

RESULT AND DISCUSSION

To evaluate the performance and accuracy of the electrical power theft detection system, several test scenarios were conducted under both load and no-load conditions.



Fig 1 Experimental Setup

The experimental setup includes a 12V DC adapter, three bulbs (two are treated as legal connections and one as illegal connection), three ACS712 5A current sensors (one at the source and two for the legal loads), an ESP32 microcontroller, a 20x4 LCD display, and a SIM900A GSM module for theft alert notifications.

1. No Load Condition



Fig 2 No Load Condition

Fig 1 shows a setup in which none of the bulbs were connected to the system. All current sensors displayed near-zero readings as shown in Fig 2. The system correctly identified that there was no power usage, and no theft or alert was triggered. This confirmed that the sensors and ESP32 logic were accurately calibrated for idle conditions.

2. Legal Load Condition (Both Bulbs Connected)

When both legal bulbs (Bulb 1 and Bulb 2) as shown in Fig- 3 or Only one legal bulb (Bulb 1) Fig- 4 were connected via ACS712 sensors, and no illegal load was attached, the system showed current readings for each load and the total source current. The sum of legal currents matched the main supply current, indicating no power theft as shown in Fig- 3. No alerts were triggered, and the system functioned as expected.



Fig – 3 Only One Legal Bulb 1 is connected



Fig – 4 Both Legal Bulbs (Bulb1 and Bulb 2) are connected

3. Partial Load with Theft Condition (One Legal Load Disconnected)

In Fig- 5 only one legal bulb was connected through its ACS712 sensor, while the second legal bulb was disconnected. The illegal bulb was again connected directly to the supply without a sensor. The current measured at the source was significantly higher than the single legal load's consumption, confirming unauthorized usage.



Fig – 5 One Legal Bulb is Disconnected (Bulb 2)

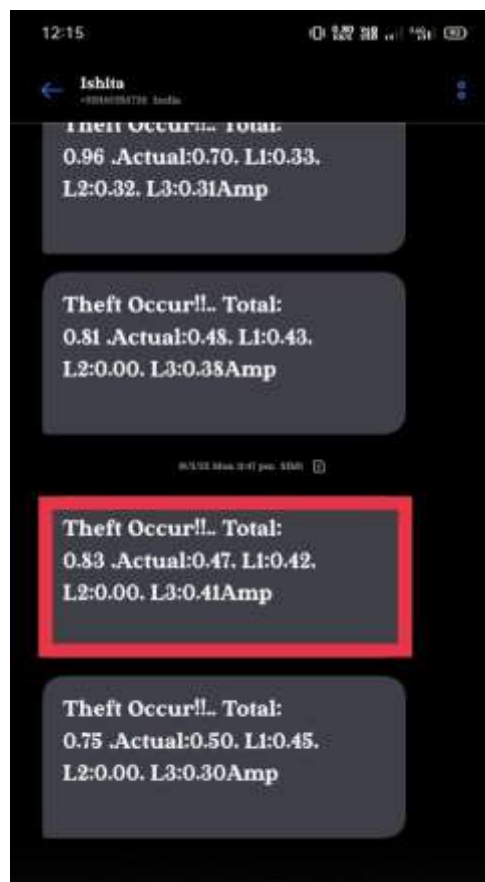


Fig – 6 Messaging Screenshot 1

The system accurately detected this theft scenario and triggered the alert mechanism. The LCD displayed the legal current, total supply current, and a theft occur warning, and the GSM module sent a theft alert to the registered number as shown in Fig- 6.

4. Theft Condition (Illegal Load Connected)



Fig- 7 Illegal Load Connected

In this case, an illegal load (Bulb 3) was connected directly to the power source, bypassing the current sensors. The ESP32 detected a mismatch between the current measured at the source and the sum of currents from the legal loads. This discrepancy indicated possible theft.

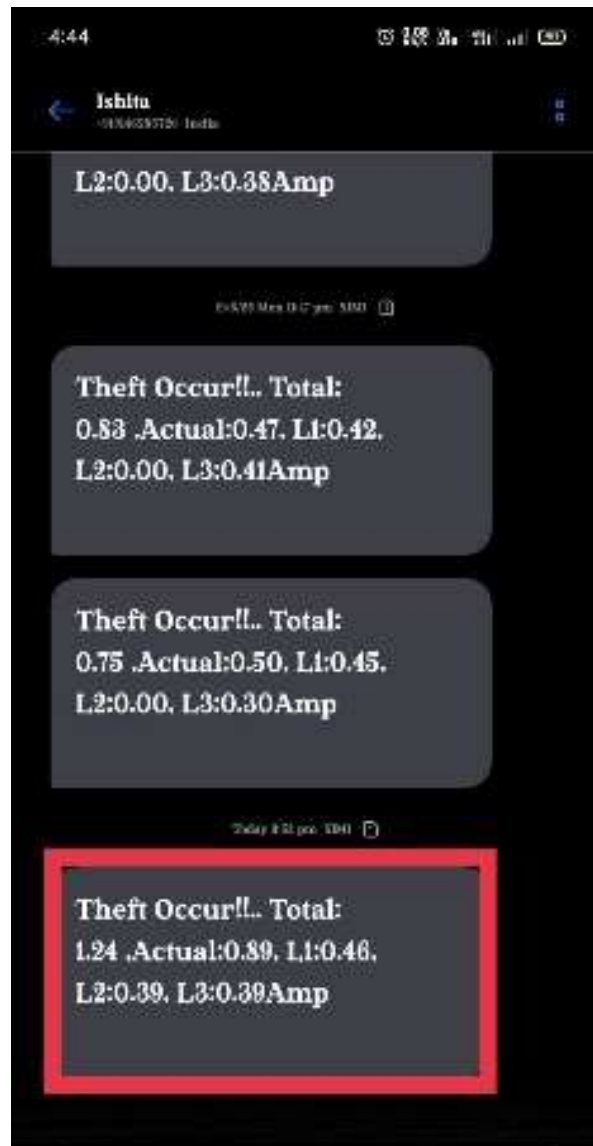


Fig- 8 Messaging Screenshot 2

The system responded by displaying a theft warning on the LCD and sent an SMS alert via the GSM module to the registered number as shown in Fig 8 .

Calculations –

For Case 3 - Partial Load with Theft Condition (One Legal Load Disconnected i.e. Bulb 2)

Here,

Legal Load Values are :

$$M1 = 0.43 \text{ A}$$

$$M2 = 0.00 \text{ A}$$

$$\text{So, Total Legal Load} = M1 + M2 = 0.43 + 0.00 = 0.43 \text{ A}$$

Since **Legal Current** shown is **0.48 A** in **Fig 5**, it may include small sensing or noise margin, or slightly rounded reading.

Illegal Load:

$$U3 \text{ (unauthorized bulb)} = 0.43 \text{ A}$$

Total Current from Main Supply:

Main ACS712 reads **0.85 A**

Theft Calculation:

$$\text{Expected Total (Legal only)} = 0.48 \text{ A}$$

$$\text{Actual Total} = 0.85 \text{ A}$$

$$\text{Theft Current} = \text{Actual} - \text{Legal} = 0.85 - 0.48 = 0.37 \text{ A}$$

(Very close to $U3 = 0.43 \text{ A}$ → measurement variation)

Conclusion:

The system correctly detects **unauthorized consumption** (0.37 A), which is not from legal loads. Hence, it displays and sends "**Theft Occur**" message.

For Case 4 - Theft Condition (Illegal Load Connected),

Here,

Legal Load Values are :

$$M1 = 0.45 \text{ A}$$

$$M2 = 0.40 \text{ A}$$

So, Total Legal Load = M1 + M2 = **0.45 + 0.40 = 0.85 A**

Since **Legal Current** shown is **0.91 A** in **Fig 7** , it may include small sensing or noise margin, or slightly rounded reading.

Illegal Load:

U3 (unauthorized bulb) = **0.42 A**

Total Current from Main Supply:

Main ACS712 reads **1.27 A**

Theft Calculation:

Expected Total (Legal only) = 0.85 A

Actual Total = 1.27 A

Theft Current = Actual - Legal = **1.27 - 0.85 = 0.42 A**
(Equal to U3 = 0.42 A)

Conclusion:

The system correctly detects **unauthorized consumption** (0.42 A), which is not from legal loads. Hence, it displays and sends "**Theft Occur**" message.