VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

A PROJECT REPORT

on

"DESIGN & FABRICATION OF BLUETOOTH BASED PIPE INSPECTION ROBOT"

Submitted in partial fulfillment of the requirements as a part of the curriculum,

Bachelor of Engineering in Mechanical Engineering

Submitted By

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Department of Mechanical Engineering

CERTIFICATE

This is to certify that the project work entitled **"DESIGN & FABRICATION OF BLUETOOTH BASED PIPE INSPECTION ROBOT"** submitted to the CMR Institute of Technology, Bangalore by **Mr. Anand Murali, Mr. Faizan, Mr. Giridhar.J, Mr. Syed Abdulla** in partial fulfillment of the requirements as part of the curriculum, VIII Semester, **Bachelor of Engineering in Mechanical** of the **Visvesvaraya Technological University, Belgaum** during the year **2019 - 20**. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The Project report has been approved as it satisfies the academic requirements in respect of Project report prescribed for the Bachelor of Engineering degree.

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(Shreyas . P)	**(Dr. Vijayanand Kaup)**	**(Dr. Sanjay Jain)**
Signature of the Guide	**Signature of the HOD**	**Signature of the Principal**

Examiners

Name of the examiners	**Signature with date**
1.	
2.	

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DECLARATION

I, **ANAND MURALI, FAIZAN, GIRIDHAR . J SYED ABDULLA** are bonafide students of **CMR Institute of Technology**, Bangalore, hereby declare that the project report entitled, **"DESIGN & FABRICATION OF BLUETOOTH BASED PIPE INSPECTION ROBOT"** has been carried out at CMR Institute of Technology, Bangalore, in partial fulfillment of the requirements for the award of **BACHELOR OF ENGINEERING** in **MECHANICAL ENGINEERING,** of the **VISVESVARAYA TECHNOLOGICAL UNIVERSITY**, Belgaum, during the year 2019 – 20. The work done in this project report is original and has not been submitted for any other degree in any university.

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I would like to express my sincere gratitude to the Principal **Dr. SANJAY JAIN,** CMR Institute of Technology for providing facilities.

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Last, but not the least, we would hereby acknowledge and thank our **PARENTS** who have been a source of inspiration and also instrumental in the successful completion of the Project Report work.

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ABSTRACT

A pipe inspection robot is a device or an instrument use to inspect and clean the pipe either an industrial or nonindustrial. This is an innovation that took place in recent year to eliminate the human factor from the work of inspecting and cleaning the pipe which is a risky task. Pipe inspection robots are used in many fields of industry and also in other work such ask cleaning and maintaining the city pipe line. The work of industrial pipe inspection robot is to monitor the inside view of the pipes, to keep the notice on the various changes and recognizing the irrelevant changes, which may cause problem and to take preventive action to prevent the problem. If the problem has been recorded then take initiative action to solve the problem. Though the industrial pipe inspection robot is monitoring the inside view of pipes still it can find out the outer surface problem of pipe such as crack formation and this can be done with the help of camera, which will be a part of our project. The pipe inspection robot can be use for the cleaning purpose by adding and attachment to it, such as scrapper which will scrap out the unwanted dross from the pipes project aims to create an autonomous robot used for in-pipe inspection and removing the rust. The mechanism used involves a central rod upon which a translational element is fitted which in turn is connected to three frames of links and wheels. DC motors are attached to the wheels to achieve the drive required. The mechanism allows for small accommodation in pipe diameters. The camera is mounted on the top of the assembly; motor is attached with the buffering wheel to remove the rust. The robot allows for detection of cracks, buckle, corrosions, pitting and many others.

CONTENTS

CHAPTER – I

INTRODUCTION

Pipelines are proven to be the safest way to transport and distribute gases and liquids. Periodic inspection is required to maintain that status. Pipeline systems deteriorate progressively over time through various means. Robotics is one of the fastest growing engineering fields of today. Robots are designed to remove the human factor from labour intensive or dangerous work environments and also to act in inaccessible environment. The use of robots is more common today than ever and it is no longer exclusively used by the heavy production industrial plants. The specific operations such as inspection, maintenance, cleaning etc. are expensive. Thus, the application of the robots appears to be an attractive solution. The project aims to create a robotic inspection technology. It is beneficial to have a robot with adaptable structure to the pipe diameter, which possesses enhanced dexterity, maneuverability and capability to operate under hostile conditions. Wheeled robots are simple, energy efficient and have a great potential for long range usage. A multi – frame robot as shown in fig. 1 offers few advantages in maneuverability with the ability to adapt to in-pipe unevenness, move vertically in pipes, and stay stable without slipping in pipes. This type of robot also has the advantage of easier miniaturization. A challenge in its design and implementation consists in combining the mobility with that of autonomy and low weight. Major design objectives are represented by the adaptability of the robot to the inner diameters of the pipes and making the machine autonomous.

Fig 1: Wired Robot

CHAPTER –II

REVIEW OF RELATED LITERATURE

2.1 LITERATURE REVIEW

- Amr Bekhit discussed that the robot capable of operating in active pipelines would be of great commercial and industrial benefit. This paper describes the requirements for such a robot and considers the benefits and limitations of existing systems. A new design for an inchworm robot is presented based on the Gough-Stewart parallel platform. The control system made relatively simple due to use of inchworm locomotion, while the use of the Gough-Stewart platform allows the robot to benefit from the accuracy, rigidity and speed of parallel robots and provides a flexible base. The design aims to provide minimal resistance to fluid flow by providing a low front area.
- E Navin Prasad designed a robot for inspection of pipes in industrial plants. The inspection of pipes may be related for improving security and efficiency in industrial plants. The operations like inspection, maintenance, cleaning etc. are expensive, thus the application of the robots appears to be one of the most attractive solutions. Pipelines which are tools for transporting oils, gases and other fluids such as chemicals, have be should have high magnetic susceptibility and should be good conductor of electricity. The materials are copper, etc. But aluminum is selected as the materials for the linkages and central body because of its much-desired properties employed as major utilities in a number of countries for long time. Aluminum is light in weight and strength; it can be used in many applications. Aluminum alloys with a wide range of properties are used in engineering structures. The strength and durability of aluminum alloys vary widely because of the components of the specific alloy as well as heat treatments and manufacturing processes.
- Edwin Dertien has discussed the design of a mechanical structure of a miniature pipe inspection robot capable of moving through very small pipes. The main objective was to negotiate bends, T-joints and steep inclinations pose another set of strict design

constraints. The proposed robot consisted of a modular design (7 modules) with a relatively low number of active degrees of freedom. The system used a novel clamping mechanism with a series-elastic drive. The design of this mechanism resulted in a high spreading factor allowing the system to operate in a wide diameter range). The Mechanical design requirements and control system in the robot were also discussed and Preliminary test results concluded that the robot was found quite effective than the conventional inspection.

- Atul Gargade explained that the robots are used to remove human being from laborious and dangerous work. This project describes an in pipe inspection robot. This robot consists of four leg system- a rear leg system and a body. The four leg systems are constructed by using three worm gear systems that are arranged at an angle of 120 degree with respect to each other to operate inside a pipe of different diameters. The springs are attached to each leg to the robot body to operate in pipes of 140mm to 200mm diameter range. Modeling and assembly of robot components is done in Solid works.

2.2 PROBLEM STATEMENT

As we have observed that in industry, home, power plant etc. there are several problems occurs inside the pipe like corrosion, Cracking, Dent Mark, Metal Losses etc. so, we are inspecting the pipe with the help of "PIPE INSPECTION ROBOT".

GEOMETRICAL DEFECTS
Buckle: regular buckle and sharp buckle
Ovality
Wrinkle
Knob
Rolling imperfection or angularity
Tube expansion
Joint imperfection: edge displacement & angle error

2.2.1OVALITY

Definition: nearly symmetric deviation of the pipe cross-section from the circular
Shape resulting in ellipse cross-section without sharp breakpoints.
Measures: –minimum outside diameter, dk min [mm]; –maximum outside
Diameter, dk max [mm].
Possible cause of origin: –pipe manufacturing; –external mechanical impact.

2.2.2KNOB

Definition: residual deformation of the pipe wall outside the pipe without sharp edge
Extending over an area.
Measures: maximum height, d [mm]; overall dimensions (axial length ×circumferential length), l ×k [mm ×mm].
Possible cause of origin: change in internal pressure interacting with another
Defect.
Remark: the knob can be interpreted as the opposite of the regular buckle.

2.2.3 RUCK

Definition: the pipe wall is rippled along its circumference partly or entirely
And the centre line of the pipe remains straight
Measures: – maximum depth of the ripple, db [mm]; –maximum height of the
Ripple, dk [mm]; angle subtended by the ruck along the circumference of the
Pipe, j [°].

Possible cause of origin: – pipe manufacturing; –soil movement.

2.2.4 ROLLING IMPERFECTION OR ANGULARITY

Definition: during the pipe manufacturing in the vicinity of the plate edge to be
Joined by welding (seam) the shape of the pipe deviates from cylindrical
Forming a sharp edge.
Measures: – height of the bevel edge, Y [mm]; –chord of the bevel edge, 2A
[Mm].
Possible cause of origin: pipe manufacturing.

2.2.5 TUBE EXPANSION

Definition: elimination of diameter difference between the two pipe ends to be
Joined with welding (girth weld).
Measures: – outside diameter of the pipe to be expanded, D1 [mm]; –wall
Thickness of the pipe to be expanded, t1 [mm]; – expansion length, L [mm].
Possible cause of origin: – pipe installation (laying); –repair.

2.2.6 EDGE DISPLACEMENT

Definition: radial displacement of parallel centre lines of pipe sections joined with Welding (girth weld).
Measures: eccentricity, e [mm].
Possible cause of origin:–pipe installation (laying); – repair; –pipe Manufacturing.

2.1.7 ANGLE ERROR

Definition: deviation of centre lines of pipe sections joined with welding (girth Weld).
Measures: angle between the centre action systems

2.3 OBJECTIVE

- To develop a machine that helps in easy and quick cleaning To provide the alternative method for pipe cleaning.
- To reduce human efforts.
- To save the time.
- To reduce the cost anyone can use and easy to operate.
- To remove rust for inner surface
- To make the environment sanitary.

2.4 SCOPE OF THE PRESENT WORK

- Memory can be used to store the appliance status during power failure.
- Appliance scheduler/timer can be implemented using RTC (Real Time Clock) Can be changes to an IoT device using WiFi connectivity.

CHAPTER – III

METHODOLOGY

Fig 2: Project Generation Flow

I. Literature study makes review on other model and focusing on how to make it simple and relevance to the project title.

II. Conceptual design sketching several type of design based on concept that being choose. State the dimension for all part.

III. Materials Selection selected the true material based on model design and criteria. Light, easy to joining and easy to manufacture. Assemble all the part to the design.

IV. Fabrication model refinement. Fabricate according to the main frame and design. Refinement at several part of joining and sharp edge. V. Performance testing.

VI. Documentation preparing a report for the project.

CHAPTER – IV

DESIGN CONSIDERATION

4.1 FACTORS DETERMINING THE CHOICE OF MATERIALS

The various factors which determine the choice of material are discussed below.

Properties: The material selected must possess the necessary properties for the proposed application. The various requirements to be satisfied can be weight, surface finish, rigidity, ability to withstand environmental attack from chemicals, service life, reliability etc. The following four types of principle properties of materials decisively affect their selection

1. Physical
2. Mechanical
3. From manufacturing point of view
4. Chemical

The various physical properties concerned are melting point, Thermal Conductivity, Specific heat, coefficient of thermal expansion, specific gravity, electrical Conductivity, Magnetic purposes etc.

The various Mechanical properties Concerned are strength in tensile, compressive shear, bending, torsion and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit, and modulus of elasticity, hardness, wears resistance and sliding properties. The various properties concerned from the manufacturing point of view are

1. Cast ability
2. Weld ability
3. Brazability
4. Forge ability
5. Merchantability
6. Surface properties

7. Shrinkage

8. Deep drawing etc.

MANUFACTURING COST:

Sometimes the demand for lowest possible manufacturing cost or surface qualities obtainable by the application of suitable coating substances may demand the use of special materials.

QUALITY REQUIRED:

This generally affects the manufacturing process and ultimately the material. For example, it would never be desirable to go for casting of a less number of components which can be fabricated much more economically by welding or hand forging the steel.

AVAILABILITY OF MATERIAL:

Some materials may be scarce or in short supply. It then becomes obligatory for the designer to use some other material which though may not be a perfect substitute for the material designed. The delivery of materials and the delivery date of product should also be kept in mind.

SPACE CONSIDERATION:

Sometimes high strength materials have to be selected because the forces involved are high and the space limitations are there.

COST:

As in any other problem, in selection of material the cost of material plays an important part and should not be ignored. Sometimes factors like scrap utilization, appearance, and non-maintenance of the designed part are involved in the selection of proper materials.

4.2 DESIGN CALCULATION

Design calculations:

The material chosen is C45 steel. The diameter of a shaft with bending moment and torsional moment is given by the relation below.

$d^3 = \frac{16}{\pi\tau_{max}} \times \sqrt{(C_m M)^2 + (C_t T)^2}$ ....(2)

Where,

d = diameter of screw rod, m

C_m = numerical shock and fatigue factor for bending moment

C_t = numerical shock and fatigue factor for torsional moment

τ_{max}= maximum shear stress, MN/m²

M = bending moment, Nm

T = torsional moment, Nm

C_m = 1.5 and C_t = 1.0 for rotating shafts with gradual or steady loa

σ_y = 353 MPa for C45 steel, FOS is chosen as 2, d = 0.007922 m = 7.922 mm ≈ 8 mm.

Therefore diameter of screw rod is 8 mm.

Motor power calculations:

Gross robot weight, W

$$= 4.67\ kg \times 9.81 m/s^2$$
$$= 45.81\ N$$

Weight per wheel, $W_w = \frac{45.81}{6} = 7.64\ N$

Radius of wheel, r = 4 cm = 0.04 m

Co − efficientoffrictionforpipe − rubberinterface, μ = 0.6 − 0.8

Tractive effort, $F_T = W_w \times \mu = 6.1\ N$

Torque required per wheel, $T_w = F_T \times r = 0.244\ Nm$

Power required per wheel, $P_w = \frac{2\pi N T_w}{60} = 1.54\ W$

Power of standard DC motor which is chosen, P = 2.88 W

Force on the screw rod due to torque from the motor:

$$T = \frac{W}{2}\left[d_2\left(\frac{\tan\alpha + f\sec\theta}{1 - f\tan\alpha\sec\theta}\right) + f_c d_c\right]$$

Where,

T – Torque applied, Nm

W – Force acting on the screw rod, N

d_2 − Pitch diameter of external thread, m

f – Friction coefficient between nut and screw

d_c - mean diameter of the friction collar, m

α - Helix angle, deg

θ - Half apex angle, deg

p – Pitch of thread = 1.25 mm

$$\alpha = \frac{p}{\pi d} = \frac{1.25 \times 10^{-3}}{\pi \times 8 \times 10^{-3}} = 3.088$$

$\theta = 30°$ for V- threads

$f = 0.5$

$d_2 = 7.16$ mm for M8 screw thread

$W = 194.5\ N$

Check for stress: Stress induced $\sigma = 3.47$ MPa

The yield strength of 1018 steel is 353 MPa. As $3.47 < 353$ MPa, there will be no distortion or failure of the links.

4.3 BLOCK DIAGRAM

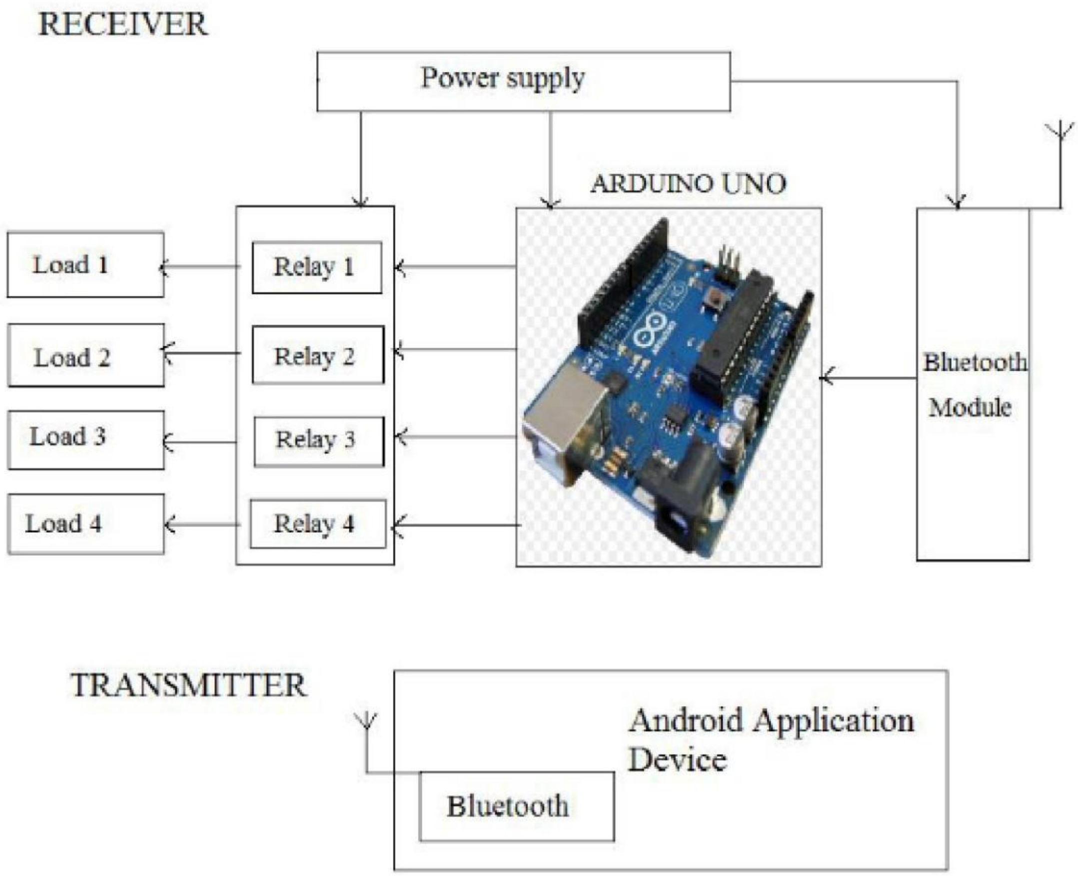


Fig 3: Block Diagram of Bluetooth Application

4.4 WORKING OF THE PIPE INSPECTION ROBOT

- As Pipe Inspection Robot is designed mainly for circular bore pipes, it have ability to move inside any bore diameter pipes ranging from 8 inch to 10 inch(203mm to 254mm). Suitable mechanisms are provided so that it gains ability to move inside pipes. This made possible by mounting the surveillance camera and LEDs on head.
- The perfect fitness between the pipe and robot is first conformed after inserting the robot in the pipe. Then the supply of DC 12Vdc current from is on for working of robot and the camera is also started. With the help robot control having three buttons, working of robot can be easily control the motions which are forward and reverse by one button, using the friction between wheels and pipe, the motion of wheels become possible. At the rear end of the robot motor is fixed with buffering tool which can

rotate up to 1000 rpm enough to scrub the rust metal to be polished. this vehicle is operated through on and off switches

4.5 DESIGN PARAMETERS

The parameter for design of the robot is the diameter of pipe. We have chosen 8’’ and 10’’ (approx. 200 mm and 260 mm) pipes as the lower and upper limits respectively for our robot. Selection of the wheel: The wheels of the robot should be chosen such that they should be capable of moving without slipping in the vertical direction by exerting the required traction force. They should also not wear out easily with use. These factors are determined by the co-efficient of friction between the wheel and the pipe. Rubber wheels are a natural choice for this environment as they meet the above demands. The co-efficient of friction between rubber and two commonly used pipe materials (concrete and PVC) are considered. Coefficient of friction between rubber and concrete is in the range of 0.6 – 0.85. Coefficient of friction between rubber and PVC is in the range of 0.5 – 0.7. The power requirements are calculated using a coefficient of friction of 0.8. The range of diameter of pipes considered in the present work is 200 to 260 mm. To accommodate the mechanism with rubber wheels and considering market availability of standard wheels, the diameter was chosen to be 80 mm.

4.6 MECHANISM SYNTHESIS:

The robot mechanism is to be designed in such a way as to expand and contract between the chosen limits. This necessitates the use of a mechanism where the input link causes the other links to move in a uniform fashion without any crossovers. A parallelogram linkage offers the required type of uniform motion.

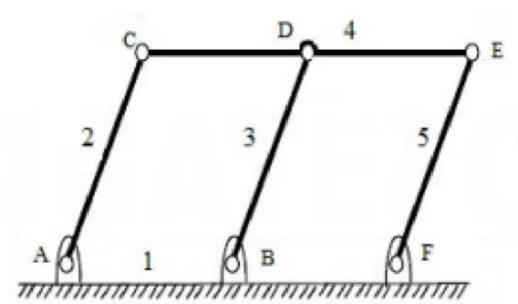


FIG 4.6.1 Simple Parallelogram Linkage

Simple Parallelogram Mechanism But, the required way of motion is not achieved from this design. The joint F is made into a screw pair. The orientation of link 5 is changed so that when the input, link 2 moves in the clockwise direction, link 5 moves in the opposite direction pushing the screw pair forward and vice versa. This combination of linkages makes the mechanism contract in the clockwise direction and expands in counter clockwise direction.

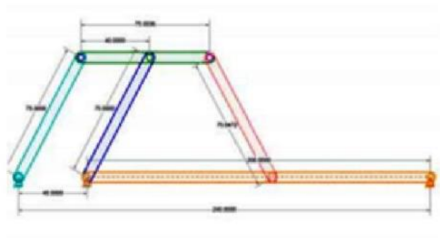


FIG 4.6.2 Simulation Position 1

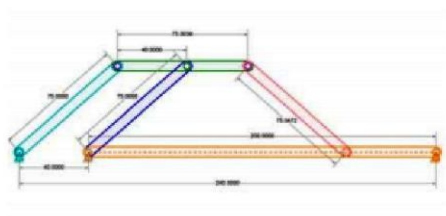


FIG 4.6.3 Simulation Position 2

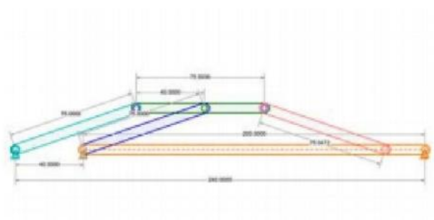


FIG 4.6.4 Simulation Position 3

The figures 5, 6 and 7 show the motion of the mechanism. The simulation showed that the chosen dimensions for the links was capable of executing the desired motion. Material Selection: The materials used for this machine are to be rigid. Different materials can be used for different parts of the robot. For optimum use of power the materials used should be light and strong. Wood is light but it is subjected to wear if used for this machine. Metals are the ideal materials for the robot as most of the plastics cannot be as strong. Material chosen should be ductile, less brittle, malleable, and have high magnetic susceptibility. Among the metals/metal alloys, aluminum is a good choice. But, mild steel 1018 were chosen as the material for links and a translational element as it is sufficiently rigid and less brittle.

It balances ductility and strength and has good wear resistance; used for large parts, forging and automotive components. However, mild steel is denser compared to aluminum and makes the robot heavier. C45 steel is chosen as the material for screw rod as it is a medium carbon steel, which is used when greater strength and hardness is desired than in the "as rolled" condition. Extreme size accuracy, straightness and concentricity combine to minimize wear in high speed applications. It is generally used for screws, forgings, wheel tyres, shafts, axes, knives, wood working drills and hammers. Design calculations: The material chosen is C45 steel. The diameter of a shaft with bending moment and torsion moment is given by the relation below.

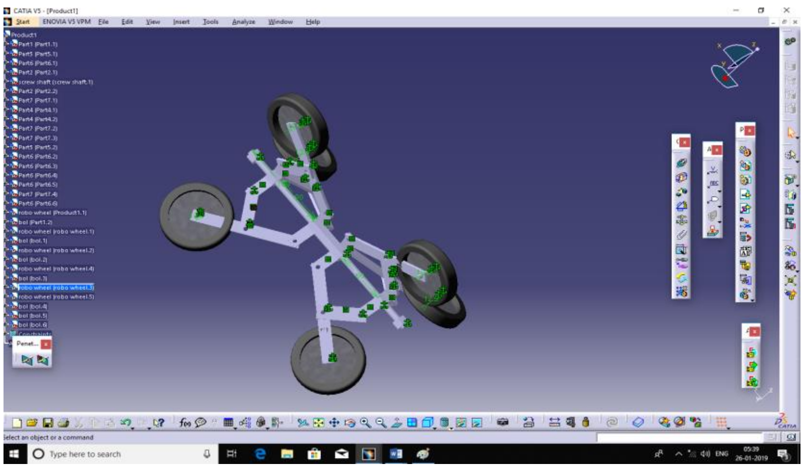


Fig 8: Assembly Isometric View

4.7 FABRICATION AND WORKING

The fabrication phase of the project involves production of the parts designed. It also entails the selection of appropriate electronic circuitry which can be effectively used to achieve and control the robot motion. The various processes used in fabrication of the components are Cutting Drilling Welding Turning.

Electronic circuit and components: The assembled robot needs to start or stop instantaneously. Also, its direction of motion ought to be easily switched over. This can be achieved by using a relay circuit and a remote control. Double Pole Double Throw (DPDT) relay is an electromagnetic device used to separate two circuits electrically and connect them magnetically. They are often used to interface an electronic circuit, which works at a low voltage to an electrical circuit which works at a voltage. At the end of fabrication, the electronic circuitry is implemented onto the robot. The DC motors are fitted for the wheels, screw rod and camera plate rod. The 4 channel relay is integrated with all the DC motors.

Appropriate wiring is done and a 12 V battery is connected to all electronic components

An important part of the Mechatronics course at Polytechnic University was designing and realizing a robot. It had to been controlled by a Basic Stamp (BS2) and includes sensors and actuators. It should be easily monitored and controlled by humans and safe. We decided to build an in-pipe inspection robot, and we called it Gennaro.

4.8 CONSTRAINTS ON THE ROBOT

Design of the inspection robot depends on two main critical factors: size and shape of the pipeline. It will weigh strongly on the maneuverability of robot and its dimensions. An ideal robot should:

1. Drive through a pipe that can change its diameter along his pattern;
2. Cope with elbows and branches, reducer, valves with unexpected mechanical damages that could change its mechanical configuration;
3. Have sufficient traction to move and to carry out tasks as measurements or clogging detection in a slippery and not plane surface as a pipe
4. Be robust and reliable several constrains were taking into account in the first phase of the mechanical design. They were:
    - Minimal and maximal dimensions
    - Weight
    - Moving ability
    - Power request
    - cost issues

Any of the above influenced the others and was sometimes in contradiction. We wanted a light robot, with high power and torque to move easily and firmly, and it must work in the small space given by the 6 inch tube pipe. These were the main features for the robot we had in mind, but being realistic we knew from the beginning that we will have to arrive to a compromise between them to be successful.

4.8.1 MINIMAL AND MAXIMAL DIMENSIONS

The maximal dimension was given by the nominal pipe diameter we wanted to expect, of six inch. In addition, the robot was build to inspect pipes clogged by limestone, so we decided that it should be able to move in pipes of up to 5 inch of inner diameter. One fundamental and critical aspect was corners. As shown in the picture below, the width (w) and high (h) of the robot influences each other, and the following formula1 has been used to design the robot: The minimal acceptable dimension instead was given by the room necessary to equip the robot with a Basic Stamp, all the circuitry, the data acquisition devices, the sensors and motors and the power supplies needed.

4.8.2 MOVING ABILITY

The moving ability was probably the greatest problem to deal with. The smooth surface of the pipes was something difficult to cope with and the round surface adds further difficulties. The robot was intended to move not only in horizontal but also in vertical pipes, so it has to hold onto the surfaces and have the necessary grip and power to climb them. All this requirements had to face with the reality of the chosen traction engine, the DC motors, and with our limited budget. We decided to use four rubber tyres of 1 inch of diameter, because they showed good grip, were light, cheap and compatible with the robot dimension. As will be better explained later we decided to have a robot made up of two different autonomous parts. In order to link them, four strips of rubber with approximate dimensions of 5 cm length 1 cm width and 1 cm height rubber were made, and fixed to the frame. The rubber was reinforced with a linear spring to obtain the desired flexibility and rigidity when approaching an elbow.

4.8.3 WEIGHT

Weight was another critical parameter. A light robot was desired in order to need less power to move, to be agile and to run in vertical pipes. However, this factor was influenced by the motor's choice and the batteries needed. Approximately 50% of the total weight was caused by the batteries and motor. However any other kind of propulsion or power supply we thought was discarded, and this seems to be the only possible way to have a compact and self-propelled vehicle.

CHAPTER- V

CAED MODELS

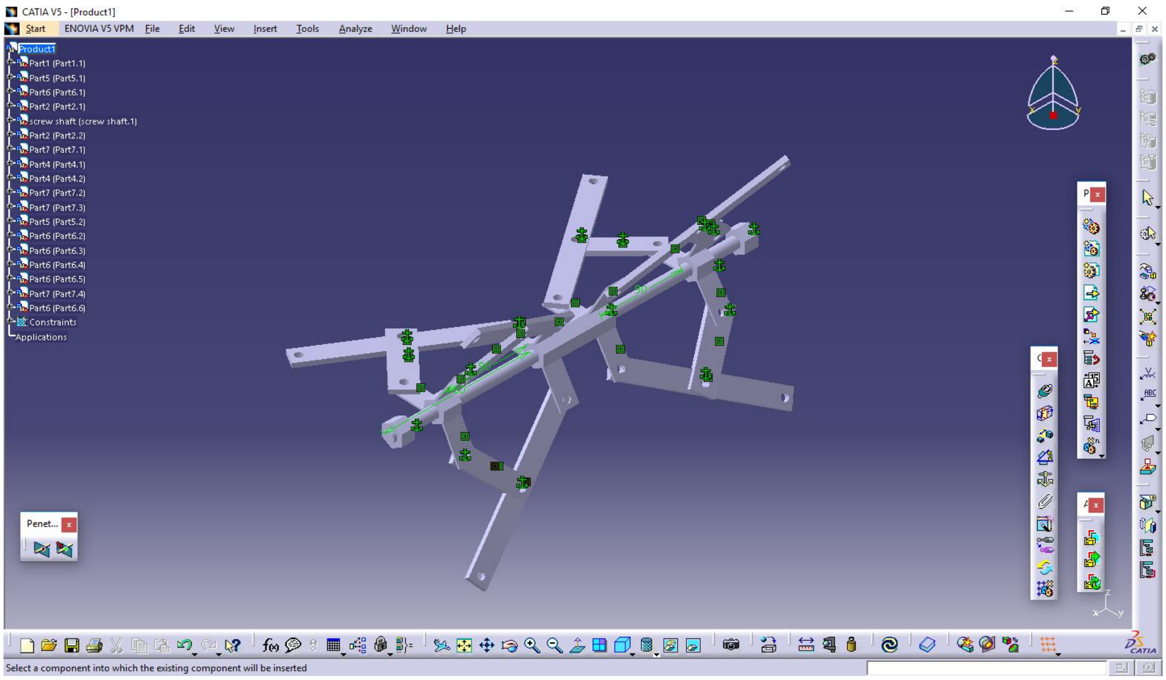


FIG 5.1 Frame Stand Model

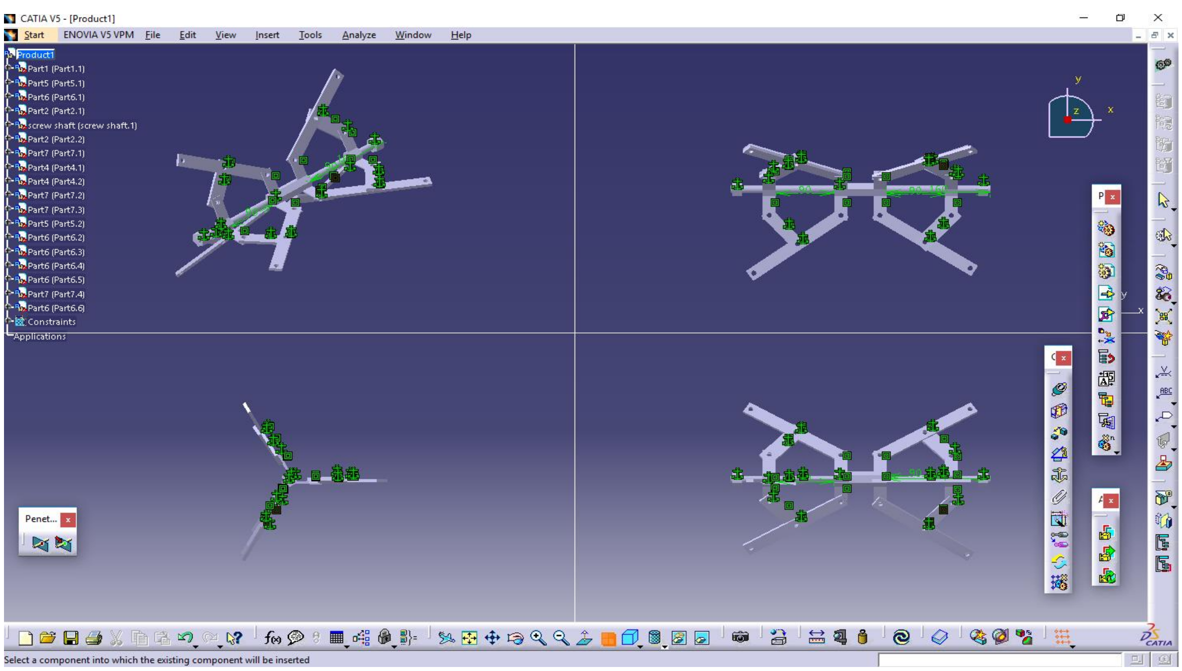


FIG 5.2 Different View of Frame Stand

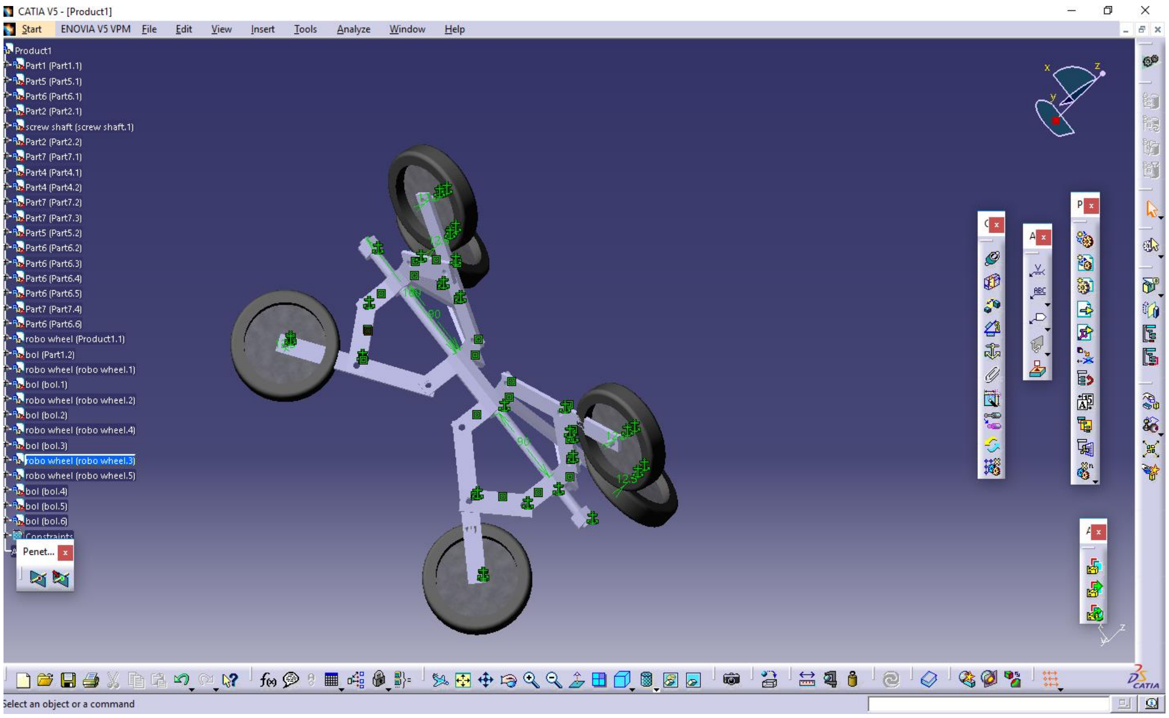


FIG5.3 Completed Assembly of Pipe Inspection Robot

CHAPTER –VI

MECHANICAL FABRICATION

6.1 MILD STEEL

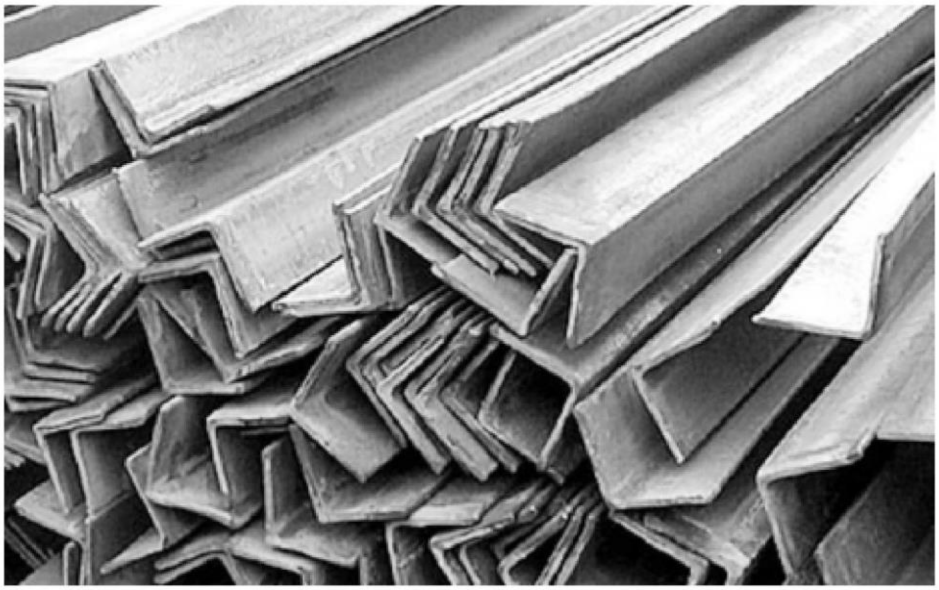


FIG 6.1 MS Flat Steel 1-inch breadth & 3mm thickness

Mild steel is a carbon steel typically with a maximum of 0.25% Carbon and 0.4%-0.7% manganese, 0.1%-0.5% Silicon and some + traces of other elements such as phosphorous, it may also contain lead (free cutting mild steel) or sulphur (again free cutting steel called resulphurised mild steel) The stuff is used everywhere, looking out of my office window I can see diesel pump injector parts, loudspeaker pole pieces, Automated packing machinery parts and I haven't even got my glasses on. How it’s made and more info, depending upon the age of your son it's probably an idea he spends a Saturday morning at the local library researching his homework. Whilst the internet's good you still can't beat browsing through books at the library for homework.

6.2 NUT AND BOLT

FIG 6.2 M6 Nut & Bolts

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction (with slight elastic deformation), a slight stretching of the bolt, and compression of the parts to be held together. In applications where vibration or rotation may work a nut loose, various locking mechanisms may be employed: lock washers, jam nuts, specialist adhesive thread-locking fluid such as Loctite, safety pins (split pins) or lockwire in conjunction with castellated nuts, nylon inserts (Nyloc nut), or slightly oval-shaped threads. The most common shape is hexagonal, for similar reasons as the bolt head - 6 sides give a good granularity of angles for a tool to approach from (good in tight spots), but more (and smaller) corners would be vulnerable to being rounded off. It takes only 1/6th of a rotation to obtain the next side of the hexagon and grip is optimal. However polygons with more than 6 sides do not give the requisite grip and polygons with fewer than 6 sides take more time to be given a complete rotation. Other specialized shapes exist for certain needs, such as wing nuts for finger adjustment and captive nuts (e.g. cage nuts) for inaccessible areas.

6.3 ARC WELD

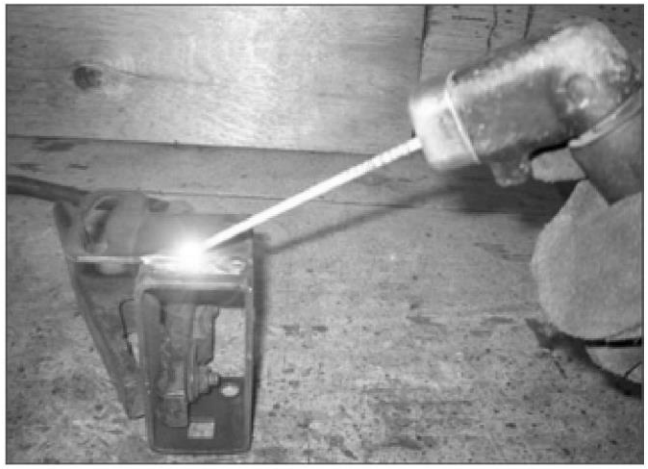


FIG 6.3 Arc Welding

Arc welding is a process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. It is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. The welding region is usually protected by some type of shielding gas, vapor, or slag. Arc welding processes may be manual, semi-automatic, or fully automated. First developed in the late part of the 19th century, arc welding became commercially important in shipbuilding during the Second World War. Today it remains an important process for the fabrication of steel structures and vehicles.

6.4 ARC WELD EQUIPMENTS

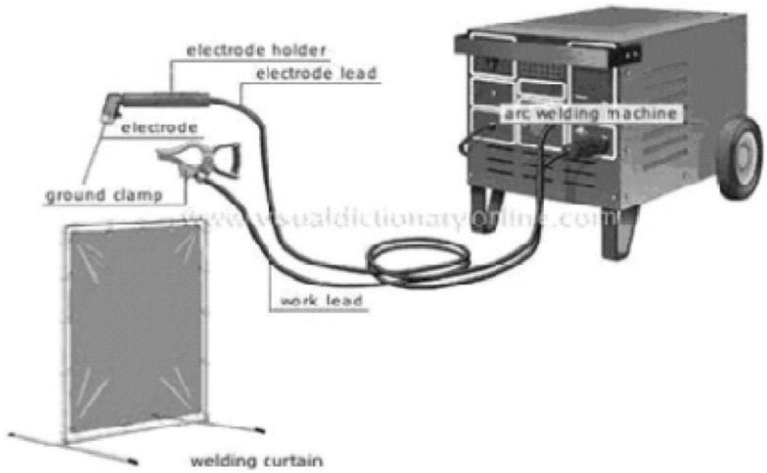


FIG 6.4 Arc Welding Equipments

Welding is the joining of metals through coalescence by the use of either heat or pressure or both. Coalescence is a term that means the joining of two materials to become as one piece. The basic arc welder components consist of the machine that generates the power, the electrode holder or wire feed gun, a means of shielding the weld as it forms, and protective equipment for the user. The process begins in all types when the wire or rod makes contact with the piece to be welded. This completes an electric circuit and creates an arc through which the transfer of the metal from the wire or rod to the piece is facilitated. Spatter occurs during transfer; some of the molten drops of metal become airborne and cover the piece and surrounding area with small globules that solidify on cooling. Spatter may be minimized depending on the skill of the operator and the welding method being used.

6.5 RUST CLEANING

Oxidation creates a scale formation on the surface of the material. Scale formation gives rough structure of surface of iron oxide. This iron oxide formation penetrates into the surface and makes the metal weak and reduces the life of the components. Different grades of emery sheets are used to remove the rust formed on the surface of the steel and cleaned properly.

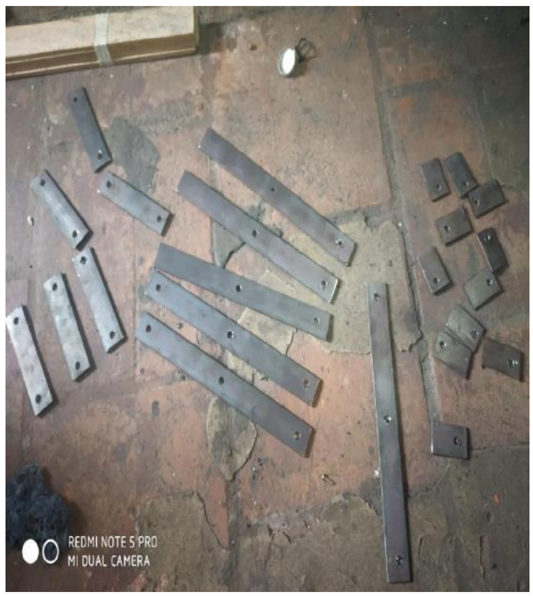


FIG 6.5 Links

FIG 6.6 Lead Srew attached with screw & bolt

FIG 6.7 Completed Mechanical Fabrication

CHAPTER-VII

HADWARE DESCRIPTION

1. Arduino UNO
2. Bluetooth Module - HC-05
3. 12V Relay
4. Relay driver - ULN2003
5. Power Supply

7.1 Arduino UNO

- The Arduino Uno is a microcontroller board based on the ATmega328P.
- It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs,a 16 MHz quartz crystal, a USB connection, a
- Power jack, an ICSP header and a reset button.
- Simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

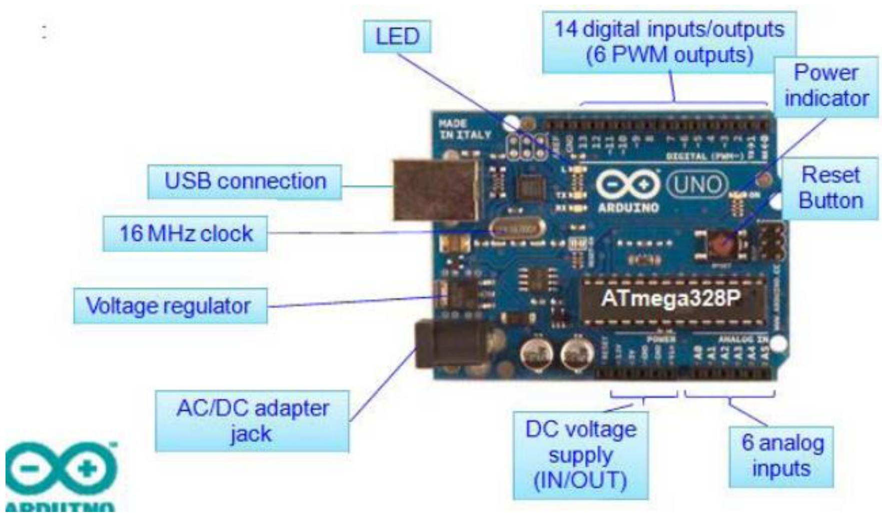


FIG 7.1 Arduino Uno Board

7.1.1 How to use Arduino Board

The 14 digital input/output pins can be used as input or output pins by using pinMode(), digitalRead() and digitalWrite() functions in arduino programming. Each pin operate at 5V and can provide or receive a maximum of 40mA current, and has an internal pull-up resistor of 20-50 KOhms which are disconnected by default. Out of these 14 pins, some pins have specific functions as listed below:

- **Serial Pins 0 (Rx) and 1 (Tx):** Rx and Tx pins are used to receive and transmit TTL serial data. They are connected with the corresponding ATmega328P USB to TTL serial chip.
- **External Interrupt Pins 2 and 3:** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM Pins 3, 5, 6, 9 and 11:** These pins provide an 8-bit PWM output by using analogWrite() function.
- **SPI Pins 10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK):** These pins are used for SPI communication.
- **In-built LED Pin 13:** This pin is connected with an built-in LED, when pin 13 is HIGH – LED is on and when pin 13 is LOW, its off.

Along with 14 Digital pins, there are 6 analog input pins, each of which provide 10 bits of resolution, i.e. 1024 different values. They measure from 0 to 5 volts but this limit can be increased by using AREF pin with analog Reference () function.

- Analog pin 4 (SDA) and pin 5 (SCA) also used for TWI communication using Wire library.

Arduino Uno has a couple of other pins as explained below:

- **AREF:** Used to provide reference voltage for analog inputs with analogReference() function.
- **Reset Pin:** Making this pin LOW, resets the microcontroller.

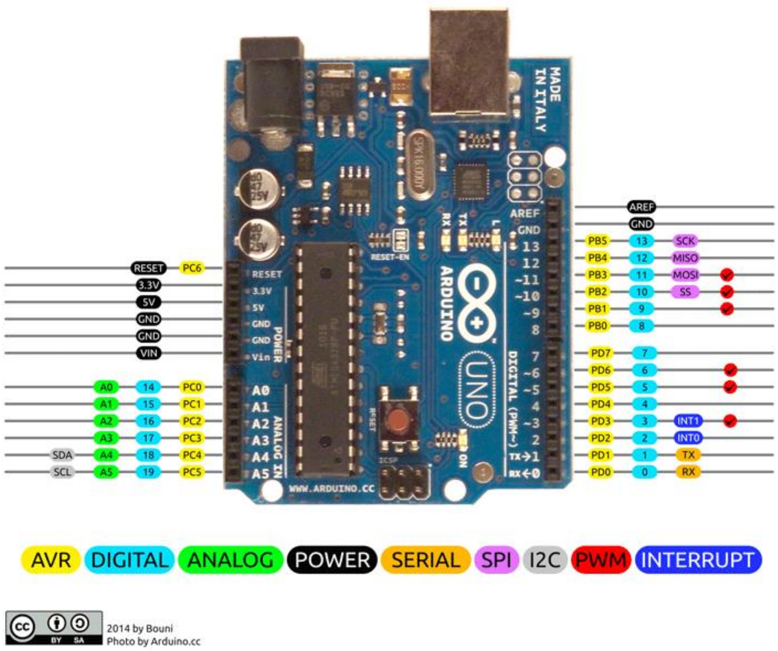


FIG6.1.1 ATmega328P Board

7.1.2 Communication

Arduino can be used to communicate with a computer, another Arduino board or other microcontrollers. The ATmega328P microcontroller provides UART TTL (5V) serial communication which can be done using digital pin 0 (Rx) and digital pin 1 (Tx). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The ATmega16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. There are two RX and TX LEDs on the Arduino board which will flash

When data is being transmitted via the USB-to-serial chip and USB connection to the computer (not for

Serial communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328P also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

7.1.3Arduino Uno R3 Specifiction

The **Arduino Uno R3 board** includes the following specifications.

- It is an ATmega328P based Microcontroller
- The Operating Voltage of the Arduino is 5V
- The recommended input voltage ranges from 7V to 12V
- The i/p voltage (limit) is 6V to 20V
- Digital input and output pins-14
- Digital input & output pins (PWM)-6
- Analog i/p pins are 6
- DC Current for each I/O Pin is 20 mA
- DC Current used for 3.3V Pin is 50 mA
- Flash Memory -32 KB, and 0.5 KB memory is used by the boot loader
- SRAM is 2 KB
- EEPROM is 1 KB
- The speed of the CLK is 16 MHz
- In Built LED
- Length and width of the Arduino are 68.6 mm X 53.4 mm
- The weight of the Arduino board is 25 g

7.2 BLUETOOTH MODULE (HC05)

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue core 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle.

7.2.1HC05 MODULE TECHNICAL SPECIFICATION

- Bluetooth protocol: Bluetooth Specification v2.0+EDR
- Frequency: 2.4GHz ISM band
- Modulation: GFSK(Gaussian Frequency Shift Keying)
- Emission power: ≤4dBm, Class 2
- Sensitivity: ≤-84dBm at 0.1% BER
- Speed: Asynchronous: 2.1Mbps(Max) / 160 kbps, Synchronous: 1Mbps/1Mbps
- Security: Authentication and encryption
- Profiles: Bluetooth serial port
- Power supply: +3.3VDC 50mA
- Working temperature: -20 ~ +75Centigrade
- Dimension: 26.9mm x 13mm x 2.2 mm

FIG7.2.1 Bluetooth Module HC05

7.3 RELAY

A relay is basically a switch which is operated by an electromagnet. The electromagnet requires a small voltage to get activated which we will give from the Arduino and once it is activated, it will pull the contact to make the high voltage circuit.

FIG 7.3 Relay

A relay is basically a switch which is operated by an electromagnet. The electromagnet requires a small voltage to get activated which we will give from the Arduino and once it is activated, it will pull the contact to make the high voltage circuit.

The relay module we are going to use is the5v relay. It runs on 5V/12V and we can control it with any micro-controller but we are going to use Arduino.

The Arduino relay module has total of six pins: three on one side and three on other side.On the bottom side, there are three pins which are signal,5V /12Vand ground. We will connect these pins with the Arduino. While on the other side, there are NC (Normally close), C (Common) and the NO (normally open) which are the output pins of the 5V/12V relay. There, we will connect the output device.

Normally open state (NO) VS Normally closed state (NC)

The Arduino relay module can be used in two states which are

1. Normally open state (NO)
2. Normally closed state (NC)

Normally open (NO)

In the normally open state, the initial output of the relay will be low when it will be powered. In this state, the common and the normally open pins are used.

Normally closed state (NC)

In the normally closed state, the initial output of the relay will be high when it will be powered. In this state, the common and the normally close pins are used.

7.4 LEAD ACID BATTERY

The storage battery or secondary battery is such a battery where electrical energy can be Stored as chemical energy and this chemical energy is then converted to electrical energy As and when required. The conversion of electrical energy into chemical energy by Applying external electrical source is known as charging of battery. Whereas conversion Of chemical energy into electrical energy for supplying the external load is known as Discharging of secondary battery.

During charging of battery, current is passed through it which causes some chemical Changes inside the battery. This chemical changes absorb energy during their formation. When the battery is connected to the external load, the chemical changes take place in Reverse direction, during which the absorbed energy is released as electrical energy and Supplied to the load. These batteries come with a light-weight (1 kg each) secure Connector.

A universal charger with the following specifications is available off the shelf.

• AC input: 240 V
• Charger output: 30 V at 2 A

FIG7.4 Battery

7.5 SERVO MOTOR

A **servo motor** is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through **servo mechanism**. If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Doe to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

Servo motors are rated in kg/cm (kilogram per centimetre) most hobby servo motors are rated at 3kg/cm or 6kg/cm or 12kg/cm. This kg/cm tells you how much weight your servo motor can lift at a particular distance. For example: A 6kg/cm Servo motor should be able to lift 6kg if the load is suspended 1cm away from the motors shaft, the greater the distance the lesser the weight carrying capacity.

The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

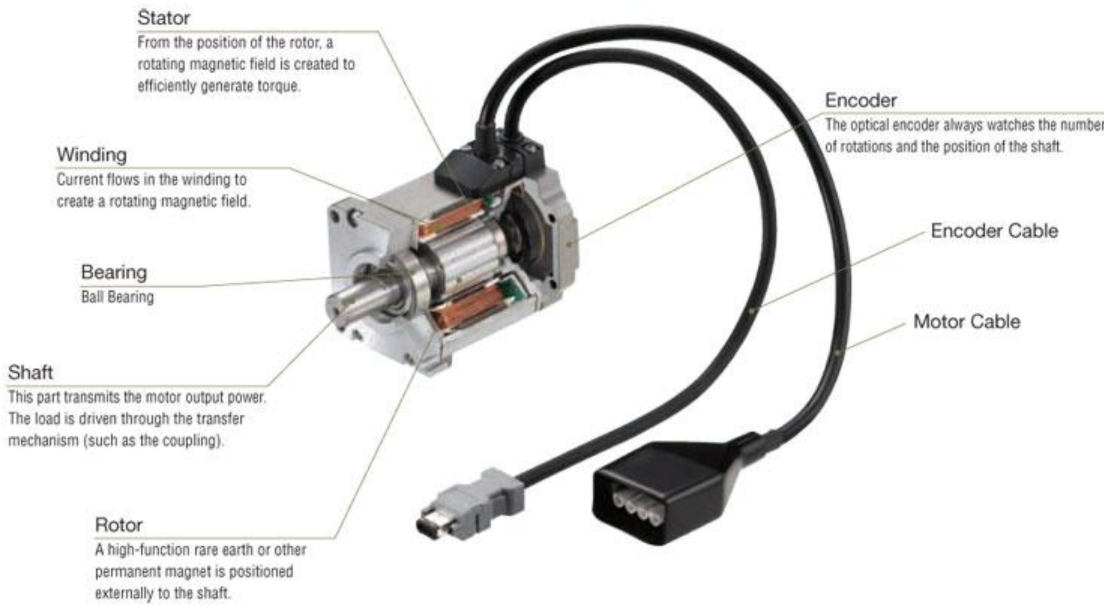


FIG7.5 Servo motor

CHAPTER-VIII

SOFTWARE DESCRIPTION

Software Used

• Arduino IDE

• Eclipse Android SDK (Software Development Kit)

Programming Languages Used

• Embedded C/C++

• Java & XML

8.1 PROGRAMMING THE ARDUINO

Step 1 − First you must have your Arduino board (you can choose your favourite board) and a USB cable. In case you use Arduino UNO, Arduino Duemilanove, Nano, Arduino Mega 2560, or Diecimila, you will need a standard USB cable (A plug to B plug), the kind you would connect to a USB printer as shown in the following image

FIG 8.1 Usb Cable

Step 2 − Download Arduino IDE Software.

You can get different versions of Arduino IDE from the Download page on the Arduino Official website. You must select your software, which is compatible with your operating system (Windows, IOS, or Linux). After your file download is complete, unzip the file.

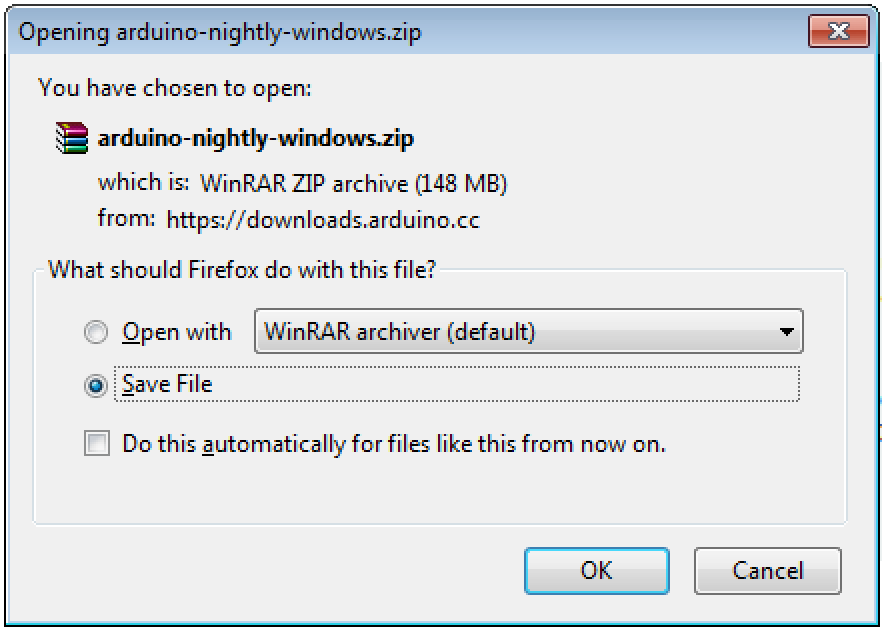


FIG 8.2 Zip File

Step 3 − Power up your board.

The Arduino Uno, Mega, Duemilanove and Arduino Nano automatically draw power from either, the USB connection to the computer or an external power supply. If you are using an Arduino Diecimila, you have to make sure that the board is configured to draw power from the USB connection. The power source is selected with a jumper, a small piece of plastic that fits onto two of the three pins between the USB and power jacks. Check that it is on the two pins closest to the USB port.

Connect the Arduino board to your computer using the USB cable. The green power LED (labeled PWR) should glow.

Step 4 − Launch Arduino IDE.

After your Arduino IDE software is downloaded, you need to unzip the folder. Inside the folder, you can find the application icon with an infinity label (application.exe). Double-click the icon to start the IDE.

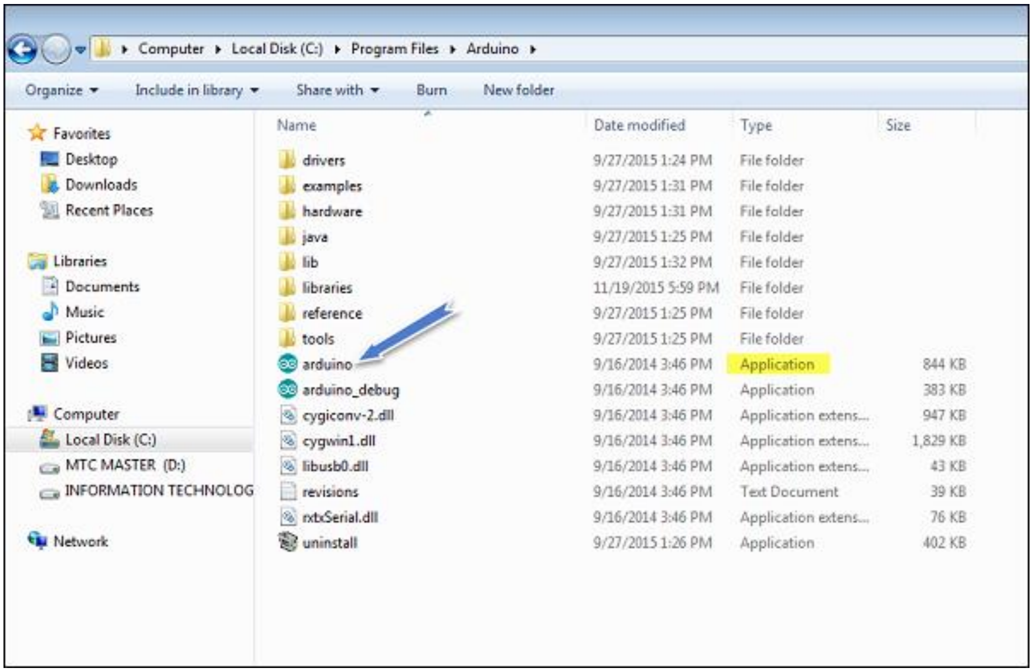


FIG 8.3 Arduino IDE File

Step 5 − Open your first project.

Once the software starts, you have two options −

- Create a new project.
- Open an existing project example.

To create a new project, select File → **New**.

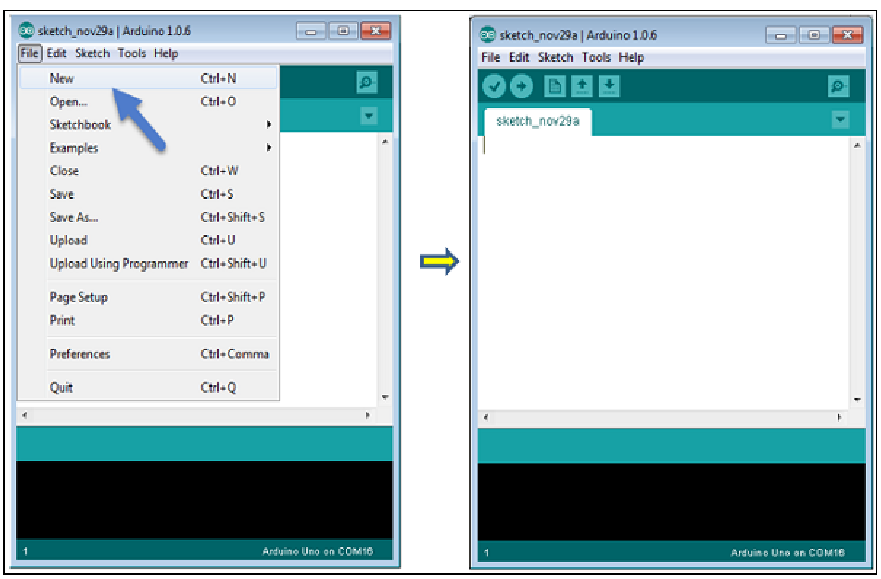


FIG 8.4 Arduino IDE Environment

To open an existing project example, select File → Example → Basics → Blink.

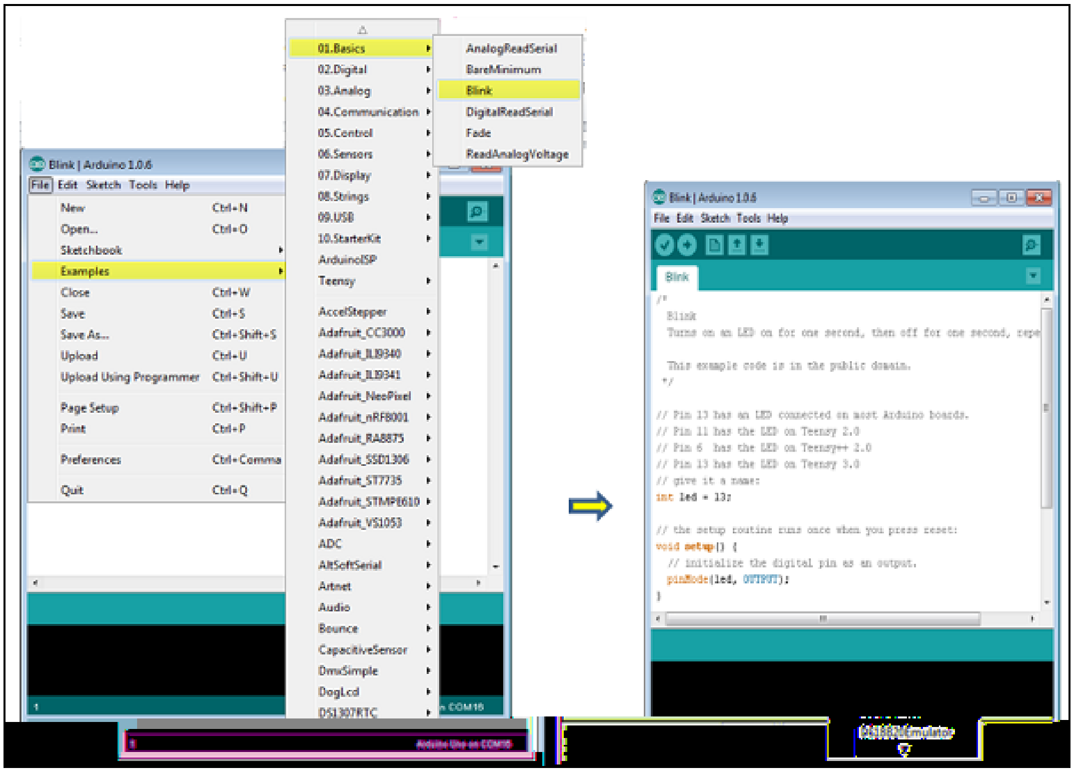


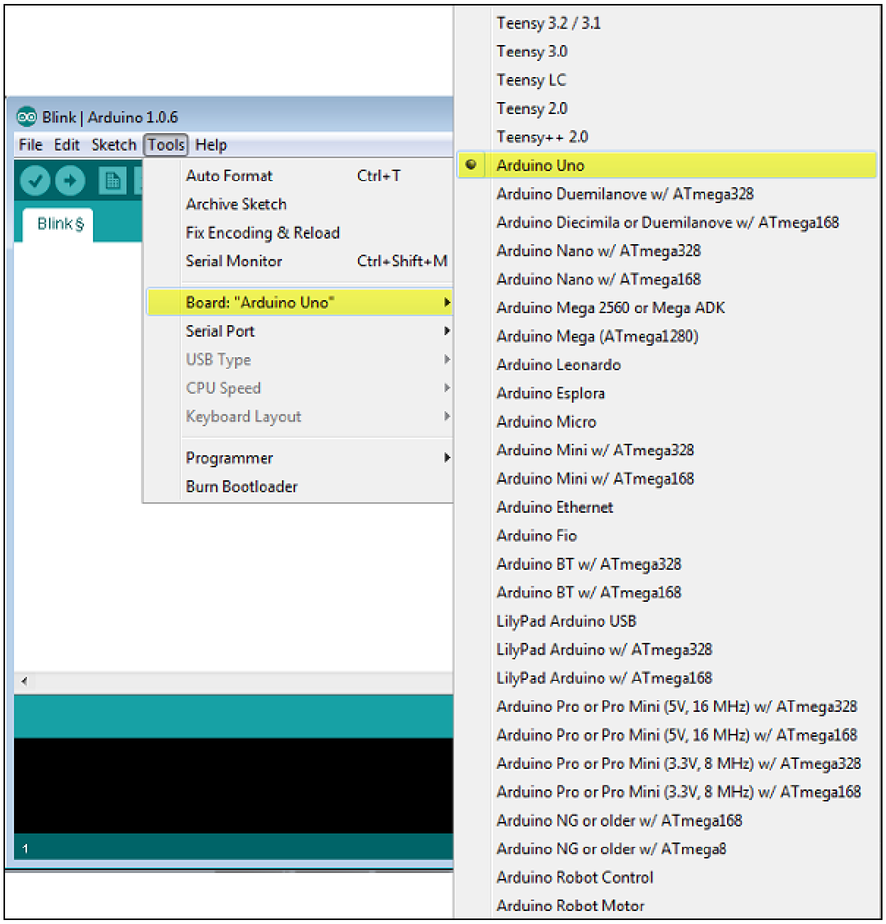
FIG 8.5 Arduino Setup

Here, we are selecting just one of the examples with the name **Blink**. It turns the LED on and off with some time delay. You can select any other example from the list.

Step 6 − Select your Arduino board.

To avoid any error while uploading your program to the board, you must select the correct Arduino board name, which matches with the board connected to your computer.

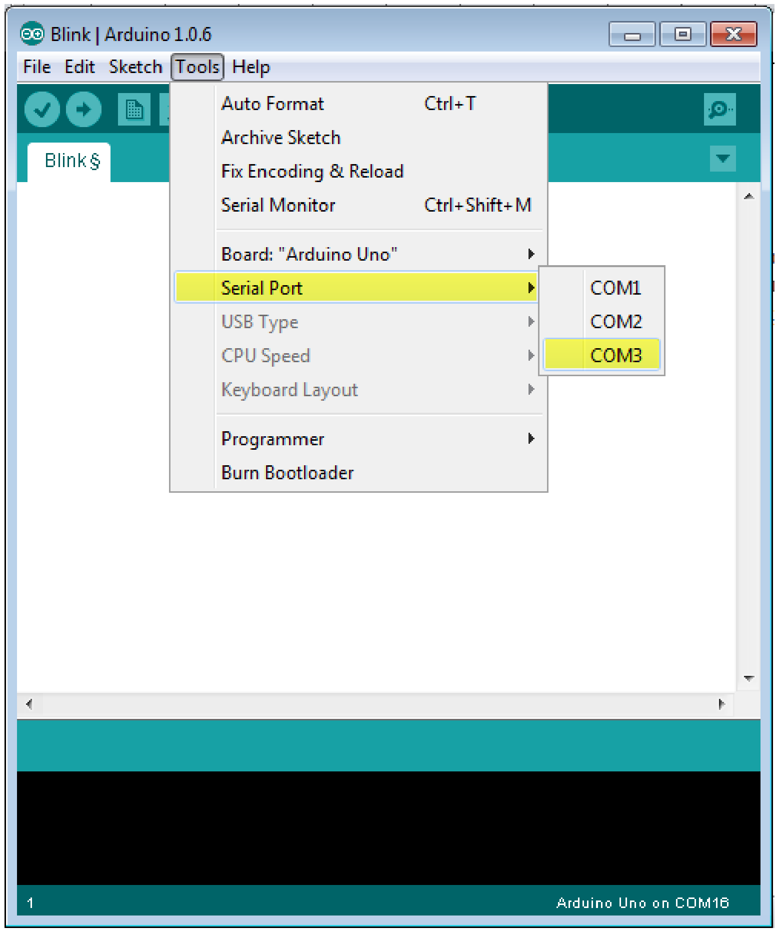
Go to Tools → Board and select your board.



Here, we have selected Arduino Uno board according to our tutorial, but you must select the name matching the board that you are using.

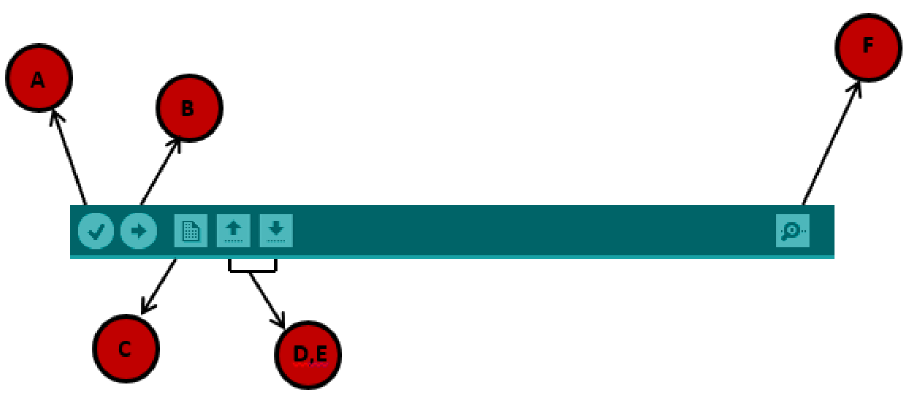
Step 7 − Select your serial port.

Select the serial device of the Arduino board. Go to **Tools → Serial Port** menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu, the entry that disappears should be of the Arduino board. Reconnect the board and select that serial port.



Step 8 − Upload the program to your board.

Before explaining how we can upload our program to the board, we must demonstrate the function of each symbol appearing in the Arduino IDE toolbar.



A − Used to check if there is any compilation error.

B − Used to upload a program to the Arduino board.

C − Shortcut used to create a new sketch.

D − Used to directly open one of the example sketch.

E − Used to save your sketch.

F − Serial monitor used to receive serial data from the board and send the serial data to the board.

Now, simply click the "Upload" button in the environment. Wait a few seconds; you will see the RX and TX LEDs on the board, flashing. If the upload is successful, the message "Done uploading" will appear in the status bar.

8.6 HOW TO USE BLUETOOTH MODULE HC-05

The HC-05 has two operating modes, one is the Data mode in which it can send and receive data from other Bluetooth devices and the other is the AT Command mode where the default device settings can be changed. We can operate the device in either of these two modes by using the key pin as explained in the pin description.

It is very easy to pair the HC-05 module with microcontrollers because it operates using the Serial Port Protocol (SPP). Simply power the module with +5V and connect the Rx pin of the module to the Tx of MCU and Tx pin of module to Rx of MCU as shown in the figure below

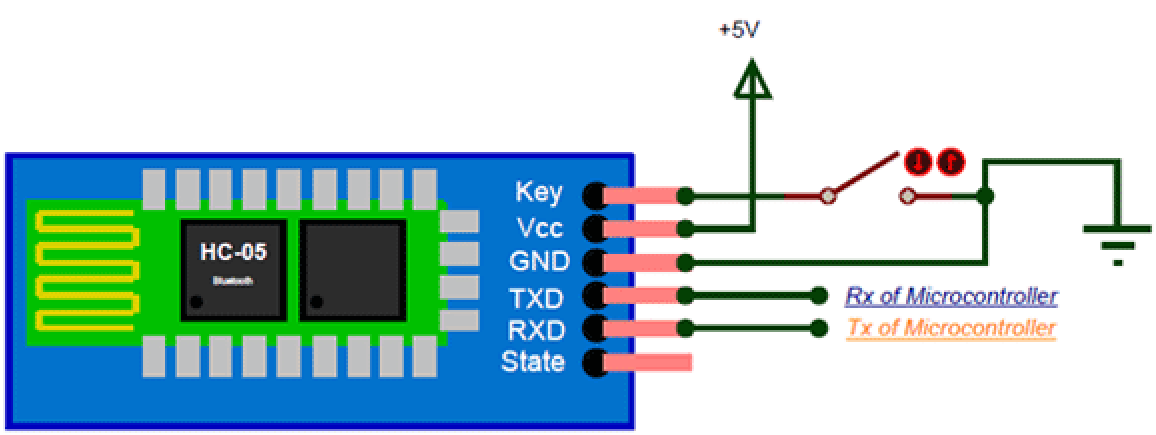


FIG8.6 HC-05 Bluetooth Module

During power up the key pin can be grounded to enter into Command mode, if left free it will by default, enter into the data mode. As soon as the module is powered you should be able to discover the Bluetooth device as "HC-05" then connect with it using the default password 1234 and start communicating with it. The name password and other default parameters can be changed by entering into the app.

For this tutorial I made two examples, controlling the Arduino using a smartphone and controlling the Arduino using a laptop or a PC. In order not to overload this tutorial, in my next tutorial we will learn how we can configure the HC-05 Bluetooth module and make a Bluetooth communication between two separate Arduino Boards as master and slave devices.

8.7 CONNECTING THE SMARTPHONE TO THE HC-05 BLUETOOTH MODULE AND THE ARDUINO

Now we are ready to connect the smartphone to the Bluetooth module and the Arduino. What we need to do here is to activate the Bluetooth and the smartphone will find the HC-05 Bluetooth module.

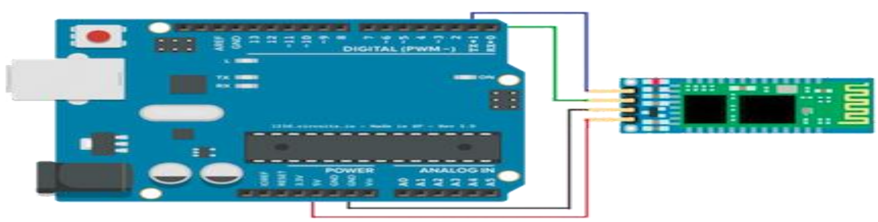


FIG8.7 Connection between Bluetooth Module and Arduino microcontroller

Then we need to pair the devices and the default password of the HC-05 module is 1234. After we have paired the devices, we need an application for controlling the Arduino. There are many applications in the Play Store for this purpose which will work with the Arduino code that we wrote.

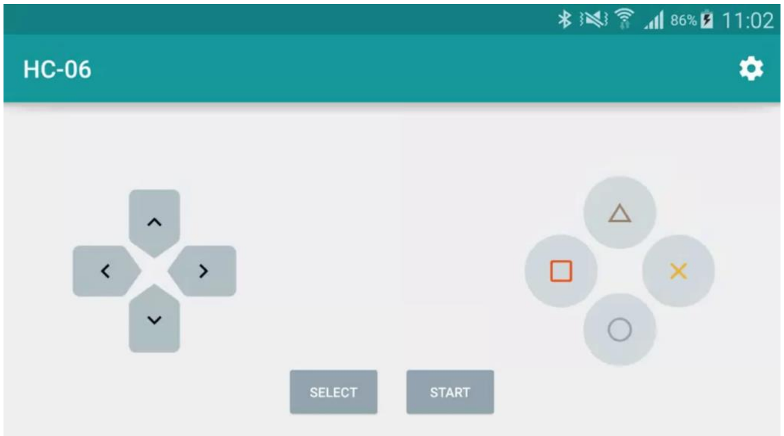


FIG 8.8 Mobile Controller

By using this app, we control devises using HC-05 Bluetooth module.

8.8 MASTER CODE

```
#define SM_Motor_pin1     6
#define SM_Motor_pin2     7
#define SM_Motor_pin3     8

char command;
void setup() {
  // put your setup code here, to run once:

Serial.begin(9600);
    pinMode(SM_Motor_pin1  , OUTPUT);
  pinMode(SM_Motor_pin2  , OUTPUT);
  pinMode( SM_Motor_pin3 , OUTPUT);



// initialised system in stop condition

  digitalWrite(SM_Motor_pin1  ,HIGH);
```

```
  digitalWrite(SM_Motor_pin2 , HIGH);
   digitalWrite( SM_Motor_pin3 ,HIGH);



}

 void loop() {
  // put your main code here, to run repeatedly:

while(Serial.available())
{
    command = Serial.read();
    Serial.print(command);

    switch(command)
    {

    case 'A':


        case 'D':
       Motoroff();
         break;


   case 'E':
   SM_Motor_stop();
    break;
    }
   }
}
```

CHAPTER -IX

RESULT

The mechanism used involves a central rod upon which a translational element is fitted which in turn is connected to three frames of links and wheels. DC motors are attached to the wheels to achieve the drive required. The mechanism allows autonomous robot used for in-pipe for small accommodation in pipe diameters. An electronic circuit consisting of three relay switches is used to control the entire circuitry of DC motors, camera and translational element. The camera is mounted on the top of the assembly, Pipeline systems are prone to degradation and corrosion resulting in a number of defects. Identification of defects is an important problem in chemical plants, sewage pipes and other industries. This project aimed to create an autonomous robot for in-pipe inspection capable of horizontal motion. The following results were obtained from the completion of the project. The robot was capable of adapting to pipe diameters in the range of 200 mm to 260 mm. The robot was tested for motion in a 250 mm PVC pipe. It was found to move horizontal direction

Robots can be effectively used as tools to carry out work in labor intensive, hazardous and unreachable work environments. Pipeline systems are one such environment. Robots will be successfully implemented in pipe line inspections and remove the rust from the inner surface.

CHAPTER – X

FIELD OF APPLICATIONS OF PIPE INSPECTION

- Conventional power plants
- Refineries
- Chemical and petrochemical plant
- Offshore
- Long distance city heating pipelines
- Food and drinks industries
- Communal waste water pipe systems
- Gas pipelines
- Video Inspection
- Visual Inspection
- Ultrasonic inspection

CHAPTER – XI

FUTURE SCOPE

The project is limited in several ways and can be worked upon to broaden its features and applications. A few of the improvements that can be implemented are mentioned below. Use of tilted and guide wheels for traversing curves and bends in pipes. Use of lighter material for the links to reduce the weight. Infrared/Ultrasonic inspection for better detection of defects. Implementation of long range sensors. Implementation as a bore well rescue robot. Alternate design without links to facilitate better motion.

ADVANTAGES

- The complete work process by reducing the human factor in dangerous work Improving the efficiency and performance of the industry.
- It can be used to replace the work place of human to increase the speed the process by increasing overall efficiency of process.
- Robot which is use to take care of pipes in terms of maintenance, cleaning and problem solving and preventing.
- This robot fit with different size of pipe by adjustment
- Camera is placed for proper view of the pipe condition

CHAPTER – XII

CONCLUSION

There are some many design configuration has been used for pipe inspection robot as showed in paper, some may have same mechanism or driven action or communication network but they are identically different from each other. As there application focused on only one purpose of inspecting and cleaning with no or less involvement of human. That's the reason we are working on designing the robot which adapt according to size of pipe considering circular pipe. Hence we have chosen the four bar linkage for our robot which is implemented on the frame of robot. Furthermore we have used many sensors and night vision camera for the purpose of inspection with scrapper for cleaning. So we believe with our project we will be able to inspect and clean the pipe effectively and efficiently.

LIST OF PARTS

Sl. No.	PARTS	**Qty.**	**MATERIAL**
i.	wheels	6	rubber
ii.	frame Stand	1	Mild Steel
iii.	Battery (12V D.C)	1	Lead-Acid
iv.	Bolts & Nuts	6	Mild Steel
v.	Permanent magnet D.C motor	3	Cu
vi.	Connecting Wire	-	Cu
vii	Lead screw	4	M.S
viii	camera	1	
ix	Controller unit	1	

COSTING

Sl. No.	PARTS	**Qty.**	**MATERIAL**	**AMOUNT (Rs)**
i.	wheels	1	ms	480/-
ii.	frame Stand	1	Mild Steel	300/-
iii.	Battery (12V D.C)	1	Lead-Acid	550/-
iv.	Bolts & Nuts	-	Mild Steel	150/-
v.	Permanent Magnet D.C Motor	3	Cu	1200/-
vi.	Connecting Wire	-	Cu	200/-
vii	Controller unit	1		4000/-
viii	Camera			1600/-
ix	Lead screw	1	M.S	150/-

TOTAL= 8630 Rs

2. LABOUR COST

DRILLING, WELDING, POWER HACKSAW, GAS CUTTING, AND PCB DESIGNING:

Cost = **2000 Rs**

3. OVERHEAD CHARGES

The overhead charges are arrived by "Manufacturing cost"

Manufacturing Cost = Material Cost + Labour cost

= 8360 +2000

= **10360 Rs**

TOTAL COST

Total cost = Material Cost + Labour cost + Overhead Charges

= **10360 Rs**

CHAPTER – XIII

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