IoT based Smart Power Grid Monitoring and Control using Arduino

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Abstract - *This project describes the digitization of load energy usage readings over the internet. The proposed system design eliminates the involvement of human in electricity maintenance. The user can monitor energy consumption in watts from a webpage by providing a channel id for the load. The Webpage utilizes the THINGSPEAK analytics to analyze the energy usage to give more detailed description and visualization of the energy usage statistics. Wi-Fi unit performs IOT operation by sending energy data of the load to the webpage which can be accessed through the channel id of the device. In the proposed system, consumer can do power management by knowing energy usage time to time. This proposed system utilizes an Arduino microcontroller. The unit which is generated can be displayed on the webpage through the Wi-Fi module.*

Smart grid is one of the features of smart city model. It is energy consumption monitoring and management system. Smart grids are based on communication between the provider and consumer. One of the main issues with today's outdated grid deal with efficiency. The grid becomes overloaded during peak times or seasons. It is also possible to hack the system, and basically, take free electricity. By using smart grid consumer and owner get daily electricity consumption reading and owner can cut electricity supply remotely through internet if bill is not paid. One more thing, the data collected from the smart meters should not be accessed by any unauthorized entities. In case meter tempering is happened then owner and consumer get message and then owner take the action accordingly. Fitting the circuit on customer's energy meter, from that energy consumption data can be acquired. After acquiring of data, that data can be updated on cloud service, so that consumer and provider can access that data through internet.

***Key Words*: Arduino Uno Board, ESP 8266 Wi-Fi Module, 16*2 LCD Display, Current Sensor.**

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.

2. LITERATURE SURVEY

One year after the past edition of the Cluster book 2012 it can be clearly stated that the Internet of Things (IOT) has reached many different players and gained further recognition. Out of the potential Internet of Things application areas, Smart Cities (and regions), Smart Car and mobility, Smart Home and assisted living, Smart Industries, Public safety, Energy environmental protection, Agriculture and Tourism as part of a future IoT Ecosystem have acquired high attention. In line with this development, the majority of the governments in Europe, in Asia, and in the Americas consider now the Internet of Things as an area of innovation and growth. Although larger players in some application areas still do not recognized the potential, many of them pay high attention or even accelerate the pace by coining new terms for the IoT and adding additional components to it. Moreover, end-users in the private and business domain have nowadays acquired a significant competence in dealing with smart devices and networked applications. As the Internet of Things continues to develop, further potential is estimated by a combination with related technology approaches and concepts such as Cloud computing, Future Internet, Big Data, robotics and Semantic technologies. The idea is of course not new as such but becomes now evident as those related concepts have started to reveal synergies by combining them.

However, the Internet of Things is still maturing, in particular due to a number of factors, which limit the full exploitation of the IOT. Among those factors the following appear to be most relevant

-No clear approach for the utilization of unique identifiers and numbering spaces for various kinds of persistent and volatile objects at a global scale.
-No accelerated use and further development of IOT reference architectures.
-Less rapid advance in semantic interoperability for exchanging sensor information in heterogeneous environments.
-Difficulties in developing a clear approach for enabling innovation, trust and owner ship of data n the IOT while at the same time respecting security and privacy in a complex environment.
-Difficulties in developing business which embraces the full potential of the Internet of Things.
-Missing large-scale testing and learning environments, which both facilitate the experimentation with complex sensor networks and stimulate innovation through reflection and experience.

1], presents the implementation of an energy meter which is based on non-invasive current sensing. Noninvasive current sensing has the advantage that it can be placed at any point where the power is to be measured. The energy consumption details in this case are displayed on a smart phone. ENC28J60 Ethernet module was used to send data over the internet. S.H Ju et.al [3] have devised an automatic meter reading device (AMR) based on power line communication (PLCC). PLCC involves sending data over the electrical wiring cables. This possibility requires appropriate modification in the domestic wiring of house. Moreover, it uses invasive technique to sense the current from the mains. The disadvantage with this kind of a system is that the user cannot measure the power consumed by an individual device.

[2], explains the implementation of a wireless automatic meter reading system (WAMRS) which incorporates the widely used GSM/GPRS network. The system includes a microcontroller, which periodically transmits power consumption values calculated from the sensed voltage and current values via an existing GSM/GPRS network, to a master station. The main disadvantage of this technology is distance factor. A strong GPRS or a GSM network coverage at long distances may not be available whereas the other disadvantage might be speed of operation.

2. SYSTEM OVERVIEW

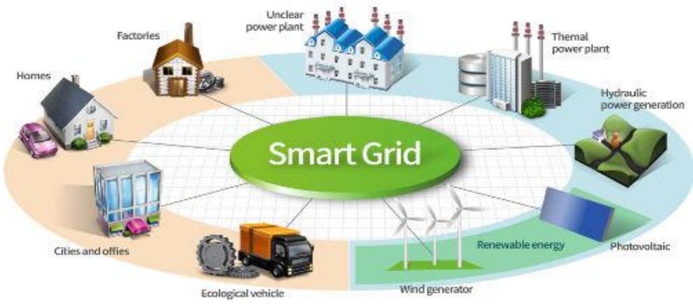

Fig -1: **Smart grid representation.**

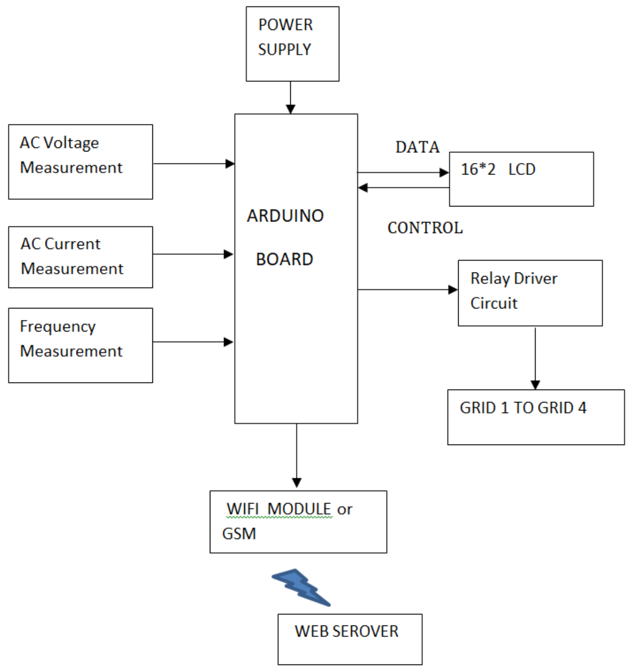

Fig -2: **Block Diagram of System**

Arduino UNO R3: In addition to all the features of the previous board, the Uno now uses an ATmega16U2 instead of the 8U2 found on the Uno (or the FTDI found on previous generations). This allows for faster transfer rates and more memory. No drivers needed for Linux or Mac (inf file for Windows is needed and included in the Arduino IDE), and the ability to have the Uno show up as a keyboard, mouse, joystick, etc. The Uno R3 also adds SDA and SCL pins next to the AREF. In addition, there are two new pins placed near the RESET pin. One is the IOREF that allow the shields to adapt to the voltage provided from the board. The other is a not connected and is reserved for future purposes. The Uno R3 works with all existing shields but can adapt to new shields which use these additional pins. The Arduino Uno is a microcontroller board based on the ATmega328. Arduino is an open-source, prototyping platform and its simplicity makes it ideal for hobbyists to use as well as professionals. The Arduino Uno has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, 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 Arduino Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 microcontroller chip programmed as a USB-to-serial converter.

Features of the Arduino UNO:

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

LIQUID CRYSTAL DISPLAY: This is the first interfacing example for the Parallel Port. We will start with something simple. This example doesn't use the Bi-directional feature found on newer ports, thus it should work with most, if not all Parallel Ports. It however doesn't show the use of the Status Port as an input for a 16 Character x 2 Line LCD Module to the Parallel Port. These LCD Modules are very common these days, and are quite simple to work with, as all the logic required running them is on board.

ESP8266 Module*:* The ESP-01 ESP8266 Serial WIFI Wireless Transceiver Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever-growing, community.

This module has a powerful enough onboard processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime.

Signal Cond. Block of voltages and current*:* While measuring voltages and current with the help of microcontroller, proportional DC analog voltage is applied to its ADC. Initially AC voltages or current (step down) by CT or PT, which is converted into DC. Capacity of CT and PT will depend upon load handling capacity and mains supply available. In our project work 5A/50 ma CT is used to sense the load current, which is connected in series with load. 230V to 6V or 9V or 12V PT may be used to measure the voltage. If input voltage is greater than 300V then special PT is used to withstand for 440V.

Current capacity of PT is not important. Current capacity of PT up to 300 ma is suitable. In case of PT voltages ratio of primary and secondary is linear. In case of CT current ratio is important. Secondary current is directly proportional to primary current. Current ratio will depend upon the number of turns for secondary and primary. The maximum secondary current will decide the value of Burdon resistor and required voltage across Burdon resistor.

4. ADVANTAGES AND DISADVANTAGES

Advantages*:*

- More efficient transmission of electricity.
- Quicker restoration of electricity after power disturbances.
- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers.
- Time saving technology.
- Tamper detection to reduce electricity theft.

Disadvantages*:*

- Exposure of sensitive customer data.
- Connectivity to untrustworthy partners that cannot be selected.
- Exposure of critical infrastructure due to connectivity reasons

5. CONCLUSION

A revolution in energy domain is underway, namely the Smart Grid. Smart Grid is owner as well as user friendly technology. User can check daily consumption from any location using internet. Owner can control customer meter from control unit. Smart grid represents one of the most promising and prominent internet of things applications. More efficient transmission of electricity. Quicker restoration of electricity after power disturbances. Reduced operations and management costs for utilities, and ultimately lower power costs for consumers. Time saving technology. Control on Meter tempering.

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