DESIGN AND FABRICATION OF WEARABLE GLOVE THAT CONVERTS SIGN LANGUAGE TO TEXT AND AUDIO

A PROJECT REPORT

Submitted by

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ABSTRACT

Loss of the ability to speak or hear exerts psychological and social impacts on the affected persons due to the lack of proper communication. Multiple and systematic scholarly interventions that vary according to context have been implemented to overcome disability-related difficulties. Sign language recognition (SLR) systems based on sensory gloves are significant innovations that aim to procure data on the shape or movement of the human hand. Innovative technology for this matter is mainly restricted and dispersed. The available trends and gaps should be explored in this research approach to provide valuable insights into technological environments. Thus, a review is conducted to create a coherent taxonomy to describe the latest research divided into four main categories: development, framework, other hand gesture recognition, and reviews and surveys. Then, we conduct analyses of the glove systems for SLR device characteristics, develop a roadmap for technology evolution, discuss its limitations, and provide valuable insights into technological environments. This will help researchers to understand the current options and gaps in this area, thus contributing to this line of research. Dumb and deaf persons make up a large portion of India's population. As a result, the system is developing a glove-based device for converting ASL to speech. The basic system is divided into 2 parts recognition of sign language and conversion to text, followed by voice. The sign language glove is made up of a pair of basic hand gloves with mems sensors that detect how much the hand moved. The sensors that increase resistance based on the degree of bend on the sensor are known as mems sensors. Data from the sensors is sent to the Arduino control unit, where the analogue signals are digitally transformed and compared to the recorded value for sign detection, and then displayed as text on the display. . The output of this system is very efficient, consistent and of high approximation of gesture processing and speech analysis.

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CHAPTER 1
INTRODUCTION

According to the statistics of the World Federation of the Deaf and the World Health Organization, approximately 70 million people in the world are deaf–mute. A total of 360 million people are deaf, and 32 million of these individuals are children [1]. The majority of speech- and hearing-impaired people cannot read or write in regular languages. Sign language (SL) is the native language used by the deaf and mute to communicate with others. SL relies primarily on gestures rather than voice to convey meaning, and it combines the use of finger shapes, hand movements, and facial expressions [2].

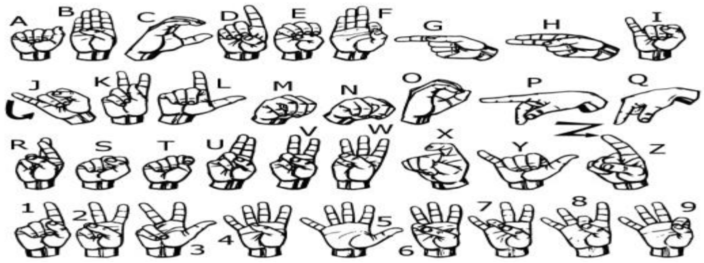


FIG 1.1 American Sign Language

This language has the following main defects: a lot of hand movements, a limited vocabulary, and learning difficulties. Furthermore, SL is unfamiliar to those who are not deaf and mute, and disabled people face serious difficulties in communicating with able individuals. This communication barrier adversely affects the lives and social relationships of deaf people [3]. Thus, dumb people need to use a translator device to communicate with able individuals. This can be achieved by developing a glove equipped with sensors and an electronic circuit. Several benefits of using this device are that no complex data processing is needed [4]; there are no limitations on movements such as sitting behind a desk or chair; hand shape recognition is not affected by the background condition [5,6]; it is a lightweight, SLR-based glove device that can be carried to make mobility easy and comfortable [7,8]; and it is a recognition system that can be employed for learning SL for both dumb and able people [9]. Furthermore, numerous kinds of applications are currently involved in gesture recognition systems such as SLR, substitutional computer interfaces, socially assistive robotics, immersive gaming, virtual objects, remote control, medicine-health care, gesture recognition of hand/body language, etc. [10–15].In addition, a roadmap is presented for technology evolution; it exhibits features of SLR systems and discusses the limitations of current technology. This objective can be achieved by answering the following six research questions: (1) How many types of relevant studies are published on glove-based SLR? (2) To what extent have SLR systems been elaborated on in the preliminary studies in terms of detail and technologies? (3) Which types of movements have been recognized in previous studies? (4) What types of sensors have been used in the primary publications? (5) What languages did the glove systems develop for SLR in the preliminary studies? (6) How were the effectiveness and efficiency of the SLR systems

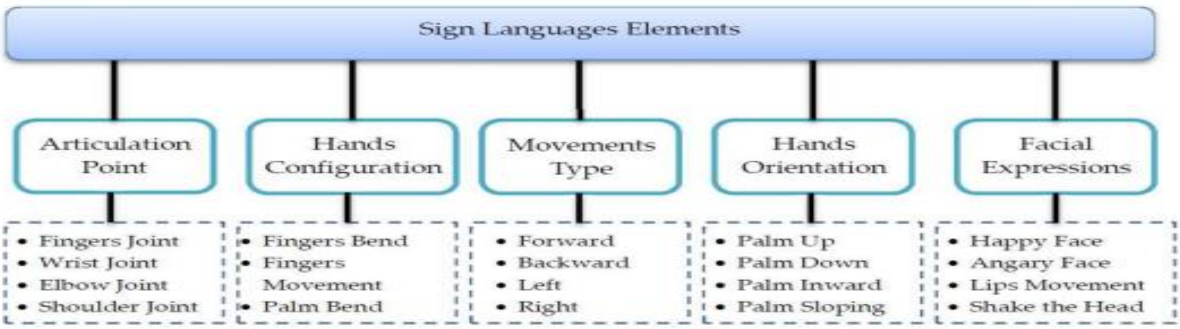


Fig 1.2 Sign Language Elements

evaluated in the initial studies? The aim was to understand the options and gaps available in this field to support researchers by providing valuable insights into technological environments. The steps taken in this study to provide Systematic Literature Review and Systematic Mapping Study are in accordance with the steps explained in the David Moher paper [16] and other research papers [11,17–21]. SL is a visual–spatial language based on positional and visual components, such as the shape of fingers and hands, the location and orientation of the hands, and arm and body movements. These components are used together to convey the meaning of an idea. The phonological structure of SL generally has five elements (Figure 1). Each gesture in SL is a combination of five building block.

CHAPTER 2
LITERATURE SURVEY

The earlier works mainly focused on a third person perspective or also known as vision based technique for gesture recognition using image processing. We have referred these papers for understanding their limitations in practical life and learning the basic gesture detection techniques. But currently, due to availability of variety of sensors and scope of application in real life, many of the researchers have started using more portable techniques for gesture recognition. These advanced techniques with the support of Android Platform can major breakthrough in the field of Assistive Technology.

P. Subha Rajam had proposed a system that recognizes sign language gestures using image processing. The gesture is captured by a camera and an outline of the image is generated. The system generates a binary code of the gesture corresponding to the finger positions. The binary code is mapped to a text and the text is shown on a screen. In this work author has explored Hidden Markov Models (HMM) as an approach for recognizing and modelling dynamic hand gestures for the User Interface of in vehicle information and entertainment systems. The proposed method in had recognized signs for all alphabets from A to Z using Scale Invariant Feature Transform which extracts the features of image by finding and Describing key points.

In the project decodes the captured signs of American Sign Language into simple English sentences using a sensor glove. In order to recognize the sensor values, form the sensor glove artificial neural networks were used. These values received were categorized in to 24 alphabets of the English language and two punctuation symbols were introduced by the writer. In, a similar kind of approach was proposed by the author that included flex sensors and an accelerometer to detect the bend in fingers and the position of the hands. The flex sensors and accelerometer send the voltage readings to the PIC microcontroller which will be mapped to the text.

Celestine Preetham et al had proposed a system to make the gloves communicate wirelessly with another Bluetooth device. The device has a speech synthesizing software that will produce the translated speech.

By referring to all these works, we have tried to provide our contribution towards society. We have extracted the best of the techniques from each of these Project, combined it under a common framework and extended it for multiple applications.

A variety of studies and research projects have been conducted on the issue of smart communication for visually and hearing-impaired persons. In addition to writing and drawing, sign language is the most efficient medium for fluent communication between regular people and these specially challenged people, according to this. Several patents have been filed in this subject with various ways to handle this challenge.

1. “Deaf-Mute Communication Interpreter” uses sensor based technique comprising of flex sensor, tactile sensors and accelerometer to translate American Sign Language gestures to both text and auditory voice. Although, they were only able to translate thirteen sign into their respective alphabets namely letters ‘A’ ‘B’ ‘C’ ‘D’ ‘F’ ‘I’ ‘L’ ‘O’ ‘M’ ‘N’ ‘T’ ‘S’ ‘W’and tactile sensor were used to improve the accuracy of three letters M, N and T .

2. Aslant provided a system for employing gloves to understand sign language. The framework consists of five flex sensors, a microprocessor that analyses sensor data, an LCD that displays individual findings, and a speaker that listens to the output. It generated both a visual display on an LCD and auditory output through the speaker. This strategy has the disadvantage of restricting the user's freedom of choice.

CHAPTER 3
FLOW CHART

Scholarly interventions to overcome disability-related difficulties are multiple and systematic and vary according to the context. One of the important interventions is SLR systems that are utilized to translate the signs of SL into text or speech to establish communication with individuals who do not know these signs [18]. SLR systems based on the sensory glove are among the most significant endeavors aimed at procuring data for the motion of human hands. Three approaches (Figure 2), namely, vision based, sensor-based, and a combination of the two, are adopted to capture hand configurations and recognize the corresponding meanings of gestures [23] Vision-based systems use cameras as primary tools to obtain the necessary input data (Figure 3). The main advantage of using a camera is that it removes the need for sensors in sensory gloves and reduces the building costs of the system. Cameras are quite cheap, and most laptops use a high specification camera because of the blur caused by a web camera. However, despite the high specification camera, which most smartphones possess [18], there are various problems such as the limited field of view of the capturing device, high computational costs [24,25], and the need for multiple cameras to obtain robust results (due to problems of depth and occlusion

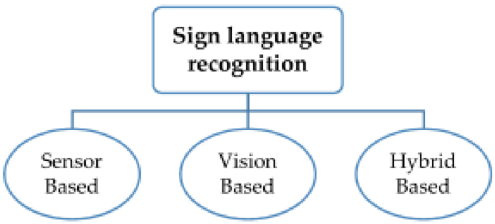


Fig 3.1 Sign Language Recognition

To overcome the disadvantages of the concept of using camera as a device to capture the sign language and compare the sign with the actual one. Scholars found that Sensors can interpreted the sign language more accurate than the camera. The third method of collecting raw gesture data employs a hybrid approach that combines glove and camera-based systems. This approach uses mutual error elimination to enhance the overall accuracy and precision. However, not much work has been carried out in this direction due to the cost and computational overheads of the entire setup. Nevertheless, augmented reality systems produce promising results when used with hybrid tracking methodology [3].

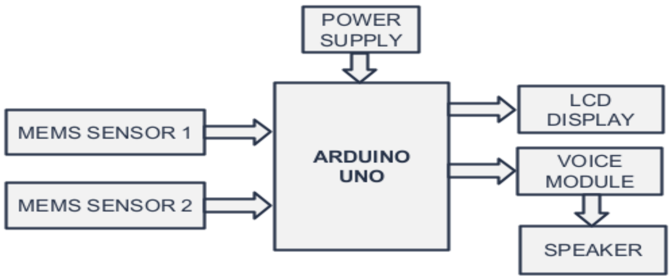


Fig. 3.2 Block Diagram

At first the sensors were embedded on a glove to accurately measure the angular movement of independent fingers. But later it is found that the sensor used i.e,, flux sensor is very rigid it rescripts the movement of the finger , also that the flux sensor breaks after a short period of time. Thus a new system to overcome this disadvantage is proposed in this report. In proposed system we have using Mems sensor to converts sign language to voice as well as displays text in LCD display of controller. A gesture based circuit is designed to express the need of speechless patient & physically challenged people. The pre-determined gesture is stored in microcontroller to process what types of gesture is generating and expressed thought is announce as voice and is displayed as text through an attachment. The device is made as compact as possible and cost efficient as possible , so the all can get an opportunity to buy this device, which will help the dum People to express their feelings to others easily.

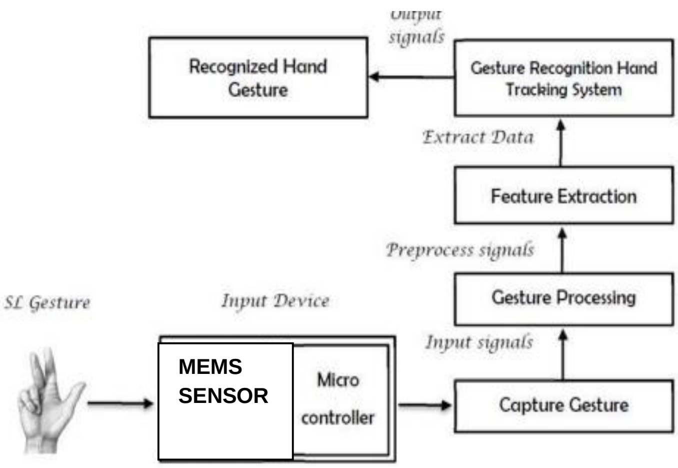


Fig 3.3 Process Flow Chart

CHAPTER 4

Materials and Method

Painstaking and intensive endeavors to find realistic and feasible solutions to overcome communication obstacles are major challenges encountered by the deaf and mute. Therefore, the implementation of a system that identifies SL in its software and hardware branches has been emphasized.

4.1. Pertaining to System Materials

With regard to hardware components, the glove-based recognition system is composed of three main units (Figure 5): I/P, processing, and O/P.

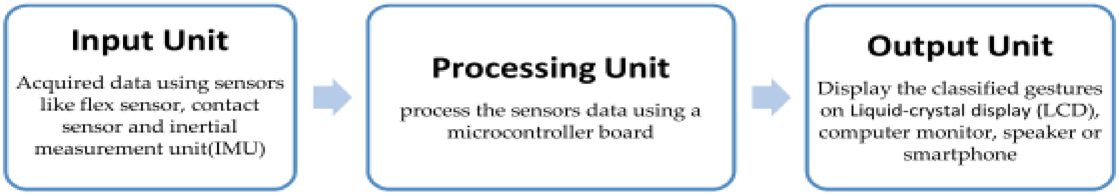


Fig 4.1 Signal Input, Processing and Output

WORKING MODULE: -

OUTPUT 1:

The Mems sensor to measure the angle of hand movement then transfer the data to Arduino Microcontroller.

OUTPUT 2:

The pre-determined gesture is stored in microcontroller to process what types of gesture is generating and expressed thought is voice and text.

Hardware Requirement:

1. Arduino UNO
2. MEMS Sensor
3. LCD Device
4. APR Voice Speaker
5. Speaker
6. Power Supply

Software Requirement:

1.Arduino IDE

2.Embedded C

4.2 MEMS Accelerometer :-

Most accelerometers are **Micro Electro-Mechanical Sensors** (MEMS). The basic principle of operation behind the MEMS accelerometer is the displacement of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams. Consistent with Newton's second law of motion (F = ma), as an acceleration is applied to the device, a force develops which displaces the mass arm.

Accelerometers can be used to effectively translate finger and hand gestures into computer interpreted signals. Integrating a single chip wireless solution with a MEMS accelerometer would yield an autonomous device small enough to apply to the fingernails because of their small size and weight. Accelerometers are attached to the fingertips and back of the hand. Arrows on the hand show the location of accelerometers and their sensitive directions. The sensitive direction of the accelerometer is in the plane of the hand. Micro-electromechanical systems (MEMS) are free scale‘s enabling technology for acceleration and pressure sensors.

MEMS based sensor products provide an interface that can sense, process or control the surrounding environment. MEMS-based sensors are a class of devices that builds very small electrical and mechanical components on a single chip. In this paper, the most recent and main applications of the MEMS technology in the automotive industry are introduced through technology scouting approach. Technology scouting is a powerful tool which contributes to technology management by identifying emerging technologies, and channel technology related information into an organization. First, we classify the general MEMS technologies into 4 classes, and different applications are investigated. Finally, MEMS market in the automotive industry at present and in future is evaluated. Besides, most forecasts suggest that their application in the vehicles will continue to grow to address vehicle safety requirements as well as government mandates.

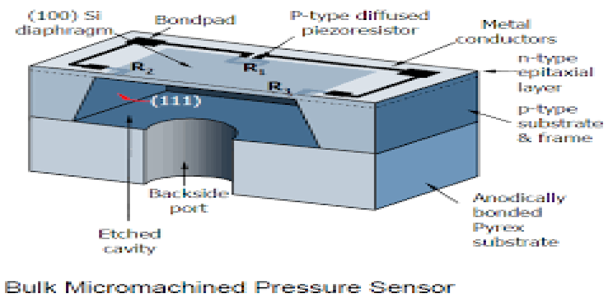
Features:

□ 3-axis sensing Small,

□ low profile package 4 mm × 4 mm × 1.45 mm LFCSP

□ Low power : 350 µA (typical)

□ Single-supply operation: 1.8 V to 3.6 V



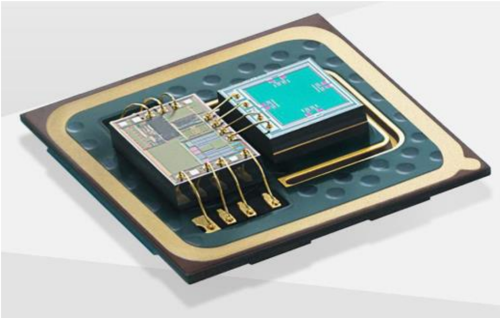


Fig 4.2 Bulk Micro machined Pressure Sensor

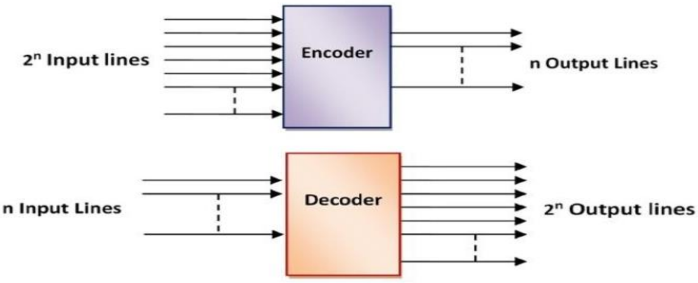
Advantages of MEMS Sensor:

1. Mems sensors provide convenient features available with every other sensor line without any space constraints.
2. MEMS makes use of very compact micro machine components so tiny that each MEMS sensor can easily fit into the palm of your hand.
3. MEMS sensors have an IP67 seal to withstand some intense temperatures ranging from 40º to +85ºC.
4. This seal enables the sensors to be submerged into shallow water for temporary periods, allowing them to monitor the offshore and subsea pitch and roll applications.
5. MEMS sensors is shock and vibrations resistance. MEMS inclinometers have a vibration resistance of 10grms @ 10-1000Hz and accelerometers bear a shock resistance of 100G.

4.3 Encoder

Simply put, an encoder is a sensing device that provides feedback. Encoders convert motion to an electrical signal that can be read by some type of control device in a motion control system, such as a counter or PLC. It can be used to determine position, count, speed, or direction. Here, HT12E [9] is 212 series encoder is used. It is capable of encoding information that consists of N address bits. It consists of 18 pins. Pin (1-9) and 14 are connected to ground. Pin number 10,11,12,13 of encoder are connected to 13,12,11,10 of Arduino Uno board respectively. A resistor of 750KOhm is connected to 15 and 16 number pin. Pin 17 is connected to Data pin of 433MHz RF transmitter module. It operates on 5V power supply .

Fig 4.3 Encoder and Decoder



4.4 Decoder

A decoder is a circuit that **changes a code into a set of signals**. It is called a decoder because it does the reverse of encoding.HT12D [10], 212 series decoder is employed that is capable of decoding information that consists of N address bits. It consists of 18 pins. Pin (1-9) connected to ground. Pin number 10,11,12,13 of decoder are connected to 10, 15, 7, 2 of Motor driver respectively. A resistor of 47KOhm is connected to 15 and 16 number pin. Pin 17 is not connected. Pin 14 is connected to Data pin of 433MHz RF receiver module. It operates on 5V power supply to which 18 number pin is connected.

4.5 ARDUINO UNO:

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE.

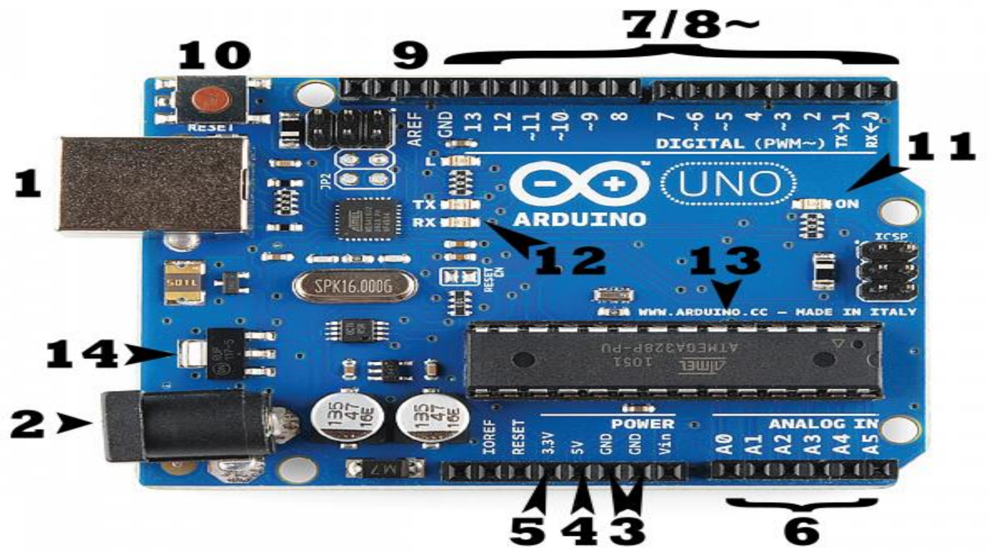


Fig 4.4 Arduino UNO

that runs on your computer, used to write and upload computer code to the physical board. The Arduino platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board – you can simply use a USB cable.Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package.

Every Arduino board needs a way to be connected to a power source. The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply (like this) that is terminated in a barrel jack. In the picture above the USB connection is labelled **(1)** and the barrel jack is labelled **(2)**.

4.6 Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF):

The pins on your Arduino are the places where you connect wires to construct a circuit (probably in conjunction with a breadboard and some wire. They usually have black plastic ‘headers’ that allow you to just plug a wire right into the board. The Arduino has several different kinds of pins, each of which is labelled on the board and used for different functions.

- **GND (3)**: Short for ‘Ground’. There are several GND pins on the Arduino, any of which can be used to ground your circuit.
- **5V (4) & 3.3V (5)**: As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.
- **Analog (6)**: The area of pins under the ‘Analog In’ label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.
- **Digital (7)**: Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).
- **PWM (8)**: You may have noticed the tilde (~) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM).
- **AREF (9)**: Stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

4.7 Reset Button:

- Just like the original Nintendo, the Arduino has a reset button **(10)**. Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino.
- This can be very useful if your code doesn't repeat, but you want to test it multiple times. Unlike the original Nintendo however, blowing on the Arduino doesn't usually fix any problems.

4.8 Power LED Indicator:

Just beneath and to the right of the word "UNO" on your circuit board, there's a tiny LED next to the word 'ON' **(11)**. This LED should light up whenever you plug your Arduino into a power source. If this light doesn't turn on, there's a good chance something is wrong. Time to re-check your circuit!

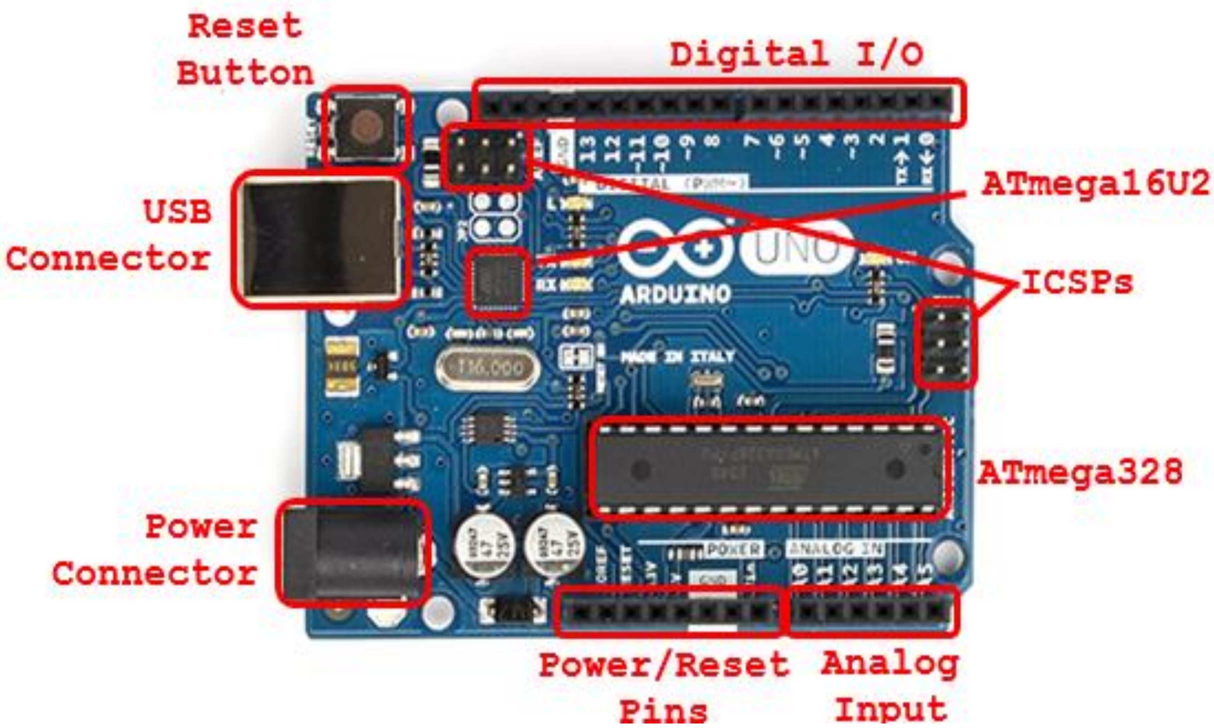


Fig 4.5 Components of Arduino UNO

4.9 TX RX LEDs:

- TX is short for transmit RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication.
- In our case, there are two places on the Arduino UNO where TX and RX appear once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs **(12)**.
- These LEDs will give us some nice visual indications whenever our Arduino is receiving or transmitting data (like when we're loading a new program onto the board).

4.10 Main IC:

- The black thing with all the metal legs is an IC, or Integrated Circuit **(13)**. Think of it as the brains of our Arduino.
- The main IC on the Arduino is slightly different from board type to board type, but is usually from the AT mega line of IC's from the ATMEL company.
- This can be important, as you may need to know the IC type (along with your board type) before loading up a new program from the Arduino software.
- This information can usually be found in writing on the top side of the IC.

4.11 Voltage Regulator:

- The voltage regulator **(14)** is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what it's for.

- The voltage regulator does exactly what it says – it controls the amount of voltage that is let into the Arduino board. Think of it as a kind of gatekeeper; it will turn away an extra voltage that might harm the circuit. Of course, it has its limits, so don't hook up your Arduino to anything greater than 20 volts

4.12 ATMEGA328 Microcontroller

- The Atmel AVR core combines a rich instruction set with 32 general purpose working registers.
- All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in a single instruction executed in one clock cycle.
- The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.
- The ATmega328/P provides the following features:
- 32Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6- channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages) , a programmable Watchdog Timer with internal Oscillator, an SPI serial port, and six software selectable power saving modes.
- The Boot program can use any interface to download the application program in the Application Flash memory.

➢ Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation.

➢ By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega328/P is a powerful microcontroller that provides a highly flexible and cost-effective solution to many embedded control applications.

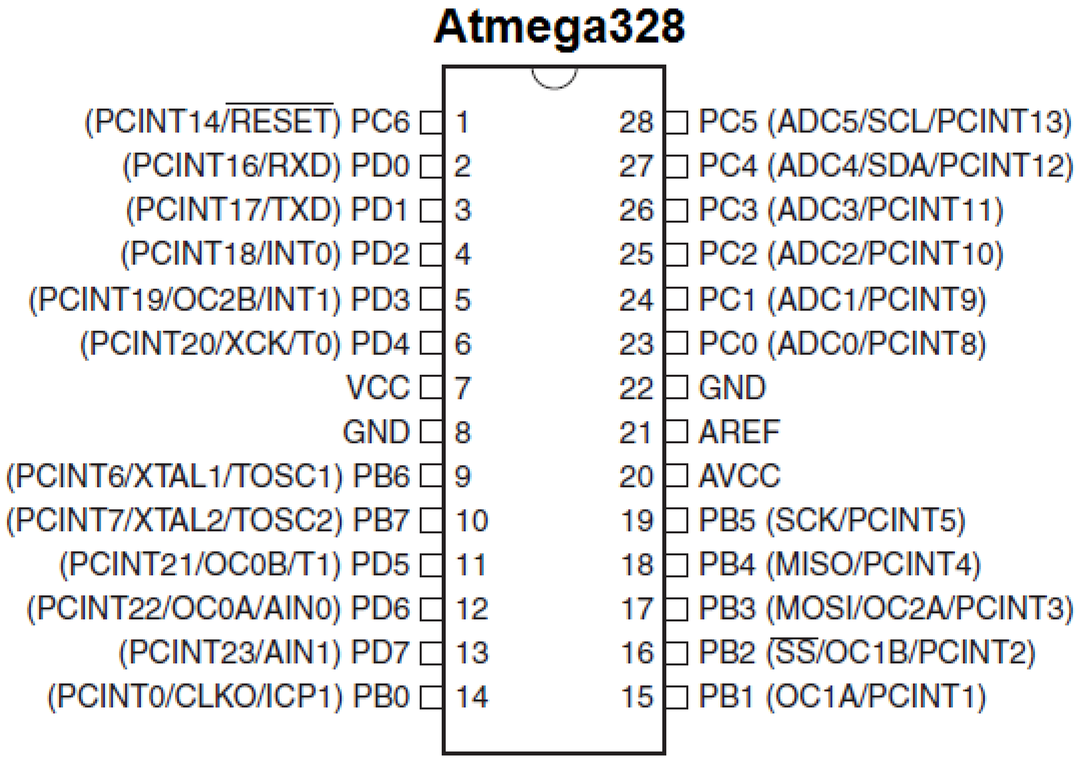


Fig 4.6 Pin Diagram of ATmega328 Microcontroller

Fig 4.7 ATmega328 Microcontroller

Input and Output:

Arduino - ArduinoBoardUno Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() 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.

Specification:

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

Table 4.1 Specification of Microcontroller ATmega328

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.

Memory:

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

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).

Arduino Pinpoint:

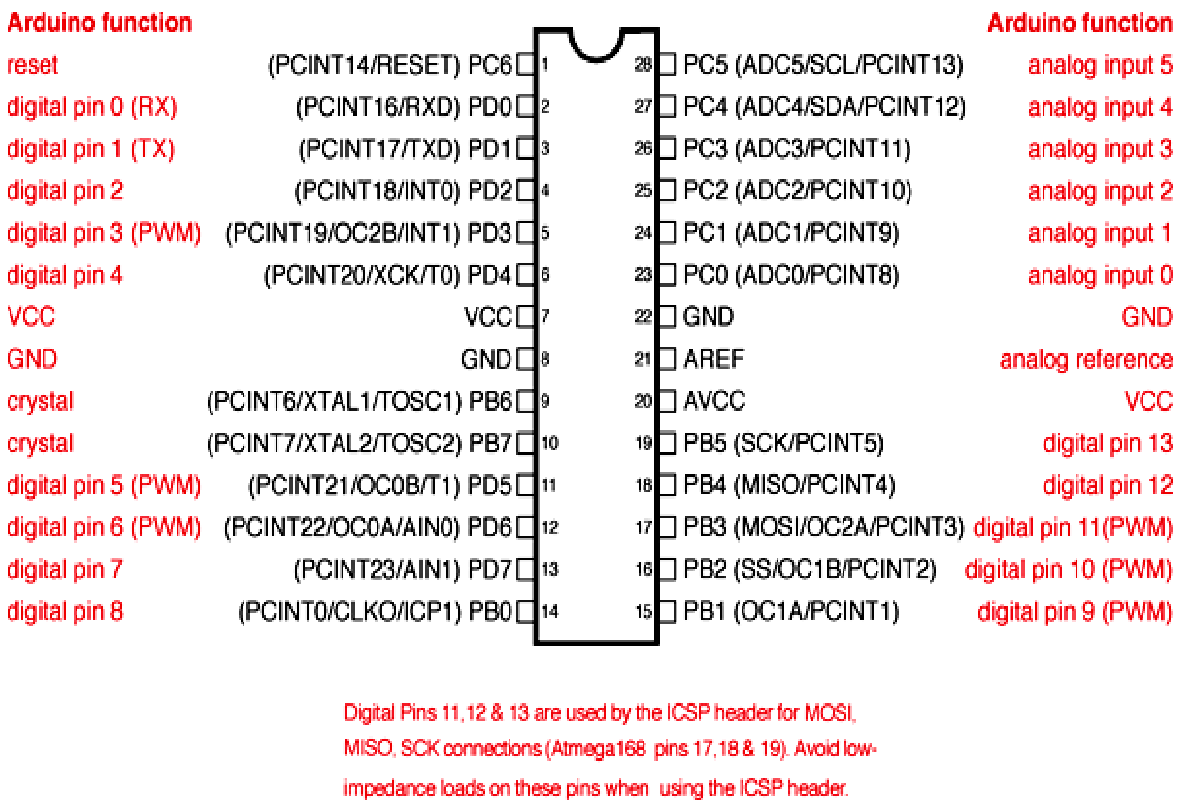


Fig 4.8 Microcontroller ATmega328 Pinpoints

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

CHAPTER 5
EMBEDDED SYSTEM

5.1 INTRODUCTION

An embedded system is one kind of a computer system mainly designed to perform several tasks like to access, process, store and also control the data in various electronics-based systems. Embedded systems are a combination of hardware and software where software is usually known as firmware that is embedded into the hardware. One of its most important characteristics of these systems is, it gives the o/p within the time limits. Embedded systems support to make the work more perfect and convenient. So, we frequently use embedded systems in simple and complex devices too. The applications of embedded systems mainly involve in our real life for several devices like microwave, calculators, TV remote control, home security and neighbourhood traffic control systems, etc. One of the facts is our world will connect to more than 50 billion devices by 2020.

5.2 Embedded System Hardware

An embedded system uses a hardware platform to perform the operation. Hardware of the embedded system is assembled with a microprocessor /microcontroller. It has the elements such as input/output interfaces, memory, user interface and the display unit.

5.3 Microcontroller (CPU)

A Microcontroller is preferred to build small applications with precise calculation. Indeed, they have a limited amount of ram and less reliable. Some of the famous manufacturing companies are Altera, Atmel, Renesas, Infineon, NXP and much more. Technically, a microcontroller is an intelligent device that computes the tasks assigned by the user in an efficient manner.

5.4 System on Chip (SoC)

SoC comprises a CPU, Peripheral devices (Timers, counters), Communication interfaces (I²C, SPI, UART), and Power Management Circuits on a single IC. If your application should be more reliable with higher performance and low-cost SoC is the best choice. It supports one or more processor cores.

5.5 ASIC processor

ASIC means Application Specific Integrated Circuit.
Firstly the chip was designed to use for a particular application and owned by a single company. So no copyrighting of the product is allowed. Secondly, it consumes little power.

5.6 DSP processor

You may wonder, these are the most used processors for Audio and video applications. DSP Processors removes the noise and improves signal quality for your DVD player, Music player, and Gaming consoles.
Note: There may be hundreds of Microcontroller/Microprocessor present in the embedded computing system.

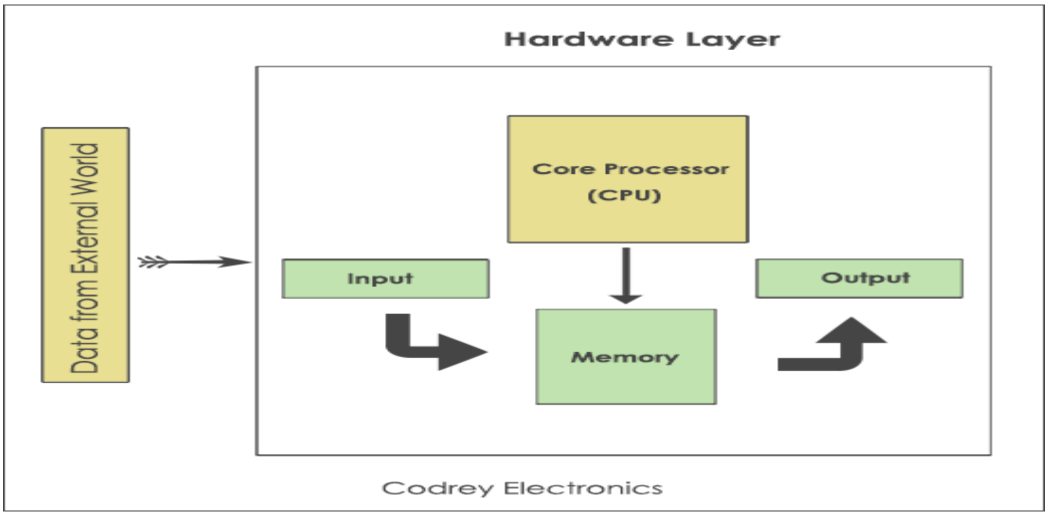


Fig 5.1 CPU Process

5.7 INPUT Device:

Input devices take input from the outside world. Some of the examples of input devices are sensors, switches, photo-diode, optocoupler etc. They accept input from the user and respond accordingly.

5.8 Devices:

The output devices are the indications or results that occur due to input events from outside the microcontroller. Examples of output devices are LCD, LED, Motors, Seven segment displays, Buzzer, Relays etc.

5.9 Bus controllers:

The **bus controller** is a communication device that transfers data between the components inside an embedded system. Some of the bus controllers are Serial Buses (I2C, SPI, SMBus etc.), RS232, RS485, etc,,.

5.10 Memory:

To store the data and deal with memory management, memory devices like flash and SD card, EEPROM is required. Some of the memories used in the embedded system are Non-Volatile RAM, Volatile RAM, DRAM.

5.11 Embedded System Software:

The software of an embedded system is written to execute a particular f/n. It is normally written in a high-level setup and then compiled down to offer code that can be stuck within a non-volatile memory in the hardware. Embedded s/m software is intended to keep in view the 3 limits.

- Convenience of system memory
- Convenience of processor's speed
- When the embedded system runs constantly, there is a necessity to limit power dissipation for actions like run, stop and wake up.

5.12 Device Driver

Device drivers are the core software components that control a peripheral device. A device driver is a piece of embedded code written for a particular hardware. The peripheral may be LCD, Touch screen, UART, USB etc.

5.13 Operating System (OS)

An operating system is a system software that manages the resources like memory, I/O (Input-Output) management etc. In an embedded system, different types of operating systems exist. Some of them are RTOS (Real-time operating systems), mobile embedded, stand-alone and network embedded systems.

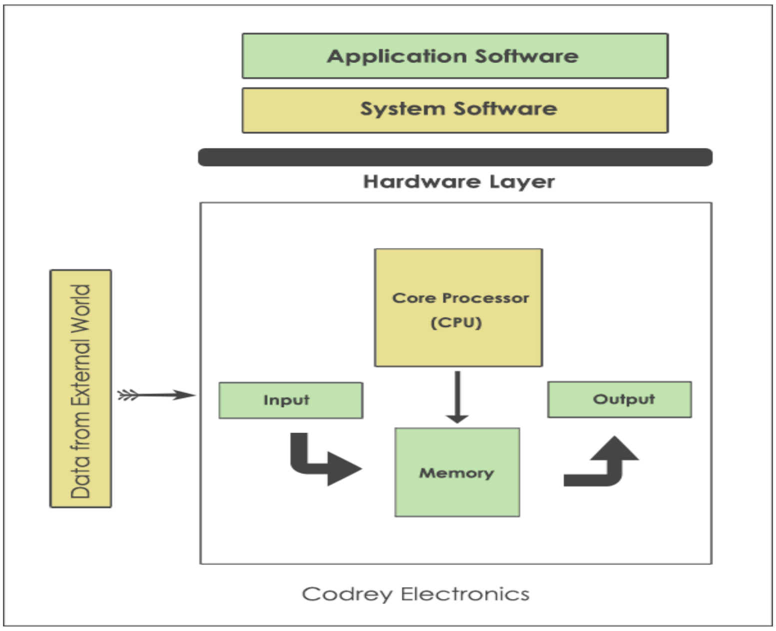


Fig 5.2 CPU

5.14 Applications

- Smart Homes
- Offices
- Transportation
- Healthcare
- Aerospace and Defence
- Industrial world

5.15 Liquid Crystal Display

LCD stands for Liquid Crystal Display. LCD is finding wide spread use replacing LEDs (seven segment LEDs or other multi segment LEDs) because of the following reasons:

- The declining prices of LCDs.
- The ability to display numbers, characters and graphics. This is in contrast to LEDs, which are limited to numbers and a few characters.
- Incorporation of a refreshing controller into the LCD, thereby relieving the CPU of the task of refreshing the LCD. In contrast, the LED must be refreshed by the CPU to keep displaying the data.
- Ease of programming for characters and graphics.
- These components are “specialized” for being used with the microcontrollers, which means that they cannot be activated by standard IC circuits. They are used for writing different messages on a miniature LCD.

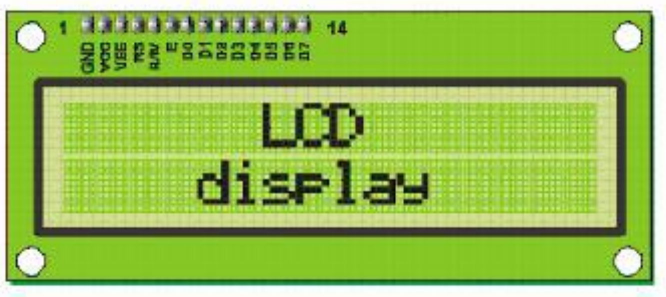


Fig 5.3 LCD Display

- A model described here is for its low price and great possibilities most frequently used in practice.
- It is based on the HD44780 microcontroller (*Hitachi*) and can display messages in two lines with 16 characters each. It displays all the alphabets, Greek letters, punctuation marks, mathematical symbols etc. In addition, it is possible to

display symbols that user makes up on its own.

- Automatic shifting message on display (shift left and right), appearance of the pointer, backlight etc. are considered as useful characteristics.

5.16 LCD Basic Commands

All data transferred to LCD through outputs D0-D7 will be interpreted as commands or as data, which depends on logic state on pin RS:

- RS = 1 - Bits D0 - D7 are addresses of characters that should be displayed. Built in processor addresses built in "map of characters" and displays corresponding symbols.
- Displaying position is determined by DDRAM address. This address is either previously defined or the address of previously transferred character is automatically incremented.RS = 0 - Bits D0 - D7 are commands which determine display mode.

5.17 Advantages of an LCD's:

- LCD's consumes less amount of power compared to CRT and LED
- LCD's are consist of some microwatts for display in comparison to some mill watts for LED's
- LCDs are of low cost
- Provides excellent contrast
- LCD's are thinner and lighter when compared to cathode ray tube and LED

5.18 Pins Functions

There are pins along one side of the small printed board used for connection to the microcontroller. There are total of 14 pins marked with numbers (16 in case the background light is built in).

CHAPTER 6

Interface MPU6050 Accelerometer and Gyroscope Sensor with Arduino:

In recent years, some crafty engineers successfully made micromachined gyroscopes. These MEMS (microelectromechanical system) gyroscopes have paved the way to a completely new set of innovative applications such as gesture recognition, enhanced gaming, augmented reality, panoramic photo capture, vehicle navigation, fitness monitoring and many more.

No doubt the gyroscope and accelerometer are great in their own way. But when we combine them, we can get very accurate information about the orientation of an object. This is where the MPU6050 comes in. The MPU6050 has both a gyroscope and an accelerometer, using which we can measure rotation along all three axes, static acceleration due to gravity, as well as motion, shock, or dynamic acceleration due to vibration.

Before we use the MPU6050 in our Arduino project, it would be good to see how accelerometers and gyroscopes really work.

6.1 How Accelerometer Works?

To know how accelerometers work, it is often useful to imagine a ball inside a 3D cube.

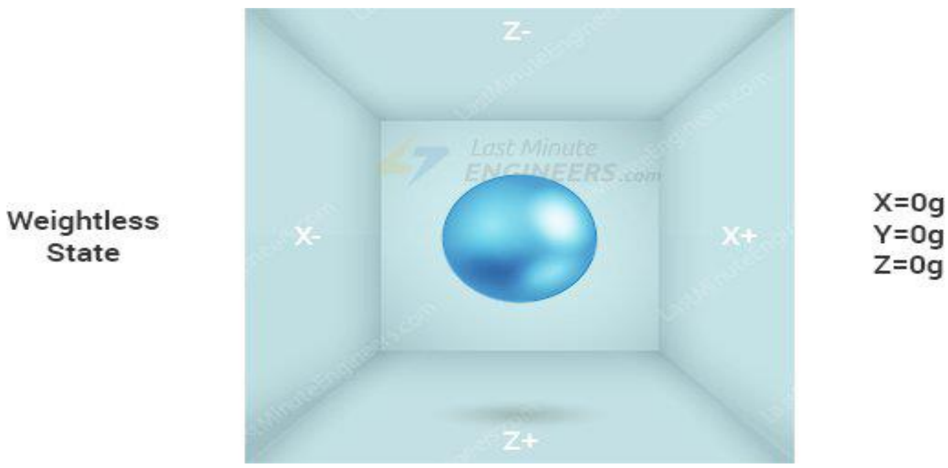


Fig 6.1 Ball at weightless State

Suppose, the cube is in outer-space where everything is in weightless state, the ball will simply float in the middle of the cube.

Now let's imagine each wall represents particular axis.

If we suddenly move the box to the left with acceleration 1g(A single G-force 1g is equivalent to gravitational acceleration 9.8 m/s^2), no doubt the ball will hit the wall X. If we measure the force that the ball applies to the wall X, we can get an output value of 1g on the X axis.

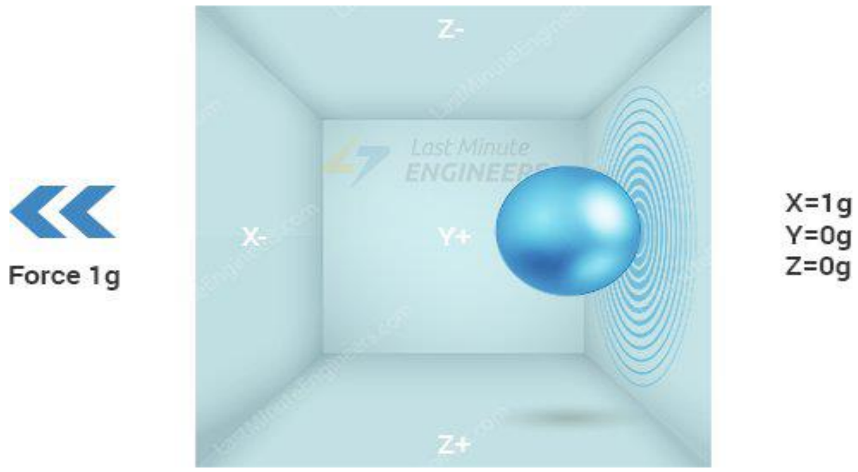


Fig 6.2 Ball with a force 1g applied on wall X

Let's see what happens if we put that cube on Earth. The ball will simply fall on the wall Z and will apply a force of 1g, as shown in the picture below:

In this case the box isn't moving but we still get a reading of 1g on the Z axis. This is

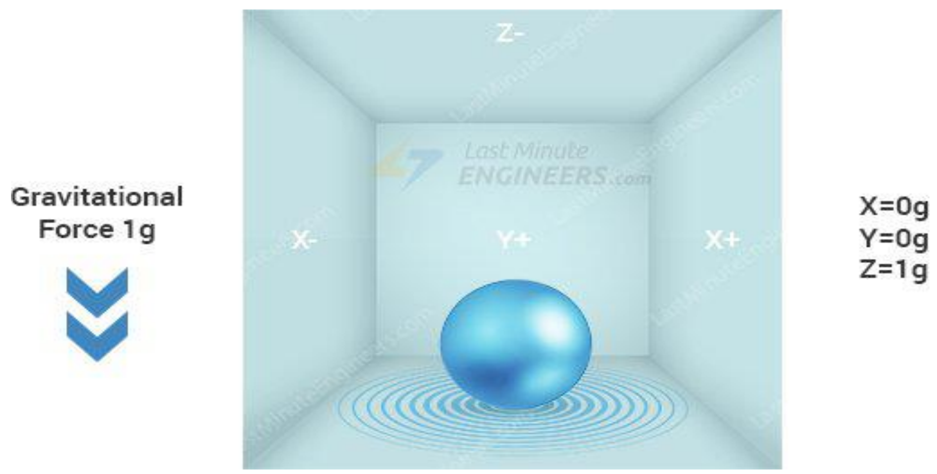


Fig 6.3 Ball with a force 1g applied on wall Z

because the gravitational force is pulling the ball down with force 1g.

The accelerometer measures the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration.

6.2 How MEMS Accelerometer Works?

MEMS(Micro Electro Mechanical Systems) accelerometer consists of a micro-machined structure built on top of a silicon wafer.

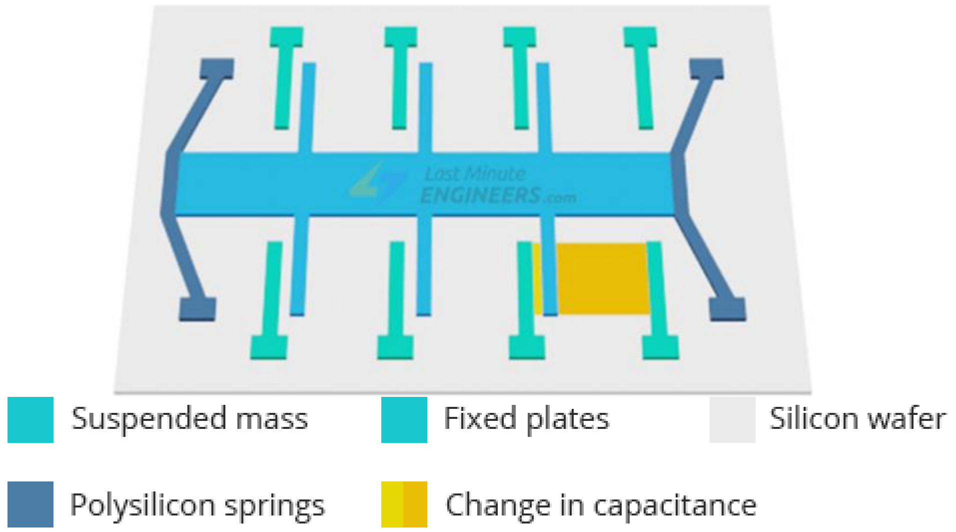


Fig 6.4 MEMS Accelerometer

This structure is suspended by polysilicon springs. It allows the structure to deflect at the time when the acceleration is applied on the particular axis.

Due to deflection the capacitance between fixed plates and plates attached to the suspended structure is changed. This change in capacitance is proportional to the acceleration on that axis. The sensor processes this change in capacitance and converts it into an analog output voltage.

6.3 How Gyroscope Works?

While accelerometers measure linear acceleration, MEMS gyroscopes measure angular rotation.To do this they measure the force generated by what is known as The Coriolis Effect. A gyroscope is a device with a spinning disc or wheel mechanism that harnesses the principle of conservation of angular momentum : the tendency for the spin of a system to remain constant unless subjected to external torque.

6.4 Coriolis Effect:

Coriolis Effect tells us that when a mass (m) moves in a particular direction with a velocity (v) and an external angular rate (Ω) is applied (Red arrow); the Coriolis Effect generates a force (Yellow arrow) that causes a perpendicular displacement of the mass. The value of this displacement is directly related to the angular rate applied.

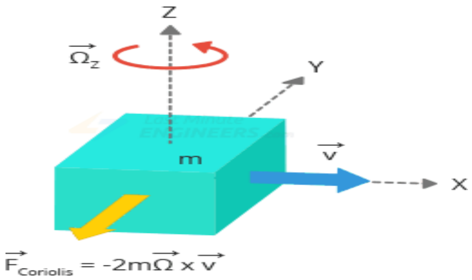


Fig 6.5 Coriolis effect

Now suppose that there are two masses that are kept in constant oscillating motion so that they move continuously in opposite directions. When angular rate is applied,

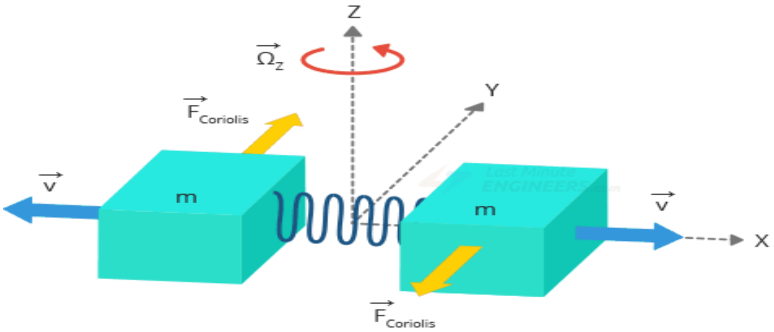


Fig 6.6 Coriolis Effect on two masses

the Coriolis effect on each mass is also in opposite directions, which results in a change in the capacitance between them; this change is sensed.

6.5 How MEMS Gyroscope Works?

MEMS Gyroscopes are **used to determine the orientation of a body in free space**. For example, gyroscopic sensors have applications in the following products: Quadcopter, planes, and robot actual position. Used in smartphones to detect smartphone orientation and rotation.The MEMS sensor is composed of a proof mass (containing 4 parts M1, M2, M3 and M4) which is kept in a continuously oscillating movement so that is reacts to the coriolis effect.

They move inward and outward simultaneously in the horizontal plane. All MEMS gyroscopes with vibrating element are based on the transfer of energy between two vibration modes caused by the acceleration of Coriolis. The Coriolis acceleration, proportional to the angular velocity, is an apparent acceleration that is observed in a rotating frame of reference.

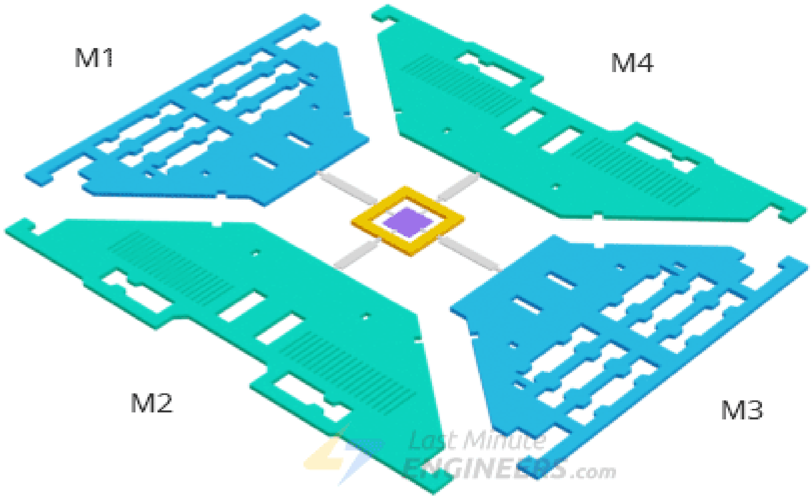
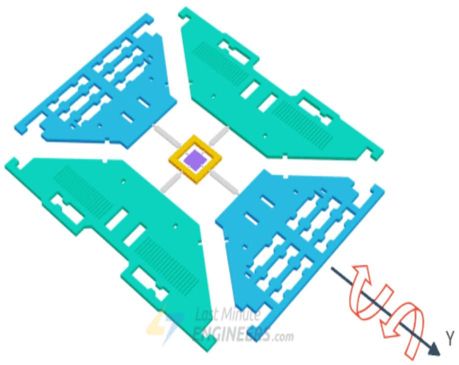


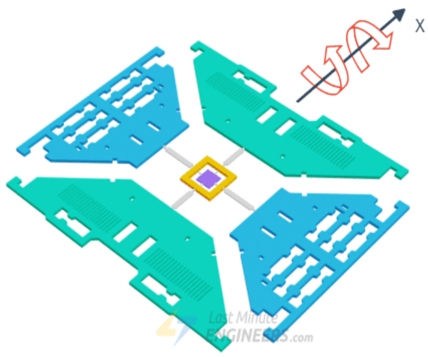
Fig 6.7 MEMS Gyroscope

When we start rotating the structure, the Coriolis force acting on the moving proof mass changes the direction of the vibration from horizontal to vertical.

There are three modes depending on which axis the angular rotation is applied.

- Roll Mode
- Pitch Mode
- Yaw Mode





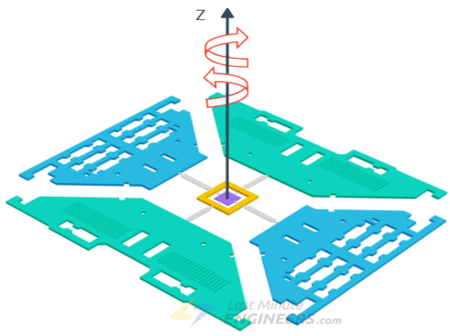


Fig 6.8 Roll Mode **Fig 6.9 Pitch Mode** **Fig 6.10 Yaw Mode**

6.6 MPU6050 Module Hardware Overview

At the heart of the module is a low power, inexpensive 6-axis MotionTracking chip that combines a 3-axis gyroscope, 3-axis accelerometer, and a Digital Motion Processor (DMP) all in a small 4mm x 4mm package.

It can measure angular momentum or rotation along all the three axis, the static acceleration due to gravity, as well as dynamic acceleration resulting from motion, shock, or vibration.

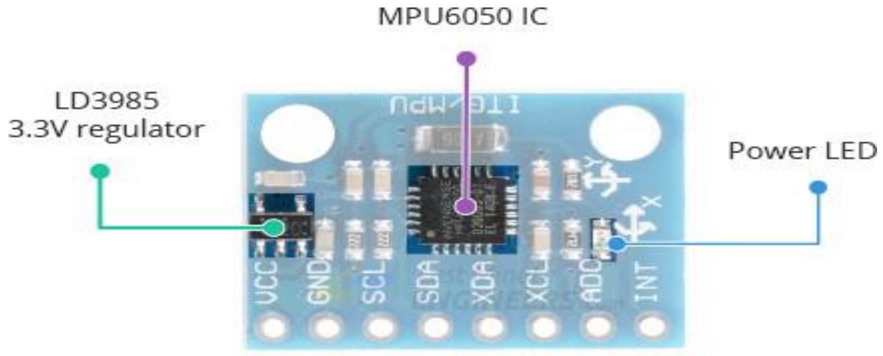


Fig 6.11 MPU6050 Module

The module comes with an on-board LD3985 3.3V regulator, so you can use it with a 5V logic microcontroller like Arduino without worry.

The MPU6050 consumes less than 3.6mA during measurements and only 5µA during idle. This low power consumption allows the implementation in battery driven devices. In addition, the module has a power LED that lights up when the module is powered.

6.7 Measuring Acceleration:

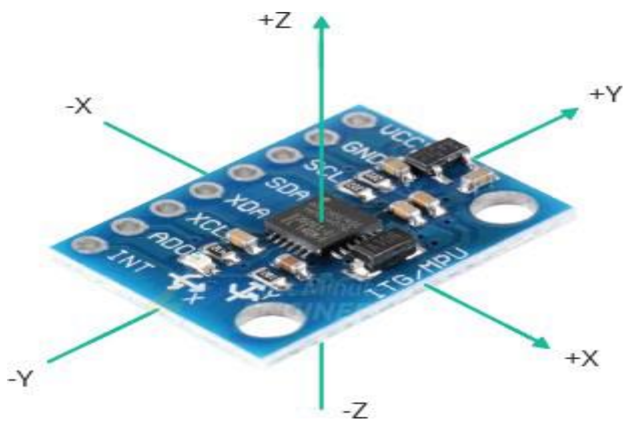


Fig 6.12 Measuring Acceleration

The MPU6050 can measure acceleration using its on-chip accelerometer with four programmable full scale ranges of ±2g, ±4g, ±8g and ±16g.

The MPU6050 has three 16-bit analog-to-digital converters that simultaneously sample the 3 axis of movement (along X, Y and Z axis).

6.8 Measuring Rotation

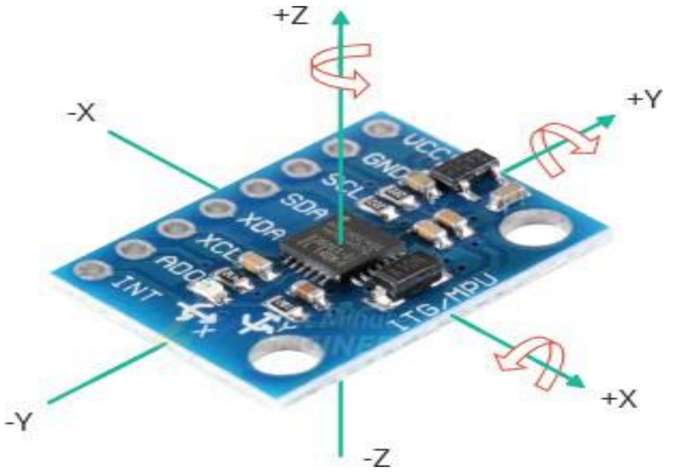


Fig 6.13 Measuring Rotation

The MPU6050 can measure angular rotation using its on-chip gyroscope with four programmable full scale ranges of ±250°/s, ±500°/s, ±1000°/s and ±2000°/s.

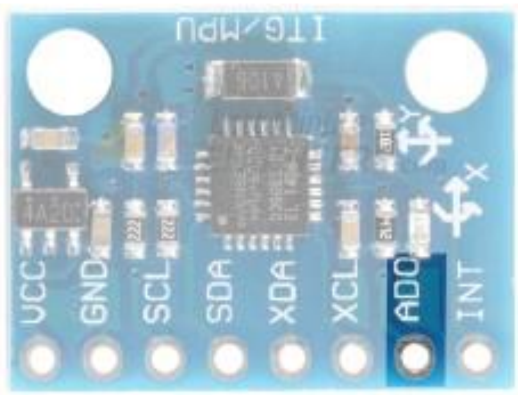


Fig 6.14 ADD

The MPU6050 has another three 16-bit analog-to-digital converters that simultaneously samples 3 axes of rotation (around X, Y and Z axis). The sampling rate can be adjusted from 3.9 to 8000 samples per second.

6.9 Measuring Temperature

The MPU6050 includes an embedded temperature sensor that can measure temperature over the range of -40 to 85°C with accuracy of ±1°C. Note that this temperature measurement is of the silicon die itself and not the ambient temperature. Such measurements are commonly used to offset the calibration of accelerometer and gyroscope or to detect temperature changes rather than measuring absolute temperatures.

6.10 The I2C Interface

The module uses the I2C interface for communication with the Arduino. It supports two separate I2C addresses: $0x68_{HEX}$ and $0x69_{HEX}$. This allows two MPU6050s to be used on the same bus or to avoid address conflicts with another device on the bus. The ADO pin determines the I2C address of the module. This pin has a built-in 4.7K pull-down resistor.

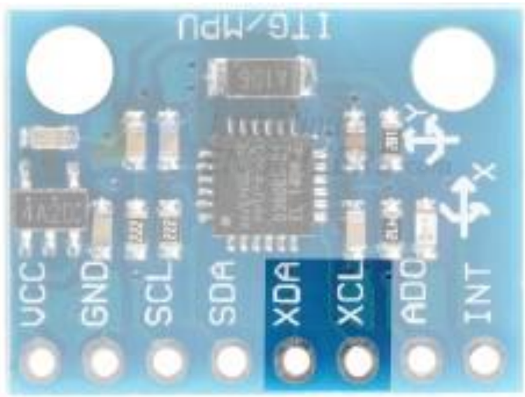


Fig 6.15 XDA and XCL

Therefore, when you leave the ADO pin unconnected, the default I2C address is $0x68_{HEX}$ and when you connect it to 3.3V, the line is pulled HIGH and the I2C address becomes $0x69_{HEX}$.

6.11 Adding External Sensors

To increase the level of accuracy even further, the MPU6050 module provides a feature for connecting external sensors. These external sensors are connected to the MPU6050 via a second I2C bus (XDA and XCL), which is completely independent of the main I2C bus.

This external connection is usually used to attach a magnetometer, which can measure magnetic fields on three axes. By itself, the MPU6050 has 6 Degrees of Freedom (DOF), three each for the accelerometer and the gyroscope. Adding a magnetometer adds an extra three DOF to the sensor, making it 9 DOF.

6.12 MPU6050 Module Pinout

The pin descriptions of the MPU6050 module are as follows:

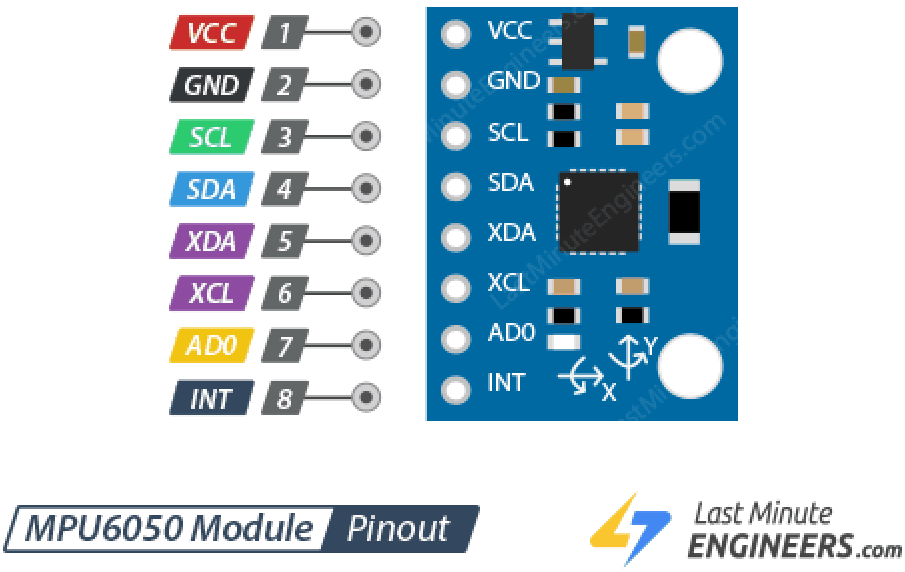


Fig 6.16 MPU6050 Module

VCC is the power supply for the module. Connect it to the 5V Arduino's O/P.

GND should be connected to the ground of Arduino.

SCL is a I2C Clock pin. This is a timing signal supplied by the Bus Master device. Connect to the SCL pin on the Arduino.

SDA is a I2C Data pin. This line is used for both transmit and receive. Connect to the SDA pin on the Arduino.

XDA is the external I2C data line. The external I2C bus is for connecting external sensors.

XCL is the external I2C clock line.

AD0 allows you to change the internal I2C address of the MPU6050 module. It can be used if the module is conflicting with another I2C device, or if you wish to use two MPU6050s on the same I2C bus. When you leave the ADO pin unconnected, the default I2C address is $0x68_{HEX}$ and when you connect it to 3.3V, the I2C address becomes $0x69_{HEX}$.

INT is the Interrupt Output. MPU6050 can be programmed to raise interrupt on gesture detection, panning, zooming, scrolling, tap detection, and shake detection.

6.13 Wiring MPU6050 Module with Arduino

Connections are fairly simple. Start by connecting VCC pin to the 5V output on the Arduino and connect GND to ground. Now we are remaining with the pins that are used for I2C communication. Note that each Arduino Board has different I2C pins which should be connected accordingly. On the Arduino boards with the R3 layout, the SDA (data line) and SCL (clock line) are on the pin headers close to the AREF pin. They are also known as A5 (SCL) and A4 (SDA). If you are using a different Arduino board, please refer below table.

	SCL	SDA
Arduino Uno	A5	A4
Arduino Nano	A5	A4
Arduino Mega	21	20
Leonardo/Micro	3	2

Table 6.1 Different Arduino Specifications

The following diagram shows you how to wire everything.

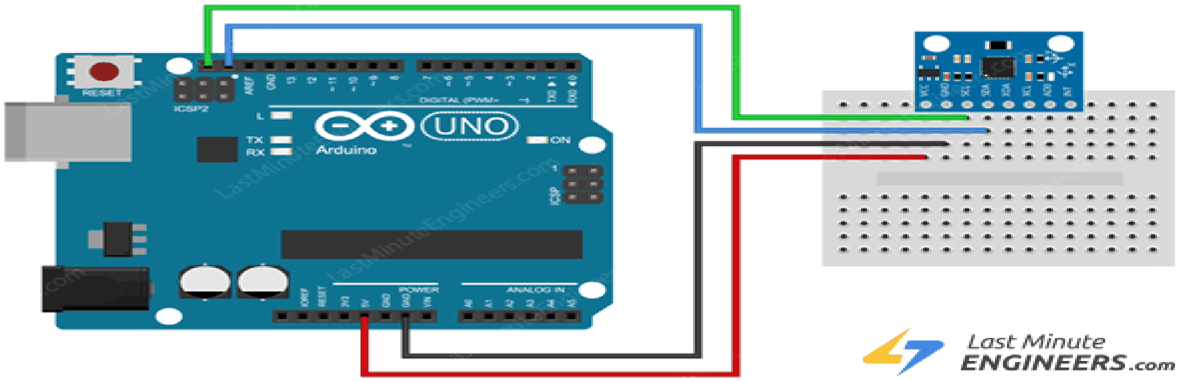


Fig 6.17 Wiring of Arduino UNO to Module

6.14 Library Installation

The MPU6050 module is relatively easy to get up and running and capturing the raw data output of the device. Manipulating the data into something meaningful, however, is more of a challenge, but there are some libraries available for using the device.

To install the library navigate to the Sketch > Include Library > Manage Libraries… Wait for Library Manager to download libraries index and update list of installed libraries.

Filter your search by typing ‘mpu6050’. There should be a couple entries. Look for Adafruit MPU6050 Library by Adafruit. Click on that entry, and then select Install. The Adafruit MPU6050 library uses Adafruit Unified Sensor Driver and Adafruit Bus IO Library internally. Therefore, search the library manager.

6.15 Arduino Code – Reading Accelerometer, Gyroscope and Temperature Data:

When you have everything hooked up try running the below sketch. It will give you a complete understanding on how to read linear acceleration, angular rotation & temperature from the MPU6050 module and can serve as the basis for more practical experiments and projects.

CHAPTER 7

Arduino UNO Program Code

```
#include <Adafruit_MPU6050.h>
#include <Adafruit_Sensor.h>
#include <Wire.h>

Adafruit_MPU6050 mpu;

void setup(void) {
	Serial.begin(115200);

	// Try to initialize!
	if (!mpu.begin()) {
		Serial.println("Failed to find MPU6050 chip");
		while (1) {
		  delay(10);
		}
	}
	Serial.println("MPU6050 Found!");

	// set accelerometer range to +-8G
	mpu.setAccelerometerRange(MPU6050_RANGE_8_G);

	// set gyro range to +- 500 deg/s
	mpu.setGyroRange(MPU6050_RANGE_500_DEG);

	// set filter bandwidth to 21 Hz
	mpu.setFilterBandwidth(MPU6050_BAND_21_HZ);

	delay(100);
```

```
}
void loop() {
    /* Get new sensor events with the readings */
    sensors_event_t a, g, temp;
    mpu.getEvent(&a, &g, &temp);

    /* Print out the values */
    Serial.print("Acceleration X: ");
    Serial.print(a.acceleration.x);
    Serial.print(", Y: ");
    Serial.print(a.acceleration.y);
    Serial.print(", Z: ");
    Serial.print(a.acceleration.z);
    Serial.println(" m/s^2");

    Serial.print("Rotation X: ");
    Serial.print(g.gyro.x);
    Serial.print(", Y: ");
    Serial.print(g.gyro.y);
    Serial.print(", Z: ");
    Serial.print(g.gyro.z);
    Serial.println(" rad/s");

    Serial.print("Temperature: ");
    Serial.print(temp.temperature);
    Serial.println(" degC");

    Serial.println("");
    delay(500);
}
```

Note that you must set your serial monitor to a speed of 115200 baud to try out the sketch. Because too much data is sent back from the MPU6050, it requires this higher speed to display it.

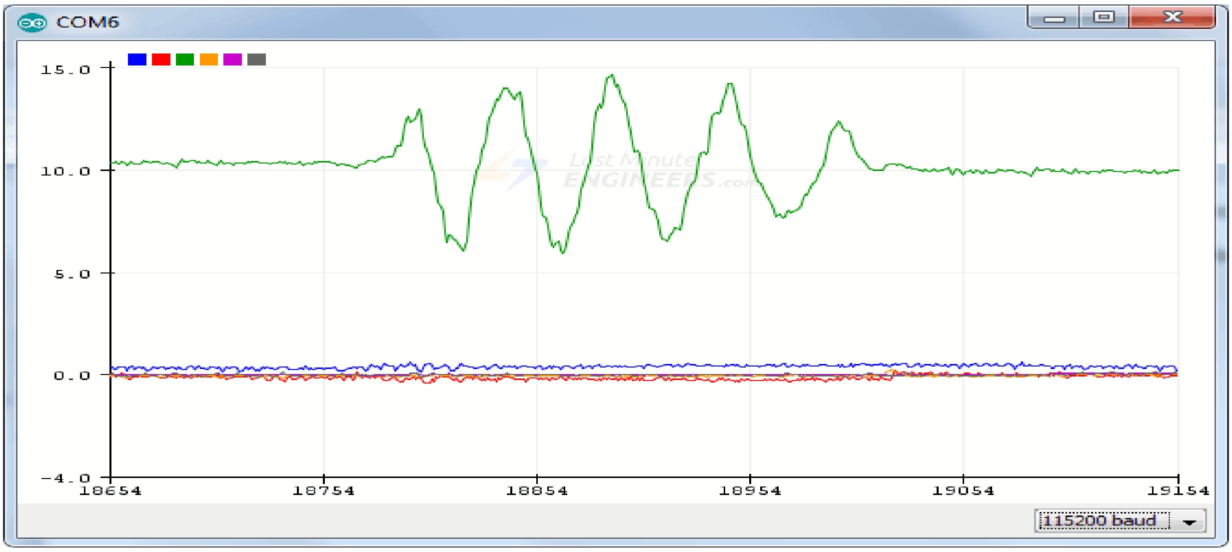


Fig 7.1 Sensor Data Plotted on Graph

You will see myriad of data displaying linear acceleration, angular rotation and temperature values. Try moving your sensor around and notice how the data changes. You should see something like this when moving the module up and down along the Z axis.

CHAPTER 8

CONCLUSION AND FUTURE SCOPE:

This technique allows deaf, dumb, and blind persons to communicate with one another. Dumb people speak in their own language, which is difficult for blind and conventional people to understand. The sign language is also translated into a written format to help deaf people. This text appears on a screen. Deaf people must be recovered. We'll using it to observe the hand motions for the deaf and blind. Hand movements are converted to text and then to voice by the system. If a person cannot hear the sound made due to those difficulties, a provision has been implemented into the text system so that the person still read and understand what the other person is trying to say.

CHAPTER 9

REFERENCES:

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