SHAH AND ANCHOR KUTCHHI
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FACE RECOGNITION SYSTEM

ABSTRACT

Biometrics have been proved to be an efficient method in identifying and recognizing a person. It includes various systems, methods and algorithms for recognition of an individual. One of the important biometric feature of human is their face. Also, the face is one of the easiest ways to distinguish the individual identity of each other.

Face Recognition System uses the face of the human as a biometric key to recognize the person. In other biometric systems like Fingerprint Sensing System, Iris Scanner, the effectiveness and efficiency of the system may degrade over a period of time. Face Recognition System proves to be a cost effective system that caters to most of these problems.

Face recognition is a personal identification system that uses personal characteristics of a person to identify the person's identity. Human face recognition procedure basically consists of two phases, namely face detection, where this process takes place very rapidly in humans, except under conditions where the object is located at a short distance away, the next is the introduction, which recognize a face as individuals. Stage is then replicated and developed as a model for facial image recognition (face recognition) is one of the much-studied biometrics technology and developed by experts.

There are two kinds of methods that are currently popular in developed face recognition pattern namely, Eigenface method and Fisherface method. Facial image recognition Eigenface method is based on the reduction of face-dimensional space using Principal Component Analysis (PCA) for facial features. The main purpose of the use of PCA on face recognition using Eigen faces was formed (face space) by finding the eigenvector corresponding to the largest eigenvalue of the face image. The area of this project face detection system with face recognition is Image processing. The software requirements for this project is Python.

This system uses the principle of Eigen Faces and Supervised classification for face detection and recognition. Initially, a training set of images is formed from captured images. From these training images, a set of basis images is formed called the Eigen Faces. Each training image is a weighted combination of these Eigen Faces. This is because humans have similar face structure but what differs is their facial features. To what extend the feature is dominant in a particular face is given by these weights. Faces of two different people will have different weights; that is, faces having more difference in weights are considered to be faces of different individual.

In the testing phase, the system captures the image of the person. It now checks this captured image with the images present in the database. If the match is found, the person is considered to be genuine and access is granted to that person. If the captured image doesn't with any of the images present in the database, the person is considered to be an intruder. Now, the image of the intruder is sent to the authority via mail and the authority is intimated about the intruder and the mail via the message sent in android messaging application. The authorized person, after checking the image of intruder, now may or may not grant access to the unauthorized person by sending the appropriate commands via SMS using the messaging application.

Database can contain upto 200 entries. The size of the database can be increased by increasing the size of Micro SD Card. The system works on OpenCV (Open Source Computer Vision) which is user friendly. Processes maximum variation of images provided that the images are captured in controlled environment. The system could achieve 90% accuracy by this approach.

Face Recognition System has its own certain advantages over other biometric systems. Face Recognition System is useful in the field of security and surveillance, medical field, business and marketing sectors, attendance systems, to trace out the missing people, social sites like Facebook and Google photos.

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PROJECT PLAN

PROJECT TITLE:

FACE RECOGNITION SYSTEM

OBJECTIVES:

1. To implement the Face Recognition System using Raspberry Pi 3 Model B.
2. To establish a link between science and society.
3. To conversant with the skills of craftsman as well as in’s and out’s of any device or process.
4. To collect the best of matter in such a way as to form an independent unit itself.
5. To provide reads some useful information regarding our project.

GROUP FORMATION: DECEMBER 2017

SELECTION OF PROJECT: DECEMBER 2017

START DATE: 27th DECEMBER 2017

COMPLETION DATE: 29th MARCH 2018

COST: 8,000/-

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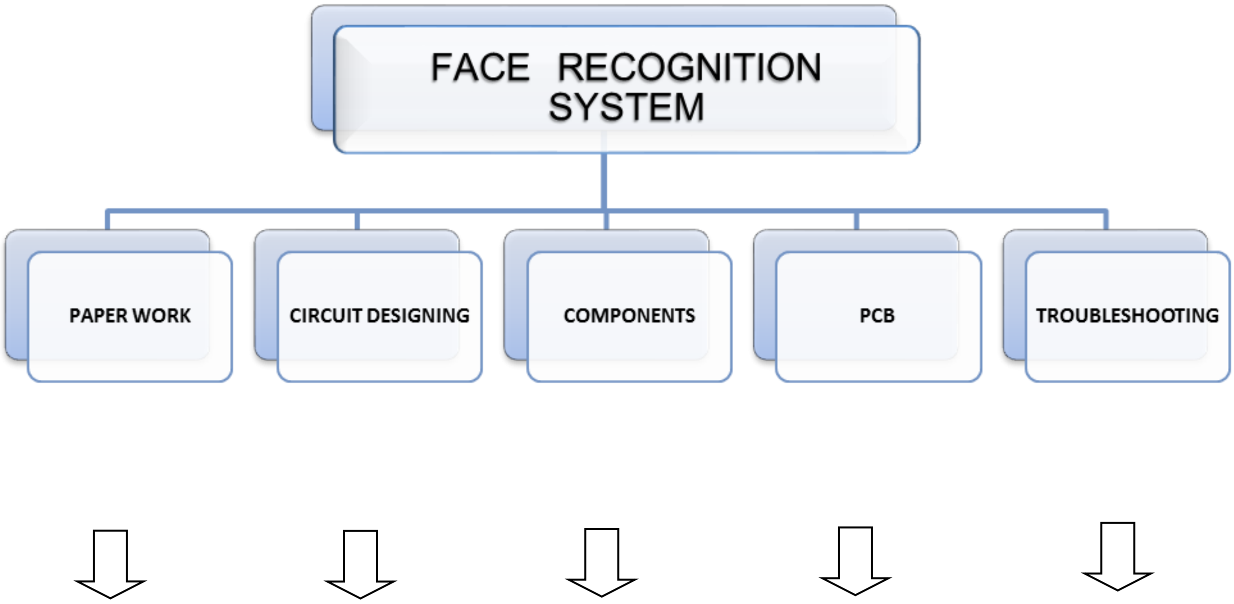
WORK BREAKDOWN STRUCTURE (WBS)



PAPER WORK

- Designing of tentative circuit.
- Selecting of components
- Designing of program to display User ID on Laptop.
- Writing a sample program to check the functioning of circuit.
- Designing a Driver Circuit.
- Writing a program for displaying text of granting / denying access

CIRCUIT DESIGNING

- Designing of schematic diagram.
- Programming of Driver circuit according to the Raspberry Pi 3 Model B and motor requirements.

COMPONENTS

- Search for alternatives if the desired one is not available.
- Selection of suitable version of Raspberry Pi
- Motor Driver Circuit section.
- Power supply section.
- Wires, connectors, etc.

PCB

- General purpose PCB (for testing purpose)
- Copper platted PCB
- Etching
- Drilling
- Assembling

TROUBLESHOOTING

- Checking for shorts between the terminals
- Writing appropriate program for displaying User ID on the Laptop.
- Writing appropriate program for displaying text of granting / denying access on the Laptop.

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CHAPTER 1 : INTRODUCTION

1.1 OBJECTIVE

Traditional ways for personal identification depend on external things such as keys, passwords, etc. But such things may be lost or forgotten. One possible way to solve these problems is through biometrics, for every person has his special biometric features definitely. Biometrics identification has gained increasing attention from the whole world. Biometrics features that can be used for identification include fingerprints, palm prints, handwriting, vein pattern, facial characteristics, face, and some other methods such as voice pattern, etc. Compared with other biometric methods, the face recognition has the following advantages: The face image acquisition requires no physical contact, so face identification system is non-invasiveness.

Face Recognition System uses the face of the human as the biometric key to recognize the person. In other biometric systems like Finger-print Sensing System, Iris Scanner, the effectiveness and efficiency of the system may degrade over a period of time. Face Recognition System proves to be a cost effective system that caters to most of these problems. The Internet of Things (IoT) can be defined as a global infrastructure which combines intelligent services with situational awareness, and allows mutual communication between one thing and another, and between people and intelligent things over a network. More recently, a variety of communication technologies have been fused to receive and provide information about things. Especially, IoT technologies have been enabled to communicate by the fusion of home appliances and mobile devices.

The proposed system provides strengthened security functions that can transfer recorded images to a user's mobile device when an invalid user attempts an illegal operation; it can also deliver alarm information to the mobile device when the door lock is physically damaged. The proposed system enables a user to check the access information and remotely operate the door lock to enhance convenience.

1.2 DESCRIPTION

Face Recognition System has converted a significant issue in several applications for example security systems, credit card proof and criminal credentials.Personal Safes are revolutionary locking storage cases that are designed as secure storage for medications, jewellery, weapons, documents, and other valuable or potentially harmful items. This utilizes face recognition technology to allow access to only those whose facial images that are present in the database.

A Face Recognition System is a technology capable of identifying or verifying a person from a digital image. It contains all the necessary electronics to allow us to store, delete, and verify face after capturing the image. Stored faces are retained even in the event of complete power failure or battery drain. This eliminates the need for keeping track of keys or remembering a combination password, or PIN. The system captures the image of the person and checks it with the images present in the database. It can only be opened when an authorized user is present, since there are no keys or combinations to be copied or stolen, or locks that can be picked.

In this project the Raspberry Pi 3 Model B is used. It is a Broadcom BCM2387 Chipset with 1.2 GHz Quad-Core ARM Cortex-A53. OpenCV library is used. Intel's OpenCV library is executed in C/C++, but interface to this library is accessible in for a quantity of diverse programming surroundings. Open Source Computer Vision is a widespread cross-platform archive that sets its emphasis on real-time image processing plus includes patent-free executions of the newest computer vision algorithms.

Python programming is used in this project, as it offers an ease to recognize over its simplicity plus suppleness of its language. Moreover, there are several libraries constructed for Python to do several scientific calculation counting Image processing, Recognition, as well as Motion detection.

1.3 PROBLEM STATEMENT

The project required to create a biometric identification system that can identify a person using the face as a biometric key that could be used to authenticate a person.

The system must be stable and efficient to cater the problems that were faced using the other biometrics also be a cost-efficient and easily deployable system.

1.4 METHODOLOGY USED

The major work of the project is to develop an efficient program and implement it into a system. System uses the principle of Eigen Faces and supervised classification for face detection and recognition.

Initially, a training set of images is formed from the captured images. From this training images are set of basis images is formed called the Eigen Faces it's raining image is a weighted combination of these Eigen Faces.

In the testing phase the system captures the image of a person. It now checks this in captured image with the images present in the database if the matches found access is granted, else the access is denied. The authority himself could also check the person using the images he received in his mail and the messaging application.

1.5 BENIFITS

- Automated time tracking system

  Automation simplifies time tracking, and there is no need to have personnel to monitor the system 24 hours a day. A time and attendance system using facial recognition technology can accurately report attendance, absence, and overtime with an identification process that is fast as well as accurate.

- Labour cost savings

  Facial recognition software can accurately track time and attendance without human error. It keeps track of the exact number of hours an employee is working, which can help save the company money.

- Enhanced security

  Facial biometric time tracking allows you to not only track employees but also add visitors to the system so they can be tracked throughout the worksite. Access can be denied to any person not in the system. If an incident should occur, facial recognition software can provide evidence for an investigation with a scanned image of a person or persons who have entered the area.

- Time saving and reduced contagion

  When contagious illnesses such as colds and viruses spread throughout the workforce, it can increase the incidence of employee absences and significantly reduce productivity. With facial recognition, employees can enter and leave the facility in considerably less time. This saves time, as well as minimizing the spread illnesses due to physical contact.

- Ease of integration

  Biometric facial recognition technology can be easily programmed into your time and attendance system.

1.6 COMMON APPLICATIONS

- Banking system
- Unique identification card
- Defense security
- Door lock system
- Network Logon
- Web access
- Airport checking
- ATMs
- Credit Cards
- Industrial application
- Home application

1.7 FUTURE DEVELOPMENTS

- The future work of this will be it can be incorporated using encryption of the servers which ask for an OTP/ SMS every time the user logs in.
- It can be merged with other Biometric techniques to enhance security.
- Processing Time can be reduced by using upcoming versions of Raspberry Pi.
- It can grant or deny access to a person through Gmail and GPS instead of using an Android Messaging Application.

1.8 FINAL PROJECT

CHAPTER 2: LITERATURE REVIEW

2.1 IMAGE CAPTURING USING RASPBERRY PI SYSTEM

An image capture system with embedded computing can extract information from images without need for an external processing unit, and interface devices used to make results available to other devices. The choosing of an embedded platform is very unique and easy to implement. The paper proposed an image capturing technique in an embedded system based on Raspberry Pi board. Considering the requirements of image capturing and recognition algorithm, Raspberry Pi processing module and its peripherals, implementing based on this platform, finally actualized Embedded Image Capturing using Raspberry Pi System (EICSRS). The paper claims that the designed system is fast enough to run the image capturing recognition algorithm, and the data stream can flow smoothly between the camera and the Raspberry Pi board.

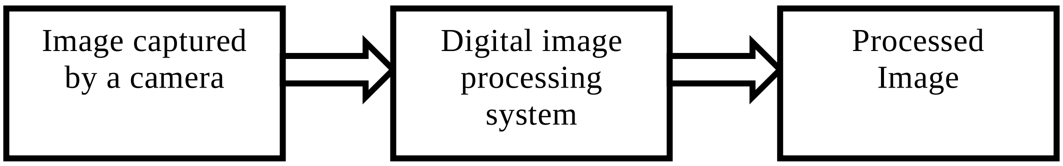
Image processing technology has entered new applications, for example, in the security and access control markets, in the automotive industry, for collision avoidance, and even – one day – for the toy industry. Even our automobiles may soon be outfitted with miniature eyes. Built into a cruise control system, for instance, such a camera would suddenly alert the driver if it noted a rapidly decelerating vehicle. The cameras could also take the place of the rear view and side-view mirrors, thereby eliminating dangerous blind spots and - in the event of an accident – recording the seconds prior to a collision.

Another example would be with intelligent lifts. An office block, with many lifts and floors, may see a lot of people travelling up and down between floors, particularly at high traffic times such as early morning or end of the working day. At the moment, lifts are called by somebody pressing a button and putting in a request for the lift to stop at a particular floor. Connected with smart camera technology, lifts could be routed on demand, working intelligently, stopping only when there was a pre-set number of passengers waiting at a floor – and missing out a floor if too many people were waiting to meet the maximum capacity of the lift.

2.2 IMPLEMENTATION OF IMAGE PROCESSING USING R-PI

The image processing is a form of signal processing in which the input is in the form of an image. The output may be in the form of image or a video frame or a set of characteristics or parameters related to the image.

The acquisition of digital camera suffers random camera motions. Hence image enhancement algorithms are required.



General block diagram of image processing

Camera is interfaced with raspberry-pi board. The camera captures the image and sends it to the R-pi, where the image is processed.

R-pi has codes written for the image processing. Python language is used for this coding.

2.3 RASPBERRY PI BASED FACE RECOGNITION SYSTEM FOR DOOR UNLOCKING

This paper deals with the design and implementation of Secure locking Automation using Raspberry Pi for Door unlocking to provide essential security to our homes, bank lockers and associated control operations and send security alert through the GSM module. Raspberry Pi operates and controls the video camera for capturing it for turning ON a relay for door unlock. The module contains a secured face recognizer for automatic door opening.

A Face Recognition System is a system which automatically identifies and/or verifies the identity of a person from digital images or a video frame from a video source.

The aim of our project is to provide a high security system using face recognition on Raspberry Pi board and send an alert to the authorized person via GSM module, this will increase the security of our project. The proposed work is as follows:

1) Interfacing of camera module to capture live Face image.

2) Create a database of authorized person

3) Capture current face, save it and compare with data base image.

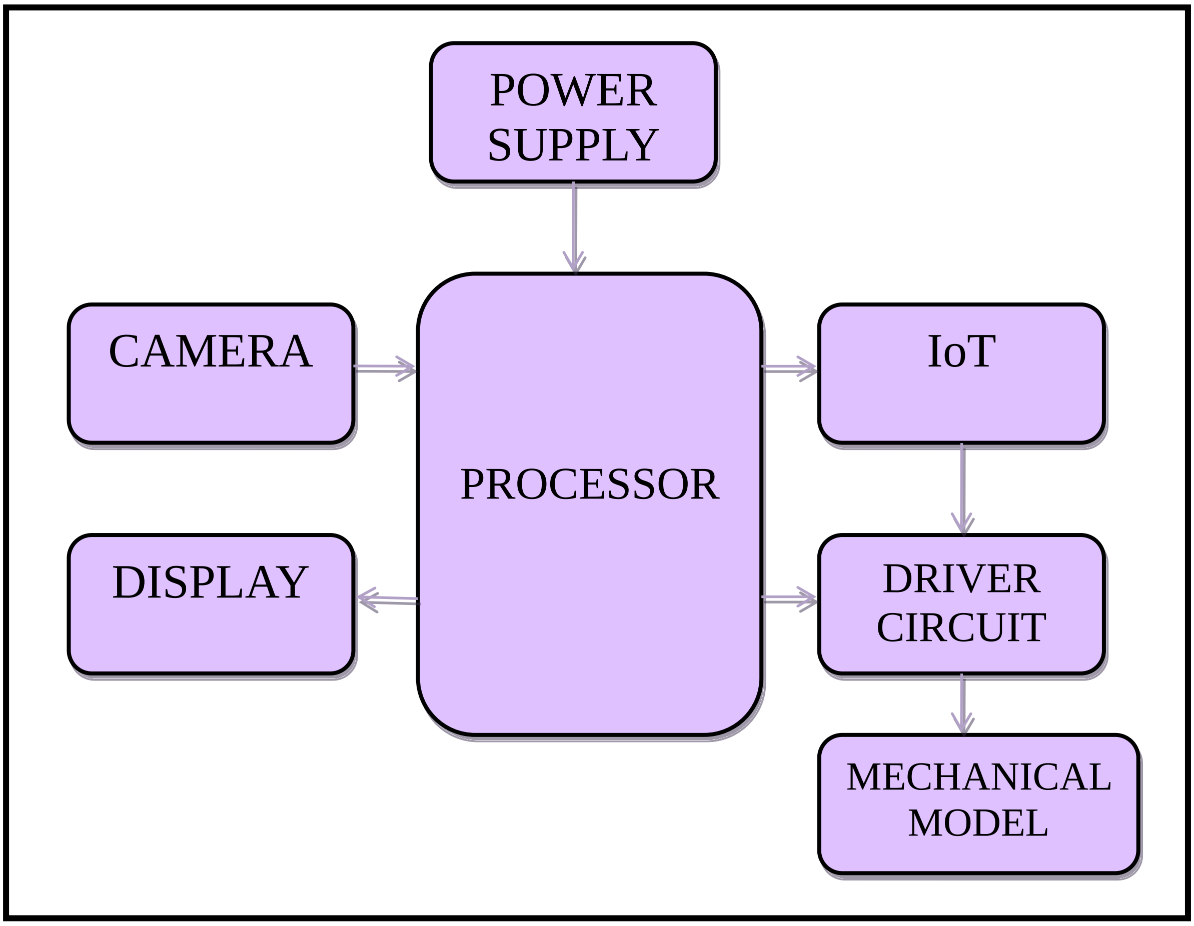
4) Interface GSM module to send security alert to Authorized person while unlocking the locked door.

5) Interface relay as an output module.

The design of the face recognition system using Raspberry pi can make the smaller, lighter and with lower power consumption, so it is more convenient than the PC-based face recognition system. Using raspberry pi the current project can be modified by an Infrared camera interfacing it can be used in Smart Surveillance Monitoring security system which any type of public security is using Living body detection or spying, Also it can be used in Attendance system of the class.

CHAPTER 3 : METHODOLOGY

3.1 BLOCK DIAGRAM

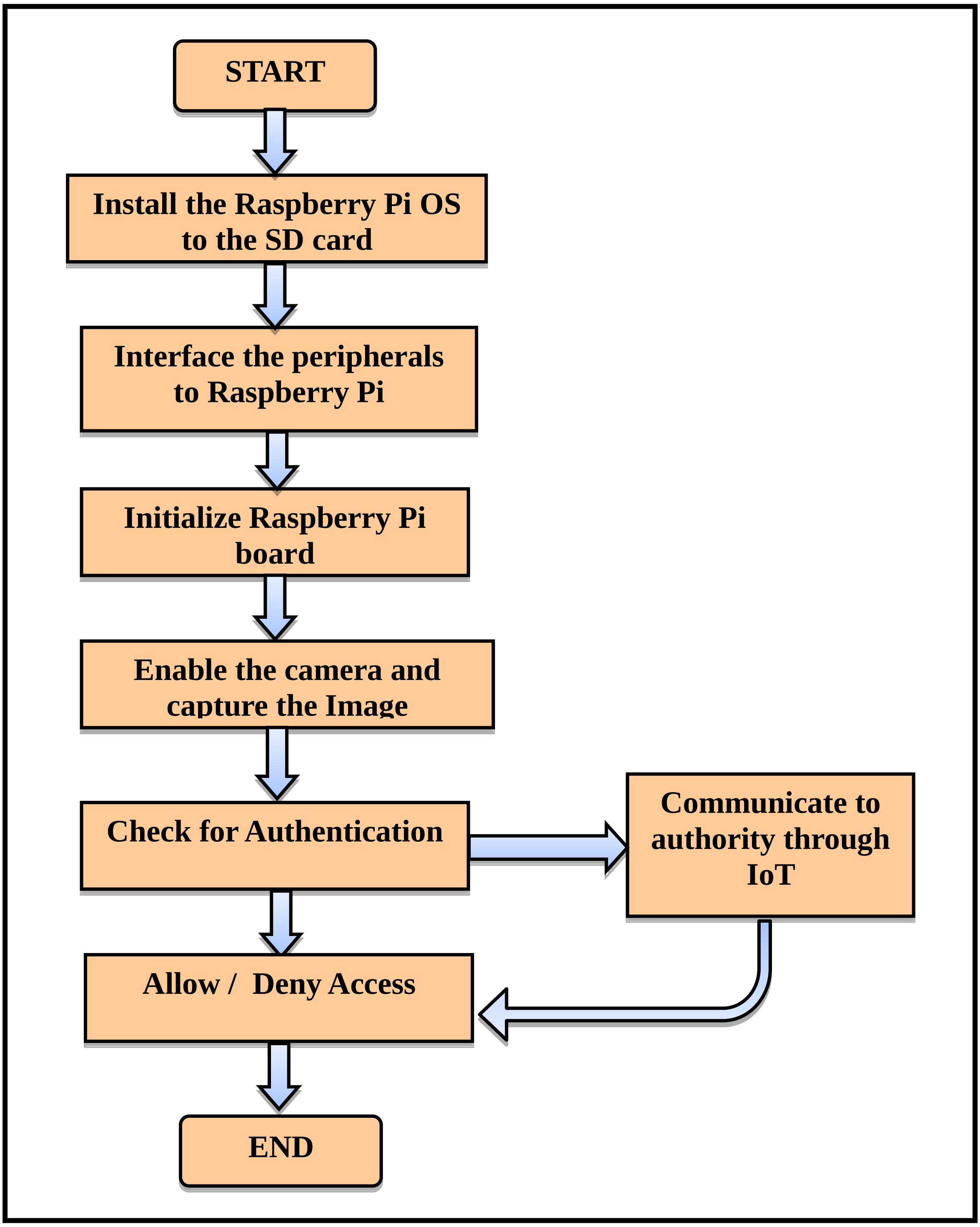


Block diagram consists of the following blocks:-

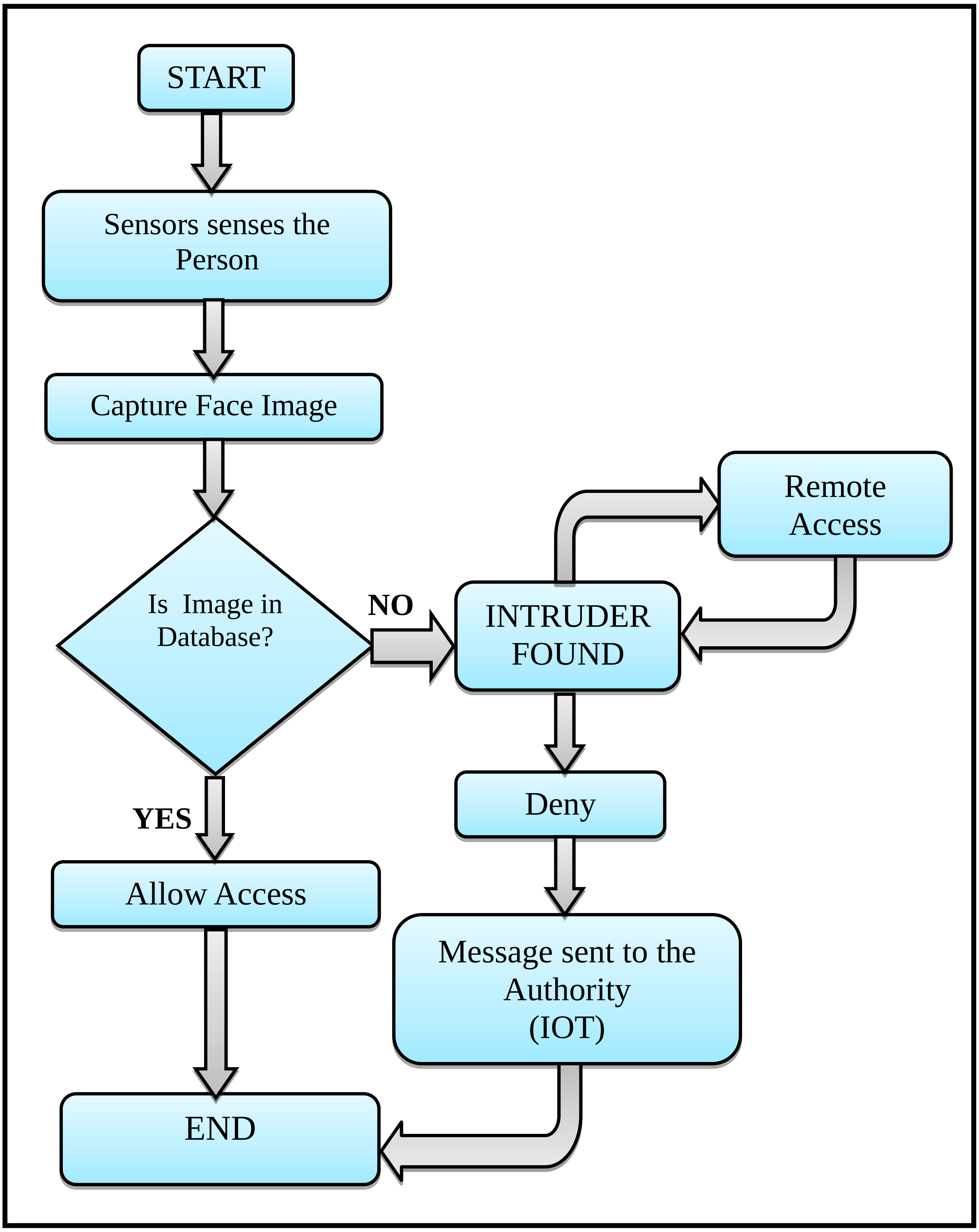
1. Power Supply
2. Processor
3. Camera
4. Driver Circuit
5. Display
6. Mechanical Model

3.2 FLOWCHART

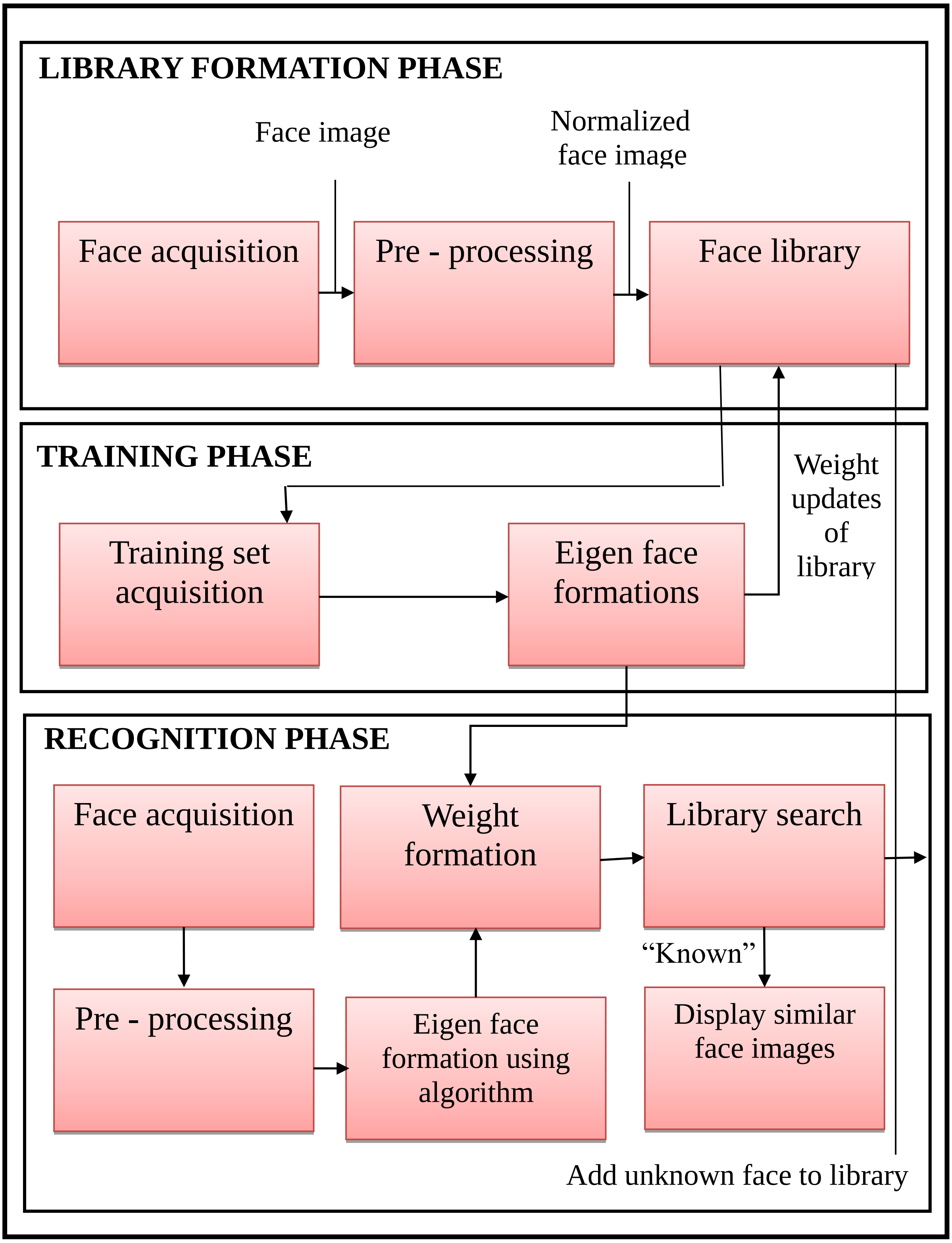
3.2.1 RASPBERRY PI INSTALLATION



3.2.2 FACE RECOGNITION SYSTEM



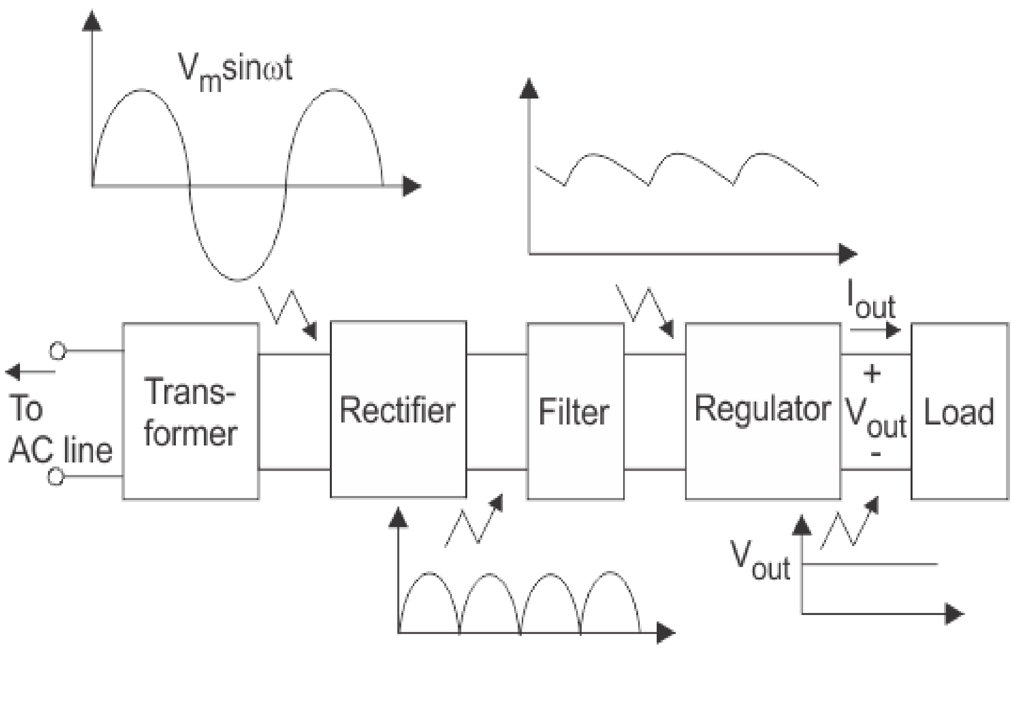
3.3 METHODOLOGY



3.4 CIRCUIT DIAGRAM

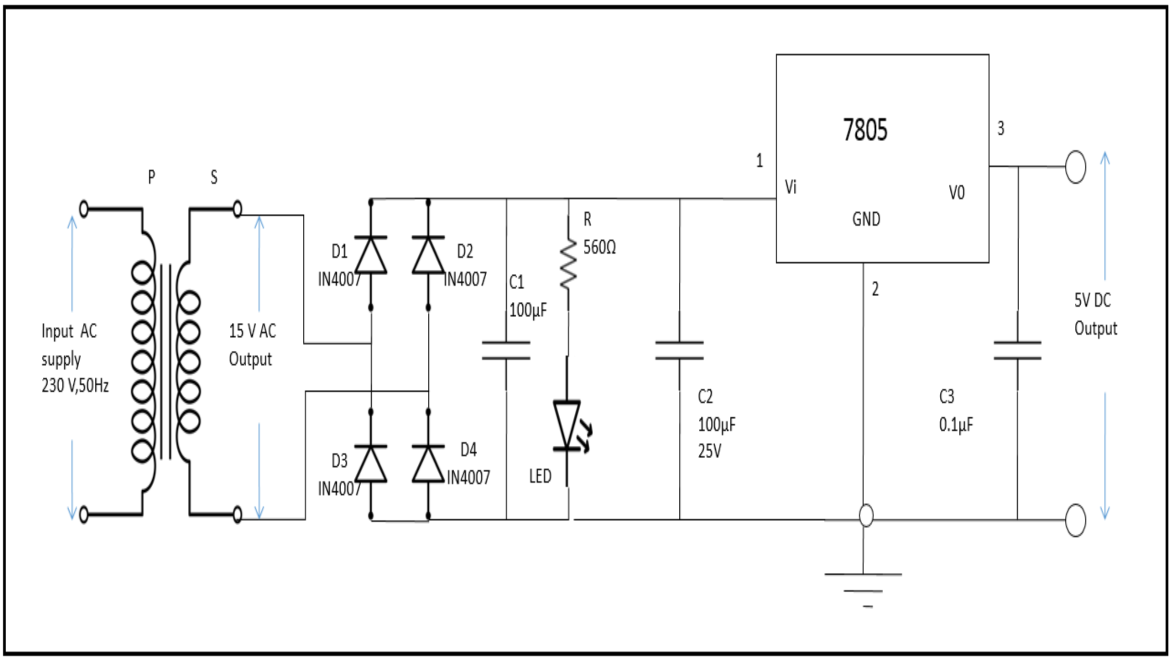
3.4.1 POWER SUPPLY SECTION

3.4.1.1 BLOCK DIAGRAM OF REGULATED POWER SUPPLY

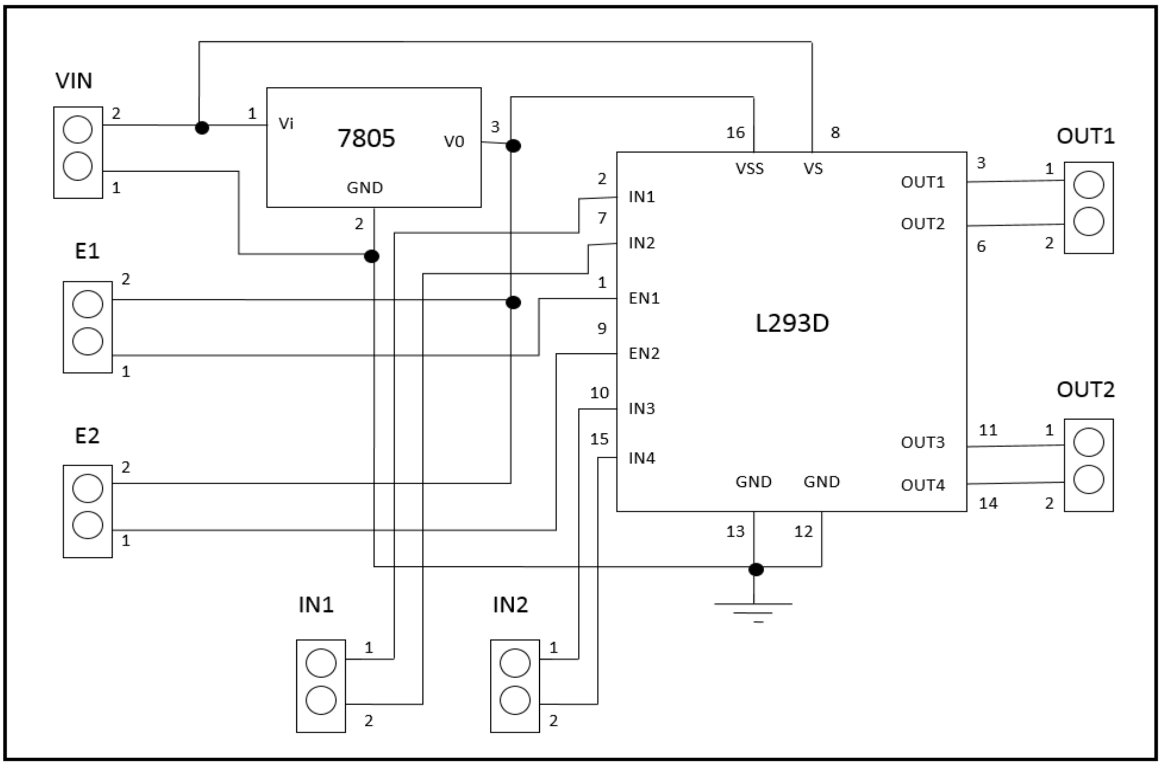


Components of typical linear power supply

3.4.1.2 POWER SUPPLY CIRCUIT



3.4.2 DRIVER SECTION



CHAPTER 4 : COMPONENT DESCRIPTION

4.1 RASPBERRY PI 3 (MODEL B)

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processer, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.

Low cost, Consistent board format, 10x faster processing, added connectivity are the key features.

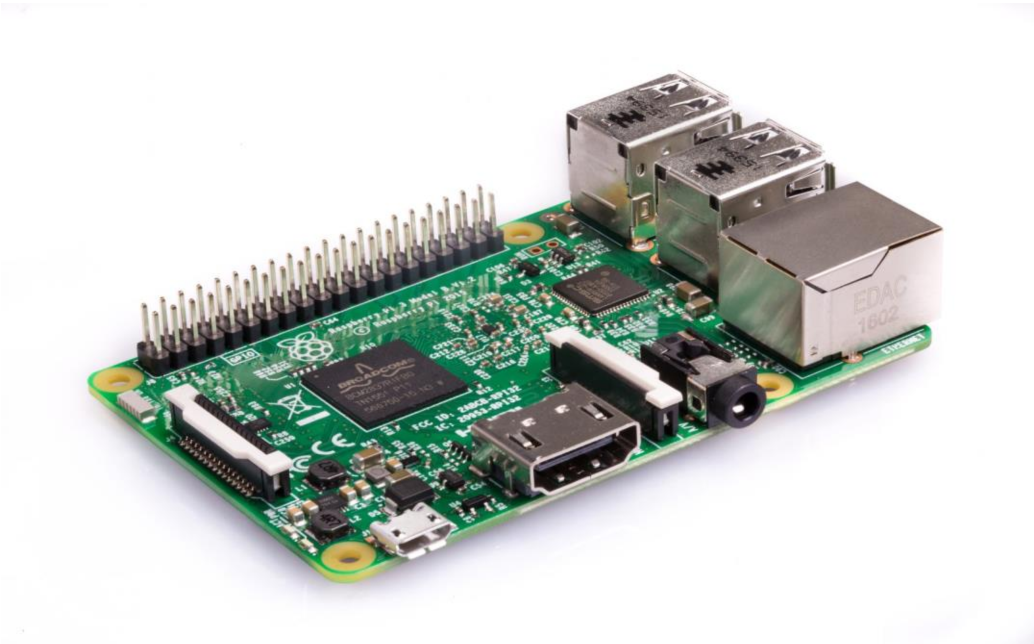


Figure 4.1 Raspberry Pi-3 Model B

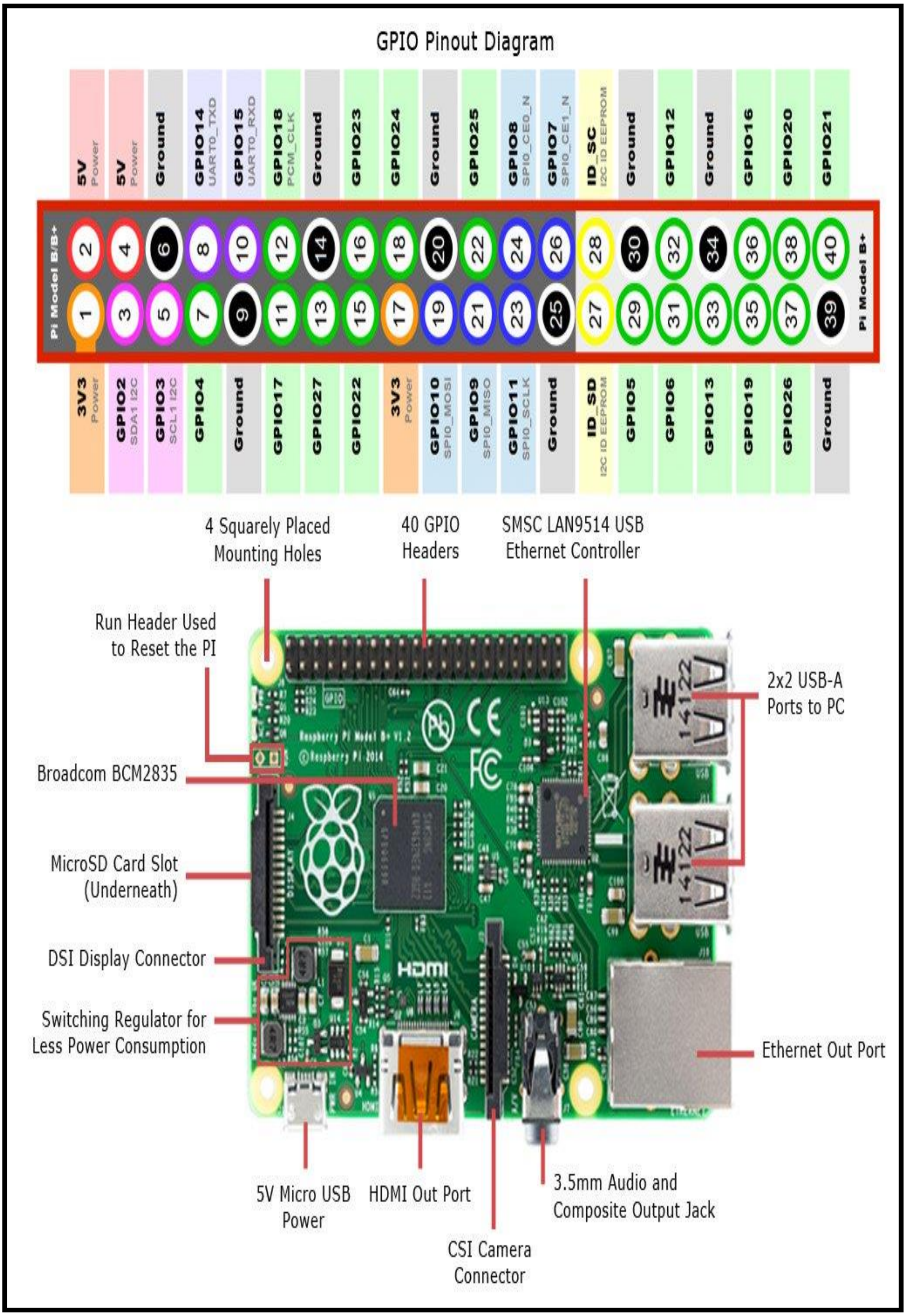
4.1.1 SPECIFICATIONS

PROCESSOR	Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
GPU	Dual Core VideoCore IV Multimedia Co-Processor. Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
MEMORY	1GB LPDDR2
OPERATING SYSTEM	Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT
DIMENSIONS	85 x 56 x 17mm
POWER	Micro USB socket 5V1, 2.5A

4.1.2 CONNECTORS

ETHERNET	10/100 BaseT Ethernet socket
VIDEO OUTPUT	HDMI (rev 1.3 & 1.4 Composite RCA (PAL and NTSC)
AUDIO OUTPUT	Audio Output 3.5mm jack, HDMI USB 4 x USB 2.0 Connector
GPIO CONNECTOR	40-pin 2.54 mm (100 mil) expansion header: 2x20 strip Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines
CAMERA CONNECTOR	15-pin MIPI Camera Serial Interface (CSI-2)
DISPLAY CONNECTOR	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane
MEMORY CARD SLOT	Push/pull Micro SDIO

4.1.3 GENERAL PURPOSE INPUT / OUTPUT (GPIO) PIN OUT



A powerful feature of the Raspberry Pi is the row of GPIO (General-Purpose Input/Output) pins along the top edge of the board. A 40-pin GPIO header is found on all current Raspberry Pi boards (unpopulated on Pi Zero and Pi Zero W). Prior to the Pi 1 Model B+ (2014), boards comprised a shorter 26-pin header.

Any of the GPIO pins can be designated (in software) as an input or output pin and used for a wide range of purposes. The numbering of the GPIO pins is not in numerical order; GPIO pins 0 and 1 are present on the board (physical pins 27 and 28) but are reserved for advanced use.

4.1.3.1 VOLTAGES

Two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V), which are not configurable. The remaining pins are all general purpose 3V3 pins, meaning outputs are set to 3V3 and inputs are 3V3-tolerant.

4.1.3.2 OUTPUTS

A GPIO pin designated as an output pin can be set to high (3V3) or low (0V).

4.1.3.3 INPUTS

A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software.

As well as simple input and output devices, the GPIO pins can be used with a variety of alternative functions, some are available on all pins, others on specific pins.

- PWM (pulse-width modulation)
  - Software PWM available on all pins
  - Hardware PWM available on GPIO12, GPIO13, GPIO18, GPIO19

- SPI
  - SPI0: MOSI (GPIO10); MISO (GPIO9); SCLK (GPIO11); CE0 (GPIO8), CE1 (GPIO7)
  - SPI1: MOSI (GPIO20); MISO (GPIO19); SCLK (GPIO21); CE0 (GPIO18); CE1 (GPIO17); CE2 (GPIO16)

- I2C
  - Data: (GPIO2); Clock (GPIO3)
  - EEPROM Data: (GPIO0); EEPROM Clock (GPIO1)

- Serial
  - TX (GPIO14); RX (GPIO15)

A handy reference can be accessed on the Raspberry Pi by opening a terminal window and running the command pin out. This tool is provided by the GPIO Zero Python library, which it is installed by default on the Raspbian desktop image, but not on Raspbian Lite.

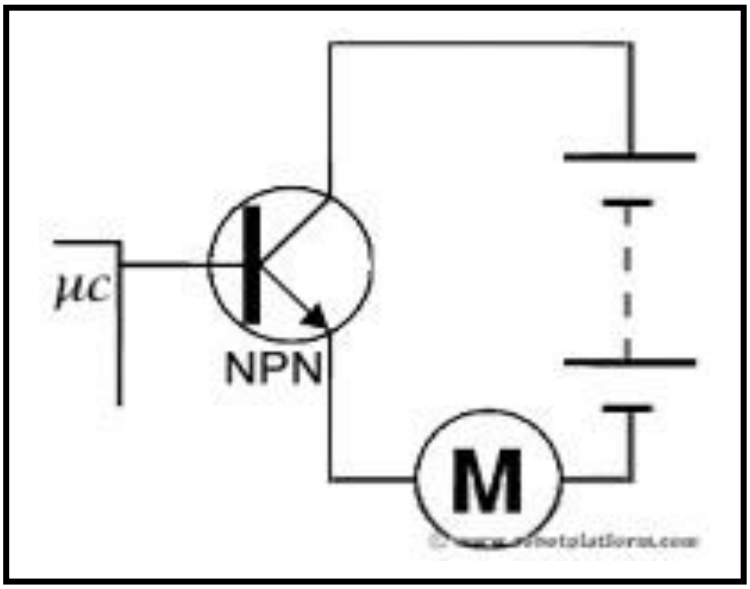
4.2 CAMERA

The camera used is an USB camera. Raspberry Pi has an inbuilt camera interface port. However, the port is meant for the strip camera of the Raspberry Pi. Raspberry Pi strip camera doesn't come with flash and has a low resolution and the images captured a lot of good quality. So we are using an USB camera of Intex since it is an USB camera it can be directly plugged to the Raspberry Pi. The camera gets interfaced and can be used to capture the images. It also has provision of focusing by rotating the lens of the camera. This camera has the flash. Show images can be taken in dark environment plus a good quality of images could be obtained. Supporting a simple clip-on mechanism, one can pin the Intex webcam on your laptop's lid or place it next to your computer so that it perfectly captures your entire face. Integrated with a powerful 8MP camera, the webcam delivers sharp, crisp image quality. Image resolution is of 3280 x 2460.

Figure 4.3 Camera (Intex Webcam)

4.3 DRIVER L293D

In our circuit only one motor is driven. Hence In2, En2 are disabled. MOTORS require more current then the processor pin can typically generate hence a switch is required.

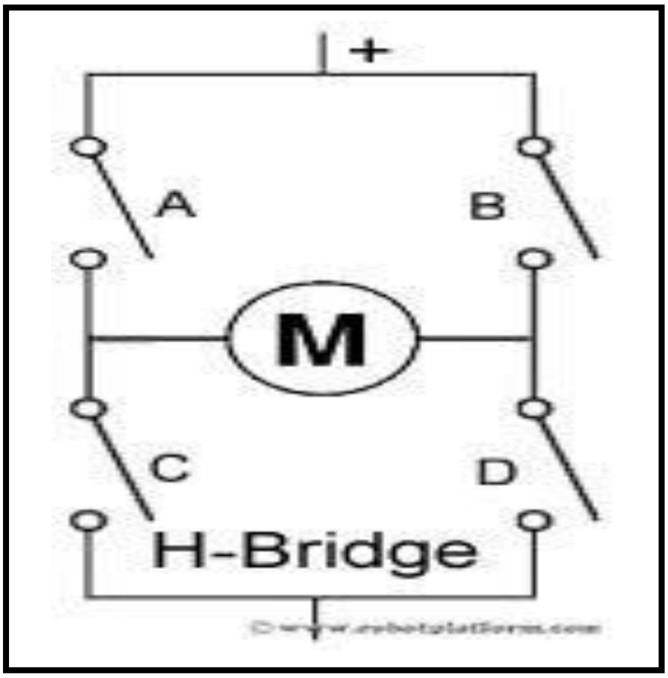


Switch such as Transistors, MOSFET, and Relay etc. which accepts a small current, amplify it and generate a larger current, which further drives a motor. This entire process is done a motor driver.

Motor driver is basically a current amplifier which takes a low-current signal from the processor and gives out a proportionally higher current signal which can control and drive a motor. In most cases, a transistor can act as a switch and perform this task which drives the motor in a single direction. Turning a motor ON and OFF requires only one switch to control a single motor in a single direction. By reversing motor polarity direction of rotation can be changed.

This can be achieved by using four switches that are arranged in an intelligent manner such that the circuit not only drives the motor, but also controls its direction. Out of many, one of the most common and clever design is an H-bridge circuit where transistors are arranged in a shape that resembles the English alphabet "H".

As you can see in the figure, the circuit has four switches A, B, C and D. Turning these switches ON and OFF can drive a motor in different ways.



1. Turning on Switches **A** and **D** makes the motor rotate clockwise.
2. Turning on Switches **B** and **C** makes the motor rotate anti-clockwise.
3. Turning on Switches **A** and **B** will stop the motor (Brakes).
4. Turning off all the switches gives the motor a free wheel drive.
5. Lastly turning on **A** & **C** at the same time or **B** & **D** at the same time shorts your entire circuit. So, do not attempt this.

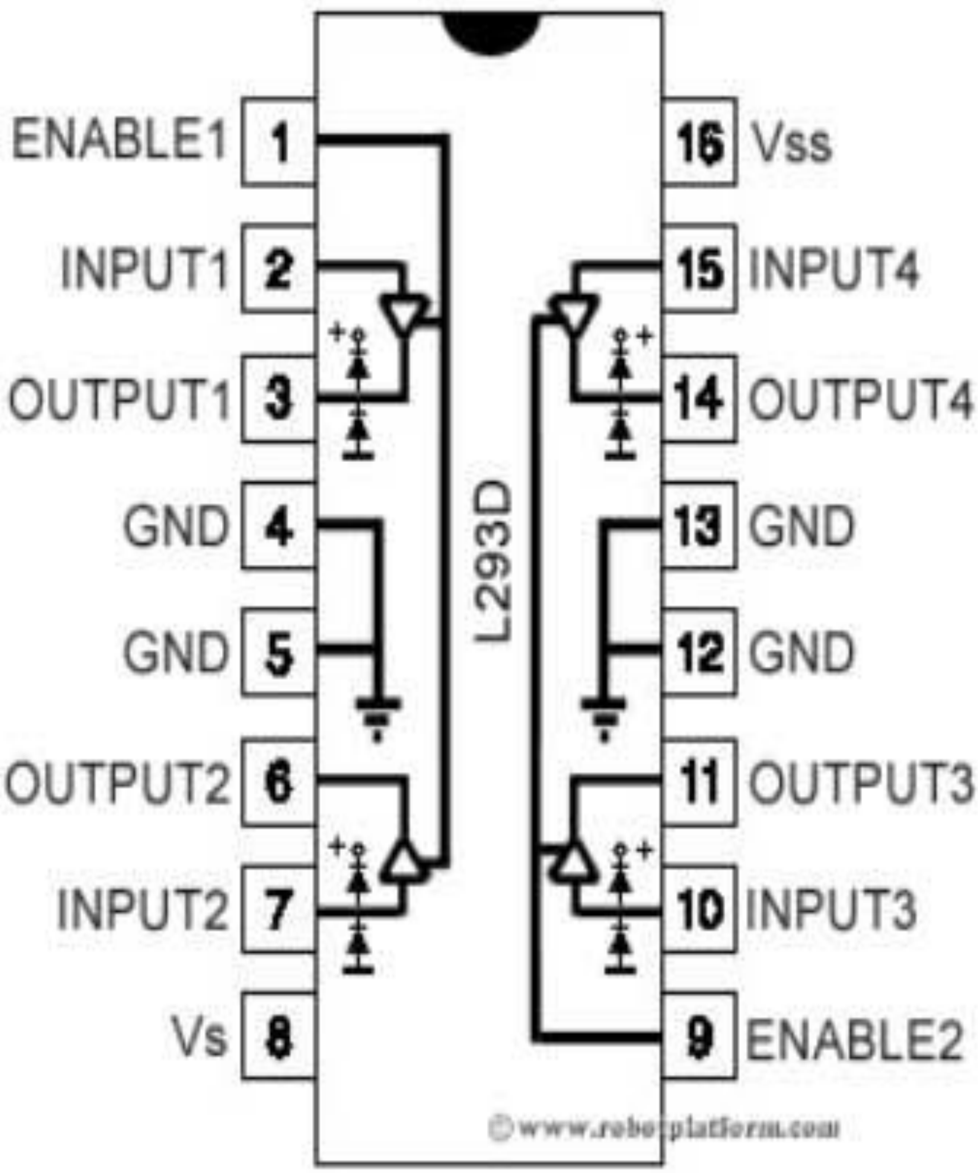
H-bridges can be built from scratch using relays, MOSFETS, Field Effect Transistors (FET), bi-polar junction transistors (BJT), etc.

For small current requirement L293D IC is used. L293D IC can interface two DC motors.

L293, L293B and few other versions also does the same job, but pick the L293D version as this one has an inbuilt fly-back diode which protects the driving transistors from voltage spikes that occur when the motor coil is turned off.

4.3.1 INTRODUCTION TO L293D IC

L293D IC generally comes as a standard 16-pin DIP (dual-in line package). This motor driver IC can simultaneously control two small motors in either direction; forward and reverse with just 4 processor pins (if we do not use enable pins).

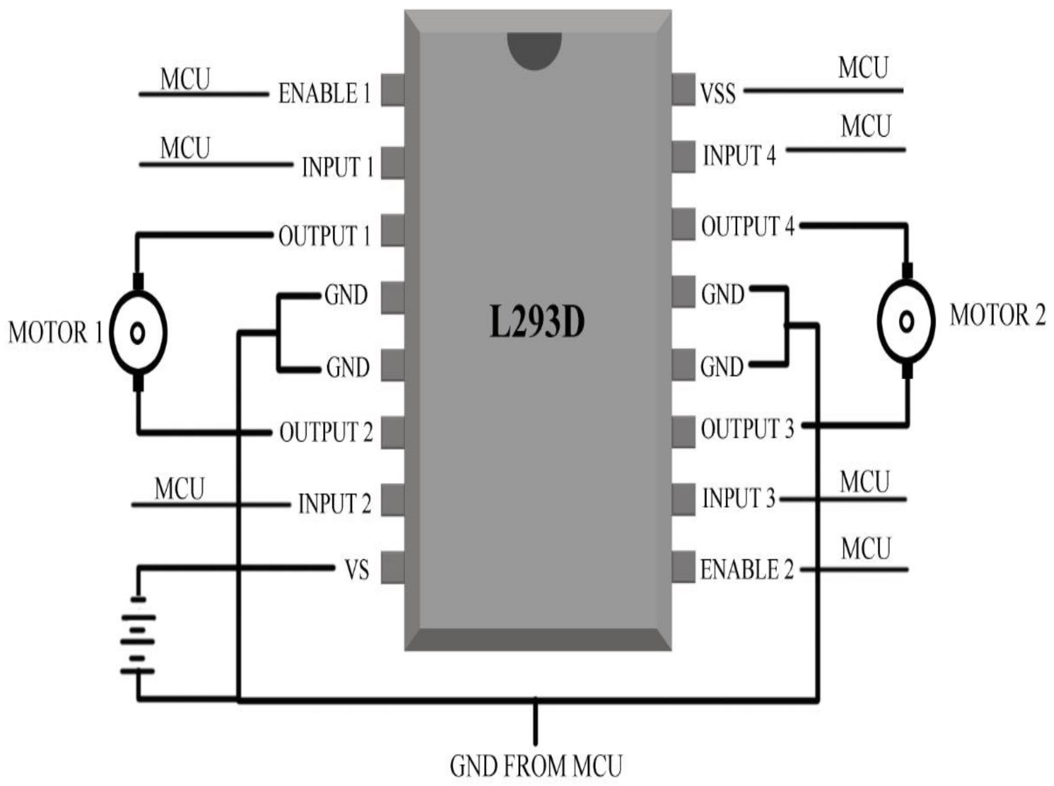


4.3.2 FEATURES OF L293D IC

1. Output current capability is limited to 600mA per channel with peak output current limited to 1.2A (non-repetitive). This means we cannot drive bigger motors with this IC. However, most small motors used in hobby robotics should work. If we are unsure whether the IC can handle a particular motor, connect the IC to its circuit and run the motor with our finger on the IC. If it gets really hot, then beware... Also note the words "non-repetitive" if the current output repeatedly reaches 1.2A, it might destroy the drive transistors.
2. Supply voltage can be as large as 36V. This means we do not have to worry much about voltage regulation.
3. L293D has an enable facility that helps us to enable the IC output pins. If an enable pin is set to logic high, then state of the inputs match the state of the outputs. If we pull this low, then the outputs will be turned off regardless of the input states.
4. The datasheet also mentions an "over temperature protection" built into the IC. This means an internal sensor senses its internal temperature and stops driving the motors if the temperature crosses a set point.
5. Another major feature of **L293D** is its internal clamp diodes. This fly-back diode helps us to protect the driver IC from voltage spikes that occur when the motor coil is turned on and off (mostly when turned off).
6. The logical low in the IC is set to 1.5V. This means the pin is set high only if the voltage across the pin crosses 1.5V which makes it suitable for use in high frequency applications like switching applications (up to 5KHz).
7. Lastly, this integrated circuit not only drives DC motors, but can also be used to drive relay solenoids, stepper motors etc.

4.3.3 L293D CONNECTIONS

The circuit shown below is the most basic implementation of L293D IC (16 pin).



1. Pin 1 and Pin 9 are "Enable" pins. They should be connected to +5V for the drivers to function. If they pulled low (GND), then the outputs will be turned off regardless of the input states, stopping the motors. If we have two spare pins in our processor, connect these pins to the processor, or just connect them to regulated positive 5V.
2. Pin 4, Pin 5, Pin 12 and Pin 13 are ground pins which should ideally be connected to processor's ground.
3. Pin 2, Pin 7, Pin 10 and Pin 15 are logic input pins. These are control pins which should be connected to processor pins. Pin 2 and Pin 7 control the first motor (left); Pin 10 and Pin 15 control the second motor (right).

4. Pin 3, Pin 6, Pin 11, and Pin 14 are output pins. Tie Pin3 and Pin6 to the first motor, Pin11 and Pin14 to second motor.
5. Pin16 powers the IC and it should be connected to regulated +5V.
6. Pin 8 powers the two motors and should be connected to positive lead of a secondary battery. As per the datasheet, supply voltage can be as high as 36 V.

4.3.4 TRUTH TABLE

High +5V

Low 0V

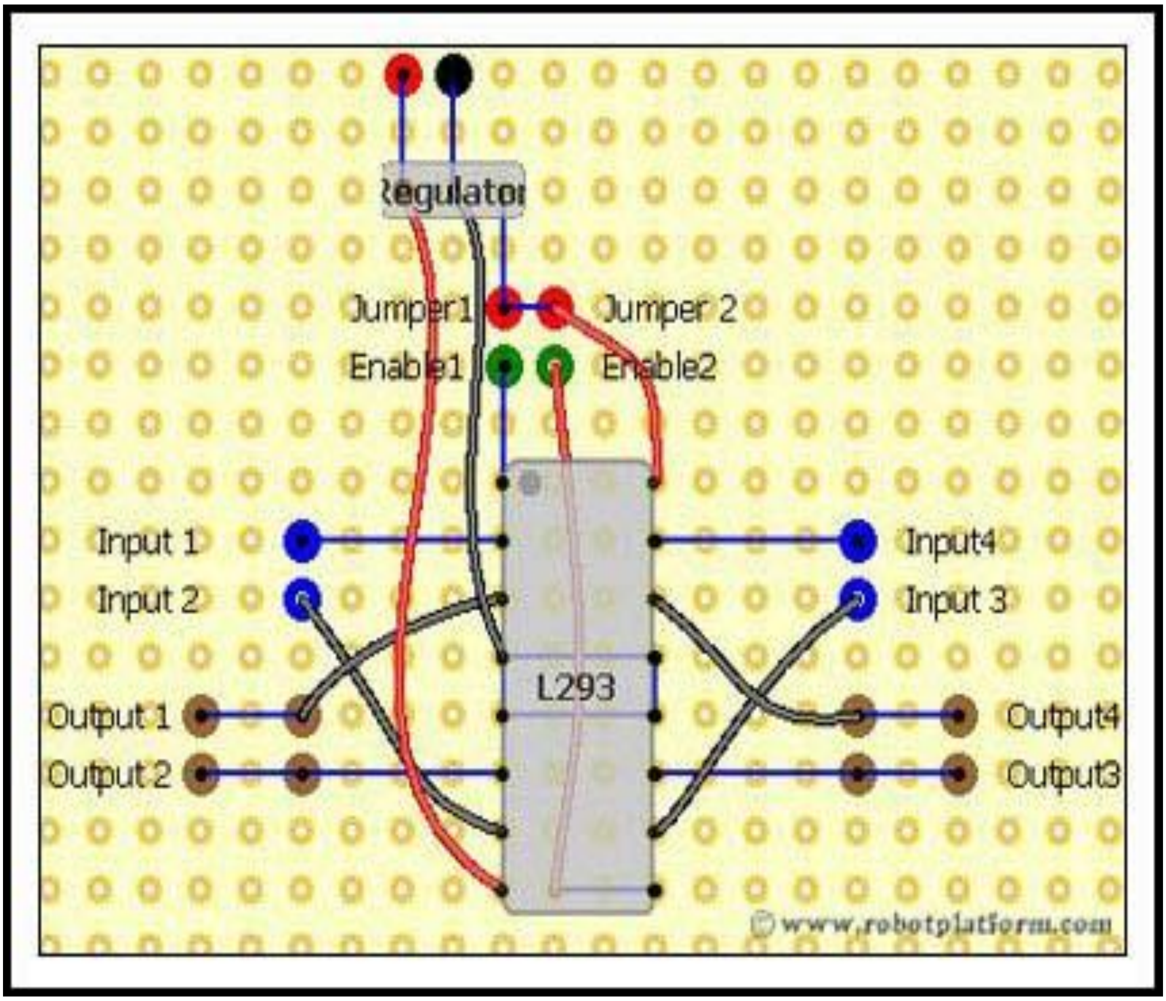
X Either high or low (don't care)

In the below truth table we can observe that if Pin 1 (E1) is low then the motor stops, irrespective of the states on Pin 2 and Pin 7. Hence it is essential to hold E1 high for the driver to function or simply connect enable pins to positive 5V.

Pin 1	Pin 2	Pin 7	Function
High	**High**	**Low**	**Turn Anti-clockwise (Reverse)**
High	**Low**	**High**	**Turn clockwise (Forward)**
High	**High**	**High**	**Stop**
High	**Low**	**Low**	**Stop**
Low	**X**	**X**	**Stop**

With Pin 1 high, if Pin 2 is set high and Pin 7 is pulled low, then current flows from Pin 2 to Pin 7 driving the motor in anti-clockwise direction. If the states of Pin 2 and Pin 7 are flipped, then current flows from Pin 7 to Pin 2 driving the motor in clockwise direction.

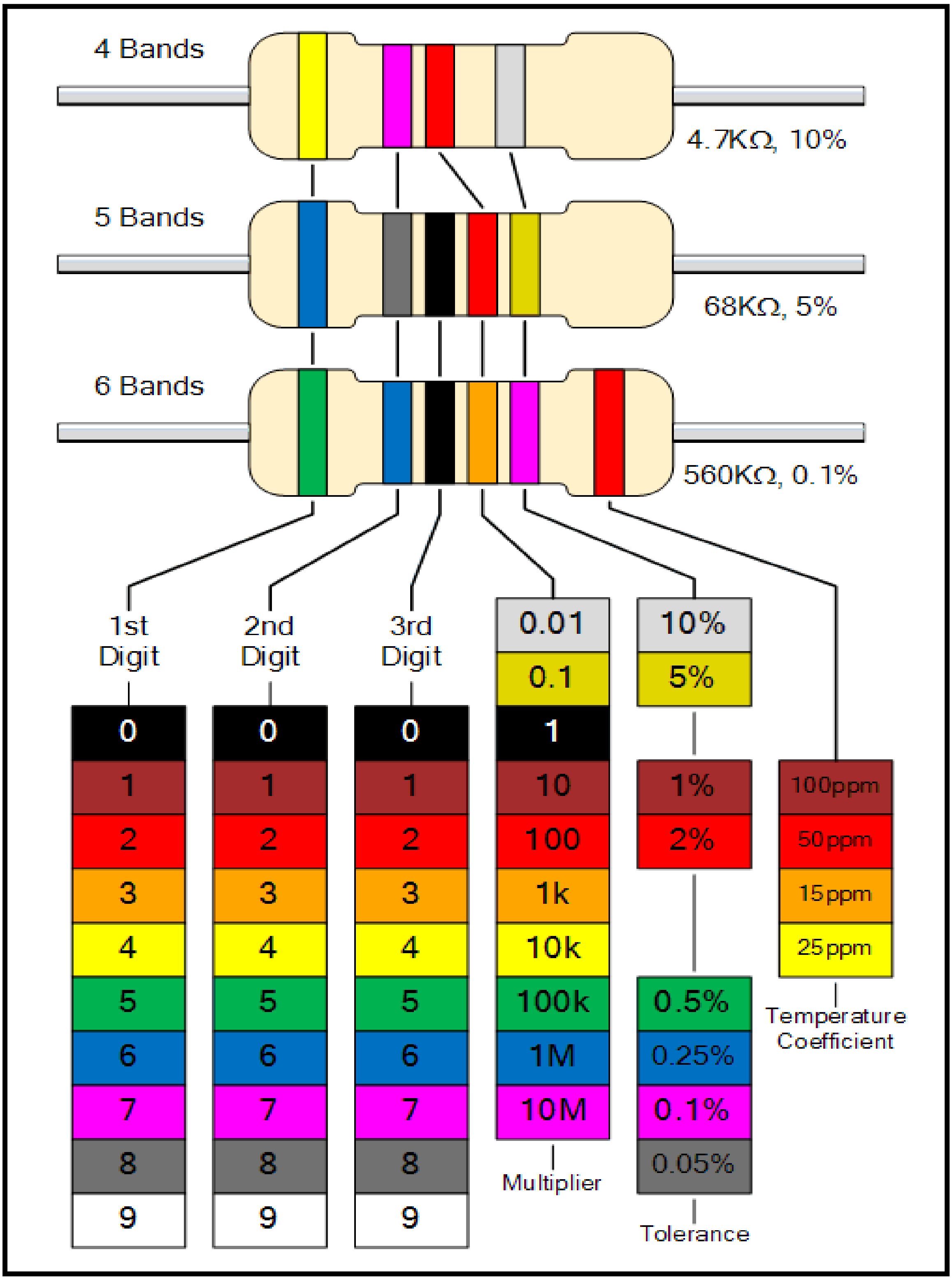
The above concept holds true for other side of the IC too. Connect the motor to Pin 11 and Pin 14; Pin 10 and Pin 15 are input pins and Pin 9 (E2) enables the driver.



Whenever we implement it, always remember that enable pins are not connected. Either connect enable pins to your processor pins and programmatically set it high or use a jumper and connect each enable pin to the header just above it (which is connected to +5V).

4.4 RESISTOR

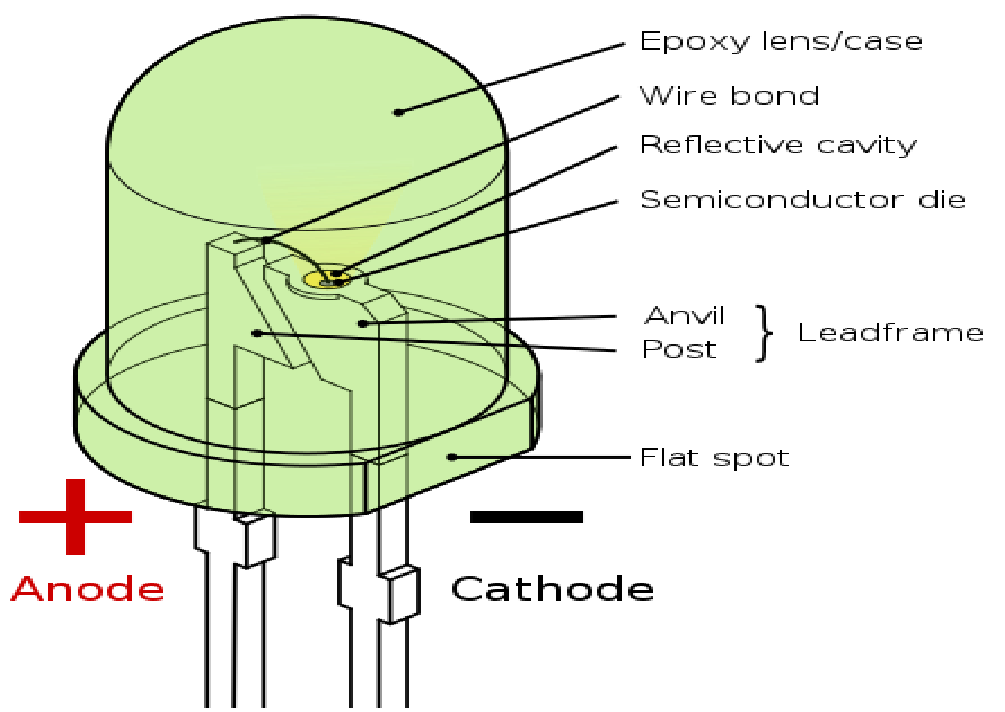
4.4.1 COLOUR CODE

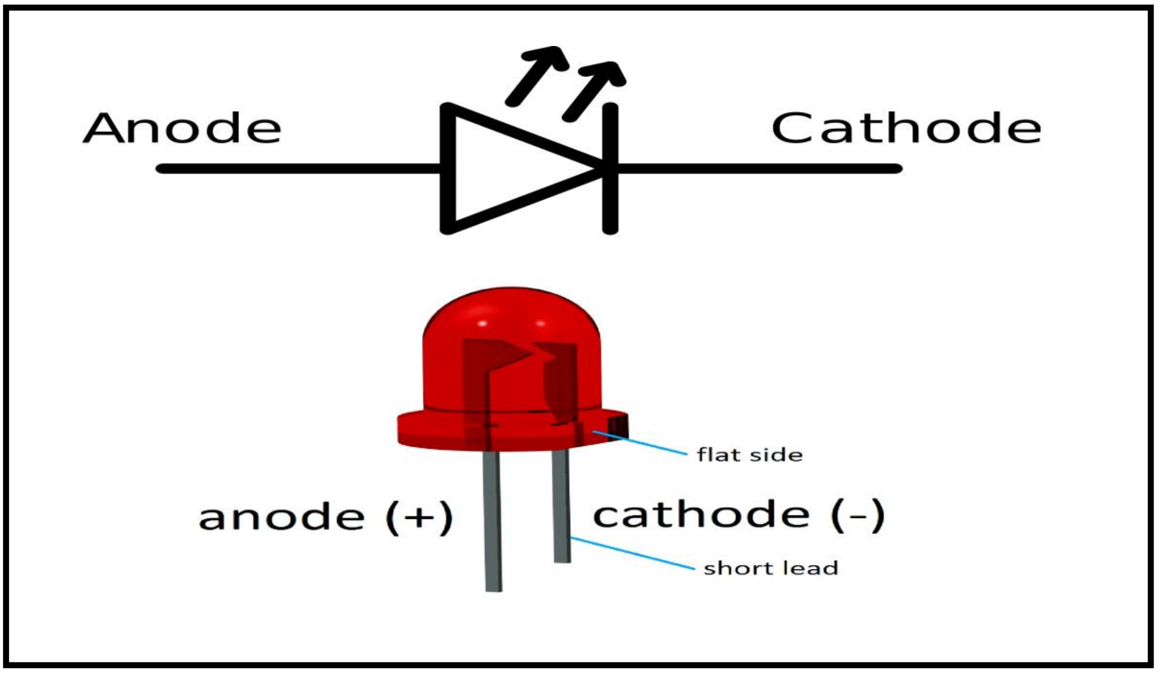


4.5 LED

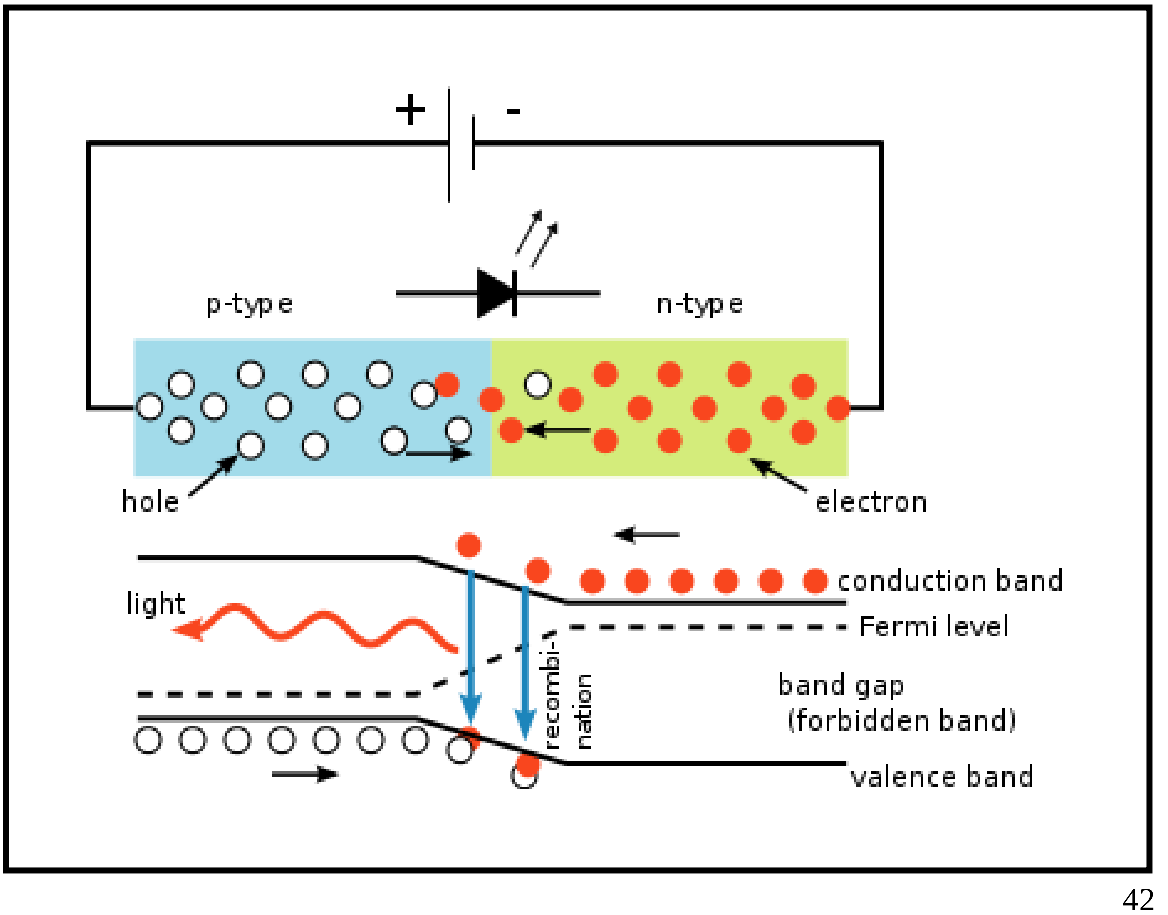
4.5.1 PRINCIPLE OF OPERATION

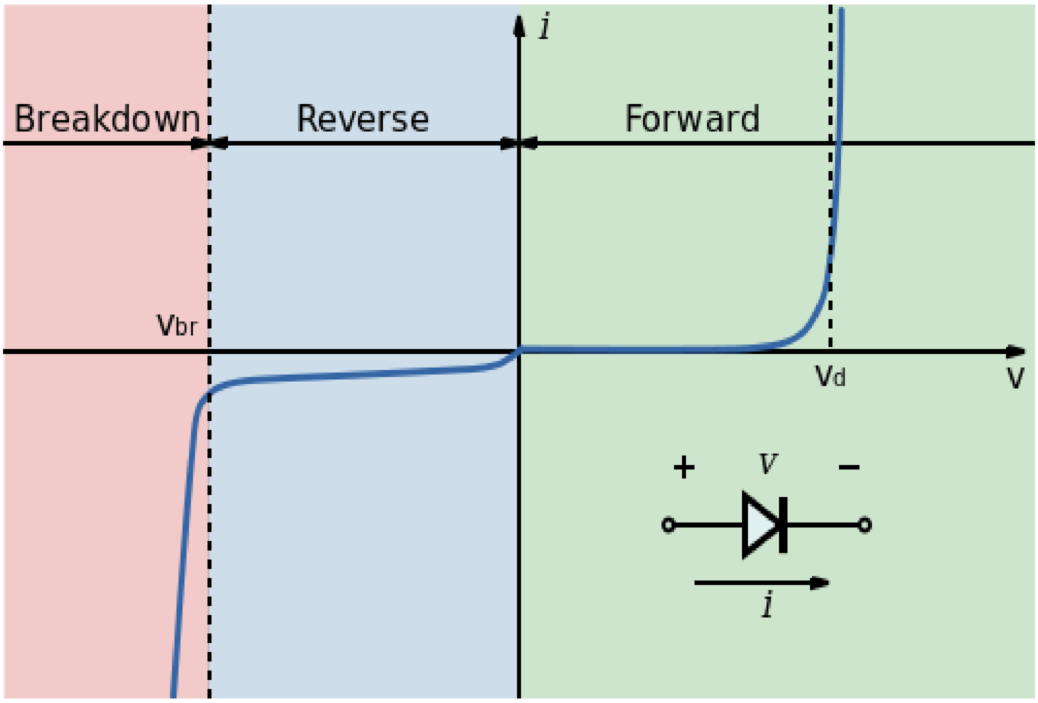
A P-N junction diode which emits lights when forward biased is known as light emitting diode. The amount of light output is directly proportional to the forward current. Thus higher the forward current, higher is the light output. When the LED is forward biased, the electrons and the holes move towards the junction and the recombination takes place. After recombination, the electrons lying in the conduction band of N- region falls into the holes lying in the valence band of a P-region. The difference of energy between the conduction band and valence band is radiated in the form of light energy in ordinary diodes. This energy is radiated in the form of heat. The materials used for the manufacturing of LED's are gallium phosphide, gallium arsenide, gallium arsenide phosphide.

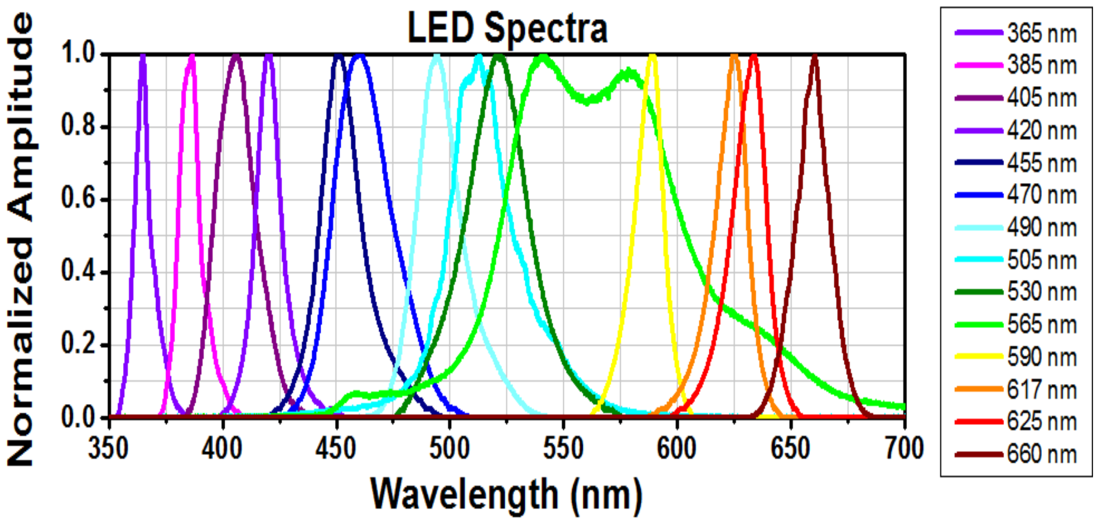



Anode
Cathode
flat side
anode (+)
cathode (-)
short lead

4.5.2 WORKING


+
-
p-type
n-type
hole
electron
light
conduction band
Fermi level
band gap
(forbidden band)
recombi-nation
valence band

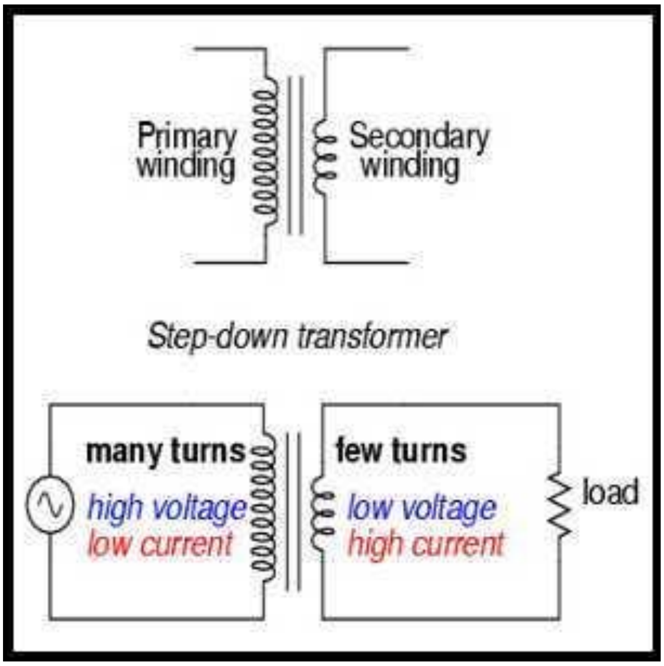




LED is used for indication purpose. Figure shows wavelength spectrum of LED.

4.6 TRANSFORMER

The transformer receives the input from AC mains that is 115/220/230V AC. Here a simple step-down transformer having turns per ratio 55:3 is used. The transformer step downs 220V AC into 12V AC which is fed to bridge rectifier circuit. The current rating of the used transformer is 1A.



TURNS RATIO = (Vp / Vs) = (Np / Ns)

where,

Vp = primary (input) voltage.

Vs = secondary (output) voltage

Np = number of turns on primary coil

Ns = number of turns on secondary coil

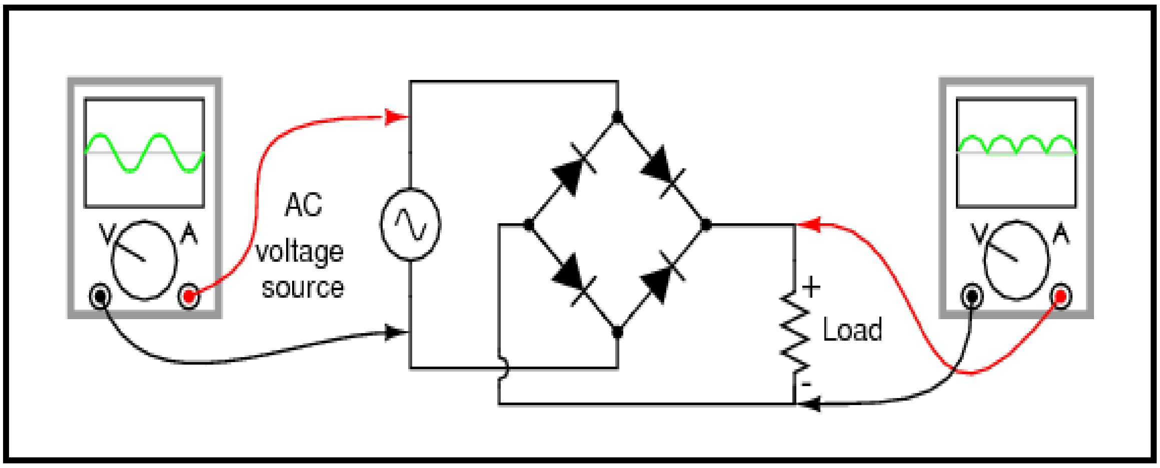
Ip = primary (input) current

Is = secondary (output) current.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}.$$

4.7 RECTIFIER

Four diodes are used to form a bridge rectifier. Here four diodes / PN junction diode IN4007 having forward voltage / knee voltage of 0.7V and made up of silicon material is used to convert input 12VAC into pulsating DC output.

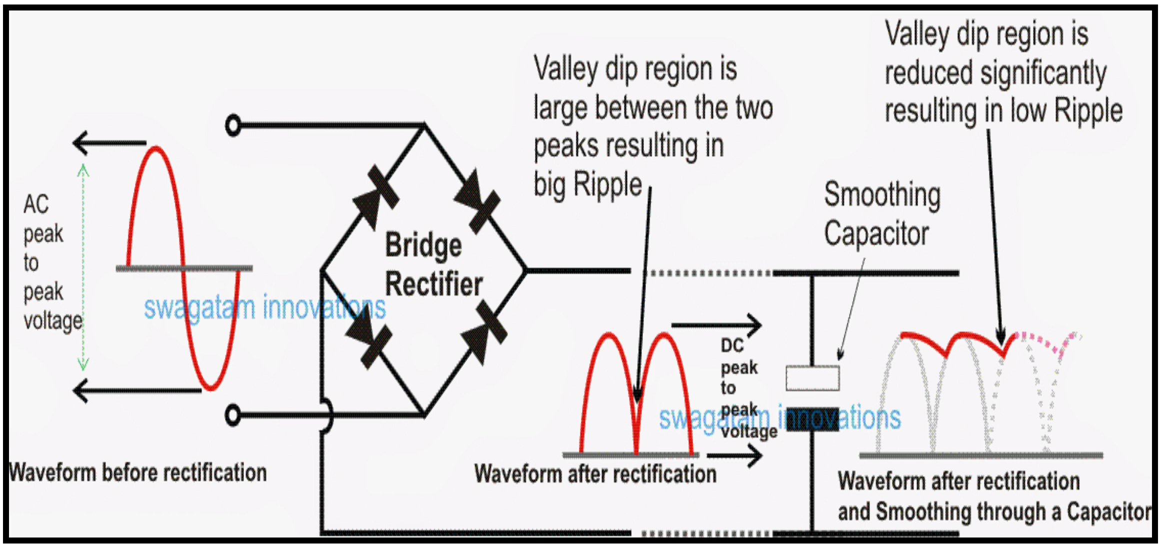


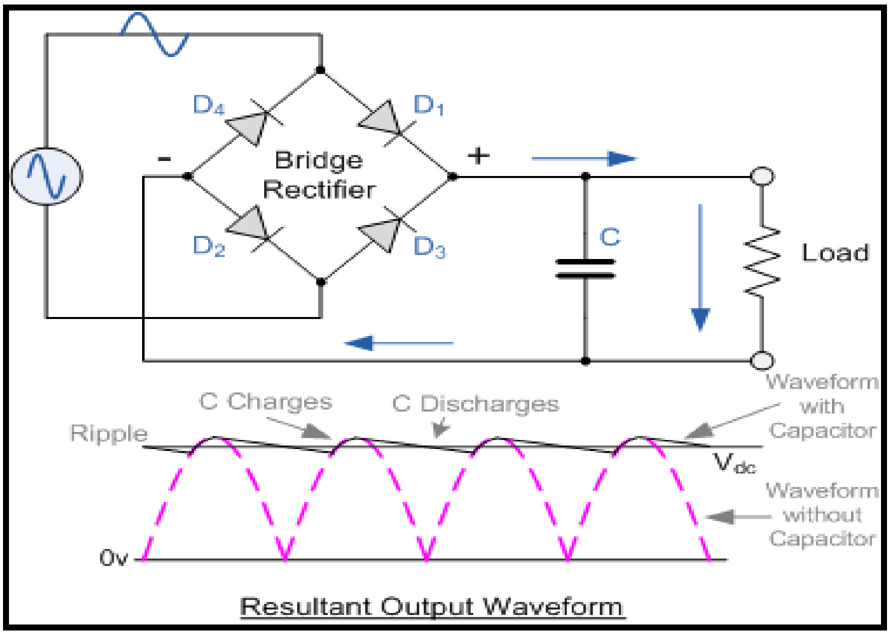
- Rectifier efficiency is 81.2%
- TUF is 0.812
- Ripple frequency is 2*Fin
- Ripple factor is 0.482
- Peak voltage is Vm
- DC output voltage is 0.636Vm

4.8 FILTER

The output of bridge rectifier is not pure DC voltage it contains some unwanted AC components called ripples hence in order to remove it and to obtain a pure DC as output voltage a filter is ought to be used. Here a 1000µF 35V capacitor is used as filter.

It is used for smoothing purpose that is to bypass AC components and to give pure DC as output.





4.9 REGULATOR 78XX SERIES

4.9.1 REGULATOR

The Voltage Regulator is a circuit that will give a constant output voltage in-spite of changes in its input voltage or load current (IL). The output of filter is given to voltage regulator. Its handles the load and line regulation problem and stabilizes / maintains output voltage constant. Here 78xx series is used to meet the requirement of main circuit and driver circuit as well as dc motor.

4.9.2 NEED OF REGULATOR

1) To maintain constant output voltage in-spite of input voltage.
2) To maintain constant output voltage in-spite of IL changes.

NAME	VOLTAGE
LM7805	+ 5 volts
LM7812	+ 12 volts

4.9.3 FEATURES OF 78XX : POSITIVE SERIES VOLTAGE REGULATOR

1) Output current up to 1A
2) Thermal overload protection
3) Short circuit protection
4) Output transistor safe operating area protection

4.10 IC MOUNTING SOCKET

An IC socket, or integrated circuit socket, is used in devices that contain an integrated circuit. An IC socket is used as a placeholder for IC chips and is used in order to allow safe removal and insertion of IC chips because IC chips may become damaged from heat due to soldering.

4.10.1 TYPES OF IC SOCKETS

There are several different kinds of IC sockets at Future Electronics. We stock many of the most common types categorized by several parameters including type, style, number of pins, termination style / mounting, centerline / pitch and packaging type. Our parametric filters will allow you to refine your search results according to the required specifications.

4.10.2 APPLICATIONS OF IC SOCKETS

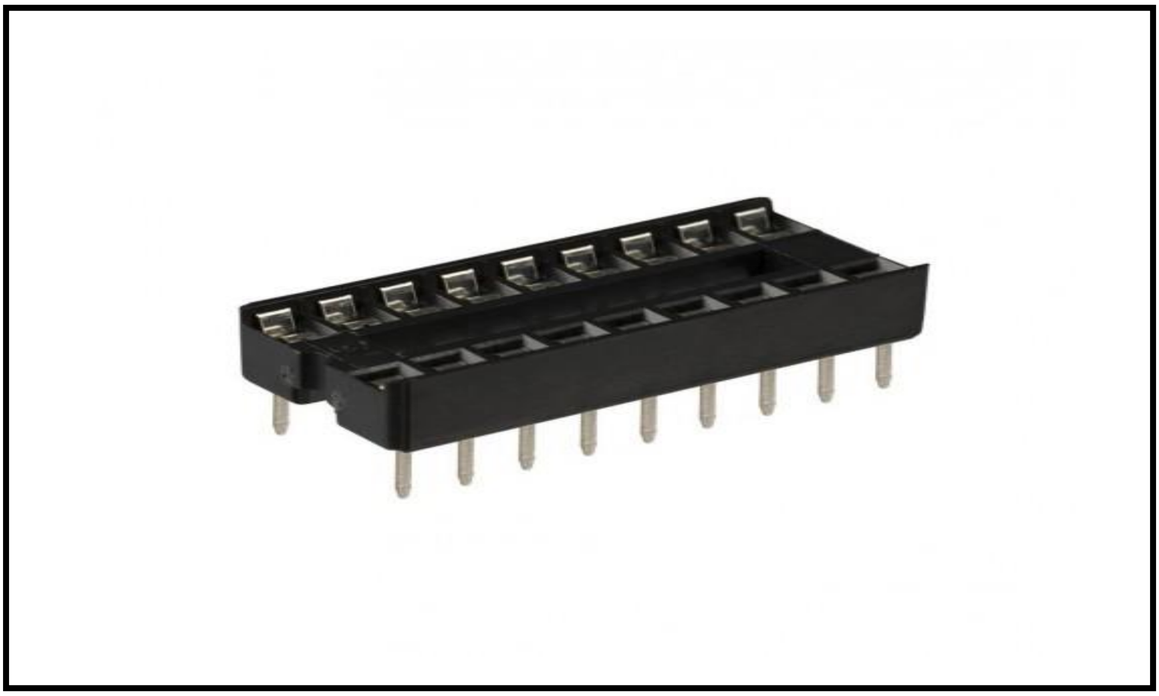
IC sockets are used in applications where integrated circuit devices have short lead pins. They help in providing safe removal and insertion of IC chips. They are often found in desktop and server computers. They are also used for prototyping new circuits because they allow easy component swapping.

4.10.3 CHOOSING THE RIGHT IC SOCKET

With the FutureElectronics.com parametric search, when looking for the right IC sockets, you can filter the results by category. We carry the following categories of IC sockets:

- Adaptors
- BGA
- DIMM
- Dual in Line Package Sockets
- PGA
- PLCC
- SIP Sockets
- Test & Burn

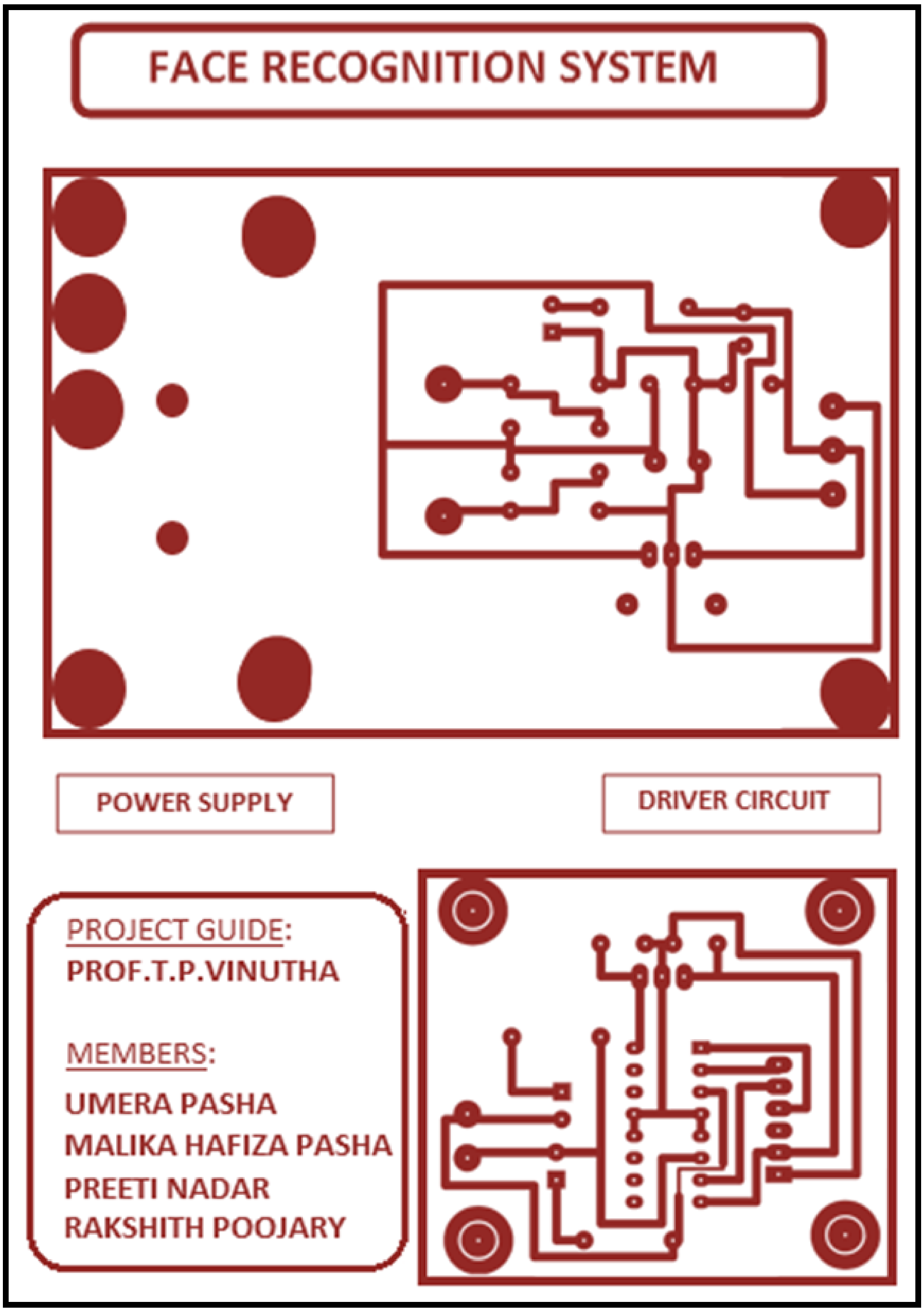
Once you choose the IC socket category, you can narrow them down by various attributes: by number of pins, type, style and termination style to name a few. You will be able to find the right IC test sockets, IC breadboard socket, IC socket adapter, IC socket connector or any other IC socket of any pin size (8 pin, 14 pin, 16 pin, 18 pin, 20 pin, 28 pin, 40 pin,…) by using these filters.



CHAPTER 5 : IMPLEMETATION

5.1 PCB LAYOUT

Below is the PCB layout, we had given for etching :



CHAPTER 6 : TESTING AND TROUBLESHOOTING

6.1 CONTINUITY TEST

In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open".

Devices that can be used to perform continuity tests include multi meters which measure current and specialized continuity testers which are cheaper, more basic devices, generally with a simple light bulb that lights up when current flows. An important application is the continuity test of a bundle of wires so as to find the two ends belonging to a particular one of these wires; there will be a negligible resistance between the "right" ends, and only between the "right" ends.

This test is the performed just after the hardware soldering and configuration has been completed. This test aims at finding any electrical open paths in the circuit after the soldering. Many a times, the electrical continuity in the circuit is lost due to improper soldering, wrong and rough handling of the PCB, improper usage of the soldering iron, component failures and presence of bugs in the circuit diagram.

We use a multi meter to perform this test. We keep the multi meter in buzzer mode and connect the ground terminal of the multi meter to the ground. We connect both the terminals across the path that needs to be checked. If there is continuation then you will hear the beep sound.

6.2 POWER ON TEST

This test is performed to check whether the voltage at different terminals is according to the requirement or not. We take a multi meter and put it in voltage mode. Remember that this test is performed without the processor.

Firstly, we check the output of the transformer, whether we get the required 12 V AC voltage. Then we apply this voltage to the power supply circuit. Note that we do this test without the processor because if there is any excessive voltage, this may lead to damaging the processor. We check for the input to the voltage regulator i.e., are we getting an input of 12V and an output of 5V.

Similarly, we check for the other terminals for the required voltage. In this way we can assure that the voltage at all the terminals is as per the requirement.

6.3 STEPS INVOLVED IN TROUBLESHOOTING

- Switch off the power supply.
- Check for any defects, this can include open circuits, lack of continuity (gap in etched copper track) Etc.
- Next test the continuity of various tracks in the circuit. Make sure that are no open circuits.
- Make sure that the IC pins which are supposed to be connected are well shorted.
- Check for non-functioning IC.
- Check all the resistors, capacitors. Etc.

6.4 IC FAILURE

Due to overheating in the circuit the IC may blow up. In order to test whether there is any fault in the IC remove the IC from the circuit and check for its utility using an IC tester. Another way for checking the IC is its substitution with a similar IC.

In order to avoid the troubleshooting or re-soldering an entire IC it is advisable to solder an IC bed or IC socket to the circuit rather than the IC. In such case if IC is found faulty it can be easily unplugged and new IC can be connected.

6.5 IC TESTING PROCEDURE

- Enter the IC number using keyboard.
- Press enter key.
- IC number is displayed on display.
- Press test.
- Then it will show pass/fail of IC.

CHAPTER 7 : CONCLUSION

This project made us familiar with the vast applications of **Face Recognition System.** We have applied our theoretical knowledge and have simultaneously gained practical experience, thus satisfying the basic objective of the “project”.

By encompassing all the problems of other biometric systems, the enhanced Face Recognition System helps to minimize the error and the other problems. Although there exists better enhanced algorithms for face recognition, this system proves to be cost-efficient system in today's market. Also, use of USB Camera in place of strip-camera of Raspberry-Pi is helpful in capturing better quality images. Its in-built Flash system helps to capture images in dark scenarios. The weights of Eigen faces formed for each individuals photo help in processing of the images in a better way. Also, it helps to recognize the face easily. The database of the system can be increased by just using the SD card of higher storage capacity.

With this project we have realized the importance of planning and organization of the work involved. Assigning different members of our project team and yet ensuring co-ordination amongst all has enabled us to complete the project in time.

We have been very fortunate to get the appropriate guidance, as and when required from our project guide and we once again thank them for the same.

APPENDICES

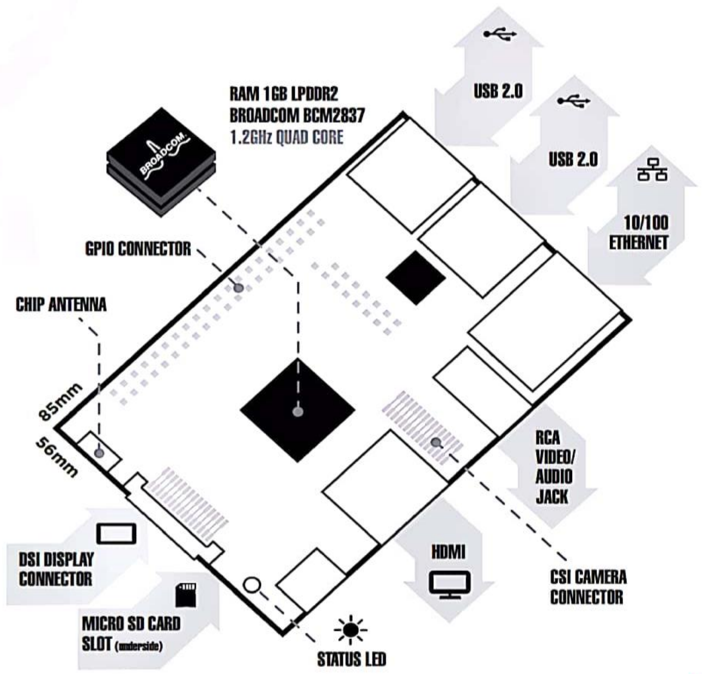
DATASHEETS

RASPBERRY PI 3 MODEL B

Raspberry Pi

Raspberry Pi 3 Model B

Product Name	**Raspberry Pi 3**
Product Description	The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processer, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN & Bluetooth connectivity making it the ideal solution for powerful connected designs.
RS Part Number	**896-8660**



www.rs-components.com/raspberrypi

Raspberry Pi

Raspberry Pi 3 Model B

Specifications

Processor	Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)
GPU	Dual Core VideoCore IV® Multimedia Co-Processor. Provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode. Capable of 1Gpixel/s, 1.5Gtexel/s or 24GFLOPs with texture filtering and DMA infrastructure
Memory	1GB LPDDR2
Operating System	Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT
Dimensions	85 x 56 x 17mm
Power	Micro USB socket 5V1, 2.5A

Connectors:

Ethernet	10/100 BaseT Ethernet socket
Video Output	HDMI (rev 1.3 & 1.4 Composite RCA (PAL and NTSC)
Audio Output	Audio Output 3.5mm jack, HDMI USB 4 x USB 2.0 Connector
GPIO Connector	40-pin 2.54 mm (100 mil) expansion header: 2x20 strip Providing 27 GPIO pins as well as +3.3 V, +5 V and GND supply lines
Camera Connector	15-pin MIPI Camera Serial Interface (CSI-2)
Display Connector	Display Serial Interface (DSI) 15 way flat flex cable connector with two data lanes and a clock lane
Memory Card Slot	Push/pull Micro SDIO

Key Benefits

- Low cost
- Consistent board format
- 10x faster processing
- Added connectivity

Key Applications

- Low cost PC/tablet/laptop
- IoT applications
- Media centre
- Robotics
- Industrial/Home automation
- Server/cloud server
- Print server
- Security monitoring
- Web camera
- Gaming
- Wireless access point
- Environmental sensing/monitoring (e.g. weather station)

www.rs-components.com/raspberrypi

LM7805

FAIRCHILD
SEMICONDUCTOR®

www.fairchildsemi.com

MC78XX/LM78XX/MC78XXA

3-Terminal 1A Positive Voltage Regulator

Features

- Output Current up to 1A
- Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
- Thermal Overload Protection
- Short Circuit Protection
- Output Transistor Safe Operating Area Protection

Description

The MC78XX/LM78XX/MC78XXA series of three terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

TO-220

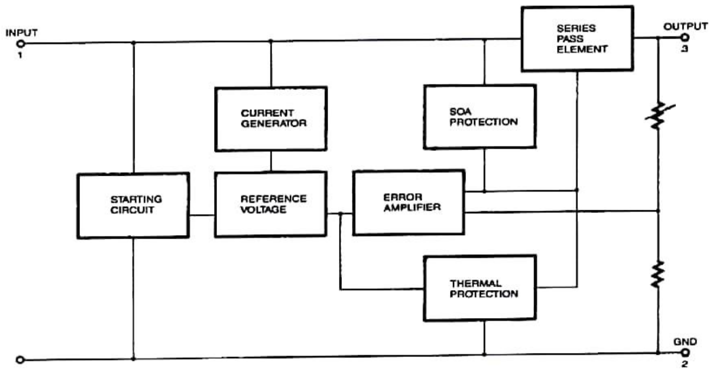
1

D-PAK

1

1. Input 2. GND 3. Output

Internal Block Digram



Rev. 1.0.1

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Input Voltage (for V_O = 5V to 18V) (for V_O = 24V)	V_I V_I	35 40	V V
Thermal Resistance Junction-Cases (TO-220)	$R_{\theta JC}$	5	$^oC/W$
Thermal Resistance Junction-Air (TO-220)	$R_{\theta JA}$	65	$^oC/W$
Operating Temperature Range	T_{OPR}	0 ~ +125	^oC
Storage Temperature Range	T_{STG}	-65 ~ +150	^oC

Electrical Characteristics (MC7805/LM7805)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I = 10V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7805/LM7805			Unit
				Min.	Typ.	Max.	
Output Voltage	V_O	T_J =+25 ^oC		4.8	5.0	5.2	V
		5.0mA ≤ Io ≤ 1.0A, P_O ≤ 15W V_I = 7V to 20V		4.75	5.0	5.25	
Line Regulation (Note1)	Regline	T_J=+25 ^oC	V_O = 7V to 25V	-	4.0	100	mV
			V_I = 8V to 12V	-	1.6	50	
Load Regulation (Note1)	Regload	T_J=+25 ^oC	I_O = 5.0mA to1.5A	-	9	100	mV
			I_O =250mA to 750mA	-	4	50	
Quiescent Current	I_Q	T_J =+25 ^oC		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.03	0.5	mA
		V_I= 7V to 25V		-	0.3	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O= 5mA		-	-0.8	-	mV/ ^oC
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A=+25 ^oC		-	42	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_O = 8V to 18V		62	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 ^oC		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	15	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A =+25 ^oC		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 ^oC		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_o due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7806)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =11V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7806 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		5.75	6.0	6.25	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 8.0V to 21V		5.7	6.0	6.3	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 8V to 25V	-	5	120	mV
			V_I = 9V to 13V	-	1.5	60	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O =5mA to 1.5A	-	9	120	mV
			I_O =250mA to750A	-	3	60	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		-	-	0.5	mA
		V_I = 8V to 25V		-	-	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	45	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 9V to 19V		59	75	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	19	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7808)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =14V, C_I= 0.33µF, C_O= 0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7808 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		7.7	8.0	8.3	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 10.5V to 23V		7.6	8.0	8.4	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 10.5V to 25V	-	5.0	160	mV
			V_I = 11.5V to 17V	-	2.0	80	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5.0mA to 1.5A	-	10	160	mV
			I_O= 250mA to 750mA	-	5.0	80	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.05	0.5	mA
		V_I = 10.5A to 25V		-	0.5	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	52	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, V_I= 11.5V to 21.5V		56	73	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7809)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =15V, C_I= 0.33μF, C_O= 0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7809 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25°C		8.65	9	9.35	V
		5.0mA≤ I_O ≤1.0A, P_O ≤15W V_I= 11.5V to 24V		8.6	9	9.4	
Line Regulation (Note1)	Regline	T_J=+25°C	V_I = 11.5V to 25V	-	6	180	mV
			V_I = 12V to 17V	-	2	90	
Load Regulation (Note1)	Regload	T_J=+25°C	I_O = 5mA to 1.5A	-	12	180	mV
			I_O = 250mA to 750mA	-	4	90	
Quiescent Current	I_Q	T_J=+25°C		-	5.0	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	**mA**
		V_I = 11.5V to 26V		-	-	1.3	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	58	-	μV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 13V to 23V		56	71	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25°C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25°C		-	250	-	mA
Peak Current	I_{PK}	T_J= +25°C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7810)

(Refer to test circuit ,0°C< T_J < 125°C, I_O = 500mA, V_I =16V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7810 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		9.6	10	10.4	V
		5.0mA ≤ I_O≤1.0A, P_O ≤15W V_I = 12.5V to 25V		9.5	10	10.5	
Line Regulation (Note1)	Regline	T_J =+25°C	V_I = 12.5V to 25V	-	10	200	mV
			V_I = 13V to 25V	-	3	100	
Load Regulation (Note1)	Regload	T_J =+25°C	I_O = 5mA to 1.5A	-	12	200	mV
			I_O = 250mA to 750mA	-	4	400	
Quiescent Current	I_Q	T_J =+25°C		-	5.1	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 12.5V to 29V		-	-	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	58	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 13V to 23V		56	71	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7812)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =19V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7812 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		11.5	12	12.5	V
		5.0mA ≤ I_O≤1.0A, P_O≤15W V_I = 14.5V to 27V		11.4	12	12.6	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 14.5V to 30V	-	10	240	mV
			V_I = 16V to 22V	-	3.0	120	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	11	240	mV
			I_O = 250mA to 750mA	-	5.0	120	
Quiescent Current	I_Q	T_J =+25 °C		-	5.1	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.1	0.5	mA
		V_I = 14.5V to 30V		-	0.5	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	76	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 15V to 25V		55	71	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	18	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J = +25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7815)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =23V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7815 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		14.4	15	15.6	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 17.5V to 30V		14.25	15	15.75	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 17.5V to 30V	-	11	300	mV
			V_I = 20V to 26V	-	3	150	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	12	300	mV
			I_O = 250mA to 750mA	-	4	150	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 17.5V to 30V		-	-	1.0	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	90	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 18.5V to 28.5V		54	70	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	19	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7818)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =27V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7818 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		17.3	18	18.7	V
		5.0mA ≤ I_O ≤1.0A, P_O ≤15W V_I = 21V to 33V		17.1	18	18.9	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 21V to 33V	-	15	360	mV
			V_I = 24V to 30V	-	5	180	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	15	360	mV
			I_O = 250mA to 750mA	-	5.0	180	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	-	0.5	mA
		V_I = 21V to 33V		-	-	1	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	110	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 22V to 32V		53	69	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	22	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7824)

(Refer to test circuit ,0°C < T_J < 125°C, I_O = 500mA, V_I =33V, C_I= 0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		MC7824 Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		23	24	25	V
		5.0mA ≤ I_O ≤ 1.0A, P_O ≤ 15W V_I = 27V to 38V		22.8	24	25.25	
Line Regulation (Note1)	Regline	T_J =+25 °C	V_I = 27V to 38V	-	17	480	mV
			V_I = 30V to 36V	-	6	240	
Load Regulation (Note1)	Regload	T_J =+25 °C	I_O = 5mA to 1.5A	-	15	480	mV
			I_O = 250mA to 750mA	-	5.0	240	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	8.0	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1.0A		-	0.1	0.5	mA
		V_I = 27V to 38V		-	0.5	1	
Output Voltage Drift	$\Delta V_O/\Delta T$	I_O = 5mA		-	-1.5	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25 °C		-	60	-	µV/Vo
Ripple Rejection	RR	f = 120Hz V_I = 28V to 38V		50	67	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J=+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	28	-	mΩ
Short Circuit Current	I_{SC}	V_I = 35V, T_A=+25 °C		-	230	-	mA
Peak Current	I_{PK}	T_J =+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7805A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 10V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C	4.9	5	5.1	V
		I_O = 5mA to 1A, $P_O \leq$ 15W V_I = 7.5V to 20V	4.8	5	5.2	
Line Regulation (Note1)	Regline	V_I = 7.5V to 25V I_O = 500mA	-	5	50	mV
		V_I = 8V to 12V	-	3	50	
		T_J =+25 °C, V_I= 7.3V to 20V	-	5	50	
		T_J =+25 °C, V_I= 8V to 12V	-	1.5	25	
Load Regulation (Note1)	Regload	T_J =+25 °C I_O = 5mA to 1.5A	-	9	100	mV
		I_O = 5mA to 1A	-	9	100	
		I_O = 250mA to 750mA	-	4	50	
Quiescent Current	I_Q	T_J =+25 °C	-	5.0	6	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A	-	-	0.5	mA
		V_I = 8 V to 25V, I_O = 500mA	-	-	0.8	
		V_I = 7.5V to 20V, T_J =+25 °C	-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	Io = 5mA	-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25 °C	-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 8V to 18V	-	68	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C	-	2	-	V
Output Resistance	r_O	f = 1KHz	-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C	-	250	-	mA
Peak Current	I_{PK}	T_J= +25 °C	-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7806A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I =11V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		5.58	6	6.12	V
		I_O = 5mA to 1A, $P_O \leq$ 15W V_I = 8.6V to 21V		5.76	6	6.24	
Line Regulation (Note1)	Regline	V_I= 8.6V to 25V I_O = 500mA		-	5	60	mV
		V_I= 9V to 13V		-	3	60	
		T_J =+25 °C	V_I= 8.3V to 21V	-	5	60	
			V_I= 9V to 13V	-	1.5	30	
Load Regulation (Note1)	Regload	T_J =+25 °C I_O = 5mA to 1.5A		-	9	100	mV
		I_O = 5mA to 1A		-	4	100	
		I_O = 250mA to 750mA		-	5.0	50	
Quiescent Current	I_Q	T_J =+25 °C		-	4.3	6	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		-	-	0.5	mA
		V_I = 9V to 25V, I_O = 500mA		-	-	0.8	
		V_I= 8.5V to 21V, T_J =+25 °C		-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25 °C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 9V to 19V		-	65	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7808A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 14V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		7.84	8	8.16	V
		I_O = 5mA to 1A, P_O ≤15W V_I = 10.6V to 23V		7.7	8	8.3	
Line Regulation (Note1)	Regline	V_I= 10.6V to 25V I_O = 500mA		-	6	80	mV
		V_I= 11V to 17V		-	3	80	
		T_J =+25 °C	V_I= 10.4V to 23V	-	6	80	
			V_I= 11V to 17V	-	2	40	
Load Regulation (Note1)	Regload	T_J =+25 °C I_O = 5mA to 1.5A		-	12	100	mV
		I_O = 5mA to 1A		-	12	100	
		I_O = 250mA to 750mA		-	5	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	6	mA
Quiescent Current Change	ΔI_Q	I_O = 5mA to 1A		-	-	0.5	mA
		V_I = 11V to 25V, I_O = 500mA		-	-	0.8	
		V_I= 10.6V to 23V, T_J =+25 °C		-	-	0.8	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-0.8	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25 °C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 11.5V to 21.5V		-	62	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2	-	V
Output Resistance	r_O	f = 1KHz		-	18	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7809A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 15V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25°C		8.82	9.0	9.18	V
		I_O = 5mA to 1A, P_O≤15W V_I = 11.2V to 24V		8.65	9.0	9.35	
Line Regulation (Note1)	Regline	V_I= 11.7V to 25V I_O = 500mA		-	6	90	mV
		V_I= 12.5V to 19V		-	4	45	
		T_J =+25°C	V_I= 11.5V to 24V	-	6	90	
			V_I= 12.5V to 19V	-	2	45	
Load Regulation (Note1)	Regload	T_J =+25°C I_O = 5mA to 1.0A		-	12	100	mV
		I_O = 5mA to 1.0A		-	12	100	
		I_O = 250mA to 750mA		-	5	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	V_I = 11.7V to 25V, T_J=+25 °C		-	-	0.8	mA
		V_I = 12V to 25V, I_O = 500mA		-	-	0.8	
		I_O = 5mA to 1.0A		-	-	0.5	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-1.0	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25 °C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 12V to 22V		-	62	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2.0	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25°C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant, junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7810A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_o =1A, V_I = 16V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25°C		9.8	10	10.2	V
		I_O = 5mA to 1A, $P_O \le$ 15W V_I =12.8V to 25V		9.6	10	10.4	
Line Regulation (Note1)	Regline	V_I= 12.8V to 26V I_O = 500mA		-	8	100	mV
		V_I= 13V to 20V		-	4	50	
		T_J =+25°C	V_I= 12.5V to 25V	-	8	100	
			V_I= 13V to 20V	-	3	50	
Load Regulation (Note1)	Regload	T_J =+25°C I_O = 5mA to 1.5A		-	12	100	mV
		I_O = 5mA to 1.0A		-	12	100	
		I_O = 250mA to 750mA		-	5	50	
Quiescent Current	I_Q	T_J =+25°C		-	5.0	6.0	mA
Quiescent Current Change	ΔI_Q	V_I = 13V to 26V, T_J=+25°C		-	-	0.5	mA
		V_I = 12.8V to 25V, I_O = 500mA		-	-	0.8	
		I_O = 5mA to 1.0A		-	-	0.5	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-1.0	-	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25°C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 14V to 24V		-	62	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25°C		-	2.0	-	V
Output Resistance	r_O	f = 1KHz		-	17	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25°C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25°C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7812A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 19V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		11.75	12	12.25	V
		I_O = 5mA to 1A, P_O ≤15W, V_I = 14.8V to 27V		11.5	12	12.5	
Line Regulation (Note1)	Regline	V_I= 14.8V to 30V, I_O = 500mA		-	10	120	mV
		V_I= 16V to 22V		-	4	120	
		T_J =+25 °C	V_I= 14.5V to 27V	-	10	120	
			V_I= 16V to 22V	-	3	60	
Load Regulation (Note1)	Regload	T_J =+25 °C, I_O = 5mA to 1.5A		-	12	100	mV
		I_O = 5mA to 1.0A		-	12	100	
		I_O = 250mA to 750mA		-	5	50	
Quiescent Current	I_Q	T_J =+25°C		-	5.1	6.0	mA
Quiescent Current Change	ΔI_Q	V_I = 15V to 30V, T_J=+25 °C		-		0.8	mA
		V_I = 14V to 27V, I_O = 500mA		-		0.8	
		I_O = 5mA to 1.0A		-		0.5	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-1.0	-	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A =+25°C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA, V_I = 14V to 24V		-	60	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25°C		-	2.0	-	V
Output Resistance	r_O	f = 1KHz		-	18	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7815A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I =23V, C_I=0.33μF, C_O=0.1μF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		14.7	15	15.3	V
		I_O = 5mA to 1A, P_O ≤15W V_I = 17.7V to 30V		14.4	15	15.6	
Line Regulation (Note1)	Regline	V_I= 17.9V to 30V I_O = 500mA		-	10	150	mV
		V_I= 20V to 26V		-	5	150	
		T_J =+25°C	V_I= 17.5V to 30V	-	11	150	
			V_I= 20V to 26V	-	3	75	
Load Regulation (Note1)	Regload	T_J =+25 °C I_O = 5mA to 1.5A		-	12	100	mV
		I_O = 5mA to 1.0A		-	12	100	
		I_O = 250mA to 750mA		-	5	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	6.0	mA
Quiescent Current Change	ΔI_Q	V_I = 17.5V to 30V, T_J =+25 °C		-	-	0.8	mA
		V_I = 17.5V to 30V, I_O = 500mA		-	-	0.8	
		I_O = 5mA to 1.0A		-	-	0.5	
Output Voltage Drift	ΔV/ΔT	I_O = 5mA		-	-1.0	-	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25 °C		-	10	-	μV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 18.5V to 28.5V		-	58	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25 °C		-	2.0	-	V
Output Resistance	r_O	f = 1KHz		-	19	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25 °C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25°C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7818A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 27V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25 °C		17.64	18	18.36	V
		I_O = 5mA to 1A, P_O ≤15W V_I = 21V to 33V		17.3	18	18.7	
Line Regulation (Note1)	Regline	V_I= 21V to 33V I_O = 500mA		-	15	180	mV
		V_I= 21V to 33V		-	5	180	
		T_J =+25 °C	V_I= 20.6V to 33V	-	15	180	
			V_I= 24V to 30V	-	5	90	
Load Regulation (Note1)	Regload	T_J =+25°C I_O = 5mA to 1.5A		-	15	100	mV
		I_O = 5mA to 1.0A		-	15	100	
		I_O = 250mA to 750mA		-	7	50	
Quiescent Current	I_Q	T_J =+25 °C		-	5.2	6.0	mA
Quiescent Current Change	ΔI_Q	V_I = 21V to 33V, T_J=+25 °C		-	-	0.8	mA
		V_I = 21V to 33V, I_O = 500mA		-	-	0.8	
		I_O = 5mA to 1.0A		-	-	0.5	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-1.0	-	mV/ °C
Output Noise Voltage	V_N	f = 10Hz to 100KHz T_A =+25°C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA V_I = 22V to 32V		-	57	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25°C		-	2.0	-	V
Output Resistance	r_O	f = 1KHz		-	19	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25°C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25 °C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in V_O due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Electrical Characteristics (MC7824A)

(Refer to the test circuits. 0°C < T_J < 125°C, I_O =1A, V_I = 33V, C_I=0.33µF, C_O=0.1µF, unless otherwise specified)

Parameter	Symbol	Conditions		Min.	Typ.	Max.	Unit
Output Voltage	V_O	T_J =+25°C		23.5	24	24.5	V
		I_O = 5mA to 1A, P_O ≤15W, V_I = 27.3V to 38V		23	24	25	
Line Regulation (Note1)	Regline	V_I= 27V to 38V, I_O = 500mA		-	18	240	mV
		V_I= 21V to 33V		-	6	240	
		T_J =+25°C	V_I= 26.7V to 38V	-	18	240	
			V_I= 30V to 36V	-	6	120	
Load Regulation (Note1)	Regload	T_J =+25°C, I_O = 5mA to 1.5A		-	15	100	mV
		I_O = 5mA to 1.0A		-	15	100	
		I_O = 250mA to 750mA		-	7	50	
Quiescent Current	I_Q	T_J =+25°C		-	5.2	6.0	mA
Quiescent Current Change	ΔI_Q	V_I = 27.3V to 38V, T_J =+25°C		-	-	0.8	mA
		V_I = 27.3V to 38V, I_O = 500mA		-	-	0.8	
		I_O = 5mA to 1.0A		-	-	0.5	
Output Voltage Drift	$\Delta V/\Delta T$	I_O = 5mA		-	-1.5	-	mV/°C
Output Noise Voltage	V_N	f = 10Hz to 100KHz, T_A = 25°C		-	10	-	µV/Vo
Ripple Rejection	RR	f = 120Hz, I_O = 500mA, V_I = 28V to 38V		-	54	-	dB
Dropout Voltage	V_{Drop}	I_O = 1A, T_J =+25°C		-	2.0	-	V
Output Resistance	r_O	f = 1KHz		-	20	-	mΩ
Short Circuit Current	I_{SC}	V_I= 35V, T_A =+25°C		-	250	-	mA
Peak Current	I_{PK}	T_J=+25°C		-	2.2	-	A

Note:

1. Load and line regulation are specified at constant junction temperature. Change in VO due to heating effects must be taken into account separately. Pulse testing with low duty is used.

Typical Perfomance Characteristics

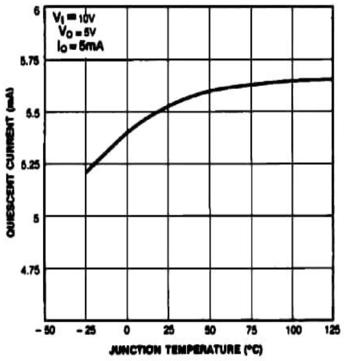


Figure 1. Quiescent Current

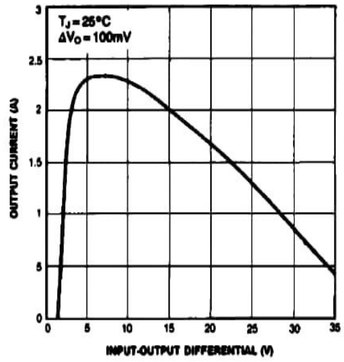


Figure 2. Peak Output Current

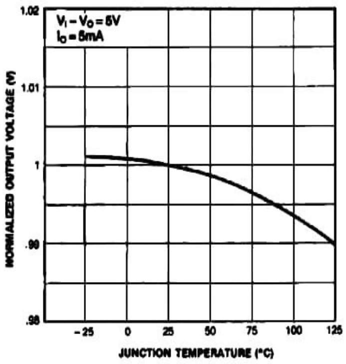


Figure 3. Output Voltage

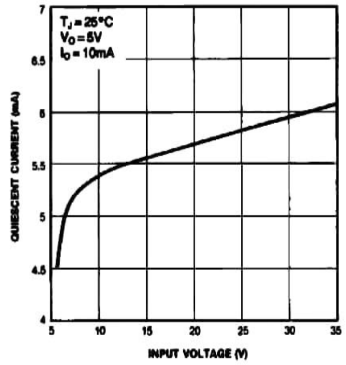


Figure 4. Quiescent Current

Typical Applications

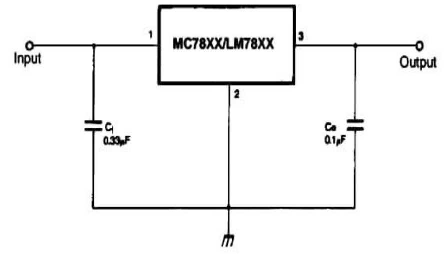


Figure 5. DC Parameters

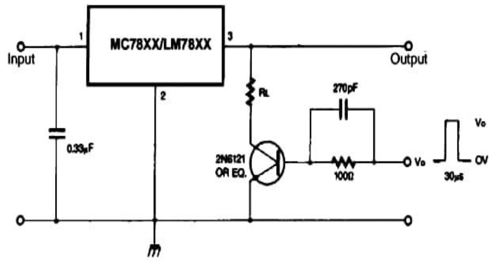


Figure 6. Load Regulation

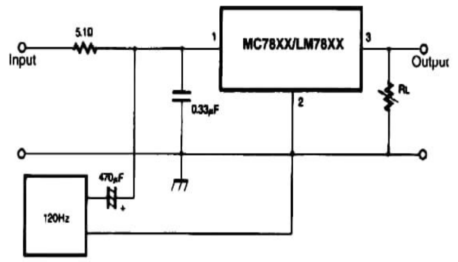


Figure 7. Ripple Rejection

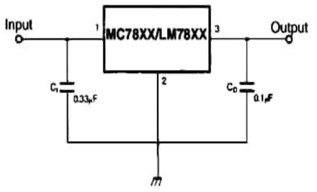
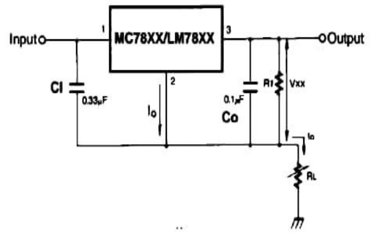


Figure 8. Fixed Output Regulator



$$I_O = \frac{V_{XX}}{R_1} + I_Q$$

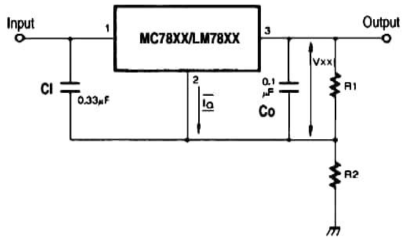
Figure 9. Constant Current Regulator

Notes:

(1) To specify an output voltage. substitute voltage value for "XX." A common ground is required between the input and the Output voltage. The input voltage must remain typically 2.0V above the output voltage even during the low point on the input ripple voltage.

(2) C_I is required if regulator is located an appreciable distance from power Supply filter.

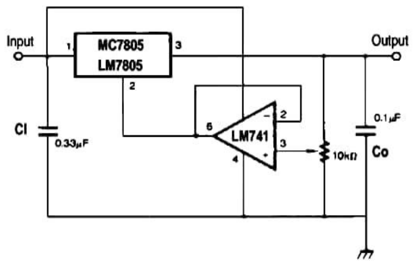
(3) C_O improves stability and transient response.



$I_{RI} \geq 5I_Q$

$V_O = V_{XX}(1+R_2/R_1)+I_QR_2$

Figure 10. Circuit for Increasing Output Voltage



$I_{RI} \geq 5\ I_Q$

$V_O = V_{XX}(1+R_2/R_1)+I_QR_2$

Figure 11. Adjustable Output Regulator (7 to 30V)

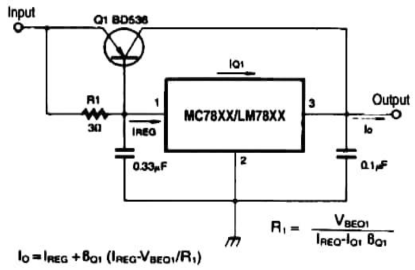


Figure 12. High Current Voltage Regulator

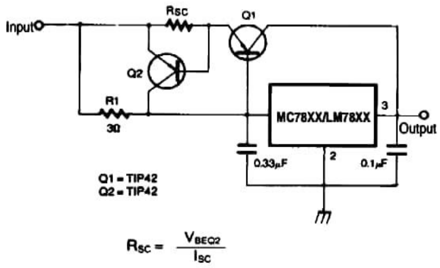


Figure 13. High Output Current with Short Circuit Protection

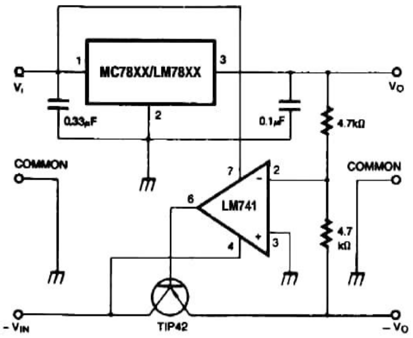


Figure 14. Tracking Voltage Regulator

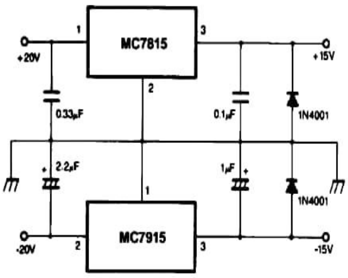


Figure 15. Split Power Supply (±15V-1A)

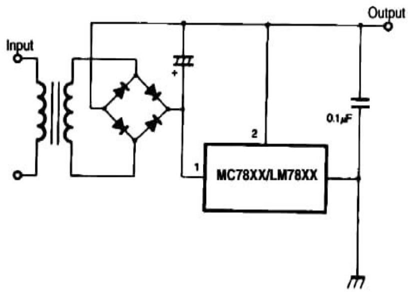


Figure 16. Negative Output Voltage Circuit

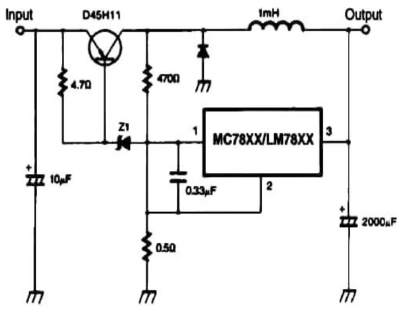
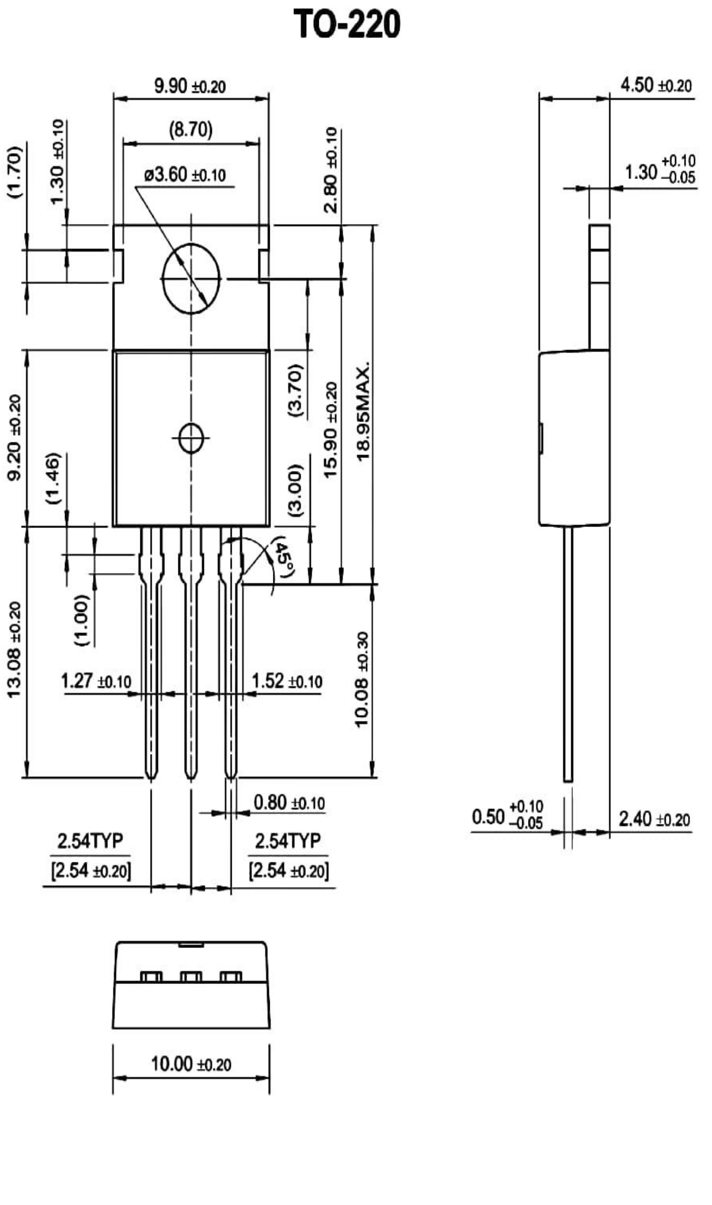


Figure 17. Switching Regulator

Mechanical Dimensions

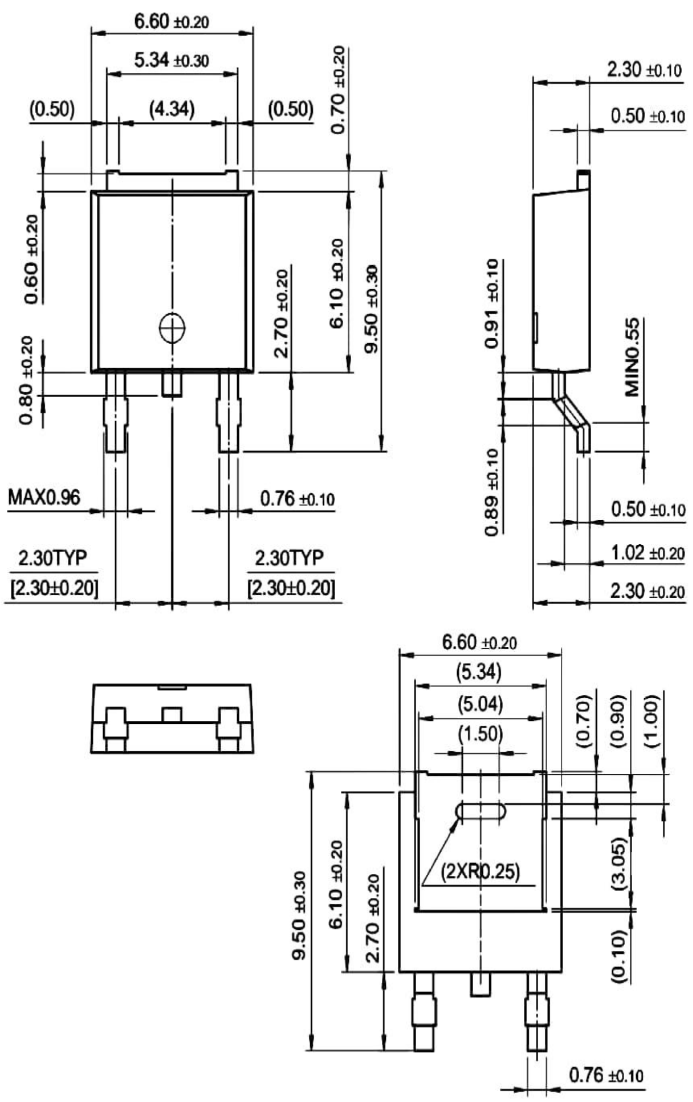
Package



Mechancal Dimensions (Continued)

Package

D-PAK



Ordering Information

Product Number	Output Voltage Tolerance	Package	Operating Temperature
LM7805CT	±4%	TO-220	0 ~ + 125°C

Product Number	Output Voltage Tolerance	Package	Operating Temperature
MC7805CT	±4%	TO-220	0 ~ + 125°C
MC7806CT			
MC7808CT			
MC7809CT			
MC7810CT			
MC7812CT			
MC7815CT			
MC7818CT			
MC7824CT			
MC7805CDT		D-PAK	
MC7806CDT			
MC7808CDT			
MC7809CDT			
MC7810CDT			
MC7812CDT			
MC7805ACT	±2%	TO-220	
MC7806ACT			
MC7808ACT			
MC7809ACT			
MC7810ACT			
MC7812ACT			
MC7815ACT			
MC7818ACT			
MC7824ACT			

L293D

SGS-THOMSON MICROELECTRONICS

L293D
L293DD

PUSH-PULL FOUR CHANNEL DRIVER WITH DIODES

- 600mA OUTPUT CURRENT CAPABILITY PER CHANNEL
- 1.2A PEAK OUTPUT CURRENT (non repetitive) PER CHANNEL
- ENABLE FACILITY
- OVERTEMPERATURE PROTECTION
- LOGICAL "0" INPUT VOLTAGE UP TO 1.5 V (HIGH NOISE IMMUNITY)
- INTERNAL CLAMP DIODES

SO(12+4+4) Powerdip (12+2+2)

ORDERING NUMBERS:

L293DD L293D

DESCRIPTION

The Device is a monolithic integrated high voltage, high current four channel driver designed to accept standard DTL or TTL logic levels and drive inductive loads (such as relays solenoides, DC and stepping motors) and switching power transistors.

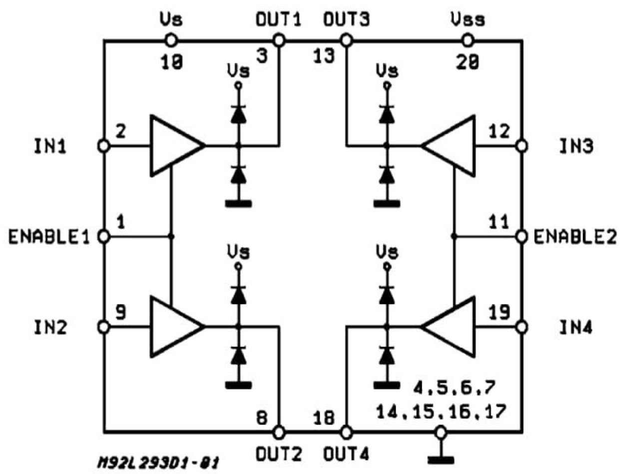
To simplify use as two bridges each pair of channels is equipped with an enable input. A separate supply input is provided for the logic, allowing operation at a lower voltage and internal clamp diodes are included.

This device is suitable for use in switching applications at frequencies up to 5 kHz.

The L293D is assembled in a 16 lead plastic packaage which has 4 center pins connected together and used for heatsinking

The L293DD is assembled in a 20 lead surface mount which has 8 center pins connected together and used for heatsinking.

BLOCK DIAGRAM

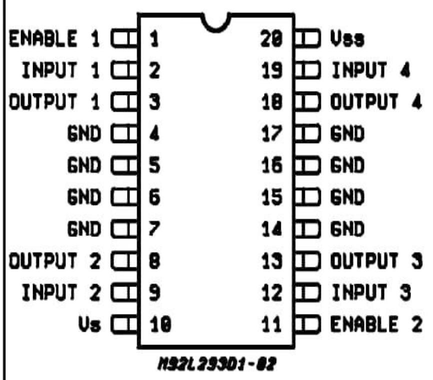


June 1996 1/7

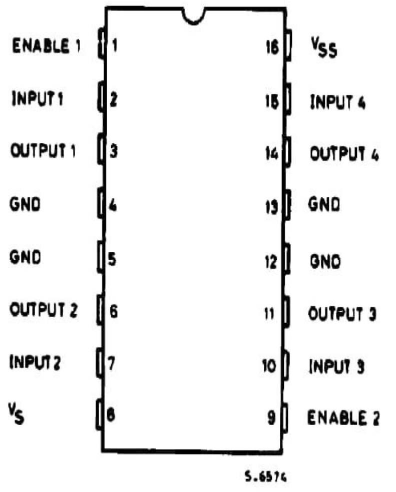
ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_S	Supply Voltage	36	V
V_{SS}	Logic Supply Voltage	36	V
V_i	Input Voltage	7	V
V_{en}	Enable Voltage	7	V
I_o	Peak Output Current (100 μs non repetitive)	1.2	A
P_{tot}	Total Power Dissipation at T_{pins} = 90 °C	4	W
T_{stg}, T_j	Storage and Junction Temperature	– 40 to 150	°C

PIN CONNECTIONS (Top view)



SO(12+4+4)



Powerdip(12+2+2)

THERMAL DATA

Symbol	Decription		DIP	SO	Unit
$R_{th\ j\text{-}pins}$	Thermal Resistance Junction-pins	max.	–	14	°C/W
$R_{th\ j\text{-}amb}$	Thermal Resistance junction-ambient	max.	80	50 (*)	°C/W
$R_{th\ j\text{-}case}$	Thermal Resistance Junction-case	max.	14	–	

(*) With 6sq. cm on board heatsink.

ELECTRICAL CHARACTERISTICS (for each channel, V_S = 24 V, V_{SS} = 5 V, T_{amb} = 25 °C, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_S	Supply Voltage (pin 10)		V_{SS}		36	V
V_{SS}	Logic Supply Voltage (pin 20)		4.5		36	V
I_S	Total Quiescent Supply Current (pin 10)	V_i = L ; I_O = 0 ; V_{en} = H		2	6	mA
		V_i = H ; I_O = 0 ; V_{en} = H		16	24	mA
		V_{en} = L			4	mA
I_{SS}	Total Quiescent Logic Supply Current (pin 20)	V_i = L ; I_O = 0 ; V_{en} = H		44	60	mA
		V_i = H ; I_O = 0 ; V_{en} = H		16	22	mA
		V_{en} = L		16	24	mA
V_{IL}	Input Low Voltage (pin 2, 9, 12, 19)		– 0.3		1.5	V
V_{IH}	Input High Voltage (pin 2, 9, 12, 19)	$V_{SS} \le 7$ V	2.3		V_{SS}	V
		$V_{SS} > 7$ V	2.3		7	V
I_{IL}	Low Voltage Input Current (pin 2, 9, 12, 19)	V_{IL} = 1.5 V			– 10	µA
I_{IH}	High Voltage Input Current (pin 2, 9, 12, 19)	2.3 V $\le V_{IH} \le V_{SS}$ – 0.6 V		30	100	µA
$V_{en\ L}$	Enable Low Voltage (pin 1, 11)		– 0.3		1.5	V
$V_{en\ H}$	Enable High Voltage (pin 1, 11)	$V_{SS} \le 7$ V	2.3		V_{SS}	V
		$V_{SS} > 7$ V	2.3		7	V
$I_{en\ L}$	Low Voltage Enable Current (pin 1, 11)	$V_{en\ L}$ = 1.5 V		– 30	– 100	µA
$I_{en\ H}$	High Voltage Enable Current (pin 1, 11)	2.3 V $\le V_{en\ H} \le V_{SS}$ – 0.6 V			± 10	µA
$V_{CE(sat)H}$	Source Output Saturation Voltage (pins 3, 8, 13, 18)	I_O = – 0.6 A		1.4	1.8	V
$V_{CE(sat)L}$	Sink Output Saturation Voltage (pins 3, 8, 13, 18)	I_O = + 0.6 A		1.2	1.8	V
V_F	Clamp Diode Forward Voltage	I_O = 600nA		1.3		V
t_r	Rise Time (*)	0.1 to 0.9 V_O		250		ns
t_f	Fall Time (*)	0.9 to 0.1 V_O		250		ns
t_{on}	Turn-on Delay (*)	0.5 V_i to 0.5 V_O		750		ns
t_{off}	Turn-off Delay (*)	0.5 V_i to 0.5 V_O		200		ns

(*) See fig. 1.

TRUTH TABLE (one channel)

Input	Enable (*)	Output
H	H	H
L	H	L
H	L	Z
L	L	Z

Z = High output impedance
(*) Relative to the considered channel

Figure 1: Switching Times

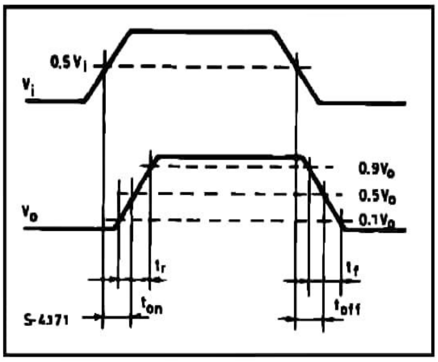
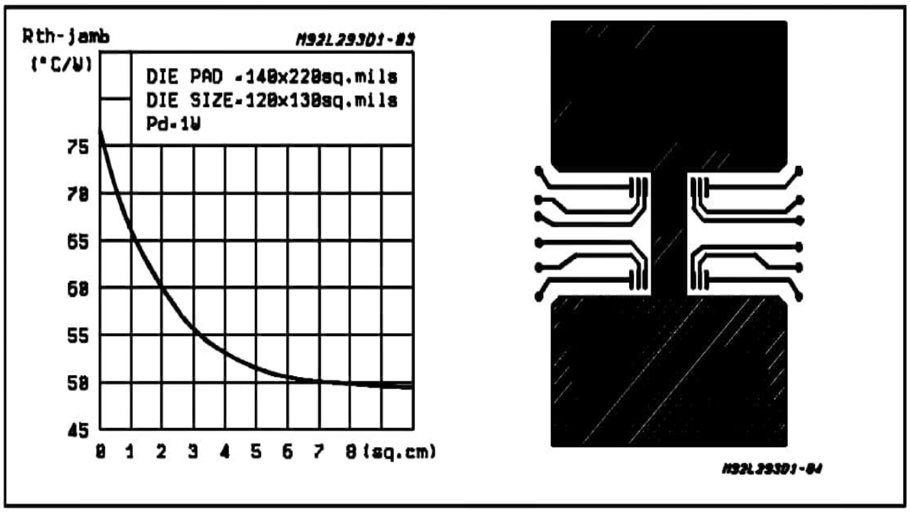
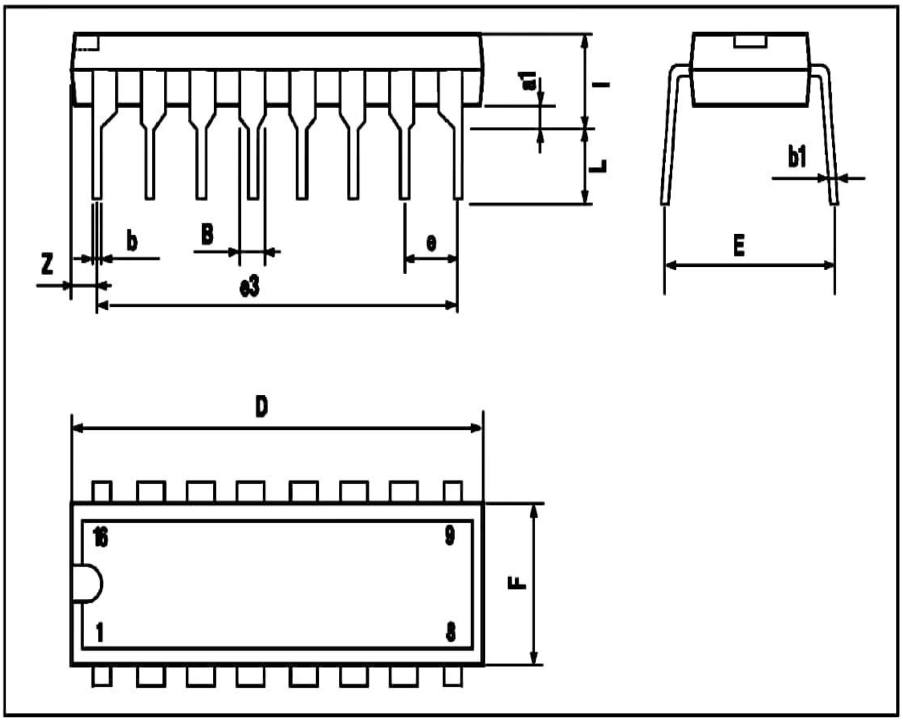


Figure 2: Junction to ambient thermal resistance vs. area on board heatsink (SO12+4+4 package)



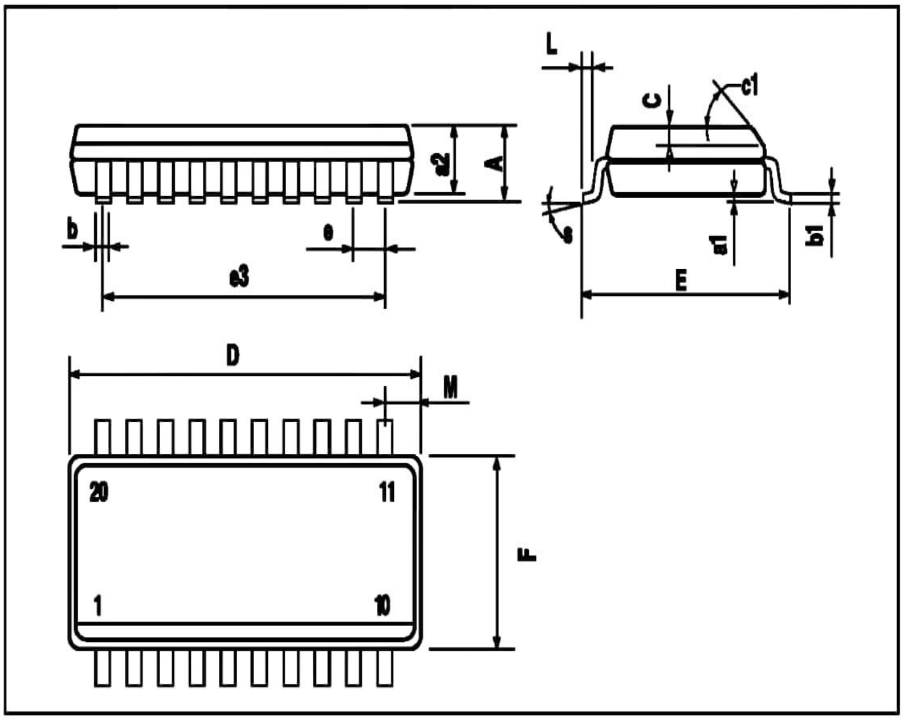
POWERDIP16 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
a1	0.51			0.020		
B	0.85		1.40	0.033		0.055
b		0.50			0.020	
b1	0.38		0.50	0.015		0.020
D			20.0			0.787
E		8.80			0.346	
e		2.54			0.100	
e3		17.78			0.700	
F			7.10			0.280
I			5.10			0.201
L		3.30			0.130	
Z			1.27			0.050



SO20 PACKAGE MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			2.65			0.104
a1	0.1		0.2	0.004		0.008
a2			2.45			0.096
b	0.35		0.49	0.014		0.019
b1	0.23		0.32	0.009		0.013
C		0.5			0.020	
c1		45			1.772	
D		1	12.6		0.039	0.496
E	10		10.65	0.394		0.419
e		1.27			0.050	
e3		11.43			0.450	
F		1	7.4		0.039	0.291
G	8.8		9.15	0.346		0.360
L	0.5		1.27	0.020		0.050
M			0.75			0.030
S	8° (max.)					



PART LIST

SR. NO.	NAME OF PRODUCT	NO. OF ITEMS
1.	RASPBERRY PI 3: MODEL B	1
2.	INTEX IT-306WC USB CAMERA	1
3.	USB CABLE	1
4.	ETHERNET CABLE	1
	POWER SUPPLY SECTION	
1.	IN4007 DIODES	4
2.	0.1 µf CAPACITOR	2
3.	560Ω RESISTOR	1
4.	100 µf CAPACITOR	2
5.	1000 µf CAPACITOR	2
6.	L7805 TRANSISTOR	2
7.	HEAT SINK	2
8.	RED LED	2
9.	15V TRANSFORMER	2
10.	3-PIN CONNECTOR	2
11.	4-PIN CONNECTOR	2
	DRIVER CIRCUIT SECTION	
1.	0.1 µf CAPACITOR	1
2.	1 kΩ RESISTOR	2
3.	RED LED	2
4.	16-PIN IC SOCKET	1
5.	L293D IC	1
6.	WS7805 TRANSISTOR	1
7.	HEAT SINK	1
8.	3-PIN CONNECTOR	1
9.	5-PIN CONNECTOR	1
	PCB SECTION	
1.	4X4 COPPER CLAD	1
2.	ETCHING SOLUTION	1
3.	DRILL BITS	2
4.	LUGS	4
5.	NUT AND BOLTS	2

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