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# ENERGY MONITORING SYSTEM

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**Abstract—** *As the world is developing at a rate of speed of light, this development is causing more and more usage of energy. This need of energy will only increase in future as the population is growing too. This will need a backbone to support and that is the tracking of consumption of energy and management. So, we thought of creating a system to keep the track of every load or home appliance in the place. This system will be the advanced version of other metering system, consisting of Arduino, Relay and Current Sensor. The methodology followed to analyze the data of energy consumption is all based on studying the switching patterns of load using IoT. By this way we can bring down the human efforts of stealing the energy for personal uses. It can also be used for efficient use of the energy produced from renewable sources. As a result, we will be getting a meter that can keep track of power consumption of our household as well as any place like offices, malls, etc.*

***Keywords: Energy Theft; Arduino NANO; Microcontroller; Cloud; Current Sensor ACS712.***

## 1. INTRODUCTION

As the electricity has been used for domestic and commercial purposes, the irregularities and power consumption in the system has been observed throughout the world. A normal electrical meter only measures the total power consumption but does not give the information about each and every device's energy consumption. Even malpractices like "Electricity theft" cannot be detected using an existing meter.

With the advent of smart meter, data analysis has become possible and the frequency of collecting household energy consumption has increased. Utilities incur great financial losses due to electricity theft. According to the World Bank estimates, power theft reduces India's GDP by around 1.5%. A recent study by the NDTV also concluded that 40% of the electricity in India is still unpaid. Of all the power generated in the country, around one fourth is either stolen or lost in transmission. There are popular methods to detect energy theft but where there is a complete bypass of meters then these methods become useless. In such cases, energy calculated at the distributing transformer or supplier and the user gives a loss which cannot be determined by a normal meter. For these reasons our energy meter came into the picture. It can directly tell user the total power consumption at their household and when at the end the bill is generated from the supplier, the user can compare the losses by themselves.

In our project we have tried a different approach towards already existing smart meter, we have added a current sensor which is further connected to relays of different loads, which will divide every load at user preferable place and at the end it will provide a database for individual loads. This can help the user understand the power consumption per unit time of each load or device at the house or office, so that management of energy can be done by proper and necessary use of appliances. Along with this, the energy consumption parameters of each individual appliance will be sent to server where an intelligent algorithm will be running to manage all the appliances as per user requirements. The user can monitor the energy parameters of each individual load using an android smartphone which will also work as a controller to switch On/Off the loads. Also in near future world will be shifting to renewable sources in some places the production will be limited due to climatic changes .Hence there is a need of a system which will help us to monitor and maintain our consumption. Applications for this system include workstations, office and home entertainment systems.

## 2. BLOCK DIAGRAM AND SYTEM DESIGN

The system design is based on three main parts; Energy metering system, Cloud (or Server) and an Application based interface.

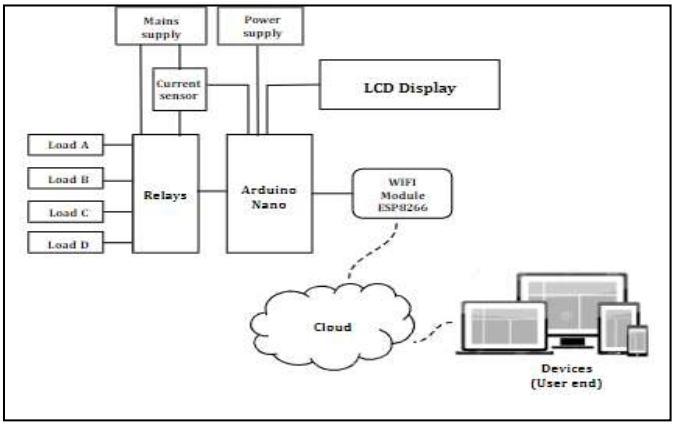



**Fig- 1**: Block diagram of energy monitoring system

An electrical meter is a device that measures the amount of electrical energy consumed by a household or any commercial building or area. It is installed at the user's premises so that units of energy can be counted for billing purposes. There are many types of energy meters like; electromechanical induction type energy meter, electronic energy meter (Analog meters and Digital meters) and Smart

energy meters. This system consists of Relays, Current sensor IC, Arduino Nano, and ESP8266 Node MCU, Mains, Power supply and Loads that we have used.

### 2.1. MICROCONTROLLER: ARDUINO NANO

A microcontroller is a compact Integrated circuit in the system. It controls functioning of embedded systems. The microcontroller that we have used is known as "Arduino NANO", contains a small chip of atmega328. Shown in Fig - 2. The Arduino does not have a separate piece of hardware in order to load new code onto the board, you can simply use a USB cable to upload, and the software of the Arduino uses a simplified version of C++.[5]

The Current sensor connected will transmit the raw data to the Arduino Nano. Here these values will be processed. It is required to analyze multiple factors of a household application's usage (May it be a refrigerator, air conditioner, television, etc.). These factors are: voltage, current, active power, apparent power, reactive power, power factor and frequency of respective appliance.

Basic Features

- It has 22 input/output pins in total.
- 14 of these pins are digital pins.
- Arduino Nano has 8 analogue pins.
- It has 6 PWM pins among the digital pins.
- It has a crystal oscillator of 16MHz.
- It has an operating voltage that varies from 5V to 12V.
- It also supports different ways of communication, which are: Serial, I2C, and SPI Protocol.

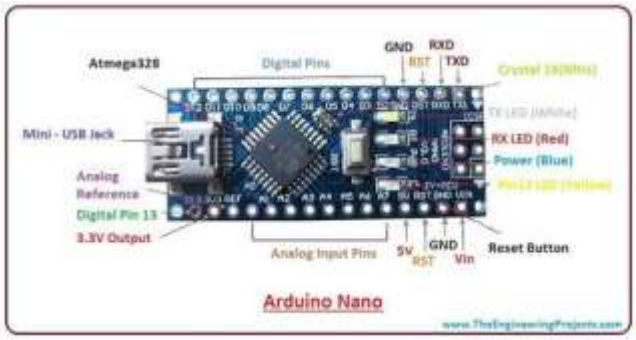



**Fig- 2**: Arduino NANO

### 2.2. CLOUD-GOOGLE FIREBASE

We have used the Google firebase software to create a cloud or a server for our application shown in Fig 3. Google Firebase is Google-backed application development software that enables developers to develop iOS, Android and Web apps. Firebase provides tools for tracking analytics, reporting and fixing app crashes, creating marketing and product experiment. The server and application is linked together for the user to access the energy usage, as well as to control it. Fig d shows the server we created, for this purpose we used the Node MCU, so that the phone Application can be connected to the server.

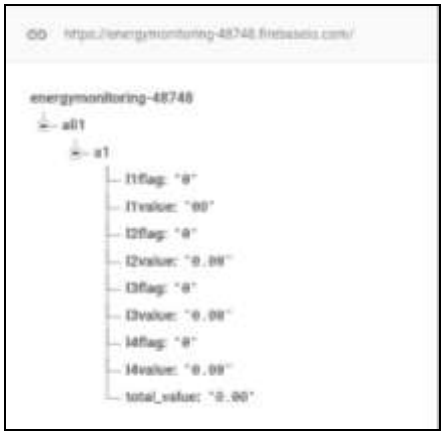



**Fig-3**: Firebase Google server

Some features of Firebase are:

- Firebase gives you functionality like analytics, databases, messaging and crash reporting so you can move quickly and focus on your users.
- Firebase is built on Google infrastructure and scales automatically, for even the largest apps.
- Firebase products work great individually but share data and insights, so they work even better together

### 2.3. APPLICATION BASED INTERFACE

An android application is designed which is responsible for reading the data from the server. The placement can be better understood by the diagram from Fig a.

We have designed an Application for the user, so that appliances or loads can be personally managed by the user even from outside their houses. This application provides user with the different values of power on their mobile phone. The Application named "Energy monitoring", was designed using Android studio shown in Fig 4 below.


**Fig- 4**: App

## 3.SCHEMATIC DAIGRAM

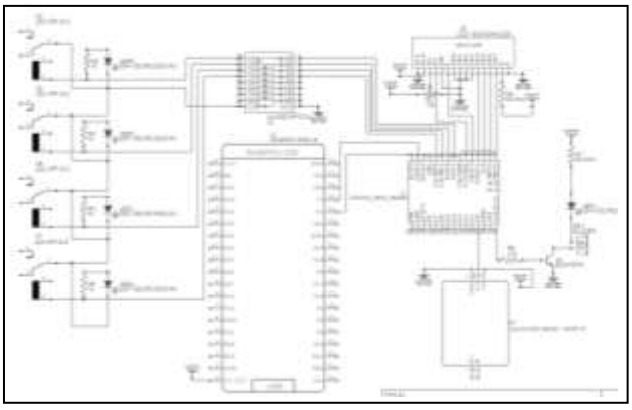


**Fig- 5**: Schematic Diagram

### 3.1. ACS712 Current Sensor

The Allegro ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device consists of a precise, low-offset, linear Hall Effect sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage.

Specifications

- Measures both AC and DC current
- Available as 5A, 20A and 30A module
- Provides isolation from the load
- Easy to integrate with MCU, since it outputs analog voltage
- Total output error 1.5% at TA = 25°C, and 4% at –40°C to 85°C
- 1.2 mΩ internal conductor resistance
- 5.0 V, single supply operation

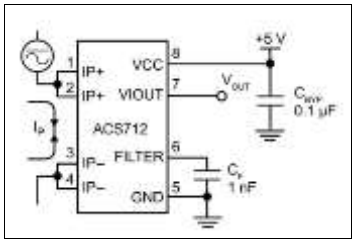



**Fig- 6**: ACS712 Model and pin diagram

### 3.2. Wi-Fi Module ESP826628

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

We are using this module to get values from Arduino to the user through an application on their respective phones.

Features

- 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2),
- General-purpose input/output (16 GPIO),
- Inter-Integrated Circuit ($I^2C$) serial communication protocol and Serial Peripheral Interface (SPI) serial communication protocol
- Analog-to-digital conversion (10-bit ADC)
- UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and
- Pulse-width modulation (PWM).

### 3.3. LCD

We used 16x2 LCD, it is named so because; it has 16 Columns and 2 Rows as shown in Fig h. Some features of this LCD are given below:

- Operating Voltage is 4.7V to 5.3V
- Current consumption is 1mA without backlight
- Alphanumeric LCD display module, meaning can display alphabets and numbers
- Consists of two rows and each row can print 16 characters.
- Each character is built by a 5×8 pixel box
- Can work on both 8-bit and 4-bit mode
- It can also display any custom generated characters
- Available in Green and Blue Backlight
- Takes only digital inputs.

**Fig- 7**: LCD Display

### 3.4. LOADS

The table given below is the list of loads we have used for experiment purpose. It contains power ratings of each device we have used to compare experimental and ideal values.

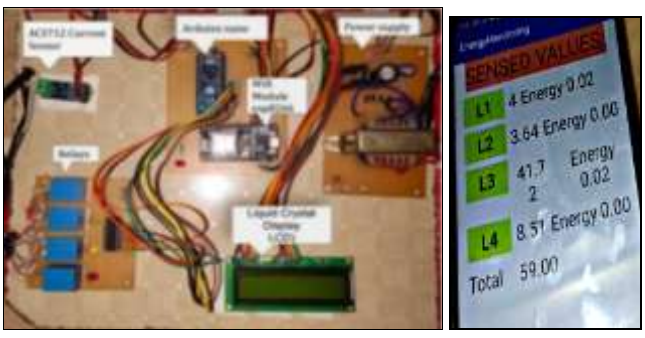
| Sr. no | Name of load | Type | Max current drawn | Power factor | Power |
|---|---|---|---|---|---|
| 1. | LED Bulb | R | 0.04mA | 1 | 10W |
| 2. | Bulb | R | 0.4347mA | 1 | 100W |
| 3. | Halogen lamp | R | 2.17A | 1 | 500W |
| 4. | Cabin fan | RLC | 0.304mA | 0.8 | 70W |

**TABLE -1.** Types of Loads

## 4. IMPLEMENTATION RESULTS

After proper study of each and every type of hardware and software out there, we started working on this design. Not only it is user friendly but the manufacturing of this system will be handy and the modifications that can be done in future with this device is quite immense.

The Households are supplied with 220V/230V, 50Hz AC; let us consider it as Main supply. The Power supply is also switched on at the same time for our System to work which is negligible. A current sensor of 30A current handling capacity is connected to the live wire coming from the mains. Live and neutral wires will be connected to our Loads or Appliances via Relay. This relay is connected to the Driver IC. Our system uses basic signals from current sensor. In the sensor the applied current flowing through a copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. A precise, proportional voltage is provided by the low-offset, to the Arduino. For every separate load we have used the relay, as it will act as switch. The driver is connected between the Relays and arduino to amplify the input signals from the arduino. Now these relays will be operating with a little technological help called IoT. When a load is on current sensor will sense the current and send the value to arduino. Now the embedded code will come in part and the current sensed will be converted to power using the formula P=V*I*cos (φ) and sent to server. For example if one load say a cabin fan is switched on by the user, as soon as this is done the server will receive the values by the Arduino, through our Wi-Fi model (Node MCU). Power consumed will be displayed on the LCD, as well as the application build inside the user's phone will display power consumed and utilization of energy if the load in on for a specified time instance(eg.3hrs ie.180 min). As we go on switching on different loads the energy used by each load will be displayed respectively with proper annotations with an intelligent algorithm. This real time data can be accessed anywhere, even from outside the house. This meter also helps to control the switch of any Load via Phones that will have our in build Application. Final setup of Energy monitoring system is shown in Fig 8.




**a)** **b)**

**Fig- 8: a)** Energy Monitoring System setup
**b)** Main Page of App

## 5. CONCLUSION

The scheme here is to create a system which can measure the proper values for energy with minimal human errors. This technology will be compatible with the old as well as new metering systems. The applications of this technology in the near future are very likely to increase. The system involves wifi module for bidirectional communication. This is the best way of billing system that can exist today because the comparison of the server's data and user's data can be done and in this way if there is a loss in some way then we can have a solid proof of energy theft. This system enables to keep the track of the power consumption in the household or an office.

Some benefits of the energy meter includes, an end to estimated bills, which are a major source of complaints for many customer and tool to help consumers better manage their energy purchases, stating that our meters with a display inside the homes could provide real time information on electricity consumption and in doing so help people to manage their energy use and reduce their energy bills. Electricity pricing usually peaks at certain predictable times of the day and the season.

## REFERENCES

[1] Implementation of WiFi-based single phase smart meter for Internet of Things (IoT); Win Hlaing ; Somchai Thepphaeng ; VarunyouNontaboot ; NatthananTangsuna ntham ; Tanayoot Sangsuwan ; Chaiyod Pira; 2017 International Electrical Engineering Congress (iEECON); Year: 2017; Conference Paper; Publisher: IEEE.

[2] Badamasi, Y. A. (2014). The working principle of an Arduino. 2014 11th International Conference on Electronics, Computer and Computation (ICECCO). doi:10.1109/icecco.20142014.6997578

[3] Arduino Based Smart Energy Meter using GSM: Himanshu K .Patel, Tanish Mody , Anshul Goyal Year;2019 Publisher; IEEE

[4] Smart home energy management system including renewable energy based on ZigBee and PLC. Publisher: IEEE Transactions on Consumer Electronics, Vol. 60, No. 2, May 2014

[5] https://businesseconomics.in/power-theft-hits-india%E2%80%99s-gdp-hard

[6] www.allegromicro.com//media/Files/Datasheets/ACS724-5LMC-Datasheet.ash