NEW HORIZON
COLLEGE OF ENGINEERING
New Horizon Knowledge Park, Ring Road, Marathalli
Autonomous College Permanently Affiliated to VTU, Approved by AICTE & UGC
Accredited by NAAC with 'A' Grade, Accredited by NBA

"SELF-BALANCING ROBOT"

A MINI PROJECT REPORT

Submitted by

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In partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING
IN

ELECTRONICS AND COMMUNICATION

NEW HORIZON COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the mini project work entitled "**SELF-BALANCING ROBOT**" carried out by**, P.SREERAJ(1NH18EC084),S.SAIHASAN(1NH018EC084),V.MAHESH(1NH18EC118),V.CHETAN(1NH18EC084)** bonafide students of Electronics and Communication Department, New Horizon College of Engineering, Bangalore.

The mini project report has been approved as it satisfies the academic requirements in respect of mini project work prescribed for the said degree.

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Name of Examiner   Signature with Date

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ACKNOWLEDGEMENT

The satisfaction that accompany the successful completion of any task would be, but impossible without the mention of the people who made it possible, whose constant guidance and encouragement helped us succeed.

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We sincerely acknowledge the encouragement, timely help and guidance to us by our beloved guide **DR K.C.R.NISHA** to complete the project within stipulated time successfully.

Finally, a note of thanks to the teaching and non-teaching staff of electronics and communication department for their co-operation extended to us, who helped us directly or indirectly in this successful completion of mini project.

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ABSTRACT

A self-balancing robot is creating a robot that is a replica of a human body. Traditional robots consisted of four wheels, were easily stabilized and comparatively bigger in size. A traditional robot uses four wheels and four motors for movement, while a self-balancing robot uses only two wheels and motors for movement. A very famous application of the self-balancing robot is the Segway. Segway is readily available in market since 2011 and is also termed as a “Human Transporter”. It is used mostly to cover shorter distances. It is a self-balancing robot where human weight and angle plays a vital role on controlling the movement of the seg-way. These types of robots are based on the physical theory of inverted pendulum. The system in itself requires active control in order to be stable. The main aim of this project is to use the self-balancing robot interfaced with a camera for Search and Rescue purposes. Mapping, maneuvering and updating natural calamities, terror attacks, accidents explosions etc. To send the robot inside unpredictable and hard-to-access areas like unknown and narrow caves, where human intervention is not possible and is risky if tried blind eyed.

Two wheeled balancing robots are an area of research that may well provide the future locomotion for everyday robots. The unique stability control that is required to keep the robot upright differentiates it from traditional forms of robotics. The inverted pendulum principle provides the mathematical modelling of the naturally unstable system. This is then utilized to develop and implement a suitable stability control system that is responsive, timely and successful in achieving this objective. Completing the design and development phase of the robot requires careful consideration of all aspects including operating conditions, materials, hardware, sensors and software. This process provides the ongoing opportunity of implementing continued improvements to its perceived operation whilst also ensuring that obvious problems and potential faults are removed before construction. The construction phase entails the manufacture and assembly of the robots circuits, hardware and chassis with the software and programming aspects then implemented. The later concludes the robots production where the final maintenance considerations can be determined. These are essential for ensuring the robots continued serviceability.

CHAPTER 1

INTRODUCTION

Robotics has always been played an integral part of the human psyche. The dream of creating a machine that replicates human thought and physical characteristics extends throughout the existence of mankind. Developments in technology over the past fifty years have established the foundations of making these dreams come true. Robotics is now achievable through the miniaturisation of the microprocessors which performs the processing and computations. New forms of sensor devices are being developed all the time further providing machines with the ability to identify the world around them in so many different ways.

To make a self-balancing robot, it is essential to solve the inverted pendulum problem or an inverted pendulum on cart. While the calculation and expressions are very complex, the goal is quite simple.
goal of the project is to adjust the wheels'

the position so that the inclination angle remains stable within a pre-determined value, When the robot starts to fall in one direction, the wheels should move in the inclined direction with a speed proportional to angle and acceleration of falling to correct the inclination angle. So I get an idea that when the deviation from equilibrium is small, we deviation is large we should move more quickly.

To simplify things a little bit, I take a simple confined on one axis (e.g. only move forward and backward) and thus both wheels will move at the same speed in the same direction. Under this assumption the mathematics become much simpler as we only need to worry about sensor readings on a single plane. If we want to allow the robot to move sidewise, then you will have to control each wheel independently. The general idea remains the same with a less complexity since the falling direction of the robot is still restricted to a single axis.

Two –wheeled or self-balancing robot is an unstable dynamic system unlike other four wheeled stale robots that are in equilibrium state. By unstable, here, we mean that the robot is free to fall ahead or backward direction without any application of force. Self-balancing means the robot balancing itself in an equilibrium state, 90 degrees upright position. This project works on the inverted pendulum concept. We are making use of Arduino Uno to build the self-balancing robot. We are using the inertial measurement unit MPU6050 for measuring the current tilt angle. A PID controller will be able to control the pendulum angle. The Raspberry pi, pi camera will help us determine the surrounding conditions through live streaming and help in the search and rescue operations. Having a clear idea of the state of devastation prior to sending any human inside a natural calamity struck area is the sole purpose of this project. To provide important information about the surrounding is why we are using a two wheeled robot mounted with a camera and sensors which help him to move.

The field of robotics is the playground of the creative minds of modern age. Dreams turned into reality with the development in this field. Two wheel self-balancing robot is also an example of advanced development in the field of robotics. The concept of two wheel self-balancing robot is based on Inverted pendulum theory. This type of robot has earned interest and fame among researchers and engineers of worldwide as it based on such a control system that is used to stabilize an unstable system using efficient micro controllers and sensors. These robots provide exceptional robustness and capability due to their smaller size and power requirements. These types of implementations find applications in several purposes such as surveillance & transportation. This project is based on development of a self-balanced two wheeled robot. In particular, the focus is on the electro-mechanical mechanisms & control algorithms required to enable the robot to perceive and act in real time. Similar concept can be applied in various control system with complex implementation such as humanoid robot, industrial robots, etc.

The self-balancing robot, concept of two-wheel inverted pendulum has gained momentum in research over the last few years. Inherently self-balancing robot is unstable and it would roll around the wheels' rotation axis without external control and eventually fall.A special electromechanical system in which the robot has to be based on balances itself onto a pair of wheels while standing tall. A self-balancing algorithm is programmed into the controller and the controller drives the motors either clockwise or anticlockwise to balance the basement by a pulse width modulation (PWM) control signal.

The robot is naturally unstable although, it has many favors over the statically stable multi wheeled robots. A special electromechanical system in which the robot has to be based on balances itself onto a pair of wheels while standing tall. If the base on which the robot stand is not stable or the platform is not balanced, the robot tend to falling off from the vertical axis. This time a gyro chip is needed to provide the PID controller about the angular position of the base of the self-balancing robot . A self-balancing algorithm is programmed into the controller and the controller drives the motors either clockwise or anticlockwise to balance the basement by a pulse width modulation (PWM) control signal. The robot has to be work upon any type of surface based on two motors constructed with wheel one for each.

CHAPTER 2

LITERATURE SURVEY

Title of the paper	Author & year of publications	Outcome
Design of a logic controller for two-wheeled self-balancing robot	Junfeg Wu, Wanying Zhang 15th September 2011 (proceedings of 6th international forum on strategic technology)	State-feedback controller and logic controller are both designed, both of which have good simulation curves at the same disturbance force.
Self-balancing Robot Modeling and Control Using Two Degree of Freedom PID Controller	Ahmad Taher Azar, Hossam Hassan, (January-2019)	Numerical simulation results indicate that the 2-DOF PID controller is superior to the traditional PID controller.
An experimental study on the PID and Fuzzy-PID controllers on a designed two-wheeled self-balancing autonomous robot	Rasoul sadeghian, Mehdi Tale Masoule , (2016 4th international conference on control, instrumentation, and automation	The controllers parameters are tuned with the Genetic algorithm. Fuzzy logics are used to improve the balance ability especially under external forces.

CHAPTER 3

EXISTING SYSTEM

Previous two wheeled balancing robot projects include the Segway, nBot, Bender Emiew and Emiew 2. The Emiew 2 robot is the enhanced (evolved) version of the original Emiew. They were both designed and created by Hitachi whilst the Segway was designed and developed by Dean Kamen who later formed the company Segway Inc. The remaining robots that were reviewed were created by robot enthusiasts who have continued to improve the robustness of their designs over time.

The design concepts between these robots are very similar. Each typically utilise a gyroscope to measure tilt, shaft encoders to measure distance and a microcontroller for performing the computations. These components combine to provide the basis of International Journal of Robotics and Autonomous System Volume3 Issue 1 maintaining stability. Inclinometers or accelerometers are sometimes added to reduce the effects of gyroscope drift thus enabling a more accurate input signal for the control system.

Segway (Segway 2008) is the commercially available two wheeled robot that is currently in its 2nd generation of released models. It is marketed to the world as a transport alternative with the image contained within the following figure. Its advertising suggests the robot is ideal for adventure, commuting, law enforcement and transportation in general.

CHAPTER 4

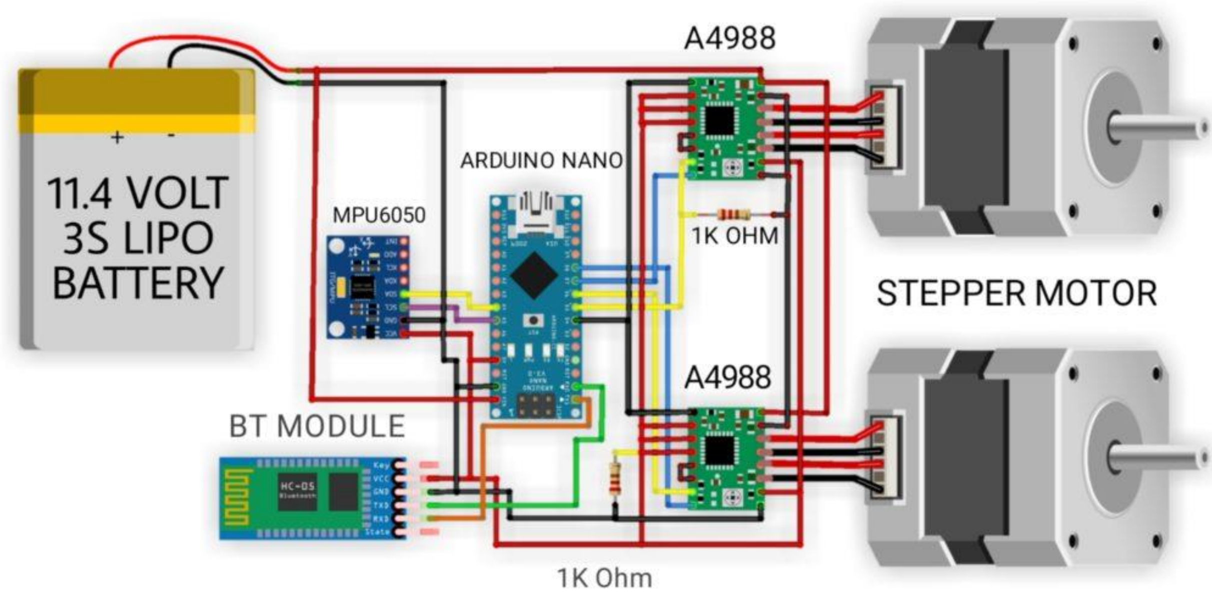
PROPOSED SYSTEM

The self-balancing robot gets balanced on a pair of wheels having the required grip providing sufficient friction. For maintaining vertical axis two things must be done, one is measuring the inclination angle and other is controlling of motors to move forward or backwards to angle, two sensors, accelerometer and gyroscope are used. Accelerometer can sense either static or dynamic forces of acceleration and Gyroscope measures the angular velocity.

maintain 0˚angle with vertical axis. For measuring the

The outputs of the sensors are fused using a Complementary filter. Sensors measure the process output say α which gets subtracted from the reference set-point value to produce an error. Error is then fed into the PID where the error gets managed in three ways. After the PID algorithm processes the error, the then gets fed into the process under control. Process under PID control is two wheeled robot. PID control signal will try to drive the process to the desired set-point in such a way that the robot is balanced.

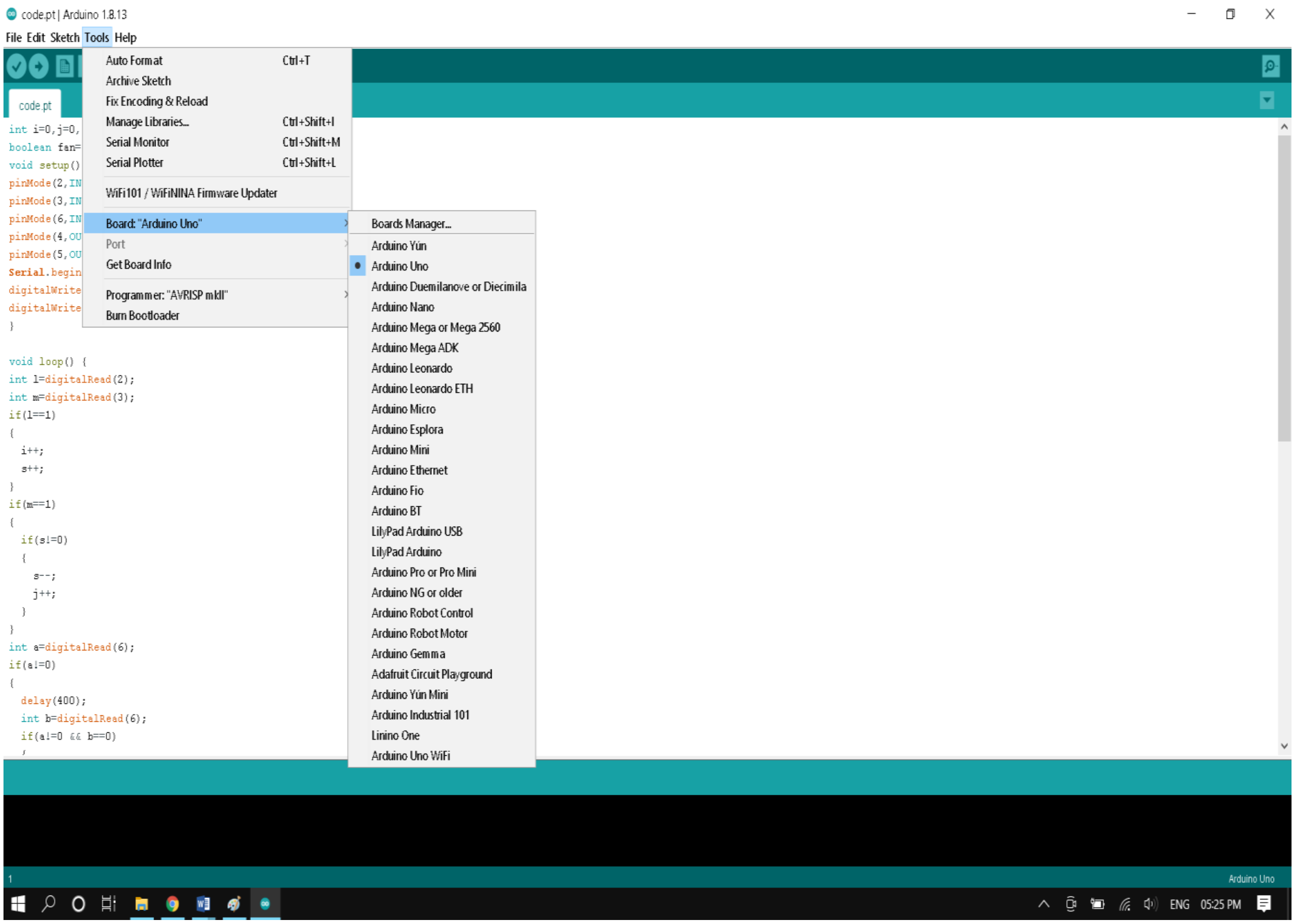
CIRCUIT DIAGRAM AND WORKING:-



controller produces a control signal µ. PID control signal

STEPS TO UPLOAD CODE :-

- Select Board “Arduino Nano” by following the path Tools →Board→ Arduino .
- Then connect the arduino board to your laptop via arduino cable.
- Then click on compile and check if there are any errors.If no errors then click on “ → ” to upload code onto arduino board.



code.pt | Arduino 1.8.13
File Edit Sketch Tools Help
Auto Format Ctrl+T
Archive Sketch
Fix Encoding & Reload
Manage Libraries... Ctrl+Shift+I
Serial Monitor Ctrl+Shift+M
Serial Plotter Ctrl+Shift+L
WiFi101 / WiFiNINA Firmware Updater
Board: "Arduino Uno"
Port
Get Board Info
Programmer: "AVRISP mkII"
Burn Bootloader
Boards Manager...
Arduino Yún
Arduino Uno
Arduino Duemilanove or Diecimila
Arduino Nano
Arduino Mega or Mega 2560
Arduino Mega ADK
Arduino Leonardo
Arduino Leonardo ETH
Arduino Micro
Arduino Esplora
Arduino Mini
Arduino Ethernet
Arduino Fio
Arduino BT
LilyPad Arduino USB
LilyPad Arduino
Arduino Pro or Pro Mini
Arduino NG or older
Arduino Robot Control
Arduino Robot Motor
Arduino Gemma
Adafruit Circuit Playground
Arduino Yún Mini
Arduino Industrial 101
Linino One
Arduino Uno WiFi
void loop() {
int l=digitalRead(2);
int m=digitalRead(3);
if(l==1)
i++;
s++;
if(m==1)
if(s!=0)
s--;
j++;
int a=digitalRead(6);
if(a!=0)
delay(400);
int b=digitalRead(6);
if(a!=0 && b==0)
Arduino Uno

FIG:

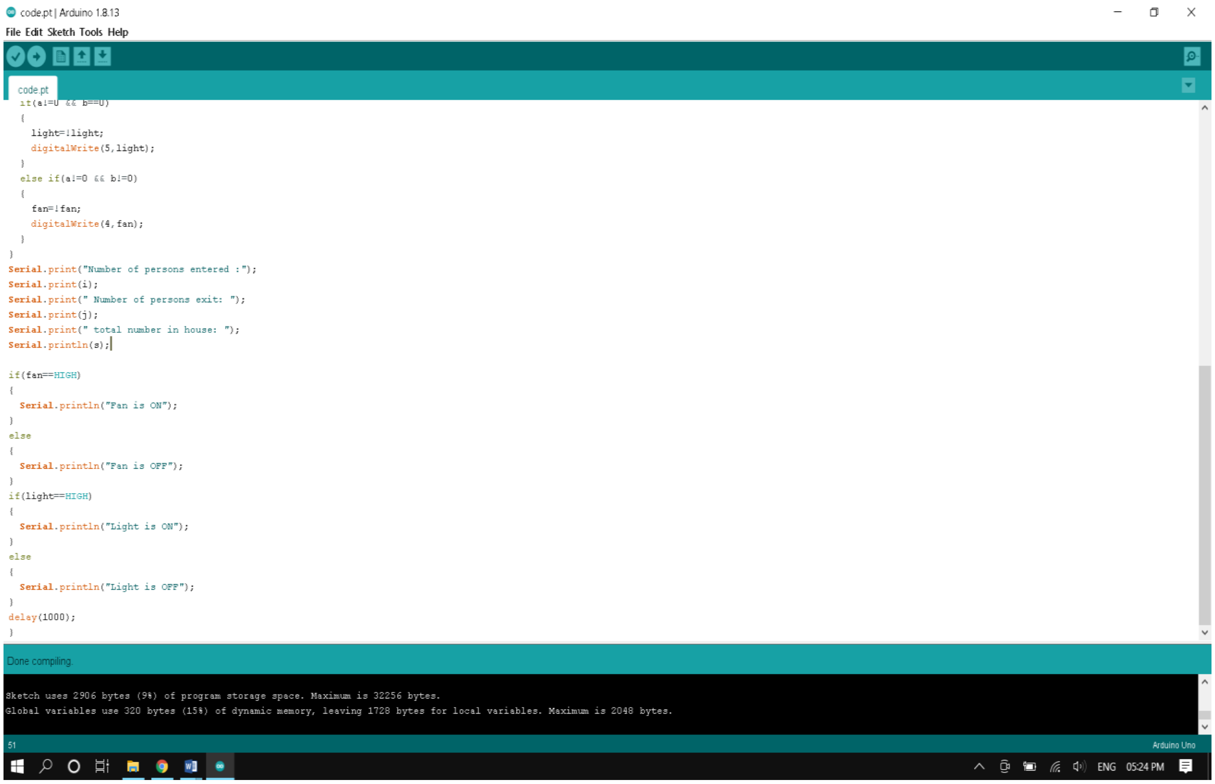


FIG:

Hardware requirement:-

SL NO	COMPONENTS	NUMBER OF COMPONENTS
1	Arduino Nano	1
2	Jumper wires	As required
3	MPU6050	1
4	A4988	2
5	HC-05 Module	1

6	**Resistor (1k**Ω)	**2**
7	**Stepper Motor**	**2**
8	**11.4V LIPO Battery**	**1**

value that is 0˚ in vertical position by driving the motors

Software requirement:-

Arduino IDE

A detailed explanation about these elements are given as follows for better understanding of the circuit.

ARDUINO NANO

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328P released in 2008. It offers the same connectivity and specs of the Arduino Uno board in a smaller form factor.

The Arduino Nano is equipped with 30 male I/O headers, in a dip-30 like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and running both online and offline. The board can be powered through a type-b micro-USB cable, or through a 9V battery.

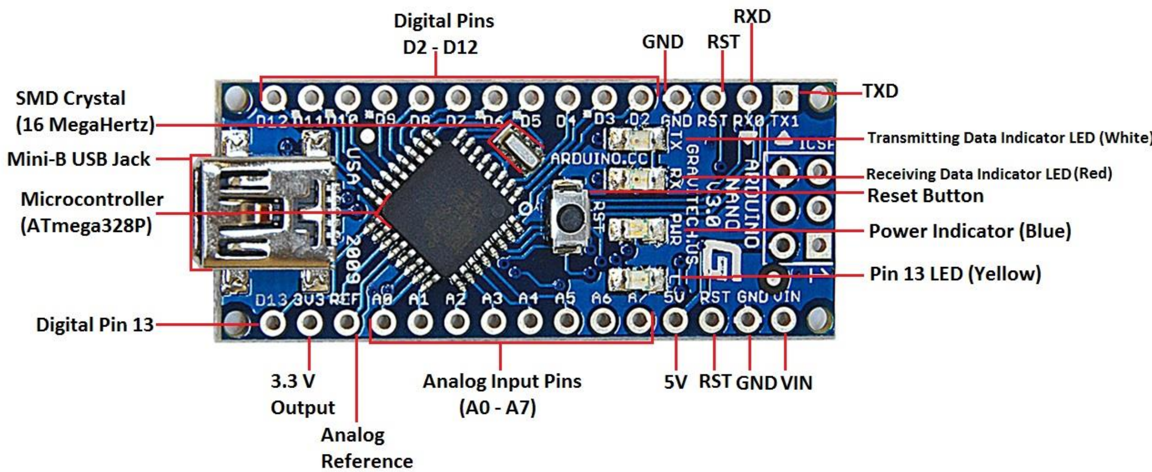
In 2019, Arduino released the Arduino Nano Every, an pin-equivalent evolution of the Nano. It features a more powerful ATmega4809 processor, and twice the RAM.

The Arduino Nano has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual com port to software on the computer. 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 FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus.

Rather than requiring a physical press of the reset button before an upload, the Arduino Nano 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 the FT232RL is connected to the reset line of the ATmega328 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip.

This setup has other implications. When the Uno is connected to 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 bootloader 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.

Pin Diagram:-



Arduino Nano V3.0 Pinout

PIN DESCRIPTION

Arduino Nano Pin	Pin Name	Type	Function
1	D1/TX	I/O	Digital I/O Pin Serial TX Pin
2	D0/RX	I/O	Digital I/O Pin Serial RX Pin
3	RESET	Input	Reset (Active Low)
4	GND	Power	Supply Ground
5	D2	I/O	Digital I/O Pin
6	D3	I/O	Digital I/O Pin
7	D4	I/O	Digital I/O Pin

Arduino Nano Pin	Pin Name	Type	Function
8	D5	I/O	Digital I/O Pin
9	D6	I/O	Digital I/O Pin
10	D7	I/O	Digital I/O Pin
11	D8	I/O	Digital I/O Pin
12	D9	I/O	Digital I/O Pin
13	D10	I/O	Digital I/O Pin
14	D11	I/O	Digital I/O Pin
15	D12	I/O	Digital I/O Pin
16	D13	I/O	Digital I/O Pin
17	3V3	Output	+3.3V Output (from FTDI)
18	AREF	Input	ADC reference
19	A0	Input	Analog Input Channel 0
20	A1	Input	Analog Input Channel 1
21	A2	Input	Analog Input Channel 2
22	A3	Input	Analog Input Channel 3
23	A4	Input	Analog Input Channel 4
24	A5	Input	Analog Input Channel 5

Arduino Nano Pin	Pin Name	Type	Function
25	A6	Input	Analog Input Channel 6
26	A7	Input	Analog Input Channel 7
27	+5V	Output or Input	+5V Output (From On-board Regulator) or +5V (Input from External Power Supply
28	RESET	Input	Reset (Active Low)
29	GND	Power	Supply Ground
30	VIN	Power	Supply voltage

ICSP Pins

Arduino Nano ICSP Pin Name	Type	Function
MISO	Input or Output	Master In Slave Out
Vcc	Output	Supply Voltage
SCK	Output	Clock from Master to Slave
MOSI	Output or Input	Master Out Slave In
RST	Input	Reset (Active Low)
GND	Power	Supply Ground

TECHNICAL SPECIFICATIONS:-

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash Memory	32 KB of which 2 KB used by bootloader
SRAM	2 KB
Clock Speed	16 MHz
Analog IN Pins	8
EEPROM	1 KB
DC Current per I/O Pins	40 mA (I/O Pins)
Input Voltage	7-12 V
Digital I/O Pins	22 (6 of which are PWM)
PWM Output	6
Power Consumption	19 mA
PCB Size	18 x 45 mm
Weight	7 g
Product Code	A000005

Jumper wires:-

A jumper wire is associate electrical wire incorporates a connector or pin at each end that we have a tendency to use it to interconnect the components of a breadboard or test circuit, internally or with any other tools or components, without soldering them. Individual jumper wires are fixed by presenting the connector ends inserted into the slots provided in a breadboard, the header connector of a circuit board, or into a part of test equipment.

The jumper wires are typically of three types:

These jumper wires are categorized into three types based on their end of the wire. Basically, the male tip has a protruding end which is used to plug into things whereas, the females do not have protruding ends and cannot be used to plug into things.

- The male-to-male:

This is the most common type of jumper wire that we are using quite often. Our project also involves the use of this male-to-male type of jumper wires. To be more specific, while connecting two ports on a breadboard a male-to-male wire is useful.

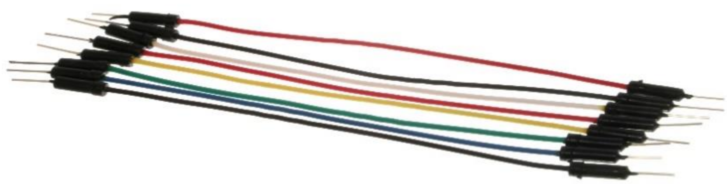


Fig:

- Male-to-female:

  Male-to-female jumper wires are very much used while connecting female header pin of a board to any other development board with a male connector.

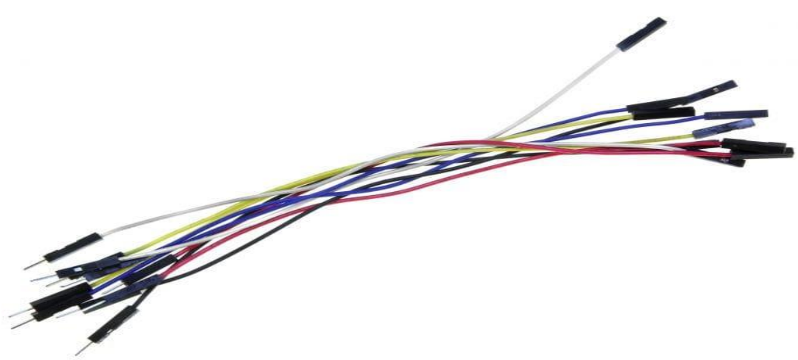


Fig:

- Female-to-female:

  Female-to-Female jumper wires are very much useful for making wire hardness on printed circuit boards.

Fig

The male ends are designed such that they can be inserted into standard 0.1 inch female sockets, while the female ends are designed so that they can be inserted onto standard 0.1 inch male headers.

These are used in Arduino based projects, breadboard kit project, PCB project, pc motherboard etc.

MPU6050:-

The MPU-6050™ parts are the world's first MotionTracking devices designed for the low power, low cost, and high-performance requirements of smartphones, tablets and wearable sensors.The MPU-6050 incorporates InvenSense's MotionFusion™ and run-time calibration firmware that enables manufacturers to eliminate the costly and complex selection, qualification, and system level integration of discrete devices in motion-enabled products, guaranteeing that sensor fusion algorithms and calibration procedures deliver optimal performance for consumers.The MPU-6050 devices combine a 3-axis gyroscope and a 3-axis accelerometer on the same silicon die, together with an onboard Digital Motion Processor™ (DMP™), which processes complex 6-axis MotionFusion algorithms. The device can access external magnetometers or other sensors through an auxiliary master I²C bus, allowing the devices to gather a full set of sensor data without intervention from the system processor. The devices are offered in a 4 mm x 4 mm x 0.9 mm QFN package.

The InvenSense MotionApps™ Platform that comes with the MPU-6050 abstracts motion-based complexities, offloads sensor management from the operating system, and provides a structured set of APIs for application development.

For precision tracking of both fast and slow motions, the parts feature a user-programmable gyro full-scale range of ±250, ±500, ±1000, and ±2000 °/sec (dps), and a user-programmable accelerometer full-scale range of ±2g, ±4g, ±8g, and ±16g. Additional features include an embedded temperature sensor and an on-chip oscillator with ±1% variation over the operating temperature range.

PIN DESCRIPTION:-

The MPU-6050 module has 8 pins,

INT: Interrupt digital output pin.

AD0: I2C Slave Address LSB pin. This is 0th bit in 7-bit slave address of device. If connected to VCC then it is read as logic one and slave address changes.

XCL: Auxiliary Serial Clock pin. This pin is used to connect other I2C interface enabled sensors SCL pin to MPU-6050.

XDA: Auxiliary Serial Data pin. This pin is used to connect other I2C interface enabled sensors SDA pin to MPU-6050.

SCL: Serial Clock pin. Connect this pin to microcontrollers SCL pin.

SDA: Serial Data pin. Connect this pin to microcontrollers SDA pin.

GND: Ground pin. Connect this pin to ground connection.

VCC: Power supply pin. Connect this pin to +5V DC supply.

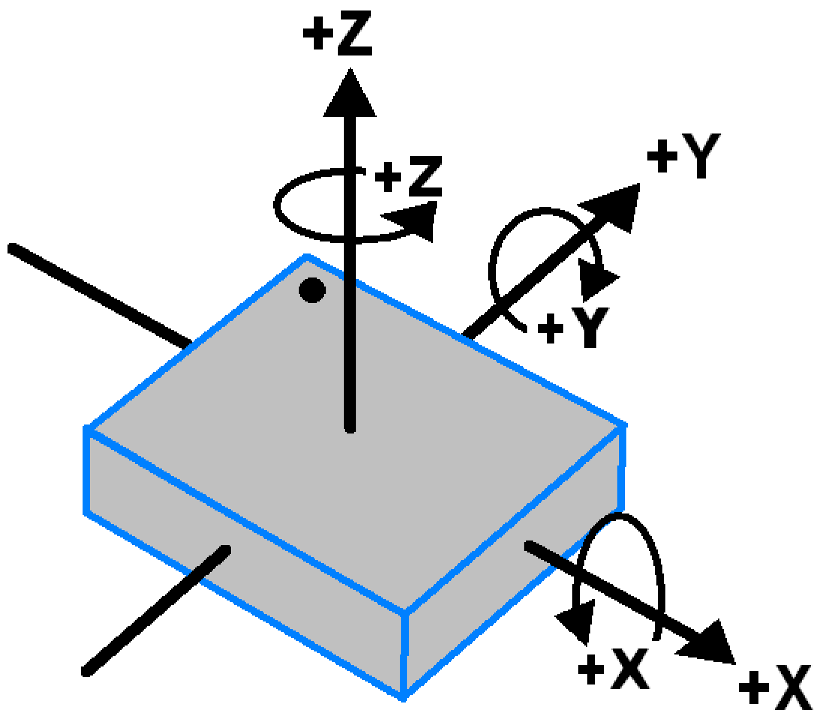
MPU-6050 module has Slave address (When AD0 = 0, i.e. it is not connected to Vcc) as,

Slave Write address(SLA+W): 0xD0

Slave Read address(SLA+R): 0xD1

MPU-6050 has various registers to control and configure its mode of operation.

The MPU6050 consist of 3-axis Gyroscope with Micro Electro Mechanical System(MEMS) technology. It is used to detect rotational velocity along the X, Y, Z axes as shown in below figure.



MPU-6050
Orientation & Polarity of Rotation

- When the gyros are rotated about any of the sense axes, the Coriolis Effect causes a vibration that is detected by a MEM inside MPU6050.

- The resulting signal is amplified, demodulated, and filtered to produce a voltage that is proportional to the angular rate.

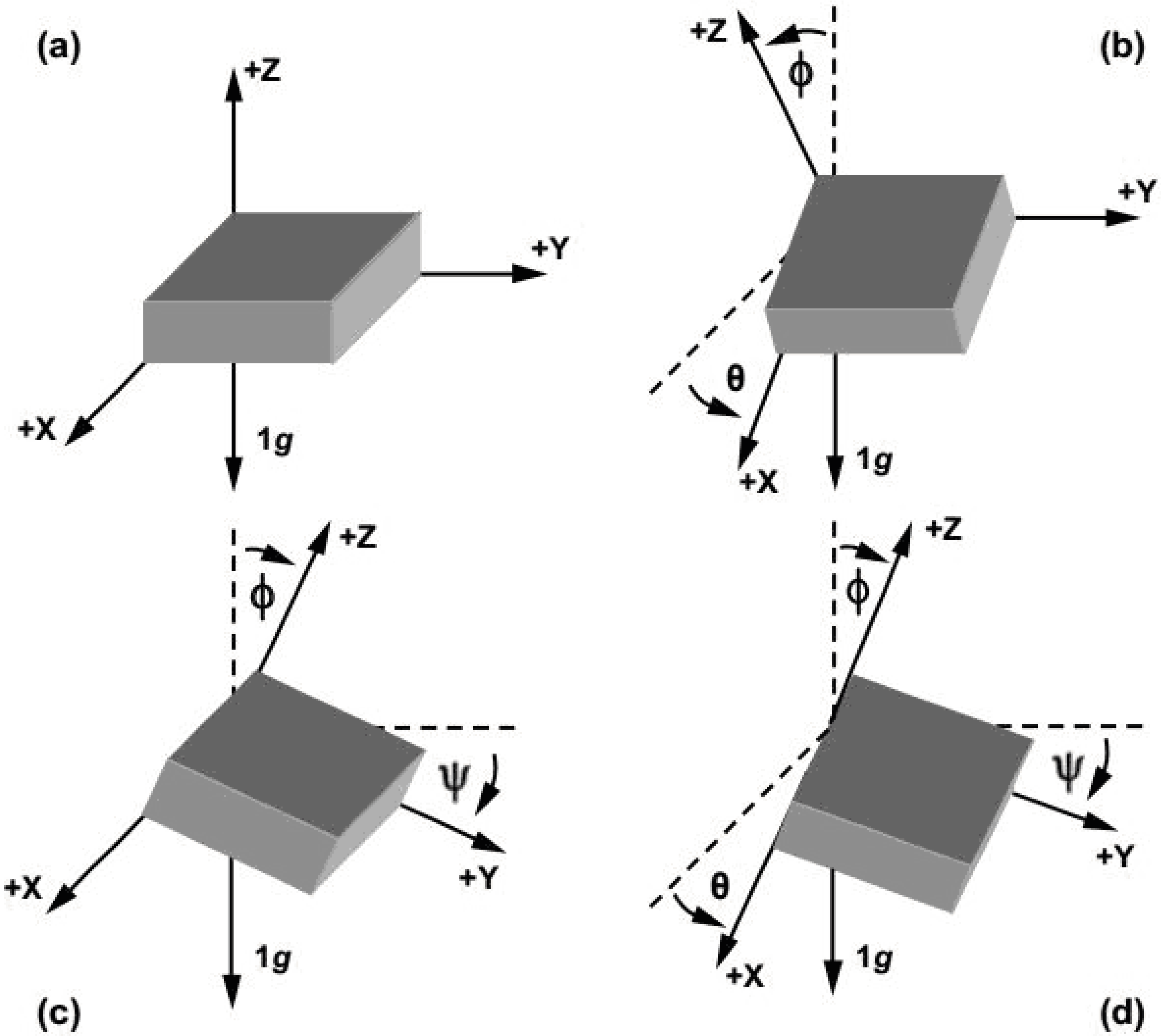
- This voltage is digitized using 16-bit ADC to sample each axis.

- The full-scale range of output are +/- 250, +/- 500, +/- 1000, +/- 2000.

- It measures the angular velocity along each axis in degree per second unit.

-Axis Accelerometer3:-

The MPU6050 consist 3-axis Accelerometer with Micro Electro Mechanical (MEMs) technology. It used to detect angle of tilt or inclination along the X, Y and Z axes as shown in below figure.



- Acceleration along the axes deflects the movable mass.

- This displacement of moving plate (mass) unbalances the differential capacitor which results in sensor output. Output amplitude is proportional to acceleration.

- 16-bit ADC is used to get digitized output.

- The full-scale range of acceleration are +/- 2g, +/- 4g, +/- 8g, +/- 16g.

- It measured in g (gravity force) unit.

- When device placed on flat surface it will measure 0g on X and Y axis and +1g on Z axis.

DMP (Digital Motion Processor):-

The embedded Digital Motion Processor (DMP) is used to compute motion processing algorithms. It takes data from gyroscope, accelerometer and additional 3rd party sensor such as magnetometer and processes the data. It provides motion data like roll, pitch, yaw angles, landscape and portrait sense etc. It minimizes the processes of host in computing motion data. The resulting data can be read from DMP registers.

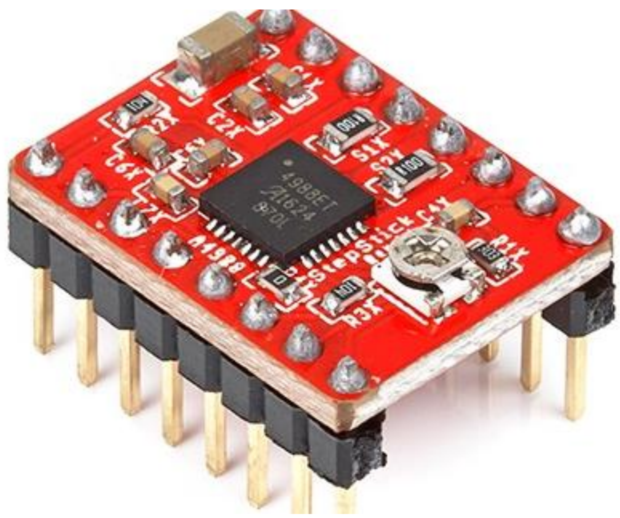
On-chip Temperature Sensor:-

On-chip temperature sensor output is digitized using ADC. The reading from temperature sensor can be read from sensor data register.

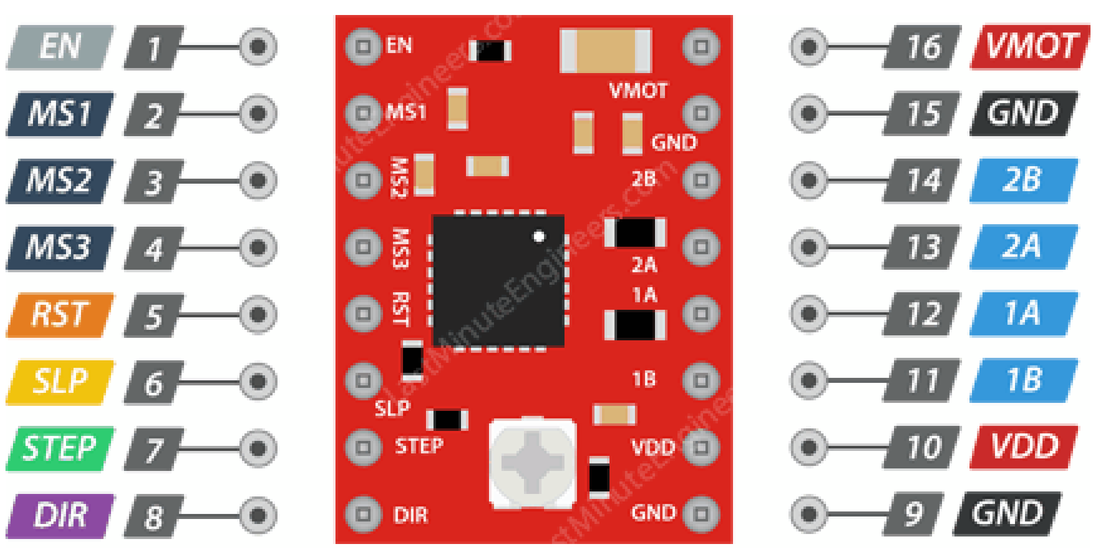
A4988:-

The A4988 is a complete micro stepping motor driver with built-in translator for easy operation. It is designed to operate bipolar stepper motors in full-, half-, quarter-, eighth-, and sixteenth-step modes, with an output drive capacity of up to 35 V and ±2 A. The A4988 includes a fixed off-time current regulator which has the ability to operate in Slow or Mixed decay modes. The translator is the key to the easy implementation of the A4988. Simply inputting one pulse on the STEP input drives the motor one micro step. There are no phase sequence tables, high frequency control lines, or complex interface stop rogram. The A4988 interface is an ideal fit for applications where a complex microprocessor is unavailable or is overburdened. During stepping operation, the chopping control in the A4988 automatically selects the current decay mode, Slow or Mixed. In Mixed decay mode, the device is set initially to a fast decay for a proportion of the fixed off-time, then to a slow decay for the remainder of the off-time. Mixed decay current control results in reduced audible motor noise, increased step accuracy, and reduced power dissipation.

Internal synchronous rectification control circuitry is provided to improve power dissipation during PWM operation. Internal circuit protection includes: thermal shutdown with hysteresis, under voltage lockout (UVLO), and crossover-current protection. Special power-on sequencing is not required. The A4988 is supplied in a surface mount QFN package (ES), 5mm × 5 mm, with a nominal overall package height of 0.90 mm and an exposed pad for enhanced thermal dissipation. It is lead (Pb) free (suffix –T), with 100% matte tin plated lead frames.



PIN DIAGRAM:-



Pin Configuration:-

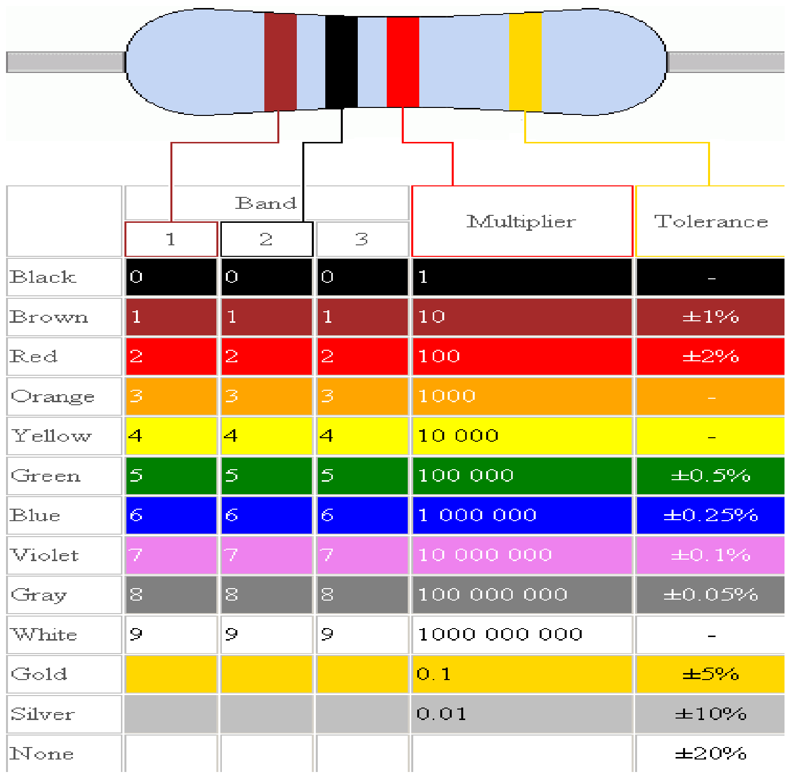
Pin Name	**Description**
VDD & GND	Connected to 5V and GND of Controller
VMOT & GND	Used to power the motor
1A, 1B, 2A, 2B	Connected to the 4 coils of motor
DIRECTION	Motor Direction Control pin
STEP	Steps Control Pin
MS1, MS2, MS3	Microstep Selection Pins
SLEEP	Pins For Controlling Power States
RESET	
ENABLE	

Resistor:-

Value of resistor that we used in our circuit is 1kΩ. Resistor is a two-terminal device which are often used in electric circuits and provides specific resistance to the flow of current in the circuit. Resistance of a resistor can be linear or non-linear depending on the application it is being used. Resistance of a linear resistor is self-determined of voltage applied. Whereas the resistance of a non-linear resistor changes with the voltage applied. Resistors that are made of semi-conductor are non-linear. Resistors can be used to control the amount of provided voltage to part of a circuit and to help create timing circuits.

Fig:

Colour coding used in resistors is to calculate the magnitude of the resistance in ohms. Colour coding is a process which is widely used in calculating the value of the resistors. The colour bands on the resistor are of very significant while calculating the value of the resistors. Each colour has a unique resistance value along with some tolerance value as shown in the figure mentioned below.



	Band 1	Band 2	Band 3	Multiplier	Tolerance
Black	0	0	0	1	-
Brown	1	1	1	10	±1%
Red	2	2	2	100	±2%
Orange	3	3	3	1000	-
Yellow	4	4	4	10 000	-
Green	5	5	5	100 000	±0.5%
Blue	6	6	6	1 000 000	±0.25%
Violet	7	7	7	10 000 000	±0.1%
Gray	8	8	8	100 000 000	±0.05%
White	9	9	9	1000 000 000	-
Gold				0.1	±5%
Silver				0.01	±10%
None					±20%

Fig:

5.1.7 USB a to USB b cable:-

This is a cable used for Arduino UNO/MEGA (USB A to B)-1feet, one can use it to connect Arduino or any board with the USB female A port of computer. Length is approximately 0.52 metres. Cable colour and cable shape may vary slightly from image.

Fig:

STEPPER MOTOR:-

A stepper motor, also known as step motor or stepping motor, is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor's position can then be commanded to move and hold at one of these steps without any position sensor for feedback (an open-loop controller), as long as the motor is carefully sized to the application in respect to torque and speed.

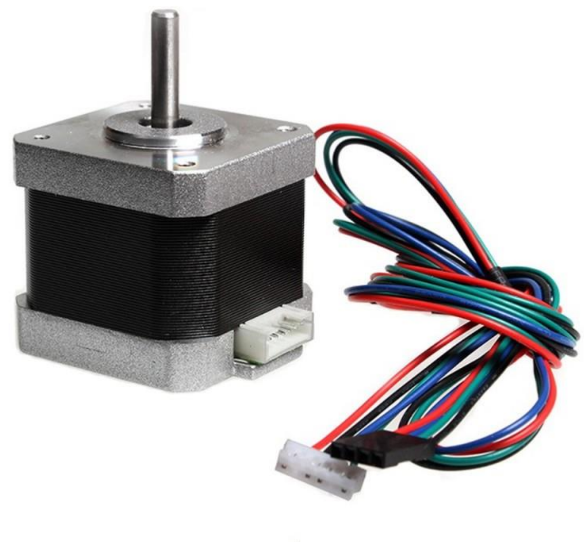
Switched reluctance motors are very large stepping motors with a reduced pole count, and generally are closed-loop commutated.

Brushed DC motors rotate continuously when DC voltage is applied to their terminals. The stepper motor is known for its property of converting a train of input pulses (typically square waves) into a precisely defined increment in the shaft's rotational position. Each pulse rotates the shaft through a fixed angle.

Stepper motors effectively have multiple "toothed" electromagnets arranged as a stator around a central rotor, a gear-shaped piece of iron. The electromagnets are energized by an external driver circuit or a micro controller. To make the motor shaft turn, first, one electromagnet is given power, which magnetically attracts the gear's teeth. When the gear's teeth are aligned to the first electromagnet, they are slightly offset from the next electromagnet. This means that when the next electromagnet is turned on and the first is turned off, the gear rotates slightly to align with the next one. From there the process is repeated. Each of those rotations is called a "step", with an integer number of steps making a full rotation. In that way, the motor can be turned by a precise angle.

The circular arrangement of electromagnets is divided into groups, each group called a phase, and there is an equal number of electromagnets per group. The number of groups is chosen by the designer of the stepper motor. The electromagnets of each group are interleaved with the electromagnets of other groups to form a uniform pattern of arrangement. For example, if the stepper motor has two groups identified as A or B, and ten electromagnets in total, then the grouping pattern would be ABABABABAB.

Electromagnets within the same group are all energized together. Because of this, stepper motors with more phases typically have more wires (or leads) to control the motor

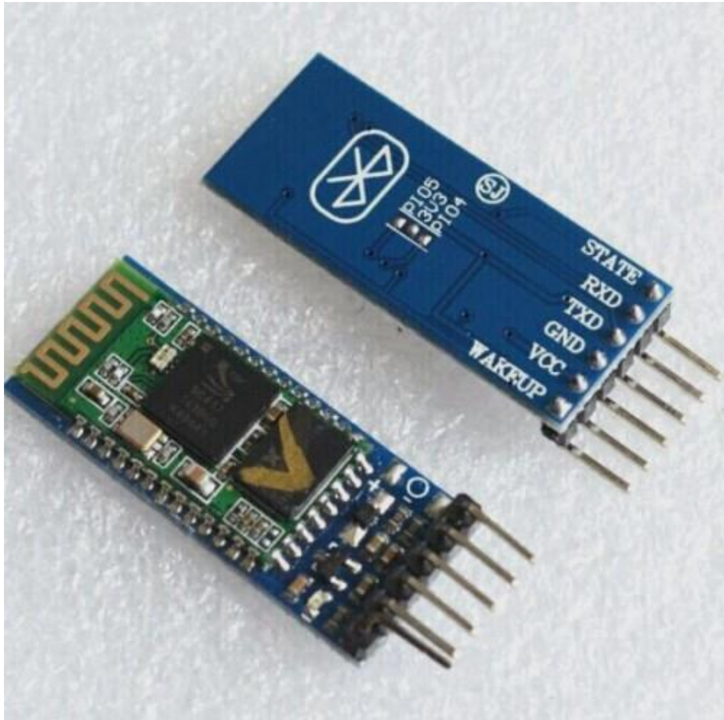


HC-05 BLUETOOTH MODULE:-

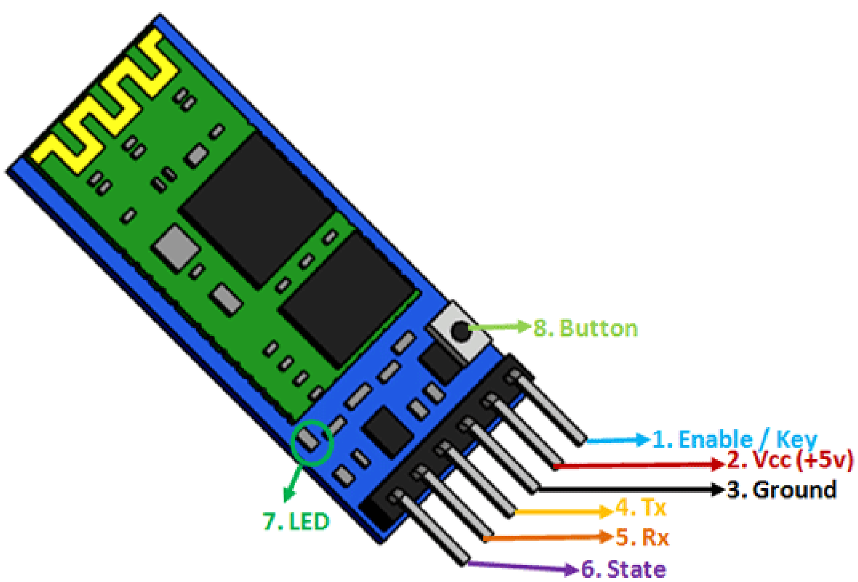
HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with controller or PC. HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

Specification:

- Model: HC-05
- Input Voltage: DC 5V
- Communication Method: Serial Communication
- Master and slave mode can be switched


STATE
RXD
TXD
GND
VCC
WAKEUP

PIN DIAGRAM:-


8. Button
1. Enable / Key
2. Vcc (+5v)
3. Ground
4. Tx
5. Rx
6. State
7. LED

PIN DESCRIPTION:-

Pin Number	Pin Name	Description
1	Enable / Key	This pin is used to toggle between Data Mode (set low) and AT command mode (set high). By default it is in Data mode
2	Vcc	Powers the module. Connect to +5V Supply voltage
3	Ground	Ground pin of module, connect to system ground.
4	TX – Transmitter	Transmits Serial Data. Everything received via Bluetooth will be given out by this pin as serial data.
5	RX – Receiver	Receive Serial Data. Every serial data given to this pin will be broadcasted via Bluetooth
6	State	The state pin is connected to on board LED, it can be used as a feedback to check if Bluetooth is working properly.
7	LED	Indicates the status of Module • Blink once in 2 sec: Module has entered Command Mode • Repeated Blinking: Waiting for connection in Data Mode • Blink twice in 1 sec: Connection successful in Data Mode

8	Button	Used to control the Key/Enable pin to toggle between Data and command Mode

Arduino IDE:-

IDE stands for "Integrated Development Environment" .It is a software that is officially introduced by Arduino.cc which is mainly used for writing, editing, compiling and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this Arduino IDE software and is available to install and start compiling the code on the go applications.

- Arduino IDE is an open source software that is mainly used for writing, editing and compiling the code into the Arduino Module.
- It is an official Arduino software, making code compilation too easy that even a common person even with no technical knowledge can get with the learning process.
- It is easily available for operating systems like MAC, Windows, and Linux and runs on the Java Platform that comes with inbuilt functions and commands that play a vital role for debugging, editing and compiling the code in the environment.
- 4.A range of Arduino modules available including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino Micro and many more.
- Each of them contains a microcontroller on the board that is actually programmed and accepts the information in the form of code.
- The main code, also known as a sketch, created on the IDE platform will ultimately generate a Hex File which is then transferred and uploaded in the controller on the board.
- 7.The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module.
- 8. This environment supports both C and C++ languages.

RESULTS AND DISCUSSION

- A self-balancing robot using Arduino, HC-05 blutooth module and MPU6050(Gyro sensor).
- EZ-GUI app is installed in the user's mobile phone.
- Change AUX Tick marks in boxes .
- Change PID values(roll , pitch ,YAW).
- Click on "Model Control" for joystick.

ADVANTAGES AND APPLICATIONS

ADVANTAGES

- It has only two wheels ,so more maneuverability.
- And less number of wheels, so more battery efficient.
- Takes less space for storage.

APPLICATIONS

- The two-wheeled design of the self-balancing Segway Personal Transporter significantly increases its maneuverability, because it reduces the turn radius to zero.
- The vehicle can rotate in place to instantly change its direction of motion and precisely navigate tight spaces that a three or four-wheeled robot cannot.
- While a passively balanced, stable-equilibrium system may tip over the instant it is put off balance, an actively balancing, unstable-equilibrium system like the Segway can take actions to recover if its balance is temporarily disturbed.
- Stability-enhancing behavior directly mimics the natural behavior of a human that avoids a fall by taking a step in the direction of motion

CONCLUSION AND FUTURE SCOPE

CONCLUSION:-

We came into this project expecting to build a two-wheeled robot that would balance itself with the help of an IMU. It took a good amount of work, and we encountered significant challenges, but we met our expectations and achieved our goal. After building the chassis, designing and testing the circuits, writing the software, and tuning the PID coefficients, we were able to sucessfully balance the robot on the two wheels, and even carry a load. But it is still not perfect - the few issues detailed above, including the minor wobble, the asymmetrical motor speeds, and the lack of encoders are small problems that can be fixed in a future update.

FUTURE SCOPE:-

- Fix the wobble by setting a minimum PWM duty cycle that is just below the threshold at which the motors begin to spin.that will get rid of the current deadspot in which the motors don't spin for a number of degress.
- Add encoders to the robot to allow it to measure and control its speed.that will prevent it from approaching its maximum speed and falling over.
- Implement automatic tilt calibration so that the robot will always remain balanced even if its center of gravity is shifted, requiring no action by the user.