Design and fabrication of real time Railway Inspection system using IoT

A Project Report submitted
in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY
in
ELECTRONICS AND COMMUNICATION ENGINEERING

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2015-2019

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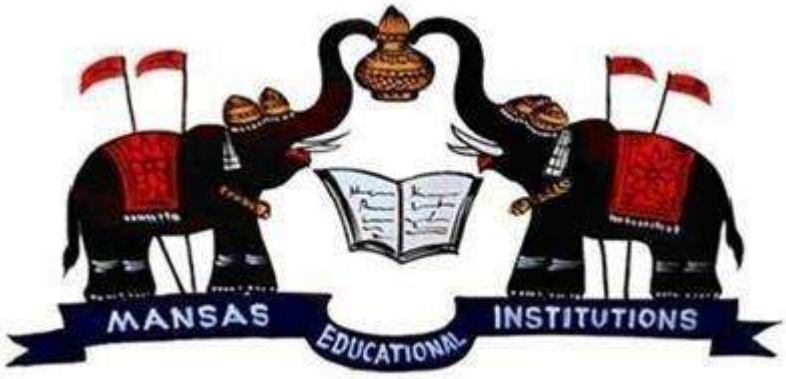

CERTIFICATE

This is to certify that project entitled **"DESIGN AND FABRICATION OF REAL TIME RAILWAY INSPECTION SYSTEM USING IoT"** being submitted by **K. Hari Krishna** (15331A0475), **N. Vishnu Teja** (15331A04A9), **P. Madhuri** (15331A04B9)**, Ch. Greeshant** (16335A0413) in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Electronics and Communication Engineering is a record of bonafide work done by them under my supervision during the academic year **2018-2019**.

PROJECT GUIDE

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ACKNOWLEDGEMENT

We wish to express our deep sense of gratitude to **Sri.D.Raja Ramesh**, Assistant professor, Department of Electronics and Communications for his wholehearted co-operation, unfailing inspiration and valuable guidance. Throughout the project work, his useful suggestions, constant encouragement has given a right direction and shape to our learning. Really, we are indebted to him for his excellent and enlightened guidance.

We consider it our privilege to express our deepest gratitude to **Dr.M.Sunil Prakash**, Professor and Head of the Department for his valuable suggestions and constant motivation that greatly helped the project work to get successfully completed.

We thank **Dr.K.V.L.Raju**, Principal, for extending his utmost support and cooperation in providing all the provisions for the successful completion of the project.

We sincerely thank all the members of the staff of the Department of Electronics & Communication Engineering for their sustained help in our pursuits.

With great solemnity and sincerity, we offer our profuse thanks to our management, MANSAS for providing all the resources to complete our project successfully.

We thank all those who contributed directly or indirectly in successfully carrying out this work.

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ABSTRACT

India has one of the world's largest railway networks, manual Inspection and detecting a crack on these railways tracks is very tedious process and consumes lot of time and human resource. The project aims in designing railway track crack detection autonomous vehicle using Microcontroller, IR obstacle sensors assembly system, which detects the cracks along its path, picks up the obstacles on the path, and it is able to remove small plastic wastes with the help of a suction mechanism; the vehicle is also capable of monitoring the location of the crack by using the GPS module and alerts through messages with the help of Node MCU module by interfacing with Google API. The central component of the whole system is a Node MCU. The vehicle is powered with the help of Solar panel and Lead Acid battery assembly. The vehicle moves along the path of railway track and IR obstacle sensors mounted on the vehicle front end inspecting the track along its path. When any crack or deformation is detected on the track the vehicle stops and the location of the crack is identified and the location Latitude and Longitude coordinates are procured using the node MCU module using Google API and it is used to send these Location coordinates in the form of messages to the pre-defined number.

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CHAPTER-1

INTRODUCTION

In India, to find that rail transport occupies a prominent position in providing the necessary transport infrastructure to sustain and quench the ever-burgeoning needs of a rapidly growing economy. Today, India possesses the fourth largest railway network in the world. The principal problem has been the lack of cheap and efficient technology to detect problems in the rail tracks and of course, the lack of proper maintenance of rails which have resulted in the formation of cracks in the rails and other similar problems caused by anti-social elements which jeopardize the security of operation of rail transport. In the past, this problem has led to a number of derailments resulting in a heavy loss of life and property. Cracks in rails have been identified to be the main cause of derailments in the past, yet there have been no cheap automated solutions available for testing purposes. These cracks and other problems with the rails generally go unnoticed due to improper maintenance and the currently irregular and manual track line monitoring that is being carried out. Owing to the crucial repercussions of this problem, this report presents an implementation of an efficient and cost-effective solution suitable for large scale application by using design and fabrication of railway track inspection using IOT.

The 90% of rail accidents now-a-days are due to cracks on the rail tracks. They are caused either due to natural causes like excessive expansion due to heat or due to anti-social elements. These cracks and other problems with the rails are unnoticed due to improper maintenance. The current track line monitoring which is being carried out is manual, which is irregular and inefficient. So, in order to make it automatic we would like to use IR Obstacle sensor, which has only one module that has both transmitter and receiver and alignment will not be an issue.

The main objective of the project is to identify any crack or deformation on the railway track using this setup, which can be implemented in live by Railway authorities. The proposed setup would make the inspection and maintenance of railways tracks. There is also a 3-axis mechanical arm with a gripper to lift the object on the track. The dust and smaller particles on the track can be removed by suction

mechanism. There is a pump for watering the track to remove the wet materials on the track. There is an IP camera in front of the robot to view the live video of the track.

Suction is the force that a partial vacuum exerts upon a solid, liquid, or a gas. Removing air from a space results in a lowered pressure, which can cause fluids to enter the space or produce adhesion. The robot can use a suction motor which is like a vacuum cleaner.

The Infrared sensor is a short-range obstacle detector with no dead zone. It has a reasonably narrow detection area which can be increased using the dual version. Here in this project we are not dealing with the Ultrasonic sensors since for short distances IR sensor work effectively than the Ultrasonic sensor.

The 3-axis pick, and place arm built by using one DC motor and 2 Johnson motors. Here Johnson's motor is side shafted with a torque of 5Kg and DC motors have a torque of 3Kg.

The chassis of the robot is built with iron in design that is suitable to do all the applications effectively. It consists of 4 DC motors and each have a torque of 3Kgs. For watering purpose there is a water pump connected to node MCU.

The above all the applications can be controlled by IoT using the Blynk application. The existing model is detection of the railway track by manual operation within the limit.

1.1 INTRODUCTION TO IOT

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enable these objects to connect and exchange data.

Internet of things has been in demand for the modernization of the conventional systems. We can deploy IoT technology with help of sensors and networks in almost each and every major fields like Home automation, Smart cities, Railway monitoring and management, Road safety and management, Water resource

management etc. IoT devices are in demand of consumer usability which includes Car, Entertainment, Wearable devices, Medical Equipment's and Smart retail. Consumer IoT user provides the experience and interface for the advancement of the IoT. Now a day's different types of smart sensors are developing for the safety and security in emergency management strategy. Smart water management is only possible with help of IoT which includes the applications in monitoring the flow of water, Management of valves, fault detection within valves, Data analysis through Observations from different meters etc. in conventional method for each and every individual process we require the human power and observation skills. To overcome these IoT plays the major role.

Internet of Things (IoT) has taken the world by storm since its conception. The idea of connecting everything by wireless technology sums up IoT. We can connect anything using the sensors designed specifically for objects. IoT is the network of objects, devices, automobiles, houses and other items embedded with electronic sensors, and connectivity to enable them to talk to each other and execute functions. IoT is evolving fast alongside with the latest innovation occurring in wireless technology and embedded technologies, With Microcontrollers working on low powers introduced that are perfect for remotely deployed IoT systems to connect us and work for years without any maintenance has made the IoT not only for luxury functions but also for needful data aggregation as for defense systems. The devices participating in IoT are designed to be interoperable with different vendors of embedded controllers as well as with different wireless technologies. IoT is progressing with millions of things connecting each day to generate large amount of information resulting in useful future actions.

1.2 LITERATURE SURVEY

CRACK DETECTION METHODS

1.2.1 Eddy Current Detection:

It is used to detect discontinuities and defects in conductive materials. Using this technique, two different types of artificial defects in a railhead were evaluated in order to analyze the relationship between different types of defects and eddy current signals, and to obtain data on the size of the rail surface defects and crack location. Two eddy current sensor probes were used. One was for detecting the signal from a rail. It was positioned on a tested sample and scanned along the rail length. Another was for reference. It was positioned in air far from a sample. The controller supplied an excitation current to a series connection of two excitation coils and amplified a signal from the detection coils. The width of the rail head was 65 mm; thus, the detection coil in the sensor probe could not effectively evaluate the entire plane of the rail top. Therefore, the position of the sensor probe was varied in five different positions along the width.

For the assessment of head check damages in the rail surface, the eddy current test technique is applied. This procedure is based on the electromagnetic interaction between the magnetic field of a test sensor and the currents induced in the metallic material. The test sensor is guided close to the rail at approx. 0,5 to 1 mm. No direct contact is necessary. Eddy current field variations caused by inhomogeneities in the rail surface are used for sizing the cracks. Following names are relevant for interpretation: The length of crack indicates the length of the crack on the rail surface and may often be identified by visual inspection. The length of the crack, which is growing into the rail body, is referred to as depth of crack. The attack depth of the damage is named depth of defect (see figure 1). With the eddy current procedure only the crack depth can be determined. The angular position of the cracks is not measurable. Hence, on the basis of long-term investigations an angle of $\alpha \approx 25° - 30°$ is assumed for the calculation of the damage depth. With the help of the measuring results taken from the grinding train this assumption could be confirmed.

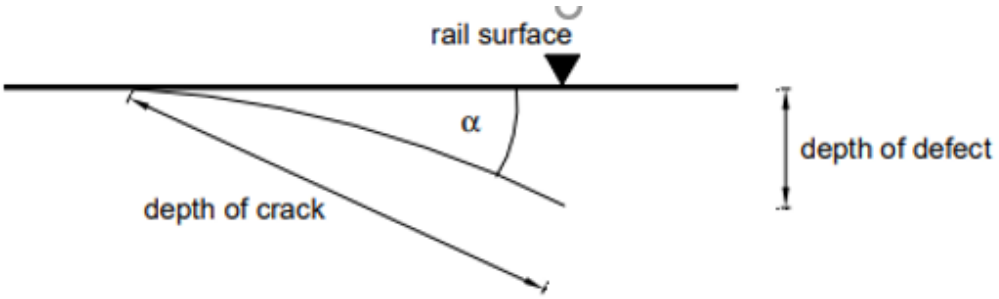


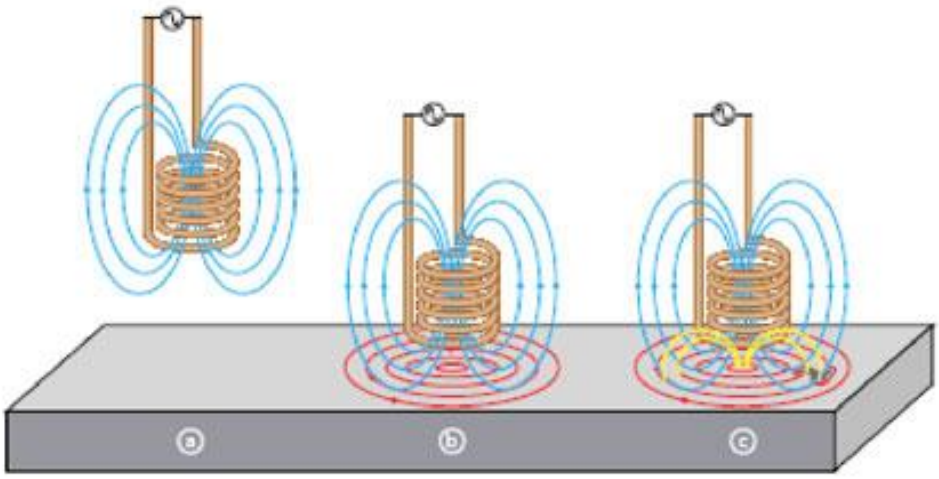
Fig 1.1: Eddy current detection

Eddy current testing is based on the physics phenomenon of electromagnetic induction. In an eddy current probe, an alternating current flow through a wire coil and generates an oscillating magnetic field. If the probe and its magnetic field are brought close to a conductive material like a metal test piece, a circular flow of electrons known as an eddy current will begin to move through the metal like swirling water in a stream. That eddy current flowing through the metal will in turn generate its own magnetic field, which will interact with the coil and its field through mutual inductance. Changes in metal thickness or defects like near-surface cracking will interrupt or alter the amplitude and pattern of the eddy current and the resulting magnetic field. This in turn affects the movement of electrons in the coil by varying the electrical impedance of the coil. The eddy current instrument plots changes in the impedance amplitude and phase angle, which can be used by a trained operator to detect changes in the deviation in track.

Eddy current density is highest near the surface of the part, so that is the region of highest test resolution. The standard depth of penetration is defined as the depth at which the eddy current density is 37% of its surface value, which in turn can be calculated from the test frequency and the magnetic permeability and conductivity of the test material. Thus, variations in the conductivity of the test material, its magnetic permeability, the frequency of the AC pulses driving the coil, and coil geometry will all have an effect on test sensitivity, resolution and penetration. There are many factors that will affect the capabilities of an eddy current inspection. Eddy currents traveling in materials with higher conductivity values will be more sensitive to surface defects but will have less penetration into the material, with penetration also being dependent on test frequency. Higher test frequencies increase near surface resolution but limit the depth of penetration, while lower test frequencies increase penetration. Larger coils inspect a greater volume of material from any given

position, since the magnetic field flows deeper into the test piece, while smaller coils are more sensitive to small defects. Variations in permeability of a material generate noise that can limit flaw resolution because of greater background variations.

While conductivity and permeability are properties of the test material that are outside of the operator's control, the test frequency, coil type, and coil size can be chosen based on test requirements. In a given test, resolution will be determined by the probe type while detection capability will be controlled by material and equipment characteristics. Some inspections involve sweeping through multiple frequencies to optimize results, or inspection with multiple probes to obtain the best resolution and penetration required to detect all possible flaws. It is always important to select the right probe for each application in order to optimize test performance.



a—The alternating current flowing through the coil at a chosen frequency generates a magnetic field around the coil.

b—When the coil is placed close to an electrically conductive material, eddy current is induced in the material.

c—If a flaw in the conductive material disturbs the eddy current circulation, the magnetic coupling with the probe is changed and a defect signal can be read by measuring the coil impedance variation.

Fig 1.2: Mechanism of Eddy currents

1.2.2 IR Transmitter and Receiver:

In this method the crack is detected by using the IR transmitter and receiver assembly. It includes a robot which will move on the tracks to detect cracks. The principle involved in this crack detection is that light reaching the IR receiver is proportional to the intensity of crack i.e. when maximum light transmitted by transmitter reaches the receiver the crack intensity is more. The IR transmitter will be attached to one side of the rails and the IR receiver to the opposite side. During normal operation, when there are no cracks, the light from transmitter does not fall on the receiver and hence the set value is low. When the light from transmitter falls on the receiver, the value gets increased and the amount by which it is incremented will be proportional to the intensity of the incident light. As a consequence, when light from the transmitter deviates from its path due to the presence of a crack or a break, a sudden increase in the value can be observed. In this proposed system we use LPC 2148 microcontroller. It is a low power, high speed technology. LPC 2148 is a low cost and easy to program microcontroller. It is the widely used IC from ARM-7 family. Before the start of the rail- way line scan the robot has been programmed to self-calibrate the IR Transmitter and Receiver. After measurement, the robot takes time for a predetermined period so that the on board GPS module starts detecting the correct geographic location. The principle involved in this crack detection is that light reaching the IR receiver is proportional to the intensity of crack i.e. when maximum light transmitted by transmitter reaches the receiver the crack intensity is more. The IR transmitter will be attached on one rails track and the IR receiver mounted on opposite rails track. During normal operation, when there are no cracks, the light from transmitter does not fall on the receiver and hence the set value is low. When the light from transmitter falls on the receiver, the value gets increased and the amount by which it is incremented will be proportional to the intensity of the incident light. As a consequence, when light from the transmitter deviates from its path due to the presence of a crack or a break, a sudden increase in the value can be observed. This change in value indicates the presence of a crack or some other similar structural defect in the rails. In order to find out current location of crack in rail track, here we use of a GPS receiver whose function is to receive the current data form faulty location. To communicate the received information, we make a use of GSM modem The GSM module is being used to send information as an SMS. The system working

is achieved by interfacing the GSM and GPS modules with the LPC2148 microcontroller. The robot having four wheels which are drive by using two motor and this powered by two 12V batteries. This design is very simple and sensible therefore device easily works.

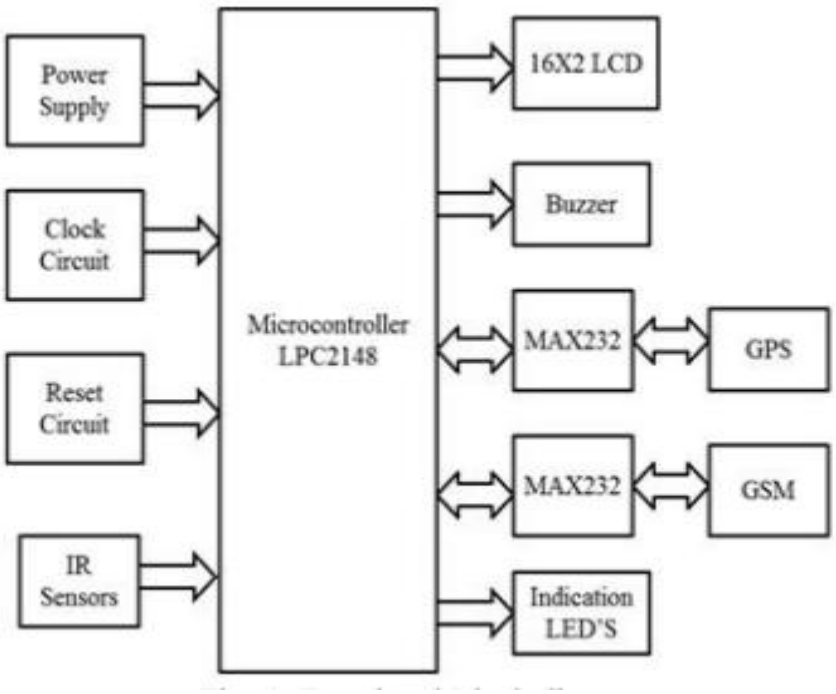


Fig 1.3: Block diagram of IR transmission and reception for crack detection

This proposed system uses the GPS/GSM system will send accurate, dependable and timely information to the controlling station. GPS module detect the train location and transfers the information to the controlling unit via GSM. The availability of such information allows the Train, and for train location controller take accurate decisions. Location data can be further processed to provide signal to the system of signalling, and it operate on train location. Therefore, the time taken for detecting the crack in the track is less and operate easily.

1.2.3 Ultrasonic Method:

The composite detection system consists of a laser source, whose beam is collimated by a suited optic lens into a light plane, two 512X512 –pixel CCD cameras for complete optimum observation of the track, a digital processing system per camera, and a supervision system. In each column of the image localizing the position

of the track profile means to find the position of the maximum laser reflection intensity. In the ideal case the intensity distribution along the column is Gaussian. Localizing the maximum implies therefore detecting the position of the expected Gaussian profile with the maximum likelihood.

Fig shows the geometry of a railroad wheel set for one of the German high-speed trains. The drawback of this configuration is clearly visible. There is a very narrow gap between the wheel and the brake. Therefore, the accessibility of phased array probes is limited. Nevertheless, in addition to this major drawback, other disadvantages must also be regarded during the optimization process. Some of the axles have surface contours not only curved in the circumference but also in the axial direction. The optimization of phased array probes must consider this circumstance. For the given geometry of the wheel set angles of incidence for shear waves in the range between 28° and 72° are necessary. This guarantees defect detectability at the defective areas. Possible probe position for one particular case is shown schematically. Coupling surface cleaning is required on this position. The probes between the brake disks and the wheels coupled at the surface of a railway axle (full metal axle) are used for crack inspection in the wheel shrinkage and adjacent area as well as the journal area. The other probes are for the inspection in the shrinkage and adjacent area of the brake disks.

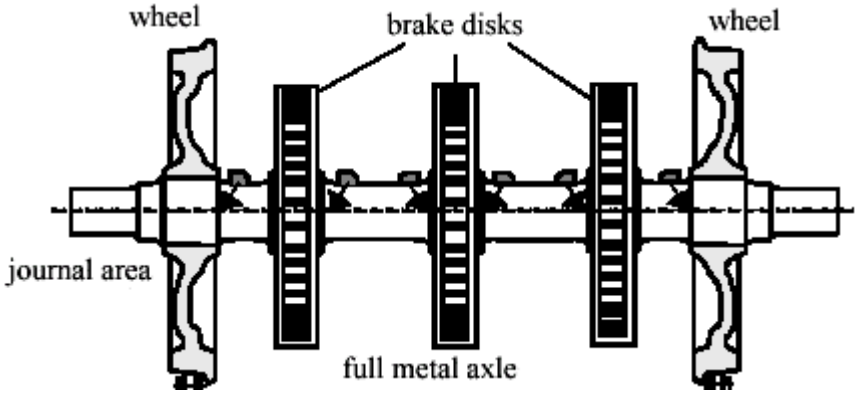


Fig 1.4: Railway track brake disks

Before mentioned and as schematically shown in Fig, the accessibility of ultrasonic probes between wheel and brake is limited. Therefore, only movement in

the circumferential direction is practicable. This requires that the whole inspection of the area of interest can be carried out using this single line scan.

NDT Technique	Systems Available	Defects Detected	Performance
Ultrasonics	Manual and high-speed systems (up to ~70 km/h)	Surface defects, rail head internal defects, rail web and base defects	Reliable manual inspection but can miss rail foot defects. At high speed can miss surface defects smaller <4mm as well as internal defects, particularly at the rail base.
Magnetic Flux Leakage	High-speed systems (up to 35 km/h)	Surface defects and near surface internal rail head defects	Reliable in detecting surface defects and shallow internal rail head defects although cannot detect cracks smaller than <4 mm. MFL performance deteriorates at high speeds.
Pulsed Eddy Current (including Field Gradient Imaging)	Manual and high-speed systems (up to 70 km/h)	Surface and near-surface internal defects	Reliable in detecting surface breaking defects. Adversely affected by grinding marks and lift-off variations.
Automated Visual Inspection	Manual and high-speed systems (up to 320 km/h)	Surface breaking defects, rail head profile, corrugation, missing parts	Reliable in detecting corrugation, rail head profile missing parts and defective ballast at high speeds. Cannot reliably detect surface breaking defects at speeds > 4 km/h. Cannot assess the rail for internal defects.
Radiography	Manual systems for static tests	Welds and known defects	Reliable in detecting internal defects in welds difficult to inspect by other means. Can miss certain transverse defects.
Electromagnetic Acoustic Transducers	Low speed hi-rail vehicle (<10 km/h)	Surface defects, rail head, web and base internal defects	Reliable for surface and internal defects. Can miss rail base defects. Adversely affected by lift-off variations.
Long Range Ultrasonics	Manual systems and low-speed hi-rail vehicle systems (<10 km/h)	Surface defects, rail head internal defects, rail web and base defects	Reliable in detecting large transverse defects (>5% of the overall cross-section).
Laser Ultrasonics	Manual and low-speed hi-rail vehicle systems (<15 km/h)	Rail head, web and base defects	Reliable in detecting internal defects. Can be affected by lift-off variations of the sensors, difficult to deploy at high speeds.
Alternating Current Field (ACF) Measurements	Manual systems (hi-speed system under development)	Surface breaking defects	Reliable in detecting and quantifying surface breaking defects. Cannot detect sub-surface defects. Very good tolerance to lift-off variations.
Multifrequency Eddy Current Sensors	Manual system, static and slow speed	Surface and near surface defects	Limited experiments conducted. Has potential to reliably quantify defects detected.

Table 1.1: Different techniques for detecting railway crack defects

In previously existing system, the same concept is used using LED and LDR sensor assembly. The main drawback of the system is that LED and LDR needs to be exactly aligned opposite to each other to detect the crack, also the environment needs to be controlled to detect the true values from LDR.

For this reason, IR Obstacle sensor is used, which has only one module that has both transmitter and receiver and alignment will not be an issue.

The previously existing project can work only with in the Wi Fi. The proposed model can be controlled from anywhere using an android or web application Blynk.

CHAPTER-2

SYSTEM DESIGN AND SPECIFICATIONS

2.1 SYSTEM DESIGN

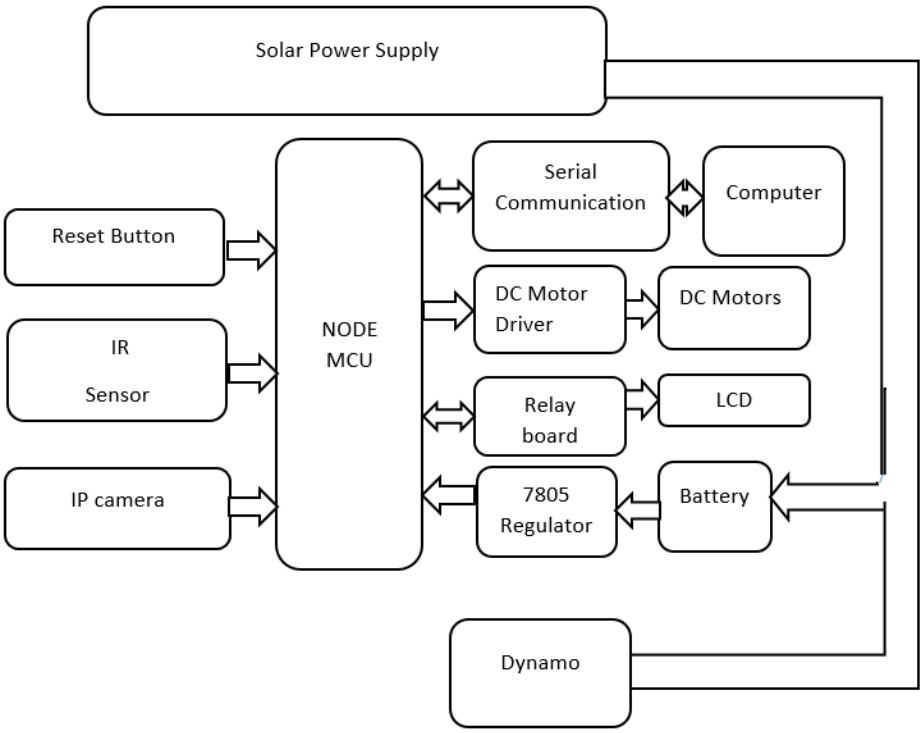


Fig 2.1: Block Representation of Railway inspection system

2.2 COMPONENTS SPECIFICATION

2.2.1 NODE MCU

a) Node MCU Module:

Fig 2.2: Node MCU module

The ESP8266 is the name of a micro controller designed by Espressif Systems. The ESP8266 itself is a self-contained WiFi networking solution offering as a bridge from existing micro controller to WiFi and is also capable of running self-contained applications. This module comes with a built in USB connector and a rich assortment of pin-outs. With a micro USB cable, you can connect NodeMCU devkit to your laptop and flash it without any trouble, just like Arduino. It is also immediately breadboard friendly.

b) Specifications:

1. Voltage:3.3V.
2. Wi-Fi Direct (P2P), soft-AP.
3. Current consumption: 10uA~170mA.
4. Flash memory attachable: 16MB max (512K normal).
5. Integrated TCP/IP protocol stack.
6. Processor: Tensilica L106 32-bit.
7. Processor speed: 80~160MHz.
8. RAM: 32K + 80K.

9. GPIOs: 17 (multiplexed with other functions).
10. Analog to Digital: 1 input with 1024 step resolution.
11. +19.5dBm output power in 802.11b mode
12. 802.11 support: b/g/n.
13. Maximum concurrent TCP connections: 5

c) Pin Definition:

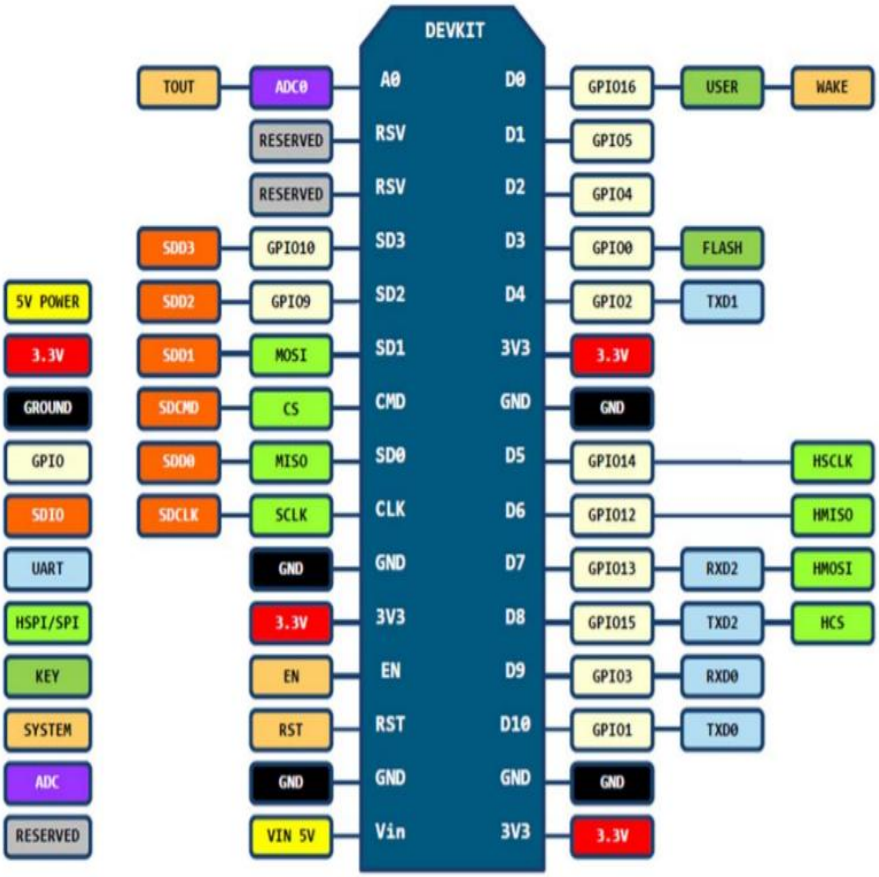


Fig 2.3: Pin diagram of Node MCU

The most basic way to use the ESP8266 module is to use serial commands, as the chip is basically a Wi-Fi/Serial transceiver. However, this is not convenient. What we recommend is using the very cool Arduino ESP8266 project, which is a modified version of the Arduino IDE that you need to install on your computer. This makes it very convenient to use the ESP8266 chip as we will be using the well-known Arduino IDE. Following the below step to install ESP8266 library to work in Arduino IDE environment.

Install the 8266-board package in the arduino by using the link http://arduino.esp8266.com/stable/package_esp8266com_index.json into Additional Board Manager URLs field in the Arduino v1.6.4+ preferences.

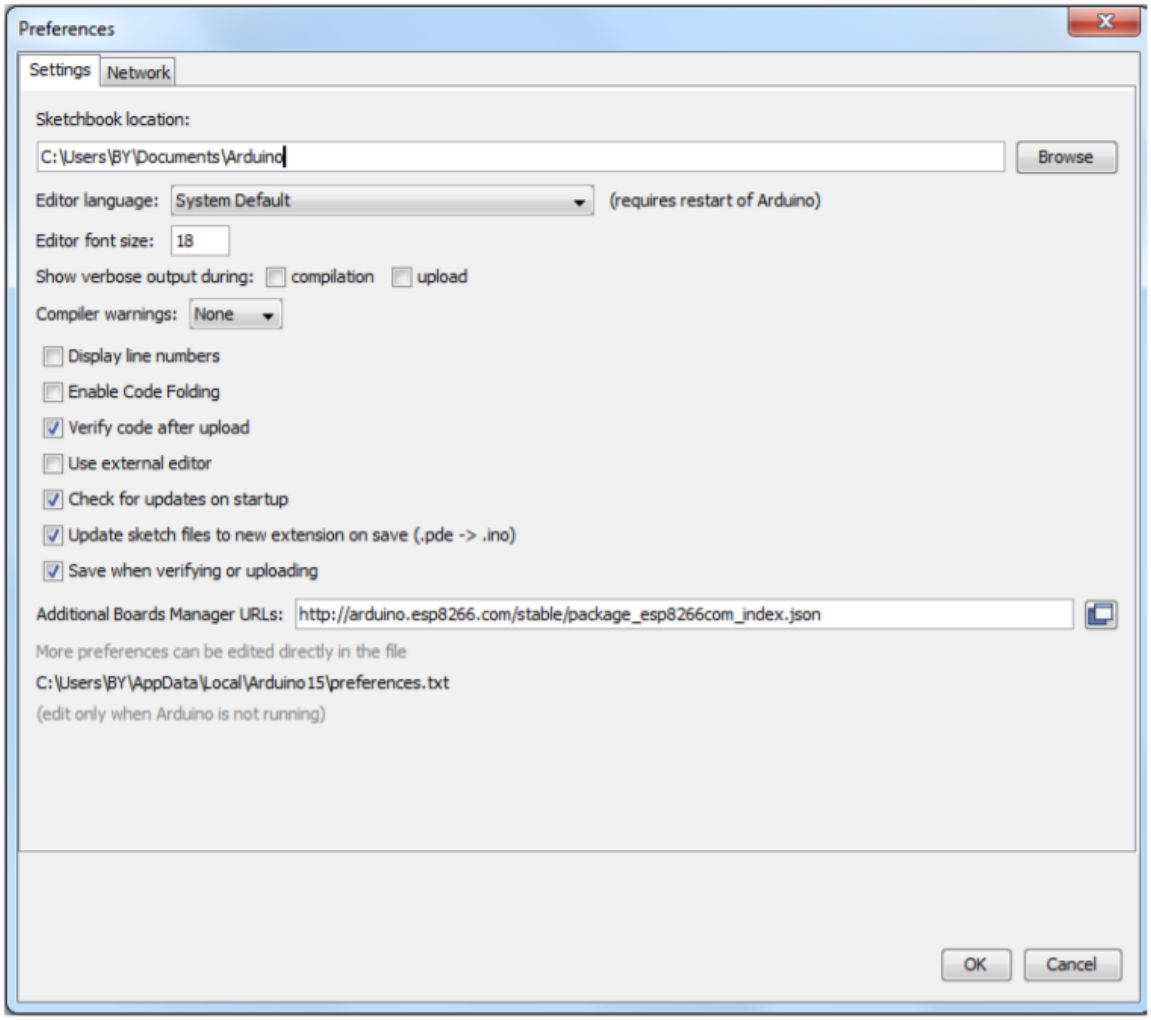


Fig 2.4: Installation of ESP8266 package

Next, use the Board manager to install the ESP8266 package.

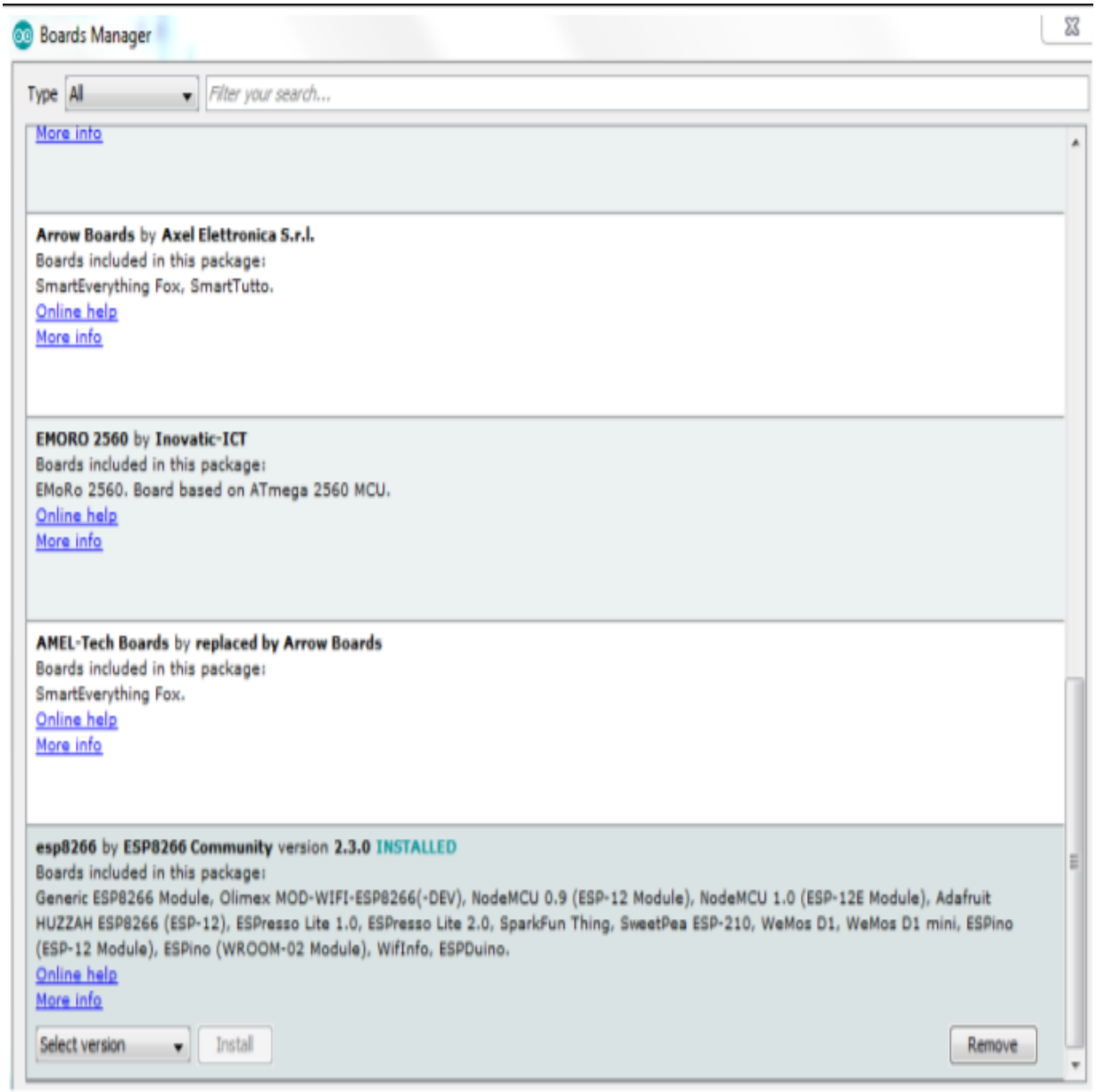


Fig 2.5: Checking the installation of ESP8266

Click ‘Tools’ -> ‘Board:’ -> ‘Board Manager…’ to access this panel. Scroll down to ‘esp8266 by ESP8266 Community’ and click “Install” button to install the ESP8266 library package. Once installation completed, close and re-open Arduino IDE for ESP8266 library to take effect.

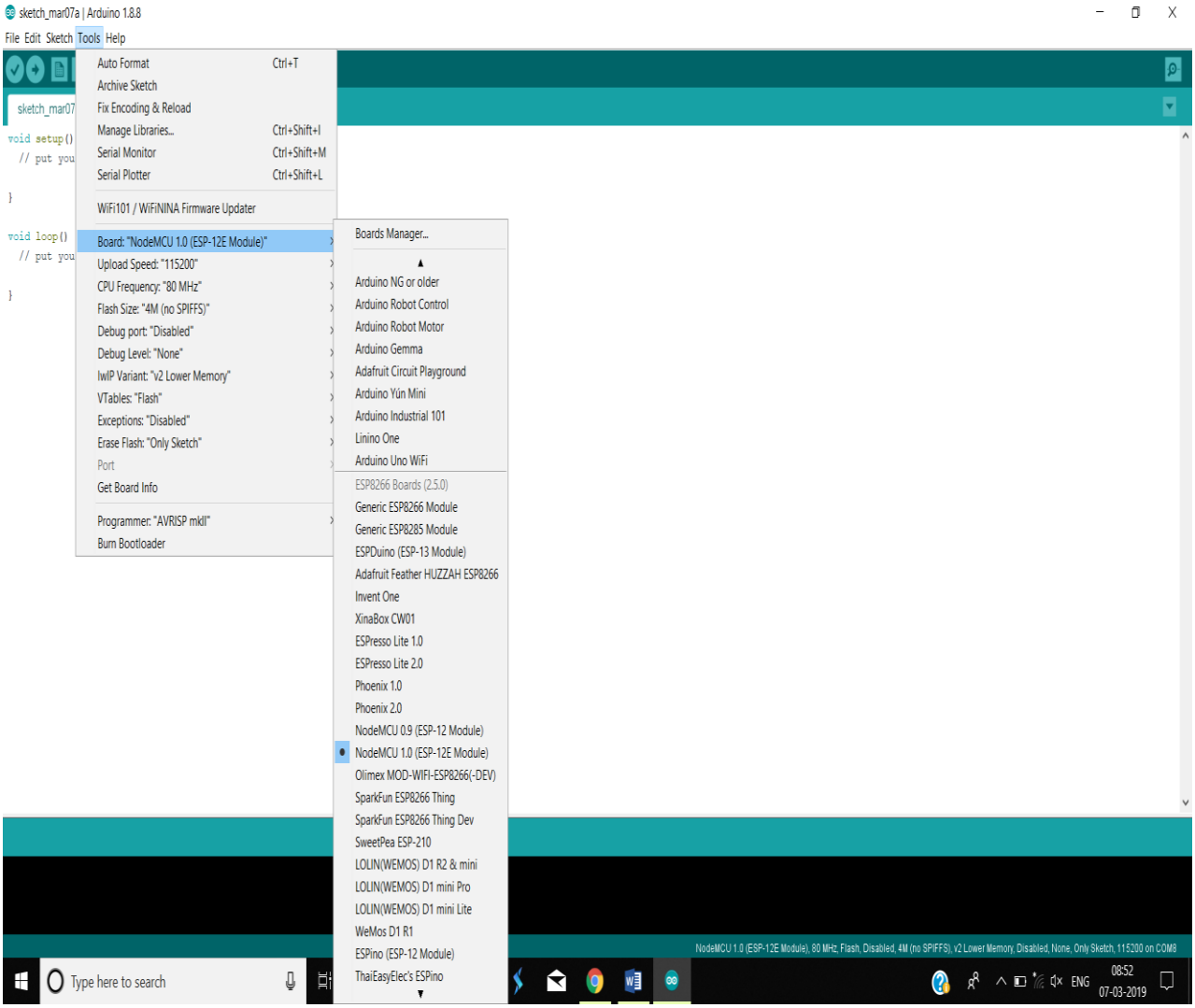


Fig 2.6: Selecting the NodeMCU 1.0 (ESP-12E Module)

Select 80 MHz as the CPU frequency (you can try 160 MHz overclock later).

Select '115200' baud upload speed is a good place to start - later on you can try higher speeds but 115200 is a good safe place to start.

d) Blink Test

We'll begin with the simple blink test. Enter this into the sketch window (and save since you'll have to). Connect a LED as shown in Figure.

```
 void setup() {
pinMode(5, OUTPUT); // GPIO05, Digital Pin D1
                    }
 void loop() {
digitalWrite(5, HIGH);
```

```
delay(900);
digitalWrite(5, LOW);
delay(500);
}
```

Now you'll need to put the board into bootload mode. You'll have to do this before each upload. There is no timeout for bootload mode.

• Hold down the ‘Flash’ button.

• While holding down ‘Flash’, press the ‘RST’ button.

• Release ‘RST’, then release ‘Flash’ 8

• When you release the ‘RST’ button, the blue indication will blink once, this means its ready to bootload.

Connecting via WiFi OK once you've got the LED blinking, let’s go straight to the fun part, connecting to a webserver. Create a new sketch with this code:

update:

```
const char* ssid = "yourssid";
const char* password = "yourpassword";
```

to your WiFi access point and password, then upload the same way: get into bootload mode, then upload code via IDE.

```
#include<ESP8266WIFI.h>
```

2.2.2 IR OBSTACLE SENSOR

This sensor is a short-range obstacle detector with no dead zone. It has a reasonably narrow detection area which can be increased using the dual version. Range can also be increased by increasing the power to the IR LEDs or adding more IR LEDs. It also consists of photodiode and two photo transistors connected in parallel.

Photodiode is a light sensitive semiconductor diode which converts the light energy into Voltage or current based on the mode of operation. In General Photodiodes are operated in reverse bias Condition.

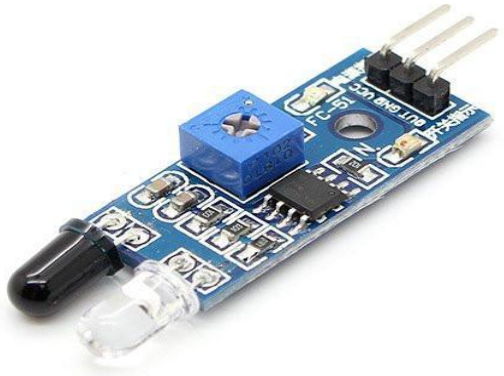


Fig 2.7: IR sensor

The clear Photodiode can detect visible and IR rays, to limit the Photodiode to detect only IR rays a black coating is applied to the glass of the Photodiode. The photodiode allows the current to pass through it if the photodiode is exposed to IR rays and it doesn't allow current to pass through it if no IR rays falls on it. The amount of current passed through on

2.2.3 RELAY

a) Description:

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contractor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts. The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in

place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Some automotive relays include a diode inside the relay case. Alternatively, a contact protection network consisting of a capacitor and resistor in series may absorb the surge. If the coil is designed to be energized with alternating current , a small copper "shading ring" can be crimped to the end of the solenoid, creating a small out-of-phase current which increases the minimum pull on the armature during the AC cycle. A solid-state relay uses a thyristor or other solid-state switching device, activated by the control signal, to switch the controlled load, instead of a solenoid. An optocoupler can be used to isolate control and controlled circuits.

A relay is an electrical switch that uses an electromagnet to move the switch from the off to on position instead of a person moving the switch. It takes a relatively small amount of power to turn on a relay, but the relay can control something that draws much more power. This is the schematic representation of a relay. The contacts at the top are normally open. When current is passed through the coil it creates a

magnetic field that pulls the switch closed. Usually a spring will pull the switch open again once the power is removed from the coil. Mechanical movement of the operating mechanism is imparted to a contact structure to close or to open contacts. When we say that a relay "operates," we mean that it either closes or opens its contacts-whichever is the required action under the circumstances. Most relays have a "control spring," or are restrained by gravity, so that they assume a given position when completely de-energized; a contact that is closed under this condition is called a "closed" contact, and one that is open is called an "open" contact. This is standardized nomenclature, but it can be quite confusing and awkward to use.

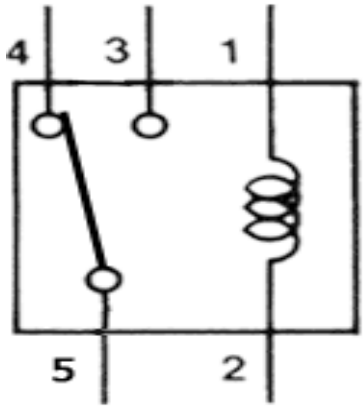


Fig 2.8: Internal Operation of Relay

b) Different types of Relays:

i) Electromagnetic relays
ii) Solid State relays
iii) Hybrid relays
iv) Thermal relays
v) Reed relays

Pole and Throw:

Relays have the exact working of a switch. So, the same concept is also applied. A relay is said to switch one or more poles. Each pole has contacts that can be thrown in mainly three ways.

- **Normally Open Contact**

NO contact is also called a make contact. It closes the circuit when the relay is activated. It disconnects the circuit when the relay is inactive.

- **Normally Closed Contact**

NC contact is also known as break contact. This is opposite to the NO contact. When the relay is activated, the circuit disconnects. When the relay is deactivated, the circuit connects.

Change-over / Double-throw Contacts:

These types of contacts are used to control two types of circuits. They are used to control a NO contact and also a NC contact with a common terminal. According to their type they are called by the names break before making and make before break contacts. Relays are also named with designations like

Single Pole Single Throw:

This type of relay has a total of four terminals. Out of these two terminals can be connected or disconnected. The other two terminals are needed for the coil.

Single Pole Double Throw:

This type of a relay has a total of five terminals. Out of these two are the coil terminals. A common terminal is also included which connects to either of two others.

Double Pole Single Throw:

This relay has a total of six terminals. These terminals are further divided into two pairs. Thus, they can act as two SPST's which are actuated by a single coil. Out of the six terminals two of them are coil terminals.

Double Pole Double Throw:

This is the biggest of all. It has mainly eight relay terminals. Out of these two rows are designed to be change over terminals. They are designed to act as two SPDT relays which are actuated by a single coil.

c) ULN2003 IC

The ULN2001, ULN2002, ULN2003 and ULN 2004 are high-voltage, high-current Darlington arrays each containing seven open collector Darlington pairs with common emitters. Each channel is rated at 500 mA and can withstand peak currents of 600 mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

The versions interface to all common logic families: ULN2001 (general purpose, DTL, TTL, PMOS, CMOS); ULN2002 (14 - 25 V PMOS); ULN2003 (5 V TTL, CMOS); ULN2004 (6 - 15 V CMOS, PMOS).

These versatile devices are useful for driving a wide range of loads including solenoids, relay DC motors, LED display filament lamps, thermal print heads and high-power buffers.

The ULN2001A/2002A/2003A and 2004A are supplied in a 16-pin DIP package with a copper lead frame to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D1/2002D1/2003D1/ 2004D1.

i) Key Features

- Seven Darlingtons per package
- Output current 500 mA per driver (600 mA peak)
- Output voltage 50 V
- Integrated suppression diodes for inductive loads
- Outputs can be paralleled for higher current
- TTL/CMOS/PMOS/DTL compatible inputs
- Input pins placed opposite to output pins to simplify layout.

ii) Circuit Diagram of ULN2003:

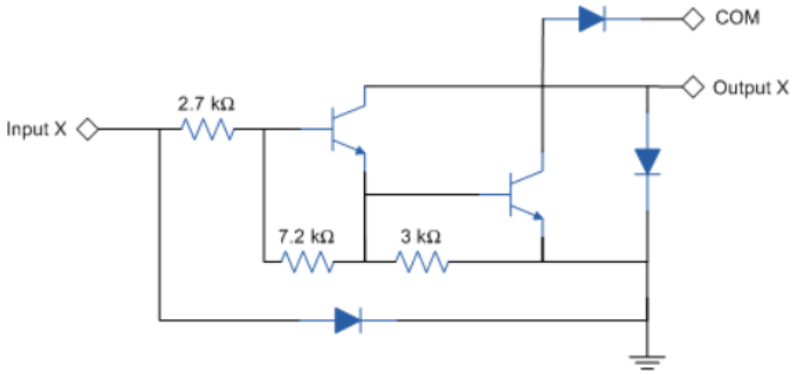


Fig 2.9: Circuit diagram of ULN2003

iii) Pin Diagram of ULN2003:

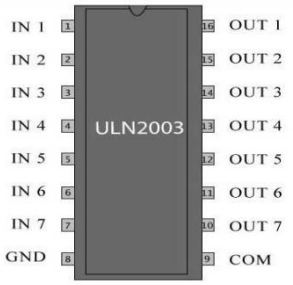


Fig 2.10: Pin description of ULN2003

ULN2003 is a high voltage and high current Darlington array IC. It contains seven open collector darlington pairs with common emitters. A darlington pair is an arrangement of two bipolar transistors.

ULN2003 belongs to the family of ULN200X series of ICs. Different versions of this family interface to different logic families. ULN2003 is for 5V TTL, CMOS logic devices. These ICs are used when driving a wide range of loads and are used as relay drivers, display drivers, line drivers etc. ULN2003 is also commonly used while driving stepper motor.

iv) Pin Description:

Pin No	Function	Name
1	Input for 1st channel	Input 1
2	Input for 2nd channel	Input 2
3	Input for 3rd channel	Input 3
4	Input for 4th channel	Input 4
5	Input for 5th channel	Input 5
6	Input for 6th channel	Input 6
7	Input for 7th channel	Input 7
8	Ground (0V)	Ground
9	Common free wheeling diodes	Common
10	Output for 7th channel	Output 7
11	Output for 6th channel	Output 6
12	Output for 5th channel	Output 5
13	Output for 4th channel	Output 4
14	Output for 3rd channel	Output 3
15	Output for 2nd channel	Output 2
16	Output for 1st channel	Output 1

Table 2.1: Pin description of Relay

Each channel or darlington pair in ULN2003 is rated at 500mA and can withstand peak current of 600mA. The inputs and outputs are provided opposite to each other in the pin layout. Each driver also contains a suppression diode to dissipate voltage spikes while driving inductive loads.

d) Relay Operation:

Relays are simple switches which are operated both electrically and mechanically. We know that most of the high end industrial application devices have relays for their effective working. Relays consist of an electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its working. But they differ according to their applications.

The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The application of relays started during the invention of telephones. They played an important role in switching calls in telephone exchanges. They were also used in long distance telegraphy. They were used to switch the signal coming from one source to another destination. After the invention of computers they were also used to perform Boolean and other logical operations. The high end applications of relays require high power to be driven by electric motors and so on. Such relays are called contactors.

There are only four main parts in a relay. They are

- Electromagnet
- Movable Armature
- Switch point contacts
- Spring

It is an electro-magnetic relay with a wire coil, surrounded by an iron core. A path of very low reluctance for the magnetic flux is provided for the movable armature and also the switch point contacts. The movable armature is connected to the yoke which is mechanically connected to the switch point contacts. These parts are safely held with the help of a spring. The spring is used so as to produce an air gap in the circuit when the relay becomes de-energized.

The diagram shows an inner section diagram of a relay. An iron core is surrounded by a control coil. As shown, the power source is given to the electromagnet through a control switch and through contacts to the load. When current starts flowing through the control coil, the electromagnet starts energizing and thus intensifies the magnetic field. Thus, the upper contact arm starts to be attracted to the lower fixed arm and thus closes the contacts causing a short circuit for the power to the load. On the other hand, if the relay was already de-energized when the contacts were closed, then the contact move oppositely and make an open circuit.

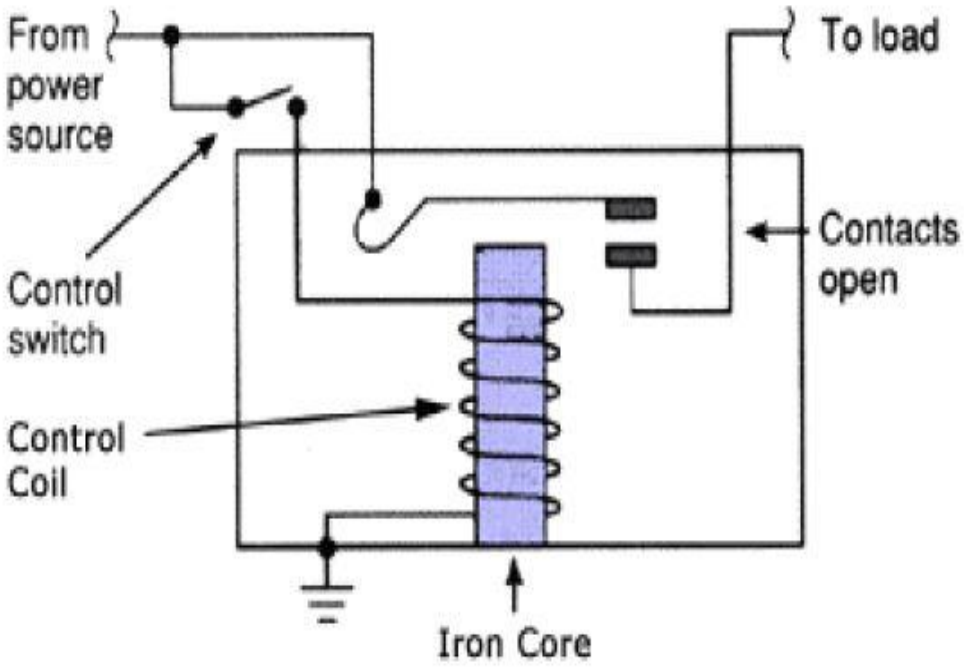


Fig 2.11: Internal Circuitry of a Relay

As soon as the coil current is off, the movable armature will be returned by a force back to its initial position. This force will be almost equal to half the strength of the magnetic force. This force is mainly provided by two factors. They are the spring and also gravity. Relays are mainly made for two basic operations. One is low voltage application and the other is high voltage. For low voltage applications, more preference will be given to reduce the noise of the whole circuit. For high voltage applications, they are mainly designed to reduce a phenomenon called arcing. Relays are switching that open and close circuits electromechanically or electronically.

Relays control one electrical circuit by opening and closing contacts in another circuit. As relay diagrams show, when a relay contact is normally open (NO), there is an open contact when the relay is not energized. When a relay contact is Normally Closed (NC), there is a closed contact when the relay is not energized. In either case, applying electrical current to the contacts will change their state. Relays are generally used to switch smaller currents in a control circuit and do not usually control power consuming devices except for small motors and Solenoids that draw low amps. Nonetheless, relays can "control" larger voltages and amperes by having an

amplifying effect because a small voltage applied to a relays coil can result in a large voltage being switched by the contacts.

Protective relays can prevent equipment damage by detecting electrical abnormalities, including over current, undercurrent, overloads and reverse currents. In addition, relays are also widely used to switch starting coils, heating elements, pilot lights and audible alarms. A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal with complete electrical isolation between control and controlled circuits, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming in from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

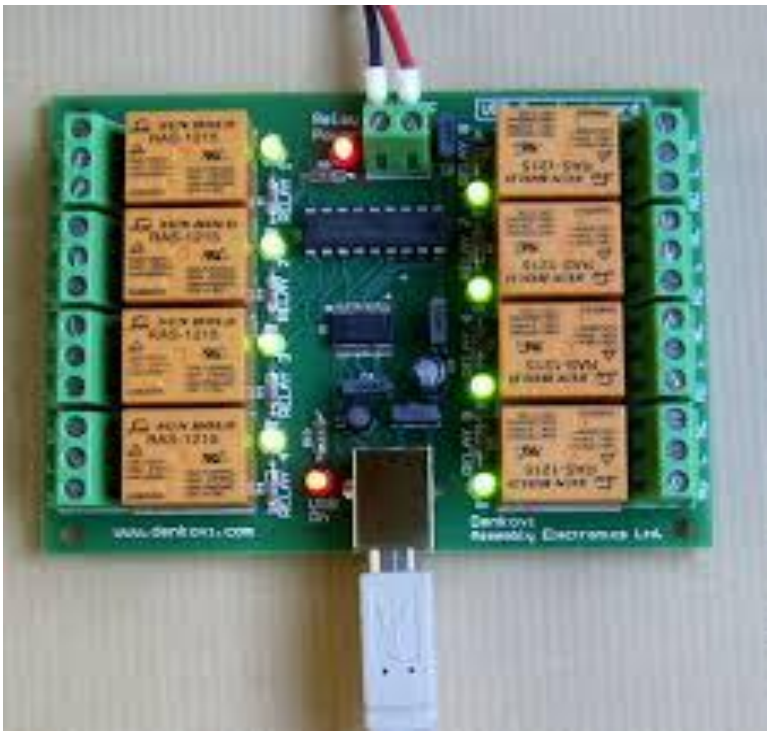


Fig 2.12: An Eight Relay Module

Applications:

1. Relays are used to realize logic functions. They play a very important role in providing safety critical logic.
2. Relays are used to provide time delay functions. They are used to time the delay open and delay close of contacts.
3. Relays are used to control high voltage circuits with the help of low voltage signals. Similarly, they are used to control high current circuits with the help of low current signals.
4. Relays are also used as protective relays. By this function all the faults during transmission and reception can be detected and isolated.

2.2.4 Voltage Regulator

A Voltage regulator is a device which converts varying input voltage into a constant regulated output voltage. Voltage regulator, any electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using that voltage. Such a device is widely used in motor vehicles of all types to match the output voltage of the generator to the electrical load and to the charging requirements of the battery. Voltage regulators also are used in electronic equipment in which excessive variations in voltage would be detrimental.

Electronic voltage regulators utilize solid-state semiconductor devices to smooth out variations in the flow of current. In most cases, they operate as variable resistances; that is, resistance decreases when the electrical load is heavy and increases when the load is lighter.

Voltage regulator can be of two types

i. Linear Voltage Regulator:

Also called as Resistive Voltage regulator because they dissipate the excessive voltage resistively as heat.

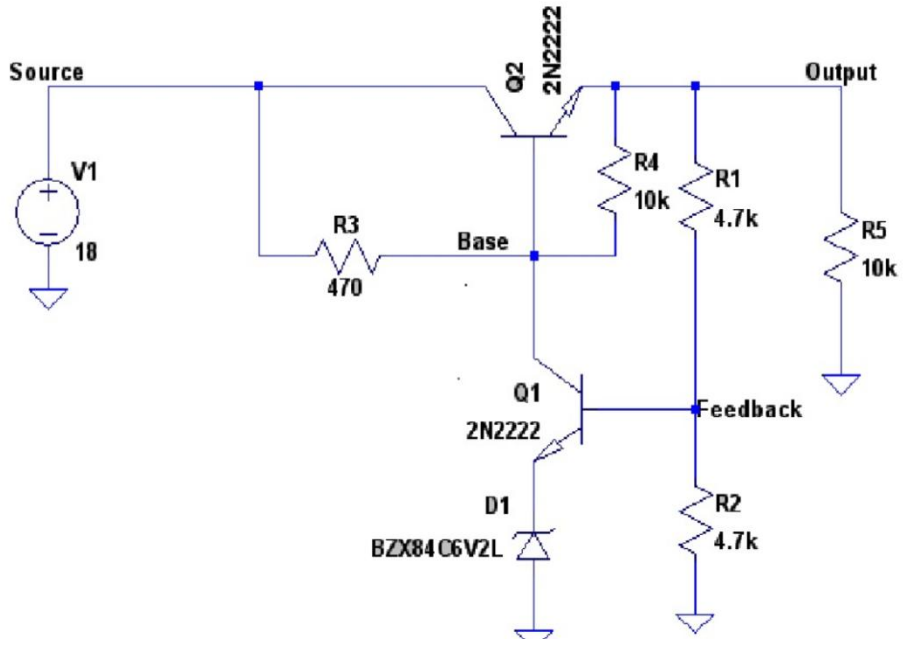


Fig 2.13: Circuit diagram of Linear Voltage regulator

ii. Switching Regulators:

They regulate the output voltage by switching the Current ON/OFF very rapidly. Since their output is either ON or OFF it dissipates very low power thus achieving higher efficiency as compared to linear voltage regulators. But they are more complex & generate high noise due to their switching action.

8The most commonly available Linear Positive Voltage Regulators are the 78XX series where the XX indicates the output voltage. And 79XX series is for Negative Voltage Regulators.

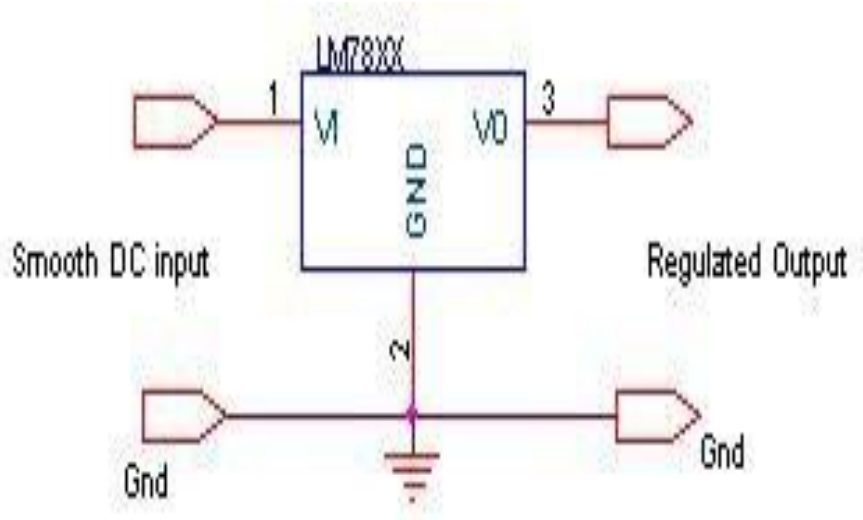


Fig 2.14: Switching Regulator

After filtering the rectifier output the signal is given to a voltage regulator. The maximum input voltage that can be applied at the input is 35V.Normally there is a 2-3 Volts drop across the regulator so the input voltage should be at least 2-3 Volts higher than the output voltage. If the input voltage gets below the Vmin of the regulator due to the ripple voltage or due to any other reason the voltage regulator will not be able to produce the correct regulated voltage.

2.2.5 SOLAR POWER SUPPLY

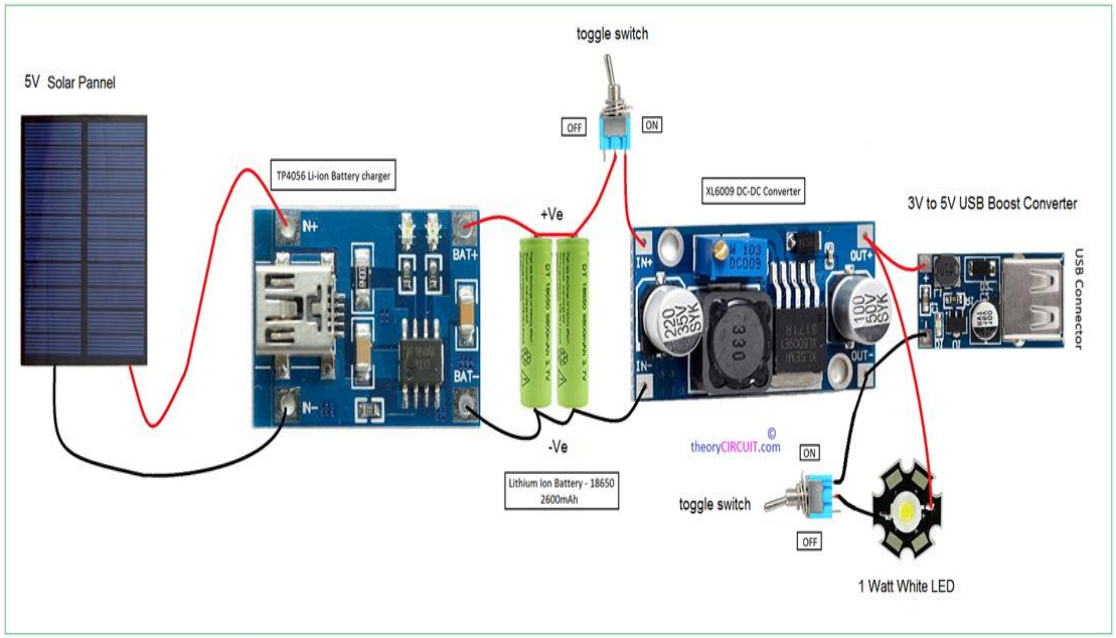


Fig 2.15: Solar power supply connection

The most efficient and expensive solar panels are made with Mono crystalline cells. These solar cells use very pure silicon and involve a complicated crystal growth process. Long silicon rods are produced which are cut into slices of .2 to .4 mm thick discs or wafers which are then processed into individual cells that are wired together in the solar panel.

Photons in sunlight hit the solar panel and are absorbed by semi-conducting materials. Electrons (negatively charged) are knocked loose from their atoms as they are excited. Due to their special structure and the materials in solar cells, the electrons are only allowed to move in a single direction. The electronic structure of the materials is very important for the process to work, and often silicon incorporating small amounts of boron or phosphorus is used in different layers.

An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

2.2.6 DC MOTORS

i) Introduction:

A DC motor relies on the fact that like magnet poles repel and unlike magnetic poles attract each other. A coil of wire with a current running through it generates a electromagnetic field aligned with the center of the coil. By switching the current on or off in a coil its magnet field can be switched on or off or by switching the direction of the current in the coil the direction of the generated magnetic field can be switched 180°. A simple *DC* motor typically has a stationary set of magnets in the stator and an armature with a series of two or more winding of wire wrapped in insulated stack slots around iron pole pieces (called stack teeth) with the ends of the wires terminating on a commutator. The armature includes the mounting bearings that keep it in the center of the motor and the power shaft of the motor and the commutator connections. The winding in the armature continues to loop all the way around the armature and uses either single or parallel conductors (wires), and can circle several times around the stack teeth. The total amount of current sent to the coil, the coil's

size and what it's wrapped around dictate the strength of the electromagnetic field created. The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a force on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor. At high power levels, DC motors are almost always cooled using forced air.

The commutator allows each armature coil to be activated in turn. The current in the coil is typically supplied via two brushes that make moving contact with the commutator. Now, some brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes to wear out or create sparks.

Different number of stator and armature fields as well as how they are connected provide different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems which adjust the voltage by "chopping" the DC current into on and off cycles which have an effective lower voltage.

Since the series-wound DC motor develops its highest torque at low speed, it is often used in traction applications such as electric locomotives, and trams. The DC motor was the mainstay of electric traction drives on both electric and diesel-electric locomotives, street-cars/trams and diesel electric drilling rigs for many years. The introduction of DC motors and an electrical gridsystem to run machinery starting in the 1870s started a new second Industrial Revolution. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles and today's hybrid cars and electric cars as well as driving a host of cordlesstools. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines.

If external power is applied to a DC motor it acts as a DC generator, a dynamo. This feature is used to slow down and recharge batteries on hybrid

carand electric cars or to return electricity back to the electric grid used on a street car or electric powered train line when they slow down. This process is called regenerative braking on hybrid and electric cars. In diesel electric locomotives they also use their DC motors as generators to slow down but dissipate the energy in resistor stacks. Newer designs are adding large battery packs to recapture some of this energy.

ii) Brushed motor:

A brushed DC electric motor generating torque from DC power supply by using an internal mechanical commutation. Stationary permanent magnets from the static field. Torque is produced by the principle that any current-carrying conductor placed within an external magnetic field experiences a force, known as Lorentz force. In a motor the magnitude of this Lorentz force (a vector represented by the green arrow) and thus the output torque is a function of rotor angle, leading to a phenomenon known as torque ripple. Since this is a single phase two pole motor, the commutator consists of split ring, so that the current reverses each half turn (180 degrees).

The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the carbon brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor. Brushes consist of conductors.

iii) Brushless motor:

Typical brushless DC motors use a rotating permanent magnet in the rotor, and stationary electrical current/coil magnets on the motor housing for the stator, but the symmetrical opposite is also possible. A motor controller converts DC to AC. This design is simpler than that of brushed motors because it eliminates the complication

of transferring power from outside the motor to the spinning rotor. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

iv) Uncommutated

a) Homo polar motor – A homo polar motor has a magnetic field along the axis of rotation and an electric current that at some point is not parallel to the magnetic field. The name homo polar refers to the absence of polarity change. Homo-polar motors necessarily have a single-turn coil, which limits them to very low voltages. This has restricted the practical application of this type of motor.

b) Ball bearing motor – A ball bearing motor is an unusual electric motor that consists of two ball bearing-type bearings, with the inner races mounted on a common conductive shaft, and the outer races connected to a high current, low voltage power supply. An alternative construction fits the outer races inside a metal tube, while the inner races are mounted on a shaft with a non-conductive section (e.g. two sleeves on an insulating rod). This method has the advantage that the tube will act as a flywheel. The direction of rotation is determined by the initial spin which is usually required to get it going.

Wound Stators

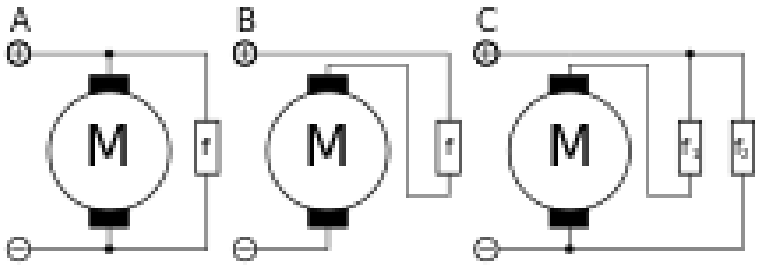


Fig 2.15: Wound stators

A field coil may be in shunt, in series, or in compound with the armature of the DC machine (motor or generator).

There are three types of electrical connections between the stator and rotor possible for DC electric motors: series, shunt/parallel and compound (various blends of series and shunt/parallel) and each has unique speed/torque characteristics appropriate for different loading torque profiles/signatures.

Series connection:

A series DC motor connects the armature and field windings in series with a common D.C. power source. The motor speed varies as a non-linear function of load torque and armature current; current is common to both the stator and rotor yielding current squared (I^2) behaviour. A series motor has very high starting torque and is commonly used for starting high inertia loads, such as trains, elevators or hoists. This speed/torque characteristic is useful in applications such as dragline excavators, where the digging tool moves rapidly when unloaded but slowly when carrying a heavy load.

With no mechanical load on the series motor, the current is low, the counter-EMF produced by the field winding is weak, and so the armature must turn faster to produce sufficient counter-EMF to balance the supply voltage. The motor can be damaged by over speed. This is called a runaway condition.

Series motors called "universal motors" can be used on alternating current. Since the armature voltage and the field direction reverse at (substantially) the same time, torque continues to be produced in the same direction. Since the speed is not related to the line frequency, universal motors can develop higher-than-synchronous speeds, making them lighter than induction motors of the same rated mechanical output. This is a valuable characteristic for hand-held power tools. Universal motors for commercial power frequency are usually small, not more than about 1 kW output. However, much larger universal motors were used for electric locomotives, fed by special low-frequency traction power networks to avoid problems with commutation under heavy and varying loads.

Shunt connection:

A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. This type of motor has good speed

regulation even as the load varies but does not have the starting torque of a series DC motor. It is typically used for industrial, adjustable speed applications, such as machine tools, winding/unwinding machines and tensioners.

Compound connection:

A compound DC motor connects the armature and fields windings in a shunt and a series combination to give it characteristics of both a shunt and a series DC motor. This motor is used when both a high starting torque and good speed regulation is needed. The motor can be connected in two arrangements: cumulatively or differentially. Cumulative compound motors connect the series field to aid the shunt field, which provides higher starting torque but less speed regulation. Differential compound DC motors have good speed regulation and are typically operated at constant speed.

Permanent magnet stators

A PM motor does not have a field winding on the stator frame, instead relying on PMs to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. PM fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Most larger DC motors are of the "dynamo" type, which have stator windings. Historically, PMs could not be made to retain high flux if they were disassembled; field windings were more practical to obtain the needed amount of flux. However, large PMs are costly, as well as dangerous and difficult to assemble; this favors wound fields for large machines.

To minimize overall weight and size, miniature PM motors may use high energy magnets made with neodymium or other strategic elements; most such are neodymium-iron-boron alloy. With their higher flux density, electric machines with high-energy PMs are at least competitive with all optimally designed singly fed synchronous and induction electric machines. Miniature motors resemble the structure in the illustration, except that they have at least three rotor poles (to ensure

starting, regardless of rotor position) and their outer housing is a steel tube that magnetically links the exteriors of the curved field magnets.

2.2.7 JOHNSON MOTOR

The Johnsons DC Gear motor offers custom engineering solutions based on a wide range of low voltage DC and high voltage DC motor platforms. The low voltage DC platform provides power density and compact packaging options.

The Johnson Geared motor is famous for its compact size and massive torque. A torque as much as x3 as compared to centre shaft or side shaft geared motor, with an affordable price tag. The motor comes with a metal gearbox and off cantered shaft, also shaft has a metal bushing for wear resistance. Apart from robotic application they are also used in industrial applications, vending system, hygiene and cleaning industry, and household electric appliance.

Specifications:

- RPM - 30 Shaft
- Diameter - 6mm (with internal hole)
- Shaft Length - 15 mm
- Dimensions: Gearbox diameter - 37mm, Motor Diameter - 28.5 mm
- Length (body only) - 63mm, Weight - 300 gms
- Torque - 25 kgcm
- Voltage - 6 to 24 (Nominal Voltage - 12v)
- No-load current = 800 mA (Max)
- Load current = 9 A(Max)

Features:

Rotations per minute: 30 rpm with gear box.
Output torque range: 5kg-cm to 7kg-cm.
No-load current = 800 ma(max).
Load current = up to 9.5 a(max).

2.2.8 IP CAMERA

Set up an effective video monitoring system within minutes! IP Camera Viewer allows you to view live video from your USB or IP cameras on your PC. Use any USB or IP camera is to keep an eye on your home, office, parking area or anywhere you need security.

View video from multiple IP cameras directly to your computer. Currently more than 2000 different IP camera models from leading camera manufactures are supported. It includes Axis, Canon, D-Link, Foscam, Panasonic, Mobotix, Pixord, Sony, Toshiba, Vivotek and many more. You can send a request to our technical team if your camera or model is not listed in our application. Virtually all USB cameras work with IP Camera Viewer.

Fig 2.17: IP camera

You can control and view up to 4 camera feeds simultaneously. Get a live preview from multiple cameras with this light-weight application. IP Camera Viewer's centralized camera and layout management allows you to view your cameras from multiple remote locations on a single screen. You can change the arrangement and preview layout of the cameras, for your security needs.

Make the live video clearer by adjusting camera image and video properties. It allows you to individually configure video properties such as resolution and frame

rate for USB cameras. You can set image properties such as saturation, brightness, contrast for USB and IP Cameras.

If your camera is mounted upside-down or its preview is tilted a bit? With IP Camera Viewer you can adjust the orientation of your camera preview. It helps you to adjust the coverage area by supporting many PTZ (Pan/Tilt/Zoom) enabled network cameras. IP Camera Viewer provides a digital zoom, even if it is not supported by your camera.

2.2.9 DYNAMO

Dynamo is an older term used to describe a generator that makes direct current power. DC power sends electrons in only one direction. The problem with a simple generator is that when the rotor rotates it eventually turns completely around, reversing the current. Early inventors didn't know what to do with this alternating current, alternating current is more complex to control and design motors and lights for. Early inventors had to figure a way to only capture the positive energy of the generator, so they invented a commutator. The commutator is a switch that allows current to only flow in one direction.

The stator is a fixed structure that makes magnetic field, you can do this in a small dynamo using a permanent magnet. Large dynamos require an electromagnet.

Fig 2.18: Dynamo for mechanical to electrical energy conversion

The armature is made of coiled copper windings which rotate inside the magnetic field made by the stator. When the windings move, they cut through the lines of magnetic field. This creates pulses of electric power.

The commutatoris needed to produce direct current. In direct current power flows in only one direction through a wire, the problem is that the rotating armature in a dynamo reverses current each half turn, so the commutator is a rotary switch that disconnects the power during the reversed current part of the cycle.

2.2.10 12V 7Ah BATTERY

i) Specifications:

Nominal Voltage: 12v
Nominal Capacity (AH): 7.0
Discharge Current (mA): 350
Dimensions: 15.1 x 6.5 x 9.4cm (5.95 x 2.56 x 3.7")
Weight: 2.7kg

ii) Capacity:

The capacity of a battery, expressed in ampere-hours (AH), is the total amount of electrical energy available from a fully charged cell. Its value depends on the discharge current, the temperature during discharge, the final cut-off voltage, and the general history of the battery.

When a battery discharges current at a constant rate, its capacity changes according to the amperage load. Capacity increases when the discharge current is less than the 20-hour rate and decreases when the current is higher.

Fig 2.19: 12V-7Ah lead acid battery

iii) Features:

- Sealed/Maintenance-Free

  The sealed construction of the battery allows trouble-free, safe operation in any position.

  There is no need to add electrolyte as gases generated during overcharge are recombined in a unique "Oxygen-Cycle".

- Economical

  The high watt-hour per pound value is made possible by the materials used in a sealed lead-acid battery; they are readily available and low in cost.

- Long Service Life

  Under normal operating conditions five to six years of dependable service life can be expected in standby applications or between 200 and 1000 charge/discharge cycles depending upon depth of discharge.

- Rugged Construction

  The high-impact resistant battery case is made of non- conductive plastic with superior resistance to shock, vibration, chemicals, and heat.

- Compact

  These batteries utilize state of the art design, highest grade materials, and a carefully controlled plate- making process to provide excellent output per cell. This high energy density results in superior power/volume and power/weight ratios.

- High Discharge Rate

  Low internal resistance allows discharge currents of over ten times the rated capacity of the battery. Therefore, a relatively smaller battery may be specified in applications requiring high peak currents.

- Long Shelf Life

  A low self-discharge rate permits storage of fully charged batteries for up to a year at room temperature before charging is required. Lower storage temperatures enhance shelf life characteristics even further.

- Wide Operating Temperature Range

  These batteries may be used over a temperature range of -60°C to +60°C.

- Deep Discharge Recovery

  Special separators, advanced plate composition, and a carefully balanced electrolyte system have greatly improved the capability of recovering from deep discharge.

2.2.11 1N4007 DIODE

i) Pin diagram:

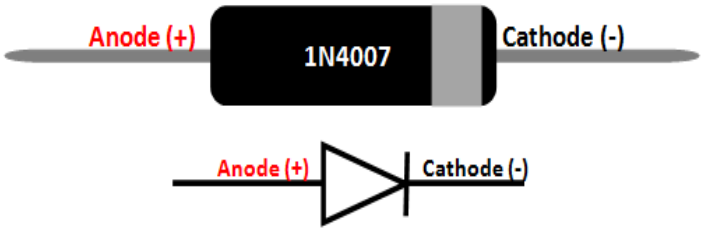


Fig 2.20: Pin diagram of 1N4007

ii) Pin configuration:

Pin No.	Pin Name	Description
1	Anode	Current always Enters through Anode
2	Cathode	Current always Exits through Cathode

Table 2.2: Pin configuration of 1N4007 Diode

iii) Features:

- Average forward current is 1A
- Non-repetitive Peak current is 30A
- Reverse current is 5uA.
- Peak repetitive Reverse voltage is 1000V
- Power dissipation 3W
- Available in DO-41 Package

iv) Description:

A diode is a device which allows current flow through only one direction. That is the current should always flow from the Anode to cathode. The cathode terminal can be identified by using a grey bar as shown in the picture above.

For **1N4007 Diode**, the maximum current carrying capacity is 1A it withstands peaks up to 30A. Hence, we can use this in circuits that are designed for less than 1A. The reverse current is 5uA which is negligible. The power dissipation of this diode is 3W.

v) Applications of Diode:

- Can be used to prevent reverse polarity problem
- Half Wave and Full Wave rectifiers
- Used as a protection device
- Current flow regulators

2.2.12 7805IC VOLTAGE REGULATOR

A regulated power supply is very much essential for several electronic devices due to the semiconductor material employed in them have a fixed rate of current as well as voltage. The device may get damaged if there is any deviation from the fixed rate.

One of the important sources of DC Supply are Batteries. But using batteries in sensitive electronic circuits is not a good idea as batteries eventually drain out and lose their potential over time.

Also, the voltage provided by batteries are typically 1.2V, 3.7V, 9V and 12V. This is good for circuits whose voltage requirements are in that range. But, most of the TTL IC's work on 5V logic and hence we need a mechanism to provide a consistent 5V Supply. It is an IC in the 78XX family of linear voltage regulators that produce a regulated 5V as output.

7805 is a three terminal linear voltage regulator IC with a fixed output voltage of 5V which is useful in a wide range of applications. Currently, the 7805 Voltage Regulator IC is manufactured by Texas Instruments, ON Semiconductor, STMicroelectronics, Diodes incorporated, Infineon Technologies, etc.

They are available in several IC Packages like TO-220, SOT-223, TO-263 and TO-3. Out of these, the TO-220 Package is the most commonly used one.

Some of the important features of the 7805 IC are as follows:

- It can deliver up to 1.5 A of current (with heat sink).
- Has both internal current limiting and thermal shutdown features.
- Requires very minimum external components to fully function.

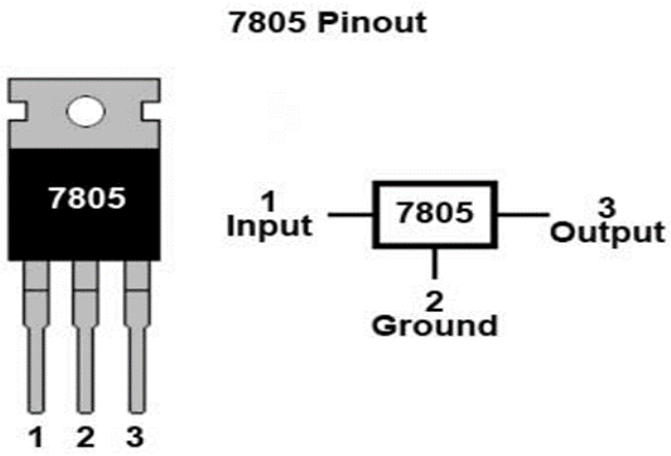


Fig 2.21: Pin diagram of 7805 IC

Pin Diagram of 7805 Voltage Regulator IC

As mentioned earlier, 7805 is a three-terminal device with the three pins being 1. INPUT, 2. GROUND and 3. OUTPUT. The following image shows the pins on a typical 7805 IC in To-220 Package.

Pin No.	Pin	Function	Description
1	INPUT	Input voltage (7V-35V)	In this pin of the IC positive unregulated voltage is given in regulation.
2	GROUND	Ground (0V)	In this pin where the ground is given. This pin is neutral for equally the input and output.
3	OUTPUT	Regulated output; 5V (4.8V-5.2V)	The output of the regulated 5V volt is taken out at this pin of the IC regulator.

Table 2.3: Pin description of 7805IC

Considerations:

- The input voltage should always be greater than the output voltage (at least by 2.5V).
- The input current and output current are almost identical. This means that when a 7.5V 1A supply is given at input, the output will be 5V 1A.
- The remaining power is dissipated as heat and hence a heat sink like the one shown below must be used with 7805 IC.

CHAPTER-3

SOFTWARE INTERFACING USING BLYNK

Blynk is a Platform with IOS and Android apps to control Arduino, ESP8266, Raspberry Pi and the likes over the Internet. It's a digital dashboard where you can build a graphic interface for your project by simply dragging and dropping widgets

You'll also need to install the **Blynk Arduino Library**, which helps generate the firmware running on your ESP8266.

3.1 CREATE A BLYNK PROJECT:

Click the "Create New Project" in the app to create a new Blynk app. Give it any name.

Blynk works with hundreds of hardware models and connection types. Select the Hardware type. After this, select connection type. In this project we have select Wi-Fi connectivity.

The **Auth Token** is very important – you'll need to stick it into your ESP8266's firmware. Copy it down or use the "E-mail" button to send it to yourself.

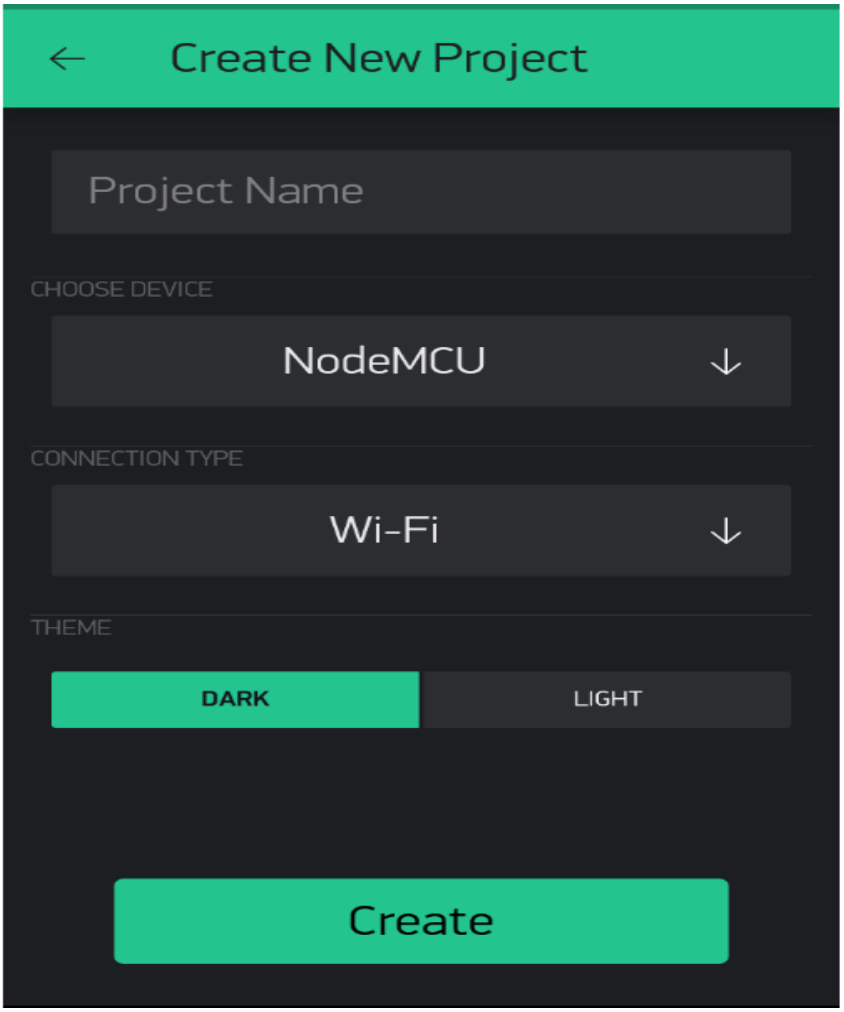


Fig 3.1: Creation of a new Blynk project

3.2 ADD WIDGETS TO THE PROJECT

Then you'll be presented with a blank new project. To open the widget box, click in he projects window to open.

We are selecting a button to control Led connected with NodeMCU.

1. Click on Button.
2. Give name to Button say led.
3. Under OUTPUT tab- Click pin and select the pin to which led is connected to NodeMCU, here it is digital pin 2, hence select digital and under pin D2. And Click continue.

Under MODE tab- Select whether you want this button as "push button" or "Switch".

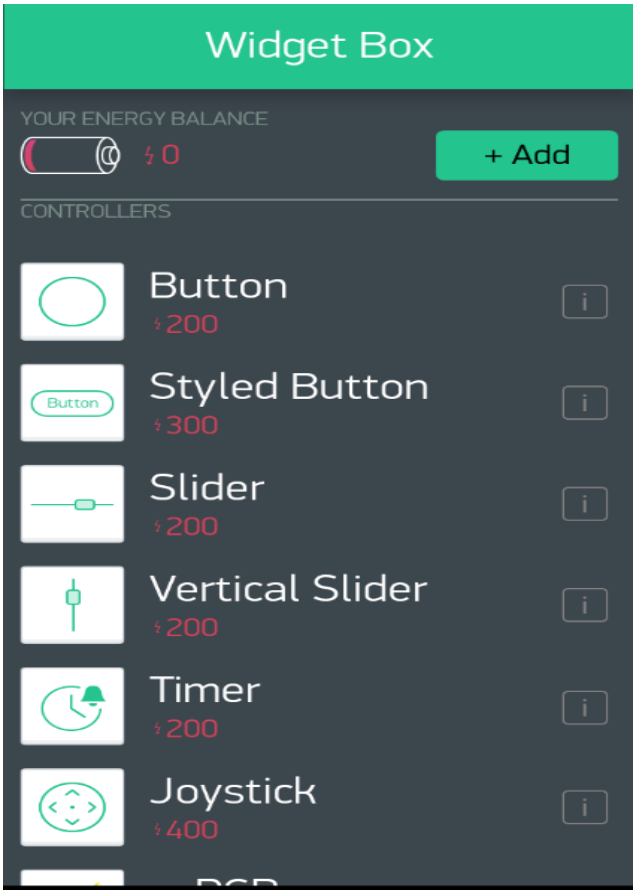


Fig 3.2: Adding widgets to the project

3.3 UPLOAD THE FIRMWARE

Now that your Blynk project is set-up, open Arduino and navigate to the ESP8266_Standalone example in the File > Examples > Blynk > Boards_WiFi> ESP8266_Standalone menu.

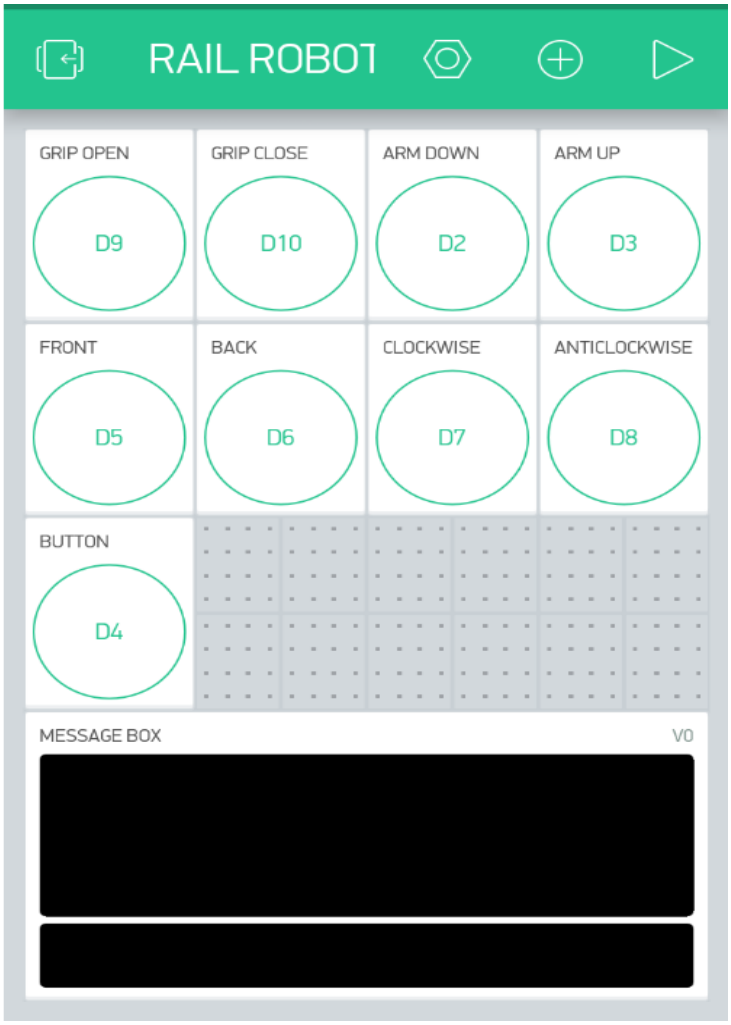


Fig 3.3: Uploading the firmware

3.4 STAND ALONE PROGRAMMING CODE

Before uploading, make sure to paste your authorization token into the auth [] variable. Also make sure to load your Wifi network settings into the Blynk.begin(auth, "ssid", "pass") function.

3.5 EXECUTION

After the app has uploaded, open the serial monitor, setting the baud rate to 9600. Wait for the “Ready” message.

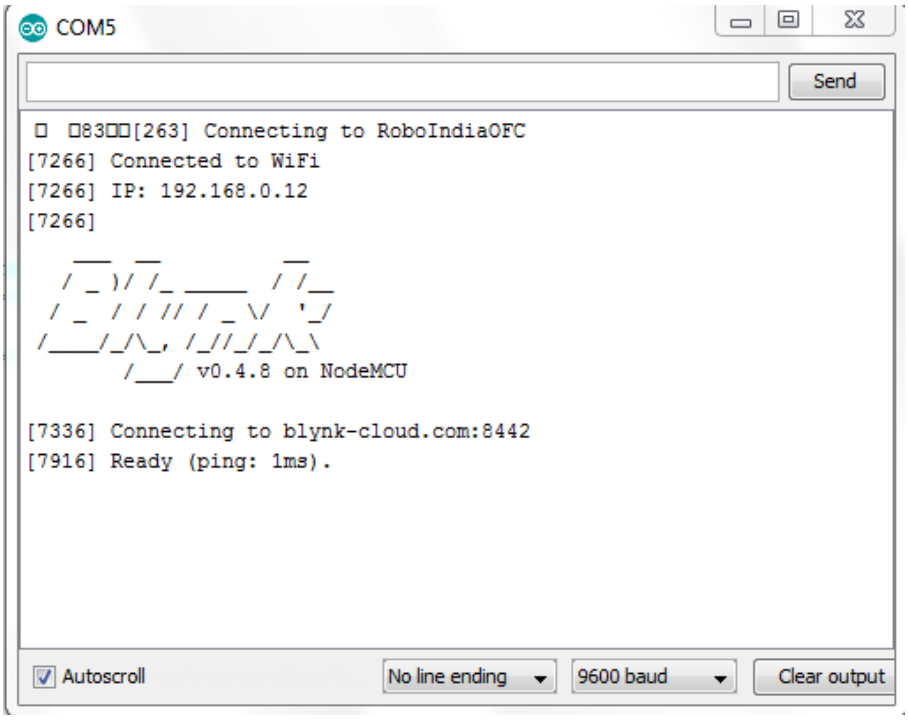


Fig 3.4: Verification of the connection of Blynk to the WiFi

Then click the “Run” button in the top right corner of the Blynk app. Press the button and watch the LED. Then add more widgets to the project. They should immediately work on the ESP8266 without uploading any new firmware.

CHAPTER-4

WORKING

4.1 SUCTION MECHANISM

A suction cleaner is one of the most essential components which we have for cleaning/sanitizing the area in between the track. It works on the principle of flow of air from area of high pressure to area of low pressure. An electric motor is attached to a fan that spins it at high velocities. The fast spinning fan creates a region of low pressure inside the suction hose of the vacuum cleaner. Air, along with dust and debris is sucked into the suction hose because of the pressure differencebetween outside and inside of the suction hose.

For instance, when animals breathe, the diaphragm and muscles around the rib cage cause a change of volume in the lungs. The increased volume of the chest cavity decreases the pressure inside, creating an imbalance with the ambient air pressure, resulting in suction.

Fig 4.1: Suction cleaner

WHY WE USED SUCTION INSTEAD OF SWEEPING?

i) CONVENIENCE

A suction technique is very light, easy to store and the dirt it collects is easy to empty into the trash and it's easy to use for quick clean-up because there is no setup involved. A suction mechanism will be light and compact, and the suction power is a convenience because it pulls out dirt automatically. Electric suction motors usually use bags that have to be replaced and have to be set up within the range of an electric outlet, and heavier units are not convenient for small jobs.

ii) VERSATILITY

Suction motors clean surface dirt from floors and short carpeting. They aren't as useful for thicker/rough surface areas. A suction motor can clean all kinds of hard surfaces. With attachments, however, an electric vacuum cleaner can clean upholstery, drapery and auto interiors, all things a manual sweeper can't do. An electric suction motor can effectively clean almost any sized area, while a manual sweeper is best used in smaller spaces.

Energy consumption of this suction motor is 60W.
Tank capacity of the suction cleaner used is 450ml.

HUMANIZED DESIGN: According to the ergonomic design of the perfect arc of the handle, feel comfortable grip is not tired.
MULTI-FUNCTION: It can effectively clean suction, the dust, crumbs and other small things on the tracks and its extended mouth can clean all corners of the track.
EASY TO OPERATE: Simple-design makes it easy to assemble and install. After use pull the filter out, discard the contents, clean the filter with a brush to maintain a new and last a longer life.

4.2 WATERING MECHANISM:

In principal, many different types of pumps can be used to pump water. The most common kind, however, is the centrifugal pump.Centrifugal pump is the most common type of pump used in industry, agriculture, municipal (water and wastewater plants), power generation plants, petroleum and many other industries. A centrifugal pump is powered by a device called an impeller. The impeller is a bit like a turbine. It has many curved blades, which channel the water through the pump. Centrifugal pumps are unique because they can provide high or very high flow rates (much higher than most positive displacement pumps). As most of the debris found in between the railway track is of dry type watering should be properly done in-order to remove the debris.

Fig 4.2: Centrifugal pump

PURPOSE OF USING CENTRIFUGAL WHEN COMPARED TO OTHER PUMPS

i) VISCOSITY

Centrifugal pumps are designed for liquids with relatively low viscosity that pour like water or like a very light oil. They can be used with slightly more viscous liquids, but additional horsepower must be added because centrifugal pumps become less inefficient with even slight increases in viscosity and require more horsepower.

When viscosity of the liquids exceeds than normal, centrifugal pumps become very inefficient and require much more horsepower. In those cases, some start recommending positive displacement pumps (such as gear pumps, progressive cavity pumps) instead of centrifugal pumps in order to keep horsepower requirements and energy usage lower.

ii) HORSEPOWER

Centrifugal pumps also require increases in horsepower when pumping non-viscous liquids that are denser than water such as fertilizer and many chemicals used in industry. Water has a density of 8.34 lbs/gallon. The specific gravity of any liquid is the density in lbs/gallon of that liquid divided by 8.34. The required increase in horsepower for a centrifugal pump used for a denser liquid than water is directly proportional to the increase in specific gravity of the liquid.

Here, the centrifugal pump is connected to D4 pin which is initially active high. So, switching the circuit ON, connection D4 must be removed. So, the control of the pump will be achieved by the blynk software.

4.3 CRACK DETECTION

Two IR sensors are fixed in front of the robot which are used to find out the crack on the rail. Each sensor will produce the signal related position with the rail. Infrared (IR) transmitter is one type of LED which emits infrared rays generally called as IR transmitter. Similarly, IR Receiver is used to receive the IR rays transmitted both IR transmitter. One important point is both IR transmitter and receiver should be placed straight line to each other. If the track is normal on its position both the sensor gives the constant Sensed output. The wavelength region which ranges from 0.75 to 3µm is known as the near infrared regions. The region between 3 and 6µm is known as the mid-infrared and infrared radiation which has a wavelength greater than 6µm is known as far infrared. When the vehicle is Powered On, it moves along the model track. The IR sensors monitors the

condition of the tracks. If the IR sensor detects crack on any side then it will send a message to the terminal through IoT that the “Track is not good”.

If both the IR sensorsare low, then only the robot will proceed forward otherwise it will provide the location of the crack which is detected.

Fig 4.3: Railway track with a crack on it

4.4 BRIDGE DIODE:

A diode bridge is an arrangement of four (or more) diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input.

When used in its most common application, for conversion of an alternating-current (AC) input into a direct-current (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two-wire AC input, resulting in lower cost and weight as compared to a rectifier with a 3-wire input from a transformer with a centre tapped secondary winding.

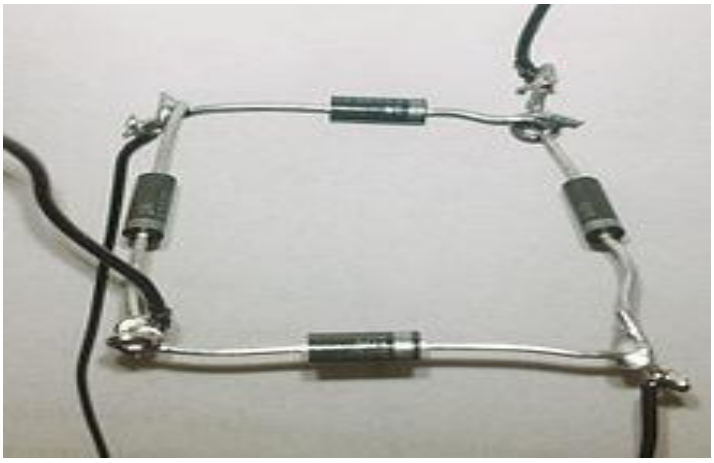


Fig 4.4: Bridge diode circuit

4.5 IOTMODULE

ESP8266 is a 3V Wi-Fi module very popular for its Internet of Things applications. ESP8266 maximum working Voltage is 3.6V.

The ESP8266 can be controlled from your local Wi-Fi network or from the internet (after port forwarding). The ESP-01 module has GPIO pins that can be programmed to turn an LED or a relay ON/OFF through the internet. The module can be programmed using an Arduino/USB-to-TTL converter through the serial pins(RX,TX).

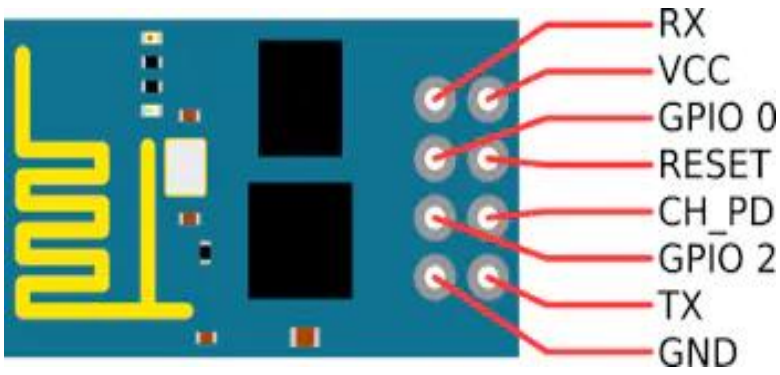


Fig 4.5: ESP 8266 module

When a crack is detected by the IR sensor, the vehicle is intended to stop by the user once and using Google API triangulates the position of the vehicle to receive the Latitude and Longitude coordinates of the vehicle position, from satellites.

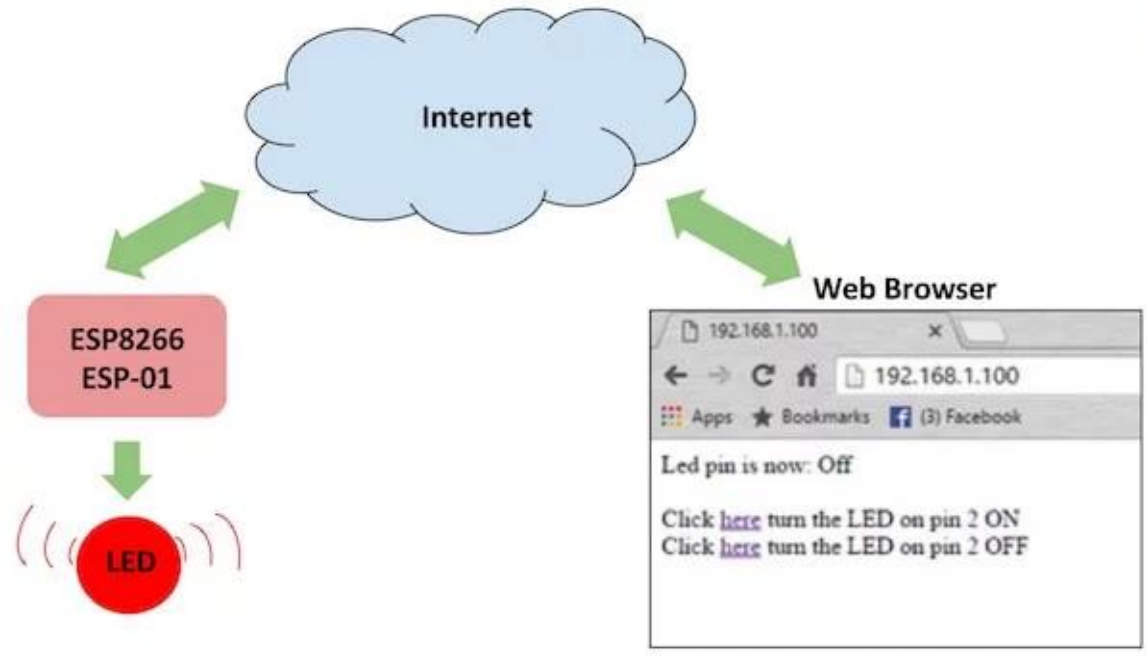


Fig 4.6: Interfacing with IOT

The Latitude and Longitude coordinates received are converted into a text message which is done by PIC microcontroller. But because using a IOT module the location obtained is accurate.

The IoT module sends the text message to the computer that is Inserted into the robot.

Once the message has been successfully sent to the number, the vehicle starts moving forward depending on the type of crack.

4.63-AXIS ROBOTIC ARM

The robotic arm is for the picking of the objects like wrapped covers and trash water bottles in between the tracks. By its 3-axis robotic arm we can throw them into the dustbin.

The 3-axis are

i) Gripper Open and Close

ii) Arm up and down

iii) Arm clockwise and anti-clockwise

Gripper Open and Close operations: hold the object tightly.

Arm up and down operations: For lifting of the object.

Arm clockwise and anti-clockwise operations: For putting the object in a dustbin.

Fig 4.7: Gripper section of the arm

CHAPTER-5

RESULTS

5.1 SIMULATION RESULTS OF THE CHASIS MOTORS

The simulation results obtained from the proteus software are as shown in the figure.

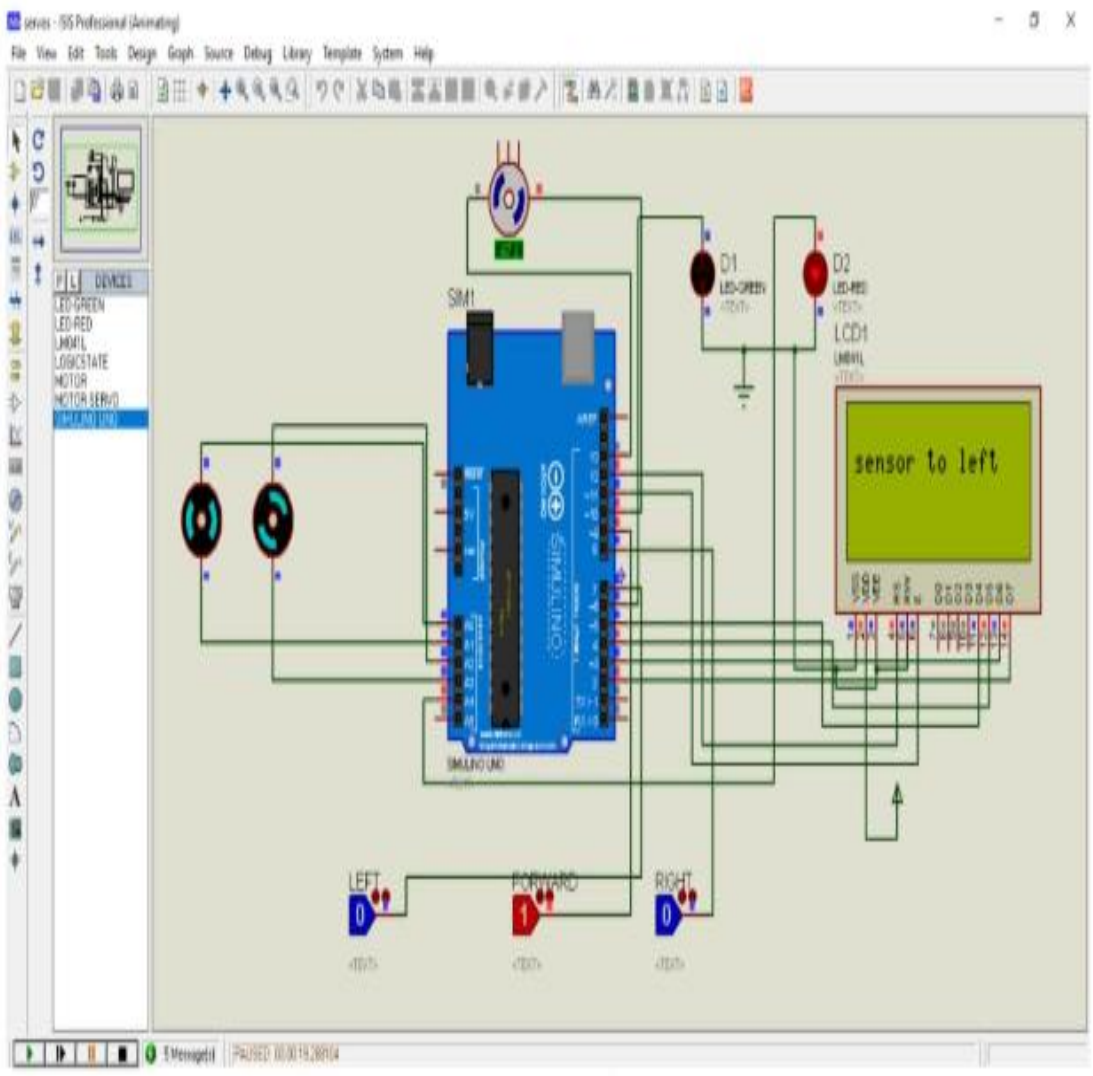


Fig 5.1: Simulation results of the chassis motors

5.2 WHEN THERE IS NO FAULT ON THE RAILWAY TRACK

The message displayed in the blynk application when there is no fault in the track is as shown in the figure.

Fig 5.2: Results in the blynk software when track is good

5.3 WHEN THERE IS A CRACK ON THE RIGHT SIDE OF THE TRACK

The message displayed in the blynk when there is a crack appeared only on the right side of the railway track.

Fig 5.3: Results in the blynk application when a crack on the right side of track

5.4 WHEN THERE IS A CRACK ON THE LEFT SIDE OF THE TRACK

The message displayed in the blynk when there is a crack appeared only on the left side of the railway track.

Fig 5.4: Results in the blynk application when a crack on the left side of track

5.5 WHEN THERE IS CRACKS ON BOTH SIDES OF THE TRACK

The message displayed in the blynk when there is a crack appeared only on the left side of the railway track.

Fig 5.5: Results in the blynk application when a crack on the both sides of track

5.6 FINAL DESIGN OF THE RAILWAY INSPECTION SYSTEM

Fig 5.6: Final design of the railway inspection system

CONCLUSION

From the monitoring data the following conclusions are drawn:

- In the railway track, cracks are occurring in two ways by natural and artificial.
- The natural means (like high expansion due to heat, water floods).
- The artificial cracks are occurring due to antisocial elements (like terrorists).

From our analysis these two cracks are occurring periodically, but apart from this crack some other cracks also occur due to soil condition, water leakage problem. As per our proposed model using this inspection system design in real time means we can able to easily avoid the accidents occur by Track side faults.

The main component of the system is the crack detection circuit. The IoT module helps to alert the railway authorities about the crack in the tracks. Thus, a crack detection and security system are proposed in this paper which makes the system more reliable, less cost, low power consumption and less analysis time and has reduced man power requirement. By this proposed system the exact location of the faulty rail track can easily be located which will mended immediately so that many lives can be saved.

Along with the crack detection, the proposed system cleans the railway track using suction mechanism, robotic arm mechanism and the watering mechanism. Suction mechanism helps to remove the minute particles on the track. The robotic arm is for picking the crushed water bottles on the track. The entire system is monitored by viewing the video capturing from IP camera in the mobile application.

FUTURE SCOPE

- The proposed design is not capable of detecting the object's shape. A person should manually check the size and shape of the objects on the railway track to adjust the arms of the gripper to grab the object. This limitation can be overcome using image processing techniques for shape detection. So that the arm can automatically pick the object and place it in the dustbin.
- A GPS Module can be included for detecting the accurate location of the cracks on the track.
- A fast and effective system can be implemented by using motors with high torque and power ratings.

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