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ZigBee Based Smart Plug to Control Power Consumption in Home Energy Management System Via MATLAB Simulation

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***Abstract:** In this paper, we propose a method to solve electrical power monitoring and managing problems. Smart Plug is a power monitoring and management system using sensor - ZigBee. The main target or the problem of energy saving and to know about energy consumed by the appliance connected to the plug by using updated knowledge and technology. Also, the Smart plug user will be able to control the plug from his mobile phone by turning it on and off and schedules it.*
Data collected from the Smart Plug system will help in investigate and under-standing actual power consumption of energy, opening opportunities for future researches related to energy consumption, and assisting modern smart grids efficiency, reliability, and sustainability features.
Keywords: MATLAB; Smart homes; Smart plug; power utility.

I. INTRODUCTION

Life of Human has evolved ever since due to change of climate and energy. Also, the lifestyles of people have changed after the exposure of Internet technologies, which allows them to connect with people through network devices regardless of distance and time zone. Due to these manufacturers developed smart home appliances that can connect to internet 24x7 which is suitable, flexible, and reliable and within reach.

In this study, we put forward a method to resolve this problem by ZigBee Wireless Sensor Network (WSN) which is used to ensure efficient working in smart plug to control power utility and home automation. To enable smart home automation, there is a need to adopt IoT-based technologies to allow flawless flow of information between the components of the grid. In in addition to this, the use of smart plugs in the distribution side of the power system is starting to gain recognition.

Smart plugs are electrical devices that allows an ordinary appliance to be connected to the internet. It also allows people to keep watch to their energy usage and in turn, affect the way of the energy consumption. In recent literature, there are proposed cheap smart plugs that are composed of simple sensors to derive electrical parameters like voltage, current, power and frequency. These smart plugs are not equipped with attractive and easy to use graphical user interface (GUI) for their software. Some of the designs of the smart plugs only relies to Wi-Fi for monitoring and control. In order to address some of these concerns, this paper proposed a smart plug that adopts the current state of art technology to control and monitor electric devices through ZigBee. As a results, Smart Plug achieved the objectives of being an innovative and safe smart plug contributing to the fast transition of power to home appliances.

A HEMS involves any device or product that can analyze energy consumption, control and monitor home electrical appliances. A smart plug is installed between the wall outlet and the electrical appliance and it is used to control and monitor appliances remotely at homes.

It allows user to get data for optimizing the use of appliance and get benefit of lower energy consumption by remotely scheduling or turning on/off the appliance in a room through tablet or smartphone using ZigBee sensor. Non-smart appliances should also be considered for energy management systems and it is necessary to find a practical solution to connect non-smart appliances to a controller. So, the design of smart plugs forms a network of distributed sensing nodes, which provide remotely switch loads (on/off) and control the electrical appliances in a HEMS. In this paper, a Stimulation on MATLAB Software of smart plug is developed by using a stand-alone device supported with ZigBee wireless communication for implementing a HEMS tppin smart home automation.

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II. SMART PLUG PROTOTYPE

A. Overview

The smart plug is designed in such a way that it uses two main sensors for current & voltage, to acquire single supply. It is designed similar to regular plug shape and size and it also provides remote monitoring and switching off/on of the appliances which showcases the smart plug connected between the electrical appliances and the HEMS controller.

The implementation of smart plug begins with the first step of ZigBee nodes which configures to initialize the parameters and to indicate the maximum and the minimum values of the measured signal of the system. For acquiring and composing the data, a USB [Universal Serial Bus] interface card is connected to the Personal Computer. Also to program & to set parameters of ZigBee, a module is directly connected to the USB serial port (COM), the software X-CTU.

One ZigBee is connected to the computer so as to configure it as a coordinator which is interfaced with a MATLAB software and another ZigBee is configured to connect through the conditioning circuits as an end device with the current & voltage sensors. Therefore, MATLAB program is used as to check the data with used proper faction to access the energy sensors data.

To communicate with the serial of external device from MATLAB, the specific serial port of the personal computer is first identified and created and then connected to the external device.

Subsequent, a command signal is sent to the external device and the data from the external device is received. Lastly, the serial communication connection is disconnected from the external device with release control of the serial port.

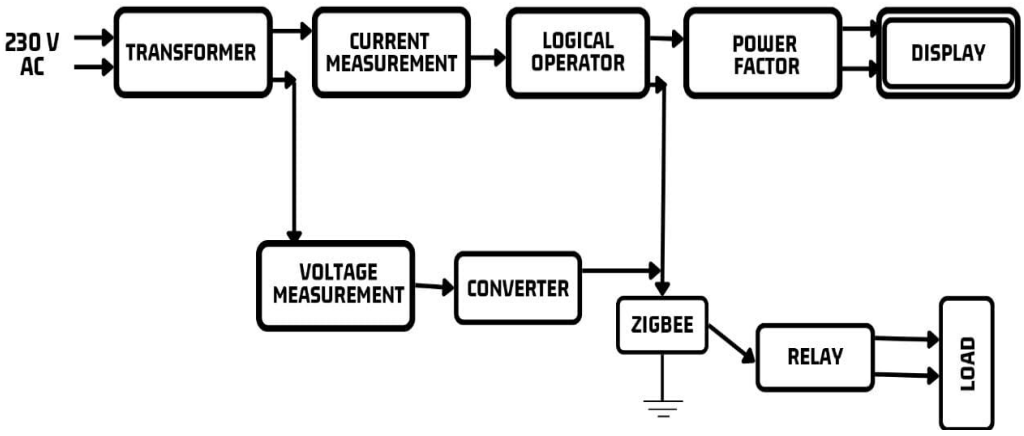

Fig. 1. Block Diagram

230 V AC Supply is given to the Linear Transformer which steps down the voltage and the secondary winding is tapped to get desired voltage value, using two diodes alternatively. Here, we will be focusing on current as voltage will be kept constant. Voltage and Current measurement devices are used to measure respective parameters. Further the current is passed through Converter which converts DC current to AC. Parallelly, the current passes through operators (logical & relational). From the word itself, "Relational" means to compare between two expressions and logical operators are used for logical manipulations. In electrical distribution systems, power factor plays an important role as it shows the (phase) difference between current and voltage i.e. power factor should be one which will get displayed on the screen (display). The comparative output current from operator will be directed to ZigBee (a personal area network with low-rate task group 4 based on IEEE 802.15.4.) which will transmit signal as soon as the current exceeds the required limit (flow) and after that relay will trip the circuit. Hence, we will get to know about the particular appliance which consumes high power.

B. Smart plug software design

The proposed real-time simulation tool has been designed based on the Load Management DSM program. Load management programs may either reduce electricity peak demand or shift demand from peak to off-peak periods. The tool demonstrates the operation of a Smart Home which is building automation control of electrical appliances (e.g., air conditioner, dishwasher, washing machine, etc.).

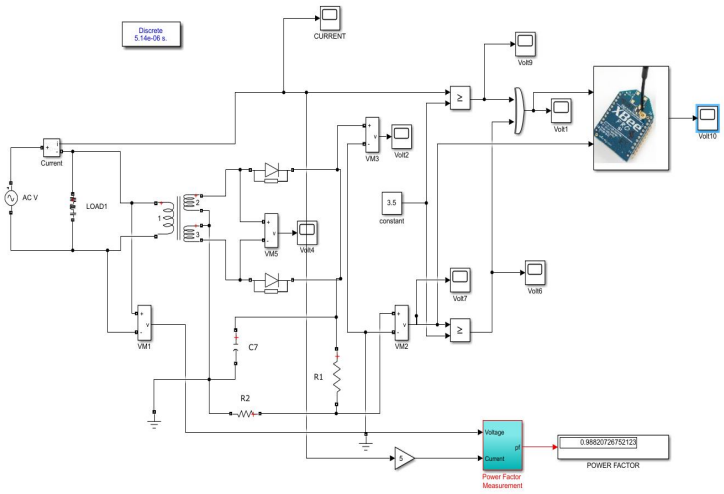

Fig. 2. Simulation Diagram

Basically, we are using normal 230 A.C., 50 Hz voltage for the home appliances then we are connecting to a step-down transformer, to get the desired voltage frequency will get double as compared to the actual supply. After that we used current measurement for measuring the current flowing in the circuit. Also, there is D.C. Voltage measurement is for measuring the instantaneous voltage between two electric nodes. But we want ac voltage so that we can connect dc to ac converter for converting the voltage in ac. The Relational Operator component performs the comparison property between two input signals.

Power factor for AC circuit is the phase ratio of current and voltage used by an electrical load in a circuit. It is a measure of how effectively power is transmitted and used by loads attached to an electrical mesh network.

Power Factor = Real Power (kW)/ Apparent Power (kVA)

In a purely linear circuit, basically the power factor is 1 then the value display not more then 0.988

ZigBee is based on version (IEEE's 802.15.4) personal-area network standard. All we need to know is that ZigBee is a microcontroller that's been around for more than a decade, and it's widely considered an alternative to Wi-Fi and Bluetooth. But we are using ZigBee as transceiver for the output signal to control the overcurrent, which flows to the relay to trip the circuit. Control and monitoring all the appliances in your house with a smart plug.

III.EXPERIMENTAL RESULTS

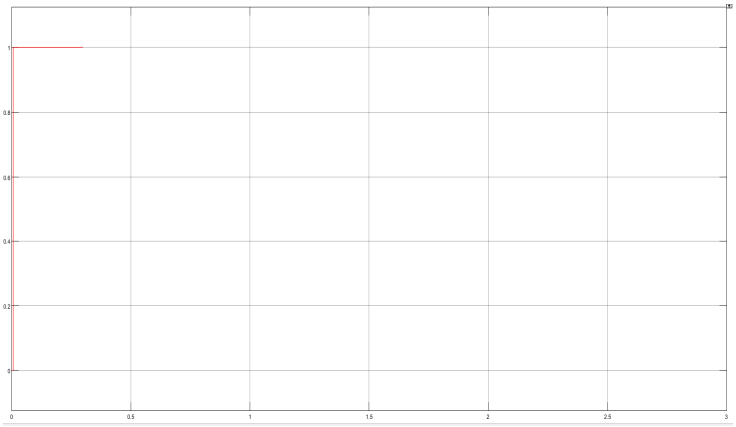

Fig. 3. Output graph (i)

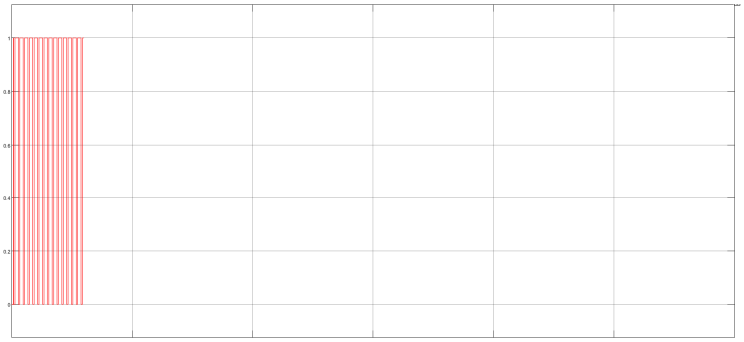

Fig. 4. Output graph (ii)

MATLAB is used to simulate, design and drawing of electronic circuits. With the use of this engineering software, we have designed circuit of smart plug and displayed results in the form of graphical representation as displayed when the current value is equal or less than the set value the output graph will show a constant line as shown in fig 3. Similarly, when the current value is more than the set value the output graph will show fluctuations shown in fig 4 i.e ZigBee will send a signal to relay operator and automatically smart plug will be turn OFF and similarly when the current value is more than the set value smart plug it will automatically turn ON as we can see it shows the current value in the block.

IV. CONCLUSIONS

This stimulation describes the working on smart plug using the ZigBee module controlling of electrical appliances in a Hems ZigBee transceivers is proven to be successful. Detailed analysis on the flow of power is also displayed to the user on MATLAB software as graphical representation. The experimental stimulation of smart plug has shown that it is accurate and efficiently working on MATLAB software as well. Smart plug provides low-consumption, low-cost, high reliability and stability on MATLAB software.

V. FUTURE SCOPE

As the experiment result shows precise value of the energy consumption and works effectively in HEMS in residential area. As future aspect it could be used in commercial and industrial sector. Hence, it provides safety and security to the appliances as well as saves consumer from losses.

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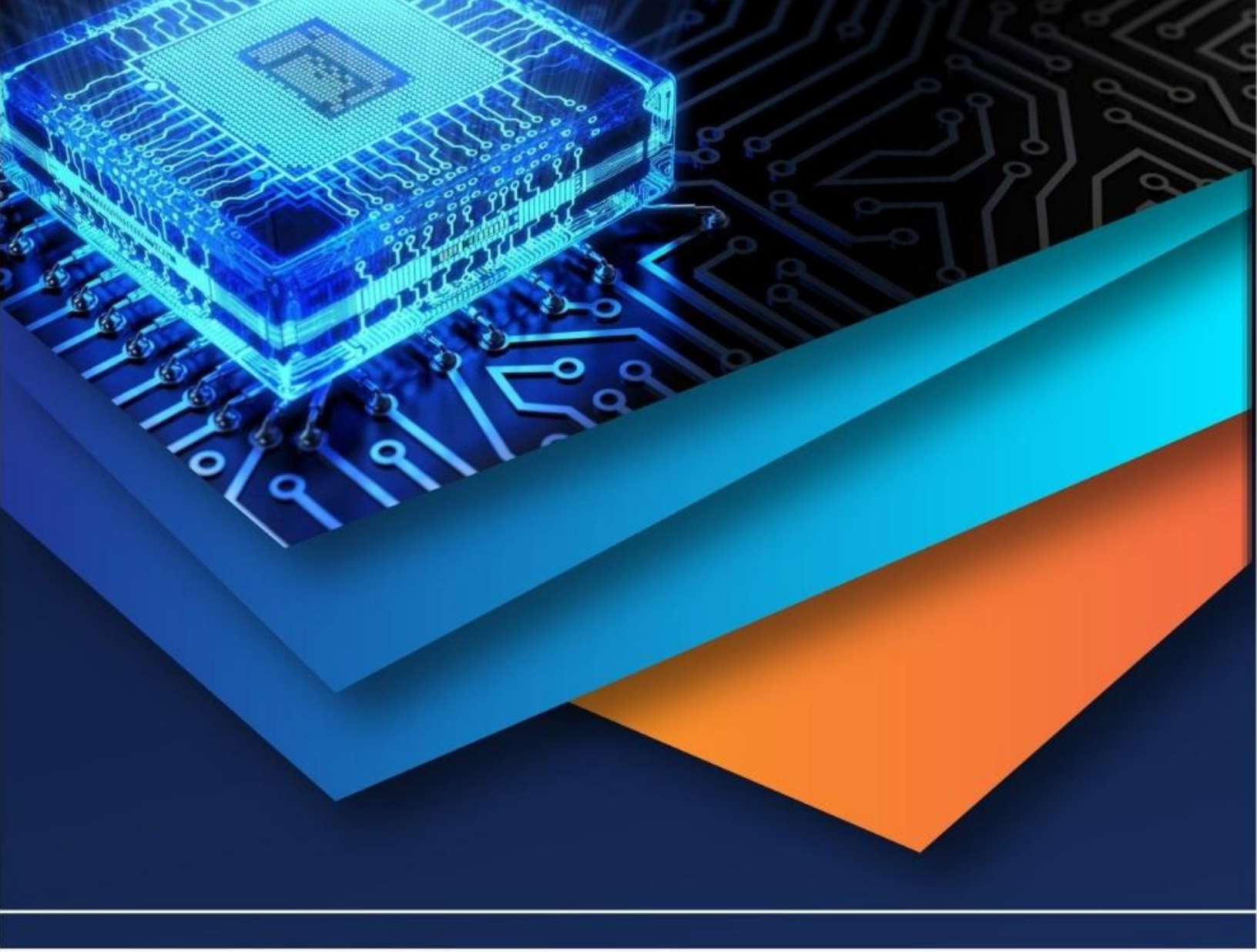

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