



Power Theft identifier Using GSM and Arduino.

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ABSTRACT

Electricity theft is one of the most significant problems faced by power distribution companies, leading to substantial financial losses, reduced efficiency, voltage instability, and overloading of distribution networks. Unauthorized tapping, illegal connections, and meter bypassing not only affect revenue generation but also compromise system reliability and public safety. To address this issue, an efficient, low-cost, and automated monitoring solution is required.

The **Power Theft Identifier Using GSM & Arduino** is a microcontroller-based embedded system designed to detect illegal power consumption by continuously comparing the source current and load current in a distribution line. The system utilizes an **Arduino Nano** as the central processing unit, two ACS712-5A current sensors for measuring source and load currents, and a SIM800L GSM module for real-time communication.

The proposed system works on the principle that under normal operating conditions, the current entering the line (source current) should be approximately equal to the current consumed by the authorized load (load current). If there is a significant difference between these two values beyond a predefined threshold, the system identifies it as potential power theft. Upon detection, the Arduino activates a buzzer for local alert, displays a warning message on a 16×2 LCD, and sends an SMS notification containing meter details and current readings to the concerned authority via GSM network.

The implementation is cost-effective, compact, and suitable for domestic and small-scale industrial

applications. It eliminates the need for manual inspection and enables real-time monitoring with immediate response capability. This project demonstrates how embedded systems and wireless communication technologies can be integrated effectively to enhance power distribution monitoring and reduce electricity theft.

INTRODUCTION

Electricity theft is a major issue that leads to huge financial losses for power distribution companies and affects the stability of the electrical system. To address this problem, a Power Theft Identification System using GSM and Arduino is designed to detect unauthorized usage of electricity in real-time.

This system uses an Arduino microcontroller to continuously monitor the current or power consumption. By comparing the input and output values (or expected vs actual consumption), it can identify any abnormal difference that indicates power theft. When such a condition is detected, the system automatically sends an alert message using a GSM module to the concerned authority or user.

The use of GSM technology allows remote monitoring and instant communication, making the system efficient and reliable. This project is cost-effective, easy to implement, and helps in reducing electricity losses by enabling quick detection and action against power theft.

Need for the Project

Power distribution companies suffer heavy revenue losses due to non-technical losses, especially theft. Manual monitoring cannot detect theft in real time. Therefore, there is a need for a system that:

- Continuously monitors current flow

- Detects abnormal differences automatically
- Provides immediate alert notification
- Reduces dependency on manual inspection
- Is low-cost and easy to implement

The **Power Theft Identifier Using GSM & Arduino** addresses this need by combining current sensing technology with microcontroller-based processing and GSM communication.

Objective of the Project

The main objectives of this project are:

1. To design and implement a power theft detection system using Arduino Nano.
2. To measure source and load current using ACS712 current sensors.
3. To compare both currents and identify mismatches beyond a threshold value.
4. To activate an audible alarm (buzzer) during theft detection.
5. To display real-time system status on a 16×2 LCD.
6. To send SMS alerts using GSM technology when theft occurs.

Scope of the Project

This project is suitable for:

- Domestic electrical systems
- Small commercial establishments
- Educational demonstration purposes
- Small-scale distribution monitoring

It is designed as a prototype model and can be further expanded for large-scale smart grid implementation.

Overview of System Components in Introduction Context

The system integrates the following major components:

- **Arduino Nano** – Central processing unit
- **Two ACS712 Current Sensors** – For source and load measurement
- **SIM800L GSM Module** – For remote SMS alert
- **16×2 LCD Display** – For real-time monitoring
- **Buzzer** – Audible warning system

By integrating sensing, processing, display, and communication technologies, the system provides a simple yet effective approach to theft detection.

Significance of the Project

The importance of this project lies in:

- Reducing electricity theft
- Minimizing revenue losses
- Improving power system reliability
- Enabling real-time monitoring
- Demonstrating embedded system applications in power engineering

This project bridges the gap between electrical power systems and embedded electronics, showing how microcontrollers and GSM communication can be effectively used in practical utility applications.

Traditional Methods of Power Theft Detection

Earlier methods for detecting electricity theft primarily relied on:

- Manual meter reading
- Field inspection teams
- Energy auditing
- Comparison of feeder and consumer consumption

In manual inspection, utility personnel physically check meters and distribution lines to identify illegal tapping. Although effective in some cases, this approach has several drawbacks:

- High operational cost
- Human error
- Limited monitoring coverage
- No real-time detection
- Delayed response

Energy auditing compares total energy supplied to a feeder with the sum of billed energy consumption. If significant losses are detected, inspections are conducted. However, this method cannot pinpoint the exact location of theft.

Smart Meter Based Approaches

With the advancement of digital electronics, smart meters were introduced to replace conventional electromechanical meters. Smart meters offer:

- Digital measurement
- Remote data logging
- Tamper detection
- Two-way communication

Smart meters often use communication technologies such as:

- GSM

- GPRS
- Zigbee
- RF modules
- PLC (Power Line Communication)

Although smart metering systems are highly accurate and efficient, they are:

- Expensive
- Complex to implement
- Suitable mainly for large-scale deployments
- Not ideal for low-cost academic or prototype projects

GSM-Based Theft Detection Systems

Several research works propose GSM-based monitoring systems because GSM networks provide:

- Wide coverage
- Reliable communication
- Low implementation cost
- Simple AT-command interfacing

In GSM-based systems, microcontrollers monitor electrical parameters and send SMS alerts when abnormal conditions occur.

Advantages of GSM-based systems:

- Real-time remote notification
- No need for internet infrastructure
- Suitable for rural and remote areas
- Easy integration with microcontrollers

The proposed project adopts this approach due to its simplicity, affordability, and reliability.

Current Sensor-Based Monitoring Techniques

Many research studies utilize current sensors such as:

- Hall-effect sensors (ACS712)
- Current transformers (CT)
- Shunt resistors

Hall-effect sensors like ACS712 are widely used because they offer:

- Electrical isolation
- Compact design
- Linear output voltage
- Easy interfacing with microcontrollers

The principle used in most theft detection research is:

$$I_{source} \neq I_{load} \quad I_{source} = I_{load}$$

If the current entering a line differs significantly from the current consumed by authorized loads, the excess current indicates illegal tapping.

This dual-sensor comparison method is simple and effective for small-scale implementations.

IoT-Based Electricity Theft Detection

Recent studies focus on IoT (Internet of Things) for power theft monitoring.

These systems use:

- Wi-Fi modules (ESP8266/ESP32)
- Cloud databases
- Web dashboards
- Mobile applications

IoT systems provide:

- Real-time data visualization
- Cloud storage
- Data analytics
- Predictive theft detection

However, IoT-based systems require:

- Stable internet connection
- Server infrastructure
- Higher implementation cost
- Advanced configuration
- For low-cost and standalone operation, GSM-based systems remain more practical.

Microcontroller-Based Embedded Systems

Embedded systems using microcontrollers such as:

- Arduino Nano
- Arduino Uno
- PIC microcontrollers
- ATmega328

have been widely used for monitoring and control applications.

Advantages of Arduino-based systems:

- Low cost
- Open-source platform

- Easy programming
- Large community support
- Rapid prototyping capability

Due to these benefits, Arduino Nano is selected as the controller for this project.

Research Gap Identified

From the reviewed literature, the following gaps were identified:

1. Smart meter systems are expensive and complex.
2. IoT-based solutions require internet infrastructure.
3. Manual inspection methods lack real-time capability.
4. Large-scale systems are not suitable for educational prototypes.

Therefore, there is a need for:

- A simple dual-current comparison system
- Real-time SMS alert capability
- Low-cost implementation
- Easy installation and maintenance
- Standalone operation without internet

The proposed project fulfills these requirements using Arduino Nano, ACS712 sensors, and GSM communication.

HARDWARE REQUIREMENTS

The hardware section consists of sensing, processing, display, communication, alert, and power supply components. Each component plays a specific role in system operation.

1. Arduino Nano

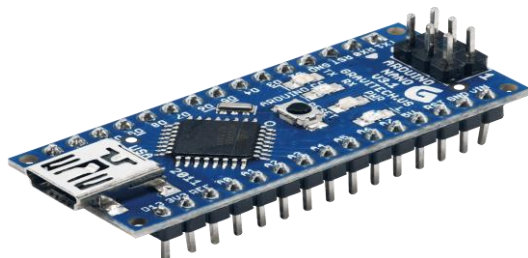


Figure 1. Arduino Nano

Arduino Nano is the central controller of the system. It is based on the ATmega328P microcontroller. It processes all input signals and controls the output devices.

Key features include compact size, low power consumption, 14 digital input/output pins, 8 analog input pins, 16 MHz clock speed, and built-in USB interface for programming.

In this project, Arduino Nano performs the following tasks:

- Reads analog signals from both ACS712 current sensors
- Converts analog signals into current values
- Compares source and load current
- Controls LCD display
- Activates buzzer during theft detection
- Communicates with GSM module using serial communication

The reason for selecting Arduino Nano is its small size, affordability, ease of programming using Arduino IDE, and sufficient I/O capability for this application.

2. ACS712 5A Current Sensor (Two Units)



Figure 2. ACS712 5A Current Sensor

The ACS712 current sensor is a Hall-effect based linear current sensor module capable of measuring both AC and DC current.

In this project, two ACS712-5A modules are used:

- One sensor measures source current
- One sensor measures load current

The sensor provides electrical isolation between the high-current line and the low-voltage Arduino circuit. This ensures safety and protects the microcontroller from high voltage damage.

The ACS712 produces an analog output voltage proportional to the current flowing through it. This output is connected to the analog input pins of the Arduino Nano.

Advantages of ACS712 include:

- Compact module design

- Low cost
- Good sensitivity for small loads
- Easy interfacing with microcontrollers
- Electrical isolation

Using two sensors allows direct comparison between supplied and consumed current, which is the core principle of theft detection.

3. SIM800L GSM Module



Figure 3. SIM800L GSM Module

The SIM800L is a GSM/GPRS communication module used to send SMS alerts.

It operates on GSM cellular network and communicates with Arduino using AT commands through serial communication. The module requires an external regulated 4V power supply because it draws high peak current during transmission.

Functions of GSM module in this project:

- Initializes GSM network connection
- Sends SMS alert to predefined mobile number
- Provides remote notification of theft event

The main advantage of GSM technology is that it does not require internet connectivity. As long as cellular network coverage is available, SMS can be delivered.

This makes the system suitable for rural and remote areas where internet access may not be available.

4. 16×2 LCD Display with I2C Adapter



Figure 4. 16×2 LCD Display with I2C Adapter

The 16×2 LCD is used to display real-time system information.

It can display:

- Source current value
- Load current value
- System status (Normal or Theft Detected)

The I2C adapter reduces the number of wires required to connect the LCD to Arduino. Instead of using multiple data pins, only two communication lines are used (SDA and SCL), which simplifies wiring and reduces circuit complexity.

The LCD enhances user interaction by providing immediate visual feedback of system operation.

5. Buzzer

The buzzer is an audio output device used to generate sound during theft detection.

When the Arduino detects abnormal current difference, it sends a signal to the buzzer, which produces a warning sound. This serves as a local alert mechanism.

The buzzer ensures that theft detection is noticeable even if the LCD is not being monitored.

It consumes very low power and is directly driven by a digital output pin of the Arduino.



Figure 5. Buzzer

6. External 4V Power Supply for GSM

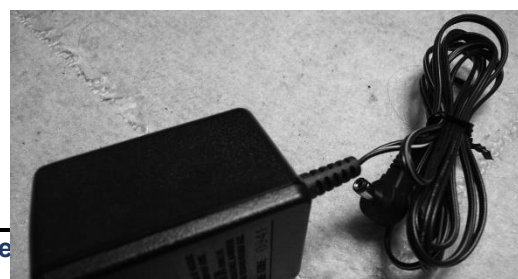


Figure 6. Power Supply

The SIM800L GSM module requires a stable 4V power supply with high current capability. During SMS transmission, the module can draw up to 2A peak current.

If powered directly from Arduino 5V pin, the system may reset due to voltage drop. Therefore, a dedicated regulated 4V external supply is used.

This ensures:

- Stable GSM operation
- Reliable SMS transmission
- Prevention of system instability

Proper grounding between Arduino and GSM module is maintained for correct communication.

7. Connecting Wires

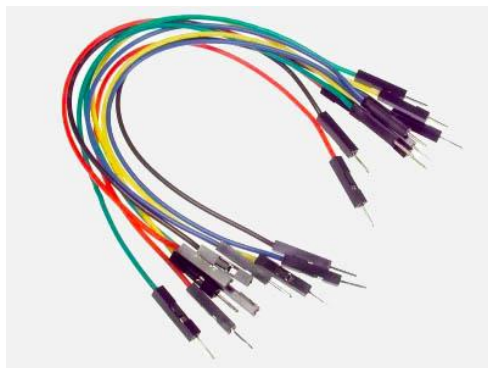


Figure 7. Connecting Wires

Connecting wires are used to establish electrical connections between all components.

Good quality jumper wires ensure:

- Stable signal transmission
- Reduced noise interference
- Reliable circuit operation

Proper wiring layout is important to prevent loose connections and signal errors.

8. Load (Lamp or Appliance)



Figure 8. Load

The load represents the authorized electrical device consuming power.

In this prototype, a lamp or small appliance is used. The load current is measured by the second ACS712 sensor.

By introducing an illegal tapping between source and load sensor points during testing, the system demonstrates theft detection capability.

Summary of Chapter

This chapter described the methodology and hardware requirements of the Power Theft Identifier system. The methodology is based on dual-current comparison for detecting unauthorized consumption. The hardware components include sensing units, processing unit, communication module, display, and alert system.

Each component plays a critical role in ensuring real-time monitoring, accurate detection, and remote alert functionality. The next chapter explains the software implementation and program execution in detail.

METHODOLOGY

The methodology of the Power Theft Identifier system is based on continuous current monitoring and comparison. The system is designed to detect unauthorized electricity consumption by measuring current at two different points in a distribution line and identifying any abnormal difference between them.

The implementation follows a structured approach beginning from hardware setup to real-time monitoring and alert generation.

Initially, two current sensors are installed in the electrical line. One sensor is placed at the source side to measure the total current entering the system. The second sensor is placed at the load side to measure the current consumed by the authorized load. These sensors continuously send analog signals proportional to the current flow to the Arduino Nano.

After powering the system, the Arduino initializes all connected peripherals including the LCD display, GSM module, and buzzer. The system performs sensor calibration to remove offset noise and ensure accurate readings. Once calibration is completed, the Arduino begins continuous monitoring.

The controller reads analog signals from both sensors, processes them, and determines the current values. It then compares the source current and load current. Under normal conditions, both currents should be nearly equal. If an illegal tapping occurs between the two sensing points, the source current becomes higher than the load current.

When the difference exceeds the predefined threshold value, the system identifies this condition as power theft. Immediately, three actions are performed:

- The buzzer is activated to provide a local audible alert
- The LCD displays a warning message indicating theft detection
- The GSM module sends an SMS alert to the registered mobile number

If no abnormal difference is detected, the system displays normal status and continues monitoring.

This methodology ensures real-time detection, immediate alert generation, and minimal human intervention. The system operates continuously in a loop, providing uninterrupted monitoring.

SOFTWARE REQUIREMENT

1. Arduino IDE

The system is developed using the Arduino Integrated Development Environment (IDE). Arduino IDE is an open-source software platform used for writing, compiling, and uploading programs to Arduino boards.

Features of Arduino IDE include:

- Simple and user-friendly interface
- C/C++ based programming language
- Built-in libraries for hardware control
- Serial monitor for debugging
- Cross-platform support

The Arduino Nano board is programmed using a USB cable connected to a computer running the Arduino IDE.

2. Programming Language

The software is written in Embedded C/C++ using the Arduino framework.

The program structure consists of two main functions:

- Setup function – Executes once during startup
- Loop function – Executes repeatedly for continuous monitoring

This structure ensures real-time and uninterrupted system operation.

3. Libraries Used

The following libraries are included in the program:

Wire.h

Used for I2C communication between Arduino and LCD display.

LiquidCrystal_I2C.h

Used to control the 16×2 LCD with I2C adapter.

SoftwareSerial.h

Used to create serial communication between Arduino and SIM800L GSM module.

These libraries simplify hardware communication and reduce program complexity.

4. Functional Modules of the Software

The software is divided into logical modules for better organization and operation.

a) Initialization Module

When the system is powered ON, the setup function performs:

- Pin configuration
- Serial communication initialization
- LCD initialization
- GSM module initialization
- Sensor calibration

The LCD displays the project title during startup. The GSM module is configured using AT commands to enable SMS text mode.

This ensures all peripherals are ready before entering monitoring mode.

b) Sensor Calibration Module

Current sensors may produce small offset voltages even when no current flows. To eliminate this error, the software performs a calibration process.

During calibration:

- Multiple analog readings are taken from each sensor
- Average offset value is calculated
- Offset is stored for future compensation

This improves measurement accuracy and reduces false theft detection.

c) Current Measurement Module

The Arduino continuously reads analog signals from both ACS712 sensors.

The process includes:

- Reading analog input values
- Converting raw ADC values into voltage
- Removing offset
- Calculating RMS current value

To improve accuracy:

- Multiple samples are collected
- Noise filtering is applied
- Very small values are treated as zero

This module ensures reliable real-time current measurement.

d) Comparison and Decision Module

This is the core logic of the software.

After measuring source and load current, the program calculates the difference between them.

If the difference exceeds a predefined threshold value:

- Theft condition is confirmed
- Alert mechanism is triggered

If the difference remains within the threshold:

- System status is considered normal

A threshold value is defined in the program to avoid false triggering due to minor fluctuations.

e) Display Module

The LCD continuously updates the following information:

- Source current value
- Load current value
- System status message

Possible messages include:

- Status: NORMAL
- THEFT DETECTED

The display provides real-time monitoring and enhances system usability.

f) Alert Module

When theft is detected:

- The buzzer is activated
- Audible alarm alerts nearby personnel

When system returns to normal condition:

- Buzzer is turned OFF

This provides immediate local notification.

g) GSM Communication Module

The GSM module operates using AT commands sent via serial communication.

During initialization:

- Communication test command is sent
 - SMS text mode is enabled
- When theft is detected:
- SMS command is issued
 - Predefined mobile number is selected
 - Alert message is transmitted

The message includes:

- Power theft alert notification
- Meter number
- Source current value
- Load current value

To avoid repeated messages:

- A flag variable ensures SMS is sent only once per theft event

This prevents network congestion and repeated alerts.

Block Diagram

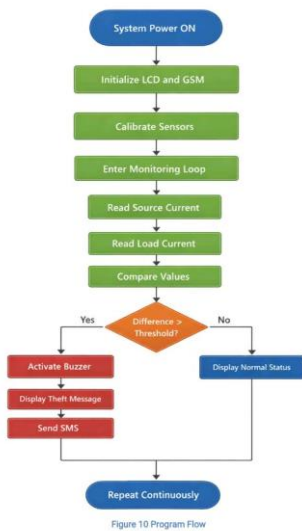


Figure 9. Program Flow

Working Procedure

1. System Initialization

- The Arduino, GSM module, and sensors are powered ON.
- GSM module connects to the mobile network.

2. Current Sensing

- Two current sensors measure:
 - Input current (main supply)
 - Output current (consumer load)

3. Data Acquisition

- Sensor outputs are sent to the Arduino.
- Arduino converts analog signals into digital values using ADC.

4. Comparison Process

- Arduino continuously compares input and output current values.

5. Theft Detection

- If input current > output current beyond a set limit,
→ Arduino detects power theft.

6. Alert Generation

- Arduino sends command to GSM module.
- GSM module sends an SMS alert to the authority/user.

7. Additional Action (Optional)

- Buzzer or LED turns ON.
- Relay can disconnect power supply.

ADVANTAGES, DISADVANTAGES AND APPLICATIONS

ADVANTAGES

• Low Cost Implementation

The system uses affordable components such as Arduino Nano, ACS712 sensors, and SIM800L GSM module, making it economical for small-scale deployment.

• Real-Time Monitoring

Continuously monitors source and load current, enabling immediate detection of abnormal conditions.

• Instant SMS Alert

GSM module sends alert messages instantly to the registered mobile number when theft is detected.

• No Internet Required

Operates using GSM network, so internet connectivity is not necessary.

• Simple Design and Easy Installation

The circuit design is straightforward and easy to assemble, making it suitable for academic projects and small installations.

• Compact and Portable

Small size of Arduino Nano and modules makes the system compact and portable.

• Reduced Human Intervention

Eliminates the need for manual inspection for theft detection.

• Electrical Isolation

ACS712 sensors provide isolation between high current line and microcontroller circuit, ensuring safety.

• Expandable System

Can be upgraded to IoT-based monitoring or integrated into smart grid systems.

• Low Power Consumption

The system consumes minimal power, making it energy-efficient.

DISADVANTAGES

• Limited to Small Load Applications

The ACS712 5A sensor limits the system to low current loads unless higher-rated sensors are used.

• Dependence on GSM Network

SMS alerts depend on mobile network availability and signal strength. .

- **Threshold-Based Detection Only**

Detection is based on preset threshold value and may require tuning for different environments.

APPLICATIONS

- **Residential Electricity Monitoring**

Can be installed in homes to detect illegal tapping before the main load.

- **Small Commercial Establishments**

Useful in shops, offices, and small businesses to monitor energy consumption.

- **Distribution Line Monitoring**

Can be installed in small distribution sections to detect unauthorized connections.

- **Educational Demonstration**

Ideal for engineering students to demonstrate embedded system applications in power systems.

- **Rural Electrification Projects**

Suitable for rural areas where GSM network is available but internet access is limited.

- **Small Industrial Units**

Can monitor limited machinery loads in small-scale industries.

- **Energy Management Systems**

Can be integrated into basic energy auditing systems.

- **Transformer Monitoring (Prototype Level)**

With modifications, it can be used for small transformer monitoring applications.

- **Government Utility Monitoring Projects**

Useful as a prototype model for power utility departments.

- **Smart Meter Development Base Model**

Can serve as a foundation for developing advanced smart metering systems.

RESULTS

The Power Theft Identifier system was successfully designed, implemented, and tested under laboratory conditions. The prototype was assembled using Arduino Nano, two ACS712 current sensors, SIM800L GSM module, LCD display, and buzzer. The system was tested with a lamp as a load to simulate normal and theft conditions.

During normal operation, the source current and load current values were nearly equal. The LCD displayed

both current readings and showed the status as NORMAL. The buzzer remained OFF, and no SMS was sent. The system operated continuously without interruption.

To simulate power theft, an additional load was connected between the source sensor and load sensor measurement points. Under this condition, the source current increased while the load current remained unchanged. The Arduino detected the difference beyond the preset threshold value.

When theft was detected, the following results were observed:

- The LCD displayed THEFT DETECTED message.

- The buzzer turned ON immediately.

- An SMS alert was successfully sent to the registered mobile number.

- The message contained meter number and both current readings.

The GSM module transmitted the alert reliably when proper power supply was provided. The SMS was received within a few seconds depending on network strength.

The system demonstrated stable operation with accurate detection under small load conditions. Noise filtering and calibration ensured that minor fluctuations did not trigger false alarms.

Overall, the prototype successfully met its intended objectives of detecting current mismatch and providing real-time alert notification.

CONCLUSION

Electricity theft is a serious issue affecting power distribution systems worldwide. Manual inspection methods are inefficient and unable to provide real-time monitoring. Therefore, an automated solution is necessary to reduce non-technical losses and improve system reliability.

The Power Theft Identifier Using GSM & Arduino project provides a simple, cost-effective, and efficient solution for detecting unauthorized electricity consumption. The system works on the principle of comparing source current and load current. If the difference exceeds a defined threshold, theft is identified.

The integration of Arduino Nano ensures reliable processing and continuous monitoring. The ACS712 sensors provide safe and isolated current measurement. The GSM module enables remote SMS notification without requiring internet connectivity. The LCD and buzzer provide local status indication.

The project successfully demonstrates that embedded systems combined with wireless communication can

effectively monitor and detect power theft in small-scale applications. The design is compact, economical, and suitable for academic projects and small distribution setups.

Thus, the objectives of designing, implementing, and testing a GSM-based power theft detection system were successfully achieved.

FUTURE SCOPE

Although the current system performs effectively for small-scale applications, several improvements can be made to enhance performance, scalability, and functionality.

One major improvement is upgrading the system to an IoT-based platform using Wi-Fi modules such as ESP8266 or ESP32. This would allow real-time cloud monitoring and data logging through web dashboards or mobile applications.

The system can be enhanced by integrating energy measurement instead of only current measurement. Adding voltage sensing would allow calculation of real power consumption and improve accuracy.

For large-scale implementation, higher capacity current sensors or current transformers can be used to monitor industrial loads. This would make the system suitable for transformers and distribution feeders.

Data logging capability can be added using SD card modules. This would allow storage of historical data for analysis and auditing purposes.

Tamper detection features such as meter cover opening detection or magnetic interference sensing can also be incorporated.

Artificial intelligence and machine learning techniques can be integrated in future versions to predict theft patterns and analyze abnormal consumption behavior.

A mobile application can be developed for utility authorities to receive instant notifications and monitor multiple meters simultaneously.

Integration with smart grid infrastructure would allow centralized monitoring and automated control mechanisms such as remote disconnection during confirmed theft.

Improving power supply design and adding battery backup can ensure uninterrupted operation during power failures.

In conclusion, the proposed system serves as a foundational prototype that can be expanded into a fully automated smart energy monitoring and anti-theft system with advanced features in future developments.

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