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IoT Based Energy Meter with Measure Current, Voltage and Cost Monitoring

Poonam Sonyabapu Varpe[1], Pawar Archana Gorakshanath[2], Jadhav Pallavi Shankar[3], Jedgule Chhaya Jagan[4], V. S. Gadakh[5]
[1,2,3,4]*Student, Department of Electronics and Telecommunication Engineering, Amrutvahini Polytechnic, Sangamner, India*
[5]*Professor, Department of Electronics and Telecommunication Engineering, Amrutvahini Polytechnic, Sangamner, India*

***Abstract*: An automatic remote meter-reading system based on GSM is presented in this paper. This paper is useful to obtain meter reading when desired so meter readers don't need to visit each customer for the consumed energy data collection and to distribute the bill slips. Microcontroller can be used to monitor and record the meter readings. In case of a customer defaulter, no need to send a person of utility to cut-off the customer connection. Utility can cut off and reconnect the customer connection by short message service (SMS). Furthermore, the customer can check the status of electricity (load) from anywhere. In this system energy meter readings are being transferred by making use of GSM.**

***Keywords*: Smart Energy Meter (SEM), Automatic Meter Reading (AMR), Global System for Mobile (GSM), Short Messaging System (SMS).**

1. Introduction

Energy generation companies supply electricity to all the households via intermediate controlled power transmission hubs known as Electricity Grid. Sometime problems arise due to failure of the electricity grid leading to black out of an entire area which was getting supply from that particular grid. The project aims to solve this problem using IoT as the means of communication and also tackling various other issues which a smart system can deal with to avoid unnecessary losses to the energy procedures.

IoT smart energy grid is based on AT mega family controller which controls the various activities of the system. The system communicates over internet by using Wi-Fi technology. A bulb is used in this project to demonstrate as a valid consumer and a bulb to demonstrate an invalid consumer. The foremost thing that this project facilitates is reconnection of transmission line of active grid. If an energy grid becomes faulty and there is an another energy grid, the system switches the transmission lines towards this grid thus facilitating an interrupted electricity supply to that particular region whose energy grid went OFF. And this information of which grid is active updated over IoT Gecko webpage where the authorities can login and can be the updates. Apart from monitoring the grid, this project has the advance capabilities of monitoring energy consumption and even detects theft of electricity. The amount of electricity consumed and the estimated cost of the usage gets updated on the IOT Gecko webpage along with the Energy Grid information. Theft conditions are simulated in the system using two switches.

Switching one each time will simulate a theft condition and also will notify the authorities over the IOT interface. In this way, the Smart Energy Grid project makes sure that the electricity supply is continuous and helps in maintaining a updated record of consumption and theft information which is quite a valuable information for the energy producing companies. remote distance GSM communication system is much efficient than others. Auto billing is one of the suitable ways to overcome the flaws of conventional billing; since conventional billing contains wastage of time and resources as well. In auto billing there is no more need of manual meter reading and bill slips.

2. Problem Definition

1. Avoid the possibility of hacking the system, and basically, taking free electricity.
2. To prevent meter tempering.
3. Real-time Models and design methods describing reliable interworking of heterogeneous systems (e.g. technical/ economical/ social/environmental systems).
4. To reduce the human efforts, and to cut the power automatically if the bill is not paid.

3. Aim of Project

Sometime problems arise due to failure of the electricity grid leading to black out of an entire area which was getting supply from that particular grid. The project aims to solve this problem using IOT as the means of communication and also tackling various other issues which a smart system can deal with to avoid unnecessary losses to the energy procedures.

4. Objectives

1) Industrial data transmission, storage and distributed

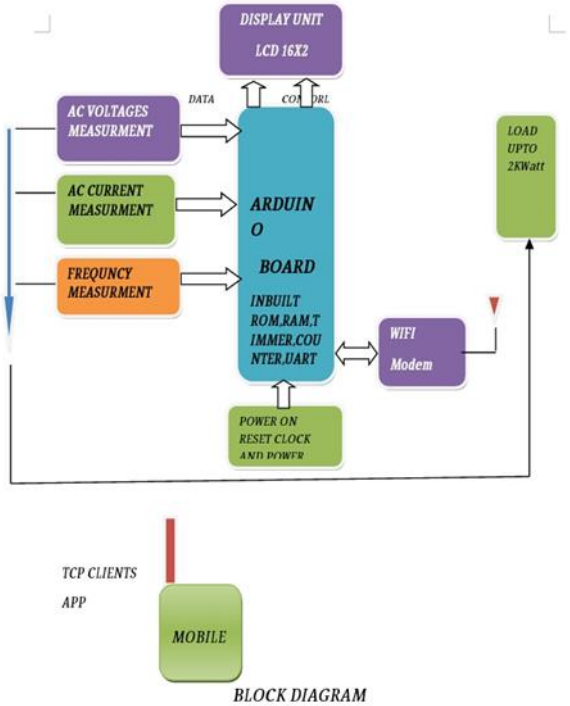
processing.
2) Remote monitoring and automation of the substation.
3) Near-real-time visualization and profiling from the smart grid.
4) Overall digitalization of the power engineering enterprises.

5. Flows in conventional billing

There are many flaws and errors in conventional billing. Some human mistakes may also occur in manual billing. Analyzing the conventional billing some of the common observed errors and mistakes are:

- There is always a chance of human error while taking the manual meter reading.
- There is no check and balance and verification procedure of this meter reading.
- There is always a chance of theft and corruption.
- Extra human power is required.
- Consumer is not updated of his usage.
- Consumer may not get the bill slip within due date.
- It's a time consuming procedure

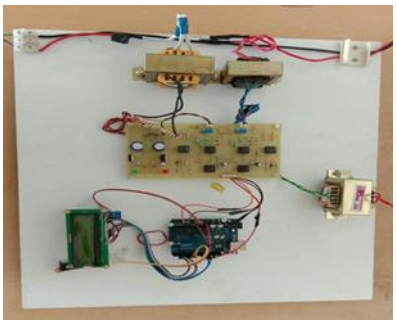
6. IoT based energy meter



BLOCK DIAGRAM

The size of IoT based meters and traditional meters is same and smart meters are digital. IoT based energy meter measures more detailed readings than Kwhr so that utility can plan the expansion of network and power quality.

The IoT based Energy Meter is designed so that it measures voltage and date it's currents by the use of voltage and current sensors instead of potential and current transformers and then feeds these values of voltage and current into power factor controller IC and energy metering IC the power factor and power calculations respectively.



The design of IoT based Energy Meter involves the measuring of load current and voltage using sensors and then feeding them to energy metering IC which converts it into the real power consumed by the load. Power factor is measured by measuring the phase shift between voltage and load current. Microcontroller used to perform the calculations related to power and energy consumed and shows the reading on LCD as well as it sends the reading of IoT based Energy Meter with the help of Arduino board. Power, voltage, load current, power factor and units (kWh) are measured and displayed successfully. Meter reading are sent from Arduino board and received on mobile successfully. Two-way communication is done by IoT based energy meter between the meter and utility administration as well as between meter and customer so that customer is able to check the status of his consumed energy units and can manage his load accordingly to reduce his bill. The main features of smart energy meter are listed as follows;

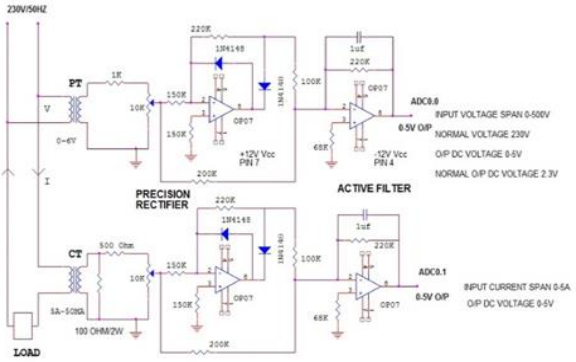
- Get automatic reading of Energy Meter and sent it to consumer as well as to utility.
- In reading it measures Voltage, Load Current, power, Power factor and units consumed.
- Utility is able to cutoff/restore the supply of the defaulter through SMS.
- Measuring energy meter reading any time we want through the use of SMS i.e. energy meter responds to the message and send u reading whenever it is asked.
- Consumer is able to check the status of his load from anywhere in the world by SMS.

7. Working of IoT based energy meter

IoT based communications network is used to transfer the electricity consumed data to the utility administration as well as to the customer when demanded. Antenna, attached on or near meter box, can be used for improvement of signal strength in GSM communication.

Smart metering communication is centralized meter reading, so meter readers don't need to visit each customer for data collection. However, for testing and maintenance meters may need to observe occasionally. The main duty of Energy Meter is to measure the meter reading and sends it to utility when

demand as well as to costumer. The voltage and current sensors measure the RMS values of voltage and current and feed them to microcontroller, where calculations for active and reactive power are performed. In Smart Energy Meter we used sensors to measure voltage and current instead of current and voltage transformers.



The reading from Utility administration SMS is being received by smart energy meter programmable interface and the action is performed by the meter according to provided information.

A major feature of Energy Meter is that utility company can cut off and reconnect the connection of energy of any user with the help of SMS without sending the person to perform the task manually [15]. It can be utilized in case when the utility company needs to disconnect a consumer due to nonpayment of bills or some other reasons. Another major feature of energy meter is that it gives alarm when the consumer load is exceeding the upper limit for which he got the utility connection. In case consumer does not reduce his load meter automatically cut off the consumer connection. IOT based communications network is used to transfer the electricity consumed data to the utility administration as well as to the customer when demanded. Antenna, attached on or near meter box, can be used for improvement of signal strength in IOT based communication.

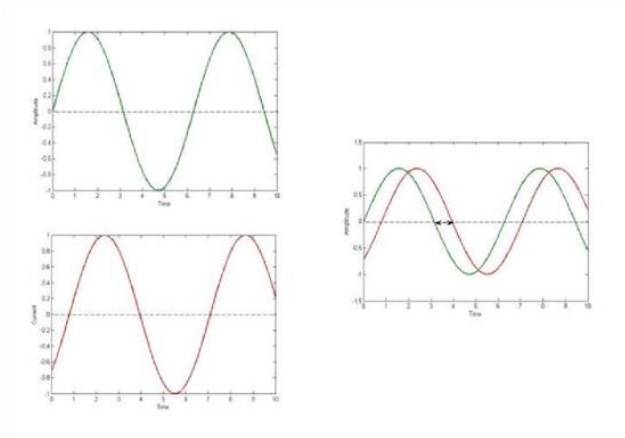
8. Main parts of IOT based energy meter

Smart Energy Meter is comprised of three main parts:

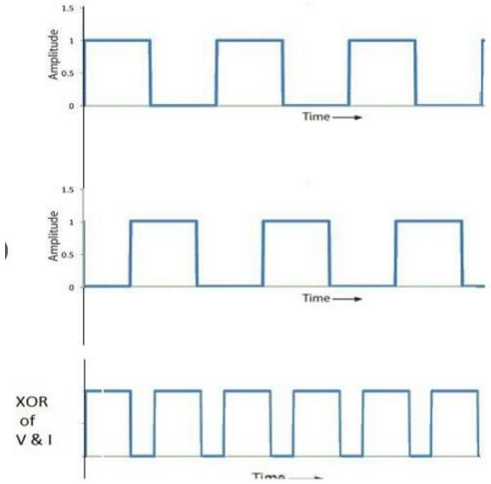
A. Voltage and current measurements
B. Power factor measurements

A. Voltage and current measurements.

In this work, a current and voltage sensor is used to measure voltage and load current. We used ACS712ELC-20A as current sensor that gives us RMS value of currents. Both AC and DC signals current measurement is precisely obtained by this current sensor. Current is measured by this sensor up to 20A. Overall power consumption, metering and measurements are taken by these sensors. Sensitive measurements of current are handled by using OPAMP stage. By adjusting the gain, we measure very small currents. ACS712ELC-20A output voltage has linear variation with measured currents. Similarly, we measured voltage by ACS712ELC-20A.



Sinewave of voltage and current and showing the phase shift difference between voltage &current.



Square wave of voltage and current and their resultant after XOR operation

B. Power factor measurements.

Power factor is the cosine of angle between voltage and current. It actually measures how effectively the power is being converted into useful work. In our project we measured it by taking XOR of voltage and current waves with the help of microcontroller and LM358. We used LM 358 to convert weak sinusoidal signals to large square signals.

After XOR we get signal of double frequency as shown in figure 4 (c). We calculated the time of XOR signal and it is the power factor. For 50Hz the output of XOR can be 10 ms if power factor is 0. And "0" if power factor is unity. So the output of XOR lies between 0 -1 for a certain value of power factor.

C. Advantages

1. More efficient transmission of electricity.
2. Quicker restoration of electricity after power disturbances.
3. Reduced operations and management costs for utilities, and ultimately lower power costs for consumers.
4. Time saving technology.
5. Tamper detection to reduce electricity theft.
6. Energy saving robust and reliable smart sensors/actuators.

7. Absolutely safe and secure communication with elements at the network edges.

D. Disadvantages

1. Exposure of sensitive customer data.
2. Connectivity to untrustworthy partners that cannot be selected.
3. Exposure of critical infrastructure due to connectivity reasons.
4. Introducing malicious software, compromised hardware could result in denial of service or security threats.
5. Biggest concern: Privacy and Security.
6. Some types of meters can be hacked.

E. Application

1. Society
2. Industry

F. Specification of project

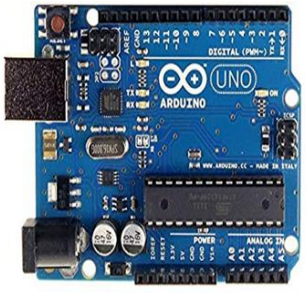
1) Hardware Specifications

- ATmega328P AVR MC- Buy ATmega328P Online
- Current Sensor
- Voltage sensor
- ESP8266 Wi-Fi Module – Buy Wi-Fi Module Online
- LCD's – Buy LCD Online
- Crystal Oscillator – Buy Crystal Oscillators Online
- Resistors – Buy Resistors Online
- Capacitors – Buy Capacitors Online
- Transistors – Buy Transistors Online
- Cables & Connectors – Buy Cables & Connectors Online
- Diodes – Buy Diodes Online
- PCB – Buy PCB & Breadboards Online
- LED's – Buy LED Online
- Transformer/Adapter – Buy Transformers & Adapters Online
- Push Button – Buy Buttons & Switches Online Load (Lamps)

2) Software Specifications

- IoTGecko
- Arduino Compiler
- MC programming language: C

G. Arduino



The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. "Uno" means one in Italian and was chosen to mark the release of Arduino

Software (IDE)1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards.

Technical specifications of Arduino board,

1. Microcontroller ATmega328P
2. Operating Voltage 5V
3. Input Voltage (recommended) 7-12V
4. Input Voltage (limit) 6-20V
5. Digital I/O Pins 14 (of which 6 provide PWM output)
6. PWM Digital I/O Pins 6
7. Analog Input Pins 6
8. DC Current per I/O Pin 20 mA
9. DC Current for 3.3V Pin 50 mA
10. Flash Memory 32 KB (ATmega328P) of which 0.5
11. KB used by boot loader
12. SRAM 2 KB (ATmega328P)
13. EEPROM 1 KB (ATmega328P)
14. Clock Speed 16 MHz
15. Length 68.6 mm
16. Width 53.4 mm
17. Weight 25 g.

9. Testing and results

The accuracy of IoT based Energy Meter is checked by comparing the readings that are displayed on the LCD of SEM and that are received by SMS. IoT Energy Meter is also checked by connecting and disconnecting the customer's connection. We connected different loads 100W, 200W, and 1000W and checked its performance.

10. Conclusion

The project describes the design and working of IoT. Energy Meter and represents how Smart Energy Meter can be used for Automatic Meter Reading. It is the most Economical

implementation to develop mankind in this era of technology. With the present enhancement in the use of technology to facilitate mankind, it is an efficient and practical utilization of present networks. This paper also shows that how customer can manage the load by using Smart Energy Meter. It provides ease in taking the meter readings, accuracy, detection of faulty conditions, power factor calculation, less operation cost and removal of possible corruption related to meter reading.

11. Future recommendations

I thought there are few possibilities which can also be done on this project in future as I have provided flexibility in the project especially in controller section. The future research should include the proper methodology for measuring the power factor of the load.

Recommendations for future are as follows:

- Power factor must be measured by different techniques.
- Smart energy Meter can be modified for the detection of illegal use of electricity.

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