A

Project Work Report

on

Automatic Solar Panel Cleaning Robot

Submitted in Partial Fulfilment of the Academic Requirements of Degree

Bachelor of Engineering

in

ELECTRONICS AND COMMUNICATION ENGINEERING

by

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CERTIFICATE

This is to certify that the Project work "Automatic Solar Panel Cleaning Robot", being submitted by, M. Sri Charan Siddharth, Gouni Sandeep and Tukkapuram Rohit Chary, in partial fulfilment for the award of Bachelor of Engineering (BE) degree, with specialization Electronics and Communication Engineering (ECE), to the Department of Electronics and Communication Engineering, MATURI VENKATA SUBBA RAO (MVSR) ENGINEERING COLLEGE, an autonomous institution under OSMANIA UNIVERSITY, Hyderabad, is a record of the bonafide work carried out by him/her under my guidance and supervision.

Signature of the Guide	Head of the Department
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Professor, ECED	Department of ECED

Signature of External Examiner

DECLARATION

We declare that this project report titled Automatic Solar Panel Cleaning Robot submitted in partial fulfillment of the degree of Bachelor of Engineering in Electronics and Communication Engineering is a record of original work carried out by us under the supervision of Dr. B. Sarala, and has not formed the basis for the award of any other degree or diploma, in this or any other Institution or University. In keeping with the ethical practice in reporting scientific information, due acknowledgements have been made wherever the findings of others have been cited.

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ABSTRACT

The dust particles accumulating on the solar panels will prevent the solar energy from reaching the solar cells, thereby reducing the overall power generation. Power output is reduced as much as by 50% if the module is not cleaned for a month. To regularly clean the dust, an automatic cleaning system which removes the dust on the solar panel is developed. In this paper, the problem is reviewed and the method for dust removal is discussed. A robot cleaning device is developed, and it travels the entire length of the panel. A arduino microcontroller is used to implement robots control system. The robot provided a favorable result and proved that such a system is viable by making the robotic cleaning possible, thus helping the solar panel to maintain its efficiency.

LIST OF FIGURES

CHAPTER-1

INTRODUCTION

1.1 GENERAL

Man has needed and used energy at an increasing rate for its sustenance and well-being since he came on the earth a few million years ago. Primitive man required energy primarily in the form of food. He derived this by eating plants or animals, which he hunted. Subsequently he discovered fire and his energy needs increased as he added as he started to make use of wood and other biomass to supply the energy needs for cooking as well as agriculture. He added a new dimension to the use of energy by domesticating and training animals to work for him. With further demand for energy, man began to use the winds for sailing ships and for driving windmills, and the force of failing water to turn water wheels. Till this time, it would not be wrong to say that the sun was supplying all the energy needs of man either directly or indirectly and that man was using only renewable sources of energy. The industrial revolution, which began with the discovery of the steam engine (AD 1700), brought about great many changes. For the first time, man began to use a new source of energy, viz. coal, in large quantities.

logy reached the skies by implementing solar panels that use the solar energy to generate electrical energy. Renewable energy is used in all the industries, and they use huge solar panels in more numbers in the form of an array. On the other hand, it has also started playing a major role in the household usage. Now the problem with the implementation of solar panels is, their maintenance. Different cleaning methods are used to clean the solar panels to maintain their efficiency [1]. After one year of exposure without cleaning, the systems were cleaned using pressurized distilled water spray with brushing for one of the plants that showed 6.9% energy generation efficiency [2]. There are many factors that affect PV panel's power efficiency, such as, shadow, snow, high temperatures, pollen, bird droppings, sea salt, dust, and dirt. The main factor that affects a PV panel's efficiency is dust, which can reduce its efficiency by up to 50%, depending on the environment. Cleaning dirty panels with commercial detergents can be time consuming, costly, hazardous to the environment or even corrode the solar panel's frame. Ideally, solar panels should be cleaned every few weeks to maintain peak efficiency, which is especially hard to do for large solar panel arrays. There is a need for an automated cleaning solution to this problem which can service large ground based solar array up to an operating park of 22,000 panels (20,000 Square meters). The cleaning of dust particles on the solar panel is a huge problem because it's time-consuming process and requires lot of manpower and money. To remove this limitation, robotics can be used as it eliminates human labor and at the same time more economical and autonomous.

1.2 NEED FOR THE STUDY

The accumulation of dust on the surface of a photovoltaic module, decreases the radiation reaching the solar cell and causes loss in the generated voltage and power. Dust doesn't only reduce radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation. According to research, daily energy loss along a year caused by dust deposited on the surface of the PV module is around 4.4%. During long periods without rain, daily energy loss can be higher than 20%. In addition, the irradiance loss is not constant throughout the day and is strongly dependent on the sunlight incident angle and the ratio between diffuse and direct radiations. When studied as a function of solar time, the irradiance loss is symmetric with respect to noon, where they reach the minimum value. PV module performance has been tested under the deposition of different pollutants (red soil, ash, sand, calcium carbonate and silica). According to the obtained results, a drop of PV module's voltage and output power is observed when dust particles are deposited on the PV module depending on the mass accumulated and the type of pollutant. Moreover, larger reduction occurs when the PV module's temperature is increased. In addition to that, keeping the PV modules clean and cool, results inefficient system performance. Power generation in the solar panel with dust and without dust with varying load resistance is experimentally determined.

1.3 OBJECTIVES OF THE STUDY

Accumulation of dust on even one panel, reduces their efficiency in energy generation. That is why; the panel's surface should be kept as clean as possible. Current human-based cleaning methods for Solar panels are costly in terms of time, water, and energy usage. No automation has taken place in cleaning the solar panels, so, there exists a need for developing automatic cleaning machines which can clean and move easily on the glass surface of the panels. Solar panels need to be fully cleaned to collect maximum energy possible. To address this need for the cleaning mechanism we developed solar panel cleaning bot. It proposes to develop a Solar Panel Cleaning System which could remove the accumulated dust on its surface on a regular basis and maintain the solar power plant output. Our device will boost the efficiency by increasing the energy output of solar panels in quick and cost-effective manner. Automation of system will also reduce the risk of the operator injury himself in high voltage environment. This bot will clean multiple solar panels in an array and increase their efficiency by at least the same amount that rainfall can.

CHAPTER – 2

LITERATURE REVIEW

V. Bhuvaneswari et al. (2014) described The Internet of Things (IoT) is the most promising area which penetrates the advantages of Wireless Sensor and Actuator Networks (WSAN) and Pervasive Computing domains. Different applications of IoT have been developed and researchers of IoT well identified the opportunities, problems, challenges, and the technology standards used in IoT such as Radiofrequency Identification (RFID) tags, sensors, actuators, mobile phones, etc. This paper is of two-fold; the first fold covers the different applications that adopted smart technologies so far. The second fold of this paper presents the overview of the sensors and its standards.

Swanand S. Wable et al. (2017) proposed the Solar Panels Farms are situated in dirt and dust areas which are mostly in case of tropical countries. The performance of solar panels depends on various factors, the power generated by farm can decreased if there is dust and dirt on panels and this is the main factor for reduction. One can assume a reduction of about 40% - 50%, if the panels are not clean properly for 1-2 months. So, to overcome this problem and to increase the efficiency of power production cleaning of module on regular basis is necessary. To clean the dust, an automatic cleaning robot is developed, which will clean the panels on regular interval of time. The mechanism is based on control circuit, DC motor; microfiber (bristles) to clean the panels. The paper provides you with the idea how the robot will work and its effect on the energy production by solar farms. It will also help to understand the problem arise due to not cleaning of solar cells.

Subhasri.G et al. (2018) presented a sunlight-based framework is the device for orienting solar photovoltaic modules and solar thermal collectors toward the sun Thinking about the state of the art of the innovation, successful strategy, robust control philosophy and the potential added benefit of different research work which can be employed on an extensive scale in maintainable manner. Presently we are entering in a new period of processing innovation i.e., Internet of things (IoT). IoT is a sort of "universal global neural network" in the cloud which associates various things. The IoT is an intelligently connected devices and framework contain brilliant machine connecting and communicate with different machines, environments, objects and infrastructures and the radio frequency identification (RFID) and sensor network technologies will rise to meet this new challenge. Furthermore, the investigation gives the different related works on iot empowered solar panel monitoring modules for the proficient way of gain power from the solar radiation

Tushar Pokharkar et al. (2018) presented the solar PV modules are employed in tropical countries like India. Dust and dirt particles accumulating on PV panels decreases the solar energy reaching the cells, thereby reducing their overall power output. The power output reduces as much as by 50% if the module is not cleaned for a month. Hence, cleaning the PV panels is a problem of great practical engineering interest in solar PV power generation. In this paper, the problem is reviewed and methods for dust removal are discussed. To regularly clean the dust, an automatic cleaning system has been designed, which senses the dust on the solar panel and cleans the module automatically. This automatic system helps in maintaining the overall output of the solar firm. For cleaning the PV modules, a mechanism consists of a sliding brush has been developed. In terms of daily energy generation, the presented automatic-cleaning scheme provides about 30% more energy output when compared to the dust accumulated PV module.

Abhishek Naik et al. (2019) proposed the solar PV modules are employed in dusty environments which is the case in tropical countries like India. The dust gets accumulated on the front surface of the module and blocks the incident light from the sun. It reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month. In order to regularly clean the dust, an automatic cleaning system has been designed, which senses the dust on the solar panel and also cleans the module automatically. In terms of daily energy generation, the presented automatic cleaning scheme provides about 30% more energy output when compared to the dust accumulated PV module.

Gargi Ashtaputre et al. (2019) proposed the efficiency of Solar PV panel is greatly affected due to the accumulation of dust, dirt, and sea salt on panel. This paper aims at developing a low-cost automatic robot which will smartly clean the panel. The project is divided into two parts: Cleaning System and Monitoring System. Cleaning task is completed according to the data received from monitoring system. Wireless technology has been implemented in order to collect all the data from individual panel. The power output of each panel is monitored thoroughly and depending on the information collected at each node, the cleaning action is triggered. This system is also able to detect breakage of panel. The system can be operated remotely, and user can access all the information on field from any part of the world.

Milan Vaghani et al. (2019) presented transparency in cleaning system by using the most newly invented technology, which provide a better performance, integrity, consistency, cost-effective and scalable solution for the removal of dust and speck. The presented cleaning system provides about 32% more energy output compared to the dust accumulated solar panel. This system is control by application from whole world. Also, this system reduces workforce for cleaning of solar panel. This is automatic solar panel cleaning system.

CHAPTER - 3

DESCRIPTION OF EQUIPMENT

3.1 SOLAR PANEL

A solar panel is a device that collects and converts solar energy into electricity or heat. It known as Photovoltaic panels, used to generate electricity directly from sunlight Solar thermal energy collection systems, used to generate electricity through a system of mirrors and fluid-filled tubes solar thermal collector, used to generate heat solar hot water panel, used to heat water. It is energy portal. A solar power technology that uses solar cells or solar photovoltaic arrays to convert light from the sun directly into electricity. Photovoltaics is in which light is converted into electrical power. It is best known as a method for generating solar power by using solar cells packaged in photovoltaic modules, often electrically connected in multiples as solar photovoltaic arrays to convert energy from the sun into electricity. The photovoltaic solar panel is photons from sunlight knock electrons into a higher state of energy, creating electricity.

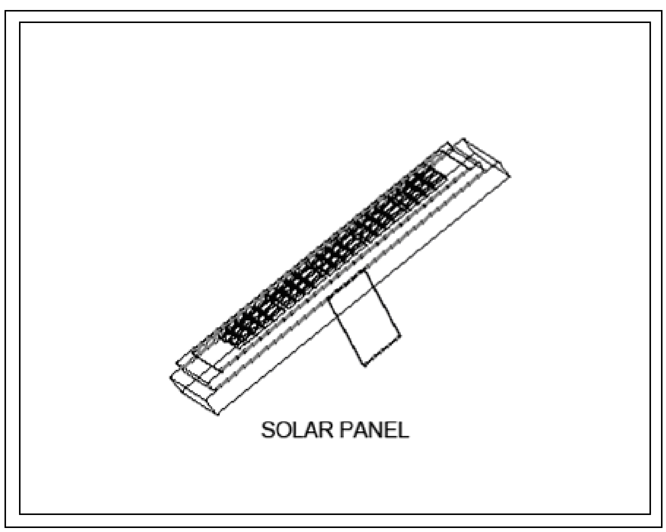


Fig 3.1 Solar Panel

Solar cells produce direct current electricity from light, which can be used to power equipment or to recharge a battery. A less common form of the technologies is thermophotovoltaics, in which the thermal radiation from some hot body other than the sun is utilized. Photovoltaic devices are also used to produce electricity in optical wireless power transmission.

3.2 BATTERY

In our project we are using secondary type battery. It is rechargeable type. A battery is one or more electrochemical cells, which store chemical energy and make it available as electric current. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy. Primary batteries can only be used once because they use up their chemicals in an irreversible reaction. Secondary batteries can be recharged because the chemical reactions they use are reversible; they are recharged by running a charging current through the battery, but in the opposite direction of the discharge current. Secondary, also called rechargeable batteries can be charged and discharged many times before wearing out. After wearing out some batteries can be recycled. Batteries have gained popularity as they became portable and useful for many purposes. The use of batteries has created many environmental concerns, such as toxic metal pollution. A battery is a device that converts chemical energy directly to electrical energy it consists of one or more voltaic cells. Each voltaic cell consists of two half cells connected in series by a conductive electrolyte. One half-cell is the positive electrode, and the other is the negative electrode. The electrodes do not touch each other but are electrically connected by the electrolyte, which can be either solid or liquid. A battery can be simply modeled as a perfect voltage source which has its own resistance, the resulting voltage across the load depends on the ratio of the battery's internal resistance to the resistance of the load.

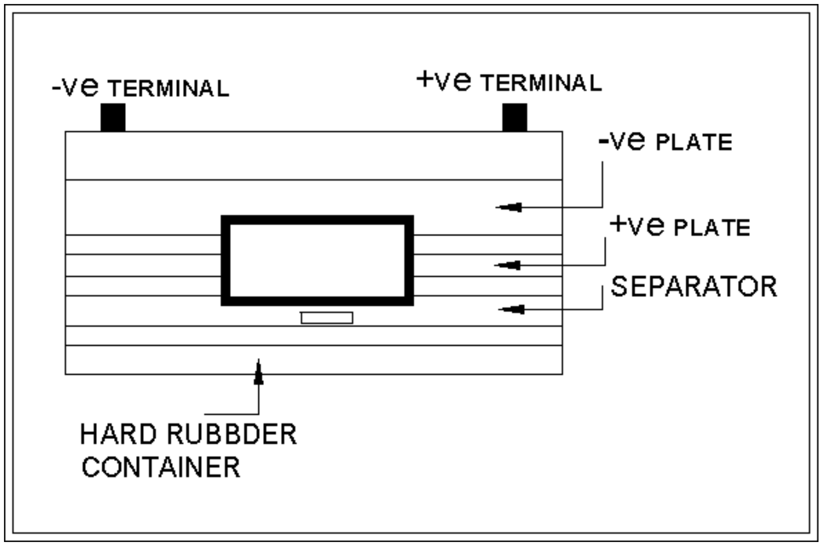


Fig 3.2 Battery

When the battery is fresh, its internal resistance is low, so the voltage across the load is almost equal to that of the battery's internal voltage source. As the battery runs down and its internal resistance increases, the voltage drop across its internal resistance increases, so the voltage at its terminals decreases, and the battery's ability to deliver power to the load decreases.

3.3 D.C MOTOR:

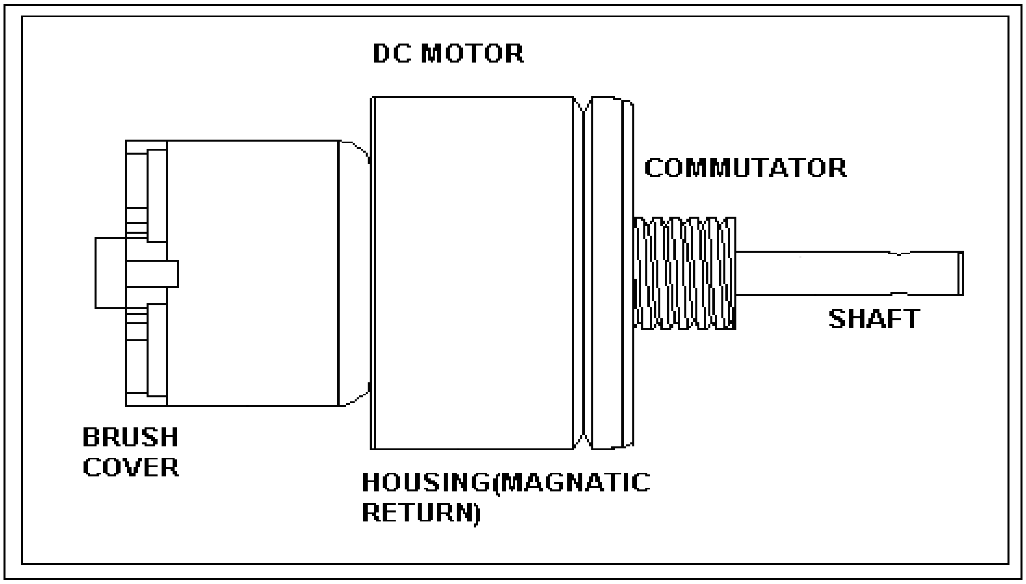


Fig 3.3.1 DC Motor

PRINCIPLES OF OPERATION

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are aware of from playing with magnets as a kid, opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

Let's start by looking at a simple 2-pole DC electric motor (here red represents a magnet or winding with a "North" polarization, while green represents a magnet or winding with a "South" polarization).

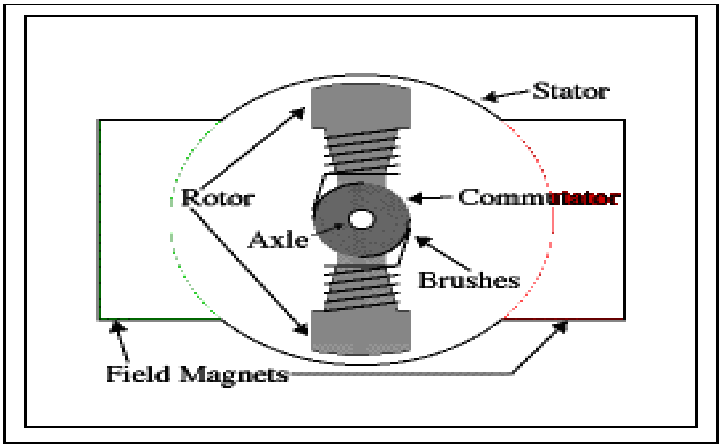


Fig 3.3.2 Inner Side Motor

Every DC motor has six basic parts -- axle, rotor (armature), stator, commutator, field magnet(s), and brushes. In most common DC motors, the external magnetic field is produced by high-strength permanent magnets. The stator is the stationary part of the motor -- this includes the motor casing, as well as two or more permanent magnet pole pieces. The rotor (together with the axle and attached commutator) rotate with respect to the stator. The rotor consists of windings (on a core), the windings being electrically connected to the commutator. The above diagram shows a common motor layout -- with the rotor inside the stator (field) magnets.

The geometry of the brushes, commutator contacts, and rotor windings are such that when power is applied, the polarities of the energized winding and the stator magnet(s) are misaligned, and the rotor will rotate until it is almost aligned with the stator's field magnets. As the rotor reaches alignment, the brushes move to the next commutator contacts, and energize the next winding. Given our example two-pole motor, the rotation reverses the direction of current through the rotor winding, leading to a "flip" of the rotor's magnetic field, driving it to continue rotating. In real life, though, DC motors will always have more than two poles (three is a very common number). This avoids "dead spots" in the commutator. You can imagine how with our example two-pole motor, if the rotor is exactly at the middle of its rotation (perfectly aligned with the field magnets), it will get "stuck" there. Meanwhile, with a two-pole motor, there is a moment where the commutator shorts out the power supply. This would be bad for the power supply, waste energy, and damage motor components as well. Yet another disadvantage of such a simple motor is that it would exhibit a high amount of torque "ripple" (the amount of torque it could produce is cyclic with the position of the rotor).

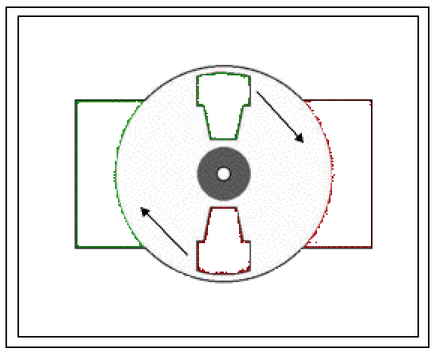


Fig 3.3.3 2 Pole DC Motor

So, since most small DC motors are of a three-pole design, let us tinker with the workings of one via an interactive animation (JavaScript required):

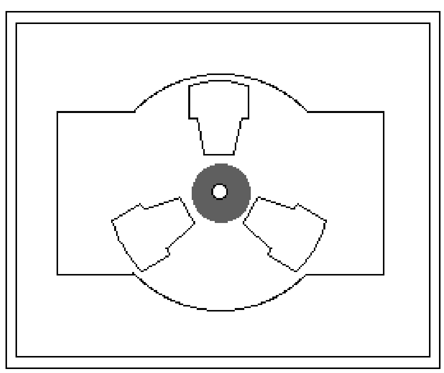
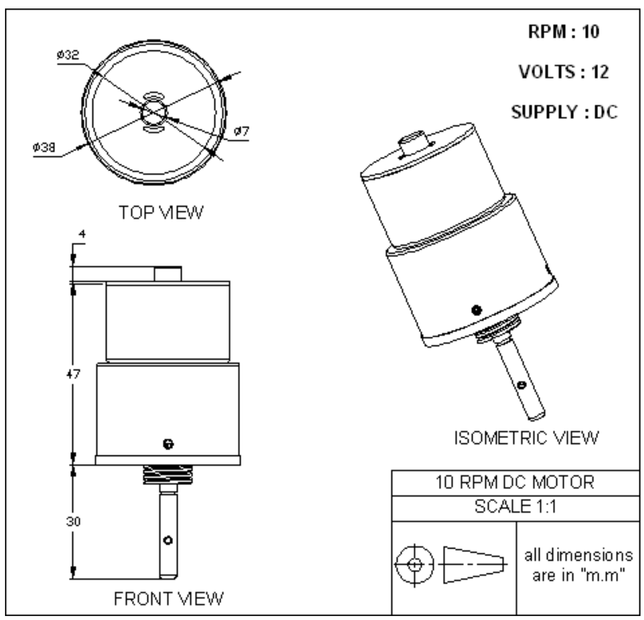


Fig 3.3.4 Three Pole DC Motor

A few things from this -- namely, one pole is fully energized at a time (but two others are "partially" energized). As each brush transitions from one commutator contact to the next, one coil's field will rapidly collapse, as the next coil's field will rapidly charge up (this occurs within a few microsecond). We will see more about the effects of this later, but in the meantime, you can see that this is a direct result of the coil windings' series wiring. There's probably no better way to see how an average DC motor is put together, than by just opening one up. Unfortunately, this is tedious work, as well as requiring the destruction of a perfectly good motor. The guts of a disassembled Mabuchi FF-030-PN motor (the same model that Solarbotics sells) are available for (on ten lines / cm graph paper). This is a basic 3-pole DC motor, with two brushes and three commutator contacts. The use of an iron core armature (as in the Mabuchi, above) is quite common, and has a number of advantages. First off, the iron core provides a strong, rigid support for the windings -- a particularly important consideration for high-torque motors. The core also conducts heat away from the rotor windings, allowing the motor to be driven harder than might otherwise be the case. Iron core construction is also relatively inexpensive compared with other construction types. But iron core construction also has several disadvantages. The iron armature has a high inertia which limits motor acceleration. This construction also results in high winding inductances which limit brush and commutator life. In small motors, an alternative design is often used which features a 'coreless' armature winding. This design depends upon the coil wire itself for structural integrity. As a result, the armature is hollow, and the permanent magnet can be mounted inside the rotor coil. Coreless DC motors have much lower armature inductance than iron-core motors of comparable size, extending brush and commutator life. The coreless design also allows manufacturers to build smaller motors; meanwhile, due to the lack of iron in their rotors, coreless motors are prone to overheating. As a result, this design is used just in small, low-power motors. Beamers will most often see coreless DC motors in the form of pager motors. Again, disassembling a coreless motor can be instructive -- in this case, my hapless victim was a cheap pager vibrator motor. The guts of this disassembled motor are available (on ten lines / cm graph paper). This is (or more accurately, was) a 3-pole coreless DC motor.

DC MOTOR CALCULATION

DIMENSION OF 10 RPM MOTOR



Motor specification:
Motor Type : DC Geared motor
Speed = 10
Volt = 12
Watt = 6

Motor calculation:

To find the rpm of the motor:

Rpm = 120 x Frequency / No. of Poles
Standard = 120
Frequency =1.125
No. of Poles = 3
There fore
Rpm = 120 x Frequency / No. of Poles
= 120x 1.125 /3
= 10 rpm

To find the torque of the motor

P = 2x3.14x nm /60

T = P x 60/2 x 3.14 x nm

T =6 x 60/2 x 3.14 x 10

T= 1.27 N-m

3.4 WHEEL

A wheel is a circular device that is capable of rotating on its axis, facilitating movement or transportation or performing labor in machines. A wheel together with an axle overcomes friction by facilitating motion by rolling. In order for wheels to rotate a moment needs to be applied to the wheel about its axis, either by way of gravity or by application of another external force. Common examples are found in transport applications. More generally the term is also used for other circular objects that rotate or turn, such as a Ship's wheel and flywheel. The wheel originated in ancient.

The wheel is a device that enables efficient movement of an object across a surface where there is a force pressing the object to the surface. Common examples are a cart drawn by a horse, and the rollers on an aircraft flap mechanism. The wheel is not a machine, and should not be confused with the wheel and axle, one of the simple machines. A driven wheel is a special case that is a wheel and axle. Wheels are used in conjunction with axles, either the wheel turns on the axle or the axle turns in the object body. The mechanics are the same in either case. The normal force at the sliding interface is the same. The sliding distance is reduced for a given distance of travel. The coefficient of friction at the interface is usually lower.

3.5 WATER PUMP

A pump is a device used to move gases, liquids, or slurries. A pump moves liquids or gases from lower pressure to higher pressure and overcomes this difference in pressure by adding energy to the system such as a water system. A gas pump is called a compressor, except in very low pressure-rise applications, such as in heating, ventilating, and air-conditioning, where the operative equipment consists of fans or blowers.

Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression. Hand-operated, reciprocating, positive displacement, water pump. A positive displacement pump causes a liquid or gas to move by trapping a fixed amount of fluid or gas and then forcing displacing that trapped volume into the discharge pipe. They are inexpensive and are used extensively for pumping water out of bunds or pumping low volumes of reactants out of storage drums. Conversion of added energy to increase in kinetic energy increase in velocity. Conversion of increased velocity to increase in pressure. Conversion of Kinetic head to Pressure Head. Meet all heads like Kinetic, Potential, and Pressure. Periodic energy addition. Added energy forces displacement of fluid in an enclosed volume. Fluid displacement results in direct increase in pressure. One sort of pump once common worldwide was a hand-powered water pump over a water well where people could work it to extract water, before most houses had individual water supplies.

3.6 ARDUINO

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

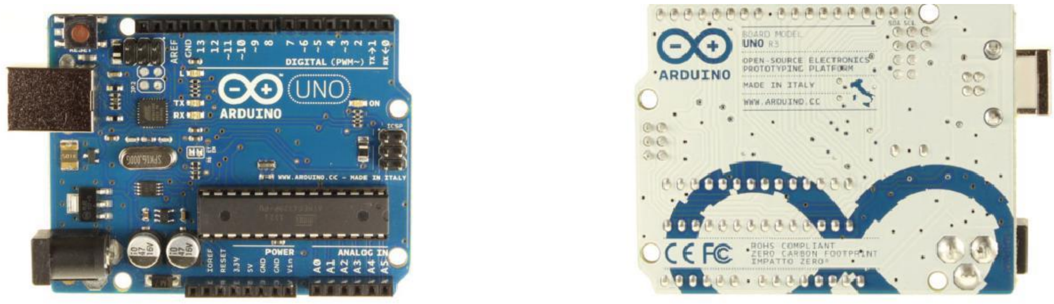
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Revision3 Of The Board Has The Following New Features

1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin that is reserved for future purposes. Atmega 16U2 replace the 8U2.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the

Arduino platform; for a comparison with previous version



Arduino Uno R3 Front   Arduino Uno R3 Back

Fig3.6 Arduino board

3.6.1 Schematic & Reference Design

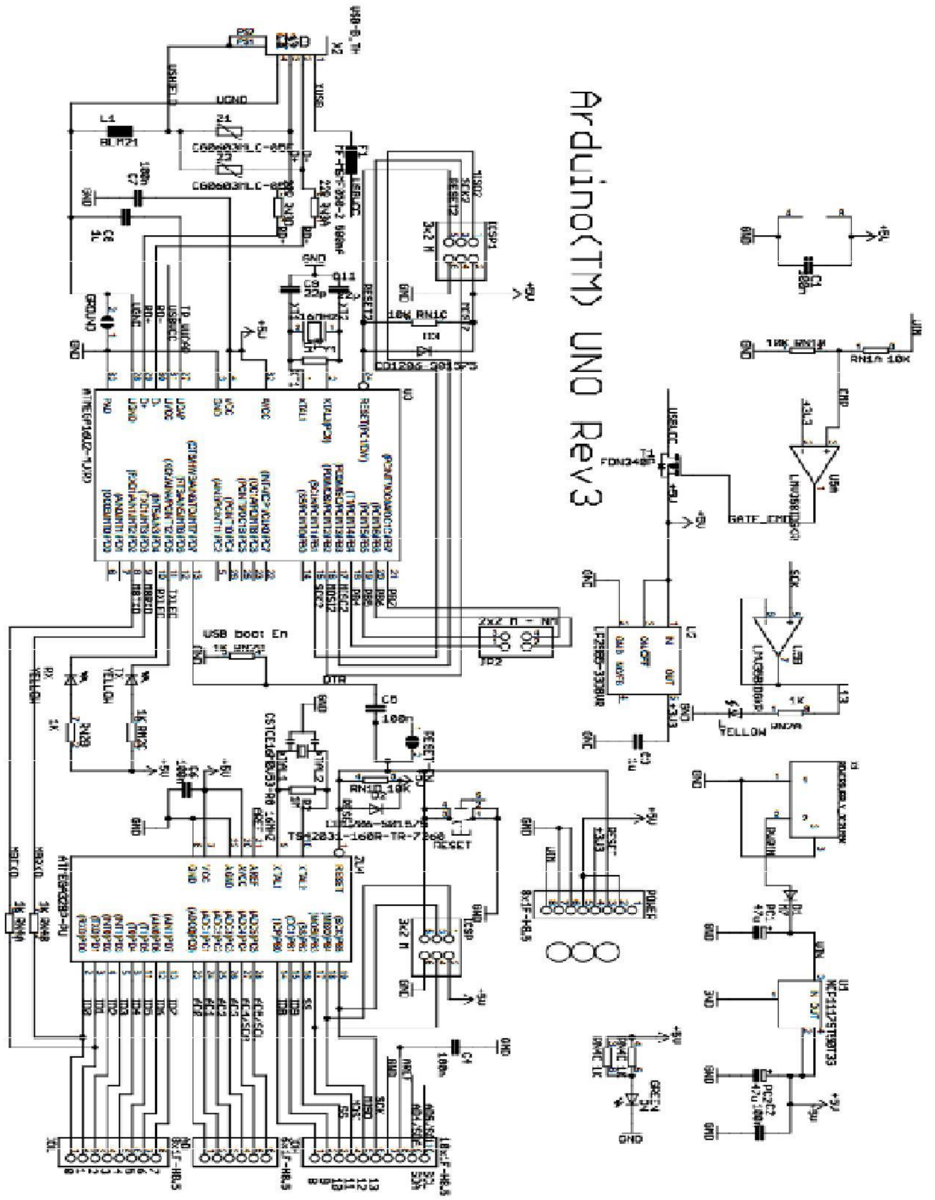


Fig 3.6.1 : Schematic & Reference Design

The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

3.6.2 Specifications

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage	7-12V (recommended)
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

3.6.3 Power

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows

VIN. The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

5V. This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

3V3. A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.

GND. Ground pins.

IOREF. This pin on the Arduino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

2 .5 Memory

The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

3.6.4 Input and Output

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode(), digital Write(), and digital Read()_functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

Serial: 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data.

These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.

External Interrupts: 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. See the attach Interrupt() function for details.

PWM: 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write() function.
SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

LED: 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference() function. Additionally, some pins have specialized functionality:

TWI: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.

There are a couple of other pins on the board:

AREF. Reference voltage for the analog inputs. Used with analog Reference().

Reset. Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

3.6.5 Communication

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 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 '16U2 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. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but 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 ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library.

3.6.6 Programming

The Arduino Uno can be programmed with the Arduino software.The ATmega328 on the Arduino Uno comes preburned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol (reference, C header files).You can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available The ATmega16U2/8U2 is loaded with a DFU boot loader, which can be activated by:On Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2.

On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

You can then use Atmel's FLIP software (Windows) or the DFU programmer (Mac OS X and Linux) to load a new firmware. Or you can use the ISP header with an external programmer (overwriting the DFU boot loader). See this user-contributed tutorial for more information.

3.6.7 Automatic (Software) Reset

Rather than requiring a physical press of the reset button before an upload, the Arduino Uno is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of theATmega8U2/16U2 is connected to the reset line of the ATmega328 via a 100 nano farad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the boot loader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.

This setup has other implications. When the Uno is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the boot loader is running on the Uno.

While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened. If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data. The Uno contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line.

3.6.8 USB Over current Protection

The Arduino Uno has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

3.6.9 Physical Characteristics

The maximum length and width of the Uno PCB are 2.7 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Four screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

L293D Motor Driver

3.7 Introduction:

The L293D motor driver is available for providing User with ease and user friendly interfacing for embedded application. L293D motor driver is mounted on a good quality, single sided non-PTH PCB. The pins of L293D motor driver IC are connected to connectors for easy access to the driver IC's pin functions. The L293D is a Dual Full Bridge driver that can drive up to 1Amp per bridge with supply voltage up to 24V. It can drive two DC motors, relays, solenoids, etc. The device is TTL compatible. Two H bridges of L293D can be connected in parallel to increase its current capacity to 2 Amp.

Fig 3.7 L293D Motor driver

3.7.1 Features

- Easily compatible with any of the system
- Easy interfacing through FRC (Flat Ribbon Cable)
- External Power supply pin for Motors supported
- Onboard PWM (Pulse Width Modulation) selection switch
- 2pin Terminal Block (Phoenix Connectors) for easy Motors Connection

- Onboard H-Bridge base Motor Driver IC (L293D)
-

3.7.2 Technical Specification:

- Power Supply : Over FRC connector 5V DC
- External Power 9V to 24V DC
- Dimensional Size : 44mm x 37mm x 14mm (l x b x h)
    - Temperature Range : 0°C to +70 °C

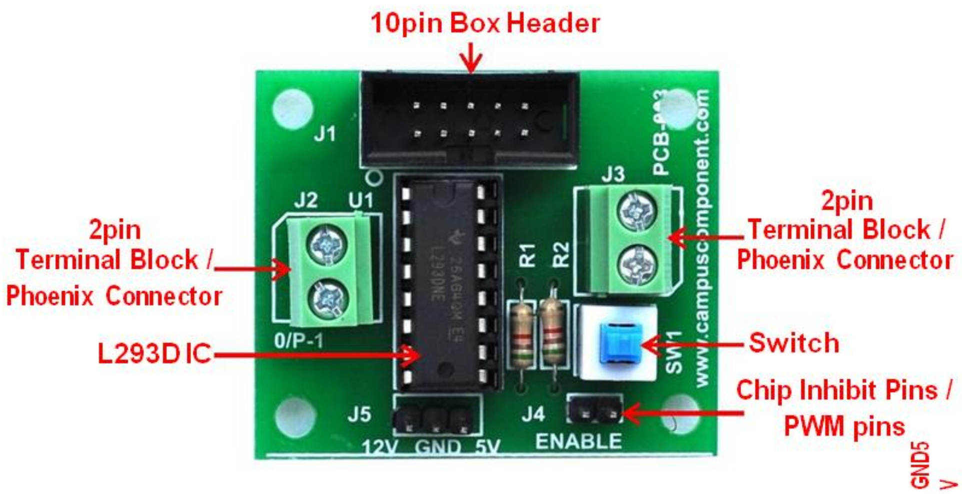


Fig 3.7.2 L293D hardware circuit

3.7.3 L293D IC

The driver IC L293D is quad push-pull drivers capable of delivering output currents to 1A per channel respectively. Each channel is controlled by a TTL-compatible logic input and each pair of drivers (a full bridge) is equipped with an inhibit input available at pin 1 and pin 9. The motor will run only when chip inhibit is at high logic i.e. chip inhibit is enabled.

The connection diagram is shown below:

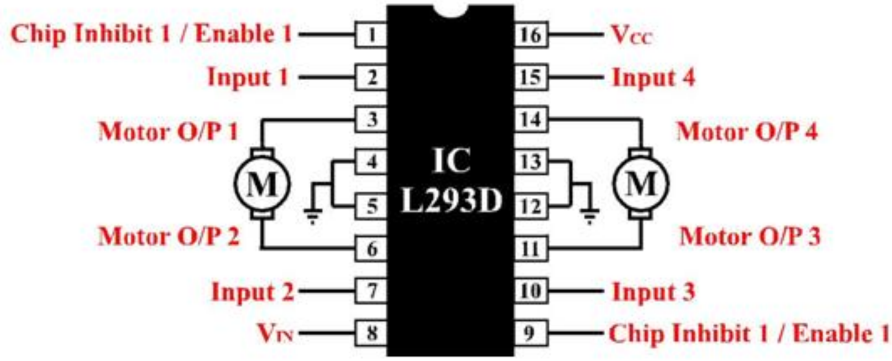


Fig3.7.3 L293D pin setup

Motor Driver Input (10pin Box Header / J1)

The input to the motor driver IC is controlled by the controller through its motor driver input connector. Pin Headers with plastic guide box around them are known as *"Box Headers"* or *"Shrouded Headers"* and are normally only used in combination with a *Flat Ribbon*

Cable (FRC) connector. A *notch* (key) in the guide box normally prevents placing connector the wrong way around. *Box Header* (denoted as J1 on board)can be connected using *FRC*s and also

Single Berg Wires for individual pin connections. It has following configuration:

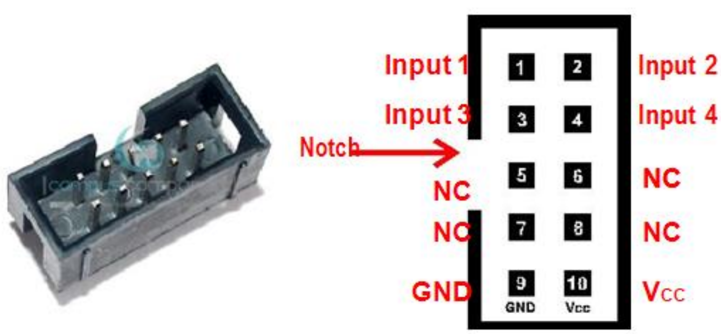


Fig3.7.4 pin box header

3.7.4 FRC Cable

Two FRC Connectors can be connected with the help of FRC cable. FRC cable has following pin configuration.

Fig3.7.5 FRC cable

Motor Output/2pin Terminal Block/Phoenix Connector (J2 and J3)

2pin Terminal Block (also known as Phoenix connectors) are used for motor connection. With one IC L293D, two motor can be interfaced and hence two 2pin Terminal Blocks (Phoenix connectors denoted as J2 and J3) are provided onboard for easy motor connection. Each terminal Block has two pockets to insert wire into it. User just need to insert uninsulated wire into one of the pocket and then tighten the screw to fit wire into it.

Fig 3.7.6 . 1 2pin terminal block/phoenix connector.

PWM selection Switch (SW1) and Enable pins (J4)

This is *push-on push-off DPDT* Switch (denoted as SW1 on board). When switch is in OFF state then 100% PWM (Pulse Width Modulation) is provided irrespective of the voltage levels at Enable pins (denoted as Chip Inhibit pins in diagram of IC, denoted as J4 onboard), whereas when switch is ON then the PWM will be set according to the voltage level at enable pins.

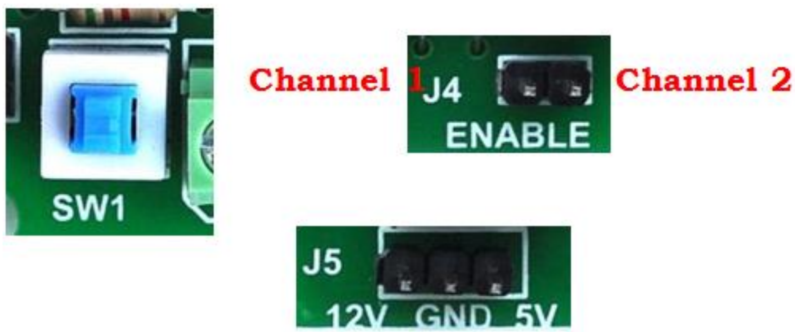


Fig 3.7.7 reset, supply pins, enable pins

VCC, GND and VIN pins (J5)

These pins are used to provide power supply to L293D IC as well as motors connected through Phoenix Connectors (J2 and J3). VCC (denoted as +5V on board) is +5V DC supply pin where User needs to provide external +5V input voltage for IC. GND (denoted as GND on board) is 0V supply pin to make common ground for other system through which motor will be controlled. VIN (denoted as +12V onboard) is input voltage / supplied voltage to DC motors connected through Phoenix connector. It ranges from 9V to 24V with maximum current consumption up to 1Amp. Generally User just need to connect +12V pin as +5V and GND can be get through FRC.

3.8 IR SENSORS

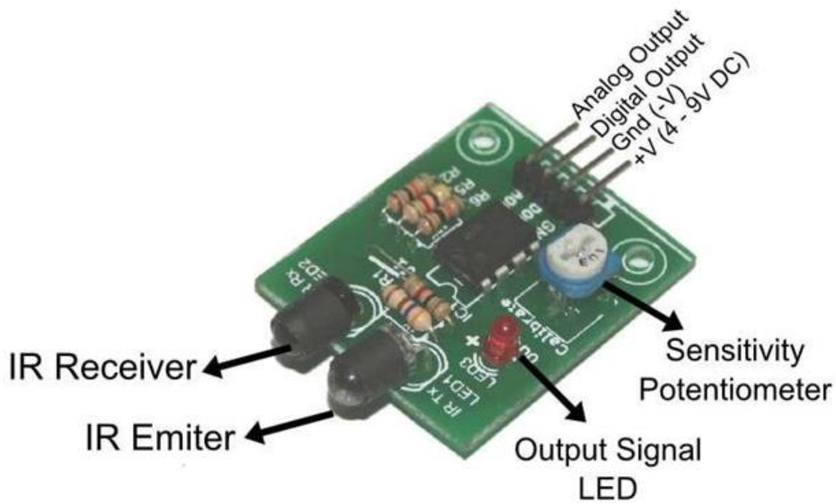


Fig3.20 IR sensors

3.8.1 Introduction

Infrared radiation is the portion of electromagnetic spectrum having wavelengths longer than visible light wavelengths, but smaller than microwaves, i.e., the region roughly from 0.75µm to 1000 µm is the infrared region. Infrared waves are invisible to human eyes. The wavelength region of 0.75µm to 3 µm is called near infrared, the region from 3 µm to 6 µm is called mid infrared and the region higher than 6 µm is called far infrared. (The demarcations are not rigid; regions are defined differently by many). infrared is light that has a wavelength longer than visible red light. The ranges of infrared include near infrared, mid infrared and far infrared, spanning wavelengths from about 710 nanometers (near infrared) to 100 micrometers (far infrared).

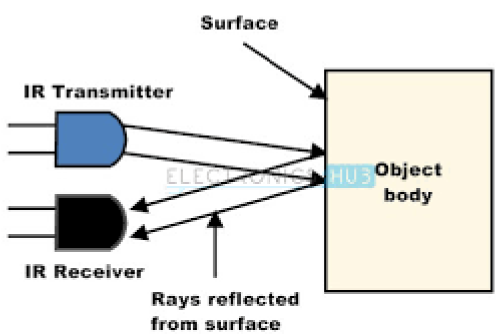
All objects emit light according to their temperature--this is called "black body radiation." The hotter the object, the shorter wavelength of light it emits. The Earth emits infrared light at a peak of about nine to 10 micrometers--and so do warm-blooded animals like humans. This light can be used to detect motion or warmth.

LED IR Detectors

IR (infrared) sensors detect infrared light. The IR light is transformed into an electric current, and this is detected by a voltage or amperage detector.A property of light-emitting diodes (LEDs) is that they

produce a certain wavelength of light when an electric current is applied--but they also produce a current when they are subjected to the same wavelength light.

A pair of IR LEDs can be used as motion detectors. The first IR LED is wired to emit LED and the second LED is wired to transmit a signal when it receives an IR input. When an object comes within range of the emitted IR, it reflects the IR back to the receiving LED and produces a signal. This signal can be used to open sliding doors, turn on a light or set off an alarm.



See For Yourself

IR detectors (and emitters) can be found almost everywhere. If you have a computer mouse with a red LED or laser--it is using IR light. Try using this mouse on a damp mouse pad--water almost completely absorbs the IR and the mouse won't work as well.

TV and stereo remotes also use IR signals--the TV has an IR detector that interprets the signal from the remote. Most digital cameras are sensitive to IR light. Turn on your camera and point the TV remote at the camera. Press a button on the remote and you will see a pinkish or purplish light coming out of the remote on the LCD display of the

camera. That is the IR signal from the remote
An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation. It is also capable of measuring heat of an object and detecting motion. Infrared waves are not visible to the human eye.

In the electromagnetic spectrum, infrared radiation is the region having wavelengths longer than visible light wavelengths, but shorter than microwaves. The infrared region is approximately demarcated from 0.75 to 1000µm. The wavelength region from 0.75 to 3µm is termed as near infrared, the region from 3 to 6µm is termed mid-infrared, and the region higher than 6µm is termed as far infrared.

Infrared technology is found in many of our everyday products. For example, TV has an IR detector for interpreting the signal from the remote control. Key benefits of infrared sensors include low power requirements, simple circuitry, and their portable feature.

3.8.2 Features

This is a multipurpose infrared sensor which can be used for obstacle sensing, color detection (between basic contrasting colors), fire detection, line sensing, etc and also as an encoder sensor. The sensor provides a digital and an analog output. The sensor outputs a logic one (+5V) at the digital output when an object is placed in front of the sensor and a logic zero (0V), when there is no object in front of the sensor. An onboard LED is used to indicate the presence of an object. The sensor outputs an analog voltage between 0V and 5V, corresponding the distance between the sensor and the object at the analog output. The analog output can be hooked to an ADC to get the approximate distance of the object from the sensor.

IR sensors are highly susceptible to ambient light and the IR sensor on this sensor is suitably covered to reduce effect of ambient light on the sensor. The sensor has a maximum range of around 40-50 cm indoors and around 15-20 cm outdoors. Operating voltage: 3 to 9V (Range maximum for 9V)

- Range of 50 cm for white objects and 35 cm for black objects(varies with surrounding light conditions)
- Comes with a highly useful analog output along with an easy to use digital output
- Sensor comes with ambient light protection
- The sensor has 2 holes of 3mm diameter for easy mounting.

Using the sensor

The sensor has a simple 4 pin interface –> +V(5V), Gnd, Digital Out and Analog Out. The sensor can operate within an operating voltage of 4 to 9V. The input power should be provided to the +V (Vcc) and the Gnd pin. The digital output of the sensor is provided on the third pin – Dout. The analog output of the sensor is provided on the third pin – Aout. Once the sensor is powered up, you will have to calibrate the sensor for the specific environment it will be used in. To calibrate the sensor, you will have to set the potentiometer by turning its knob by hand or a screw driver. You will have to power the sensor and rotate the knob of the potentiometer until the output of the sensor changes from high to low.

3.8.3 Types of Infra-Red Sensors

Infra-red sensors are broadly classified into two types:

- **Thermal infrared sensors** – These use infrared energy as heat. Their photo sensitivity is independent of wavelength. Thermal detectors do not require cooling; however, they have slow response times and low detection capability.

- **Quantum infrared sensors** – These provide higher detection performance and faster response speed. Their photo sensitivity is dependent on wavelength. Quantum detectors have to be cooled so as to obtain accurate measurements. The only exception is for detectors that are used in the near infrared region.

3.8.4 Working Principle

A typical system for detecting infrared radiation using infrared sensors includes the infrared source such as blackbody radiators, tungsten lamps, and silicon carbide. In case of active IR sensors, the sources are infrared lasers and LEDs of specific IR wavelengths. Next is the transmission medium used for infrared transmission, which includes vacuum, the atmosphere, and optical fibers.

Thirdly, optical components such as optical lenses made from quartz, CaF_2, Ge and Si, polyethylene Fresnel lenses, and Al or Au mirrors, are used to converge or focus infrared radiation. Likewise, to limit spectral response, band-pass filters are ideal.

Finally, the infrared detector completes the system for detecting infrared radiation. The output from the detector is usually very small, and hence pre-amplifiers coupled with circuitry are added to further process the received signals.

3.8.5 Applications

The following are the key application areas of infrared sensors:

- Tracking and art history
- Climatology, meteorology, and astronomy
- Thermography, communications, and alcohol testing
- Heating, hyper spectral imaging, and night vision\
- Biological systems, photobiomodulation, and plant health

Hand operated pumps are considered the most sustainable low-cost option for safe water supply in resource settings, A hand pump opens access to deeper groundwater that is often not polluted and improves the safety of a well by protecting the water source from contaminated buckets. This means that communities are often stuck without spares and cannot use their hand pump anymore and have to go back to traditional and sometimes distant, polluted resources. This is unfortunate, as water projects often have put in a lot of resources to provide that community with a hand pump.

3.9 TUBE

A hose is a hollow tube designed to carry fluids or air from one location to another. Hoses are also sometimes called tube or pipes (the word pipe usually refers to a rigid tube, whereas a hose is usually a flexible one), or more generally tubing. The shape of a hose is usually cylindrical (having a circular cross section). Hose design is based on a combination of application and performance. Common factors are Size, Pressure Rating, Weight, Length, Straight hose or Coil hose and Chemical Compatibility. Hoses are made from one or a combination of many different materials. Applications mostly use nylon, polyurethane, polyethylene, PVC, or synthetic or natural rubbers, based on the environment and pressure rating needed. In recent years, hoses can also be manufactured from special grades of polyethylene (LDPE and especially LLDPE). Other hose materials include PTFE (Teflon), stainless steel and other metals.

SOFTWARE DESCRIPTION

3.10 creating project in arduino 1.7.11 version

ARDUINO IDE INSTALLATION:

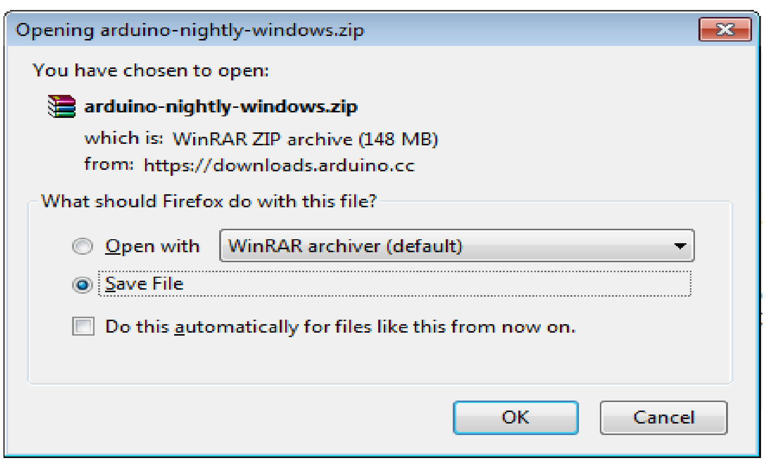
In thise we will get know of the process of installation of Arduino IDE and connecting Arduino uno to Arduino IDE.

Step 1

First we must have our Arduino board (we can choose our favorite board) and a USB cable. In case we use Adriana UNO, Arduino Duemilanove, Nano, Arduino Mega 2560, or Diecimila, we will need a standard USB cable (A plug to B plug), t In case we use Arduino Nano, we will need an A to Mini-B cable..

Step 2 − Download Arduino IDE Software. We can get different versions of Arduino IDE from the Download page on the Arduino Official website. We must select wer software, which is compatible with wer operating system (Windows, IOS, or Linux).

After wear file download is complete, unzip the file.



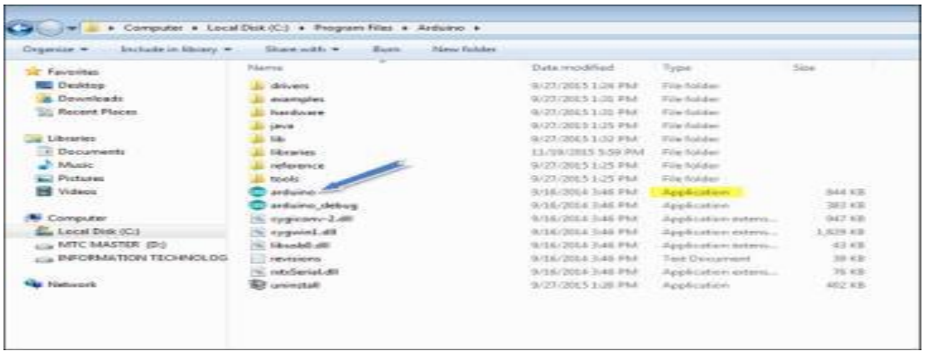
Step 3 − Power up our board.

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 we are using an Arduino Diecimila, we 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 wer computer using the USB cable. The green power LED (labeled PWR) should glow.

Step 4 − Launch Arduino IDE.



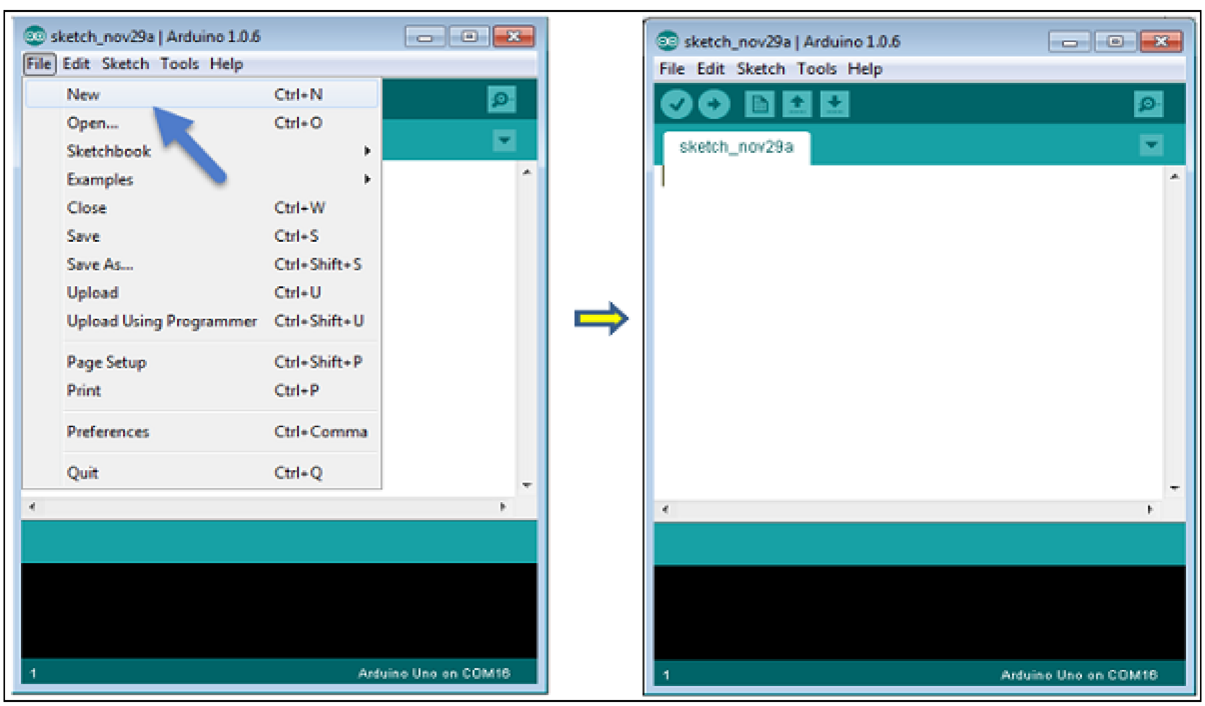
After our Arduino IDE software is downloaded, we need to unzip the folder. Inside the folder, we can find the application icon with an infinity label (application.exe).

Double click the icon to start the IDE.

Step 5 − Open our first project.

Once the software starts, we have two options

* Create a new project



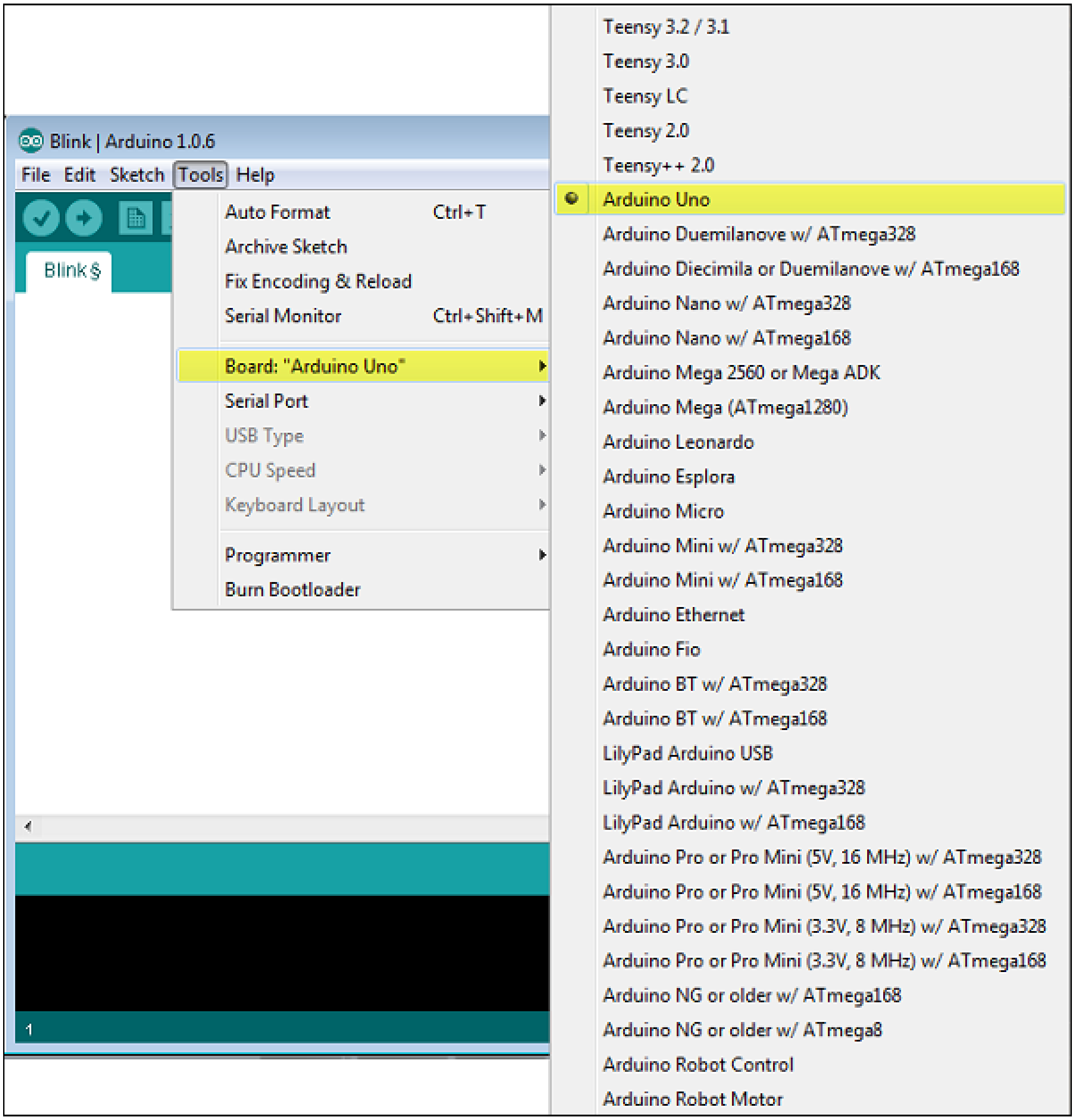
* Open an existing project example.

To create a new project, select File → New.

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

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

Step 6 − Select our Arduino board.

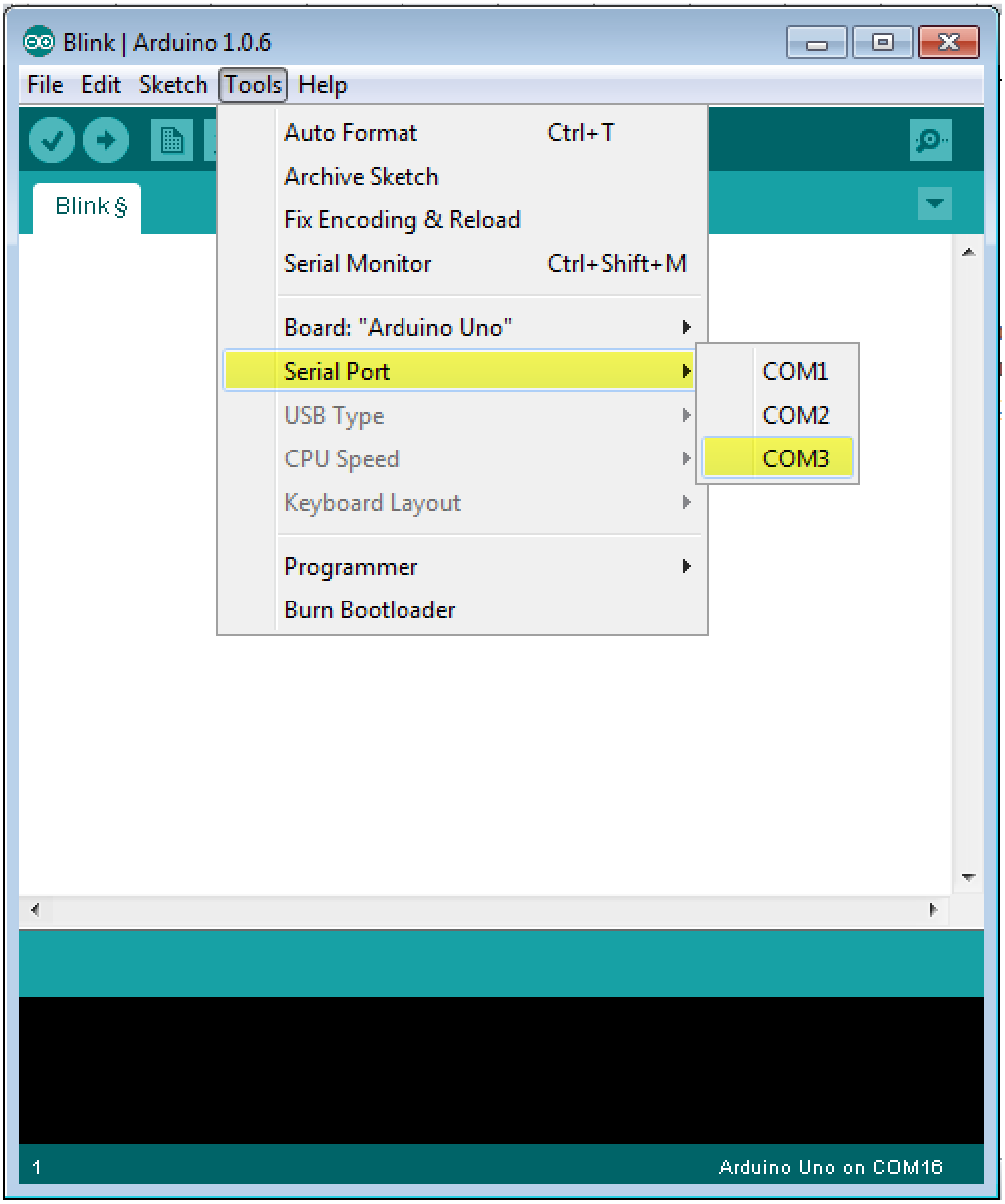


To avoid any error while uploading wear program to the board, we must select the correct Arduino board name, which matches with the board connected to wer computer.

Go to Tools → Board and select wear board.

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

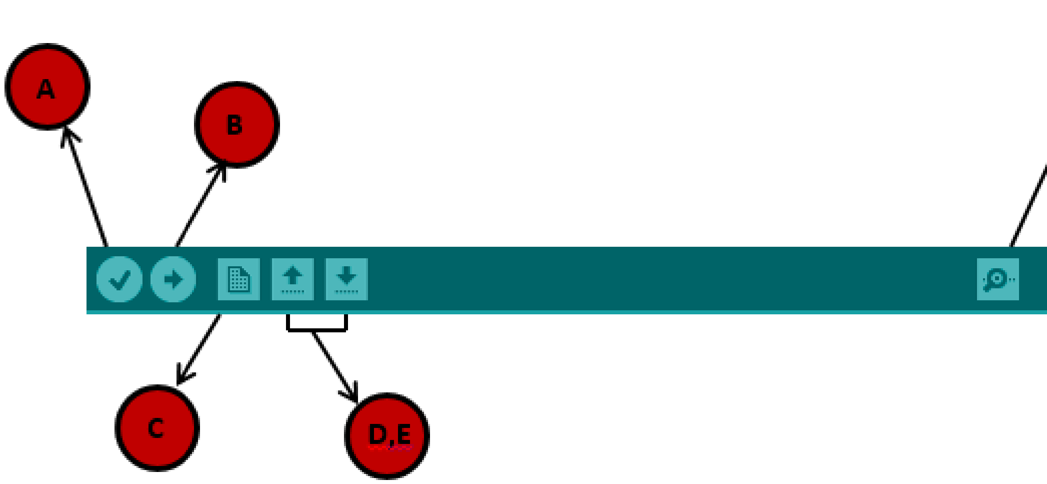
Step 7 − Select wer serial port.



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, we can disconnect wer 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 wer 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 wer 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; we 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.

Note − If we have an Arduino Mini, NG, or other board, we need to press the reset button

physically on the board, immediately before clicking the upload button on the Arduino Software.

CHAPTER-4

DESIGN AND DRAWING

SOLAR PANEL CLEANING ROBOT

4.1CIRCUIT DIAGRAM

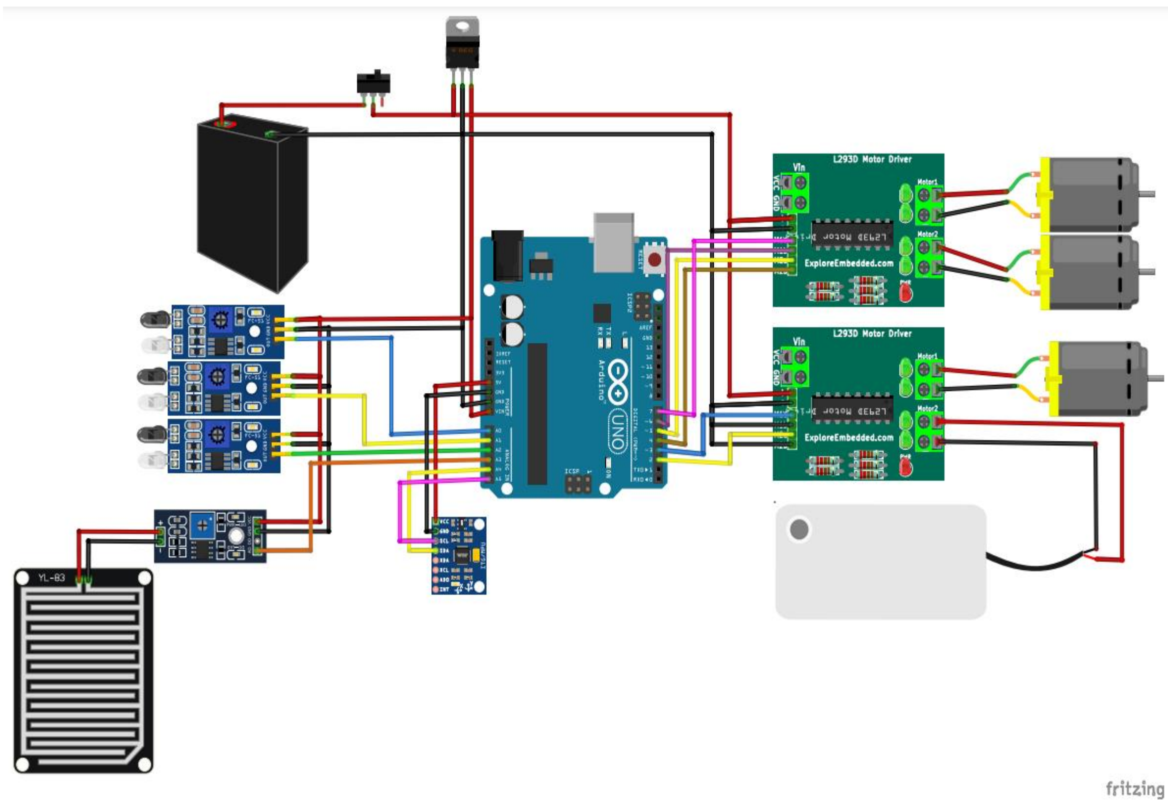


Fig 4.1 Circuit Diagram

4.2 DRAWING

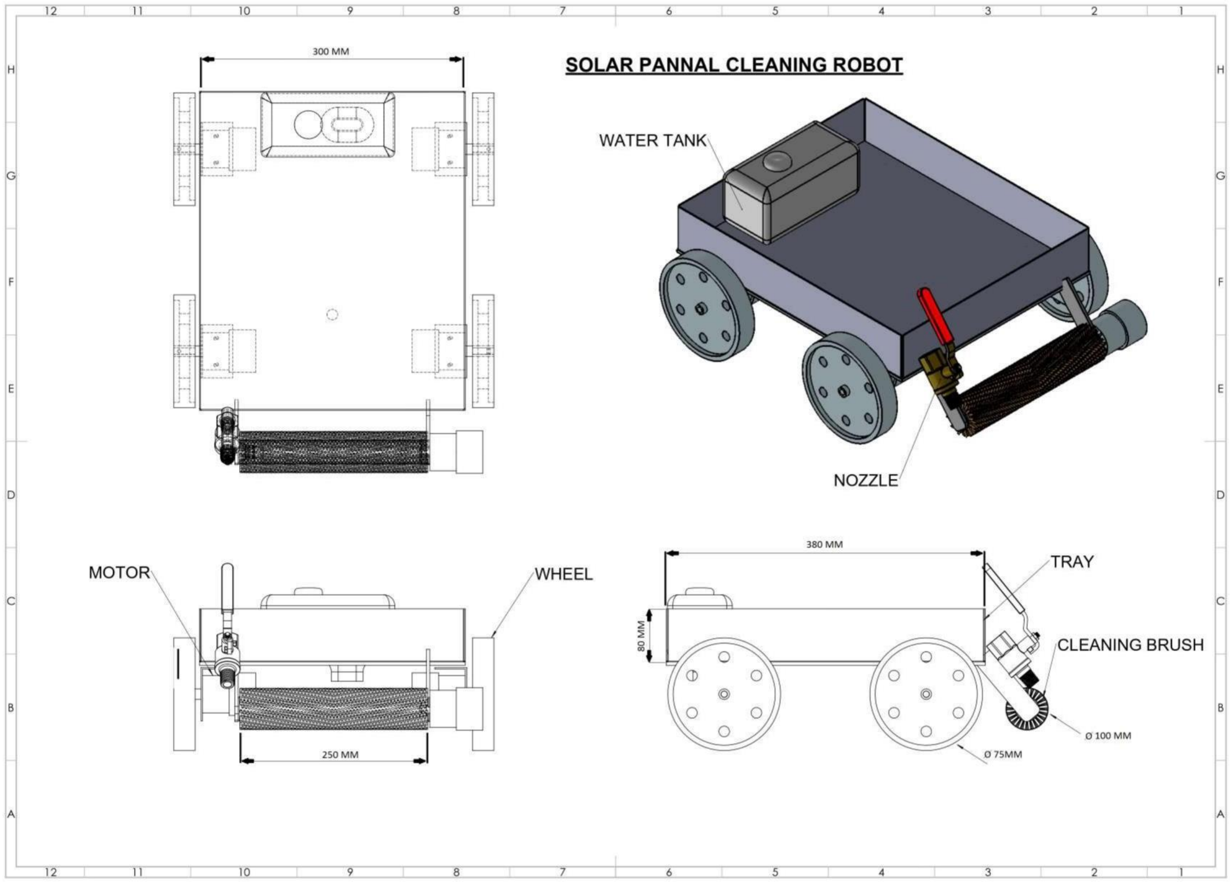


Fig 4.2 Drawings of Solar Panel cleaning robot

4.3 DESIGN

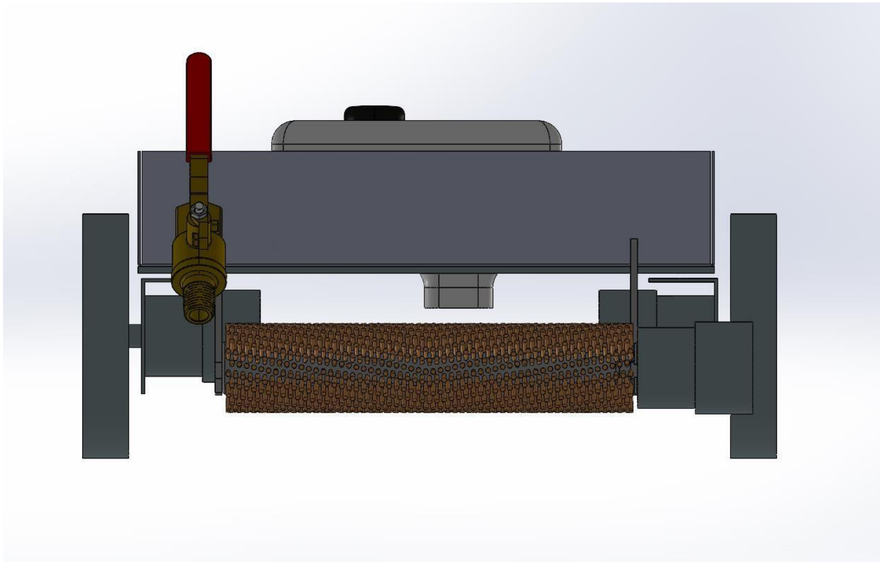


Fig 4.3.1 Front View

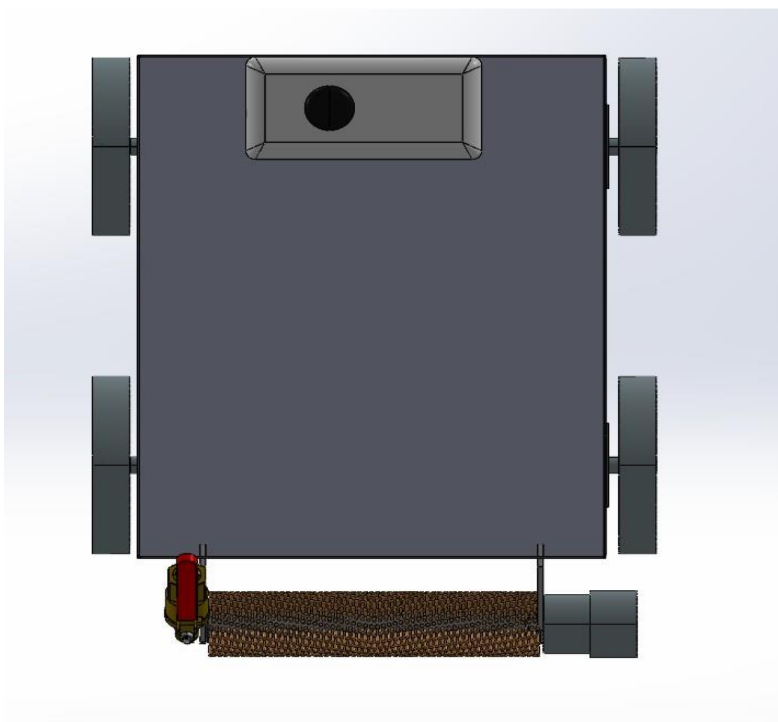


Fig 4.3.2 Top View

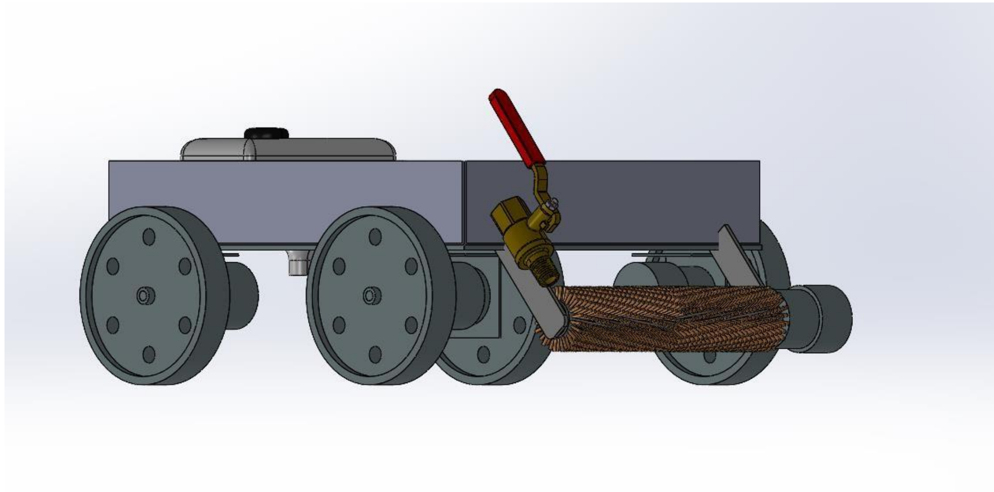


Fig 4.3.3 Side View

CHAPTER-5

WORKING METHODOLOGY

The carrier robot, along with the cleaning robot moves towards the solar panel and stops its movement by sensing the solar panel. The carrier robot then sends the signal to the cleaning robot. By receiving the signal, the cleaning robot travels to the entire length of the solar panel in both forward and left and right directions and cleans the panel for the specified time duration.

FACTORS DETERMINING THE CHOICE OF MATERIALS

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

1. **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

   a. Physical
   b. Mechanical
   c. From manufacturing point of view
   d. 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, torsional and buckling load, fatigue resistance, impact resistance, elastic limit, endurance limit, and modulus of elasticity, hardness, wear resistance and sliding properties.

The various properties concerned from the manufacturing point of view are,

1. Cast ability
2. Weld ability
3. Surface properties
4. Shrinkage
5. Deep drawing etc.

2. Manufacturing case:

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

3. Quality Required:

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

4.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.

5.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.

CHAPTER-6

RESULTS AND CONCLUSION

This project highlights the effect of dust, dirt, pollen, sea salt, and bird droppings on the PV systems' efficiency. Dust has a major impact on the efficiency and performance of the solar panels. The reduction in the peak power generation can be up to 10 to 30%. Power reduction was observed due to dust accumulation on the panels, and this can be improved by using robotic cleaning method. It has increased Power generation capacity of the solar panels. Easy maintenance, low cost and less power usage are few advantages of this process. Finally, the reduction in the peak power generation can also be overcome by using this cleaning system. The device is lightweight because most of its material is made of aluminum. Comparing the costs of cleaning by Manual operation and Automatic operation, the cost for automatic cleaning is proved to be more economic and significantly less cumbersome, particularly, in systems with large number of solar panels. Frequent and periodical cleaning ensures that the solar panels work consistently with a good transmittance at all times

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