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DESIGNING AND IMPLEMENTATION OF SMART ENERGY METERING SYSTEM

Dr. Monika Gairola* , Aanya Garg# , Dr. Ravi Saxena*, Varija Pandey* , Riya Dimri*, Stuti Bhaguna*

** College of Technology , G.B.P.U.A.T, Pantnagar, Uttarakand, India*
 # RAN Public School, Rudrapur, Uttarakhand, India

***Abstract*:- The demand for power has grown exponentially over the last century, especially in countries like India where energy consumption is high and generation is insufficient to meet needs. This rising demand is driven by population growth and industrial expansion. One of the effective way to address today's energy challenges is by reducing energy usage in households. This has highlighted the need for accurate and cost-effective methods of power measurement. Currently,traditional energy meters used in households are offline devices where readings are taken manually and are provided monthly to consumers in the form of a bill showing kilowatt-hours (kWh) consumed. To improve this system, the smart energy meter is needed to develop a comprehensive system for measuring, monitoring, and controlling power and energy consumption. In addition to energy consumption, these smart energy meters provides detailed information about other parameters like voltage (v) , current (i), power (p) , power factor, and frequency. The developed system also allows monitoring of changes in various load parameters, facilitating optimal load management and implementing an automatic billing system. The measurement of all these parameters is facilitated by an Energy Chip. Real-time data collection and monitoring are also achieved using Excel Data Streamer. Raspberry Pi is used to transmit data to the cloud, enabling remote access and analysis through graphical representations of load parameter variations. Consumers can view their energy consumption on a 16X2 LCD display and receive alerts through an LCD screen and buzzer in case of overload conditions. The developed Smart Energy Meter system aims to enhance energy efficiency, helps consumers with real-time information and control, and contribute towards effective and reliable energy management in households.**

Keywords*- *Smart Energy Meter (SEM), Raspberry Pi, Energy Chip,Excel Data Streamer etc.

I. Introduction

In current power utility setups, consumers typically receive usage information only once a month with their bill. This infrequent feedback interval makes it so difficult for consumers to observe how changes in behavior affect their power usage. Due to this consumers are not able to use power efficiently. For instance, if consumers are able to see the power usage regularly, they become more careful in using the equipments and power efficiently. The ultimate goal of the present work is to increase the awareness among consumers for energy usage, leading to optimized consumption, reduced costs, and energy conservation.

To address the above issue , there is the requirement of an efficient system that provides real-time feedback on energy consumption in households. One such tool is PZEM-004T energy chip, that helps to measures power consumption, voltage, current, energy usage, power factor, and frequency. By integrating this chip with an Arduino Uno and an LCD display, a practical measurement tool can be developed. This setup not only inform users about their electricity usage but also alert them about the overloading conditions, thereby able to reduce the electricity consumption. The present work constitutes the design, fabrication and operation of Cloud Based Smart Metering and Load Management using Raspberry Pi which are playing important role in the effective energy management. These systems offer advantages such as preventing energy metertampering and ensuring fair usage of electricity. All in all, the implementation of advanced metering technologies and real-time monitoring tools can significantly enhance consumer awareness and management of energy consumption whichultimately lead to cost savings, energy efficiency, and conservation efforts. The architecture of Smart Energy Meter is shown in Fig.1.

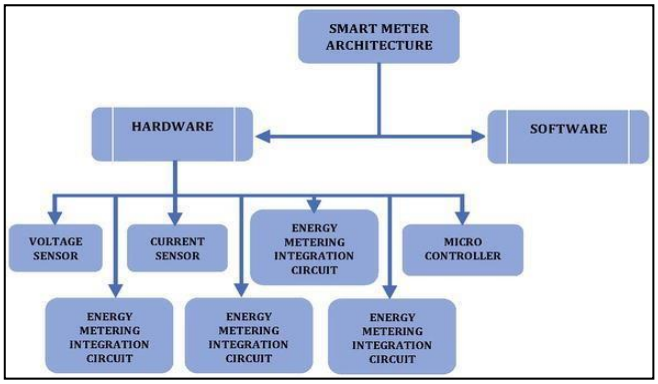
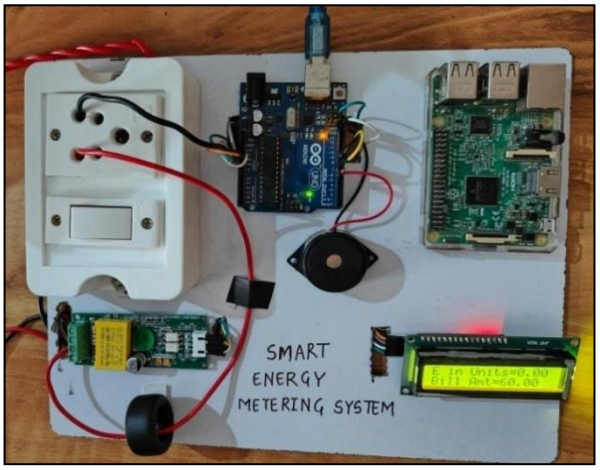


Fig.1. Smart Energy Meter Architecture

real-time stored data from Raspberry Pi is further sent to IoT analytics platform service "Things peak" that is used to graphically monitor data by just using mobile phone/computer at the click of a button. The complete experimental setup of SEM is shown in Fig.3. which shows the integration of different component.

Fig.3. Complete Setup of SEM



VI. Experimental Results

The software that is used in the present work is Arduino IDE and python 3. In order to get the correct results it is important to test the Energy chip in order to check whether the values of voltage and current obtained from Energy Chip (serial Monitor Output) is matching with the value of ammeter and multimeter or not. The testing setup of this is shown in Fig. 4.

Fig.4. Testing Setup of Energy Chip

Table 2. Comparison of Ammeter Current with Current using Energy chip

Sr. No	Serial Monitor Current	Ammeter Current
1	1.02 A	1.0 A
2	1.5 A	1.5 A
3	2.0 A	2.0 A
4	2.49 A	2.5 A
5	3.02 A	3.0 A

Table 3. Comparison of Multimeter Voltage with Voltage using Energy Chip

Sr No.	Serial Monitor Voltage	Multimeter Voltage
1	93.7 V	94.4 V
2	110.5 V	111.2 V
3	148 V	148.7 V
4	191.2 V	192 V
5	222.1 V	223 V
6	245.9 V	246.3 V

From Table 2 and Table 3 it is found that the output of Energy chip matches with that of Ammeter and Multimeter results.

The Data Sheet is generated by the transmission of the real time data from Arduino to Excel Data Streamer via serial communication. This data sheetis used to monitor the variation in different electrical parameters as shown in the table 4 below.

Table 4. Datasheet Generated

Data In (From Source)

Data coming from the current data source will appear below as it is received.

Current Data

Time	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
45:40.7	Voltage: 79.50V	Current: 1.63A	Power: 129.40W	Energy: 0.325kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	

Historical Data

Time	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
45:01.0	Voltage: 79.50V	Current: 1.63A	Power: 129.30W	Energy: 0.323kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:03.1	Voltage: 79.40V	Current: 1.63A	Power: 129.20W	Energy: 0.323kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:05.2	Voltage: 79.40V	Current: 1.63A	Power: 129.10W	Energy: 0.323kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:07.3	Voltage: 79.30V	Current: 1.63A	Power: 128.90W	Energy: 0.323kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:09.4	Voltage: 79.30V	Current: 1.63A	Power: 128.90W	Energy: 0.323kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:11.5	Voltage: 79.30V	Current: 1.63A	Power: 129.00W	Energy: 0.324kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:13.5	Voltage: 79.40V	Current: 1.63A	Power: 129.10W	Energy: 0.324kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:15.6	Voltage: 79.40V	Current: 1.63A	Power: 129.20W	Energy: 0.324kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:17.7	Voltage: 79.50V	Current: 1.63A	Power: 129.30W	Energy: 0.324kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:19.8	Voltage: 79.50V	Current: 1.63A	Power: 129.30W	Energy: 0.324kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	
45:21.9	Voltage: 79.50V	Current: 1.63A	Power: 129.30W	Energy: 0.324kWh	Frequency: 50.0Hz	PF: 1.00	Bill=61.02	

Data from the Arduino is also sent to the Raspberry Pi. This real-time stored data from Raspberry Pi is further sent to IoT analytics platform service called “Thingspeak” that is used to graphically monitor the parameters by using mobile phone or computer at the click of a button. The graphical results obtained are shown in Fig.5. below.

(a)

(b)

Fig.5. (a) and (b) Thingspeak Plots

VII. Conclusion

From the above experimental results it becomes clear that the smart meters are more efficient when compared with the conventional meters. They provide an efficient way of measuring electricity consumption in near real time. The future of smart energy metering systems using PZEM-004, Arduino, and Raspberry Pi is promising, with significant potential for innovation and impact. By leveraging advancements in data analytics, machinelearning, and IoT connectivity, these systems can offer enhanced predictive maintenance, detailed energy usage insights, and efficient load forecasting. Integration with smart grids will enable responsive demand managementand support the seamless incorporation ofrenewable energy sources. Due to t

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