IC	20	1	20
22	Battery	9V	60	2	120
23	Miscellaneous		5000	1	5000
	TOTAL				24,140

Table 6.1 cost analysis of project

8.PROBLEM FACED

8.1Sensor

The microwave Doppler radar sensor is not available in the local market of Nepal and had to be ordered from abroad. It took about three months for the vendor to ship the sensor to Nepal. The sensor initially worked well but quickly broke down due to some unseen reasons. It took another few months for the next sensor to be available. Designing and real time testing was not possible without the sensor and a huge time was wasted waiting for the piece to arrive.

The Hb100 sensor has a range of 10 meters which is not sufficient for a good speed detection system. However this problem can be solved by using other sensors like DF00 which work on the same principle but have effective range of upto 100 meters.

Also the sensor used has a wide angle of coverage. The sensor is affected not only by the objects moving directly ahead but by the objects in the surrounding as well. The directivity of the radiator can be improved by using a directional antenna.

The sensor detects the speed of not only moving vehicles but any moving object in its field of view. This could be prevented by using a sensor whose radiation wavelength is of the order of the dimension of vehicles.

8.2Camera

The type of camera required for our system is a high resolution high speed camera. Few vendors could supply such camera but with cost that was far beyond our budget. There is a different category of cameras made for the specific purpose of License Plate Recognition. Such cameras use their own light of specific wave length and so are least affected by the external lighting condition and illuminance of surface. But such camera was not affordable for a student project like us and we had no resource to access and test one.

The camera we used is a 5 Megapixel High definition camera that comes with the raspberry pi. It is easy to interface with the Pi board but the image quality is very poor and unacceptable for image processing operation such as License Plate Recognition. The camera takes nearly one second to take a picture of good quality but this time is not acceptable when working on the road with vehicles running over 60 km/hr.

8.3Number Plate recognition

Optical Character recognition of the characters of Devnagari has been least explored in the past. Very few attempts have been made to digitize the number plate written in Devnagari characters. And the success of those works is also very limited. The accuracy of the systems developed so far is far below the acceptable limit for designing any real time working system. As such we had very little help from any experienced person who had worked in this field. This posed a great problem for us and a lot of time had to be spent in reviewing the research papers written on this topic.

Another problem faced in the Nepali Number Plate is the dissimilarity in the font used by different persons. There is a standard for the font, height and width of the characters in the plate. But inspection of a number of plates showed that the standard set by the government has not been implemented effectively. So the dimension of the character and the font varies among different number plates. Our approach of Character recognition in the number plate is by template matching. So the accuracy of the system depends on the prior knowledge of the dimension and style of the characters.

Figure 6.1 Real time image

8.LIMITATION AND FUTURE ENHANCEMENT

Although automatic systems are advantageous regarding the simplicity of the task, the reliability won't be like that from human work. At such, our system has different limitations whose prime cause being the ones we discussed in problem Faced. Resolving these issues will help to enhance our system to a level where following objectives could be met:

- The stolen vehicle can be detected by comparing with the registered entry of stolen vehicles.
- Accuracy can be increased using Neural Networks. Advanced image processing algorithms and libraries could be used so that the system can be used efficiently even during unfavorable lighting conditions and during the night time as well.
- Can be used as traffic counters to count the number of vehicles plying on a highway.
- The Number plate of vehicle which has crossed over speed limit can be sent to mobile of traffic police in the area using Android application.
- Adding more vehicle detection wireless sensing networks and implementing a wireless sensor network will be another interesting application which will open up much more applications areas.
- Security of data during communication can be another important work for the future development of this project.

10.CONCLUSION

The designed speed detection system was capable of continuously monitoring the speed of the approaching vehicle. The sensor worked well for the vehicle at a close range of about 7 meters. The output was more accurate with no other moving objects in the surrounding. The value of speed of each passing vehicle was displayed in the LCD display. With each over speeding vehicle passing by the sensor, the camera was triggered and the image was saved in the SD card. The image was also transferred to the server via internet where the image was processed for the extraction of the characters from the number plate. The Number Plate Recognition system was not perfect and requires modification. It accurately identified few of the characters but not all. The character extraction also depended on the font and dimension of the character as well. The system was more accurate in identifying the characters that was written in the style similar to the one used in our template.

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12.APPENDIX

Appendix A

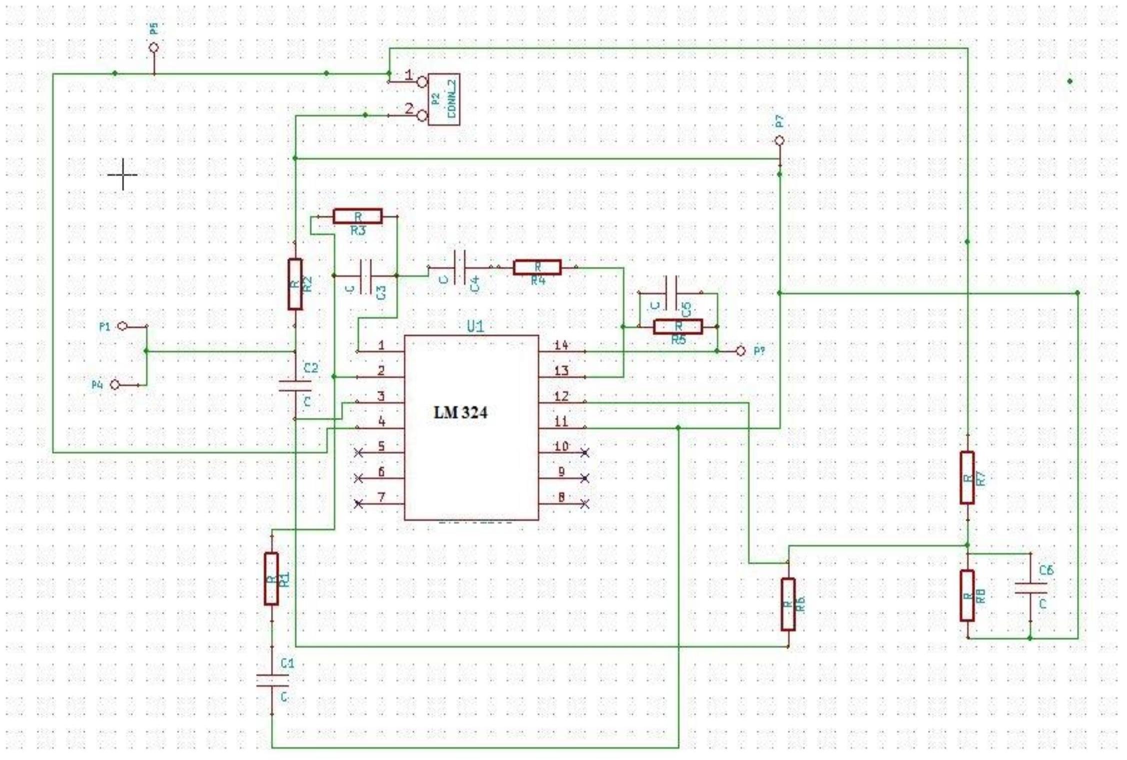

Figure 12.1 Amplifier Schematic

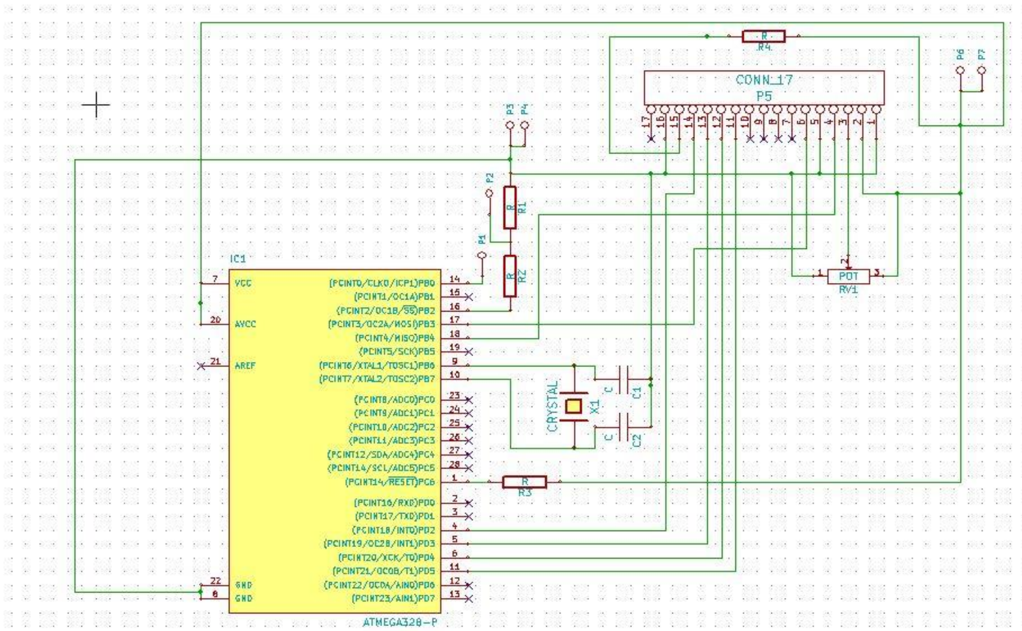

Figure : 12.2 LCD Interface schematic

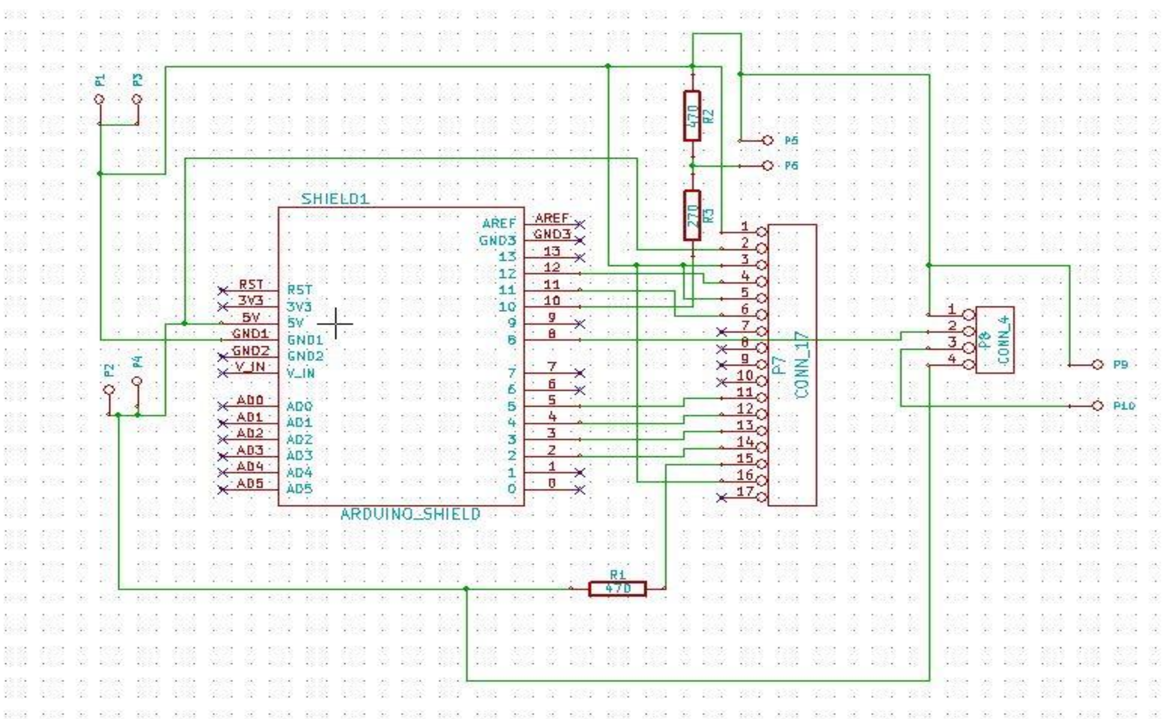

Figure 12.3 Arduino Shield schematic

Appendix B

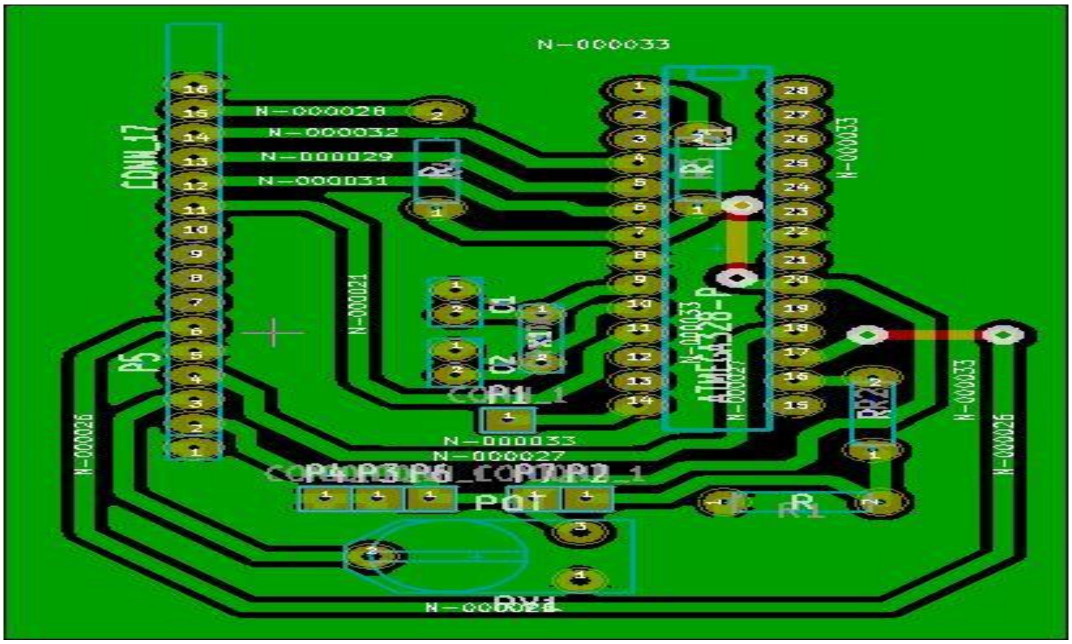

Figure 12.4 LCD Interface circuit PCB design

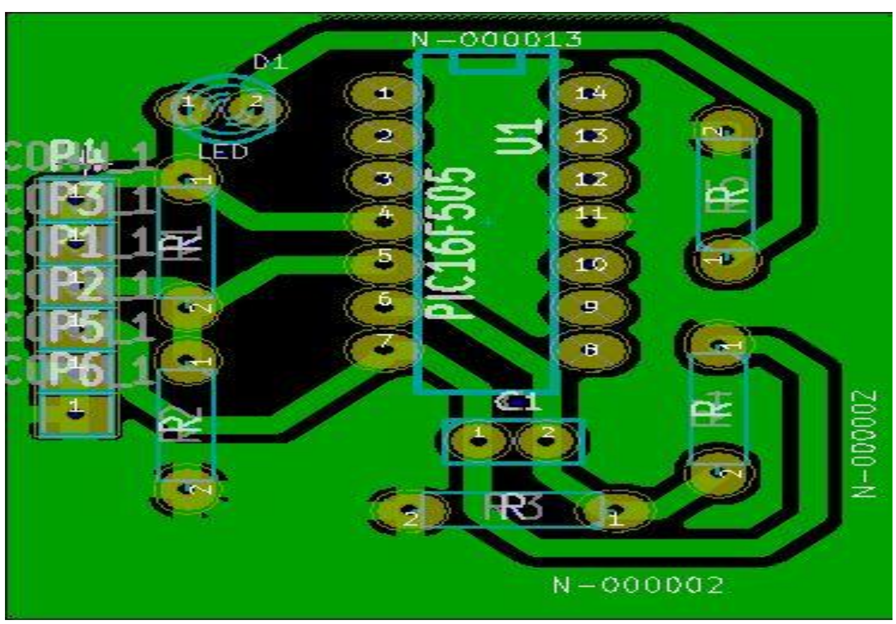

Figure 12.5 Amplifier PCB design

Appendix C

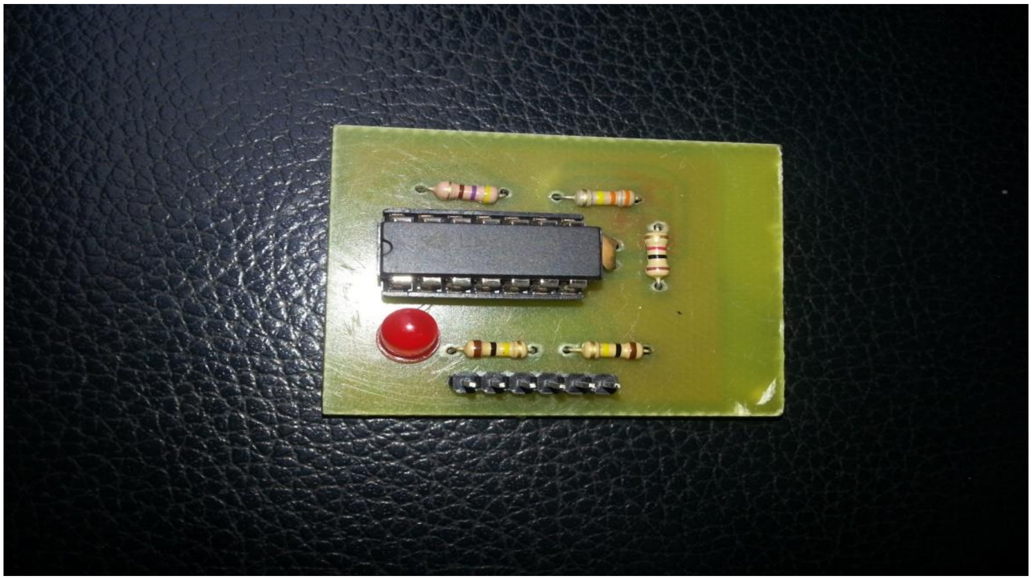

Figure 12.6 Amplifier

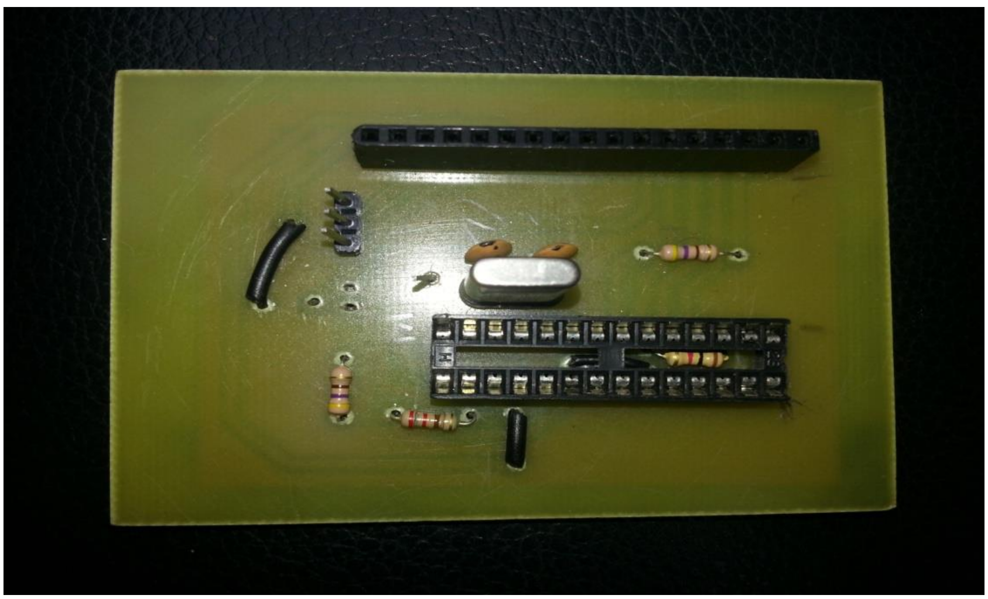

Figure 12.7 LCD Interface