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CHAPTER 1
INTRODUCTION

This chapter gives an overview of E-Scale, presents the need and the objective of the project.

1.1 OVERVIEW OF THE PROJECT

Measurement is crucial in determining the dimensions and angles of an object. It is the assignment of a number to a characteristic of an object, which can be compared with other objects. The scope and application of measurement are dependent on the context and discipline. In social and behavioural sciences, measurements play a key role in determining the properties of the objects. Multiple measuring devices have been invented time to time and each of them had its own precision in quantifying the physical attributes of objects.

Measurement is a cornerstone of trade, science, technology, qualitative and quantitative research in many disciplines. Historically, many measurement systems existed for the varied fields of human existence to facilitate comparisons in diverse fields. As technology evolved, developments progressed towards unifying widely accepted standards as the scales of measurement. Measurement scales are used to categorize the four scales of measurement used in statistical analysis like nominal, ordinal, interval, and ratio scales.

Multiple physical components are required to measure the various dimensions of an object. Involvement of manpower is more in the case of traditional methods. Manual measurement of physical properties of an object is tedious and the precision is too low. There occurs a need to use different measuring devices for measuring objects of varied dimensions.

It is pivotal that an automated scale is used for measuring the attributes such as length, width, volume, weight, area of an object.An E-Scale is constructed using a laser sensor, encoder, accelerometer and gyroscope, controlled by a microcontroller and output is displayed using an OLED display.

E-scale measures theangle, the distance between the object and the user and between objects, height, area and volume of the objects. The object disparity, dragging distance and device orientation are used as features to determine a distance between the target object and the device. This improves the precision of measurement when compared to traditional means of measurement of objects such as tape meters, ultrasonic devices and laser distance meters.

1.2 OBJECTIVE OF THE PROJECT

The objective of the project is to construct an E-Scale which measures all physical attributes of an object. This removes the need for using different devices to measure the different parameters of measurement. E-scale ensures easier and more precise measurement of objects than the conventional means of measurement.

The E-scale isused to calculate the distance between user and an object and between objects, angle between the two planes, length and height of an object, area of square and rectangular objects, circumference and area of the circular objects, volume of cylindrical and cubical objects.

1.3 NEED FOR THE OBJECT

Various distance parameters require different methodologies and equipments to be measured. This project aims in integrating all the required measuring components as a single functioning unit where the measuring complexity is highly reduced. To reduce the man made errors, automation is required. In order to overcome all these shortcomings a simplified method of calculating length parameters is highly necessary.

1.4 PROBLEM DEFINITION

Conventional modes of measurement are tedious and involve huge manpower. To calculate the different attributes of an object, various measuring devices have to be used. There is a need for an automated measuring device which integrates all the devices to quantify all physical attributes of an object in an efficient and easy manner.

1.5 ORGANISATION OF THE REPORT

CHAPTER 1: Gives an overview of E-scale, states the objective of the project and the need for the project.

CHAPTER 2: Discusses the literature survey of existing system.

CHAPTER 3: Explains the proposed system.

CHAPTER 4: Explains the hardware and software description of the project.

CHAPTER 5: Discusses the measurement techniques involved and its analysis.

CHAPTER 6: Discusses the outcome of the project.

CHAPTER 7: Gives the conclusion and explains about the future work that can be made.

CHAPTER 2

LITERATURE SURVEY

This chapter gives an overview of researches carried out related to the project work on “E-Scale”.

A.M. Kassim, H.I Jaafar, M.A. Azam and N. Abas, et.al, 2013, “Performances Study of Distance Measurement Sensor with Different Object Materials and Properties’’ discussed on misbehaviour that occurs during the distance measurement of objects in industry, due to different type of material or different environment condition. Two different sensors using two different principles are taken under study. A sharp GP2D120 IR sensor measures distance using the principle of optical polarization. The IR sensor uses reflected waves to obtain distance. The optical transmitter projects light over the target under study. The reflection of that light is focused via an optical lens on a light sensitive receiver. Another sensor taken under study is Parallax’s PING))) Ultrasonic sensor. In this sensor two electro-acoustic transducers perform the task of distance measurement. In order to evaluate the performance of distance measurement sensors with different object properties the distance between the target and the sensor is varied also the physical state of the target is varied and the corresponding net results are examined. When the distance exceeds 80cm, IR sensor lost its function to detect the object because IR sensor can only detect objects for a maximum range of 80cm whereas sonar sensor shows accurate distance. Ultrasonic sensor’s precision for soft material seems to have dropped due the fact that soft materials absorb vibrations and the reflection of sound wave gets delayed and the calculated distance is slightly greater than the actual distance. Similarly IR sensor lost its affinity towards all transparent materials because the infrared beam cannot reflect on the transparent surface. Though the ultrasonic sensor is better in comparison with IR sensor it lacks its efficiency when it comes to soft materials. Hence to overcome the disadvantages of the above mentioned sensors Laser sensor is used since laser beam does not penetrate through transparent medium.

LU Guizhu, et.al, 2010, “Research on High-resolution Colour OLED Display Technology” discussed on a new OLED colour display method in which the impact of the brightness stability and life factors of various materials are analysed. High resolution OLED panels and colour balance is enhanced. In addition to that total power consumption is reduced which turns out to be an major advantage. Compared to LCD, OLED has a splendid performance in the areas of low power consumption, wide range angle, temperature withstanding capability, simple manufacturing process. OLED follows the basic principle of electroluminescent in which some organic materials can emit light while passing an electric current through them. Typically, the lifetime of OLED is inversely proportional to the density specified to the driving current. Driving power affects the lifetime of OLED. Now known that white light OLED materials have higher stability and efficiency when compared to the other Red(R), Green(G) and Blue(B) materials. So the current density required to drive the white OLED materials is significantly lower when compared to the other materials which in turn consumes low power. By calculating the peak brightness level of Red, Green and Blue OLED’s, and applying the white transmitter power efficiency, the required current to drive the OLED can be calculated. To display the colour images each pixels of Red, Green, Blue and White needed a supply for each one of them an it can be supplied via DAC. OLED provides 65k colour display with each pixel has a 16 bit data where Red is allocated with 5 bits, Green with 6 bits and Blue with 5 bits. By this gray scale is achieved with 65k full colour display. Full colour of OLED is achieved by using Red, Green, Blue and White colour emitters. Current of each RGB is controlled when the brightness and service of every emitters specified should be fully guaranteed. So, OLED is thinner, lighter and more flexible and it does not require any backlighting like LCDs. It has faster response time than other displaying units. It has improved image quality, better contrast and wide range displaying compatibility. So it is known that OLED is a low cost, low power consumption and high efficient which is highly suitable for displaying the data.

D. Thomas and A. Hunt, et.al, 2016, "State machines," discussed on state machine implementation. A state machine is a system with a set of unique states. One state is special—it represents the system's initial state. One or more of the other states are final states; when an event causes us to reach one of these the state machine exits. States are connected by transitions. Each transition is labelled with the name of an input event. When that event occurs, we follow the corresponding transition from the current state to arrive at the new state. State machines are often represented as diagrams with the states shown as circles and the transitions as labelled arrows between the states. This type of state machine is sometimes called a deterministic finite state machine or automaton. For very simple state machines, we find it is easiest to implement the states and transitions manually. We use a variable to keep the current state and update it as events happen. Typically, we'll have a case statement to handle the different states or events. However, once we start becoming more complex, we convert the state transition diagram to a 2D table. The table is indexed by the current state and the input event, returning the resulting next state. It's convenient to include an action code in each table entry too, because this tells us what to do on each transition. Depending on the target language, we might then generate from this a header file containing the definitions of the states, events and actions, and a source file containing the transition table. The actions could be defined as enumerations or possibly as a set of function pointers. From this paper we had learnt that how to prepare the state diagram and implement in the embedded c language.

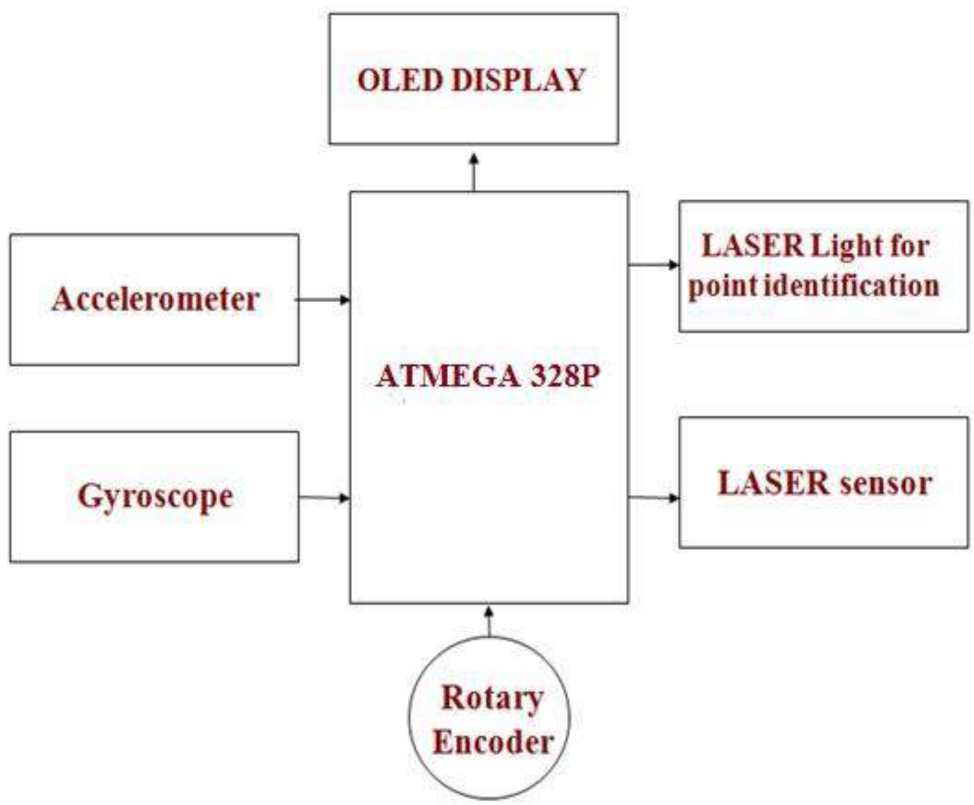
D. Sueaseenak, N. Namjirachot and K. Sukkit, et.al, 2015, "Accelerometer-Based Angle Measurement System with Application in Hospital Bed" discussed on angle measurement using Accelerometer and Arduino. The accelerometer used is ADXL335 IC chip. Its function is to perform an AC amplification, Demodulation unit and output amp. The Arduino servers as signal amplification,analog to digital converter, low pass filter, isolator and SPI. While performing brain surgeries or head injury surgeries, the angle at which the patient is very important which controls the blood pressure too. The accelerometer sensor can measure the angle in X, Y and Z axis. The ADXL335 is a small, thin, low power 3-axis accelerometer with signal conditioning voltage outputs. It measures acceleration with a minimum full scale range of 3g. It can also measure the static acceleration of gravity in tilt-sensing applications. A LCD display is used to display the angle values obtained. The ADXL335 supports I2C protocol through which the data from the accelerometer can be sent to any microcontroller having I2C provision. To evaluate the accuracy of the angle measurement, the goniometer was used. It measures the angle and compares the accuracy of the angle. The Arduino will read the angle measured by the accelerometer and it also reads the angle form goniometer. Both the values are compared and it seen that the results have an accuracy of more than 80%. The results are also very promising. The main disadvantage of this paper is that it uses LCD display which has a complex coding to be done when compared to other display units. Also it is clear than ADXL335 is a lost cost, highly accurate and high efficient module which is very much suitable for simple angle measurement systems.

CHAPTER 3
PROPOSED SYSTEM

3.1 INTRODUCTION

This chapter explains about the works undertaken in developing an integrated distance parametric analyzing electronic scale. In the field of architecture length parameters play a vital role in portraying the efficiency of the constructed building. This electronically triggered scale will help meeting the demand of the construction site.

3.2 BLOCK DIAGRAM

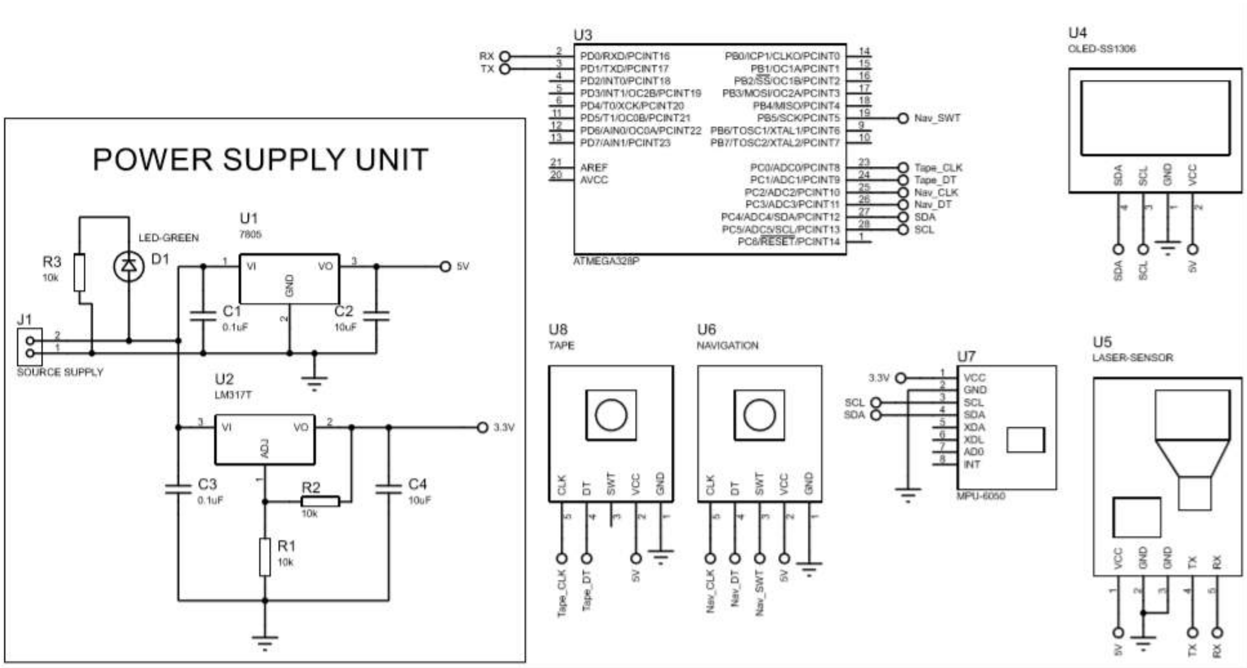


Block diagram of E-Scale

3.2 PROPOSED SYSTEM MODEL

The proposed model consists of four I/O modules namely accelerometer sensor, OLED display, Encoder and Laser sensor. The data from these modules are received and manipulated by a single master unit. The master here ATMEGA 328p microcontroller has various astonishing features which brings it into consideration.

Accelerometer and Gyroscope sensor gives the angle between two points , the laser module gives the distance between two points suspended in free space, the encoder gives distance between two points placed in a ground also it has a unique feature of measuring even minute distances. These three modules are input devices. They get input from the environment and feed it to the controller. As per the algorithm that has been dumped into the controller the data manipulation and calculation takes place. OLED display here is an output device which displays the calculated data to the user. To measure the length of an object cosine rule is used. Pythagoras theorem is helpful in calculating the unknown length of a triangle. Through all these mathematical functions the length, breadth, height, angle, circumference and several other dimensions can be estimated with higher accuracy. This model aims in using a single electronically triggered device to calculate the measurement parameters therefore this model is helpful in eliminating the time complexity, man power involved and the error caused due to manual inspection. Also in order to facilitate data transfer the I/O devices should follow certain protocols. Accelerometer and OLED display follows I^2C protocol whereas Laser module follows USART protocol. These protocols are helpful in carrying a lossless data communication. The below is a block diagram portraying how the I/O devices are linked with the master microcontroller device.

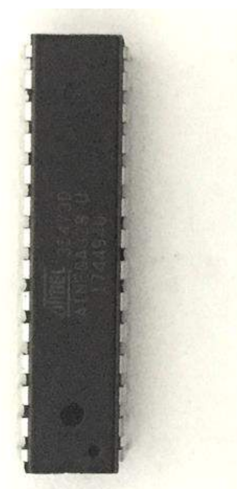


Proposed model of E-Scale

CHAPTER 4
HARDWARE AND SOFTWARE DESCRIPTION

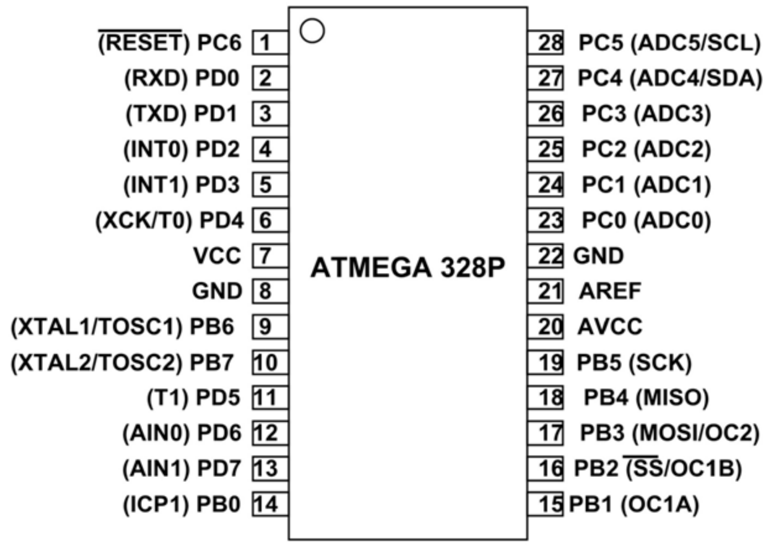
4.1 ATMEGA 328P MICROCONTROLLER

The high-performance Microchip picoPower 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.



ATMega 328p IC

4.1.1 PIN DIAGRAM



Pin diagram of ATMega 328p

20 of the pins function as I/O ports. This means they can function as an input to the circuit or as output. Whether they are input or output is set in the software. 14 of the pins are digital pins, of which 6 can function to give PWM output. 6 of the pins are for analog input/output. 2 of the pins are for the crystal oscillator. This is to provide a clock pulse for the Atmega chip. A clock pulse is needed for synchronization so that communication can occur in synchrony between the Atmega chip and a device that it is connected to.

The chip needs power so 2 of the pins, Vcc and GND, provide it power so that it can operate. The Atmega328 is a low-power chip, so it only needs between 1.8-5.5V of power to operate.

The Atmega328 chip has an analog-to-digital converter (ADC) inside of it. This must be or else the Atmega328 wouldn't be capable of interpreting analog signals. Because there is an ADC, the chip can interpret analog input, which is why the chip has 6 pins for analog input. The ADC has 3 pins set aside for it to function- AVCC, AREF, and GND. AVCC is the power supply, positive voltage, that for the ADC. The ADC needs its own power supply in order to work. GND is the power supply ground. AREF is the reference voltage that the ADC uses to convert an analog signal to its corresponding digital value. Analog voltages higher than the reference voltage will be assigned to a digital value of 1, while analog voltages below the reference voltage will be assigned the digital value of 0. Since the ADC for the Atmega328 is a 10-bit ADC, meaning it produces a 10-bit digital value, it converts an analog signal to its digital value, with the AREF value being a reference for which digital values are high or low. Thus, a portrait of an analog signal is shown by this digital value; thus, it is its digital correspondent value.

The last pin is the RESET pin.

4.1.2 SPECIFICATIONS

- IC type: AVR microcontroller
- Core size: 8-bit
- Speed: up to 20MHz
- Number of I/O: 23
- Program memory size: 32Kb (16K x 16)
- Program memory type: Flash
- EEPROM size: 1K x 8
- RAM size: 2K x 8
- Package: DIP-28 (0.1" x 0.3" pin spacing)
- Supply voltage: 1.8 V - 5.5 V
- Lead-free (RoHS compliant): Yes
- Manufacturer: Atmel
- Manufacturer part number: ATmega328P-PU

4.1.3 INTERNAL PHERIPERALS USED

4.1.3.1 GPIO

All AVR ports have read-write which means the direction of one port pin can be changed without unintentionally changing the direction of any other pin with the SBI and CBI instructions. The same applies when changing drive value of pull-up resistors. Each output buffer has similar characteristics with high sink as well as source capability. The pin driver has enough capacity of driving LED displays without any intermediate driver. All port pins have seperately selectable pull-up resistors with supply-voltage of invariant resistance. All the I/O pins have protection diodes to Vcc and Ground.

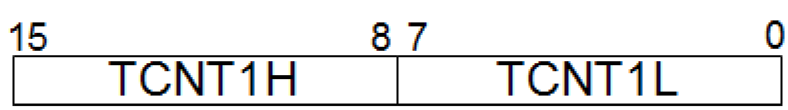
All registers and bit references employed here are written in general form. A lower case “x” for representing the numbering letter for the port and a lower case “n” for representing the bit number. For instance, PORTB3 for a bit number 3 in Port B is shown here as PORTxn.

Three I/O memory address locations are allocated for each port, one each for

- Data Register – PORTx – Read Write
- Data Direction Register – DDRx – Read Write
- Port Input Pins – PINx – Read Only

4.1.3.2 TIMER

Atmega328 has a 16 bit timer, which is far superior when comparing to 8-bit timers. A 16-bit timer is also called Counter1. Counter1 has twice more bits than 8 bit Counter0, so gives more counts leading to longer duration and more precise timings.



16-bit Timer control register

The 16-bit timer has the same functionality as Timer0. CTC, fast PWM, and correct phase PWM modes are not discussed as these are equivalent to Timer0.

4.1.3.3 I2C

Two wire interface terminology is used by AVR microcontroller. Therefore all the registers are named as TWI. One important register is bit rate register **TWBR**. It is used to scale down CPU frequency into SCL. Additionally, there are two bits (TWPS1 and TWPS2) in status register **TWSR** to pre-scale the SCL frequency with values 1, 4, 16, and 64. As usually there is control register **TWCR** which has a set of bits that are used to enable TWI to interrupt, TWI, Start and Stop. Status register **TWSR** holds earlier mentioned pre-scaled bits but its primary purpose to sense I2C bus status with TWS [7:3] bits. **TWDR** is data register which is used to hold next byte to transmit or received the byte. **TWAR** and **TWARM** register are used when AVR works as an I2C slave.

4.1.3.4 USART

The USART stands for universal synchronous and asynchronous receiver and transmitter. For transmitting and receiving the data bit by bit with respect to clock pulses on a single wire this protocol is used. The AVR microcontroller has two pins-TXD and RXD, which are specially used for transmitting and receiving the data serially.The Main Features of AVR USART are,

- The USART protocol facilitates full-duplex protocol.
- It generates baud rate of high resolution.

- It supports transmitting serial data bits from 5 to 9 and it consists of two stop bits.

The USART of AVR consists of three Pins:

RXD- USART receiver pin (Pin 14)

TXD- USART transmitter pin (Pin 15)

XCK- USART clock pin (Pin 1).

4.2 OLED DISPLAY

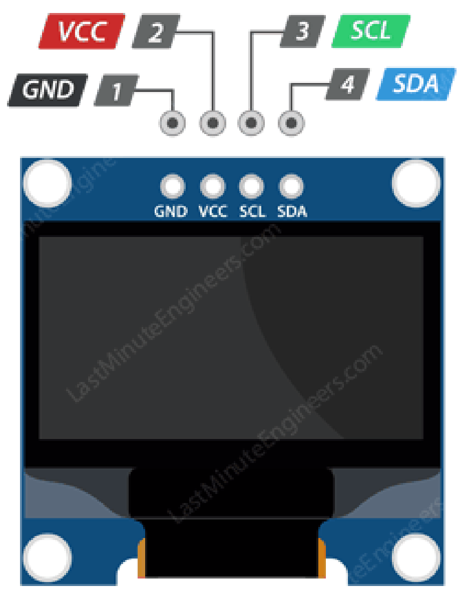
Organic Light Emitting Diodes are a new technology that produces super bright light within a few small organic film layers. This same principle is used to create digital screens and is also being developed for other lighting purposes due to its brightness and efficient energy. OLED displays are not just thin and efficient they also provide best image quality ever and they also have the capability of being transparent, flexible and even more brighter. It represents the future of displays.

SSD1306 OLED

4.2.1 PIN DIAGRAM

Pinout of SSD1306 OLED

S.NO	PIN	FUNCTION
1	VCC	Power supply : 2.4 to 5.2V
2	GND	Ground
3	SCL	Serial clock for I2C
4	SDT	Serial data for I2C



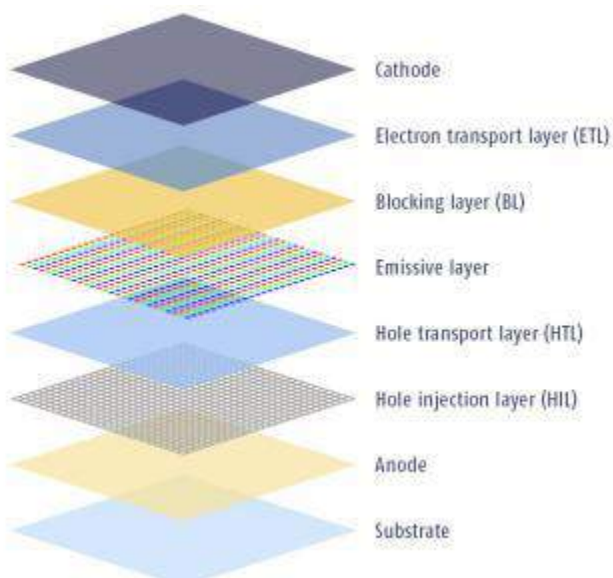
Pin diagram of SSD1306 OLED

4.2.2 SPECIFICATIONS WORKING

- OLED Driver IC: SSD1306
- Resolution: 128 x 64
- Visual Angle: greater than 160°
- Input Voltage: 3.3V - 6V

- Compatible I/O Level: 3.3V, 5V
- Mini Size: 2.7 x 2.8cm
- Only Need 2 I/O Port to Control
- Pixel Color: Blue
- Full Compatible with Arduino
- Working temperature: -30°C - 70°C
- Module volume (generous): 27.0 x 27.0 x 4.1mm
- Factory configured for SPI protocol (can be easily changed to IIC)

The main display component is the OLED emitter - an organic carbon based material that emits light when electrified. This emissive layer is sandwiched between a cathode which is responsible for injecting electrons and an anode which removes the electrons. The layers are shown below.



Layers in OLED

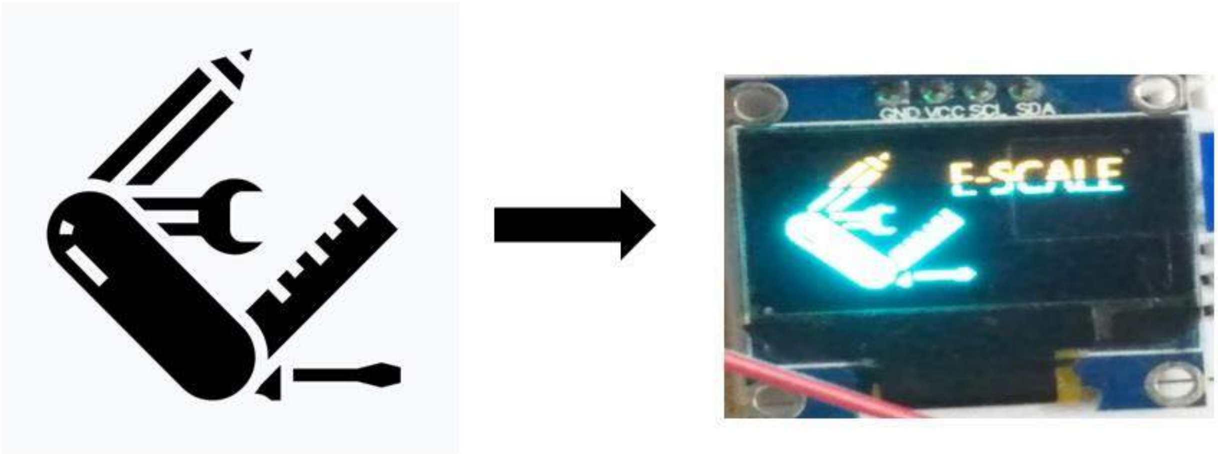
Modern OLED devices have more layers in order to make the display efficient and durable, but the objective remains the same. An OLED panel is made from a substrate, backplane, front plane and an encapsulation layer. Since OLEDs are sensitive to oxygen and moisture they are encapsulation critically. The substrate and backplane are as same as LCD display; the front plane deposition alone is unique in OLEDs. There are several ways to pattern the organic layers. Currently most OLED displays are manufactured using vacuum evaporation which uses a Shadow Mask generally a fine metal mask to pattern. This is a relatively simple but inefficient because a lot of material is wasted and very difficult to scale up to large substrates.

4.2.3 I2C COMMUNCIATION WITH OLED

The Inter-integrated Circuit Protocol is intended to allow multiple slave devices to communicate with one or more master chips. It is only capable of short distance communications within a single device and it requires only two signal wires to exchange data. Each I2C bus consists of two signals namely SCL and SDA. SCL is the clock signal, and SDA is the data signal. The clock signal is generated by the master. Messages are split up into two types of frame: an address frame where the master indicates the slave to whom the message is being sent and one or more data frames, which are 8-bit data messages passed from master to slave and vice versa. Data is placed on the SDA line after SCL goes low, and is sampled after the SCL line goes high.

4.2.4 GRAPHICAL WORK

For displaying the image in the display, it has to be converted into a specified format. The image format can be JPG, JPEG and PNG etc. It has to be converted into Bit Map format. The BMP format can be obtained by converting the obtained image to a format by using a bitmap converter which is available as a freeware. The obtained bitmap format output needs to be converted into a hex code based on the resolution specified by the OLED. So LCD assistant software is used here to convert the particular BMP format into the required hex code and the obtained array of hex values is loaded into the OLED to get the specified output.



Logo of E-Scale

Similarly, the main menu logos are also designed in the same manner.

Logos of Main menu modes

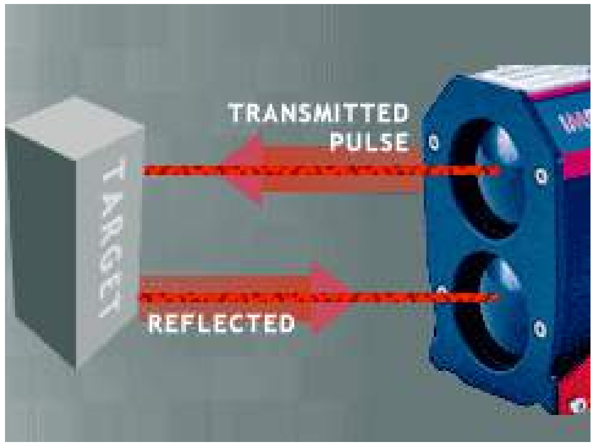
4.3 LASER SENSOR

This electrical device is used to sense minute objects. It produces a laser beam which traverses through a straight path. The laser light beam is very hazardous for human eyes. This light can be used to transmit the information over long distances.

VL53LOX LASER SENSOR MODULE

4.3.2 SPECIFICATION AND WORKING

- Interface: 2.8V TTL signal .by PC show date.
- Three wire serial interface (the single chip microcomputer UART interface).
- Start bit 1 + 8 data bits + 1 stop bit and no flow control
- 2 mA electrical flow: DC 2.8V, standby, measuring 120 mA.
- Laser type: 635nm (red).
- Range: 0.02 to 100 meters.
- Measurement speed: 0.3 - 3 s.
- Typical accuracy: + (or) - 2 mm
- module size: Approx 72*40*18 mm.



Principle of Laser sensor

Initially a laser beam is generated by the laser. This beam is incident on the surface of the target material. After hitting the target the beam is reflected back to the source. Since the laser consists of a transmitter and receiver, this operation is performed with ease. The time taken by the beam to reach the receiver is directly proportional to the distance between the source and the target. Since the speed of the laser beam is already known, the distance is calculated by multiplying the known velocity and calculated time. This is the working involved inside a laser module.

4.3.3 USART COMMUNICATION WITH LASER MODULE

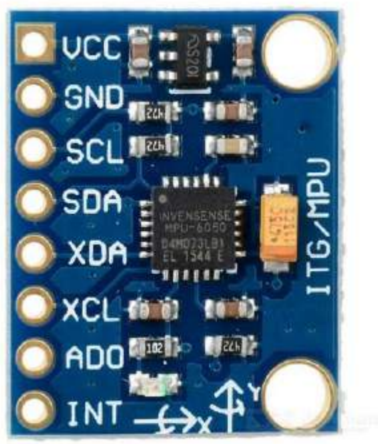
The Laser module and the master device communicate through USART protocol. The laser and the controller are connected through Rx and Tx pins. It is communicated using AT commands. For example, for getting the distance the AT command "ATD1#" is used. The laser will return the distance measured by it. The output will be in the following frame format - "ATD < 3 bytes Data field > <1byte Checksum>#". From this the three byte data alone is spliced.

4.4 ACCELEROMETER AND GYROSCOPE

An accelerometer is a compact device designed to measure non-gravitational acceleration. When an object shows any change in its velocity, the accelerometer is designed in such a way to respond to the vibrations associated with such movement.

Microscopic crystals go under stress when vibrations occur and from that stress a voltage is generated. Accelerometers are important to devices that track fitness and other measurements.

A gyroscope is a device that uses Earth's gravity to determine orientation of an object suspended in a medium. Its design consists of a freely-rotating disk called a rotor, mounted on a spinning axis in the center of a large and more stable wheel. The rotor remains stationary to indicate the central gravitational pull as the axis turns.



GY-521 GYRO WITH ACCELEROMETER SENSOR MODULE

4.4.1 PIN DIAGRAM

- VCC (The breakout board has a voltage regulator. Therefore allows the board to connect to 3.3V and 5V sources.)
- GND
- SCL (Serial Clock Line- I2C protocol.)
- SDA (Serial Data Line-I2C protocol.)
- XDA (Auxiliary data - I2C master serial data connects the module to external sensors.)

- XCL (Auxiliary clock -I2C master serial clock connects the module to external sensors.)
- AD0 (If this pin is LOW, the I2C address of the board will be 0x68. Otherwise, if the pin is HIGH, the address will be 0x69.)
- INT (Interrupt digital output)

4.4.2 SPECIFICATIONS AND WORKING

- Three-axis gyroscope and three-axis accelerometer
- Power Supply: 4.3 to 9 V
- Communication Mode: I2C communications protocol
- Chip built-in 16bit ADC converter, 16-bit data output
- Gyroscope Range: +/-250, +/-500, +/-1000, +/-2000 °/s
- Acceleration Range: +/-2g, +/-4g, +/-8g, +/-16g
- Dimensions: 21.2mm length x 16.4mm width x 3.3mm height
- Weight: 2.1g

MPU-6050 is a chip manufactured by Invensense which combines 3 axis accelerometer and 3 axis gyroscope with an on-board digital motion processor. It also includes an embedded temperature sensor and an on chip oscillator. Being accurate it also consists of analogue to digital conversion hardware for each channel thereby capturing x,y,z channels at the same time.

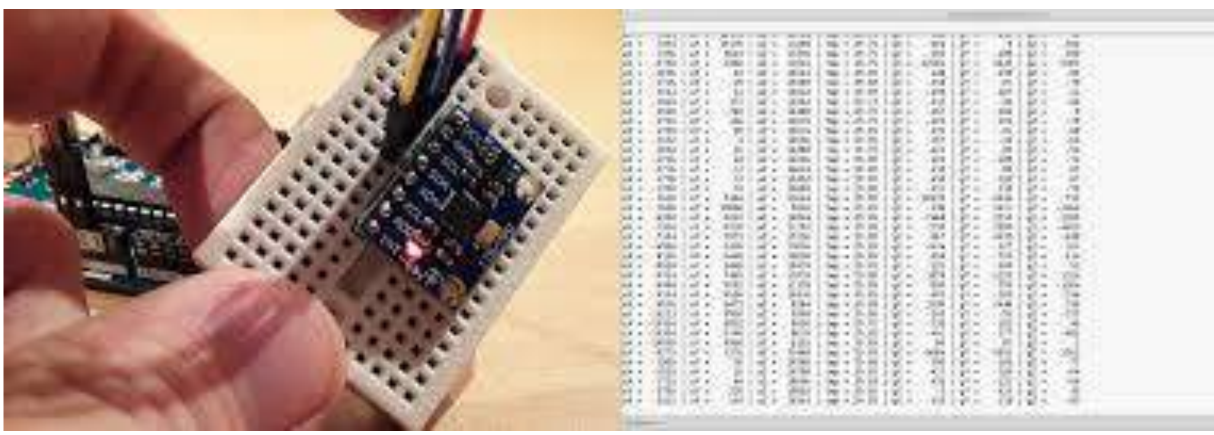
The MPU-6050 consist of a 3 axis gyroscope which is capable of detecting rotational velocity along the x,y,z axis using micro electro mechanical system technology (MEMS).

- When the sensor is held in motion along any axis, a vibration is produced due to Coriolis effect which is detected by the MEMS.

- 16-bit ADC is used to digitize voltage to sample each axis.
- Angular velocity is measured along each axis in scale of degree per second.

The MPU-6050 consist of a 3 axis accelerometer which detects angle of tilt or inclination along the x,y,z axis using micro electro mechanical system technology (MEMS). Acceleration along the axes deflects the moving mass which in turn unbalances the differential capacitor. The obtained amplitude is proportional to acceleration incurred.

- 16-bit ADC is used to digitize the values.
- +/- 2g, +/- 4g, +/- 8g, +/- 16g are the full scale range of output.
- In initial position, that is when the device is placed on a flat surface, the values are 0g on x axis, 0g on y axis and +1 on z axis.



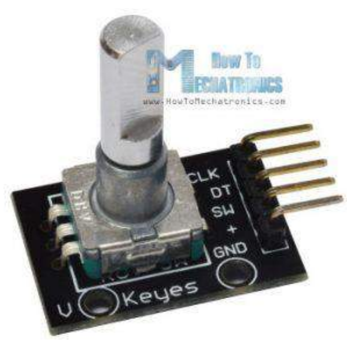
Working of GY-521

4.4.3 I2C COMMUNICATION WITH GY-521

I2C is a two-wire interface having serial data and serial clock signals. In general, the lines are open-drain and bi-directional. In an I2C interface implementation, attached devices can act as a master or a slave. The master device puts the slave address on the bus, and the slave device which matches the address acknowledges the master. The GY-521 always operates as a device when communicating to the system processor, which thus acts as the master. SDA and SCL lines need pull-up resistors to VDD. The maximum bus speed is 400 KHz. The slave address of the MPU-6050 is b110100x which is 7 bits long. The LSB bit of the address is determined by the pin AD0 logic level. This permits connecting two devices to the same I2C bus. When used under this configuration, the address of the devices should be b1101000 where pin AD0 is logic low and the address of the other should be b1101001 where pin AD0 is logic high.

4.5 ROTARY ENCODER

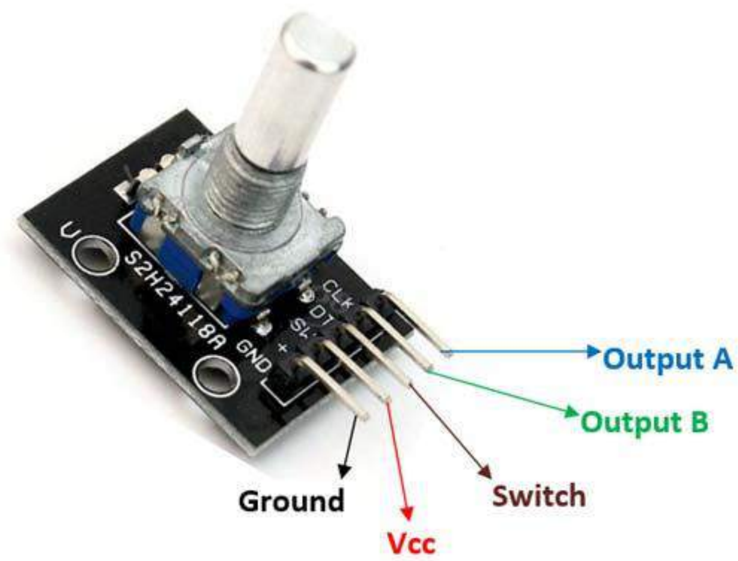
A rotary encoder is a position sensor which determines the angular position of a rotating shaft. It generates an electrical signal, either analog or digital based on its rotational movement. There are many different types of rotary encoders which are classified by either Output Signal or Sensing Technology. Incremental rotary encoder is preferred here because it has the simplest position sensor to measure rotation.



MO-50 Rotary Encoder

4.5.1 PIN DIAGRAM

The first two pins - GND and Vcc are used to power the Encoder, typically +5V supply is used. Besides rotating the knob in clock wise and anti-clockwise direction, the encoder also has a switch which can be pressed by pressing the knob inside and the nature of the switch is active low. The signal from this switch is obtained through the pin 3. Finally it has the two output pins which produce the waveforms.



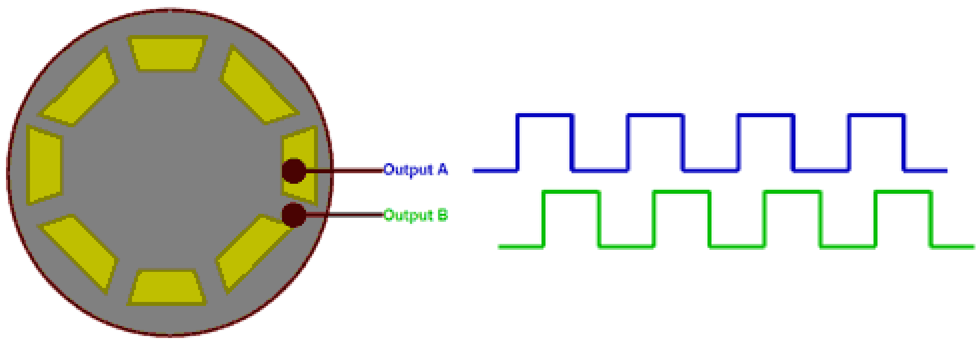
Pinout of MO-50

4.5.2 SPECIFICATION AND WORKING

- 360º free rotation.
- 20 steps or cycles per revolution.
- Incremental type encoder.
- Can work on low voltages.
- Maximum operating temperature: 0°C to + 80°C.

This encoder is called as electromechanical transducer because it converts mechanical movements into electronic pulses. It consists of a knob which when rotates will move step by step and produce a sequence of pulse trains with pre-defined width for each step.

The internal mechanical structure for the Encoder is shown below. It basically consists of a circular disc with conductive pads placed on top of the circular disc. These conductive pads are placed at an equal distance. The Output pins are fixed on top of this circular disc, in such a way that when the knob rotates the conductive pads get in contact with the output pins. Here there are two output pins namely Output A and Output B.



Working principle of Rotary Encoder

Two output waveform produced by the Output pin A and Output B. When the conductive pad is directly under the pin it goes high resulting in ON time and when the conductive pad moves away the pin goes low resulting in OFF time. By counting the number of pulses it is possible to determine how many steps the Encoder has been moved.

Though a single pulse signal is enough to count the number of steps taken while rotating the knob, two pulses are required. This is identify the direction in which the knob has rotated. It is observed that the two pulses are always 90 degrees out of phase. Hence when the knob is rotated clockwise the Output A will go high first and viceversa.

4.6 PCB DESIGNING

A printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and between sheet layers of a non-conductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it. The steps involved in designing a PCB are briefly discussed below.

4.6.1 BOTTOM COPPER LABELLING

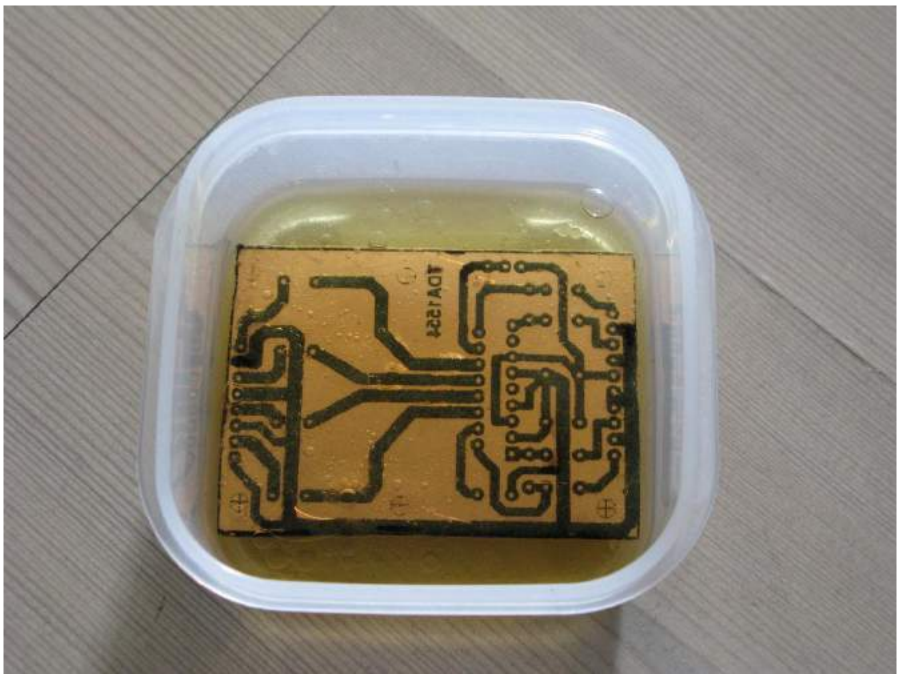
The term bottom copper labeling is the process by which the track connects the all discrete components present. The track width varies with respect to the current consumed by the end components. Power line and signal line have variable track width. Track width of power line is greater than that of signal line. In simulation software, virtual tracks can be formed by dragging the point from initial position to the final position.

4.6.2 ETCHING PROCEDURE

Two types of acids are used for etching. They are Ferric chloride (Eisen-3-Chlorid) and Sodium Persulfate (Natriumpersulfat - Feinätzkristall). Although etching can also be done in simple plastic boxes, the quality of the results will improve dramatically when it is done using a machine that controls temperature and constantly keeps the fluids in motion. There are small etching tanks with heating and air pump and there are small spray etching machines which can handle bigger PCBs and even the development and cleaning processes are involved. The sprayer also decreases the etching time and the amount of acid needed.

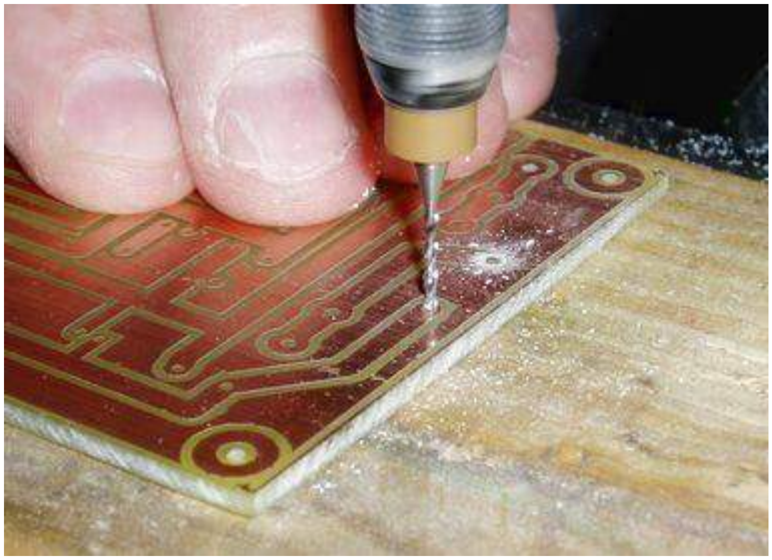
To get rid of all unwanted copper following steps are involved :

1. Put the board in the acid tank for about 20 minutes until the copper traces are completely etched. The board turns from opaque pink to transparent yellow when it's finished
2. Move the board into the rinse tank for a few seconds. An Iso-propanol spray can also be used.
3. Dry the board with a cloth.



Etching process

4.6.3 DRILLING PROCESS



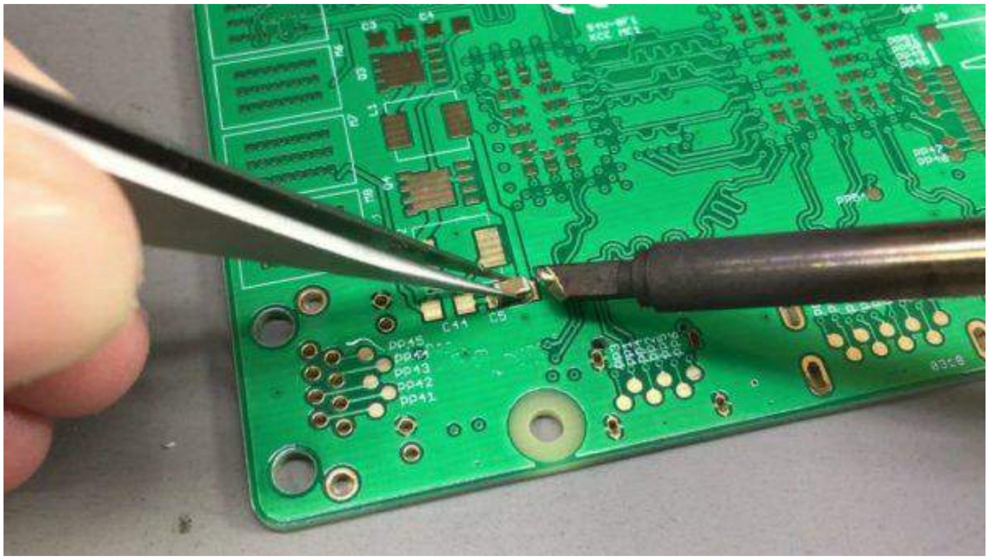
Drilling process

Drilling process is the process of putting holes on the printed circuit board which enables the user to place the component in that board .The drill holes size is variable which depends on the dimension of the component that is to be placed . This dimension information is always available in the datasheet of the component. There are two types of handling namely,

- Hand drilling
- CNC drilling

4.6.4 SOLDREING PROCESS

Soldering is a way of connecting two or more different electrical components on a circuit board. The components required include a soldering iron, some solder and the materials being soldered together. A soldering iron looks a bit like a pen and is a tool that gets extremely hot. The iron melts and fuses with the component over the board.



Soldering process

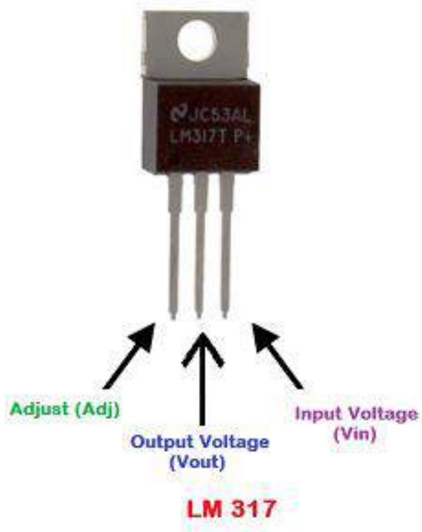
4.6.5 TOP SILK LABELLING

After finishing the drilling process, soldering need to be done. Misplacing of the components may occur since the holes are not labeled. Hence to overcome this defect, top silk labeling is done where the holes are named after the component that needs to be fixed over it. Usually this is pasted on the top surface of the board.

4.7 POWER SUPPLY UNIT

A power supply is an electrical device that supplies power to the electrical load. The primary function of a power supply is to convert electric current from a source to its correct voltage, current, and frequency rating to power the load.

4.7.1 LM317



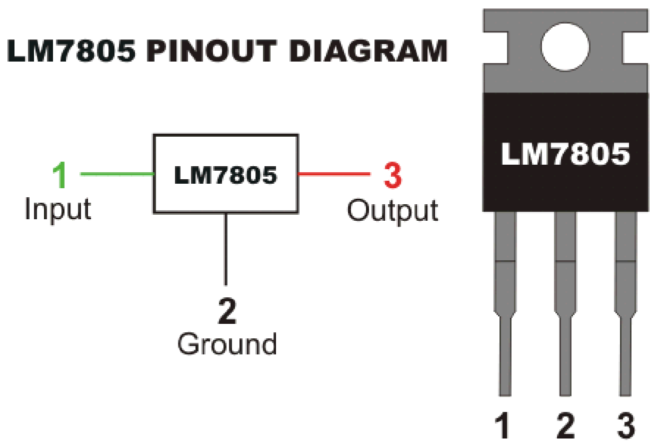
Pin out of LM317

- Adjustable 3-terminal positive voltage regulator
- Output voltage can be set to range from 1.25V to 37V
- Output current is 1.5A
- Maximum Input to output voltage difference is 40V, recommended 15V
- Maximum output current when voltage difference is 15V is 2.2A
- Operating junction temperature is 125°C
- Available in To-220, SOT223, TO263 Package

LM317 is a 3-terminal regulator IC and it is very simple to use. It is used in various applications but this IC is known for being used as a variable voltage regulator.

The IC has 3 pins, in which the input voltage is supplied to pin3 (VIN) then using a pair of resistors (potential divider) voltage is set at pin 1 (Adjust) which will decide the output voltage of the IC that is given out at pin 2 (VOUT). Now to make it act as a variable voltage regulator, variable voltages are set at pin 1 which can be done by using a potentiometer in the potential divider.

4.7.2 7805



Pinout of 7805

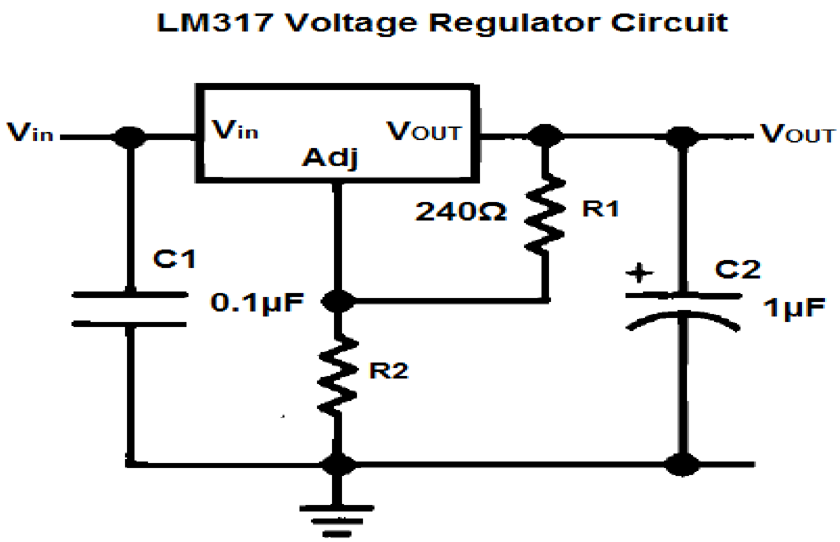
7805 IC, a member of 78xx series of fixed linear voltage regulators used to maintain fluctuations. It is a popular voltage regulator integrated circuit (IC). The xx in 78xx indicates the output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add a heat sink.

Pinout of 7806

Pin No.	Pin	Function	Description
1	INPUT	Input voltage (7V-35V)	In this pin of the IC positive unregulated voltage is given in regulation.
2	GROUND	Ground (0V)	In this pin where the ground is given. This pin is neutral for equally the input and output.

3	OUTPUT	Regulated output; 5V (4.8V-5.2V)	The output of the regulated 5V volt is taken out here.

4.7.3 CALCULATIONS



3.3V voltage regulator circuit

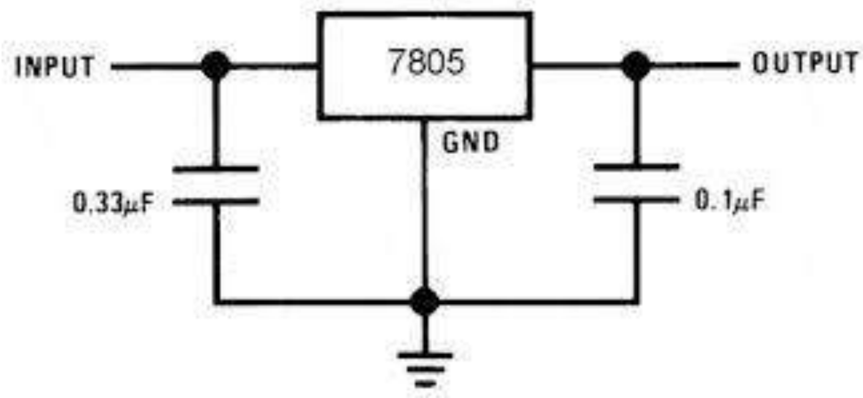
The LM317 3.3V voltage regulator circuit consists of LM317, two capacitors and two resistors. The input voltage is given between pin 3 and ground and the output voltage is observed between pin 2 and ground. It is a linear voltage regulator in which the output voltage depends on the input fed. The capacitor 0.1µF is connected between pin 3 and 1. Another capacitor 10µF is connected between pin 1 and 2. The pin 1 is grounded. The resistor values R1 and R2 are calculated based on the required output voltage. Let us assume the value of R1 to be 10KΏ. For getting the output voltage as 3.3V,

$$Vout = 1.25\,(1 + (R2/R1))$$

$$3.3 = 1.25\,(1 + (R2/10K))$$

$$R2 = ((3.3/1.25)-1)*10000$$

$$R2 = 16.4K\Omega$$



5V voltage regulator circuit

The 7805 5V voltage regulator circuit consists of only the 7805 IC and two capacitors. The capacitor 3.3µF is shorted between pin 1 and 2. The capacitor 0.1µF is shorted between pin 2 and 3. The pin 2 is grounded. The input voltage is between pin 1 and ground and the output voltage is observed between pin 3 and ground.

4.8 MPLABX

MPLABIDEis a free and integrated set of tools only assigned for the development of embedded applications on microcontrollers like PIC and dsPIC. It is also known as Integrated Development Environment (or) IDE, because it can able to provide and to establish a single integrated environment to develop the required codes for the embedded microcontrollers.

4.8.1 FILE HANDLING

MPLAB IDE window is shown with the appropriate source files linked into the main program file.

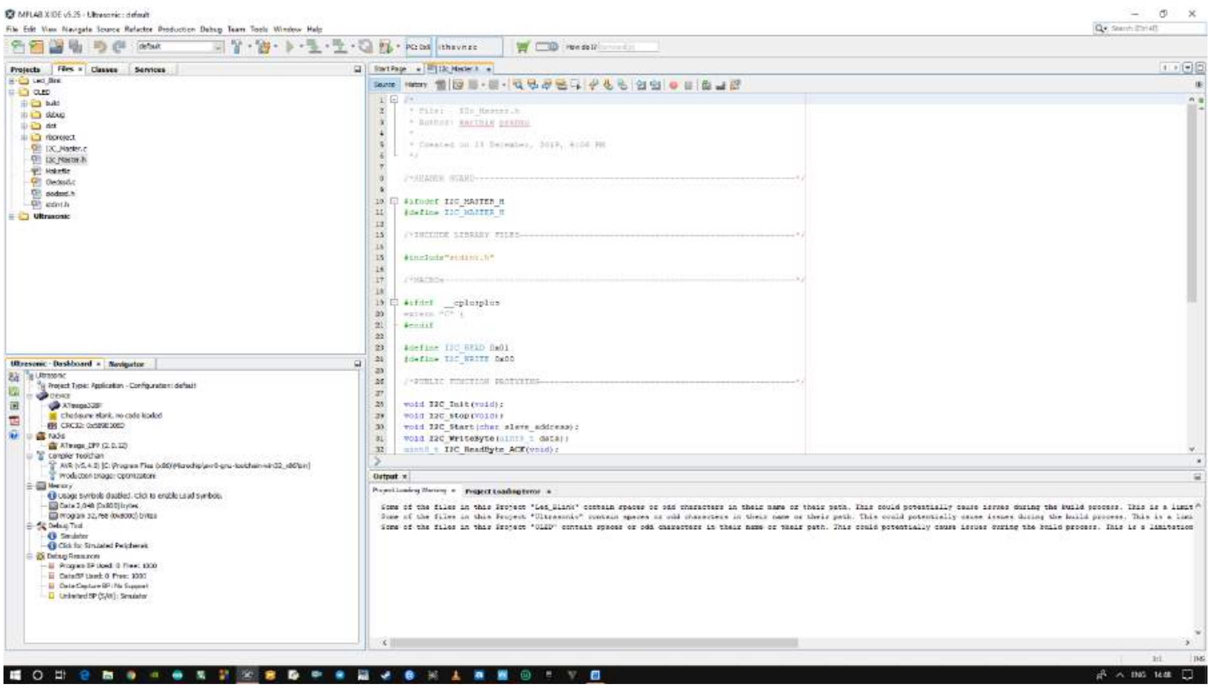


Fig 4. Image showing MPLAB X IDE window

Use MPLAB X IDE to program a device using the steps given below:

- **Install MPLABX IDE**

  Install the required MPLAB X IDE software on the system meeting all the requirements.

- **Setup Program Hardware**

  Setup the Atmega IC hardware in preparation for programming a device.

- **Install a Compiler**

  Install the appropriate language tool chain, such as one of the MPLAB XC C compilers, to build the project. Here we are using the AVR gnu tool chain for compiling the AVR microcontrollers including Atmega328p IC.

- **Launch MPLAB X IDE and Create/Open a project:**

To create a project in MPLAB X IDE:

- Ensure MPLAB X IDE is aware of your compiler tool chain by selecting Tools--->Options, Embedded, Build Tools, and finding your compiler in the list. (i.e.) AVR gnu Compiler.
- Select File--->New Project and set up an MPLAB X IDE project by following the steps in the project wizard. Once completed the steps, the project tree will open in the Projects window.
- Select File--->New File to open an existing file template in which the user can enter the code (or) import existing code into the project by right clicking on the source files folder of the project tree and selecting the option "Add Existing Item".
- To open an existing project, select File-->Open Project, browse to the project file which is saved on to the storage medium and click Open Project.

By following these methods, a new file or an existing file can be opened.

- **Setup for Programming**

Once you have opened a project in MPLAB X IDE, check the properties the project and ensure that the MPLAB X IDE is set up correctly to program the appropriate device.

After the programming stage gets completed, the controller needs to be uploaded with the required hex file and the process for generating the hex file is followed by this stage.

- **Generate a Hex File**

To build the project, user needs to generate a hex file, right click on the project name in the projects window and select the option “Build" from the drop-down menu appear on the window. If you have buildthe project file and analysed the errors appeared, check the project setup and look for any flagged issues in the code generated. Then start building it again.

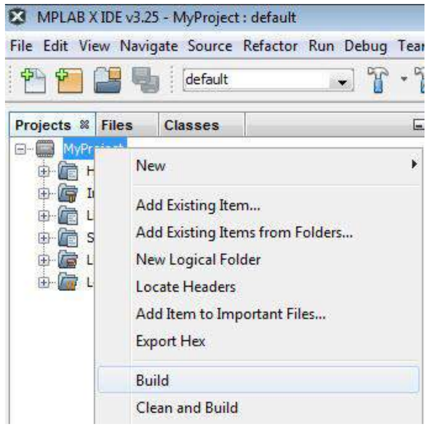


Fig4. Image showing the build option appearing in the dropdown menu

- **Insert and Program the Device**

Insert the device that needs to be programmed into the socket module. Position the pin one on the device to match the pin-one indicator in the socket module.Secure the device by pushing down the silver lever on the socket or by closing the shell. On the MPLAB X IDE toolbar, click the Run icon which appears in the toolbar. The project will start building and the device will be programmed perfectly. The program will immediately start its execution on the completion of programming.

Click the Upload Target Project icon to transfer what is in target memory to MPLAB X IDE.

4.8.2 COMPILER SECTION

Among the numerous compilers available out in the MPLAB XIDE, AVRtool chain is preferable and proved to be an effective tool chain to get used into it. This tool chain is a collection of tools (or) libraries which is used to create applications for AVR microcontrollers. This collection includes compiler, assembler, linker and standard C and math libraries that are available in the IDE itself. The Atmel AVR gnu tool chain is also available as part of Atmel studio. The users who wish to run only the

Atmel AVR gnu tool chain as standalone tools from the command line need to download and install this package. There are two sets of downloads for this package, one for Windows platform and the other for Linuxoperating systems. Some of the key features of this IDE are listed below:

1. C/C++ cross compiler
2. Assembler and linker
3. C-libraries for developing C/C++ programs

Thus, using AVR compiler is more efficient and compatible for this project programming while choosing for other compilers.

4.9 AVR TOOL CHAIN

The AVR gnu tool chain is the compiler which is appropriate for the compiling the Atmega 328p IC. For programming the IC, the compiler alone isn't sufficient. So, a programmer named AVR dude is used to dump the required program into the appropriate Integrated Circuit.

4.9.1 AVR DUDE AND ITS WORKING

As mentioned above AVR dude is used to dump the particular program into the controller. So, it plays the vital role in dumping the code into the controller by itself.

Fig4. Image showing the USBasp programmer module

The above mentioned pins should be connected to the terminals of MOSI, NC, RES, SCK, MISO, VTG and the others are GND pins. These will help the programmer to power up and starts working towards dumping the code into the particular controller.

The circuit connection for the programmer to he controller is shown below:

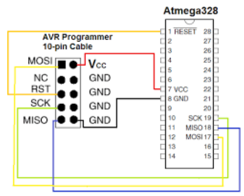


Fig4. Image showing the connection between USB programmer and controller

The default fuse settings for Atmega 328p:

Table 4. Fuse settings for Atmega 328

Low Fuse	0xFF
High Fuse	0xDA
Extended Fuse	0x05

The major features of AVR dude includes:

- Command line driven user interface for all the downloading and uploading features including handling fuse bytes, for easy automation (e.g.)by inclusion into making the required file inclusion.
- Interactive examination and modification of various memory regions that are present in it and so it is called terminal. Also it offers an one more option to modify the operational parameters of an Atmel development board which includes target voltage, Voltage reference and amaster clock frequency.
- It is known to run on all the major style operating systems, as well as in the

Windows 32 bit and 64 bit platforms. By using existing operating system drivers on the command line driven systems, it alsohas a secure parallel port access without root privileges can be maintained. On Win32 platforms,the parallel port access requires the files of previous installation of a driver known as (giveio.sys) that grants a user process its direct access to the IO registers.

- It supports a wide range of programming hardware from cheap ISP plugs that can connect the particular AVR's ISP interface directly to a system's parallel port with no additional circuitry or serial port which means some additional circuitry is needed, more advanced ISP adapters using a buffer/driver chip up to serially connected programmers which is more complex like other AVRstyle ISP devices, the Atmel development board and the Atmel ICE. Most popular adapters come pre-defined, adding a new parallel-port adapter is as simple as editing a configuration file with no recompilation is required.
- It can also support Intel hex, Motorola and raw binary files for input and output, as well as direct memory contents specification on the command line useful (i.e.) for fuse bytes. Forthe input, the file format can be auto-detected.
- In terminal mode, the device's memory areas can be examined carefully and possibly it can be modified. This allows to set fuses interactively for the user or to modify a few EEPROM cells.

4.10 PROTEUS

The Proteus Design Suite is a designing software tool suite which is primarily used for electronic designing and automation. The software which is mainly used by the electronic design engineers and technicians to create schematics and the electronic prints for the manufacturing process of printed circuit boards.

It is one of the leading fast microcontroller simulation software and it enables rapid prototyping of both the hardware and firmware designs of the prototype mainly in the software based side. It enables you to write and apply the user's required firmware to a supported microcontroller on the schematic type and then co-simulate the program along with the schematic design. SO, the Schematic design is the ,major part before executing it in completely.

4.10.1 SCHEMATIC DESIGN

The schematic design for the prototype is shown below:

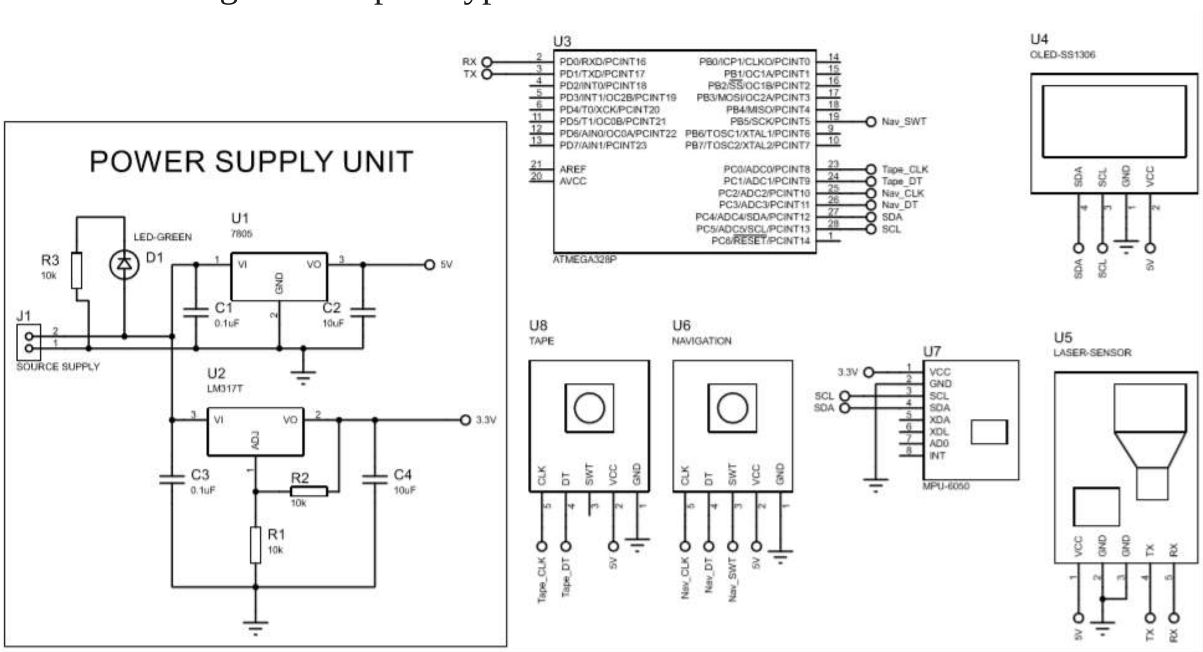


Fig4.Schematic design done via proteus design tool

The schematic design is the initial procedure for the project before developing it into a live working model design. It can be done by the following methods:

- Open the Proteus schematic capture to start creating the schematic design for the hardware.
- In proteus, the left toolbar contains a mode called Component mode which contains several tools for designing process.
- Click on “P” which means Pick from Libraries which contains the pre-installed libraries and the required libraries that a user can able do download by manually.
- From that libraries list, it contains all the components listed in it and the user needs to select the required components from the components listed from it.

- In the Proteus workspace window, place all the components that are selected by the user for simulation process.
- The components that are placed in the workspace needs to be wired to have a proper connection between them. Then only it can work as same as it gets connected physically.
- Finally click on the play button which is placed on the bottom left of the toolbar to start simulating the project file which is created by the user.

Thus these are the exact procedures which needs to be followed by the user to develop a schematic design.

Here, the following modules are placed in order to complete the design required for fulfilling the required prototype.

- Power Supply Unit
- Atmega 328p IC
- Rotary Encoder
- OLED Display module
- Gyroscope/Accelerometer
- Laser Sensor Module

4.10.2 TESTING AND SIMULATION

The most exciting and important feature of the Proteus design tool is its one of the main ability to simulate the interaction between the software running on a particular microcontroller and any type of analogue or digital electronics which is connected to it. The model of the microcontroller model sits on the schematic along with the other elements of the product design. If the program code writes to a port, the logic levels in circuit can change accordingly. More than 750 supported microprocessor variants, Proteus remains the first choice for embedded simulation.

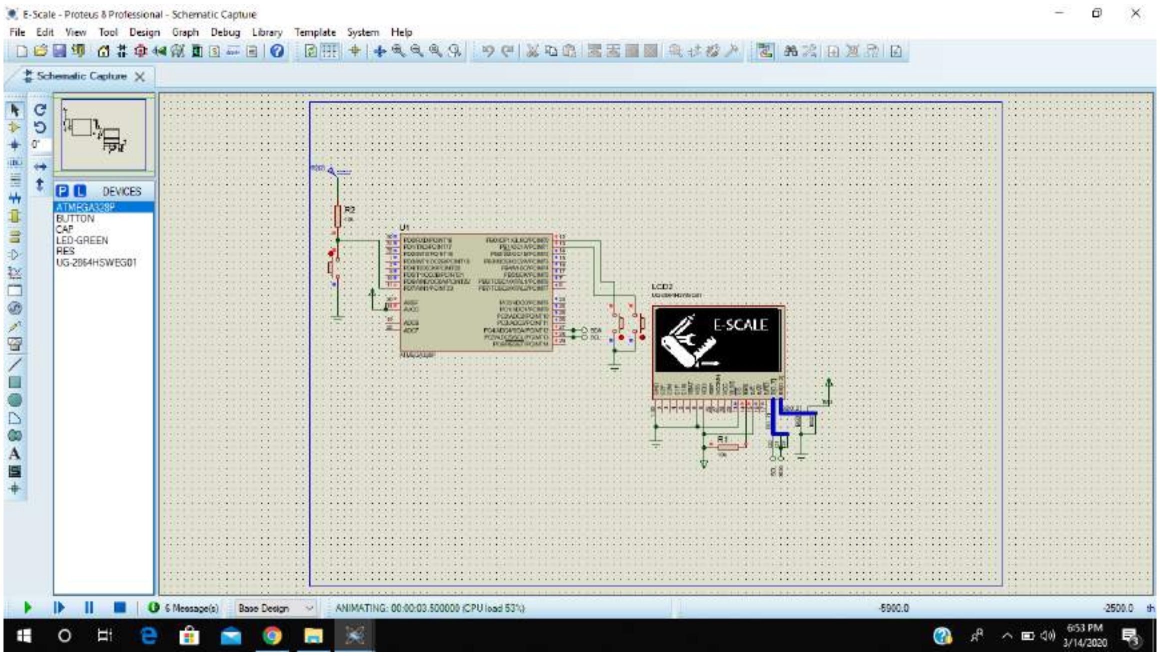


Fig4. Simulation of OLED display module

The connected components of the prototype are wired to make connection between them and when the user decides to start simulating it, the run button should be selected for starting the simulation. Before starting the simulation, the user needs to load the hex file in order to display the output in the required OLED module or else nothing will be displayed. It means the hex code drives the module based on the algorithm developed into the code.

The image displayed above shows the exact output of the OLED module by providing it the exact hex file into it and so the output is displayed via OLED display. The main advantage of having this simulation method is only to test the hardware components working and its flow before getting it into connection manually. So the bugs can be easily rectified before it is happening and so it is stated as one of the best designing tools. So, this prototype is completely designed using this tool before it starts developing into a model and the error rectification is made before getting them into work.

4.10.3 PCB DESIGNING

Proteus has the integrated ARES PCB designing suit which is used to design the appropriate PCB for the schematic design that is done for the prototype. By using this the user can easily able to develop the layout for PCB. After the simulation gets completed, save the particular circuit designing without affecting it by any ways and then click on tools then select the net list option to ARES. After that a window will be opened with the list of component packages to be selected.

4.10.3.1 LAYOUT CREATION

The PCB layout for the appropriate hardware can be created by a proper way and is shown below along with its schematic model:

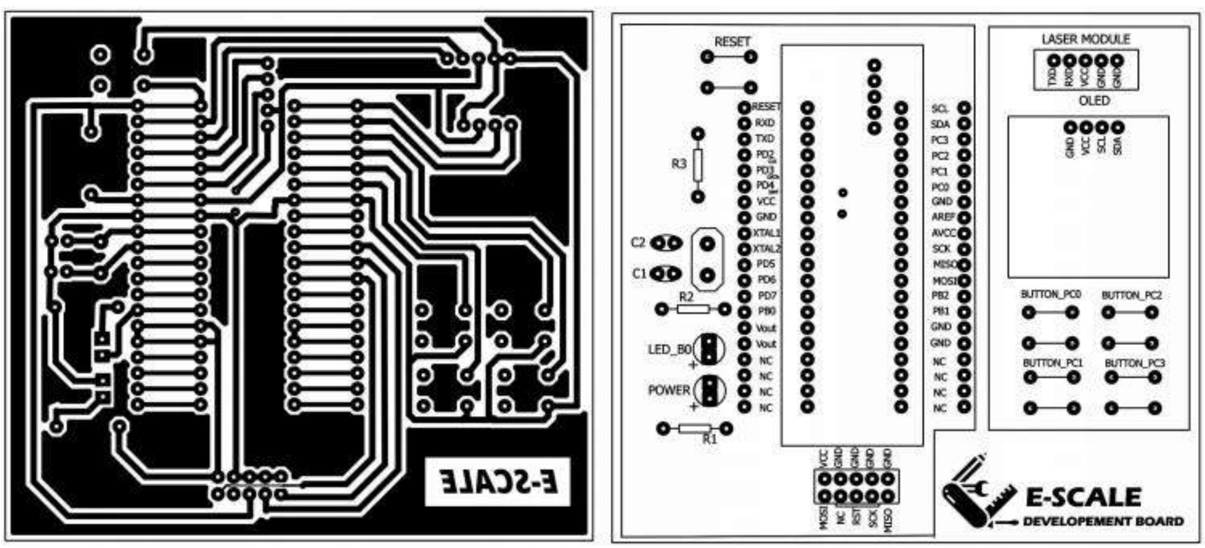


Fig4. Layout of the E-Scale development board

The procedure for the proteus simulation is listed below:

A black colour window would appear that is termed as the PCB layout that can be able to switch the tab to the schematic capture by the user.

Click on "P" button which stands for the term place then a new window would appear and this window will allow the user to search for the components by mentioning the exact name of the components. The user needs to check out whether the selected component has a separate PCB design specified for it which can be shown in PCB preview. Double click on the required component and it would appear on the devices and search for other

components and place all of them in the devices section. The components which does not have the PCB preview specifically for them cannot be used but it can be added later.
Board Edge (or) Board Size can be done by the following methods:

- Click on the PCB layout tab and then zoom in to the upper left corner as which is appeared in the proteus design window.
- Now from the left toolbar click on the square button available and from the bottom toolbar select Board Edge to getting into that mode.
- Draw a rectangle of any size by clicking it anywhere inside the blue area of the PCB window to mark the dimensions that are required to do it . This is the size of the PCB that can able to change it by hovering your mouse pointer at any corner off this block. As it have mentioned the user can able to change the design based on the way it has mentioned.
- Now click on the small diode icon which indicate that component lists. Select the component and then click inside the yellow Square to place it.
- When it comes to be placing a component it can be able to show the green lines which indicates the connection of one point to the other point and the yellow arrow head which indicates that this component is to join with this terminal of the other component. Place the components wherever the user like to keep in mind so that it is easy to choose simple and easy path which is indicated by the green lines. After placing all the components it can adjust the yellow rectangle.

Make sure there are no DRC errors on the bottom status bar, DRC error appears when there is an overlapping of a terminal with other terminals or with board edge.

Auto routing can be done by the following ways:

- Click on the routing button from the left toolbar in the design window then double click on the default option then change the default width to 20th option or theotherone as 25th option (This is the thickness of the PCB routing that needs to be done) and then click OK.

- Now click on the second last icon (Auto-Router) and check the wire-grid and via-grid and it should be more than 15 otherwise the soldering part would be difficult in close connections to be done. So avoiding that will be the better choice. Then click on Begin Routing to start routing the path between the components that are placed in the window**.**

After routing make sure there are no CRC errors, in case there is an error there would be a connection missing press CTRL+Z (Undo method)and then rearrange that component and start routing again.

Manual Routing can be done by the following ways:

- Click on the routing button from left toolbar that is available in the designing tool and then double click on the default option and then change the default width tospecified 20^{th} option or the other one as 25^{th} option (This is the thickness of the PCB routing that needs to be done) and then click OK**.**
- Click on any terminal the point that terminal wants to connect would be highlighted just click on that highlighted terminal same as the procedure that followed while making the schematic design. Make all the connections that would be noticeable that whenever it is necessary in making the connection the CRC errors would be reduced after all the connections there would be no CRC error in the end and so it can be done.

Auto (or) manual methods can be followed but it is necessary to be done without having any errors in it. Power plan generator option is more professional and efficient way to make PCB's more professional.

Proteus offers a 3D visualisation tool so that the circuit can be viewed in 3D format and it is more effective to analyse.

4.10.3.2 3D VIEW DEBUGGING

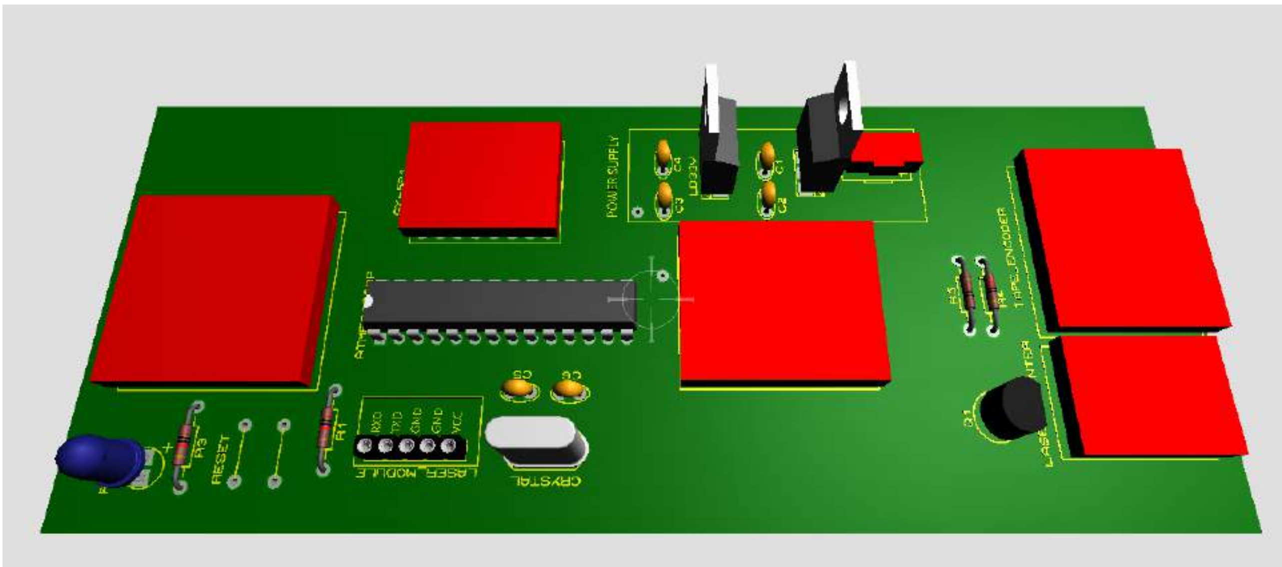


Fig4. 3D visualisation of the designed PCB

The modelled PCB should be developed into a Gerber file by selecting the option Output→ Generate Gerber file to generate the required Gerber file and we can get the schematic sheets can be available as a zip file. The files needed to be printed in a photo sheet paper and they need to be done based on the dimensions that needs to be specified.

For printing the PCB layout there are two methods available. They are listed below:

- Go to output and then click on export graphics then click on export Adobe PDFfile in this method you will save the PCB layout as a PDF file and a dialog box will open from the box and select only the bottom copper and the Board Edge and un-check everything else and click on OK**.** The user needs to check the actual size ofthe printing option while printing from a adobe or any other PDF viewer.
- Go to output click on the print layout option and then a dialog box will appear.

Check only the bottom copper and board Edge adjust the PCB as mentioned above. The user can print it anywhere on the page and then click OK**.**

Toner Transfer can be done by the following ways:

- Cut the PCB sheet with scale and paper knife you can watch a YouTube video about how to cut acrylic sheet the same that user can cut the PCB sheet.
- Take the glossy paper sheet in which the user has a print of the PCB layout and place the printed area on the copper side of the PCB sheet and it is recommended to use a scotch tape to hold it properly.
- Use the electric iron to transfer the ink from glossy sheet to your PCB board and it will take less than 5 minutes to transfer the glossy sheet and then it has to stick properly on the PCB board like a sticker. After 5 to 7 minutes check from one corner gently if the ink has been pasted on the PCB board. If not iron more for some time gently.
- Remove the glossy sheet paper from your PCB board under warm waterand check whether there are any paper particles stuck on new PCB board. If there are any particles found in it. Kindly remove them by scratching them with a sandpaper.
- Dry the PCB board with a tissue paper to dry it and check if there are proper markings on it and you can check it by taking a look on your computer. The PCB design should be printed on the PCB board if there are some missed printings you can mark those points with a permanent black marker

The etching process can be done by the following ways:

- Take a pot or a flat bottom bowl of the size that should be little bigger than the PCB board.
- Place the PCB board in a bowl and add 1 to 2 tablespoons of powdered ferric chloride on the upper surface of the PCB which can be used to etch the PCB. It means it can able to split out the Copper away from the permanent black marker

used area.

- Boil one glass of water and pour a small amount of water on the PCB containing ferric chloride and the solution should be concentrated to a particular extent and they dilution should not be made for the ferric chloride solution to use it efficiently.
- Gently shake the bowl to know the solution whether it is concentrated or not and the water should besuper hot and so the etching would not take more than 3 minutes of time.

Notice that all the copper is removed from the upper layer of the board and expect the black markered/printed area to be remained in the board respectively.

Clean the board with water and nail polish remover to remove the printings alone and it is found that nail polish remover is more effective when compared to the heating method used with the help of Iron box.

Finally, the required PCB is prepared successfully by this method.

CHAPTER 5

MEASUREMENTS AND ANALYSIS

5.1 FINITE STATE MACHINE:

Measurement of various parameters of an object needs various sensor data that are taken by microcontroller through finite state machine. State machine shows the proper work flow of execution of code and required output. Below topics explains the various state machine flow.

5.1.1 MENU STATE DIAGRAM:

This state diagram shows the basic execution of accessing the menu between different modes available in the module. Initial state is starting from S1 from which the menu access begins based on the state diagram shown below:

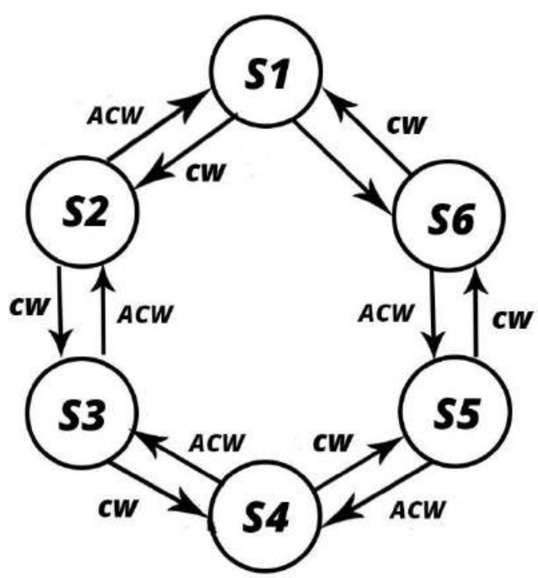


Fig 5.1 Menu State Diagram

The notation of the state level is mentioned in the table below. Each state depends on the input that user provided by the user. The transition between one state to another state is occurred based on clockwise or anti-clock wise direction of the rotation of encoder.

Table 5.1 Menu State Table

STATE	MODE
S1	ENCODER TAPE
S2	LASER TAPE
S3	ANGLE MEASURE
S4	AREA MEASURE
S5	VOLUME MEASURE
S6	PYTHAGORAS

INPUT: CW – Clock wise rotation.

ACW- Anti-clock wise rotation.

5.1.1 ENCODER STATE DIAGRAM:

This state diagram shows the basic execution of the Encoder option accessing in the module.Initial state is S1 from which the Encoder menu access is begin based on the state diagram.

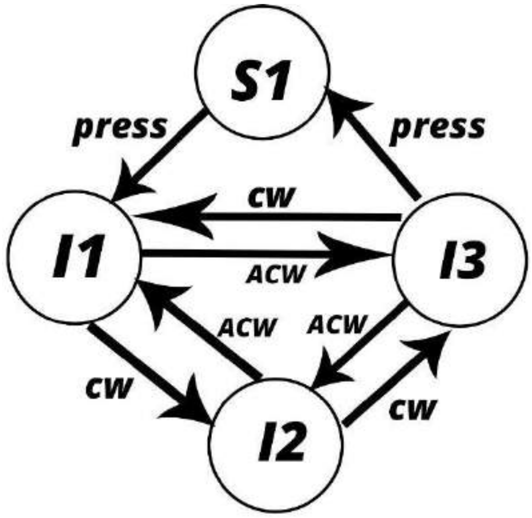


Fig 5.2 Encoder menu State Diagram

The notation of the state level is mentioned in the below table.Each state is depends on the input that user gives.the transition between one state to another state is occurred based on clockwise or anti-clock wise direction of rotation of encoder.

Table 5.2 Encoder **menu State Table**

STATE	MODE
S1	**ENCODER TAPE**
I1	**CLEAR**
I2	**UNIT CONVERT**
I3	**EXIT**

INPUT: CW – Clock wise rotation.

ACW- Anti-clock wise rotation.

PRESS-Enter button.

5.1.1 LASER STATE DIAGRAM:

This state diagram shows the basic execution of the Laser option accessing in the module.Initial state is S2 from which the Laser menu access is begin based on the state diagram.

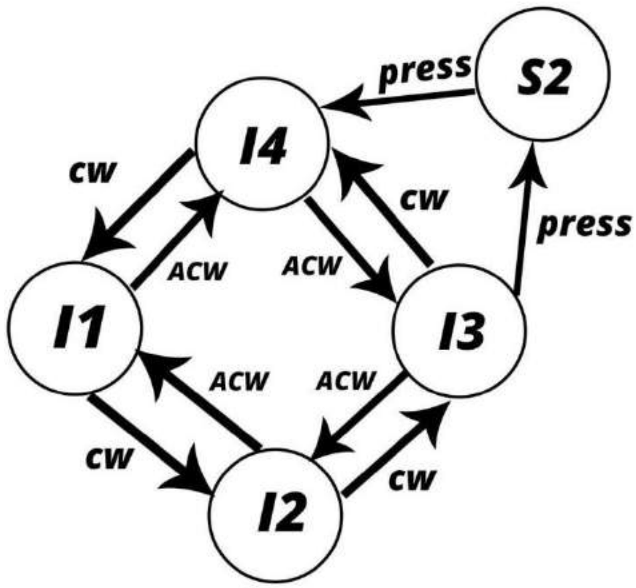


Fig 5.3 Laser menu State Diagram

The notation of the state level is mentioned in the below table.Each state is depends on the input that user gives.the transition between one state to another state is occurred based on clockwise or anti-clock wise direction of rotation of encoder.

STATE	MODE
S2	LASER TAPE
I1	CLEAR
I2	UNIT CONVERT
I3	EXIT
I4	MEASURE

5.1 DISTANCE ANDANGLE:

In many situations there may be need for measure distance and Angle of the plane. E-scale has laser sensor and Accelerometer which calibrate the distance and angle that gives the data which was processed and displayed in OLED display. Below diagram shows the basic idea of measure the height of an object.

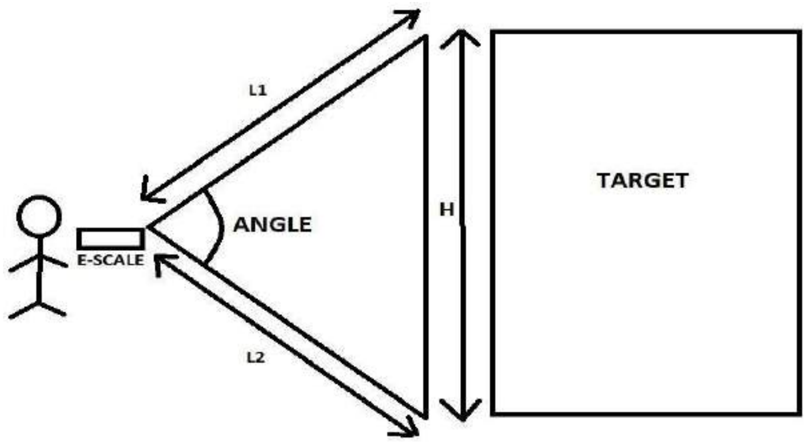
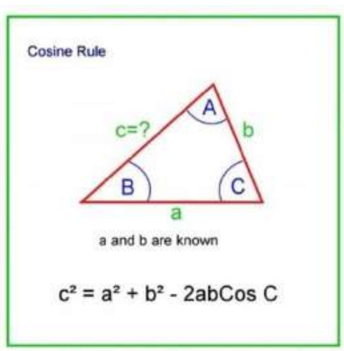


Fig 5.4 Heightmeasurement

Procedure for the measurement of a height inE-scale.

- Point to the top of the target and measure length(L1)
- Point to the bottom of the target and measure length(L2)
- Simultaneously measure the difference angle(A)

Formula used and example for the height measurement is given by,



5.2 DISTANCE

Distance is one of the basic parameter that has to be measured for any kind of application. Distance is a very important so that more information can be taken and the size of the object can be got. So the distance can be measured using E-Scale for various purposes. Here, Laser sensor module and Rotary encoder are employed in the measurement of distance.

Here, the laser module will emit the laser out of the module. It will hit the target through a straight line. The maximum limit of the distance is 40meters. The laser will hit the target and reflect back to the receiver that is present in the laser module. The laser is emitted in a fixed velocity. The time taken for the laser to start from the module and to reach back the module is noted, which will be two times the time taken for the laser to hit the target. Hence, using the time taken and the velocity, the distance between the module and the target is found using Time-of-Flight (TOF) principle.

The laser module is used to measure long distances i.e. more than 5m. For calculating linear length or small contact distance values, encoder is used. The encoder wheel is just rolled over the surface for which the length has to be found. As the roller rolls over it, the encoder will return the distance it has covered continuously.

The steps involved in measuring the distance using laser module are described below:

1. First, enter into the Laser tape mode.

2. Click the button and enter into the mode. There are four options available namely: Measure, unit convert, clear and exit.

3. Click the measure button to get the distance from the E-Scale to the target
4. Click the exit to the get back to the main menu

The steps involved in measuring the length using encoder are described below:

1. First, enter into the Encoder tape mode.

2. Click the button to enter. There are three options available namely: Clear, unit convert and exit.
3. Roll the rotary encoder over the target to get the length of it.
4. Click the exit to get back to the main menu.

5.3 ANGLE

Angles are important everywhere. When you draw any shape, that shape may not be symmetric. Hence when angles are taken into consideration, perfect shapes can be obtained. In measurement aspect, for advance measurements where distance alone is not sufficient, with the angle help of angles we can derive at other dimension distances too.

Here, the gyro with accelerometer module is used get the angle. The module will give the raw data of position and orientation i.e. accelerometer will give the linear acceleration and gyroscope will give the orientation of the module in x, y and z axis. These raw values are first applied into a filter which involves mathematical calculations and convert the raw data into the real value angle. This angle value is further used for the measurement. For the difference angle, we get the real values at two different points and calculate the difference angle between them to get the angle that has titled. These angles are fully dependent on how the module has be placed and held in free space.

The steps involved in measuring the angle are described below:

1. First enter into the Angle mode from the main menu.

2. Click the button to enter. There are three options available namely: Measure, clear and exit.
3. Get the two values of angle to find the difference angle.
4. Click the exit to get back to the main menu.

5.4 AREA AND VOLUME

The measurement of area and volume is crucial to construction projects, crafts and other applications. Area is the space inside the boundary of a two-dimensional shape. Volume is a measure of the three-dimensional space taken up by objects, such as cuboid, sphere etc. Area is calculated by the product of the sides in general of side objects and Volume is found by multiplying the area with one more dimension value.

Here, Area and volume are calculated as the extension of the previous mode, distance. The various dimension distances are collected and integrated together to get area and volume. It just involves multiplying the obtained values and produce the result in square or cubic unit.


GND VCC SCL SDA
Area
3/5
GND VCC SCL SDA
Volume
4/5