Power Theft Detection by Introducing Current Measuring Device with Smart Meter

S. M. Mehedi Hasan, Nayeem Hasan Mahmud, K. M. A. Salam

Abstract— In everyday life, electricity is a vital commodity and pillar for the whole community. However, the government or power company is losing a significant amount of money due to the proper theft detection as a system loss every year. The present automatic smart meter system is used for energy measurements. Still, it cannot detect the total theft as system loss properly due to a lack of regular interval checking consumers' door to door. A new technique, the current measuring device introduced in the system with a smart meter, allows consumers to monitor each device's use in their homes. This paper has imposed a particular current measuring device (CMD) with the smart meter system to detect the power theft in our total system loss from the main line to the load side.

Index Terms— Smart metering, Power theft, CMD, AMI, IoT, Tempering, Power losses, Meter fault.

1 Introduction

IN the present era, a smart meter is very popular in power systems [1]. Smart meters relay data to the user and energy suppliers for device control and customer billing, allowing greater transparency in usage behavior. Usually, smart meters record real-time energy and report regularly within short intervals [2]. So, it can store data, real-time report data as per energy consumption [3], transfer data, innovative billing system, measuring the power consumption, and control a smart city [4] based on the internet of things (IoT) [5]. The smart grid is a modern electric power-grid infrastructure for improved efficiency, reliability, and safety, with smooth integration of renewable and alternative energy sources, through automated control and modern communication technologies [6,7]. The smart meter has a two-way communication system that can transmit data from meter to online database and database to meter's controller and control panel of power suppliers to monitor it from their central system. It is also possible to monitor the proper use of the asset, power use [8,9]. A memory segment of the smart meter contains the owner information, including registration number, mobile number, serial number, bill information, meter types, and location [10]. There are different protocols to share data through the wireless or wired system [11]. It is for the administrator panel of power suppliers to extract the central system's data and manage their assets and billing for the users based on their usage. It is for the user where users can check their meter according to their wish. They can check how much electricity is used and how much electricity can be used according to their recharge and confinement of the breakdown period time [12]. Also, the remaining electricity accordingly, even any problem occurred, can be disconnected from the electricity supply. Users have radio frequency identification (RFID) [13] card or other systems to recharge electricity balance to keep a continuous electric supply [14]. The electricity meter communicates with Local Data Concentrators (LDCs) using the low voltage power supply cables between the meters and the transformers, which come under local area networks (LANs) [15].

Even though we can use this smart meter properly in our power distribution site, there are many advantages. Advanced metering infrastructure (AMI) can detect power outages and monitor voltage profiles [16,17]. However, some lack of noticing the theft or other system loss from the mainline to the meter. If anyone bypassing the cable line before going through the smart meter, the meter did not recognize the bypassing line. In that case, the present smart meter system did not identify the fault correctly. This paper has developed an intelligent approach by introducing a current measuring device [22] with smart meter.

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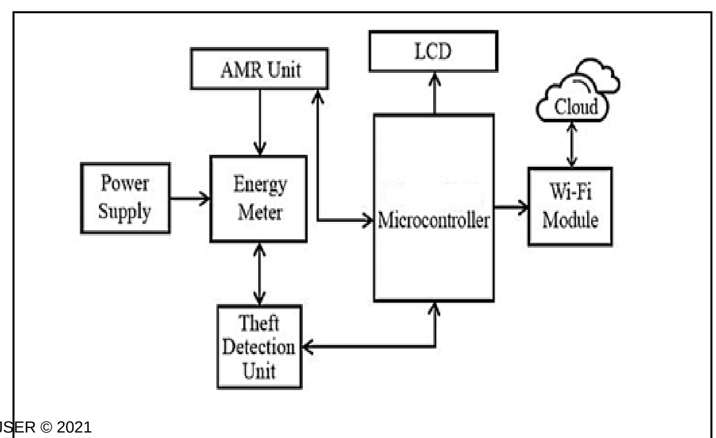
2 Basic Architecture of Smart Meter

The basic architecture of a smart meting system is depicted in Fig. 1 [18].



ISSN 2229-5518

The microcontroller is linked to the automated meter reading (AMR) module, a theft detection module, and a Wi-Fi module in the innovative meter plan. The microcontroller is a vital component of the smart meter system installed at the consumer end to measure meter readings, detect theft, and store data. This information is transmitted via IoT ESP3866 Wi-Fi from the consumer end to the energy supplier [19]. The AMR module monitors the meter continuously and collects the reading, and transmits it to the microcontroller. The power module provides the complete power needed to operate the system at the consumer's end. By using a microcontroller, the meter reading information is collected and collected from the electricity meter. The control process is completed, and information is sent to the energy service provider, such as the number of units consumed using the Wi-Fi module. The LCD module is intended to provide visual information on the number of units is used, alerts, and the connection status. At the end of the energy supplier, the meter reads and generates the facts on the server computer. If theft is detected, a warning message will be sent, and the energy supply disconnected. In the present scenario, the smart meter device needs to be identified reliably remotely. This paper focuses on detecting theft, optimal power utilization, and transmit information on energy consumption to the end-user. Fig. 2 depicts our proposal for dealing with power theft. We have introduced a current measuring device with a new algorithm to detect power theft from the supply line to the load through the meter.

3 Working Principle of the System

Fig.2 shows the block diagram of the proposed system. Smart meters operate on a two-way communication process and should have a memory segment. Two-way communication is done through Radio Frequency (RF) mesh networking or PLC [20,21], allowing the creation of LAN and WAN. Here two types of fault detect one is incoming temper and another is meter fault.

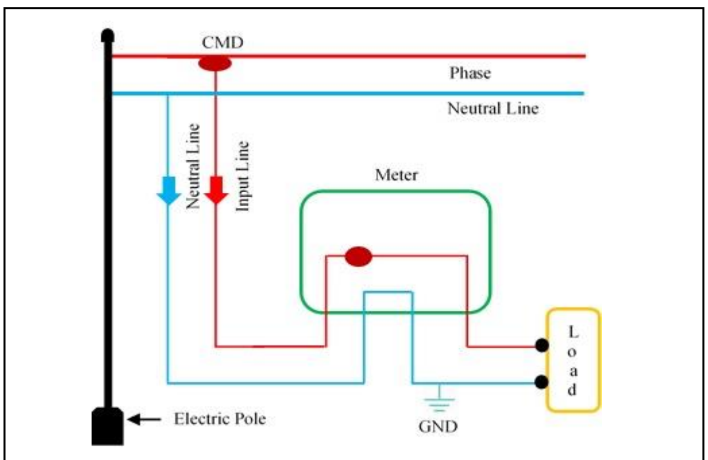


Fig. 2. Block diagram of proposed system

The current measuring devices are connected at the supply l Fig.1. IoT Based Smart Meter Monitoring System the supply line of mainline is treated as the phase. If there is any temper on the input line or meter fault, it will be detected by measuring and comparing the currents and tolerances.

The supply line current indicated i_1, the supply line to the meter is called the input line current, indicated i_2, and from the meter to the load is called the output line current, indicated i_3. The communication between CMD and smart meter through wired or wireless and exchange data determine the fault type. Tolerance is the material loss of the conductor (copper, aluminum, etc.). Supply line tolerance is indicated T_1, and output line tolerance is indicated T_2. The difference between the tolerance values of the supply line and the input line is recorded through smart meter. The difference in the tolerance value can also detect the fault [24]. The fault is divided into two parts: (I) line fault is also called input fault, indicated f_i, and (II) meter fault, indicated f_m. We have developed an algorithm based on the following equations:

$$f_i = \frac{|i_1|-|i_2|}{|i_1|} \times 100 \tag{1}$$

Where f_i indicates the fault between the supply line and the input line, suppose there is any difference between the supply line current and input line current (up to the meter), it's called input fault (f_i). If $i_1 - i_2=0$, there is no input fault.

Another equation is developed regarding the meter fault as the following:

$$f_m = \frac{|i_2|-|i_3|}{|i_2|} \times 100 \tag{2}$$

Where f_m indicates the fault between the input line and the output line (load), Suppose there is any difference between the input current and the output current, it's called meter fault (f_m). If $i_3 - i_2=0$, indicated there is no meter fault. Another verifying parameter is tolerance. If $f_i \geq\geq T_1$ and $f_m \geq\geq T_2$ both are valid results, indicated input line is tempered and meter fault. Data stored in local memory and sent to the server. If both are false, it meant there is no fault, and this data will also keep in local memory and sent to the server. Similarly, $f_i \geq\geq T_1$ and $f_m \geq\geq T_2$ are individually checked and verified whether any fault occurred or not in the input line and meter, and data stored and sent to the server.

4 Design Implementation Flowchart

The flowchart of theft prevention system which is showing in Fig. 3 and how the smart meter system will work which is based on the equation [23].

The theft prevention system has several doorsteps in its flowchart. This program is launched by the start button. Then read the data from CMD and collect data, electricity amount on supply line (i_1), Input line(i_2) and output line(i_3). Here tolerance value of supply line (T_1) and tolerance value of input line (T_2). After the read data, calculate the value of f_i (Fault in supply line) with equation (1), then check condition $f_i \geq T_1$, is it true or not. After that check condition, if $f_i \geq T_1$ true, it will cal-

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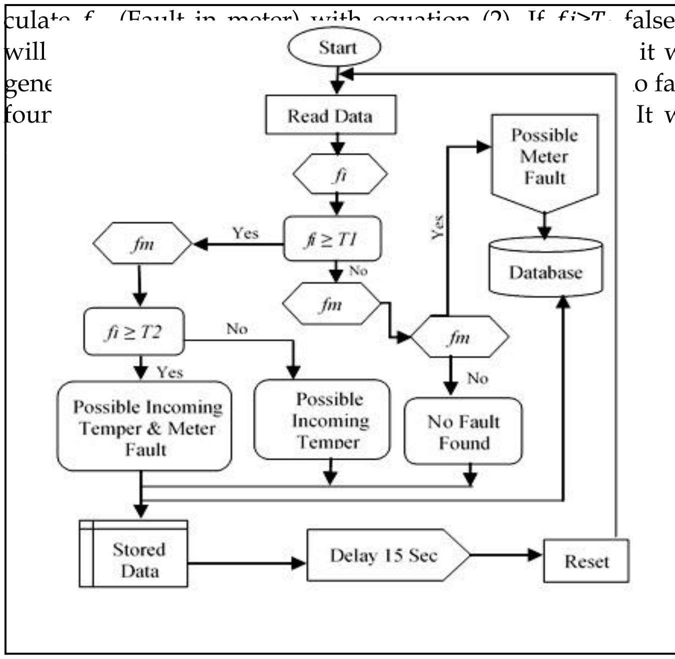

Fig. 3. Flowchart of theft detection system

create results about both incoming temper and meter fault. In addition, if the condition $f_m \geq T_2$ false, it will generate an incoming temper result. After generating the result, stored data on a local machine and stored the data in a database. Finally, delay about a certain period and return to the read data to find out the fault.

5 Results And Discussion

In our system, we developed an algorithm with C programming. We also measure practically four types of data using this algorithm for tempering and without tempering. Table 1 shows the data regarding the supply line, input line, output current, and meter tolerance.

We used four different types of data for testing purposes. We assume that 10 amp current is fixed for all supply lines and varied the input line by including four separate data sets. On the input line, it started with an 8 amp current and gradually rising to 9.8 amp that depicted in Table 1. Increasing the input line current is that if there is an unusual case or any tampering in the supply line, then the line current will be changed as a result easily can detect any fault. Therefore, we took different values in the input line current.

TABLE 1
Measuring Data of The System

Set	Supply line current (i_1) [amp]	Input line current (i_2) [amp]	Output line current (i_3) [amp]	Tolerance value on supply line T_1 (%)	Tolerance value of input line T_2 (%)	Input fault f_i (%)	Meter fault f_m (%)	Result
01	10	8	7	2	1.5	20	10	Incoming temper and Meter Fault
02		9.5	9	1	10	5	5	Incoming temper
03		9.8	9.5	10	5	2	3	No fault found
04		9.8	7	10	2	2	28	Meter Fault

From set-1 in Table 1, the data indicates that the supply line current is 10 amp and input line current is 8 amp. There is a variation between the supply current and Input line current indicated incoming tempering. It also showed a variation of output current (7 amp) and input line current (8 amp) indicated meter tempering. The statement is also satisfied that the value of f_i is more than tolerance (T_1) which is the tolerance value of the supply line and the value of f_m is also more than tolerance (T_2) indicated both incoming tempering and meter tempering occurred.

From set-2 in Table 1, the supply line current is 10 amp and input line current is 9.5 amp. There is a variation between the supply current and Input line current indicated incoming tempering. Another statement is that the difference of electricity of supply line and input line will be more than tolerance value that fulfills the condition $f_i > T_1$ indicated only incoming tempering.

From set-3 in Table 1, the supply line current is 10 amp, and input line current is 9.8 amp; as a result, the difference is very nominal and can be neglected. On the other hand, the statements $f_i \geq T_1$ and $f_m \geq T_2$ are not satisfied indicated that there is no line tempering or meter fault occurred.

Similarly, from set 4 in Table 1, the supply line current is 10 amp, and input line current is 9.8 amp; as a result, the difference is very nominal and can be neglected. However, the data showed a variation of output current (7 amp), and input line current (9.8 amp) indicated meter tempering. In addition, the statement $f_m \geq T_2$ is also satisfied indicated only meter fault occurred.

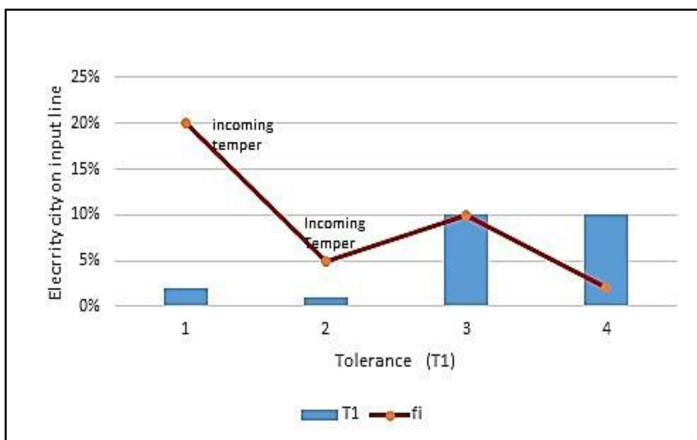

Fig. 4.

Fig. 4 shows graphically represent the point where the incoming temper fault and when it is happening. The bar diagram illustrates the supply line's tolerance value (T_1), and the line diagram represents input fault, f_i value. When the f_i value is more than the tolerance value of the supply line (T_1) then occurs the incoming temper. Set-1 and set-2 show in Fig. 4 indicated the incoming tempering. Fig.5 shows graphically represent the point where the meter fault and when it is happening. The bar diagram illustrates the tolerance value of input line of meter (T_2), and the line diagram represents the meter fault, f_m

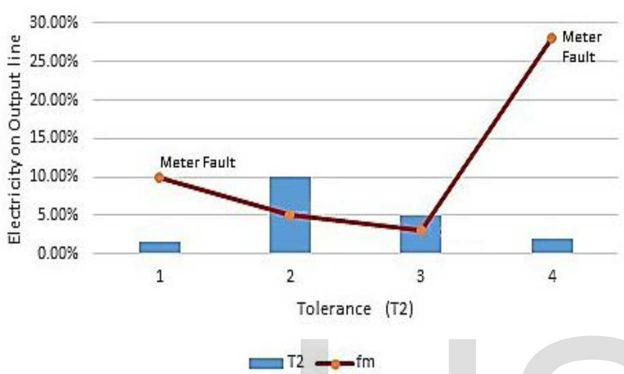

Fig. 5. Meter Fault

value. When the f_m value is more than the tolerance value of output line of meter (T_2) then occurs the meter fault. Set-1 and set-4 show in Fig. 5 indicated the meter fault.

6 Conclusion

Power theft detection by introducing a current measuring device with a smart meter has been studied. Both theoretical and practical work has been conducted, and also developed an algorithm using C programming. We have found good results through this system. The theft or any tempering in our power systems, mainly from the supply line to the load side, could identify even the total system loss. Although some deficiencies between theoretical and practical data, this technology works appropriately in leakage or any theft detection so that it will be easier to overcome the total system loss. Considering all aspects, we think this system is an effective method for theft detection, improves system loss, and can be applied to our power distribution system.

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