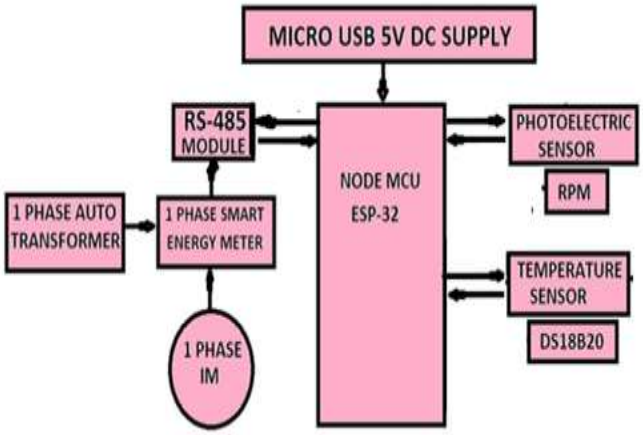
-: TABLE OF THE CONTENTS: -

CHAPTER: 1

1.1 INTRODUCTION:

Condition monitoring of motor is very important, and a maintenance schedule is always implemented for every electrical machine. In the proposed work with the use of **IOT technology** motor parameters like **voltage (V), current (I), frequency (Hz), power factor (PF), temperature, speed (RPM),** can be accessed wirelessly. All these parameters can be analysed by operator from anywhere and in case of any fault condition alert can be raised **IOT based condition monitoring** when joined with machine learning can help in **classification and prediction of fault** electrical motor are work horse for any industry.

1.2 BLOCK DIAGRAM OF THE CAPSTONE PROJECT:



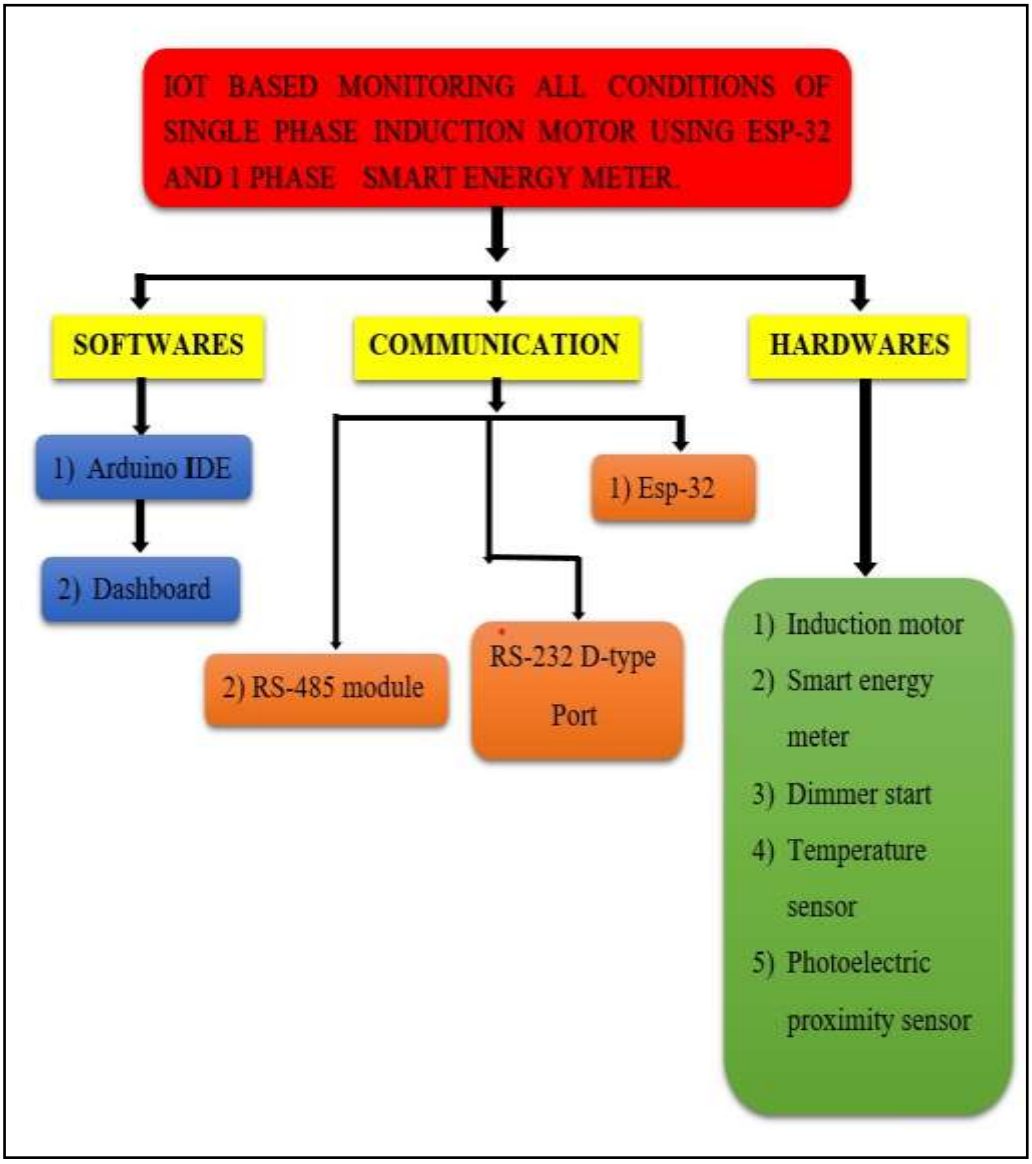
1.3 SCOPE OF THE CAPSTONE PROJECT:

The condition monitoring of rotating machines for critical applications plays an important role in reducing downtime. With Industry 4.0, the role of IoT in online condition monitoring of electrical machines has gained considerable significance. The main aim of the project is the use of IoT for online monitoring of motor parameters like **voltage, current, power factor, frequency, temperature, speed** and observing its online trending using a web server (**DASHBOARD**). Data can be accessed in form of graphs and widgets by visiting the web page. The advantage of this project is **the real-time monitoring** of the motor from any remote area and in case of any abnormality operating personnel can take necessary steps for preventing complete breakdown.

CHAPTER: 2

CAPSTONE PROJECT PLANNING:

2.1 WORK BREAKDOWN STRUCTURE (WBS):



2.2TIMELINE DEVELOPMENT – SCHEDULE:

SL NO	TASK SCHEDULE	START TIME	DURATION TIME
1.	To prepare a complete project synopsis.	**1st week**	**7 days**
2.	To prepare a hardware block diagram of the project.	**2nd week**	**7 days**
3.	The components needed for the project can be picked up at the store.	**3rd week**	**7 days**
4.	To prepare the circuit or connection diagram of the project.	**4th week**	**7 days**
5.	To prepare "PROGRAMMING CODE" of the programme.	**5th week**	**7 days**
6.	To check working condition of the sensors and other components.	**6th week**	**7 days**
7.	To check if the 1 phase smart energy meter and 1 phase capacitor start induction motor are working or not.	**7th week**	**7 days**
8.	Arduino code to extract the programme output according to the block diagram and circuit diagram.	**8th and 9th week**	**14 days**
9.	To prepare the report the project.	**10th,11th,12th,13th, 14th, 15th, 16th weeks**	**49 days**
10.	**TOTAL SCHEDULE**	**4 MONTHS (16WEKS)**	**105 DAYS**

2.3COST BREAKDOWN STRUCTURE (CBS):

SL NO	MATERIALS REQUIRED	QUANTITY	COST PRICE
1)	MICROCONTROLLER ESP-32	01	650 RS
2)	RS485 MODULE	01	150 RS
3)	PHOTOELECTRIC PROXIMITY SENSOR (IR SENSOR) FOR RPM	01	700RS
4)	DS18B20 TEMPERATURE SENSOR	01	170 RS
5)	1 PHASE SMART ENERGY METER	01	2500 RS
6)	1 PHASE INDUCTION MOTOR	01	8500 RS
7)	1 PHASE AUTOTRANSFORMER	01	3500 RS
8)	PCB	01	200 RS
9)	PATCH CARDS AND WIRES	AS FOR REQUIRED	150 RS
	TOTAL COST PROJECT	-----	13,500RS~

2.4CAPSTONE PROJECT RISKS ASSESSMENT:

SL NO	PROBLEMS	REMIDIES
1.	Operation time delay because of slow internet connection.	Provide high speed internet facility.
2.	Induction motor is abnormal condition.	Provide master/emergency switch to turn off induction motor.
3.	Excessive vibration of motor.	Motor should be installed in bending using bolts and nuts Tightly.
4.	When an error occurs in the program.	"**DEBUGGING**" option should be select in Arduino software When find error in programme.

DESIGN SPECIFICATIONS:

2.5CHOSEN SYSTEM DESIGN:

Arduino IDE: 2.0.1 Version

The Arduino **Integrated Development Environment** - or Arduino Software (IDE) - connects to the Arduino boards to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called **sketches.** These sketches are written in the text editor and are saved with the file extension.

Basic Arduino language: **C/C+**

2.5.1 FEATURES OF ARDUINO SOFTWARE:

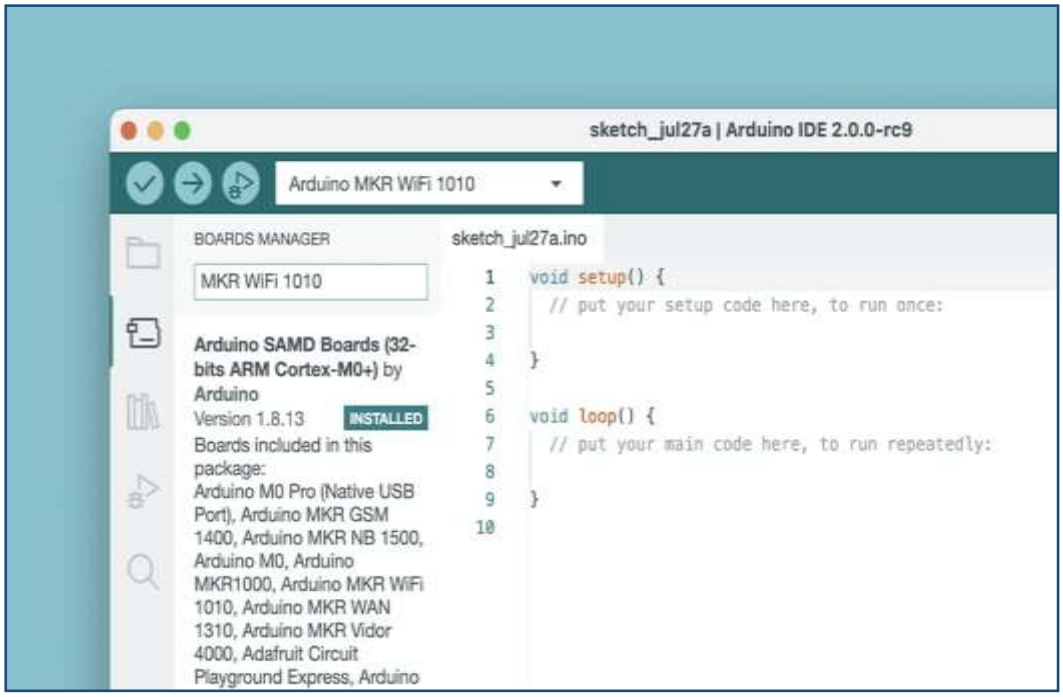
- **Verify / Upload** -compile and upload your code to your Arduino Board. Select Board & Port - detected Arduino boards automatically show up here, along with the port number.

- **SKETCHBOOK:**

Your sketchbook is where your code files are stored. Arduino sketches are saved as. Into files, and must be stored in a folder of the exact name.

- **BOARD MANAGERES:**

With the Boards Manager, you can browse and install packages, or "cores" for your boards. A core is always required when compiling and uploading code for your board.

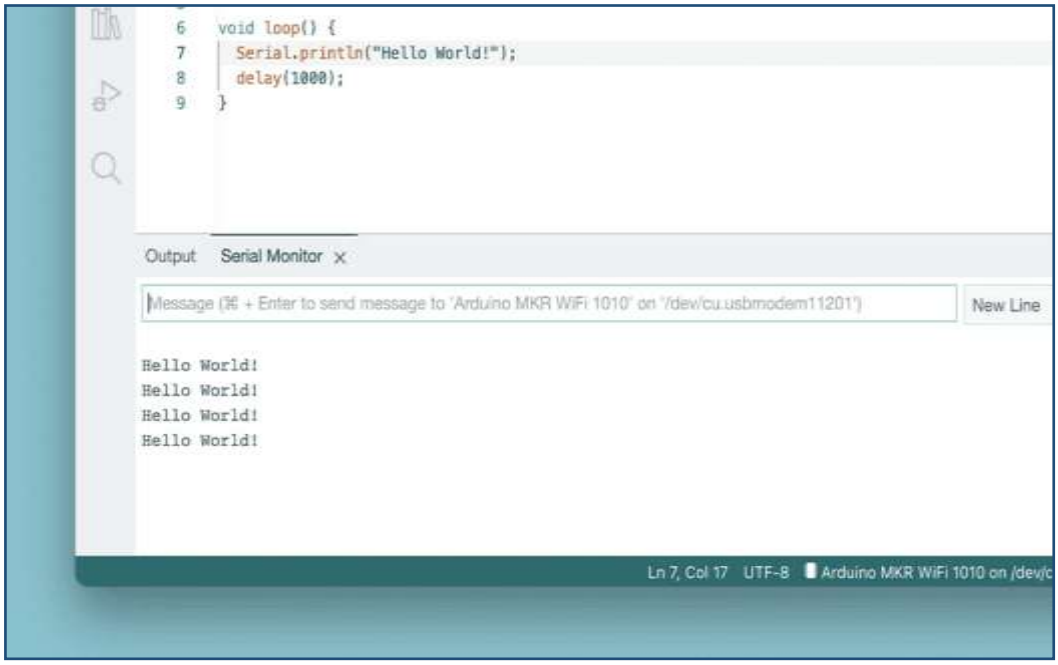


- **LIBRARY MANAGERS:**

With the library manager you can browse and install thousands of libraries. Libraries are extensions of the Arduino API, and makes it easier to for example control a servo motor, read specific sensors, or use a Wi-Fi module.

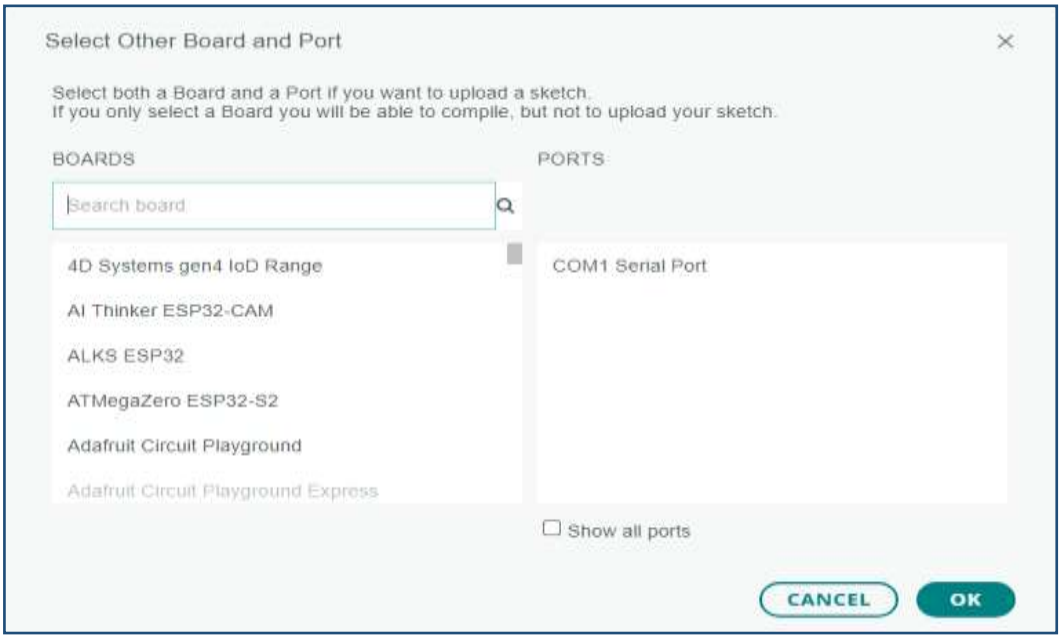
- **SERIAL MONITOR:**

The Serial Monitor is a tool that allows you to view data streaming from your board, via for example the Serial. Print () command.



- **SELECT OTHER BOARDS AND PORTS:**

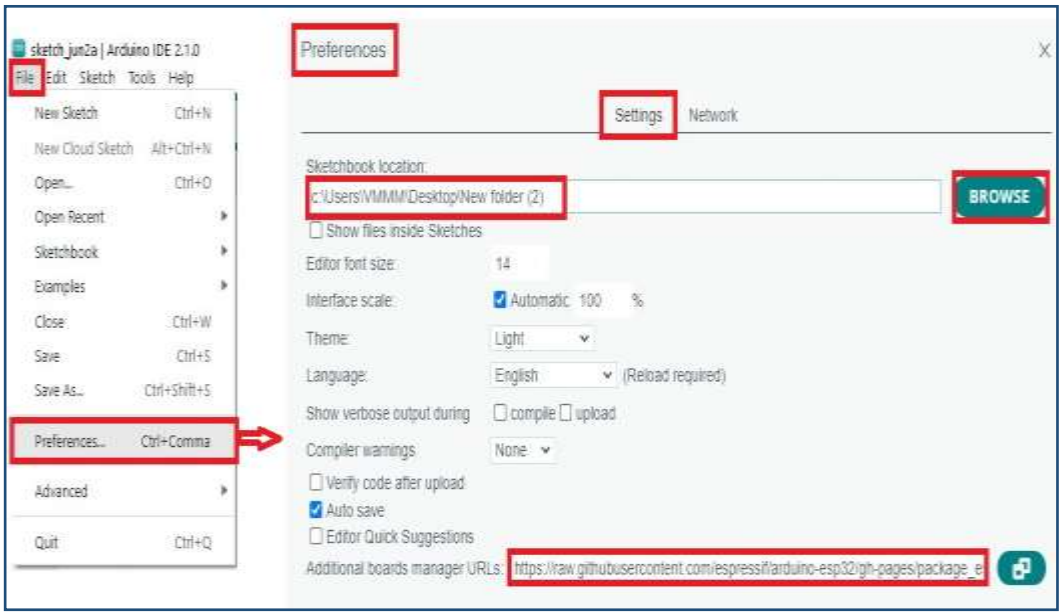
Search any Arduino boards and select to port.



2.5.2 HOW TO DESIGN PROGRAM IN ARDUINO IDE SOFTWARE:

STEP-1:

- Download Arduino ide 2.1.0 software, and open that soft.
- https://www.arduino.cc/en/software.
- Go to FILE option.

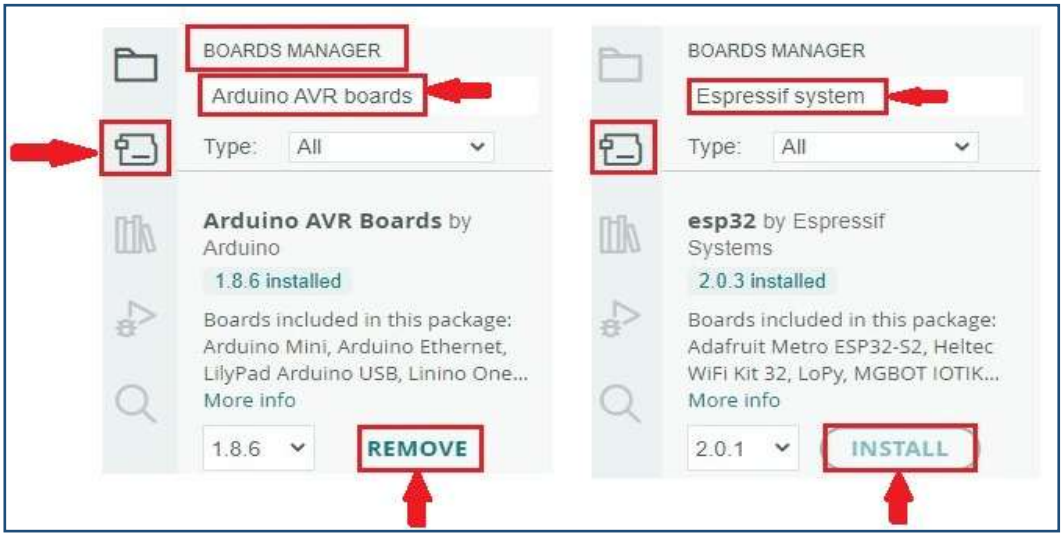


- Click the preference then go for settings.

- See the picture "sketchbook location" browse and add the file "New Folder (2)" for the Arduino library folder.
- Then add "additional board's manager URLs" link.https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json.
- This link is esp-32 microcontroller core packages.

STEP-2:

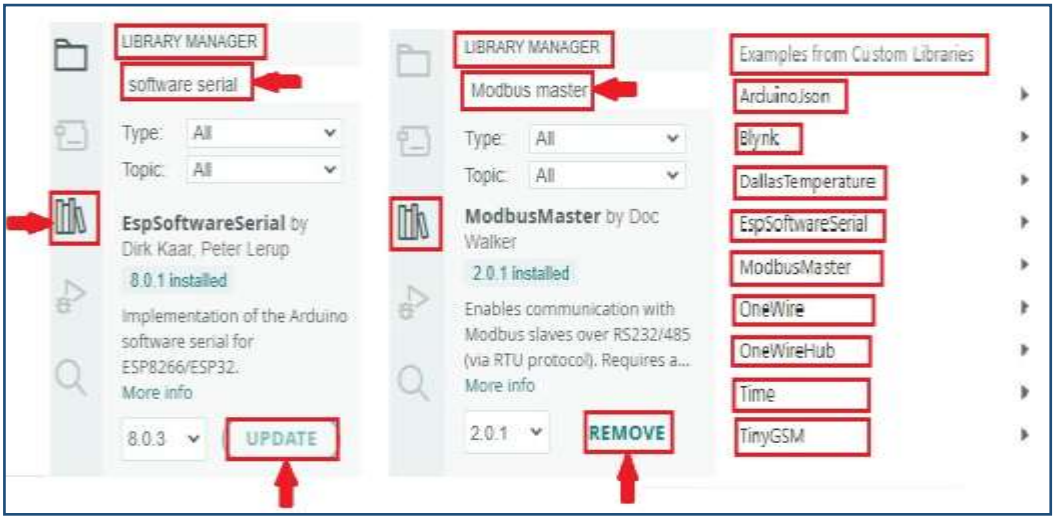
- Go to "BOARD MANAGERS".



- Search ***Arduino AVR boards*** and installed.
- Search ***Espressif system*** and installed.

STEP-3:

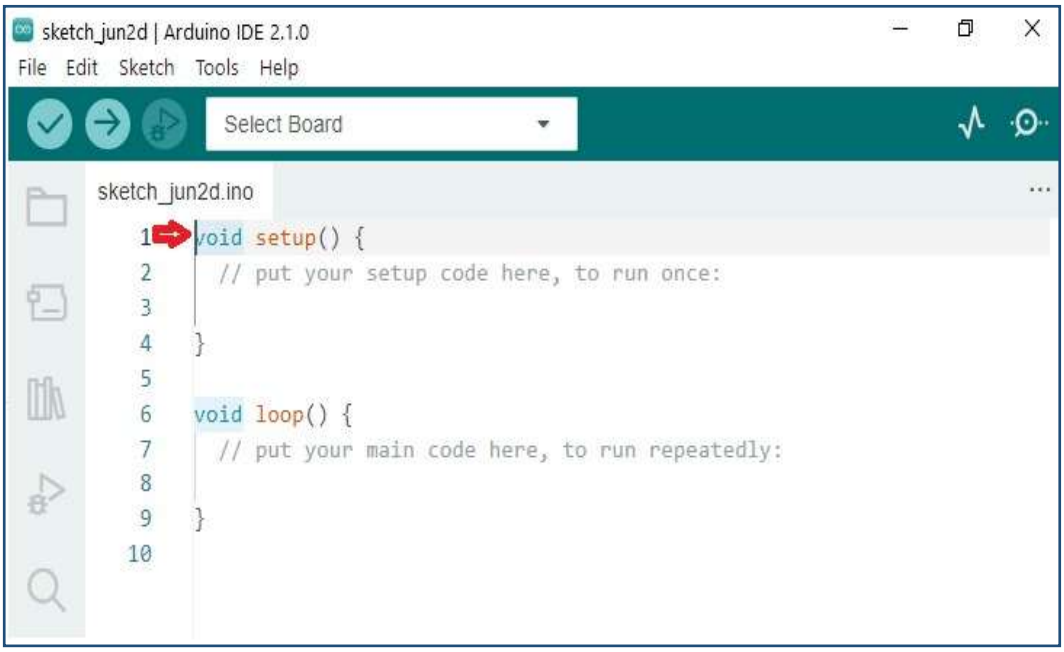
- Go to "LIBRARY MANAGERS".



- Search ***software serial*** and installed.
- Search ***Modbus master*** and installed.
- Search ***Dallas temperature*** and installed.

STEP-4:

- Go to ***file*** and select a ***new sketch***.



- Prepare a ***programming code.***
- ***Verify/Compile*** the program.
- ***Configure/Upload*** the program.

NOTE:click this below link and download Arduino software for Version of **2.0.1.**

https://www.arduino.cc/en/software.

NOTE: How to start up Arduino ide esp-32.

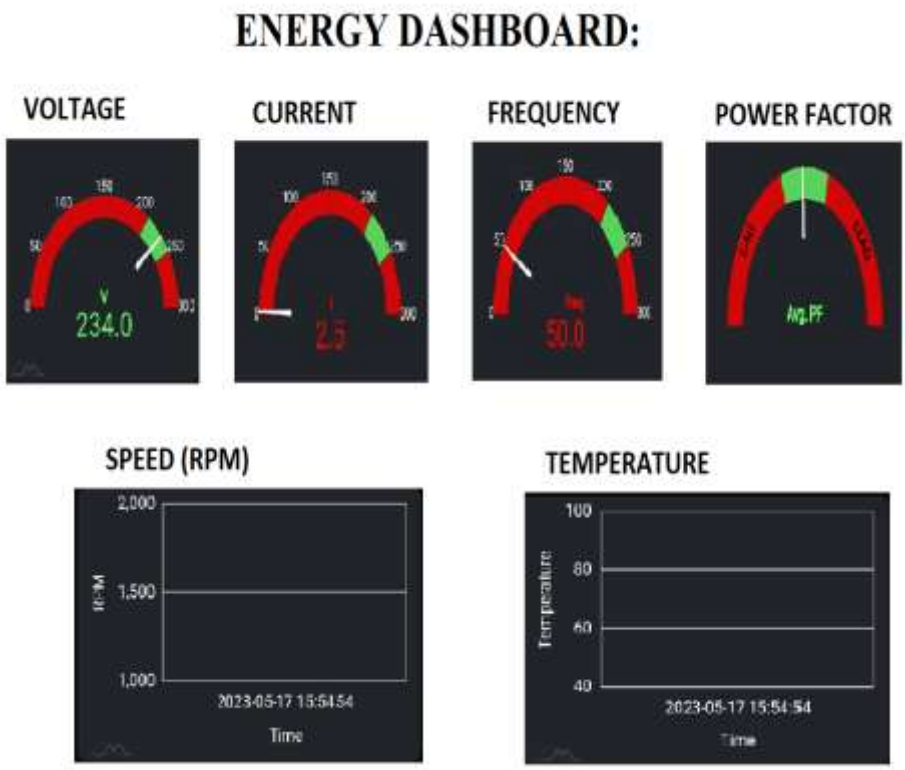
https://randomnerdtutorials.com/.

2.5 DASHBOARD:

A dashboard is an information management tool that receives data from a linked database to provide data visualizations. It typically offers high-level information in one view that end users can use to answer a single question. In many cases, they can be configured to provide specific information to the end user and how this information is visualized. E.g., Numbers, charts, or graphs.

2.5.1 THE IMPORTANCE OF THE DASHBOARD:

Dashboards provide users from all different businesses the ability to monitor performance, create reports, and set estimates and targets for the future.



NOTE: click this bellowed link directly go to

Web dashboard platform

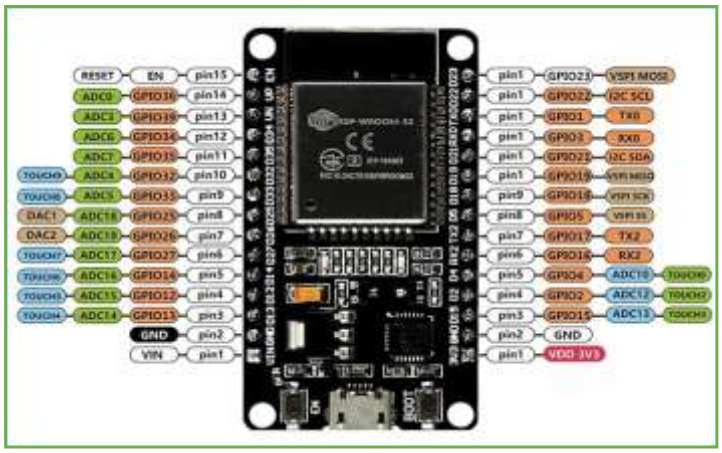
http://motormonitoring.hexitronics.in/.

2.6DETAILED DESCRIPTION OF COMPONENTS:

2.6.1 MICROCONTROLLER ESP-32:

ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. ESP-32 is created and developed by **Espressif system**. The ESP32 either a **Tensilica Xtensa LX6** microprocessor in the both dual-core and single-core variations.

PINOUT DIAGRAM:



a) ADVANTAGES OF ESP-32:

- More powerful than the ESP8266
- Contains more GPIOs with multiple functions
- Faster Wi-Fi, and also supports Bluetooth.

b) DISADVANTAGES OF ESP-32:

- I2C at 100 kHz bus frequency runs slowly. No DAC-based audio output. Current versions of the ESP-IDF SDK do not have the required APIs for DAC-based audio output....
- Deep Sleep & Wake-up sources.

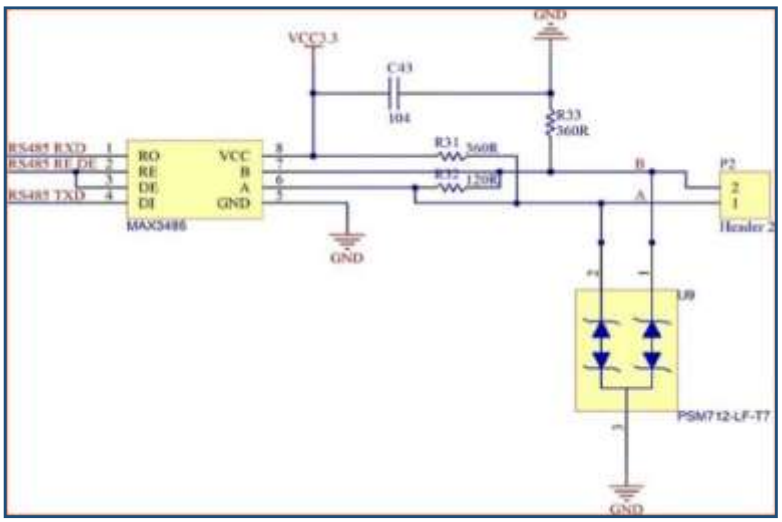
c) APPLICATIONS OF ESP-32:

- Generic Low-power IoT Sensor Hub.
- Generic Low-power IoT Data Loggers.
- Home automation.
- Industrial automation.

2.6.2 RS-485 MODULE:

RS485 is **serial communication protocol** which uses differential signals to transmit binary data. It uses positive and negative **5V** to create differential voltage.It supports higher data rate with higher distance compare to RS232 protocol. Unlike one to one communication between driver and receiver, **RS485 supports multiple receivers with single driver.**

CONNECTION DIAGRAM:

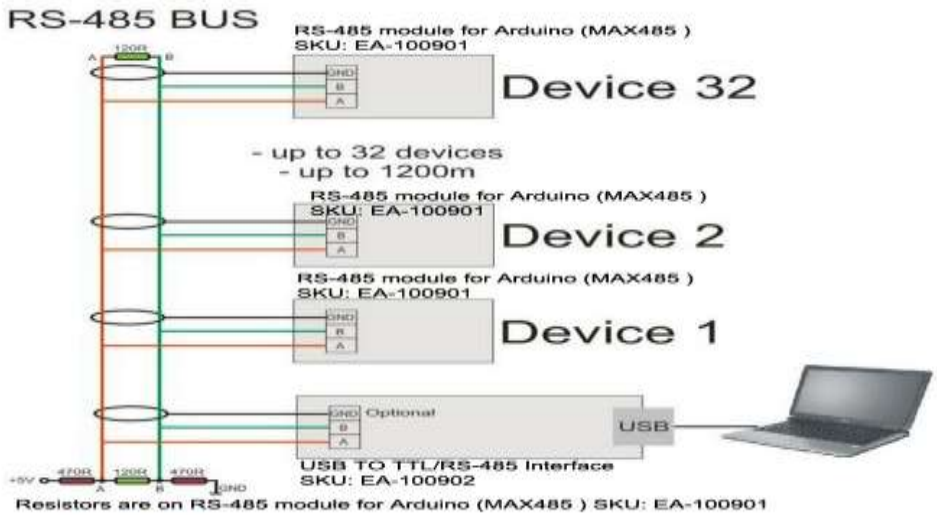


a) RS-485 MODULE OVERVIEW:

Standard transmits differential balanced signals. This has strong anti-interference ability in the common mode, allows a twisted pair transmitter driver on a number of connected devices. The communication distance is up to 1200 meters, the rate is up to 20Mbps, and it can be used in high noise environments, such as industrial automation.

In an RS485 network only one device is in the sending state at any time, and all other equipment should be in the receiving state. Each Arduino controls its RE / DE pin control to specify the device which is sending data to the RS485 network, or receiving data from the RS485 network.

b) RS-485 NETWORK CONNECTION DIAGRAM:



c) ADVANTAGES OF RS-485 MODULE:

- Due to use of differential signalling, maximum data transmission speed (100 Kbps) and distance up to 1200 meters (i.e. 4000 ft.) are supported.
- Due to differential signalling RS485 interface is immune to noise.
- It supports single master and multiple slaves due to balanced transmission line.
- It is considered to be lower signal level interface.
- The communication is faster compare to I^2C protocol.

d) DISADVANTAGES OF RS-485 MODULE:

- In RS485 mode, only single node can transmit data at a time.
- It requires 4 wires to communicate in multidrug mode unlike RS232 which requires only 2 wires to communicate between master and slave in point to point mode.
- RS485 is not suitable to transfer large amount of data at 115.2 Kbps speed. This is due to occurrence of data loss at such high speed. Data transfer at 56.2 Kbps is stable but takes longer time.
- In RS485, backing up of system is difficult.

2.6.3 PHOTOELECTRIC PROXIMITY SENSOR:

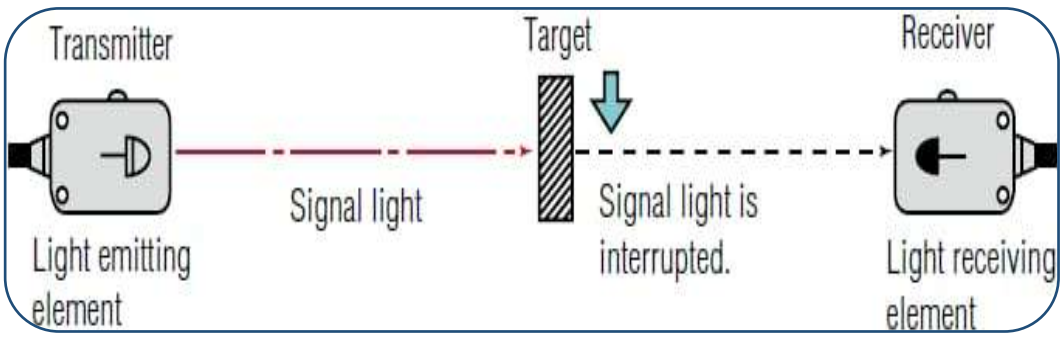
Photoelectric sensors are able to detect both **metallic** and **non-metallic** targets. The main components of this sensor are emitter, detector and associated electronics. Emitter (Light Emitting Diode, laser diode) sends a beam of light. The detector (photo diode or phototransistor) detects emitted light. Associated electronics required to amplify the detected signal. The emitter sometimes called the sender transmits a beam of either visible or infrared light to the detecting receiver. All photoelectric sensors operate under similar principles. Dark-on and light-on classifications refer to light reception and sensor output activity. With no reception of light, the output produces then the sensor is dark-on. If output from light received, then it is light-on.

There are three main sensing methods of the photoelectric proximity sensor:

- **Through beam method**
- **Retro-reflective method**
- **Diffuse or Reflective method**

a) Through beam method:

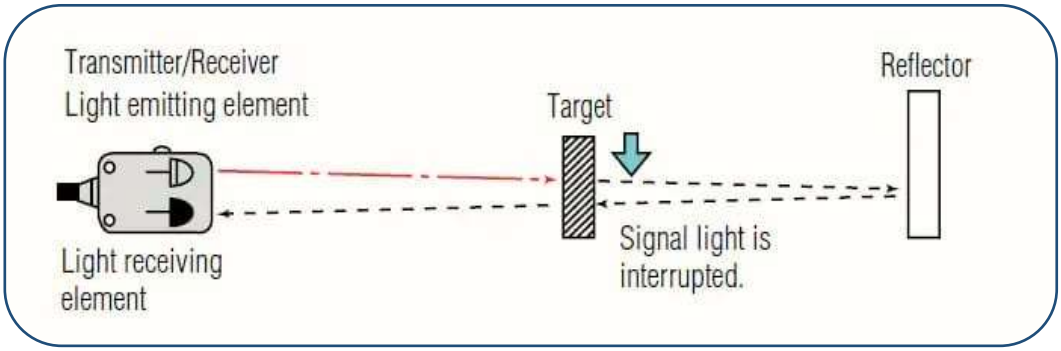
In this type of method, an emitter sends out a beam of light directly in the line-of-sight of the emitter to a receiver. When an object breaks this beam of light, it detects as a presence. This type of setup requires two components they are an emitter and a separate detector, which makes it a bit more complex to install and wire. However, the advantage is that it's the most accurate of the sensing methods with the longest sensing range.



New laser diode emitter models can transmit a well-collimated beam 60 m for increased accuracy and detection. At these distances, some through-beam laser sensors are capable of detecting an object the size of a fly, at close range, that becomes 0.01 mm. One ability unique to through beam photoelectric sensors is effective sensing in the presence of thick airborne contaminants.

b) Retro-reflective method:

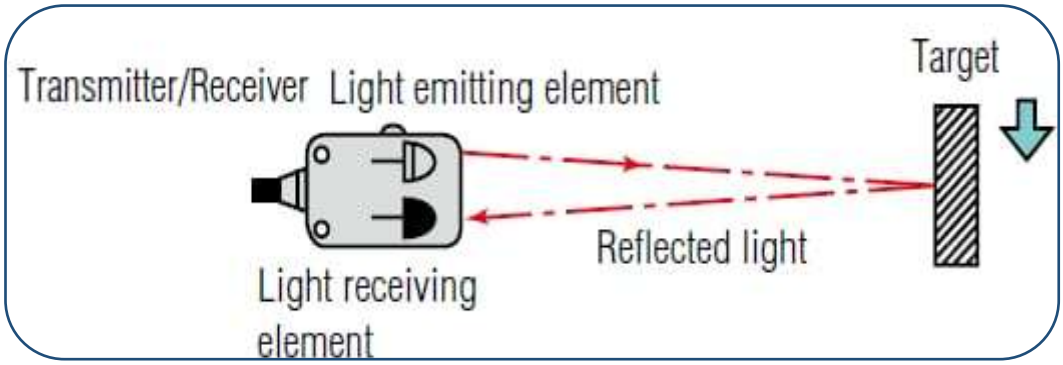
In this method, detection occurs when the light path breaks or disturbs. Both the light emitting and light receiving elements are in same housing. The light from the emitting element hits the reflector and returns to the light receiving element. When a target is present, the light gets interrupt.



One reason for using a retro-reflective sensor over a through-beam sensor is for the convenience of one wiring location, the opposing side only requires reflector mounting.

c) Diffuse or Reflective method:

As in retro-reflective sensors, emitters and receivers located in the same housing. In this diffuse method, both the light emitting and light receiving elements contain in a single housing. The sensor receives the light reflected from the target.



Diffuse photoelectric sensors are similar in some respects to reflective sensors. This is because like reflective sensors they emit a light beam in the direction of the object to be detected. However, instead of a reflector used to bounce the light back to a detector, the object to be sensed functions as the reflector, bouncing some of the light back to be detected and register an object's presence.

a) Advantages of Photoelectric Proximity Sensor:

- The sensor senses all kinds of materials.
- It has longer life, long sensing range and very reliability.
- Very fast response time and less costly.
- Diffuse photoelectric sensor detects small objects including colour mark and label detection.
- Mostly retro-reflective type sensor can detect transparent objects.
- Through beam type can detect long range and it is tolerant of dirty environment.

b) Disadvantages of Photoelectric Proximity Sensor:

- Over course of time lens get contaminated.
- Generally, the sensing range is affected due to colour and reflectivity of the target.
- Through beam type requires transmitter (TX) and receiver (Rx) at two separate locations.
- Retro reflective type requires reflector in addition to TX/Rx.
- This makes system installation complex.

c) Applications of Photoelectric Proximity Sensor:

- Checking objects on production lines or conveyors.
- Counting of small objects.
- Detection of colours.
- Monitoring bigger areas for objects with light grids.
- Measuring distance.
- Logistics and materials handling.
- Automatic doors.

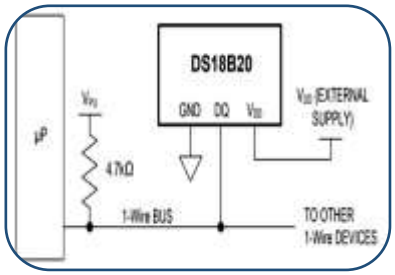
2.6.4 TEMPERATURE SENSOR (DS18B20):

- This sensor is a programmable and digital temperature sensor. Communicates over one wire bus communication.
- Stands for Dallas semiconductor temp sensor.
- This sensor is a transistor-type component, enclosed into a metal covering.

PIN CONFIGURATION:

SL NO:	PIN NAME	DESCRIPTION
1	GROUND	Connect to the ground of the circuit
2	VCC	Powers the Sensor, can be 3.3V or 5V
3	DATA	This pin gives output the temperature value which can be read using 1-wire method

How to use the (DS18B20)Sensor: The sensor works with the method of 1-Wire communication. It requires only the data pin connected to the microcontroller with a pull up resistor and the other two pins are used for power.



The pull-up resistor is used to keep the line in high state when the bus is not in use. The temperature value measured by the sensor will be stored in a 2-byte register inside the sensor. This data can be read by the using the 1- wire method by sending in a sequence of data.

APPLICATIONS:

- Measuring temperature at hard environments.
- Liquid temperature measurement.

2.6.5 SMART ENERGY METER:

CONFIGURATION LOCK PARAMETER DESCRIPTION:

NOTE: "The lockable parameter can be modified only once and 15 minutes' post modification. In case, if unit is turned off within that specific 15 minutes, parameter is locked".

* Lockable Parameter - Energy Reset.

ORDER CODE INFORMATION			
Product	**Outputs**	**Certification**	
EM2M-1P-C-100A MID	RS485 (Modbus RTU) & Pulse	CE	**MID**

SERIAL COMMUNICATION	
Interface standard and protocol	RS485 AND MODBUS RTU
Communication address	1 to 255
Transmission Mode	Half duplex
Data types	Float and Integer
Transmission distance	500 Meter maximum
Transmission speed	9600 &19200 (in bps)
Parity	None, Odd, Even
Stop bits	1 or 2

RESOLUTION	
Energy	0.01k

ACCURACY	
Measurement	Accuracy
Voltage V_{L-N}	±0.5% of Full scale
Current	±0.5% of Nominal
Power Factor	±0.01 of Full scale
Frequency	±0.1% of Full scale
Active Power	1.00 % of Full scale
Reactive Power	1.00 % of Full scale
Apparent Power	1.00 % of Full scale
Active Energy	EN50470(Class B)
Reactive Energy	EN62053-23(Class 2)
Apparent Energy	Class1
Demand Active Power	1.00 % of Full scale
Demand Reactive Power	1.00 % of Full scale
Demand Apparent Power	1.00 % of Full scale

Config. page	Function	Range or Selection	Factory Setting
1	Password	0000 to 9998	1000
2	Change Password	No / Yes	No
2.1	New Password	0000 to 9998	0001
3	Demand interval method	Sliding / Fixed	Sliding
4	Demand interval duration	1 to 30	15
5	Demand interval length	1 to 30 min	1
6	POP	kWh - Total/IP/EP kVArh -Total/IP/EP	Total VArh
7	Pulse Weight	1/10/100/1000	1000
8	Pulse Duration	0.05 to 2 sec	0.1
9	Slave Id	1 to 255	1
10	Baud rate	9600, 19200 bps	9600 bps
11	Parity	None, Odd, Even	None
12	Stop Bit	1 or 2	1
13	Backlight	0 to 7200	0
14	Factory default	No / Yes	No
15	Reset	No / Yes	No
15.1	Password	0001 to 9999	1001
15.2	Reset kWh	No / Yes	No
15.3	Reset kVArh	No / Yes	No
15.4	Reset kVAh	No / Yes	No
15.5	Reset Max Demand	No / Yes	No

PULSE OUTPUT DESCRIPTION

Pulse Output	Type	Description	Pulse width
POP1	Fixed 1000 Pulses	Per kWh	0.05 to 2 sec
POP2	Configurable 1/10/100/1000 Pulses	Per kWh - Total/IP/EP Per kVArh - Total/IP/EP	0.05 to 2 sec

SAFETY PRECAUTIONS:

All safety related codifications, symbols and instructions that appear in this operating manual or on the equipment must be strictly followed to ensure the safety of the operating person as well as the instrument. If the equipment is not used in a manner specified by the manufacturer it might impair the protection provided by the equipment.

- Do not use the equipment if there is any mechanical damage.
- Ensure that the equipment is supplied with correct voltage.

CAUTIONS:

- Read complete instructions prior to installation and operation of the unit.
- Risk of electric shock.
- The equipment in its installed state must not come in close proximity to any heating sources, oils, steam, caustic vapours or other unwanted process by products.

WIRING GUIDELINES:

- To prevent the risk of electric shock, power supply to the equipment must be kept OFF while doing the wiring Arrangement.
- Wiring shall be done strictly according to the terminal layout. Confirm that all connections are correct.
- Use lugged terminals.
- To reduce electromagnetic interference, use of wires with adequate rating and twists of the same in equal size shall be made with shortest connections.
- Layout of connecting cables shall be away from any internal EMI source.
- Cable used for connection to power source, must have a cross section of 25mm2 (13 to 11AWG; 750C (min)). These wires shall have current carrying capacity of 100A.
- Copper cable should be used (Stranded or Single core cable).

INSTALLATION GUIDELINES:

CAUTION:

- This equipment, being built-in type, normally becomes a part of main control panel and in such case the terminals do not remain accessible to the user end after installation and internal wiring.
- Conductors must not come in contact with the internal circuitry of the equipment or else it may lead to a safety hazard that may in turn endanger life or cause electrical shock to the operator.
- The equipment shall not be installed in environmental condition other than those mentioned in this manual.
- Connector screw must be tightened after installation.

CONFIGURATION:

There are 2 dedicated keys (Scroll & Enter) to enter into configuration Menu / B change settings.

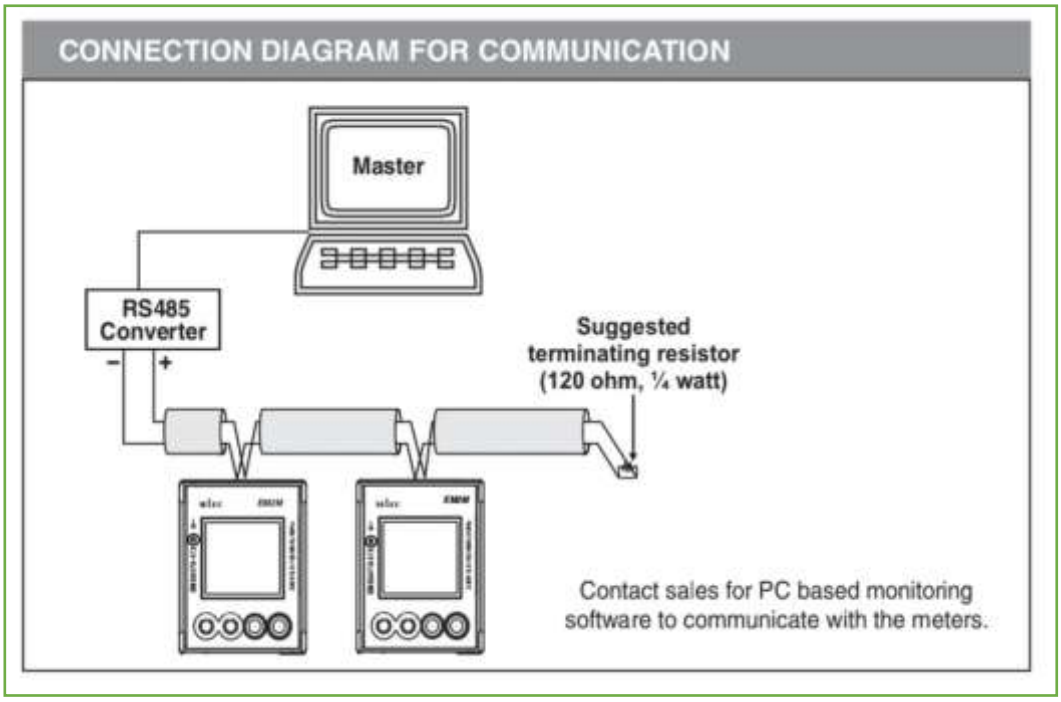
- The settings should be done by a professional, after going through this user manual and after having understood the application situation (Please refer to configuration lock note before entering into configuration mode).

For the configuration setting mode:

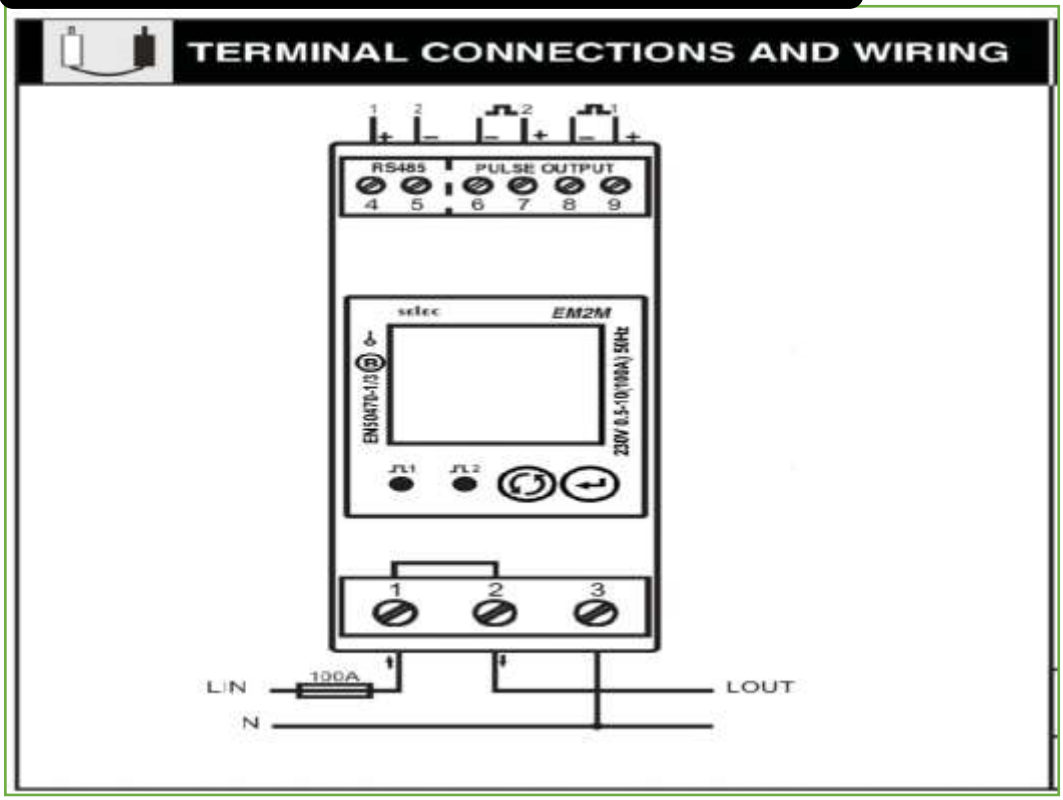
- Press the (Scroll & Enter) keys for 3 sec to enter or exit from the Configuration menu.
- In online mode, press Scroll key to move on to next page.
- In configuration mode, press Enter key to change the parameters value / page and Scroll key to enable the editing and save the changes in configuration.
- Press the Enter key to check Serial no. and CRC no.
- Press the Enter key for 3sec for communication Lock.

NOTE: Above 70A current pulse duration should be set to 0.05sec.

COMMUNICATION CONNECTION DIAGRAM:



TERMINALS CONNECTION DIAGRTAM:



FRONT PANEL DESCRIPTION

FOR EM2M-1P-C-100A-MID

Key Press	Online Page Description	
Press ◉	1st screen	Displays Total Active Energy
	2nd screen	Displays Import Active Energy
	3rd screen	Displays Export Active Energy
	4th screen	Displays Total Reactive Energy
	5th screen	Displays Import Reactive Energy
	6th screen	Displays Export Reactive Energy
	7th screen	Displays Apparent Energy
	8th screen	Displays Active Power
	9th screen	Displays Reactive Power
	10th screen	Displays Apparent Power
	11th screen	Displays Voltage L-N
	12th screen	Displays Current
	13th screen	Displays Power Factor
	14th screen	Displays Frequency
	15th screen	Displays Max Demand Active Power
	16th screen	Displays Max Demand Reactive Power
	17th screen	Displays Max Demand Apparent Power

AUTOMATIC / MANUAL

Long press scroll key to toggle between Automatic/Manual mode.

ENERGY METER MODBUS REGISTER LISTS:

Readable parameters for Communication [Length (Register) : 2; Data Structure : Float]

Address	Hex Address	Parameter
30001	0x01	Total Active Energy
30003	0x03	Import Active Energy
30005	0x05	Export Active Energy
30007	0x07	Total Reactive Energy
30009	0x09	Import Reactive Energy
30011	0x0B	Export Reactive Energy
30013	0x0D	Apparent Energy
30015	0x0F	Active Power
30017	0x11	Reactive Power
30019	0x13	Apparent Power
30021	0x15	Voltage L-N
30023	0x17	Current
30025	0x19	Power Factor
30027	0x1B	Frequency
30029	0x1D	Max Demand Active Power
30031	0x1F	Max Demand Reactive Power
30033	0x21	Max Demand Apparent Power

Energy rollover counter addresses : Energy rollover counter will increment when energy is roll over from 99999.99 to 0.
[Data Structure: Integer]

30150	0x96	Total kWh
30151	0x97	Import kWh
30152	0x98	Export kWh
30153	0x99	Total kVArh
30154	0x9A	Import kVArh
30155	0x9B	Export kVArh
30156	0x9C	kVAh

2.6.7 AUTOTRANSFORMER (DIMMERSTART):

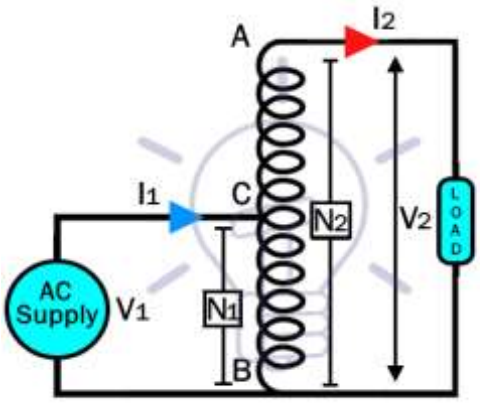
Autotransformer is a special type of transformer that consists of a single winding. This winding is used for both primary & secondary (High voltage & low voltage) sides. It is widely used for its variable output voltage function, lower cost & small size. In a conventional two winding transformer, there are two separate windings for high & low voltage side. The connection between these two windings is purely magnetic (mutual induction). It implies that there is electrical isolation between both windings.

Types of Autotransformers:

Based on increasing & decreasing the voltage, autotransformer is divided into two types i.e. Step up transformer & step down transformer. Just like two winding transformers, a single autotransformer can be used in both configurations.

a. StepUp Autotransformer:

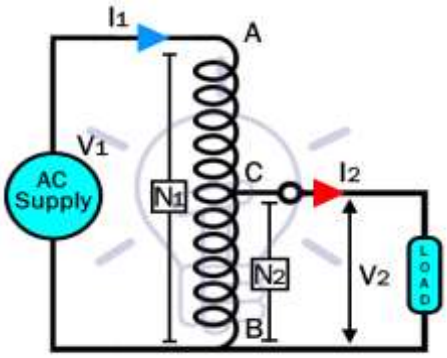
- Such kind of autotransformer's output voltage exceeds its input voltage & vice versa for its current.
- For performing the step-up function, the AC supply is connected to the variable tap point C & B. while the load is connected to the terminal A & C.



- In such configuration, the number of turns in the primary winding N_1 (input winding) which between C & B, is less than the number of turns in the secondary winding N_2.
- So, the turn ratio (N_2 / N_1) becomes greater than one, which is the condition for a step-up transformer.

b. Stepdown Autotransformer: In step down autotransformer, the output voltage is less than the input voltage & the output current is greater than the input current.

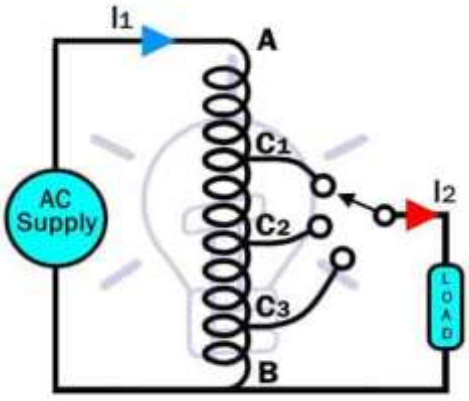
- In order to perform step down function, the connections are reversed to the step-up configuration. The AC supply is connected to the fixed terminals (A & B) of the autotransformer, while the load is connected between terminals C & B.



- The number of turns in the primary winding N_1 between point A & B exceeds the number of turns in secondary winding N_2. Hence the turn ratio becomes less than 1, which is the condition for step down transformer.

c. WORKINGPRINCIPLEOFAUTOTRANSFORMER

Has one single winding around a laminated core. This single winding is used for both primary & secondary circuit.



- Their winding consists of at least three terminals i.e. A, B & C as shown in the figure. The terminals A & B are fixed terminals while the terminal C is a variable tap point.

- The AC supply is applied to fixed terminals A & B while the load is connected between variable Tap Point C & B.
- The autotransformer can have multiple tap points to provide a variable output voltage. Each of these tap points is designed to provide a different turn ratio of the transformer, hence varying the output voltage.

d. Advantages of Autotransformer:

- The most prominent feature of an autotransformer is that it saves copper. The amount of copper used in an autotransformer is less than a two winding transformer of the same ratings. Thus, it reduces the **capital** required for its construction.
- The single winding used in the autotransformer significantly reduces its size & weight.
- Having small size & weight of the autotransformer, it enables it to have a high VA rating than an ordinary two winding transformer for the same amount of material.
- The voltage regulation is much better than the two-winding transformer because of the elimination of the losses in the second winding.
- Due to the electrical conduction, magnetic induction & reduction in the losses due to the second winding, the efficiency of the autotransformer is higher than the two-winding transformer.

e. Disadvantages of Auto transformer:

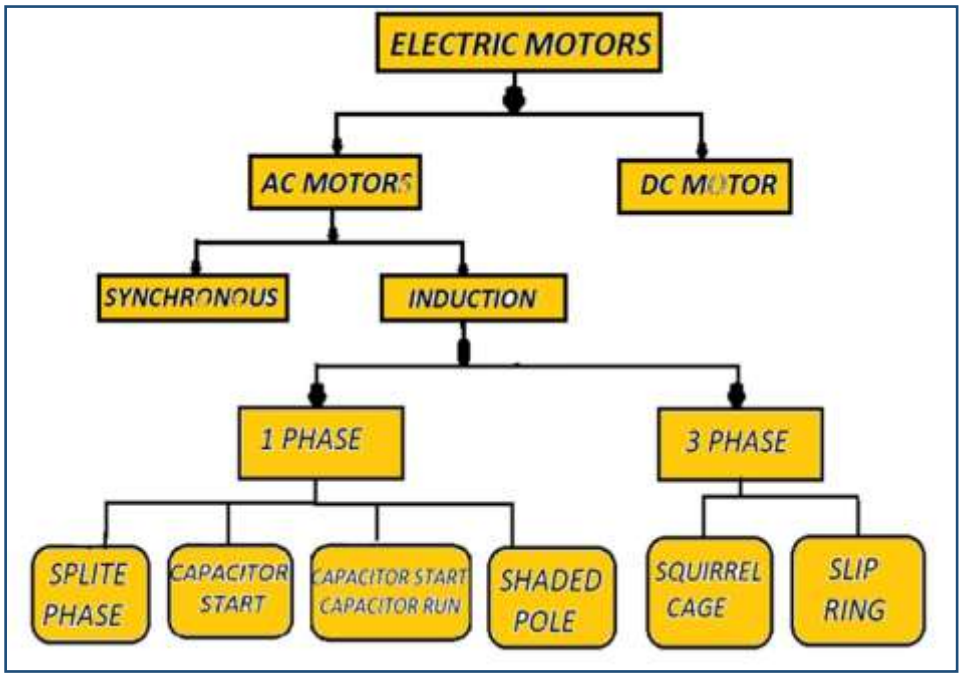
- There is no electrical isolation between the windings. So grounding the primary of an autotransformer won't eliminate the risk of an electrical shock as both windings are electrically connected. The circuit will still complete through the ground.
- Due to the electrical isolation present between the winding, two winding transformer blocks the transfer of harmonics between the load & supply, while autotransformer actually can't.
- Because of the low leakage flux between primary & secondary, the impedance of the autotransformer is low. Thus, it may result in large fault currents in the secondary.

f. Applications of Autotransformer:

- They are used for the compensation of the voltage drop in the distribution transformers.
- For starting induction & synchronous motors, several methods are used. One of the methods is using an autotransformer.
- **A variable autotransformer also known as Varian**, which has continuous variable output voltage is used in the laboratories.
- A break in the common winding of the autotransformer will result in full input voltage at the load.

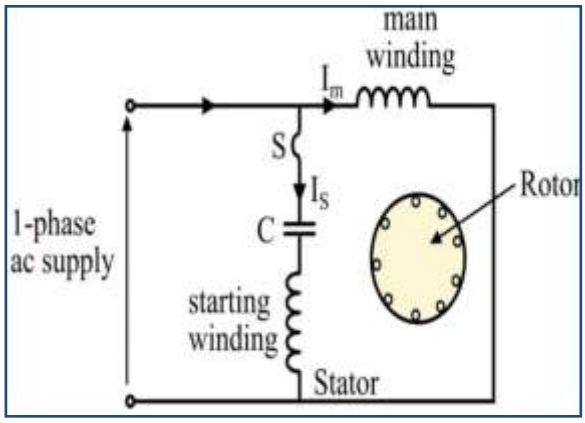
2.6.8 INDUCTION MOTOR

CLASSIFICATION:



CAPACITOR START INDUCTION MOTOR:

WORKING PRINCIPLE:

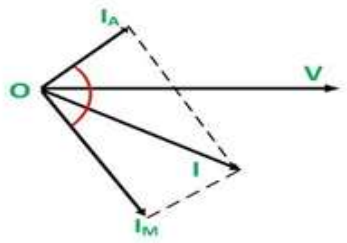


A capacitor start induction motor is a 1-phase motor that includes a stator as well as a rotor with a single cage. The stator ofthis motor mainly includes two windings namely **main winding** as well as **auxiliary winding.** An alternate name of an auxiliary winding is **starting winding.** In motor Construction, the arrangement of these two windings can be done 90 degrees separately in space.A capacitor C_S is

connected in series with the starting winding. A centrifugal switch S_C is also connected to the circuit.

NOTE: The capacitor C_a is used in this motor to produce a greater phase difference between main winding and auxiliary winding currents.

The Phasor Diagram of the Capacitor Start motor:



- I_M is the current in the main winding which is lagging the auxiliary current I_A by 90 degrees as shown in the phasor diagram above. Thus, a single-phase supply current is split into two phases. The two windings are displaced apart by 90 degrees electrical, and their MMF's are equal in magnitude but 90 degrees apart in the time phase.

- The motor acts as a balanced two-phase motor. As the motor approaches its rated speed, the auxiliary winding and the starting capacitor are disconnected automatically by the centrifugal switch provided on the shaft of the motor.

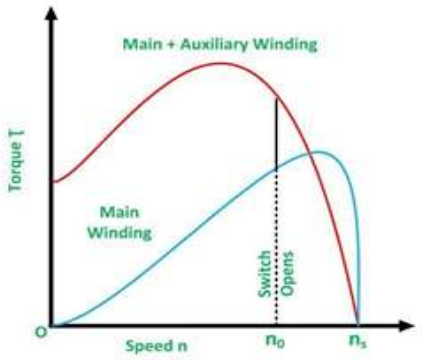
"CHARACTERISTICS"of the Capacitor Start Motor: The capacitor starts motor develops a much higher starting torque of about 3 to 4.5 times the full load torque. To obtain a high starting torque, the two conditions are essential. They are as **follows:**

- The Starting capacitor value must be large.

- The valve of the starting winding resistance must be low.

The electrolytic capacitors of the order of the 250 μF are used because of the high Var rating of the capacitor requirement.]

The "**TORQUE SPEED CHARACTERISTIC"** of the motor:



The characteristic shows that the starting torque is high. The cost of this motor is more as compared to the split-phase motor because of the additional cost of the capacitor. The Capacitor start motor can be reversed by first bringing the motor to rest condition and then reversing the connections of one of the windings.

a. Advantages of the Capacitor Start Induction Motor:

- Because of high starting torque and low starting current, capacitor start induction motors have a wide range of applications.
- The capacitor is in series with the start circuit, so it creates more starting torque, typically 200 to 400% of rated load.

b. Disadvantages of the Capacitor Start Induction Motor:

- The cost of the paper capacitor used in the motor is expensive and also its size is larger as compared to an electrolytic capacitor with the same ratings.
- It has **less starting torque**.

c. Applications of the Capacitor Start Induction Motor:

- These motors are used for the loads of higher inertia where frequent starting is required.
- Used in **pumps and compressors**
- Used in the **refrigerator and air conditioner compressors.**
- They are also used for **conveyors** and **machine** tools.
- **Heavy-duty** applications requiring high starting torque.

2.6.9 TERMINALS:

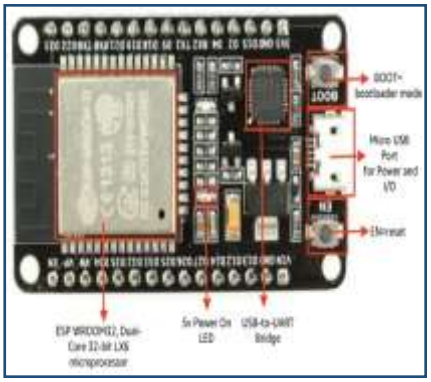
A terminal is the point at which a conductor from a component, device or network comes to an end. Terminal may also refer to an electrical connector at this endpoint, acting as the reusable interface to a conductor and creating a point where external circuits can be connected.

- **RED** Terminal is used in L-in phase of input supply for single phase autotransformer.
- **GREEN** Terminal is used in L-out phase of output supply for single phase capacitor start induction motor.
- **BLACK** Terminal is used in neutral of both input and output supply.

2.7 COMPONENTS SPECIFICATIONS:

2.7.1 MICROCONTROLLER ESP-32 SPECIFICATIONS:

- **Wi-Fi:** 2.4GHz up to 150 Mbit/s.
- **Number of cores:** 2(dual core)
- **Bluetooth:** BLE (Bluetooth Low energy) and legacy Bluetooth.
- **Architecture:** 32 bits.
- **Clock frequency:** up to 240MHz.
- Pins: 30

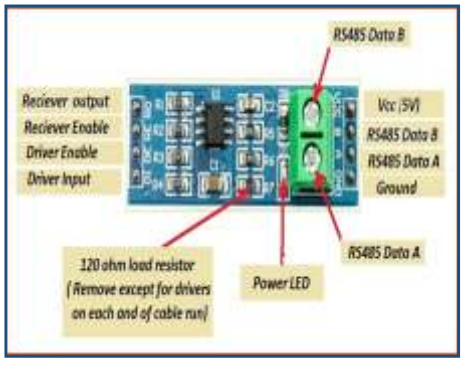


2.7.2 TEMPERATURE SENSORSPECIFICATIONS:

- **Model:** DS18B20
- **Power supply range:** 3.0V to5.5V
- **operating temperature range: -** 55ºC to +125ºC
- **Accuracy** +/-0.5 ºC (Between the range -10ºC to 85ºC)

2.7.3 RS-485 MODULE SPECIFICATIONS:

- **Stands form:** recommended Standard#485.
- **IC Chip:** MAX485
- **Operating voltage:** 5V DC
- RS-485 uses two signal lines,"A" and "B", which must be balanced **And differential**.



2.7.4 PHOTOELECTRIC PROXIMITY SENSOR SPECIFICATIONS:

- **Rated voltage:** 5V DC
- **Model:** E18-D80NK
- **Rated current:** 100mA
- **Sensing range:** 3-80cm
- **Output:** DC three-wire system (NPN)
- **Outer diameter:** 18mm,
- **Length**: 45mm
- **Ambient temperature:** -22 to 75 degree Centigrade.

2.7.5 SMART ENERGY METER SPECIFICATIONS:

- **Phase:** single
- **Brand:** SELEC
- **Model:** EM2M-1P-C-100A
- **Voltage:** 176 - 276V AC (L-N)
- Version of communication: RS-485 and MODBUS RTU
- **Current:** 5A AC (min -100mA, max -100A)
- **Type:** Digital

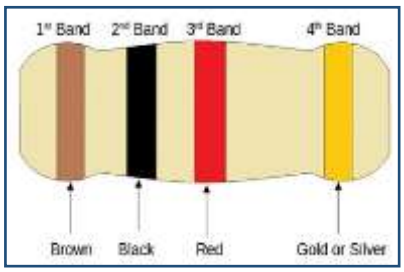
2.7.6 CAPACITOR STARTS INDUCTION MOTOR SPECIFICATIONS:

- **Phase**: single
- **HP:** 0.25
- **Rated voltage:** 220v AC (L-N)
- **Rated frequency:** 50Hz
- **Rated current:** 2.5A
- **Rated speed:** 1440 RPM
- **Operating temperature:** between-20 to +40 Degree centigrade

2.7.7 AUTOTRANSFORMER (DIMMER START) SPECIFICATIONS:

- **Phase:** single
- **Max load:** 15 Amps
- **Input:** 270 V 50-60~
- **Output:** AT E&C 0-240v or 0-270v.
- For input at A&C or B&C Respectively.

2.7.8 RESISTER SPECIFICATION:



- **Resistance:** 1K ohm
- **Tolerance:**5%
- **Colour Code:**Brown / Black / Red / Gold
- **Type:**Carbon Film
- **Voltage Maximum Operating:**350V
- **Polarization**: None
- **Operating Temp:**-55C – +155C
- **Package:**Conformal Coated, Axial
- **Dimensions:**Body diameter: 2.3mm
- **Body Length:**6mm
- **Lead Length:**28mm
- **Lead Diameter:** 0.55mm
- **Stack pole:** Electronics
- **Datasheet:**CF14JT1K00

2.7.9 USB to 232 D-Type:

- **MODEL**: ICI – 42
- **Output Voltage:** 5.0V DC (Max)
- **Output Current:** 2.0A (Max)

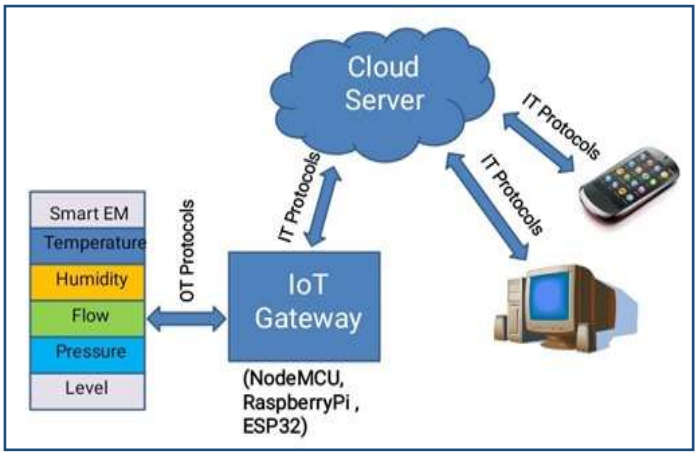
CHAPTER: 3

APPROACH AND METHODOLOGY:

3.1 DESCRIPTION OF IOT TECHNOLOGY:

The **Internet of Things** (**IoT**) describes the network of physical objects—"things"—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet or other communications networks. The ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

BLOCK DIAGRAM OF IOT:



a. MAJOR COMPONENTS OF IOT:

- **Things or Devices:** Theseare fitted with sensors and actuators. Sensors collect data from the environment and give to gateway whereas actuators perform the action (as directed after processing of data).
- **Gateway:** The sensors give data to gateway and here some kind of pre-processing of data is even done. It also acts as a level of security for the network and for the transmitted data.
- **Cloud:**The data after being collected is uploaded to cloud. Cloud in simple terms is basically a set of servers connected to internet 24*7.
- **Analytics:** the data after being received in the cloud processing is done. Various algorithms are applied here for proper analytics of data (techniques like machine learning etc. are even applied**.**
- **User interface:** User end application where user can monitor or control the data.

b. COMMUNICATION DEVICES OF IOT:

- RFID.
- Ethernet.
- Wi-Fi.
- VHF/UHF/SHF radio.
- Bluetooth.
- DSL
- Fibber.
- IPv4 and IPv6.
- Eocene
- GSM (Global System for mobile communication)

c. TYPES OF BOARDS USED IN IOT:

- Node-MCU ESP8266 board.
- Raspberry pi board.
- Arduino Boards.
- Beagle Bone Board.

d. PLATFORMS OF IOT:

- Google cloud IOT platform
- Amazon web service platform for IOT
- Thing work
- Microsoft Azure IOT platform
- IBM Watson IOT
- IRI Veracity
- Oracle IOT

e. CHARACTERISTICS OF THE IOT:

- **Connectivity:** connectivity is an important pillar of the IoT infrastructure. IoT devices should be connected regardless of their presence. Without connection, nothing makes sense.
- **Identity:** Each IoT device has its unique identity. If it needs to access the data from specific device, then its identification element is very helpful.
- **Intelligence:** the extraction of data from the sensor devices is very important. This data is only useful if it is interpreted properly. IoT perform operations on sensed data in such a way that the results are useful for us. It is the intelligence properly of IoT.
- **Scalability:** The number of IoT devices are increased day by day. Hence, the scalability of an IoT should be enough that it can handle the massive traffic.
- **Dynamic and self-adapting:** IoT devices should dynamically adapt themselves according to situations. For example, a camera can capture data according to light conditions. It is shifted to night or day mode automatically. It is self-adapting technique.
- **Architecture**: IoT architecture should be hybrid, supporting different manufacturers so it cannot be homogeneous in nature IoT is not the name of any engineering branch, IoT comes to picture when multiple domains come together.
- **Safety**: safety should be the top priority, but in case IoT,safety is big challenge because multiple things are connected through internet, and security at each node is a critical and tough task.

f. IMPORTANCE OF IOT:

- The IoT of things help people live and work smarter, as well as gain complete control over their lives in addition to offering smart device to automate homes, IoT is essential to business, IoT provides businesses with a real-time look into how their systems really work, delivering insight into everything from the performance of machines to supply chain and logistics operation
- IoT enable companies to automate processes and reduce labour costs, it also cut down on waste and improve service delivery, making it less expensive to manufacture and deliver good, as well as offering transparency into customer transaction.
- As such, IoT is one of the most important technology everyday lives, and it will continue to pick up steam as more business realize the potential of connected devices to keep them competitive.

3.2 DESCRIPTION OF PROGRAMMING:

Arduino IDE software is used in programming

- It itself has 0.5KB of the boot ladder that makes the program be burned into the circuit.
- All we have to play with Arduino is to download the Arduino software and start the code.
- The Arduino programs are called sketches.
- Basic Arduino language**: C/C++.**

ADVANTAGES OF ARDUINO SET UP PROCEDURE:

- Open-source electronics prototyping platform.
- The simplest and the beginner's choice.
- It is first microcontroller-based development board.
- It is inexpensive.
- It is cross-platform/multiplatform.
- Flexible and easy prototyping.
- Provides pre-wiring and free code libraries.
- More reliable for hardware applications.
- To create interactively (IoT) electronics applications.
- Easy to program for beginners by Arduino IDE.

PROGRAMMING CODE:

```
#include<Arduino.h>
#include<WiFi.h>
#include<WiFiMulti.h>
#include<HTTPClient.h>
#defineUSE_SERIAL Serial
WiFiMulti wifiMulti;

#include<SoftwareSerial.h>
#include<ModbusMaster.h>
SoftwareSerial mySerial(26, 27); // RX, TX
floattemp(void);
/*!
  We're using a MAX485-compatible RS485 Transceiver.
  Rx/Tx is hooked up to the hardware serial port at 'Serial'.
  The Data Enable and Receiver Enable pins are hooked up as follows:
*/
uint16_tmbr [] = {0x15,0x0017,0x0019,0x001b,0x0096};
#defineMAX485_DE   13
String mdata;
float t = 0;
float d = 0;
String in;
float datain = 0;
// instantiate ModbusMaster object
ModbusMaster node;

voidpreTransmission()
{
  digitalWrite (MAX485_DE, 1);
}
voidpostTransmission ()
{
  digitalWrite (MAX485_DE, 0);
}
// Include the libraries we need
#include<OneWire.h>
#include<DallasTemperature.h>

// Data wire is plugged into port 2 on the Arduino
#defineONE_WIRE_BUS4

// Setup a oneWire instance to communicate with any OneWire devices
(not just Maxim/Dallas temperature ICs)
OneWire oneWire(ONE_WIRE_BUS);

// Pass our oneWire reference to Dallas Temperature.
DallasTemperature sensors(&oneWire);
```

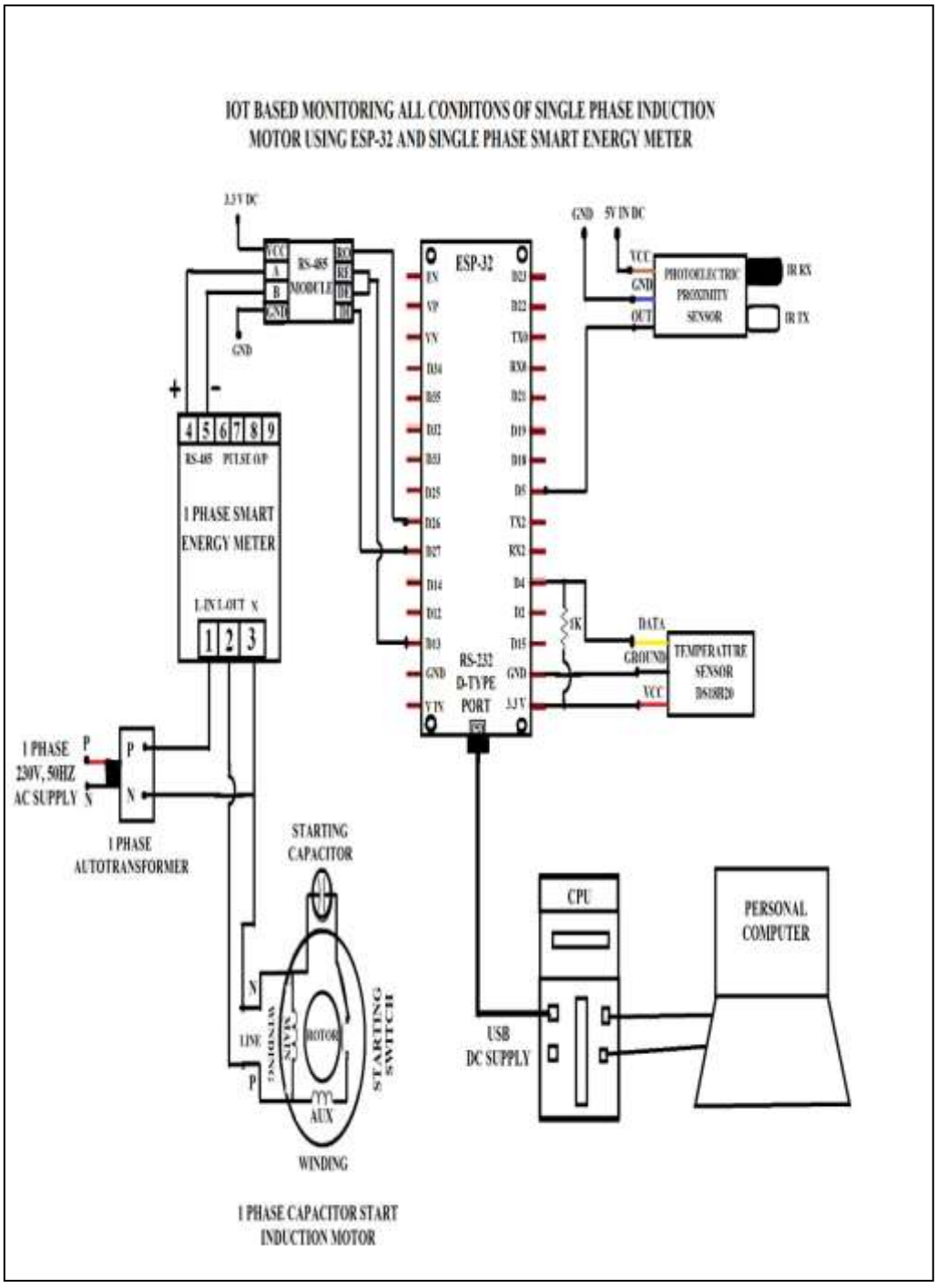
```
/*
 * The setup function. We only start the sensors here
 */
int rotation = 0;
float rpmx = 0;
int numberOfDevices; // Number of temperature devices found
DeviceAddress tempDeviceAddress; // We'll use this variable to store
a found device address
voidsetup (){
  Serial.begin(115200);
  // Serial.setDebugOutput(true);
  mySerial.Begin (9600);

  pinMode (MAX485_DE, OUTPUT);
  pinMode (2, INPUT);

  digitalWrite (MAX485_DE, 0);

  Serial.println();
  Serial.println();
  Serial.println();
 node. begin(1,mySerial);
   node.preTransmission(preTransmission);
  node.postTransmission (postTransmission);
  for(uint8_t t = 4; t >0; t--){
    Serial.printf("[SETUP] WAIT %d...\n", t);
    Serial.flush();
    delay (1000);

  }
 pinMode(5,INPUT_PULLUP);
      sensors.begin();

 wifiMulti.addAP("iot1", "iot1234567890");
}
voidloop (){
    mdata = meterdata ();
    Serial.println(mdata);
    Serial.print("Requesting temperatures...");
  sensors.requestTemperatures(); // Send the command to get
temperatures
  Serial.println("DONE");
  // After we got the temperatures, we can print them here.
  // We use the function ByIndex, and as an example get the
temperature from the first sensor only.
    mdata += "val5=";
    String t = tempdata();
    mdata += String(t);
    Serial.println(mdata);
```

```
    float r = rpm ();
  Serial.print("RPM= ");
  Serial.println(r);
  Mdata+="&val6=";
  Mdata += String(r);
Serial.println(mdata);
if ((wifiMulti.run () == WL_CONNECTED)){

        HTTPClient http;
Serial.print("http");
Serial.println(mdata);
        USE_SERIAL.print("[HTTP] begin...\n");
        // configure traged server and url
        //http.begin("https://www.howsmyssl.com/a/check", ca);
//HTTPS
        http.begin(mdata); //HTTP

        USE_SERIAL.print("[HTTP] GET...\n");
        // start connection and send HTTP header
        int httpCode = http.GET ();

        // httpCode will be negative on error
        If (httpCode >0){
            // HTTP header has been send and Server response header
has been handled
            USE_SERIAL.printf("[HTTP] GET... code: %d\n", httpCode);

            // file found at server
            If (httpCode == HTTP_CODE_OK){
                String payload = http.getString();
                USE_SERIAL.println(payload);
            }
        }else{
            USE_SERIAL.printf ("[HTTP] GET... failed, error: %s\n",
http. errorToString(httpCode).c_str ());
        }

        http.end();
    }
 Delay (5000);
}
String meterdata(void)
{
   uint8_t result=0;
  uint16_tI = 0x0000;
// uint8_t d [2];
union
{
  uint16_tu [2];
  float f;
```

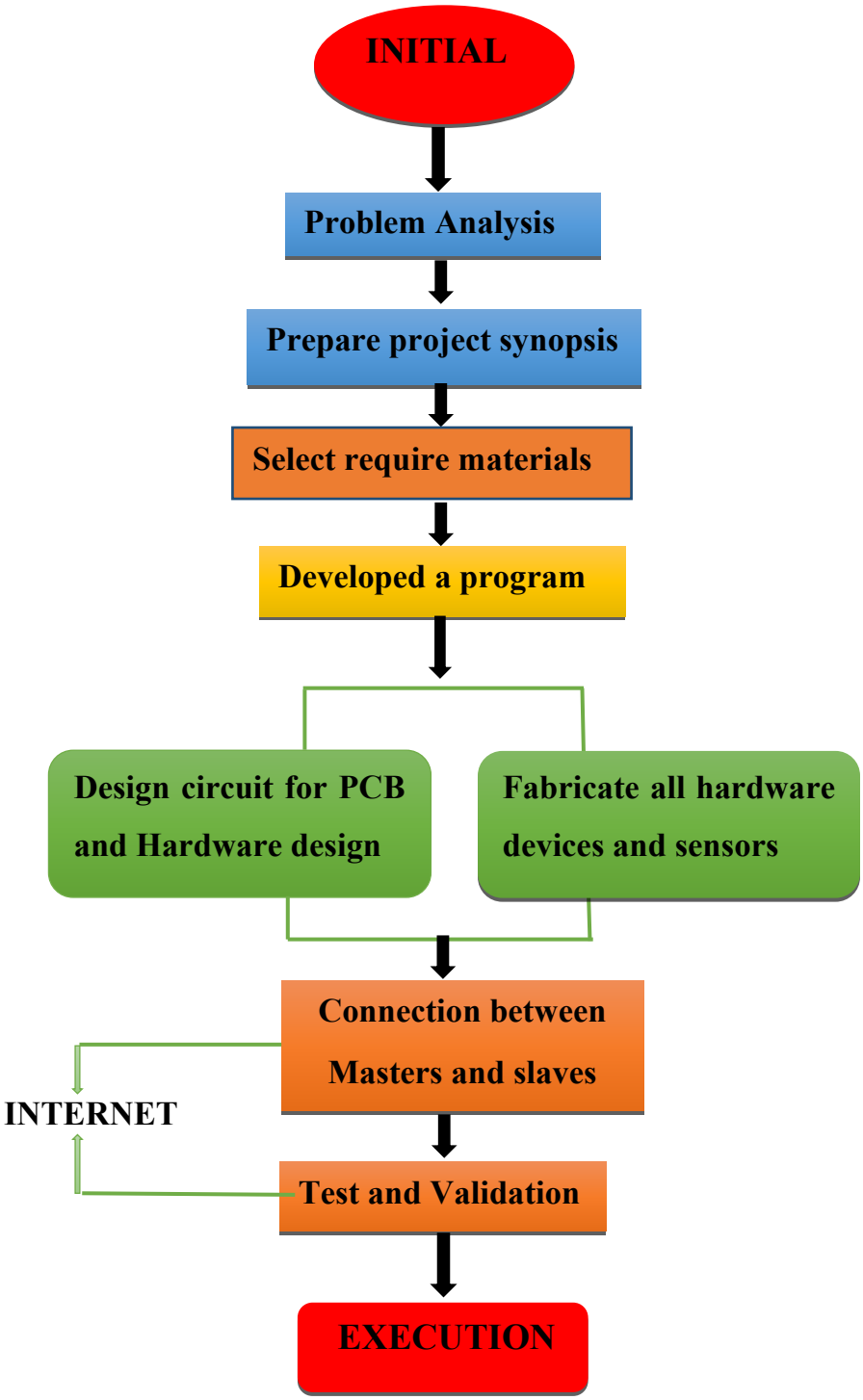
```
} meterdata;
String data= "https://motormonitoring.hexitronics.in/data.php?";
for (int k = 0; k<5; k++)
{
  data.concat("val");
  data.concat(String(k));
  data.concat("=");
  Serial.println(k);
  Serial.println(data);
  result =  node.readInputRegisters(mbr[k], 2);
 if(result == node.ku8MBSuccess)
  {
    meterdata.u[0] = node.getResponseBuffer(0x01);
    meterdata.u[1] = node.getResponseBuffer(0x00);

    Serial.print("k");
    Serial.print("= ");
    Serial.println(k);
    Serial.println(meterdata.f);
    data. concat (String (meterdata. f));
  }
  Else
  {
    Serial.println ("failed");
    Data.Concat (String ("0.0"));
  }
  data. concat ("&");

  delay(100);
}
  return data;
}

floatrpm () {
unsignedlong t = 0;
int b=0;
while(digitalRead(5) == 1)
{
  Serial.println("idle");
   Serial.println(digital Read (5));
b++;
if(b>5000)
{
  return0;
}
}
while (digital Read (5) == 0)
{
  //Serial.println(digital Read (5));
  T++;
```

```
Serial.println (t);
  delay (1);
  if (t >2000)
  return0;
}
Serial.println(t);
Rpmx = 60.00/ (t);
Serial.println (rpmx);
Rpmx = rpmx *1000.00;
Serial.println (rpmx, 5);
return rpmx;
}
String tempdata(void)
{
String data = "";
float value=0.0;
Serial.print(" Requesting temperatures...");
  sensors. request Temperatures (); // Send the command to get
temperatures
  Serial.println("DONE");

  //Serial.print (sensors.getTempCByIndex(0)); // Why "byIndex"?
 Value = sensors.getTempCByIndex (0);
Serial.println (value);
while (value < -55)
{
  sensors. request Temperatures (); // Send the command to get
temperatures
  Value = sensors.getTempCByIndex (0);
}
 data. concat(String(value));
Serial.println(data);
  return data;
}
```

3.3 PROCESS CONNECTION DIAGRAM:



3.4 PRODUCT DESIGN:



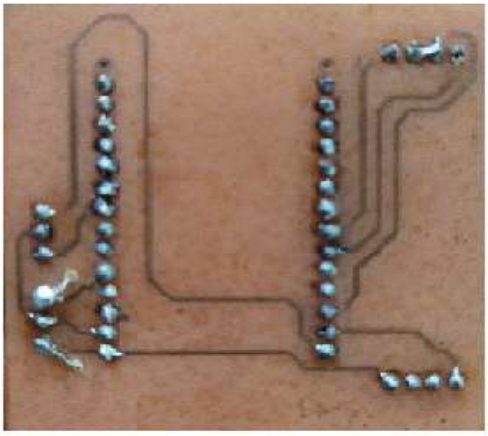
3.5 CONSTRUCTION AND FABRICATION MATERIAL:

Select required components in our project.

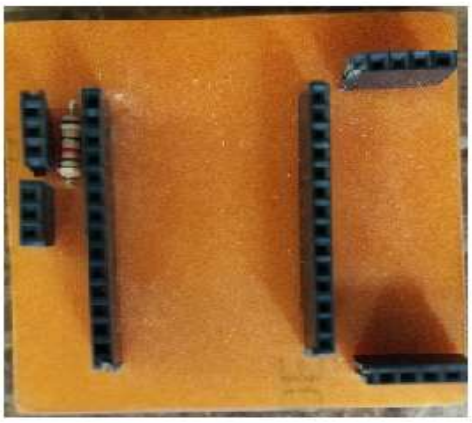
SL NO	MATERIALS	QUALITY	QUANTITY
1)	Microcontroller ESP-32	30 bit, and 32pins	1 NO
2)	Energy meter	EM2M-1P-C-100A digital 276V AC, 5A	1 NO
3)	Temperature sensor	DS18B20, 3.0V to 5.0V	1 NO
4)	Photoelectric proximity sensor	3 wire NPN type, 5V DC	1 NO
5)	RS-485 module	MAX485, 5V DC	1 NO
6)	Induction motor	1 phase AC 220V, 2.5A, 0.25HP, 50HZ.	1 NO
7)	Autotransformer	1 phase AC 270V, 15A load	1 NO

- Carrying that required components in electrical shops.
- Test all components is working or not.
- Carrying wood box pieces and prepare small box of required project product.
- Then design PCB for required connection diagram.

PCB BACK VIEW:



PCB FRONT VIEW:



- Place ESP-32, RS-485 module and sensors for required space.

- Complete hardware connection diagram:

CHAPTER 4:

TEST AND VALIDATION

4.1 Details of laboratory experiments:

- We have done the **IOT based Smart Energy Meter** experiment in the laboratory.
- We have use **NODE MCU ESP8266.**
- **Arduino IDE soft** is used for programming.
- Use **Blink IoT** App to create a dashboard.
- Because **Blink IoT** is an open-source server.
- **Blink IoT** app is worked in mobile too.
- Applications of this practical is used to **energy transforming**.
- This experiment we are implemented for **IoT based monitoring all conditions of induction motor using ESP-32 and smart energy meter.**

4.2 Details of Programming:

- The **Arduino IDE** software is used for programming.
- Because this **open-source** software, Easy to install.
- **C++ language** is used to developing a program.
- First down load **core packages** in your Arduino soft.
- Like **ESP32 by Espressif system**, **software serial, Modbus master, Dallas temperature, data, Arduino board.**
- Download **Modbus master** because we are used **RS 485 module** this module is **Modbus serial communication** device.
- Download **Dallas temperature** because we are used temperature sensor **DS18B20.**
- Once the program is finished, the board should again **select the port and upload** it, and the output should be seen in the serial monitor.

4.2Details of simulation:

- We have use Arduino IDE soft.
- First, develop a programming language.
- Click to port option, select board of **DOIT ESP32 DEVKIT V1** and select required **PORT** of microcontroller.
- Click **verify/compile** option all program is verify.
- Click **configure/upload** option program is upload.
- See, output for **serial monitor**.
- We have use **Dashboard platform.**
- First create **Dashboard** in web dashboard.
- Dash board is not an open source this is personal concern server.
- We see, **Dashboard i**n all parameters.

Chapter- 5

Financial considerations:

5.1 Capstone project budget:

Total budget for our project is approximately 13,500 RS.

Total amount in words:

(THIRTEEN THOUSAND FIVE HUNDRED RUPEES)

5.2 Cost capstone projections needed for either for profits:

- Improved knowledge of IOT.
- Developed technical skills.
- Improved project management skills.
- Developed ability of project skills.

Conclusion and Recommendation:

4.3 Describe state of completion of capstone project:

The power supply is turned ON; the Arduino and all the interface components get the required power supply. Sensors unit senses the corresponding motor parameters and feeds it to the Arduino. Arduino reads the data from various sensors and analyses it according to the given instructions, and then send the sensors and energy meter information to network gateway through Wi-Fi. In Parallel, Arduino reads the commands from internet and then provides control signals to the sensors, which then monitoring the conditions of induction will motor. The sensors information's are then displayed visually in the server of dashboard. The induction motor monitoring is based on IOT.

4.4 Future work of the project:

- It's applicable for large industry applications, energy transforming applications, and smart grid stations applications.

4.5 Outline how the capstone project may be extended:

- We have to use 3 phase induction motor and 3 phase energy meter.
- In future, such methods can be used for data acquisition from industrial motors, and at the same time, all the data set can be given to ANN (Artificial neural networks) model for fault prediction and classification.
- Processor such as raspberry pi can be used for data collection and running ANN algorithm. ANN is used for achieving fault prediction and classification.

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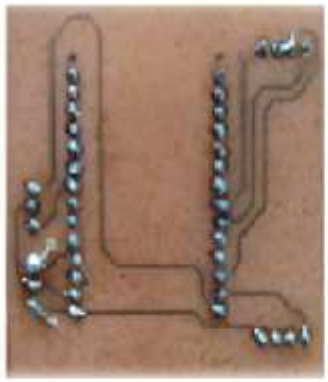
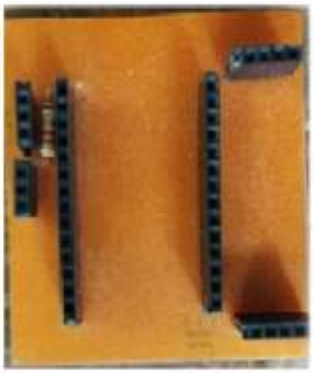
PROJECT PHOTOGRAPY:

GALLERY PHOTOGRAPPY


THANKING YOU