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Energy Monitoring and Conservation using Smart Plug

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Abstract
This paper presents an economical and easiest way to control and supervise the home appliances using the Smart Plug. It is like a control switch which can be accessed through WiFi association. Clients can plug gadget into the existing control plug to remotely & automatically switching ON and OFF control, get data of device's for control utilization. There are two ways to get access to the smart Plug, that's, either interfacing its specifically in WiFi remote or local client and terminal equipment, enabling the intelligent control of the home appliances. Internet of Things (IoT) is an emerging field and IoT based devices have created a revolution in Electronics and IT Field. This paper presents the design and implementation of an energy meter using Arduino microcontroller which can be used to measure the power consumed by any individual electrical appliance or device. The main intention of the proposed energy meter is to monitor the power consumption at device level, upload it to the server and establish remote control of any appliance. The energy monitoring system exactly calculates the power consumed by various electrical devices and displays it through a home energy monitoring website. The advantage of this device is that a user can understand the power consumed by any electrical appliance or device from the website and can take further steps to control them and thus, it help in the energy conservation.

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I. INTRODUCTION

Conservation of an energy is one of the most important need of the day. The concept of energy efficient devices has come up in various areas such as lighting, air conditioning, microwave oven and so on. The Energy monitoring is an important tool for determining the energy efficiency of various appliances. Energy bills are generated on monthly basis and the user has the option of analysing the consumption details for every month. The energy meter installed in the residential buildings or houses show the energy consumed by the household. Very often, devices like laptops, PC's which operate in standby mode consume a significant amount of power about which the end customer is unaware of. Many a times, consumers are dissatisfied with the power bills as it does not show the power consumed at the device level. Since, smart plugs can control almost any device that uses electricity, they offer many possible solutions to the inventive homeowner. Buildings constitute a large portion of the overall energy consumption, nearly half of which is consumed by residential buildings or homes. To reduce the energy consumption of residential buildings, it is necessary to know the types of electrical appliances in a home and their power consumption behavior. Every electrical appliance or device possesses its own power signature which can be used to automatically identify the specific appliance. In this research, we develop a smart plug platform that achieves the following goals: accurate measurement the power consumption data of electrical appliances, analyzing the collected data for real-time classification of the appliance energy consumption model and remote control of the attached appliance. The smart plug offers RESTful web APIs which can be utilized by smart phones and web clients to interact with the smart plug.

II. LITERATURE SURVEY

With respect to our problem statement, we have referred research papers related to our project Energy Monitoring and Conservation using Smart Plug. In this section, an overview of recent developments to smart plugs is provided.

1) An Intelligent Smart Plug with Shared Knowledge Capabilities

This paper proposes an advancement of Environmental Awareness Smart Plug (EnAPlug) that is centered around the specific situation. The past adaptation of EnAPlug was made utilizing a microcontroller and functioned as an aloof framework. The proposed advancement isn't simply ready to figure out the controllable asset's specific circumstance yet in addition to gain from the asset utilization history and from the cooperation among clients and assets. The proposed EnAPlug has a specialist based engineering utilizing a helpful methodology, where the information learned can be divided among its companions to give a decentralized asset advancement. The proposed strategy of shared information is introduced and is the principal development of this paper. In addition, the paper presents the EnAPlug design and information abilities. Two actual establishments of EnAPlugs are utilized as contextual investigations: one in a cooler; and a second in a work area light. Also, different fake brain network designs were tried and assessed to give information to each EnAPlug. At last, an appropriated streamlining situation is introduced utilizing the common information EnAPlug ability[1].

2) Smart plug prototype for monitoring electrical appliances in Home Energy Management System

To start with, Ahmed et al. proposed a smart plug model that actions power utilization in home energy the board frameworks [2]. It is helped by a Zigbee microcontroller. It has been illustrated, from their discoveries, that the proposed plug ingests less power and accomplishes better accuracy interestingly, with the oscilloscope. As a matter of fact, the framework gives the choice to associate/separate the appended gadget from the power supply. As of late, the innovation of Home Energy Management System (HEMS) has extended to diminish energy utilization. This paper gives the advancement of a smart fitting a remote Zigbee sensor for estimating power utilization of electrical apparatuses in the HEMS. Tests were done to assess the power utilization of a remote sensor hub in a smart plug utilizing just Zigbee as a microcontroller. Trial results showed that the smart plug utilizing Zigbee is equipped for handling and investigating the simple sensor signal with lower power utilization. Also, the information got from the remote sensor is more precise and smoother as contrasted and the information acquired from the oscilloscope. The proposed brilliant attachment has the qualities of straightforward plan, minimal expense, low power utilization and simple to control electrical home machines by turning on/off from the HEMS regulator[2].

3) Data acquisition and control using Arduino-Android platform: Smart plug

Moreover, Hajahan and Anand have proposed an Arduino microcontroller-based smart fitting that involves ENC28J60 for correspondence. This is controlled by a split center style current transformer for painless current computation and an Android-based UI. In this work, we propose to foster a brilliant fitting, an energy checking framework that gives continuous update of the energy utilization at the gadget level. The proposed gadget is utilizing an arduino microcontroller board, an ENC28J60 ethernet module, and an ongoing transformer sensor. The strategy for current detecting utilized is harmless sort. The User Interface of the gadget is to be created in android and the information will be transferred onto a server utilizing the ethernet association. The last result will be a smart plug that can screen a distant gadget utilizing arduino-android stage[3].

III. PURPOSE

A comprehensive study has been presented in which compares various feedback devices for residential real-time energy monitoring. According to this study, real-time in-home feedback is a relatively new technology. These days a number of instruments are available to monitor energy consumption in the residential sector. These instruments allow users to input utility rate structures and receive feedback in the form of numerical and graphical data. Users are informed of their electricity consumption with costs. Energy monitoring and conservation holds prime importance in today’s world because of an imbalance between power generation and demand. The current scenario says that the power generated, which is primarily contributed by the fossil fuels may get exhausted within the next couple of decades. Currently, there are very accurate electronic energy monitoring systems available in the market place. Most of these monitor the power consumed in a domestic household, in case of residential or household applications. Smart plugs can be used to improve home security by turning lights and appliances on and off while you’re on vacation, making smart plugs a safe and effective way to look like you’re home while you’re out of station. Smart homes give homeowners total control over everything from energy use to home security. Smart plugs, sometimes known as smart sockets or smart outlets, let homeowners turn any dumb device into a smart device.

III. Constructional Details

1. Arduino UNO:

Act as a microcontroller, the central controller for the whole unit of smart cart. Arduino Uno based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and a reset button. The board can be programmed with Arduino Software (IDE). The board can operate on an external supply from 6 to 20 volts. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The ATmega328 has 32 KB flash memory. It also has 2 KB of SRAM and 1 KB of EEPROM.

2. ESP8266 WiFi Module:

An ESP8266 is a microcontroller made by Espressif Systems. Since, ESP8266 Module is not capable of 5-3V logic shifting and will require an external Logic Level Converter. So, never power it directly from your 5V board. It can be simply connected up to arduino and can get about as much WiFi connectivity as a WiFi shield offers. The ESP8266 is a low-cost Wi-Fi chip with the full TCP/IP stack. It has 1MB Flash Memory. It has an Integrated low power 32-bit CPU that could be used as application processor.

3. AC Voltage Sensor:

ZMPT101B AC Single Phase voltage sensor module is based on a high precision ZMPT101B voltage Transformer. ZMPT101B AC Voltage Sensor is the best for the purpose of the DIY project, where we need to measure the accurate AC voltage with a voltage transformer. This is an ideal choice to measure the AC voltage using Arduino/ESP8266/Raspberry Pi like an open-source platform.

4. Relay Module:

A power relay module is an electrical switch that is operated by an electromagnet. The electromagnet is activated by a separate low-power signal from a micro controller. When activated, the electromagnet pulls to either open or close an electrical circuit.

5. Micro Current Transformer:

ZMCT102 is a Micro precision current transformer having current ratio of 5A/2.5mA. ZMCT102 is the best choice to measure the AC current using a microcontroller. This CT is very easy to mount on PCB, It also provides high galvanic isolation and very high accuracy.

6. Switch Mode Power Supply:

A switch mode power supply is a power converter that utilises switching devices such as MOSFETs that continuously turn on and off at high frequency; and energy storage devices such as the capacitors and inductors to supply power during the non-conduction state of the switching device. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power, see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics. A hypothetical ideal switched-mode power supply dissipates no power.

7. LCD Display Module:

The term LCD stands for Liquid Crystal Display. It is a type of electronic display module which is used in a wide range of applications like various circuits \& devices i.e., mobile phones, computers, TV sets, etc. These type of displays are mainly used for multi-segment LEDs and seven segments. Results are displayed on LCD.

IV. WORKING

In this system, instead of connecting the whole circuit directly to the main supply, it is connected through Switch Mode Power Supply (SMPS). The reason behind this is, the main supply if directly given, may damage the circuit due to fluctuations. SMPS reduces those fluctuation and provides the circuit with a constant power supply for smooth working. After this, the supply is given to the Voltage Transformer (or AC Voltage Sensor) where the 0-250V supply is reduced to 0-5V bearable supply so that circuit components works properly without getting damaged. Further, this 0-5V is given to the Relay Module. A power relay module is an electrical switch that is operated by an electromagnet. The electromagnet which is activated by a separate low-power signal from a microcontroller. When activated, the electromagnet pulls to either open or close an electrical circuit. After this, the micro current transformer is there, which is used to measure the AC current. Here, the 3-pin plug and Bulb holder are provided so that we can connect the devices and bulb respectively.

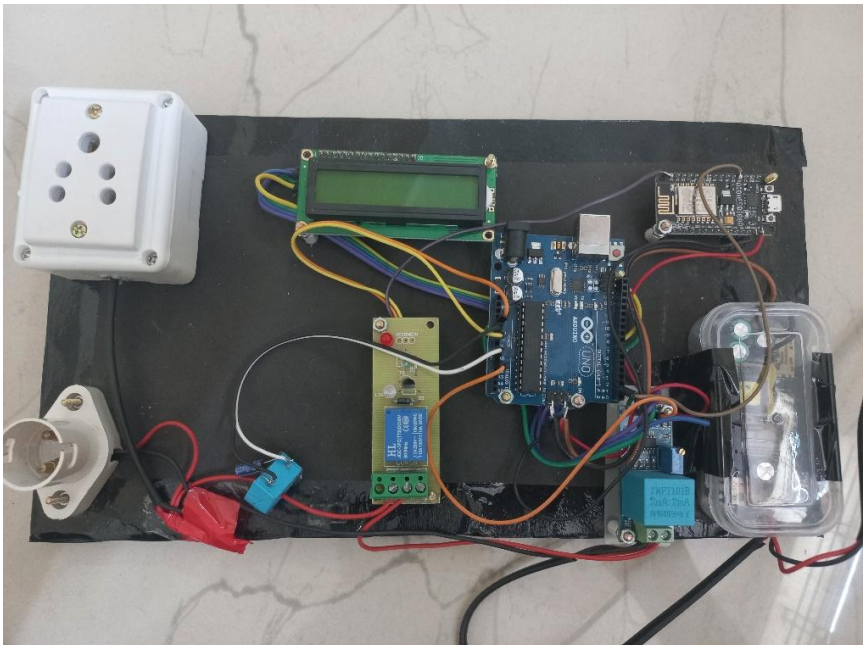

Fig. 1: Setup of Smart Plug

After connecting a device (in this case a bulb or cooler), the supply is given to the circuit. Here, we can made the gadget ON/OFF by utilizing transfer. At the point when the gadget is turned ON, it begins consuming power. The amount of current and voltage utilized by the gadget is consistently given by current transformer and voltage transformer individually to the analog pins of Arduino UNO. Here, the LCD Display is interacted with Arduino so the current, voltage and power utilization of associated gadget is shown on the LCD screen. The LCD is use to show the information. Presently, to utilize the IOT stage, the Arduino is associated with ESP8266 WiFi Module. ESP8266 is utilized to transfer the information on the cloud. After this, the information got at the simple contribution of Arduino is persistently given to the ESP8266 which transfer it to the server. The open IOT stage Thinger.io give us the power utilization information of the gadget of each and every moment. Thinger.io give us the graphical portrayal of the power utilization of gadget and an office to make the gadget ON/OFF by utilizing versatile or PC carefully. Also depending on need of keeping device ON/OFF and power consumption user can switch ON/OFF any device. The power consumption data on webpage will be updated automatically by refreshing the webpage.

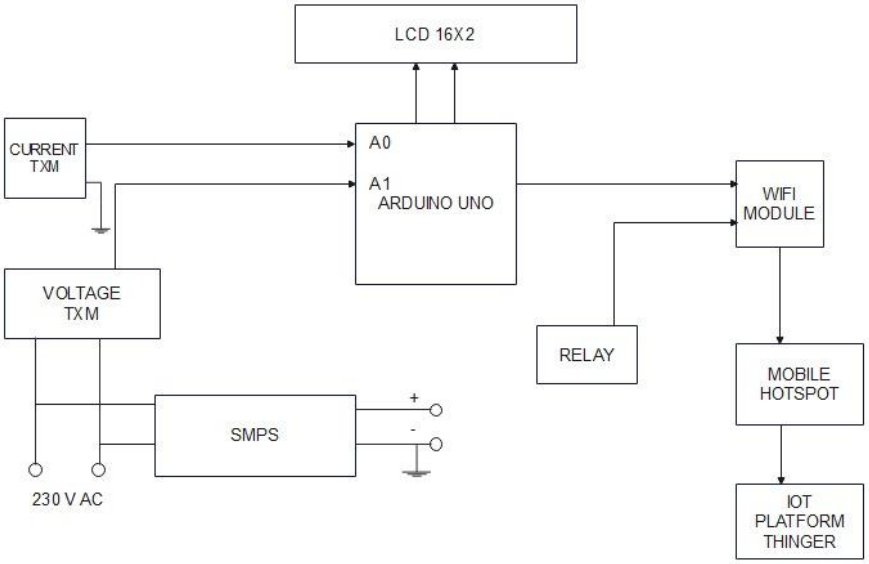

Fig. 2: Block Diagram

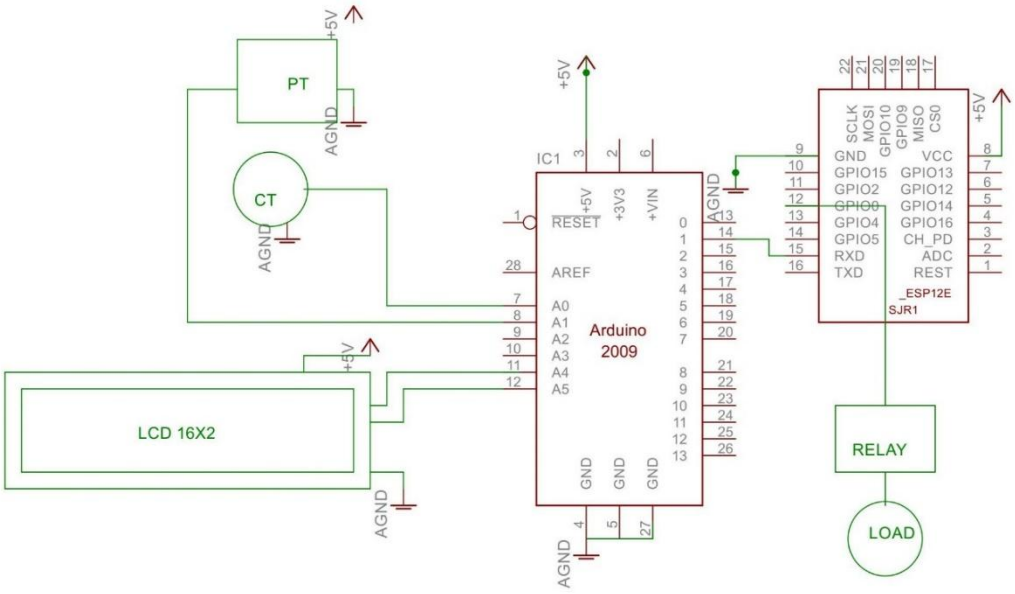

Fig. 3: Circuit Diagram

V. DATA ANALYSIS

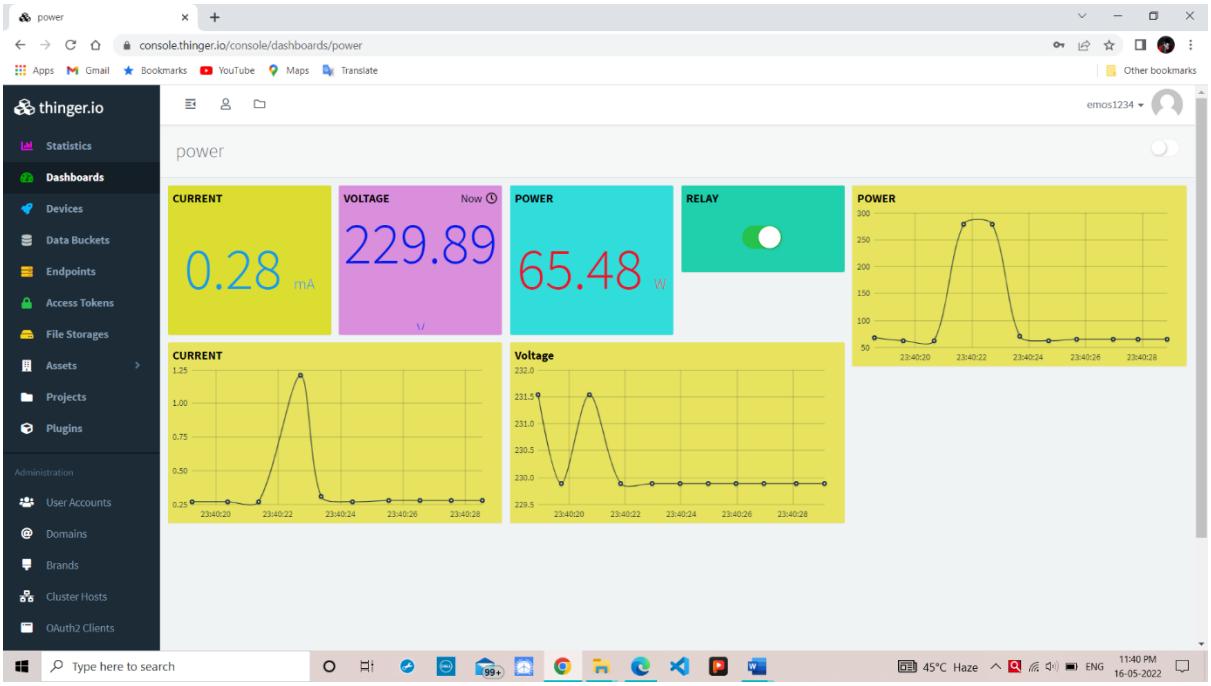

Fig. 4: Power Usage by a Bulb

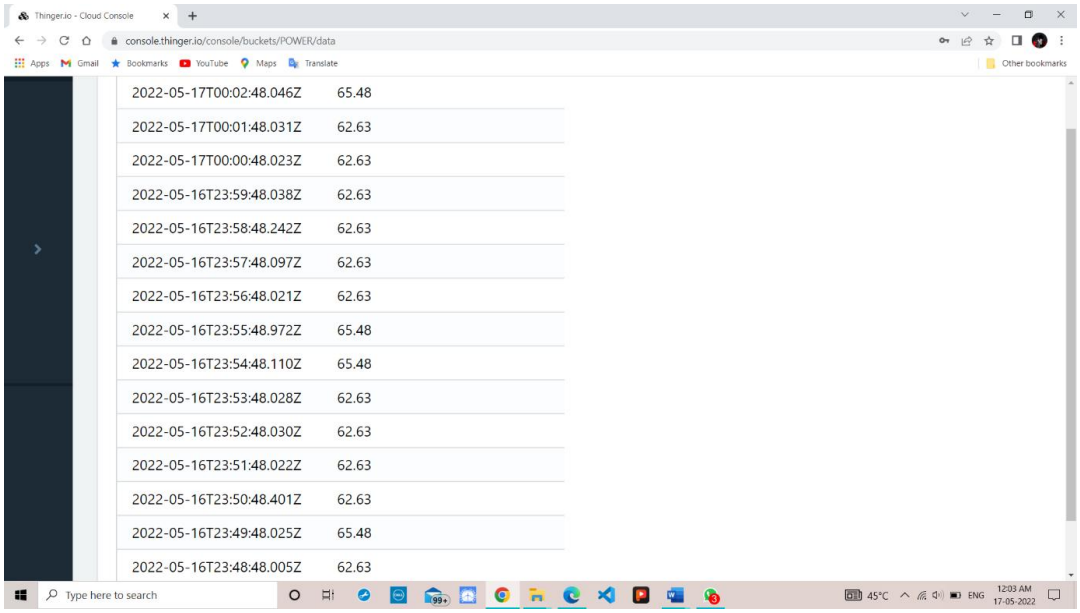

Fig. 5: Power Usage Data of Bulb

VI. CONCLUSION

Our design of smart plug uses arduino UNO chip, voltage sensor, relay module, the target of the project has been archived through this model. We built a wireless network to measure the energy consumption at device level by collecting different data. This updated model is simple to use, is cost effective and doesn't would like abundant exertions. The architecture to collect data from smart plugs allows to reduce home energy consumption as well as save on electricity bills. This smart plug can also be used by mobile applications, to know the interactive function between smart plugs and interpretation of different appliances, we use a network database system. In this study, the magnitude and time of usage regarding these appliances are not controlled, yet it is assumed that they can be monitored by the home appliances.

VII. FUTURE WORK

The review presents the various paradigms in smart plug technology. Smart plug technology will be widely used for monitoring and control energy consumptions in any spaces that incorporate electrical devices. A lot of work is continuously being done to test and integrate newer communication protocols and features into the smart plug for use in a variety of scenarios in the Energy Ecosystem. It is also observed that the applications of smart plugs are not limited to energy management and will only increase with the integration of more intelligence. With the introduction of new efficient and cost-effective IoT technologies in the future, the smart plug is expected to be in high demand in the coming years and this work intends to be a positively aggressive initiation of the future work of the group. We also intend to make contributions to Device identification in smart plugs and Electricity Theft detection in the future. The good news is that all the plugs on the market work with Android or iOS. Thanks to this, the vast majority of users will not have incompatibility problems with their devices. We firmly believe that the smart plug can prove to be a vital component in smart energy management systems leading to an even smarter grid and Smart Cities.

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