ABSRACT

In this project, prevention of power theft can be achieved through an IoT based smart electricity energy meter using ESP32 and real time monitor data on the Blynk application. With existing technology, the user needs to go to the energy-meter reading room and take down the readings. Thus, monitoring and keeping track records of the electricity consumption is a tedious task. This can be automated, thus saving time and money by automating remote data collection.

Efficient energy utilization plays a very vital role for the development of smart grid in power systems. Therefore, proper monitoring and controlling of energy consumption is a chief priority of the smart grid. The existing energy meter system has many problems associated to it and one of the key problems is that there is no full duplex communication. To solve this problem, a smart energy meter is proposed based on the Internet of Things (IoT). The proposed smart energy meter controls and calculates the energy consumption using ESP32, a Wi-Fi module and uploads it to the cloud from where the consumer or producer can view the reading. Therefore, energy analysis by the consumer becomes much easier and controllable. This system also helps in detecting power theft by measuring the data in real time. Thus, this smart meter helps in home automation using IoT and enabling wireless communication, which is an initiative towards digital India.

Problem Statement:

With a technical view, “power theft” is a non-ignorable crying that is highly prevalent, and at the same time, it directly affects the economy of a nation. Detecting and preventing such crimes with the help of the developing scientific field is the need of the hour.

TABLE OF CONTENTS

INTRODUCTION

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. These devices range from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, it is expected that this number will grow up-to 22 billion in coming years.

Over the past few years, IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects, kitchen appliances, cars, thermostats, baby monitors – to the internet via embedded devices, seamless communication is possible between people, processes and things.

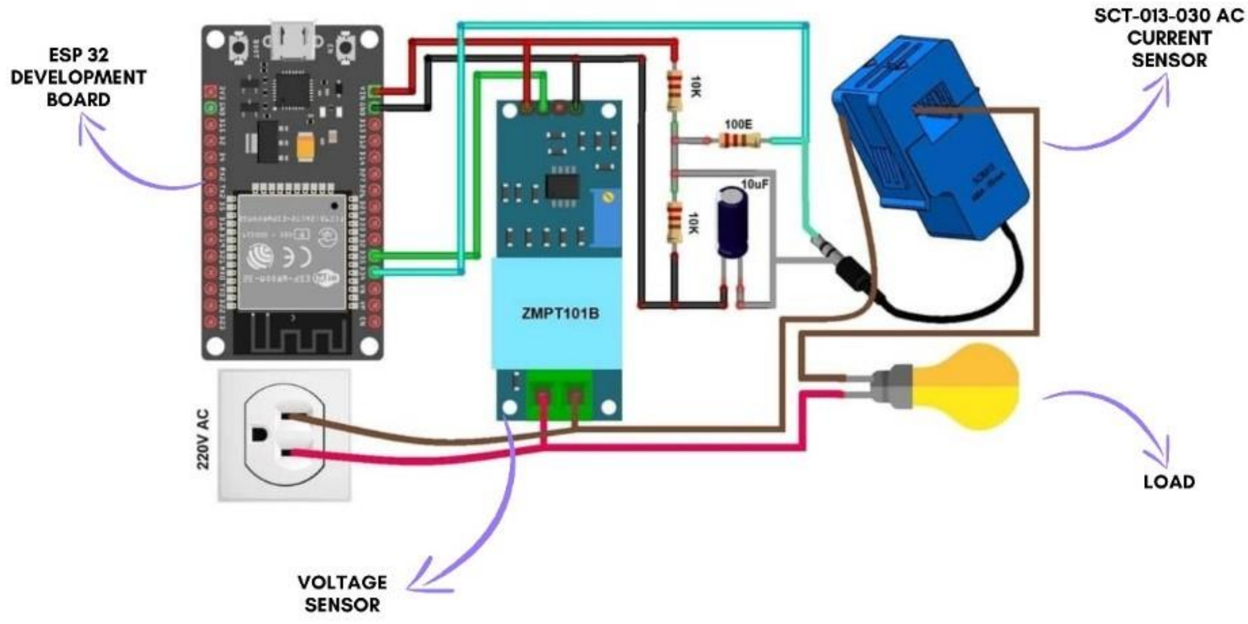
By means of low cost computing, the cloud, big data, analytics and mobile technologies, physical things can share and collect data with minimal human intervention. In this hyper-connected world, digital systems can record, monitor and adjust each interaction between connected things. The physical world meets digital world – and they co-operate.

An **Energy meter** is a device, which is used for measuring the energy utilized by the electric load. This energy is basically the total power consumed by the load at a particular interval of time. It is used in domestic and industrial AC circuits for measuring power consumption.

In this project, a smart electricity energy meter using ESP32 Wi-Fi module is made, which can monitor the energy usage anytime, and from anywhere in the world. This will help the use to detect any kind of energy loss as soon as possible and also, make the whole system more controllable.

Electricity thefts are increasing every year across domestic as well as industrial domains which affect the economic status of the country. Various wireless communication systems are available to detect the power theft, but lacks the required infrastructure needed to employ them. The project's aim is to design a system to monitor the power consumed by load and to detect and eliminate the power theft in energy meters.

DESCRIPTION OF PROJECT

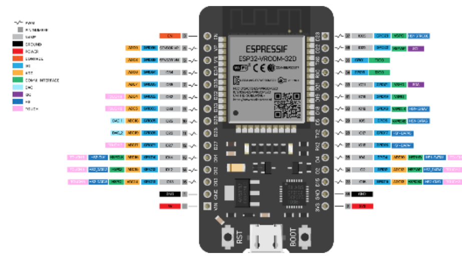


The smart energy meter monitoring system is shown in Fig. 1. The block diagram consists of 220V AC source, ESP32 module, ZMPT101B Voltage sensor and ACT013 current sensor. Blynk application has been used for monitoring of data.

Components used:

- **ESP32 Development Board**
- **ZMPT101B AC Single Phase Voltage Sensor**
- **SCT-013 Current Sensor**
- **10k Ω Resistors**
- **100Ω Resistor**
- **10μF Capacitor**
- **Bread Board**
- **Jumper Wires**
- **Bulb**
- **3-pin plug**

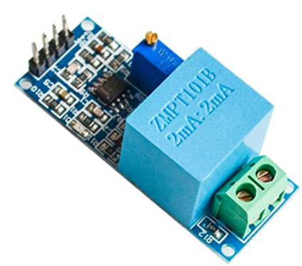
1. **ESP32 Development Board**



ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process.

- Processors:
    - Main processor: Tensilica Xtensa 32-bit LX6 microprocessor
        - Cores: 2 or 1 (depending on variation)
          All chips in the ESP32 series are dual-core except for ESP32-S0WD, which is single-core.
        - Clock frequency: up to 240 MHz
        - Performance: up to 600 DMIPS
- Ultra-low power co-processor: allows you to do ADC conversions, computation, and level thresholds while in deep sleep.
- Wireless connectivity:
    - Wi-Fi: 802.11 b/g/n/e/i (802.11n @ 2.4 GHz up to 150 Mbit/s)
    - Bluetooth: v4.2 BR/EDR and Bluetooth Low Energy (BLE)

2. **ZMPT101B AC Single Phase Voltage Sensor**



The ZMPT101B AC Single Phase voltage sensor module is based on a high precision ZMPT101B voltage Transformer used to measure the accurate AC voltage with a voltage transformer. This is an ideal choice to measure the AC voltage using Arduino or ESP32. The Modules can measure voltage within 250V AC voltage & the corresponding analog output can be adjusted. The module is simple to use and comes with a multi-turn trim potentiometer for adjusting and calibrating the ADC output.

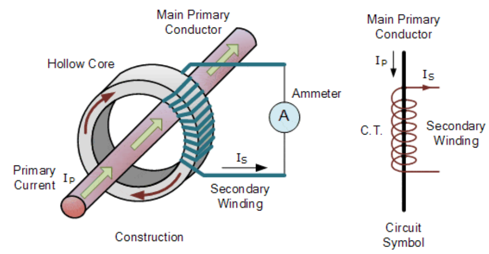
Specifications-

- *Voltage up to 250 volts can be measured*
- *Lightweight with on-board micro-precision voltage transformer*
- *High precision on-board op-amp circuit*
- *Operating temperature: 40ºC ~ + 70ºC*
- *Supply voltage 5 volts to 30 volts*

3. SCT-013 Current Sensor

The **SCT-013** is a Non-invasive AC Current Sensor Split Core Type Clamp Meter Sensor that can be used to measure **AC current** up to 100 amperes. Current transformers (CTs) are sensors are for measuring alternating current. They are particularly useful for measuring whole building electricity consumption. The SCT-013 current sensors can be clipped straight either to the **live** or **neutral wire** without having to do any high voltage electrical work.

Like any other transformer, a **current transformer** has a primary winding, a magnetic core, and a secondary winding. The secondary winding comprises many turns of fine wire housed within the casing of the transformer.



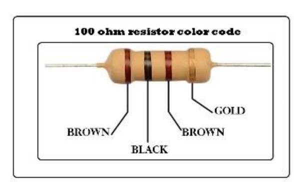
Specifications-

- *Input Current:* **0-30A AC**
- *Output Signal:* **DC 0-1 V**
- *Non-linearity:* **2-3 %**
- *Build-in sampling resistance (RL):* **62 Ω**
- *Turn Ratio:* **1800:1**
- *Resistance Grade:* **Grade B**
- *Work Temperature:* **-25 °C~+70 °C**
- *Dielectric Strength (between shell and output):* **1000 V AC / 1 min 5 mA**

4. 10k Ω Resistors

A resistor reduces (or resists) the flow of current. The value of the resistance is expressed as a number of ohms (the symbol Ω is used for "ohm"). The number of ohms is coded with a colour and appears as a band on the device itself. A 10k Ω resistor has a value of 10,000 ohms and the number code is 10,000.

5. 100 Ω Resistor

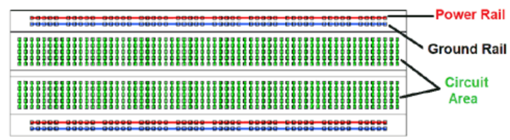


A resistor reduces (or resists) the flow of current. The value of the resistance is expressed as a number of ohms (the symbol Ω is used for "ohm"). The number of ohms is coded with a colour and appears as a band on the device itself. A 10k Ω resistor has a value of 10,000 ohms and the number code is 10,000.

6. **10μF Capacitor**

A capacitor is a device that stores electrical energy in an electric field. It is a passive electronic component with two terminals.
The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit. The capacitor was originally known as a condenser or condensator.

7. **Bread Board**



Bread Board Breadboard is a plastic board with a bunch of tiny holes and is used for building and testing circuits. It has holes on them which are connected internally in a particular pattern as shown in the below picture. The holes which are connected through green line represents they are connected internally. The Red line indicates Power, which is normally connected to the power rail. The Blue line indicates Ground, which is normally connected to the ground of the circuit.

8. **Jumper Wires**

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Though jumper wires come in a variety of colours, the colours don't actually mean anything. This means that a red jumper wire is technically the same as a black one. But the colours can be used to your advantage in order to differentiate between types of connections, such as ground or power.

9. **Incandescent bulb**

An incandescent light bulb, incandescent lamp or incandescent light globe is an electric light with a wire filament heated until it glows. The filament is enclosed in a glass bulb with a vacuum or inert gas to protect the filament from oxidation. Current is supplied to the filament by terminals or wires embedded in the glass. A bulb socket provides mechanical support and electrical connections.
Incandescent bulbs are manufactured in a wide range of sizes, light output, and voltage ratings, from 1.5 volts to about 300 volts. They require no external regulating equipment, have low manufacturing costs, and work equally well on either alternating current or direct current.

10. 3-pin Plug

AC power plugs and sockets connect electric equipment to the alternating current (AC) mains electricity power supply in buildings and at other sites. Electrical plugs and sockets differ from one another in voltage and current rating, shape, size, and connector type. Different standard systems of plugs and sockets are used around the world.

METHODOLOGY FOLLOWED

Both the Sensor, i.e., SCT-013 Current Sensor & ZMPT101B Voltage Sensor VCC is connected to **Vin** of ESP32 which is a **5V Supply**. The GND pin of both the modules is connected to the **GND** of ESP32. The output analog pin of the ZMPT101B Voltage Sensor is connected to **GPIO35** of ESP32. Similarly, the output analog pin of SCT-013 Current Sensor is connected to **GPIO34** of ESP32. You need a two resistor of **10K** & a single resistor of **100 ohms** connected along with a **10uF** Capacitor.

Apart from the circuit part, the AC wires where the current and voltage needs to measured are connected to the **input AC Terminal** of Voltage Sensor. Similarly, the **current sensor clip** doesn't have any connection and a single live wire or neutral wire is inserted inside the clip part as shown in the above circuit.

Energy meter measures the live current, voltage and power in terms of kWh when a load, i.e., Incandescent bulb is used. The microcontroller reads this parameter and sends this to the cloud. ESP32 is a Wi-Fi module which has a microcontroller in it. Blynk application is used to make a connection with the ESP32 module through IoT. The status of these parameters can be obtained through laptop or mobile. Wi-Fi module is used for data communication.

Setting Up Blynk Application-

Blynk is an application that runs over **Android** and **IOS** devices to **control any IoT based application** using Smartphones. It allows you to create your Graphical user interface for IoT application. Here we will display the IoT Energy Meter Data on Blynk Application.

a) So, download and install the **Blynk Application** from Google Play Store. IOS users can download from the App Store. Once the installation is completed, open the app & sign-up using the required Email id and Password.

b) From the dashboard create a new project and select ESP32 & WIFI Connection.

c) Then drag & drop or add 4 widgets and assign the variable as per code and then email the authentication code.

d) The user will get the authentication code in the mail. Copy this authentication code. This will be used in the code.

Required Library Installation-

1. EmonLib Library

The Emonlib Library is used for **Electricity Energy Meter**. EmonLib is a Continuous Monitoring of Electricity Energy repeats, every **5 or 10s**, a sequence of voltage and current measurements. EmonLib continuously measures in the background the voltage and all the current input channels, calculates a **true average quantity** for each and then informs the sketch that the measurements are available and should be read and processed.

2. Blynk Library

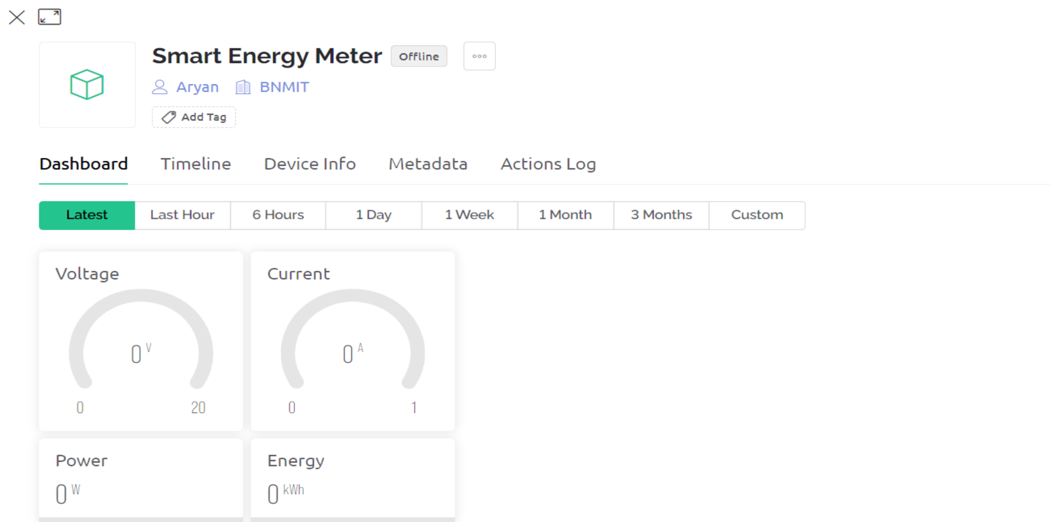
Blynk is the most popular **Internet of Things** platform for connecting any hardware to the cloud, designing apps to control them, and managing your deployed products at scale. With Blynk Library you can connect over 400 hardware models including A**rduino, ESP8266 & ESP32** to the **Blynk Cloud**.

Working-

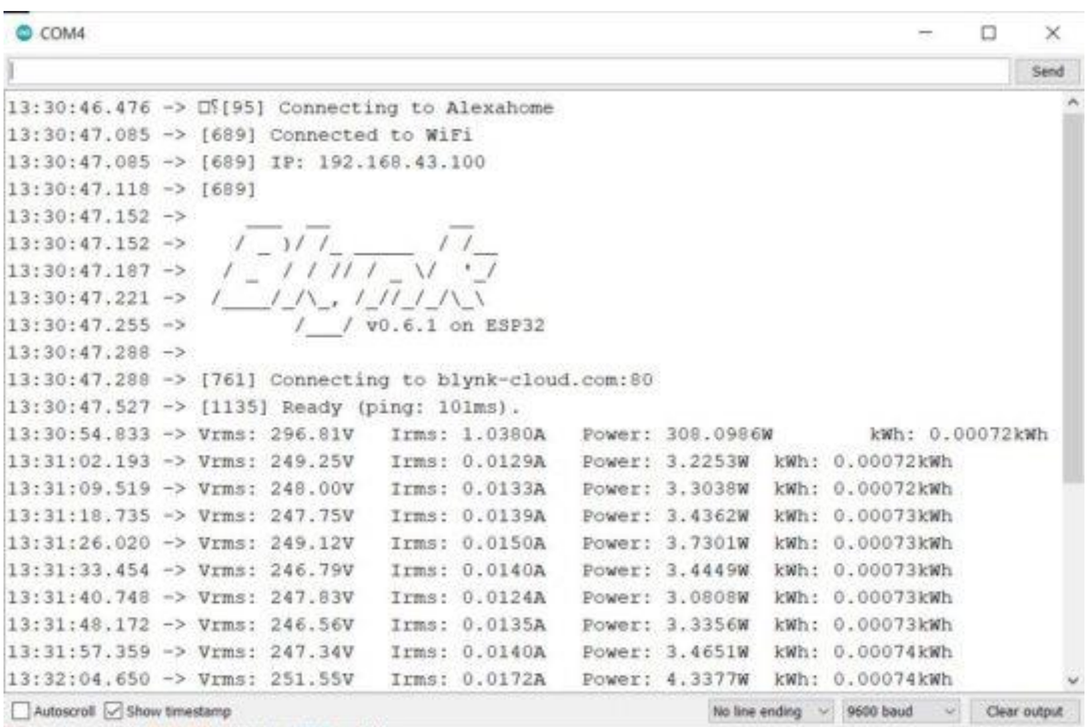
1. First, include the necessary libraries for ESP32 Board. EmonLib handles the retrieval of data from both sensors as well as the calculation for the RMS and power values. BlynkSimpleEsp32 integrates the program to the Blynk Mobile app.
2. The EnergyMonitor object emon is created &calibration factors are defined. The Blynk timer object is then created to handle the sending of data to the Blynk mobile app.
3. Then define the SSID & Password on our local WIFI network & insert the authentication code from the Blynk.
4. The milli & kWh values have to be initialized. The kWh starts at 0 and will slowly go up as time goes on.
5. The values from the sensors are being retrieved & calculated. Using *emon.calcVI(20, 2000),* the real power, apparent power, power factor, Vrms, and Irms are being calculated.
6. Then use *Blynk.virtualWrite* to send the data to Blynk based on the virtual pins set.
7. Under the setup function, initialize the Serial baud rate and set the current and voltage sensor analog pin as GPIO34 & GPIO35. Then set the timer to 5000L for an update time of 5 seconds.
8. Inside the loop function run the timer and Blynk.

RESULTS AND DISCUSSION

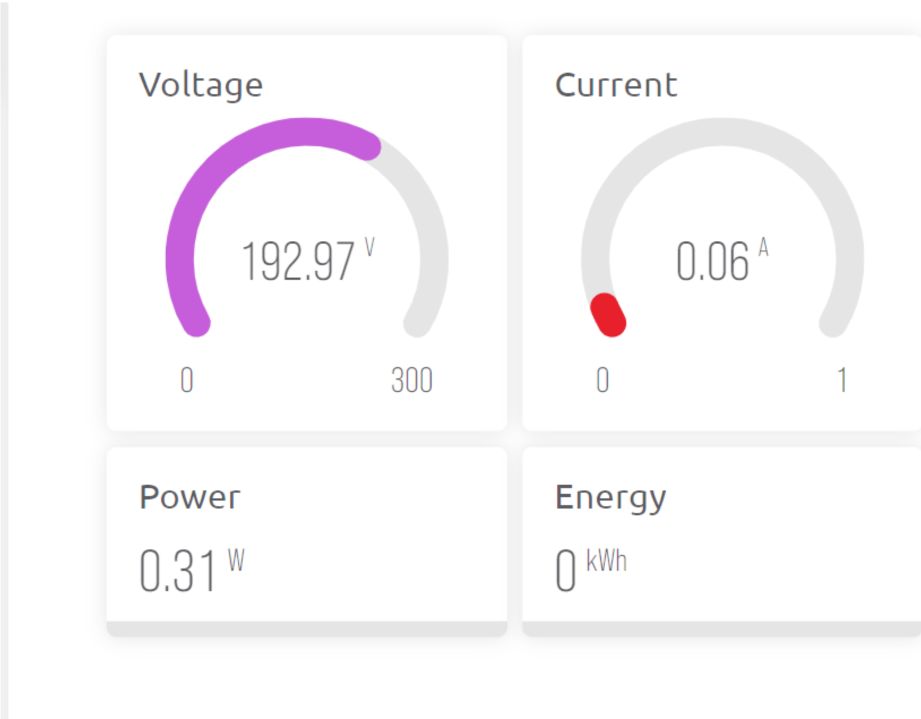
When the device is offline, the readings will be set at 0.

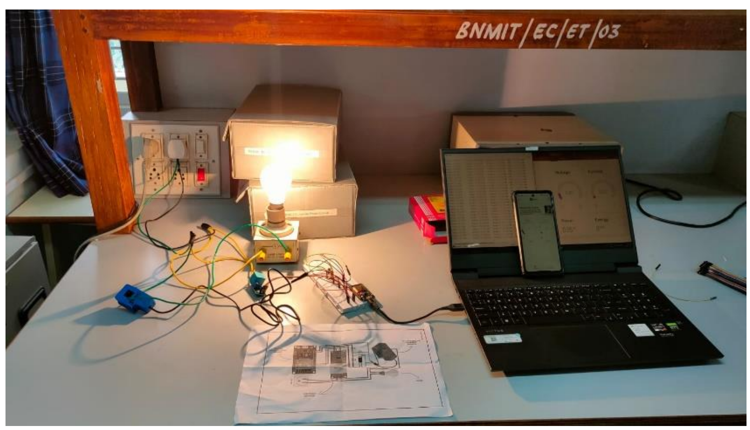


Once the device is made online, the energy meter data is uploaded to **Blynk Application** after the interval of every **5 seconds**. The data can be observed on Serial Monitor as well as Blynk Application.



The data is sent to the Blynk Application in real time.





Energy Monitoring using IOT is an application of internet of things developed to control home appliances remotely over the cloud from anywhere in the world. In the proposed project current sensor and voltage sensor are used to sense the current and voltage and display it on internet using IoT. The system updates the information in every 5 seconds on the internet using BLYNK app. In the present system, energy load consumption is accessed using Wi-Fi and it will help consumers to avoid unwanted use of electricity.

IoT system where a user can monitor energy consumption and pay the bill Online can be made. Also, a system where a user can receive SMS, when he/she crosses threshold of electricity usage slab can be equipped. A system can be made which can send SMS to the concerned meter reading man of that area when theft is detected at consumer end. Also using cloud analytics, future predictions of energy consumptions can be made.

CONCLUSION

This chapter projects the analysis and discussion of results and findings during and after the implementation of design. It describes in detail the final design perspective as well as highlighting the probable defects engulfing the project.
A preview to the entirety of this project establishes the essence and need for embedded systems towards technological advancement.

The IOT based Smart Energy Meter is the anti-theft detection system. Even if theft is caught, the victim cannot get back their valuable belongings. That is why it is clear that '**prevention is better than cure**'. It is easier to stop something happening in the first place than to repair the damage after it has happened. By using this technique, crime of stealing power may be brought to an end and thereby a new bloom may be expected in the economy of our motherland and also there will be less scarcity for power utilization.

Future Scope:

- Use of a GPS system to track exact location of power theft.
- Save the data reading continuously into a database.
- Use of multiple secondary modules at every customer for better accuracy.

REFERENCES

[1] *https://www.researchgate.net/publication/344357016_Internet_of_Things_Based_Electricity_Theft_Detection_Using_Raspberry_PI*

[2] *https://iopscience.iop.org/article/10.1088/1742-6596/1362/1/012027/meta*

[3] *https://www.ijert.org/research/smart-energy-meter-and-monitoring-system-using-iot-IJERTCONV8IS14011.pdf*

[4] *https://www.smart-energy.com/industry-sectors/energy-grid-management/energy-theft-and-fraud-reduction/*

[5] *https://how2electronics.com/iot-based-electricity-energy-meter-using-esp32-blynk/#Circuit_Diagram_038_Hardware_Setup*