A

Project Report

On

IoT Based Smart Energy Meter with Theft Alert Detection & Energy Consumption

Submitted in partial fulfillment for award of the degree of

Bachelor of Technology

In

Electronics and Communication Engineering

By

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STUDENT'S DECLARATION

We, **Mansi Joshi, Gaurav Dangwal, Sahil Singh Dasila, Vivek Suyal,** hereby declare the work, which is being presented in the project report entitled **'IoT Based Smart Energy Meter with Theft Alert Detection and Energy Consumption '** in partial fulfillment of the requirement for the award of the degree **Bachelor of Technology (B.Tech.)** in the session **2024-2025**, is an authentic record of our work carried out under the supervision of **Dr. Sandeep Sunori.**

The matter embodied in this project has not been submitted by us for the award of any other degree.

Date:

Mansi Joshi
Gaurav Dangwal
Sahil Singh Dasila
Vivek Suyal

CERTIFICATE

The project report entitled "**IoT Based Smart Energy Meter with Theft Alert Detection and Energy Consumption"** being submitted by **Mansi Joshi (2118766), Gaurav Dangwal(2162053), Vivek Suyal(2262001), Sahil Singh Dasila(2162057)** of B.Tech.(ECE) to Graphic Era Hill University Bhimtal Campus for the award of bonafide work carried out by them. They have worked under my guidance and supervision and fulfilled the requirement for the submission of a report.

Dr. Sandeep Sunori **(Project Guide)**

Dr. Sandeep Sunori **(HOD, ECE)**

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Finally, yet importantly, We would like to express our heartiest thanks to our beloved parents, for their moral support, affection, and blessings. We would also like to pay our sincere thanks to all our friends and well-wishers for their help and wishes for the successful completion of this research.

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ABSTRACT

Electrical power theft is a noteworthy issue in power framework organize everywhere throughout the world, which is unlawful and ought to be carefully precluded. Power theft can be characterized as the use of the electrical power with no agreement with the provider. So as to kill control theft, the area of intensity theft is to be known so suitable move will be made on the lawful offenders. In this framework we decrease the human cooperation in electrical energy support. The theft of the electricity expands the costs paid by client. Henceforth this framework is utilized for the discovery of theft.

The Arduino checks the fundamental meter and sub meter perusing. In the event that the distinction between the fundamental meter and sub meter is happened, at that point that theft has happened message will be show on the LCD show and furthermore getting message on telephone. Client can get message from wherever. By utilizing the purchaser number, it tends to be access on the globe at the whenever.

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LIST OF ABBREVIATIONS

Abbreviation	Full Form
IoT	Internet of Things
LDR	Light Dependent Resistor
LCD	Liquid Crystal Display
IDE	Integrated Development Environment
USB	Universal Serial Bus
SRAM	Static Random Access Memory
EEPROM	Electrically Erasable Programmable Read only Memory
SPI	Serial Peripheral Interface

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1. Prologue

In today's rapidly evolving technological landscape, energy management has become a critical concern across households, industries, and public utilities. With growing populations and increasing energy demands, issues like electricity theft, wastage, and inefficient monitoring continue to challenge energy providers and consumers alike.

Traditional energy meters offer limited capabilities—they require manual reading, provide no real-time feedback, and are unable to detect tampering or unauthorized usage. This gap has created an urgent need for smarter, more responsive solutions that align with the goals of digital transformation and smart infrastructure.

The IoT-Based Smart Energy Meter project is conceived as a solution to these challenges. It aims to transform the way energy is measured, monitored, and managed by introducing real-time data tracking, remote access, and theft detection capabilities using Internet of Things (IoT) technology.

This system not only empowers consumers to understand and control their power usage but also enables electricity providers to detect irregularities, respond quickly to theft attempts, and ensure more accurate billing. By integrating microcontroller technology with cloud-based platforms and mobile applications, the project presents a cost-effective and scalable approach to achieving smart energy management.Through this work, we take a step toward building transparent, efficient, and tamper-resistant energy systems that contribute to a more sustainable and accountable energy future.

1.2. Background and Motivation

In recent years, the increasing global demand for electricity and the rise of power-related issues—such as energy theft, inaccurate billing, and inefficient monitoring—have posed serious challenges to power distribution networks, especially in developing countries like India. Traditional energy meters are outdated, relying on manual readings that are not only time-consuming and prone to human error but also incapable of providing real-time usage data or detecting unauthorized access.

This lack of transparency often results in electricity theft going unnoticed, contributing to substantial financial losses for utility providers and leading to frequent load shedding and power disruptions. Furthermore, consumers remain unaware of their daily or hourly energy consumption, making it difficult to control or reduce their electricity usage. Motivated by these concerns, this project introduces a smart, IoT-enabled energy meter designed to automate consumption tracking, alert users and authorities about theft or tampering, and provide easy access to usage data via mobile apps or web dashboards. The integration of cost-effective hardware such as Arduino and ESP8266, combined with cloud platforms like ThingSpeak and Blynk, makes the system accessible, scalable, and suitable for both residential and commercial applications, ultimately supporting the development of intelligent, theft-resistant, and energy-efficient smart grids.

1.3. Problem Statement

The traditional energy metering systems used in many regions today are limited in functionality, offering no real-time monitoring, theft detection, or remote access. These systems rely heavily on manual meter reading, which is not only labor-intensive and time-consuming but also prone to human error and manipulation. One of the most critical issues **is** electricity theft, which often goes undetected and results in significant financial losses for utility providers and unfair billing for honest consumers. Additionally, consumers are typically unaware of their real-time energy consumption, receiving bills only once a month, which prevents them from managing or optimizing their usage effectively. There is a clear need for a smarter, more efficient, and tamper-resistant system that can address these shortcomings. Therefore, this project aims to design and develop an IoT-based smart energy meter capable of real-time energy tracking, theft alert detection, and cloud-based remote access, providing a reliable solution to improve transparency, reduce losses, and promote responsible energy consumption.

1.4. Objective

The objective of the project titled "IoT Based Smart Energy Meter with Theft Alert Detection & Energy Consumption" is to design and implement an intelligent energy monitoring system that can detect electricity theft in real time and provide remote monitoring capabilities using IoT.

- The objectives of proposed model are summarized below:

- Ease of accessing information for consumer from energy meter through loT.
- Theft detection at receiver end in real time.
- LCD displays energy consumption units
- Disconnection of service from remote server.
- Energy consumption on web server.

Proposed Smart energy meter surveillance using IoT about IoT, internet of things as an emerging field and IoT based devices have created a revolution in electronics and IT. The foremost objective of this project is to create awareness about energy consumption and. efficient use of home appliances for energy savings. Due to manual work, existing electricity billing system has major drawbacks. This system will give the information on meter reading, power cut when power consumption exceeds beyond the specified limit usingIoT. The Arduino esp8266 micro controller is programmed toper form the objectives with the help of GSM module. It is proposed to overcome all the disadvantages in the already existing energy meter. All the details are sent to the consumers mobile through the IoT and the GSM module and it is also displayed in the LCD. It is a time savings and it helps to eliminate the human interference using IoT.

These objectives aim to improve energy management, reduce theft-related losses, and automate billing and monitoring using IoT and Arduino-based technologies.

1.5. Scope of the Project

The scope of the IoT-Based Smart Energy Meter with Theft Alert Detection & Energy Consumption project extends across multiple domains, including electrical energy management, smart home automation, utility monitoring, and digital governance. The project is designed to offer a real-time, automated, and remotely accessible energy metering solution that not only tracks power consumption but also identifies instances of electricity theft—an issue that significantly impacts the economy and efficiency of power distribution systems, particularly in developing countries. Traditional energy meters fail to provide live data, rely on manual readings, and cannot detect tampering or power pilferage, leading to inaccurate billing and financial losses for utility providers. This smart meter overcomes such limitations by leveraging Internet of Things (IoT**)** technology, enabling continuous monitoring of energy usage, automatic updates to cloud servers, and theft alerts sent directly to users and electricity boards.

This project serves as a foundation for smart grid development, where data-driven energy systems can automatically respond to usage patterns, load variations, and unauthorized activities. It benefits both consumers and electricity providers: consumers gain access to their real-time consumption statistics through mobile apps or web dashboards, allowing them to make informed decisions about their electricity usage, optimize consumption, and reduce wastage; utility providers can remotely monitor thousands of meters, detect anomalies, generate accurate bills, and even disconnect services in case of consistent tampering or excessive usage beyond set thresholds.

In addition, the project is scalable and adaptable, making it suitable for a wide range of applications—from small households to large industrial plants. It also opens the door for integration with renewable energy systems such as solar power setups, where accurate tracking and monitoring are crucial. Furthermore, it supports government initiatives aimed at digital infrastructure development and smart city implementation by promoting transparent billing, reducing non-technical losses, and enhancing the reliability of power supply systems. As the system is built using low-cost components like Arduino UNO and ESP8266, it is not only economically feasible but also easy to maintain, upgrade, and replicate across larger areas.

Overall, this project contributes significantly to the modernization of electricity metering, offering a secure, transparent, and efficient energy management solution. It aligns with the future goals of energy conservation, sustainability, and automation, making it a valuable tool for shaping the next generation of smart energy infrastructure.

CHAPTER 2
SYSTEM COMPONENTS

2.1. Hardware Components

1. Arduino UNO : Microcontroller for control and data processing.

2. Energy Meters: Main and Sub meters for consumption monitoring.

3. ESP8266 Wi-Fi Module : Internet connectivity for IoT features.

4. LDR (Light Dependent Resistor): Theft/tamper detection via light sensitivity.

5. LCD Display (16x2) : To show energy usage and alert messages.

6. NPN Transistor: Used for signal amplification and switching purposes.

7. Keypad (4x4 matrix) : Used for user input if needed (like entering user ID or authentication).

2.2. Software Components

1. Arduino IDE : Writing and uploading code to the microcontroller.

2. Embedded C/C++ : Programming logic and condition checks.

3. ThingSpeak Platform : Online data visualization and cloud storage.

4. Blynk App : Mobile monitoring and alert notification system.

5. AT Commands : Communication with ESP8266 module.

2.3. Description about the Components:

2.3.1. Light Dependent Resistor : A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells.

They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a LDR, one of the most commonly used symbol is shown in the Fig. 2.1 below. The arrow indicates light falling on it.

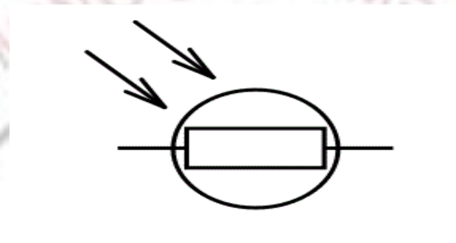

Fig. 2.1 LDR

Working Principle of LDR :-

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This is the most common working principle of LDR.

Applications of LDR :-

LDR**'s** have low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

2.3.2. Keypad :

The 4*4 matrix keypad usually is used as input in a project. It has 16 keys in total, which means the same input values.

The SunFouner 4*4 Matrix Keypad Module is a matrix non- encoded keypad consisting of 16 keys in parallel. The keys of each row and column are connected through the pins outside – pin Y1-Y4 as labeled beside control the rows, when X1-X4, the columns.

Working :

First test whether any key is pressed down. Connect power to rows, so they are High level. Then set all the rows Y1-Y4 as Low and then detect the status of the columns. Any column of Low indicates there is key pressing and that the key is among the 4 keys of the column. If all columns are High it means no key is pressed down.

Next, locate the key. Since the column in which the pressed key lies is identified, knowing the line would finalize the testing. Thus, set the rows as Low in turns until any is unveiled accordingly – other rows will still be High.

Now the row can be identified. Detect the status of each column in turns. The column tested Low is the one intersecting with the line – their cross point is just the key pressed. The schmatic diagram is shown in the Fig. 2.2 below

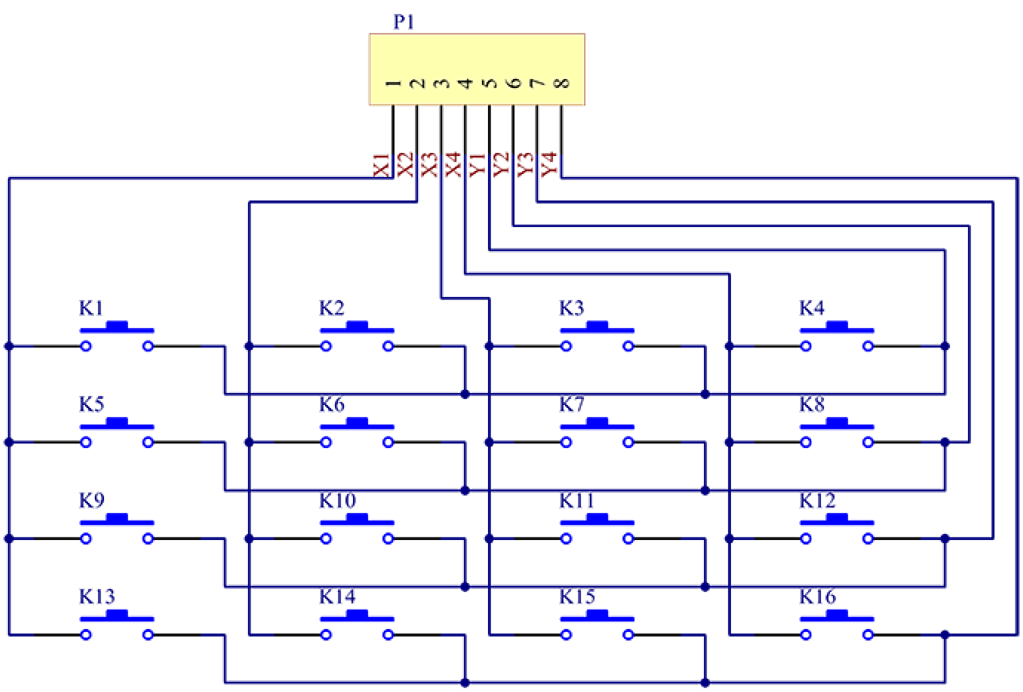

Fig. 2.2 Working of Keypad

2.3.3. Microcontroller:

It is a micro-computer. As any computer it has internal CPU, RAM, IOs interface. It is used for control purposes, and for data analysis.

Famous microcontroller manufacturers are MicroChip, Atmel, Intel, Analog devices, and more.

2.3.4. NPN Transistor:

NPN Transistor is a type of transistor that uses both electron and hole charge carriers. In contrast, unipolar transistors, such as field-effect transistors, only use one kind of charge carrier. NPN is one of the two types of bipolar transistors, consisting of a layer of P-doped semiconductor (the "base") between two N-doped layers. A small current entering the base is amplified to produce a large collector and emitter current.

NPN Transistor operations :

A forward-biased pn- junction is comparable to a low-resistance circuit element because it passes a high current for a given voltage. In turn, a reverse-biased pn- junction is comparable to a high-resistance circuit element. By using the Ohm's law formula for power ($P = I^2 \cdot R$) and assuming current is held constant, you can conclude that the power developed across a high resistance is greater than that developed across a low resistance. The Fig. 2.3. shows NPN transistor

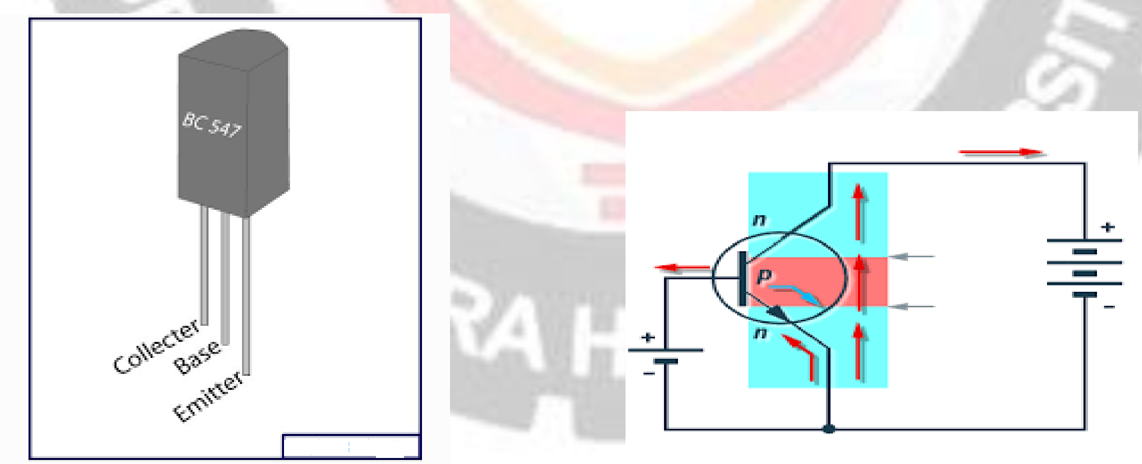

Fig . 2.3 NPN transistor

Thus, if a crystal were to contain two pn- junctions (one forward-biased and the other reverse-biased), a low-power signal could be injected into the forward-biased junction and produce a high-power signal at the reverse-biased junction. In this manner, a power gain would be obtained across the crystal. This concept, which is merely an extension of the material covered in the previous topics, is the basic theory behind how the transistor amplifies. With this information fresh in your mind, let's proceed directly to the npn transistor.

2.3.5. Arduino UNO:

The Arduino Uno is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one.

Specifications:

Microcontroller	Atmel ATmega168 or ATmega328
Operating Voltage (logic level)	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limits)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	8
DC Current per I/O Pin	40 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz
Dimensions	0.73" x 1.70"
Length	45 mm
Width	18 mm
Weigth	5 g

2.3.6. Power: The Arduino Uno can be powered via the Mini-B USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

2.3.7. Memory: The ATmega168 has 16 KB of flash memory for storing code (of which 2 KB is used for the bootloader); the ATmega328 has 32 KB, (also with 2 KB used for the bootloader). The ATmega168 has 1 KB of SRAM and 512 bytes of EEPROM (which can be read and written with the EEPROM Librrary); the ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

2.3.8. Communication: The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega168 and ATmega328 provide UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An FTDI FT232RL on the board channels this serial communication over USB and the FTDI driver(included with the Arduino software) provide a virtual com port to software on the computer. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the FTDI chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
A Software Serial libray allows for serial communication on any of the Nano's digital pins.

The ATmega168 and ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation for details. To use the SPI communication, please see the ATmega168 or ATmega328 datasheet.

2.3.9. Programming: The Arduino unocan be programmed with the Arduino software . Select "Arduino Diecimila, Duemilanove, or Nano w/ ATmega168" or "Arduino Duemilanove or Nano w/ ATmega328" from the **Tools > Board** menu (according to the microcontroller on your board).

The ATmega168 or ATmega328 on the Arduino Uno comes preburned with a Bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header using Arduino ISP or similar.

2.3.10. Arduino NANO Pin Layout:

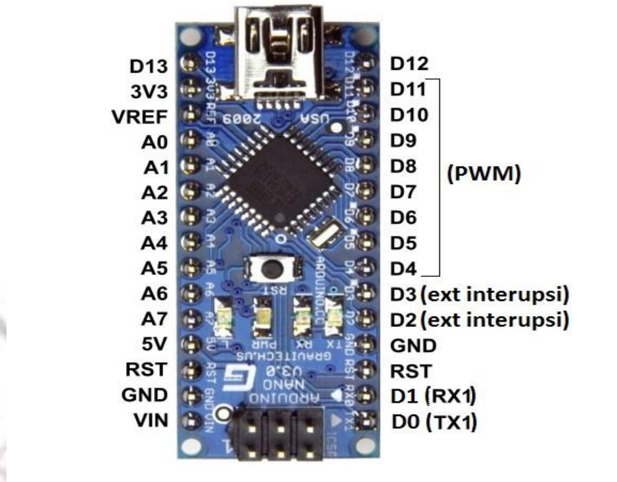

Fig. 2.4 Arduino Pin Layout

Pin No.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3, 28	RESET	Input	Reset (active low)
4, 29	GND	PWR	Supply ground
17	3V3	Output	+3.3V output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or Input	+5V output (from on-board regulator) or +5V (input from external power supply)
30	VIN	PWR	Supply voltage

Table describing Arduino Pins

2.3.11. LCD 16x2 :

(LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals.

- Liquid crystals do not emit light directly.
- 16x2 LCD has 2 horizontal line which comprising a space of 16 displaying character.

It has two type of register inbuilt that is

- Command Register
- Data Register
- Command register is used to insert a special command into the LCD.
- While Data register is used to insert a data into the LCD.
- Command is a special set of data which is used to give the internal command to LCD like Clear screen, move to line 1 character 1, setting up the cursor etc

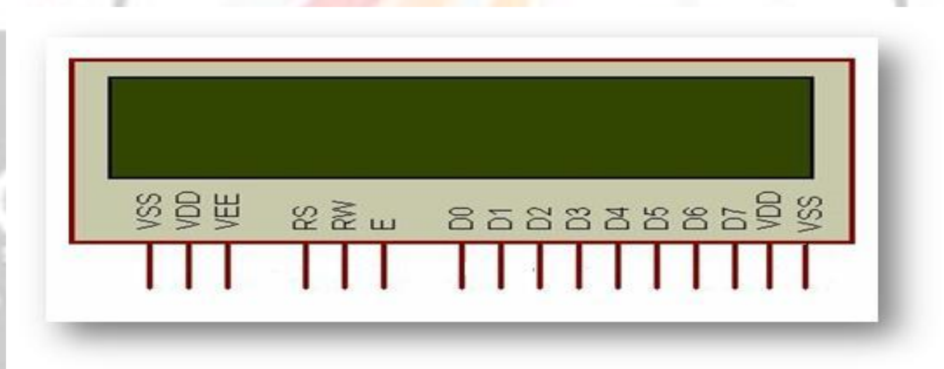

Fig. 2.5 Pin Diagram of 16x2 LCD

Sr. No	Pin No.	Pin Description
1	Pin 1 (GND)	This is a ground pin to apply a ground to LCD.
2	Pin 2 (VCC)	This is the supply voltage pin to apply voltage to LCD.
3	Pin 3 (VEE)	This is the pin for adjusting a contrast of the LCD display by attaching a veriable resistor in between VCC and GND.
4	Pin 4 (RS)	RS stands for Register Select. This pin is used to select command/data register. If RS=0 then command register is selected. If RS=1 then data register is selected.
5	Pin 5 (R/W)	R/W stands for Read/Write. This pin is used to select the operation Read/Write. If R/W=0 then Write operation is performed. If R/W=1 then Read operation is performed.
6	Pin 6 (EN)	En stand for Enable signal. A positive going pulse on this pin will perform a read/write function to the LCD.
7	Pin 7-14 (DB0-DB7)	This 8 pin is used as a Data pin of LCD.
8	Pin 15 (LED+)	This pin is used with pin 16(LED-) to setting up the illumination of back light of LCD. This pin is connected with VCC.
9	Pin 16 (LEC-)	This pin is used with pin 15(LED+) to setting up the illumination of back light of LCD. This pin is connected with GND.

Table describing LCD Pins

2.3.12. ESP8266:

The ESP8266 module enables microcontrollers to connect to 2.4 GHz Wi-Fi, using IEEE 802.11 bgn. It can be used with ESP-AT firmware to provide Wi-Fi connectivity to external host MCUs, or it can be used as a self-sufficient MCU by running an RTOS-based SDK. The ESP8266 arduino compatible module is a low-cost Wi-Fi chip with full TCP/IP capability, and the amazing thing is that this little board has a MCU (Micro Controller Unit) integrated which gives the possibility to control I/O digital pins via simple and almost pseudo-code like programming language.

CHAPTER 3
DESIGN

3.1. SYSTEM DESIGN

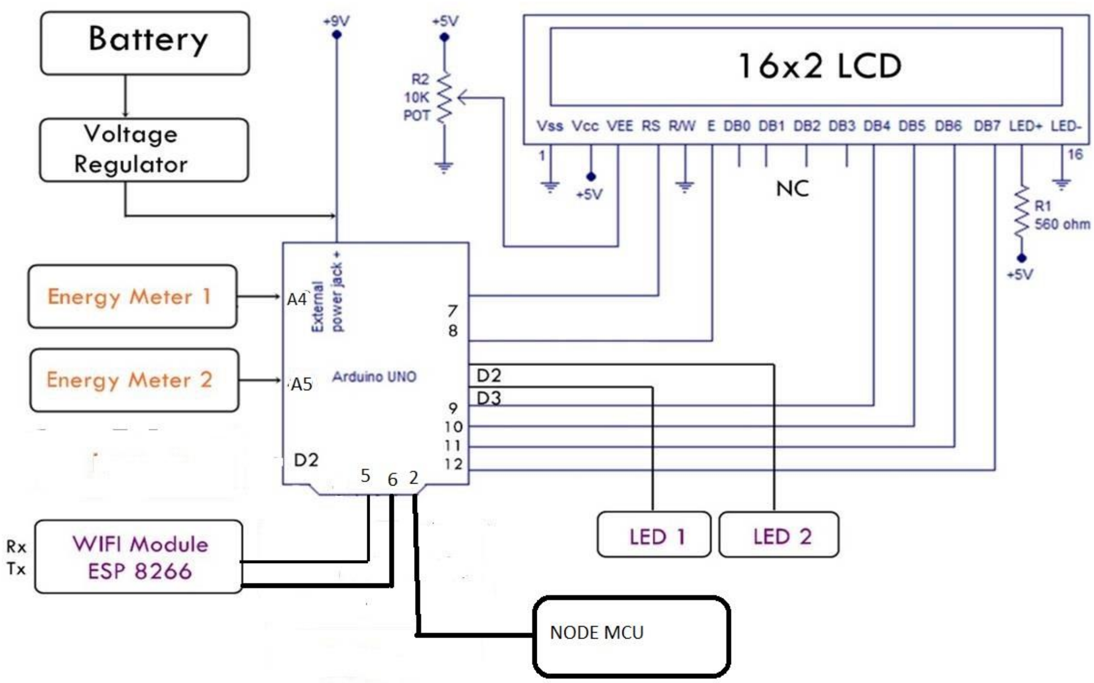

Fig. 3.1 Block Diagram

The design of the IoT-Based Smart Energy Meter with Theft Alert Detection revolves around integrating low-cost microcontroller technology with real-time sensing, data processing, and wireless communication capabilities shown in Fig. 3.1. At the core of the system is an **Arduino UNO** microcontroller, which reads data from two energy meters—one placed at the source (main meter) and the other at the consumer end (sub-meter). These readings are continuously monitored and compared to detect discrepancies that may indicate electricity theft. An **LDR sensor** is included to detect physical tampering by sensing sudden light exposure inside a normally closed meter box. The system uses a **16x2 LCD display** to show local readings and alerts. For connectivity, an **ESP8266 Wi-Fi module** transmits the data to cloud platforms such as **ThingSpeak** or **Blynk**, enabling remote access and real-time monitoring from anywhere in the world. The design also allows for the integration of a **relay circuit** to remotely disconnect the power supply in case of detected theft. This modular and scalable setup ensures ease of deployment in both residential and commercial environments, offering a practical and intelligent solution for energy monitoring and theft prevention.

The above diagram in Fig. 3.1 shows the circuit diagram. The post number gives us with the area of the theft of intensity. The framework will arrange and shape a factual information for observing voltage levels in territory where theft is occurring for a timeframe, the experts can intently screen the region and lead a review to discover where control theft happens. We will think about the sending end and getting end voltage levels, see request of burden on the off chance that the thing that matters is more than allowed esteem, at that point a nearby check must be planned to investigate unexpected ascent of intensity request. The experts can utilize this to discover the locales where there is truly ascend in power utilization and where control theft is occurring.

CHAPTER 4
IMPLEMENTATION AND METHODOLOGY

This section provides a unified view of both the methodology (step-by-step approach) and the implementation (practical execution) of the smart energy meter system. It highlights how the concept was turned into a working prototype using microcontrollers, sensors, and IoT technologies.

4.1. System Planning and Objective Setup

- **Goal :** To create a smart energy meter that detects electricity theft in real time, monitors energy consumption, and provides data remotely using IoT.
- **Method** : Divide the system into sensing, processing, detecting, alerting, and remote monitoring stages.

4.2. Hardware Design And Assembly

Components Used:

- **Arduino UNO** : Core controller that manages sensor data and decision logic.
- **Main & Sub Ennergy Meters** : Measure power usage from input and output points.
- **LDR Sensor:** Detects tampering or unauthorized meter access.
- **ESP8266 Wi-Fi Module:** Sends data to cloud platforms (ThingSpeak, Blynk).
- **LCD Display:** Displays units used and theft alerts in real-time.
- **Relay Module (optional):** Cuts off power in case of theft.
- **Power Supply Unit:** Regulates voltage for all components.

Wiring and Integration:

- Energy meters connected to analog or digital pins of Arduino, as shown in Fig. 4.1.
- LDR wired with a voltage divider to detect light changes.
- ESP8266 connected to Tx/Rx pins for Wi-Fi communication.
- LCD connected to digital pins for local data display.

The Fig. 4.1 shows the prototype of the project.

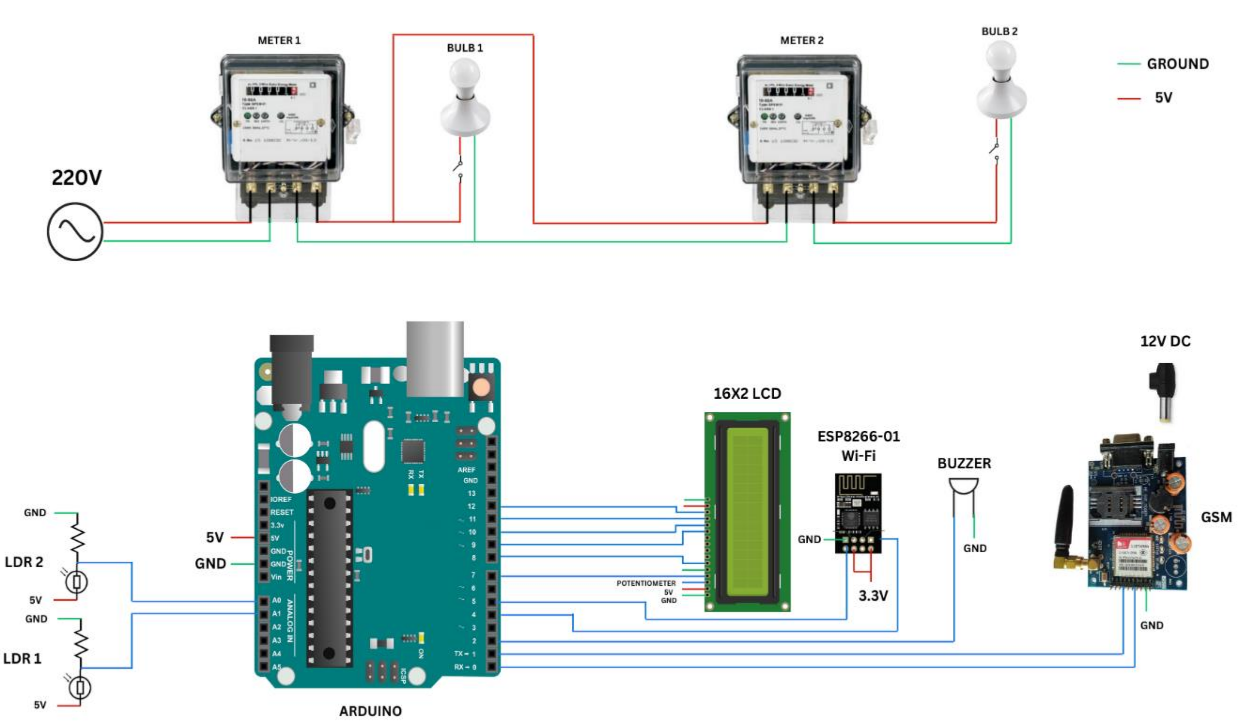

Fig. 4.1 Block Diagram

4.3. Data Acquisition & Processing (Logic Implementation)

- The Arduino continuously reads values from both main and sub meters.
- It also monitors the LDR sensor for any unexpected light presence (e.g., meter box opened).
- The controller compares readings : If sub meter reading exceeds the main meter by a threshold → Theft is detected.
- This detection logic is programmed using **Embedded C** in the Arduino IDE.

4.4. Iot Integration And Real-Time Monitoring

- The ESP8266 connects to Wi-Fi using AT commands.
- Real-time data (units used, theft alerts) is:
  - Sent to **ThingSpeak** (for web dashboards and charts).
  - Displayed on **Blynk App** (mobile notifications).
- Periodic uploads (e.g., every 10–15 seconds) ensure updated consumption data.

4.5. Theft Alert And Control Response

- Upon detecting theft:
  - **LCD** shows "Theft Detected"
  - **Blynk** or **ThingSpeak** logs the alert
  - Optional **relay** cuts power supply to prevent further misuse
  - A **buzzer** or **LED** may also be triggered for physical alert

4.6. Output Visualization And User Access

- **LCD Display:** Shows current readings and alerts locally.
- **ThingSpeak Dashboard:** Provides real-time graphs and data logs as shown in Fig 4.2
- **Mobile App (Blynk):** Allows consumers to view usage remotely and receive alerts.

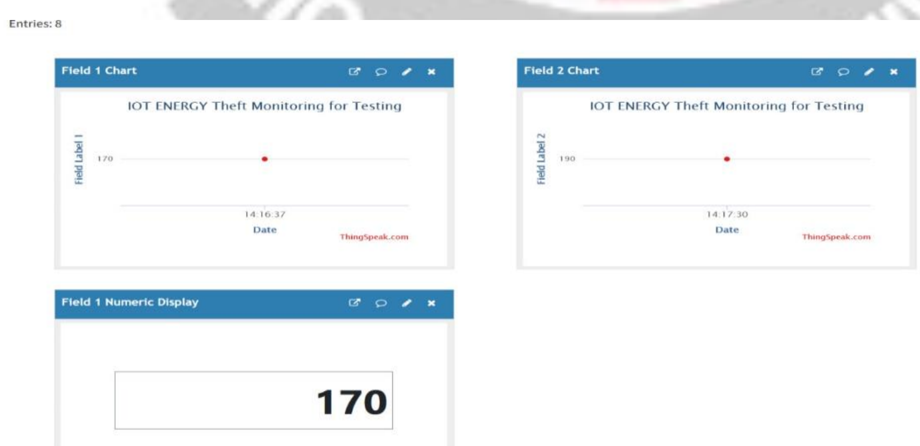

Fig. 4.2 User Interface

4.7. Continuous Monitoring And Feedback

- System loops through reading and detection continuously.
- Provides constant monitoring and updates every few seconds.
- The server stores and displays historical data for analysis.

The Fig. 4.3 shows the final image of the project.

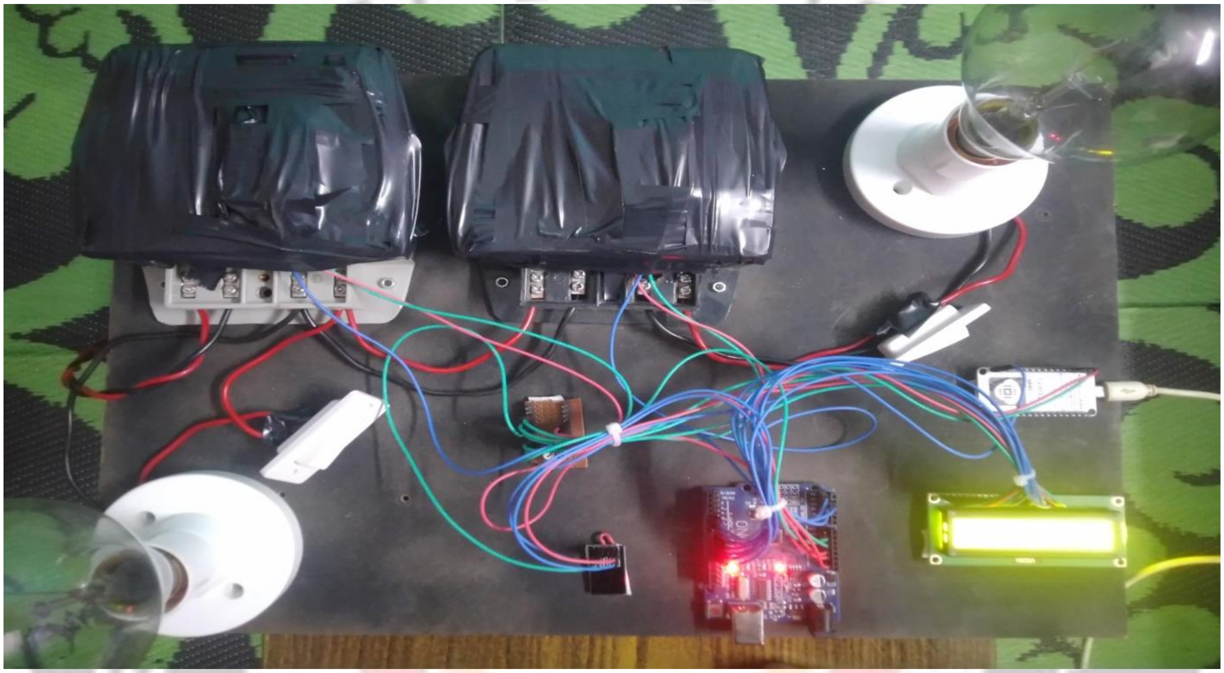

Fig. 4.3 Project Image

CHAPTER 5

CODING OF FUNCTIONS

```
#include<LiquidCrystal.h>
LiquidCrystal lcd(7,8,9,10,11,12);
#include <SoftwareSerial.h>
long  t2=0;
SoftwareSerial ser(5, 6); // RX, TX
String stri;
char buf1[16];
// replace with your channel's thingspeak API key
String apiKey = "9LVQAFNWN6CQHPSN";
int sem1=0;
int count3=0;
int i=0;
int sem=0;
int count =0;
int count1 =0;
int count2 =0;
int count12 =0;
long measurementStartTime = 0;

void setup(){
  Serial.begin(9600);
  lcd.begin(16,2);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Energy Meter ");
  delay(3000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Testing theft");
  lcd.setCursor(0,1);
  lcd.print("C1:");
  pinMode(A3, OUTPUT);
  digitalWrite(A3, LOW);
   pinMode(A2, OUTPUT);
   digitalWrite(A2, LOW);
   analogReference(DEFAULT);
   // enable software serial
  ser.begin(115200);
// reset ESP8266
  ser.println("AT+RST");
```

```
  delay(500);
 ser.println("AT+CWMODE=3");
  delay(500);
 ser.println("AT+CWJAP=\"project\",\"12345678\"");
 delay(500);
}
void loop(){
//Serial.println(analogRead(A5));
 if((analogRead(A4) > 500) && (sem == 0))
{
 sem = 1;
 count++;
 //Serial.println(count1);
}
lcd.setCursor(4,1);

 lcd.print(count);
if((analogRead(A4) <= 500) && (sem == 1))
{
 sem = 0;

}
if((analogRead(A5) > 500) && (sem1 == 0))
{
 sem1 = 1;
 count2++;
 //Serial.println(count2);
}
lcd.setCursor(10,1);
lcd.print("C2:");
     lcd.print(count2);
if((analogRead(A5) <= 500) && (sem1 == 1))
{
 sem1 = 0;
}
 if (millis() - measurementStartTime >= 10000)  //time is up
  {
     Serial.println("10secs");
    measurementStartTime = millis();
    if(count2 >= (count+3))
    {
   Serial.println("Theft detected");
    digitalWrite(A2, HIGH);
    digitalWrite(A3, HIGH); //notif
   delay(1000);
```

```
  digitalWrite(A3, LOW);
    digitalWrite(A2, LOW);
    }
  //count2=0;
  //count1=0;
  }
stri = dtostrf(count, 4, 1, buf1);
  // Serial.print(stri);
//  Serial.println(" ");
    if(millis() - t2>15000)
 {
   t2=millis();
  // TCP connection
 String cmd1 = "AT+CIPSTART=\"TCP\",\"";
 cmd1 += "184.106.153.149"; // api.thingspeak.com
 cmd1 += "\",80";
 ser.println(cmd1);
 if(ser.find("Error")){
   //Serial.println("AT+CIPSTART error");
   return;
 }
 // prepare GET string
 String getStr1 = "GET /update?api_key=";
 getStr1 += apiKey;
 getStr1 +="&field1=";
 getStr1 += String(stri);
 getStr1 += "\r\n\r\n";
// send data length
 cmd1 = "AT+CIPSEND=";
 cmd1 += String(getStr1.length());
 ser.println(cmd1);
  if(ser.find(">")){
   ser.print(getStr1);
 }
  else{
   ser.println("AT+CIPCLOSE");
   // alert user
   Serial.println("AT+CIPCLOSE");
 }
 }
```

CHAPTER 6

TESTING AND ANALYSIS

6.1. Testing

To ensure the reliability and effectiveness of the system, various testing and validation procedures were performed:

6.1.1. Functional Testing

- Verified correct reading and comparison of data from both the main and sub energy meters.
- Checked if the system detects electricity theft when a mismatch is introduced.
- Confirmed that alerts are generated and displayed on the LCD upon detection.

6.1.2. Connectivity Testing

- Ensured stable connection of the ESP8266 Wi-Fi module to the internet.
- Verified data transfer to **ThingSpeak** or **Blynk app** via AT commands.
- Monitored latency and update frequency of data uploads.

6.1.3. Temper Detection Testing

- Simulated physical tampering using LDR by opening the meter box; confirmed theft alert was triggered and displayed.

6.1.4. Relay and Control Testing (Optional)

- Validated automatic relay cut-off in response to theft detection.
- Tested manual control of energy supply through remote server logic.

6.1.5. User Interface Testing

- Checked real-time display on the 16x2 LCD.
- Verified correct rendering of data and alerts on web dashboard and mobile app.

6.2. Analysis Summary

- The system was tested under various theft and tampering scenarios and performed reliably.
- Data was accurately uploaded to cloud platforms and accessible in real-time.
- The design is responsive, cost-efficient, and well-suited for both small-scale and large-scale deployment.
- Overall, the system met all the **functional, performance, and usability requirements** successfully.

CHAPTER 7
LIMITATIONS

While the IoT-Based Smart Energy Meter with Theft Alert Detection offers many advantages, there are some limitations to consider:

- **Dependence on Internet Connectivity :** The system relies heavily on a stable Wi-Fi connection for real-time data transmission. In areas with poor internet, its functionality is limited.
- **Limited Range of Wi-Fi Module :** The ESP8266 module has a limited range, which may not be suitable for large industrial areas or remote meter locations.
- **No Backup Power Supply :** If there is a power outage, the system becomes non-functional unless integrated with a battery backup or UPS.
- **Installation Complexity :** Setting up sensors, calibrating the meters, and integrating with IoT platforms requires technical knowledge, which may not be feasible for all users.
- **Accuracy of Sensors:** Low-cost sensors may not provide high-precision readings, especially over time without regular calibration.
- **Limited User Interface :** The current interface (via LCD and basic web dashboard) lacks rich visualizations, interactive features, or user customization options.
- **Mobile Platform Dependency :** If users rely on third-party apps (like Blynk) without a dedicated mobile app, features may be limited or dependent on external service availability.

CHAPTER 8
APPLICATIONS AND FUTURE ENHANCEMENTS

8.1. APPLICATIONS

1.Smart homes and Smart Cities.

2 **Industrial Monitoring** : Tracks energy usage in factories or plants and ensures operational efficiency

3. **Billing Automation** : Enables automatic, accurate billing based on real-time usage, eliminating manual errors.

4. Useful where physical access for meter reading is difficult, data can be accessed remotely.

8.2. FUTURE ENHANCEMENTS

- **Mobile App with User Dashboard :** A dedicated Android/iOS app for consumers to track usage history, receive alerts, and manage accounts.
- **SMS Alerts and Notifications :** Send SMS to users when consumption exceeds a preset limit or when theft is detected.
- **Solar Power Integration :** Monitor usage and theft in solar panel installations and hybrid energy systems..
- **Battery Backup :** Add an uninterrupted power supply (UPS) to ensure data logging continues during outages.
- **Enhanced Security Protocols :** Implement data encryption and authentication to prevent hacking or tampering with readings.

CONCLUSION

The project "IoT Based Smart Energy Meter with Theft Alert Detection & Energy Consumption" successfully demonstrates an efficient, modern solution to monitor electrical energy usage and detect power theft in real time. By integrating Arduino with IoT technologies like ESP8266, and platforms such as ThingSpeak and Blynk, the system ensures seamless data transmission, online monitoring, and automated theft detection.

This smart meter setup not only reduces manual labor and billing errors but also helps utility providers monitor consumption patterns, identify theft instantly, and remotely disconnect power in case of unauthorized usage. Consumers also benefit by being able to track their own energy usage live, promoting energy efficiency and awareness.

Overall, this project offers a cost-effective, scalable, and user-friendly approach to enhance transparency and security in energy distribution systems. With further enhancements such as mobile app alerts, automated billing, and AI-based analytics, this system can be a strong step toward smart grid implementation and energy conservation in the future.

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