Real-Time IoT Energy Monitoring System

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Abstract : In this paper, we describe an energy monitoring system that can monitor multiple appliances in a household measuring voltage, current, power individually. With the help of current sensors, the device can connect to a central microcontroller, and the gathered information can be uploaded and processed using Arduino. The data can then be displayed in the hosted webpage interface. The user interface allows users to access the data from any device with the link. To reduce cost the system requires energy metering nodes that can communicate with the microcontroller in such a way that only one WiFi access point is needed for a household containing many monitored appliances.

***Index Terms* – Microcontroller, nodemcu, current sensor, hosted webpage.**

I. INTRODUCTION

The main goal of our project was to develop a system which tracks each and every appliance at home and the user can acquire energy consumption parameters of all appliances. The user can monitor the energy parameters of each individual load using webpage which will also work as a data setter to set various user programmable parameters like high/low cutoff voltage, etc. By automatically turning off loads when not in use, the system can provide energy savings in homes, rented buildings, hotels and offices.

Considering rising electricity costs and global warming campaigns to reduce general electricity consumption, there is interest in analyzing electricity consumption in households. By analyzing the power consumption of each individual device separately, they can make more accurate decisions about their capacity and replacement requirements. Additionally, it can also determine whether an appliance takes unusually high power when switched off and whether to remove it. This can reduce electricity consumption and cost. Most conventional electric meters currently installed in homes display only the actual consumption of their energy and the amount of electricity used. There is no way to see what day, month, or month usage of these meters. Existing products are not capable of monitoring devices individually; hence hiding important information about personal devices.

II. METHODOLOGY

Electronic devices are an important part of our daily lives. Therefore, it is imperative to know how much energy our equipment consumes. To simplify this calculation, we use a real-time IoT power monitoring system. Since we need an Internet connection in homes, we consider microcontrollers that provide WiFi compatibility with the Arduino Mega and NodeMCU .

Whenever a new power event was detected (electronic device switched on), the Arduino board captures information such as microcontroller time, current value (current sensor), hours used, and how many times the device was switched on. The microcontroller converts the collected information into JSON (java objected notation) and then transmits it to the webpage (user interface). Figure. 1 shows an overview of our model of the hardware. The current sensor along with relay connects to appliances which sense the current variations. Temperature sensor and motion sensor were added on features to make it smarter in a household. The heart core of our system was microcontroller Arduino which gets connected to appliances. Then data gets passed to nodemcu (IoT board) which acts as a wifi module pushes the data to the server cloud and later on to the webpage interface. Now the user was able to saw the power/energy consumed by personal devices. The hosted webpage was designed to alert the user with a warning message when its tariff plan was about to change due to excessive energy consumption and identify the device was using normal power or overloaded. Moreover, it exhibits human's presence and senses temperature variations.

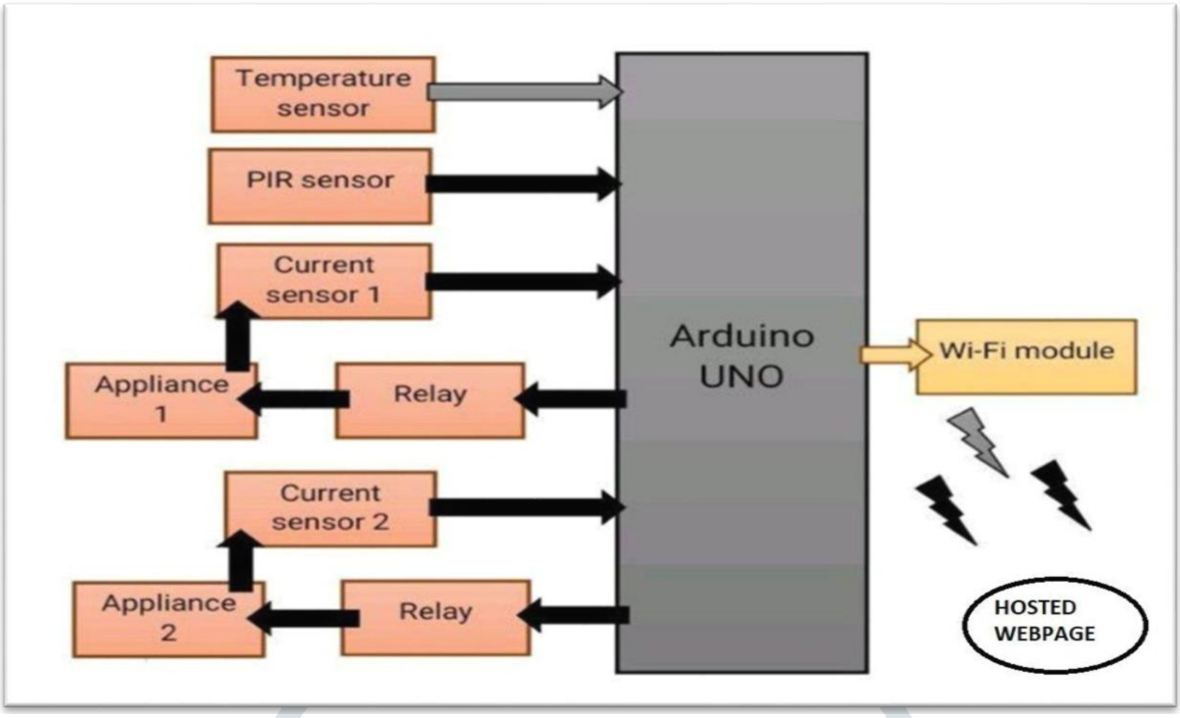

Figure 1: Block Diagram of the system

III. EXPERIMENTAL SETUP

The whole system was based on the power consumption monitoring of each and every appliance of our house. For this, the appliance of which the measurement was to be taken was considered first. Current sensors were connected across each appliance. The measurement taken by the current sensor system was given to the Arduino. The experimental setup was set up as shown in Figure 2. Each component was connected accordingly, including each pinned. The connections were made as such as to balance the circuit and its functioning's.

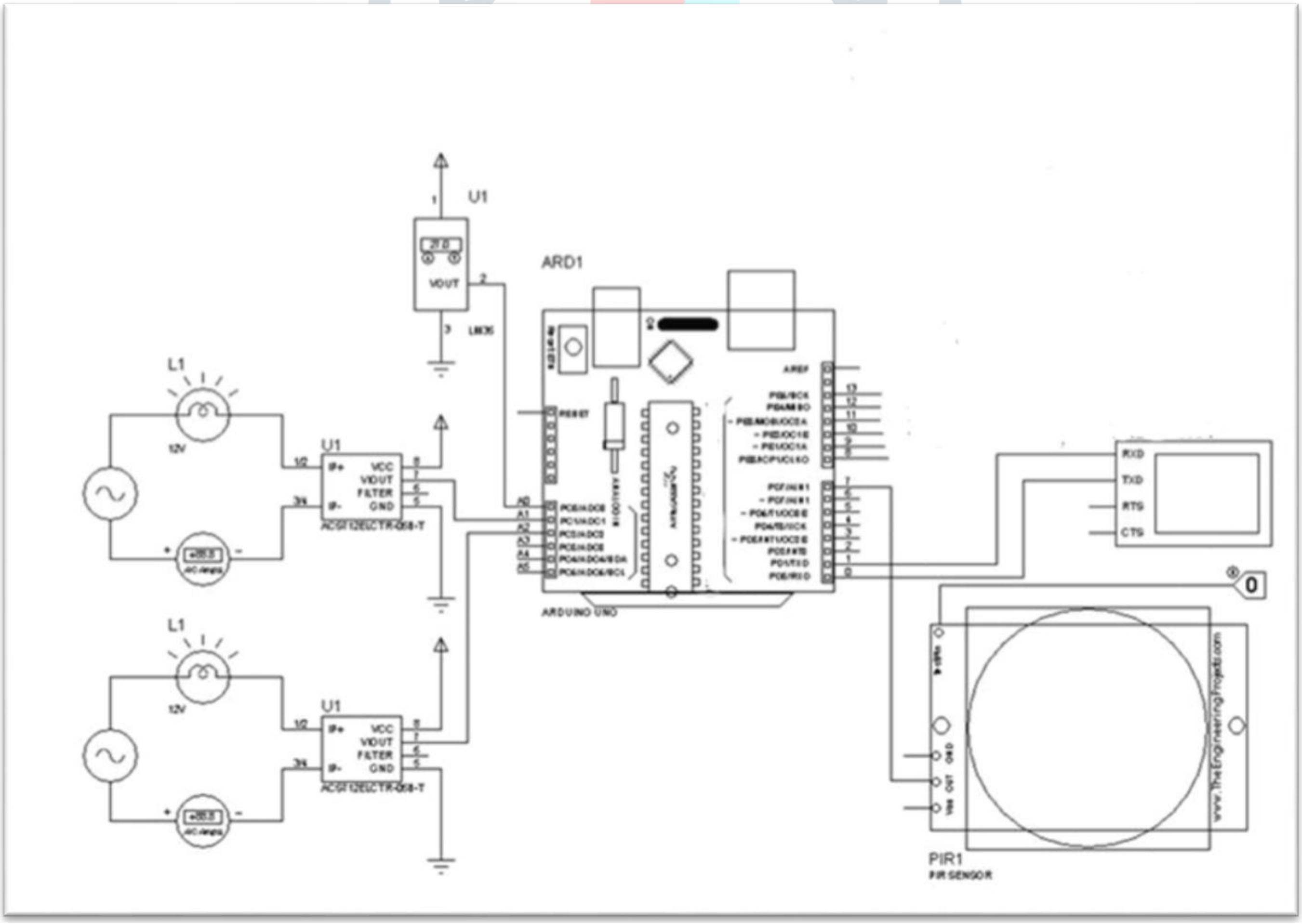

Figure 2: Circuit diagram of the system with specified pin numbers

Arduino was programmed accordingly so that the data measurements sent by the current sensors were pushed to the cloud. The data pushed to the cloud was retrieved and used by webpage for further calculation regarding power consumption and its analysis. The current consumption data were converted to the units of power consumed and energy. The data thus obtained was used to show the timely power and electricity bill. This was used to set the tariff. The further features such as on/off system of appliances were in co-operated via webpage interface. The appliances which were at on state without human interventions were made switch off by webpage interface. So that users could control their appliances from anywhere. The relay system connected across each appliance was controlled via Arduino which was programmed for all these features. Beyond the relay system further features like sensor controlled home appliance modifications were also included in this energy conservation unit. Temperature sensor, PIR sensor was also in co-operated to this system. All the connections are controlled and exhibited based on IoT .

3.1 Hardware Section

- Arduino UNO (ATMEGA 328)
- WiFi Module (ESP8266)
- Current Sensor (ct1270)
- Motion Sensor (PIR Sensor)
- Temperature Sensor (LM35)

3.2 Software Section

- Arduino IDE
- Arduino programming
- Hosted webpage(HTML, CSS, PHP)

IV. CALCULATIONS

Temperature=(ADC*500)/1023
Temperature in Fahrenheit= (ADC*108)+32
Current=current +(0.264*Analog Current)/1000
Power= 220*current
Energy= Power *time

The AC current in analog values was converted to digital values for calculations. Current and temperature conversion was done using the above mentioned formulas. From current values we obtain necessary power and energy readings.
User interface shows the following results accordingly. For the calculations and results we have set some preset threshold values.

4.1 Current Sensor

CT Sensor— threshold value set -100
case1: value>100-Current overload
case2: value< 100-Normal usage

Low current reading devices like bulb were connected to our system; it shows "normal usage" at the output. And when heavy current driving devices like iron box or the fan was connected it gives "overload usage " at the output. It's based on the threshold that we set.

4.2 Temperature Sensor

Temperature values are measured from 0-1023
When value>=55 – Over Temperature
Temperature values above adc value 55 gives "over temperature" printed at output.

4.3 Motion Sensor

PIR Sensor- threshold set-600
When value>=600 -Human detected
Senses the human presence when adc values is 600 and analog value is In the range of 5-12m

4.4 Billing

Bill— threshold set-280 Rs
Light load device displays – Normal usage
It adds up each 10secs-5 Rs
Heavy load device displays- Over Load Usage
It adds up each 10secs-10 Rs

As minimum wage by KSEB is 280 rupees we start our readings with that threshold. For better analysis, we provided an increment of 5 Rs for each 10 Sec duration for low load device usage and an increment of 10rs for heavy load devices.

The user interface section provides an opportunity to control the device from remote places. If the device is on state, even when user is not currently using it, we can off it.

V. RESULTS AND DISCUSSION

5.1 Normal Usage

Log Date	Log Time	Usage	Current	Power	Energy	Bill Amount
6/05/2020	17:07:42	Normal Usage	0.11A	23.99W	40.03	280Rs
6/05/2020	17:07:54	Normal Usage	0.12A	24.01W	40.05	285Rs
6/05/2020	17:08:05	Normal Usage	0.09A	20.02W	33.71	290Rs
6/05/2020	17:08:21	Normal Usage	0.00A	0.06W	0.10	290Rs
6/05/2020	17:07:42	Normal Usage	0.09A	19.36W	32.31	295Rs

Table 5.1: Normal usage of bulb output in webpage

Table 5.1 indicates the readings of bulb when connected to the system. It shows respective date, time, current readings, power consumed, energy utilized (no units as for experimental purpose not converted to Kwh) and its bill rose.

5.2 Overload Usage

Log Date	Log Time	Usage	Current	Power	Energy	Bill Amount
6/05/2020	19:04:59	Overload Usage	0.00A	00.00W	00.00	280Rs
6/05/2020	19:05:10	Overload Usage	20.03A	4407.12W	7214.45	290Rs
6/05/2020	19:05:44	Overload Usage	20.56A	4421.00W	7324.80	300Rs

Table 5.2: Overload usage readings in webpage

Table 5.2 shows overload usage when iron box connected. Respective current, power, energy, and bill rose is shown here.

Both the tables 5.1 & 5.2 can also show “Human detected” when it senses movement in the range of 5-12m and temperature variations when it’s more than room temperature.

5.3 Interface Section

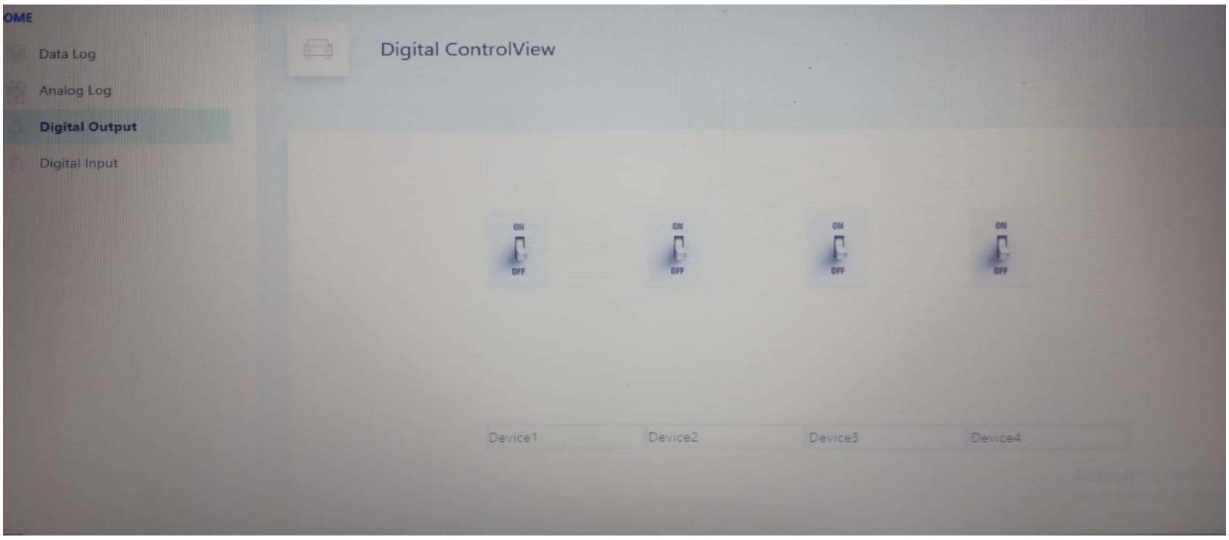

Figure 3 : Interfacing section in hosted webpage

The system also has an interface section as shown in figure 3 wherein we can control the device connected from remote places. Even the appliance is on after the use and we find later after moving from home or room we can turn it off from the place we were standing rather than travelling all the distance way back.

IV. Acknowledgment

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