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Smart Hub For Energy Meters

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Abstract

Our country is progressing towards the goal 'DIGITAL INDIA' .As a result, DISCOMS are gradually replacing existing energy meters with smart energy meters. But using our idea, we can upgrade the existing system to a smart metering system. Our concept can be cost-effective in some places when compared to smart energy meters. Example: In apartments, streets with lots of houses where the cost per consumer is significantly less in our project. A Smart Energy Metering System enables us to monitor live energy consumption and also gives avg. Power over some time (seconds, minutes). This system can even be established with the help of energy meters which are already installed in the place. Energy Meters used in India have an Led which is used to calibrate the energy meter. The blinking of the Led is proportional to Energy consumed.

Keywords: Smart Metering, Smart Hub, Energy Monitoring

1. Introduction

The idea of the project is to upgrade existing energy meters into the smart meter. In this way, the existing meters currently working correctly don't need to be scrapped, saving a lot of money. WHAT IS A SMART METER? IN WHAT WAY IT IS DIFFERENT FROM EXISTING ENERGY METERS? If we can answer the above questions, we can understand what we need to do for upgrading the existing energy meters into smart meters. A Smart Meter is a device that records the usage of electricity and updates it to a remote server or to a cloud network from where the user and distributor can access the data to know the usage of the consumer at any point of time from any place. The data sent by the meter can be used to create further statistical analysis, which can be helpful for both the consumer and the distributor. Existing meters only record the data, and it doesn't store any record of the data; it can only show what amount of electricity is consumed till that point of time by that consumer. While the smart meter not only stores the data of energy consumption, but it can also share it with any remote server through the internet. If we can create a system to record data from existing meters, that system converts existing energy meters into a Smart Meter. We can create a system to record data from existing meters, that system converts existing energy meters into a Smart Meter.

2. Existing System

2.1 Meters

In India, the energy meters in use are static kWh meters which replaced the conventional mechanical energy meters a few years ago. The static energy meters available today come with an LCD for making the door-to-door metering convenient and comfortable. The only possible way to eliminate this door-to-door metering by replacing the existing energy meters with smart meters.

2.2. Metering System

The energy consumption tariff is calculated by a length, time-consuming, and exhausting procedure known as door-door metering. This involves a person with a handheld device going door to door to calculate the energy consumption data from households and industry and registering the collected data in their handheld device. After collecting the data, the handheld device is taken to their office. It is connected with the server, and the collected consumption data is uploaded, and the tariff is calculated.

2.3. Difficulties Faced by the Consumers

The door-door data collection from the energy meter is carried out once every two months. Consumers cannot keep track of their daily energy consumption, which sometimes leads to substantial electricity bills. Consumers sometimes have to pay the caution deposit for their connection due to their overconsumption.

In case the consumer has gone out of town along with his family during the metering time, it becomes impossible for the person in charge to collect data from the energy meter since the house is locked. After returning home, the consumer has to approach the EB office in his locality requesting the metering, which doubles the job for both consumer and the EB authorities.

3. Proposed System

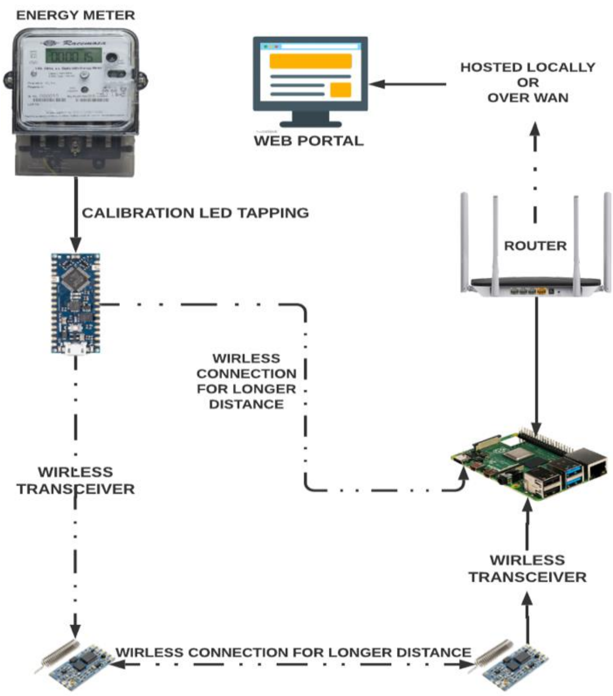
3.1.Block Diagram

The above diagram portrays the design of the project, the calibration LED signal is sent to an Arduino which thereupon transmits the signal to the Raspberry Pi. The raspberry pi upon receiving the signal from Arduino stores the timestamp of the appearance of the signal or blinking. This data is further processed and rendered as user-readable data in a web portal which can be hosted locally in a LAN network. The data base for the web portal is also hosted locally on the LAN by the raspberry pi, Raspberry pi can connect to a LAN network either through WIFI or over an ethernet cable. The data transmission from Arduino to Raspberry Pi can done in both wired and wireless methods.

3.2.Energy Meter tapping

To get the energy consumption data from the conventional energy meters a parallel connection is made between the 2 ends of a calibration LED using a couple of jumper cables. While the event of blinking of the calibration LED a HIGH state is witnessed (i.e. increase in voltage) over these wires. the dc voltage

presented in the energy meter circuit is not a pure DC, consequently, a small fluctuation can be witnessed in the energy meter circuit, which is likewise seen across these jumper wires.



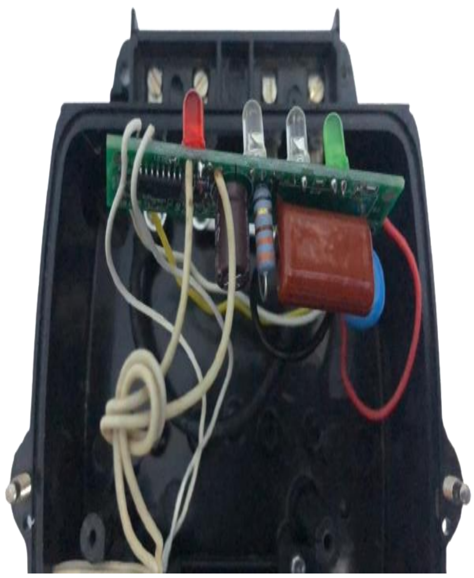


Figure 1. Tapped Calibration LED

When these wires are connected to the GPIO port of a device there is a possibility of the erroneous triggering of the HIGH state due to the residence of AC elements in the voltage across the LED, this mistaken triggering can be reduced by using a suitable resistor while connecting the wire and the GPIO port if the sensitivity of the GPIO port is low, in case of a high sensitive device there is a necessity for an external device to eliminate the fluctuation in the circuit.

Figure 2. Energy Meter After Tapping

The voltage fluctuations observed during the low state are of the magnitude of millivolts (around 3 to 6 millivolts) whereas a true high state produces a voltage of 1.79 volts across the LED terminals. the consequence of this AC element in the energy meter is witnessed largely when there is no supply connected to the energy meter or when there is no load connected to the energy meter, from this observation it can be assumed that the voltage fluctuations could be prompted to the behavior of capacitors in the energy meter circuit, the voltage could be interjected due to the discharging of the capacitors in the circuit as there is no flow of current over the circuit when the supply or load gets disconnected and the capacitors currents may produce these false HIGH states or voltage fluctuations.

3.3.Need for Analog Pin

Due to the presence of ac components i.e. voltage fluctuations in the energy meter circuit, employing GPIO pins blinking can not be perfect as there is a risk to misread minute voltage fluctuations as a HIGH state (i.e. a LED blink) because GPIO pins can only distinguish two states either a HIGH state or a LOW state, the voltage fluctuations are about millivolts whereas the LED blinks only when the voltage is 1.79 volts which is 40 to 50 times the magnitude of voltage fluctuations witnessed during the LOW state, therefore, these two states can be effortlessly distinguished by weighing the magnitude of the voltage across the jumper wires, which is achievable only with the aid of an analog i/o port. so a device with a built-in analog port is required or an ADC converter is needed to compute the LED blinks using a GPIO port.

There is no analog pin in Raspberry Pi so there is a call for an external device like an ADC converter or device with analog pins like an Arduino to transmit a pure DC signal to the Raspberry Pi GPIO pins to bypass flaws while computing the blinking of the calibration LED.

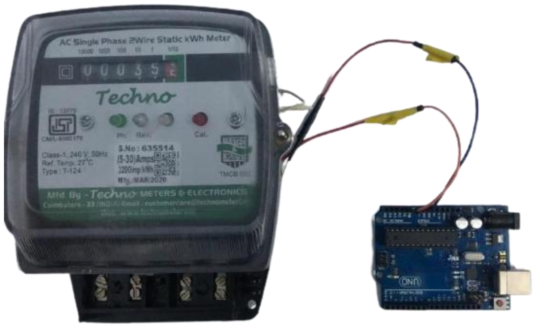


Figure 3. Intermediate Device Arduino Connected To
id False Triggering

Figure 4. Connecting Raspberry Pi to Energy Meter -

3.4.Energy and Power calculation

3.4.1.Energy calculation by counting the LED blinks

The energy meters being used in India has two different meter constants, the meter constant is the same for all single-phase energy meter and three-phase energy meters has a different meter constant. the meter constants for these meters are as follows:

1.Single-phase energy meters - 3200 impulses per kWHr

2. Three phase energy meters - 1600 impulses per kWHr

The energy meter constant can be described as the number of times the calibration LED blink per unit energy consumption. which implies that the LED blinks 3200 times in a single-phase energy meter a unit of energy is consumed, while 1600 blinks refer to a unit energy consumption in a three-phase energy meter. Thus, by computing the LED blinks from the energy meter the energy consumption can be determined in the raspberry pi, by summing the number of blinks between 2-time intervals we can determine the energy consumed in that period. Also, by summing the blinks with the initial reading the energy consumption at any point in time can be determined instantly.

3.4.2.Power or Load calculation

There are two different approaches to determine the load connected to the energy meter, for instantaneous load calculation frequency-based estimate should be employed and the load connected over a particular period can be calculated as an average load over that period.

1. **Frequency-based approach**: In this method, the load connected to the energy meter is determined based on the frequency of LED blinking. the estimation of load based on this approach is presented here considering the frequency of 10 LED blinks.

Let time taken for 10 pulses be 't' seconds, hence load can be

Power = energy/time

Load = ((1/320) kWHr) / (t/3600)) H

Load = (3600/ (320*t)) kW

Load Connected = (11.25/t) kw

Where t , Time taken for 10 pulses

2. **Average Load Calculation:**

In this approach, a particular time interval is defined and the number of LED blinks that occurred during that period is calculated, and based on that the average load connected to the energy meter is calculated

1 Pulse = (1/3200) kWHr

1 Pulse = (1/3200)*(3600) kWSec

1 pulse = 1.125 kWSec

1 pulse/Sec = 1.125 kW

"implies that when Led blinking is at the rate of one pulse per second the load connected is 1.125 KW"

Based on the above equation load connected can be determined using the below formula

Load Connected = 1.125 * (P/T)

Where P is led blinks in time 'T'

T is Time in seconds

IV. TESTING & RESULTS

Testing done on the smart metering system

- Led Tapping
- Load Testing
- Variable Load Testing
- Constant Load Testing

3.4.3.Led Tapping

The test was conducted by connecting a parallel connection between the calibration led to raspberry pi. We observed a back emf in the energy meter which caused false triggering on raspberry pi. By observing the errors, we found a fluctuation in voltage (0.01 ~ 0.03 v) which caused the false triggering. which is observed when there is no supply or load is connected to energy meter. To eliminate the false reading, we need a device which can distinguish between actual high state (1.7 v) and minor voltage fluctuations. Using a analog input pin we can get the magnitude of the voltages hence a device with analog pin can eliminate the false reading. ADC converters, Arduino, or microprocessor, etc., can be used. We used Arduino to pass an HIGH□LOW state change to Pi when there is an true high state in the energy meter.

3.4.4.Load testing

The test was by connecting a load of know power rating to the energy meter and calculating the led blinking rate

1 Pulse = (1/3200) kWHr

1 Pulse = (1/3200) *(3600) kWSec

1 pulse = 1.125 kWSec

1 pulse/Sec = 1.125 kW

Which implies that when Led blinking is at the rate of one pulse per second the load connected is 1.125 KW, based on the above equation load connected can be determined using the below formula

Load Connected = 1.125 * (P/T)

Where, P is led blinks in time ‘T’

T is Time in seconds

3.4.5.Variable load testing

The test was conducted by switching between loads of different power rating. The two loads which we selected were a ‘refrigerator’ and an ‘electric iron’. The power rating of refrigerator and iron box were 300 watts and 1000 watts respectively. First the refrigerator was connected to the energy meter and later the iron box was connected. The electric iron was then disconnected from the energy meter after some time

Raspberry Pi stored the data in the SQL Server, and we took data from the server and cross verified it using our calculation. By calculation the time taken to produce 10 pulses we can find the load connected to the energy meter. 3 sample period was selected one when only refrigerator was connected, when both refrigerator and electric iron was connected and when iron box was disconnected. This test shows that by calculating the frequency of pulses we can identify the load connected to the meter.

count	reading	time
1	0	2021-02-11 17:08:51.935559
2	0.0003125	2021-02-11 17:09:10.526105
3	0.0003125	2021-02-11 17:11:43.540377
4	0.0003125	2021-02-11 17:12:12.841175
5	0.0003125	2021-02-11 17:12:38.719573
6	0.0003125	2021-02-11 17:12:39.660580
7	0.0003125	2021-02-11 17:12:46.685999
8	0.0003125	2021-02-11 17:12:46.870564
9	0.0003125	2021-02-11 17:12:54.078105
10	0.0003125	2021-02-11 17:13:01.274924
11	0.0003125	2021-02-11 17:13:08.447190
12	0.0003125	2021-02-11 17:13:15.846142
13	0.0003125	2021-02-11 17:13:17.780445
14	0.0003125	2021-02-11 17:13:18.378714
15	0.0003125	2021-02-11 17:13:18.680454
16	0.0003125	2021-02-11 17:13:23.340347
17	0.0003125	2021-02-11 17:13:30.941093
18	0.0003125	2021-02-11 17:13:38.185561
19	0.0003125	2021-02-11 17:13:38.333350
20	0.0003125	2021-02-11 17:13:39.231230
21	0.0003125	2021-02-11 17:13:40.275835
22	0.0003125	2021-02-11 17:13:41.319442
23	0.0003125	2021-02-11 17:13:42.363308
24	0.0003125	2021-02-11 17:13:43.407186
25	0.0003125	2021-02-11 17:13:44.452285
26	0.0003125	2021-02-11 17:13:45.499000
27	0.0003125	2021-02-11 17:13:46.550211
28	0.0003125	2021-02-11 17:13:47.577548
29	0.0003125	2021-02-11 17:13:48.047809
30	0.0003125	2021-02-11 17:13:48.658571
31	0.0003125	2021-02-11 17:13:49.711148
32	0.0003125	2021-02-11 17:13:50.764295
33	0.0003125	2021-02-11 17:13:51.813566
34	0.0003125	2021-02-11 17:13:52.866578
35	0.0003125	2021-02-11 17:13:53.915232
36	0.0003125	2021-02-11 17:13:54.967087
37	0.0003125	2021-02-11 17:13:56.012668
38	0.0003125	2021-02-11 17:14:02.621114
39	0.0003125	2021-02-11 17:14:10.256313
40	0.0003125	2021-02-11 17:14:17.839851

Figure 5. SQL Database For Variable Load

Calculation

1 Pulse = (1/3200) kWHr

10 Pulse = (1/320) KWHr

Let time taken for 10 pulses be ‘t’ seconds, hence load can be

Power = energy/time

Load = ((1/320) KWHr) / (t/3600) Hr

Load = (3600/ (320*t)) KW

Load Connected = (11.25 / t) Kw

Where t is Time taken for 10 pulses

Three sample periods are selected and load during the sample period is calculated as given below.

Load$_{06-15}$ = (11.25/39.01) = ~290 Watts

Load$_{20-29}$ = (11.25/08.81) = ~1270 Watts

Load$_{41-50}$ = (11.25/77.48) = ~ 150 Watts

Pulse No.	Time of 1st Pulse	Time of 10th Pulse	Time for 10 pulses
6 → 15	17:12:39.66058	17.13.18.680454	39.019874 Sec
20 → 29	17:13:39.23123	17:13:48.047809	08.816579 Sec
41 → 50	17:14:25.38575	17:15:32.870398	67.484648 Sec

Time Interval	Pulse Count	Time in Seconds	Load Connected
0 → 10 minutes	601 - 4 = 597 pulses	600	1.119375 KW
0 → 5 minutes	303 - 4 = 299 pulses	300	1.121250 KW
5 → 10 minutes	601 - 303 = 298 pulses	300	1.117500 KW
0 → 3 minutes	184 - 4 = 180 pulses	180	1.125000 KW
6 → 9 minutes	540 - 361 = 179 pulses	180	1,118750 KW
1 → 2 minutes	122 - 63 = 59 pulses	60	1.106250 KW
9 → 10 minutes	601 - 540 = 61 pulses	60	1.143750 KW

Thus the variation in load was observed during this phase of testing.

3.4.6. Constant Load Testing

The test was conducted by connecting a constant load to the energy meter. The loads which we selected were an ‘induction stove’ and a ‘mixer Grinder’. The power rating of ‘mixer grinder’ was ‘450 watts’ and ‘induction stove’ could be used at a load of ‘100 - 1900 watts. A constant load was connected to energy meter for a period of time 5-10 mins. Average load is calculated for the entire time period and it is compared with avg. load at various intervals in that time period

Raspberry Pi stored the data in the SQL Server, and we took data from the server and cross verified it using our calculation. The average load is calculated for different time intervals within a particular sample period. 3 sample period were selected with time period of 10 minutes, 5 minutes and 3 minutes. This test shows that by taking any time interval the load calculated from the data collected is consistent for a constant load.

Average Load during different samples of time intervals during the first 10 minute of the Constant Load test is calculated as follows.

After calculating we found that the manually calculated load from the table and the load connected to the supply (An Induction Stove with rating of 1100 W) was equal. This proves the accuracy our project.

4.. Future Scope

The data collected from the energy meters can be used to train a machine learning model for more accurate load forecasting. A wide range of statistical analysis is possible with the help of collected data.

5 Conclusion

Even existing smart meters becomes outdated when a new generation of smart meters are introduced into the market. The existing smart meters are first generation of smart meters produced in India. Hence, the upcoming generation of smart meters will have more functionality and use cases. Until the forthcoming generations of smart meters are readily available in the Indian market, our idea of upgrading existing smart meters will be a more cost-effective solution for the smart metering system..

References

[1] Rahman IU "Smart Net Energy Metering System"Journal of Electrical and Electronics Systems,J Electr Electron Syst 2018, Vol 10.4172/2332-0796.1000285

[2] Milan Preet Kaur, Lini Mathew, Dr. Alokdeep and Ajay kumar "Implementation of Smart Metering Based on Internet of things" IOP Conference Series: Material Science and Engineering

[3] Qie Sun, Hailong Li, Zhanya Ma, Javier Campillo, Qi Zhang, Fredrik Wallin,Jun Guo "A Comprehensive review of smart energy meters in intelligent Energy Networks" published by IEE

[4] Naziya Sulthana,Rashmi N,Prakyathi NY,Bhavana,K B Shiva Kumar "Smart Energy meter and monitoring system using IOT Vol 8 Issue 14

[5] K.T Venkatraman,K.T Meenaabarna "Evolution of Smart Energy meter monitoring and billing using IOT Vol 8-Issue 06 Published on IJERT

[6] Brian R Kent "Science and computing with raspberry Pi"

[7] Anand Nayyar, Vikram Puri "Raspberry Pi-A Small, powerful, cost effective and efficient form factor computer : A review" Published on research-gate

[8] Leo Louis "Working principle of Arduino and using it as a tool for study and research" published on International journal of control, Automation, Communication and Systems

[9] Kuldeep Singh Kaswan, Santar Pal Singh, Shrddha Sagar "Role of Arduino in real world appliances" published in international journal of scientific & technology research vol 9 issue 01 January 2020

[10] Vladimir M Cvjetkovic, Milan Matijevic "Overview of Architectures with Arduino Boards as Building block systems" published in International journal of Online and Biomedical Engineering

[11] Leo Louis "Working principle of Arduino and using as a tool for study and research" published on International Journal of Control, Automation, Communications and systems vol 1 no.2 April 2016

[12] Sabah Al-Fedaghi "Developing Web applications" published on International journal of Software Engineering and its applications vol 5 no 2 April 2011

[13] Male S., Vethekar P. and Moore K. 2014 A Smart Wireless Electronic Energy Meter Reading Using Embedded Technology International Journal of Engineering Research and Application 4145-147 January

[14] Popa M. Data Collecting from Smart Meters in an Advanced Metering Infrastructure IEEE 15th International Conference on Intelligent Engineering Systems (INES) (Slovakia, 23 June 2011)137-142.

[15] Zualkernan Imran A., Al-Ali A. R., Jabbar Mustafa A., Zabalawi Imad and Wasfy Ahmed 2009 InfoPods: Zigbee-based remote information monitoring devices for smart-homes IEEE Transactions on Consumer Electronic

[16] Hai-xiang Zhao,Frédéric Magoulès , A review on the prediction of building energy consumption, Renewable and Sustainable Energy Reviews, Elsevier, August 2012

[17] Saika L.C., Das H., Choudhry N.B Dev and Malakar T. GPRS enabled smart energy meter and automation of home appliances IEEE Annual India Conference (Bangalore, December 2016) 1-5

[18] Li H., Gong S., Lai L., Qiu R. C. and Yang D. 2011 Efficient and Secure Wireless Communication for Advance Metering Infrastructure in Smart Grids IEEE Transactions on Smart Grid 3 1540 September

[19] Uzair Ahmed Rajput, Khalid Rafique, Abdul Sattar Sa and, Mujtaba Shaikh, Muhammad Tarique, Modeling of Arduino Based Prepaid Energy Meter using GSM Technology, International Journal of Advanced Computer Science and Applications, 9(5), 445-449, 2018

[20] R. Bhavani and S. Alagammal, Design and Implementation of GSM Based Smart Energy Meter for Home Applications, International Journal of Latest Trends in Engineering and Technology, 8(1), 431 439.