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IOT-Enabled SCADA System for Home Energy Monitoring

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Abstract—The tracking of house hold appliance power consumption. The goal of an IoT-based SCADA system is to improve home safety and energy efficiency. To identify whether it is day or night and to maximize power consumption, the system makes use of an LDR sensor. Temperature is tracked by a DHT11 sensor, which when needed turns on a CPU fan to cool the system. To reduce risks, a fire sensor identifies potential fires and activates an exhaust fan.The PZEM004T sensor measures essential electrical parameters such as voltage, current, power, energy, frequency, and power factor. Three 5V relays for appliance control and bulb holders with 200W bulbs for load testing are part of the configurationAn Arduino Mega processes the data, buzzers generate alarms, and an LCD displays the readings in real time. A NodeMCU module enables connectivity to the Internet of Things.

Index Terms—IoT, SCADA, Energy Management, Smart Home, Arduino, Sensors, Energy Efficiency, Remote Monitoring, Home Automation.

I. INTRODUCTION

Monitoring the Power Consumption of Home Appliances Using an IoT-Based SCADA System is a new and effective solution that can save energy, enhance security, and offer real-time monitoring of home appliances. With the application of the operation of more than one sensor like the LDR (Light Dependent Resistor) to sense light, DHT11 to sense temperature and humidity, and fire sensors to sense safety, the system can realistically regulate the climate of a home. For example, the LDR sensor is able to automatically detect how bright the light is in the surrounding environment and control lighting by switching it off immediately when natural light is available, which cuts energy consumption and saves electricity charges. The temperature and humidity level in the surroundings are detected using the DHT11 sensor to control appliances such as fans, air conditioners, or humidifiers to provide comfort without unnecessary power wastage. Also, the fire sensors prevent damage to the house by sensing danger of fire and sending alarms or triggering protection devices such as exhaust fans, emergency lights, or appliance shutdown automatically.[1]

The system also incorporates the PZEM004T sensor to provide very accurate readings of the main electrical parametersfor voltage, current, power, energy, frequency, and the power factor.Through this,users are able to monitor the actual energy usage of their appliances in real-time and determine any inefficiencies. Users are then able to make appropriate decisions regarding their energy usage either by adjusting appliance use or by replacing inefficient appliances. The **Arduino Mega** is used as the processor chip, taking input from all sensors and controlling appliances using relays.""* An *NodeMCU** also provides IoT connectivity, enabling remote monitoring and control of the system over the cloud. Parallel real-time[6] access enables individuals to monitor and manage their energy use from anywhere in the world, providing enhanced energy saving, enhanced security, and enhanced convenience. Overall, the system is a very convenient device for homes in today's modern world who wish to reduce wastage of energy, increase security, and have more control of home environments[3].

II. LITERATURE SURVEY

1. "Energy Monitoring and Management System for Smart Homes Using IoT"
Author(s): A. G. K. Reddy, P. J. Nayak. This paper discusses the integration of IoT-based systems for energy monitoring in smart homes, focusing on the use of sensors like current, voltage, and temperature for optimizing power consumption and improving energy efficiency.

2."IoT Based Home Automation and Power Consumption Monitoring"
Author(s): R. Kumar, R. Gupta, V. Raj.This paper presents an IoT-based home automation system that includes power consumption monitoring and control mechanisms using sensors and a cloud-based platform for real-time analysis of energy usage and appliance control.

3."Smart Home Energy Management System Using IoT"
Author(s): M. I. Ahmed, M. F. Alhamid.This research explores smart home systems integrated with IoT to manage and monitor energy consumption. It covers the use of various sensors such as temperature, motion, and light to control appliances and improve energy efficiency.

III. PROPOSED METHOD

Here in this project, we attempt to create an intelligent home automation system using different IoT sensors to control and monitor home appliances in a cost-effective way. The system will provide power optimization along with security and convenience.[9]

To the same effect, an LDR (Light Dependent Resistor) sensor is used to detect light intensity inside a room so that the system can recognize day or night from here. Possessing this information, it is capable of adjusting the

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consumption of power by turning on and off the lights and other appliances as necessary. Second, a temperature and humidity sensing DHT11 sensor constantly monitors room temperature. Whenever the temperature crosses a defined threshold, the system starts up a CPU fan as a cooler and provides higher efficiency with power.

For safety purposes, a fire sensor is provided to detect fire risks and inform the system in this respect. The system automatically initiates an exhaust fan for risk reduction on the event of fire. In addition, the PZEM004T sensor also has a vital function since it tracks important electrical parameters like voltage, current, power, and total energy consumption.The resulting data is displayed on an LCD screen for real-time tracking.[2]

The main component of this system is an Arduino Mega, which takes inputs from sensors and turns on appliances that are plugged to it via relays. In order to facilitate the system's accessibility from any remote location, a NodeMCU module is also included that facilitates cloud connection via an IoT platform[2]. Through this, monitoring and controlling domestic appliances from anywhere remotely with a computer or a smartphone is enabled, making home automation intelligent and convenient[15].

With the convergence of these technologies, this project not only adds convenience but also facilitates improved energy management and home security.

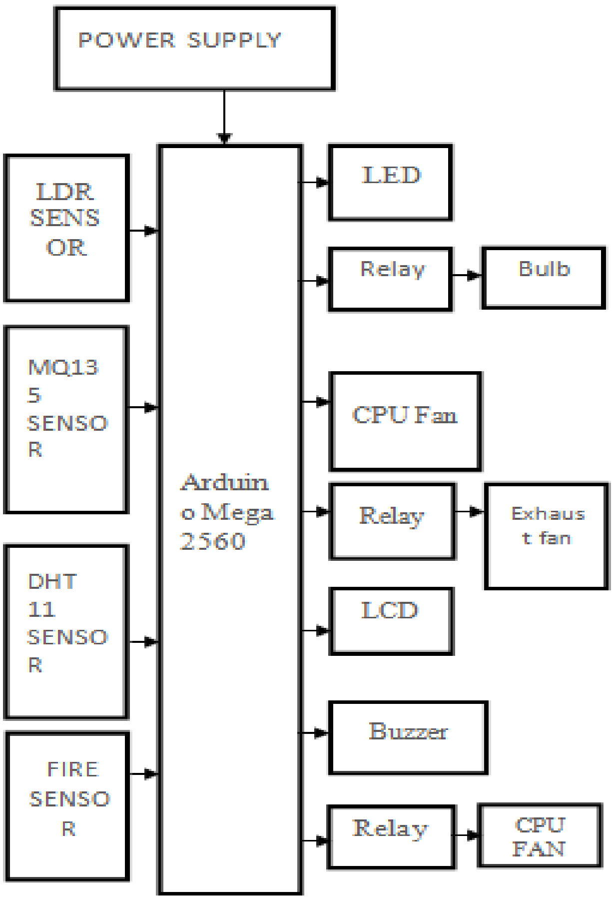

Fig 1. Block Diagaram

A. ARDUINO MEGA 2560

Based on the ATmega2560 processor, the Arduino Mega 2560 board has a reset button, USB connector, power jack, ICSP header, 16 analog inputs, 4 UARTs, 54 digital I/O pins (14 PWM), and a 16 MHz crystal oscillator. USB or an external power source (7–12V is recommended) can be used to power it. Programmable with the Arduino IDE, without a bootloader or ICSP header, or with one. It has 4 KB of EEPROM, 8 KB of SRAM, and 256 KB of Flash. There is onboard serial monitor connection via PWM, SPI, I2C, and UART. Externally interfaced special function pins include USB overcurrent and AREF, as well as external interrupt and LED (pin 13). USB overcurrent is managed through Polyfuse resettable protection. ATmega16U2 manages the USB-to-serial conversion with auto-reset to facilitate an easy programming environment. SPI is accessible from the ICSP header, and TWI support is provided in the Wire library. Arduino Uno boards are supported, and revision 3 has enhanced reset circuits and more I2C and expansion pins. The Mega 2560 is ideal for very complex projects where lots of I/O and serial ports are required.

Fig 2. Arduino Mega 2560

B. LDR SENSOR

A component whose resistivity changes in response to incident electromagnetic radiation is known as a light-dependent resistor, photoresistor, or LDR. They are hence components that are sensitive to light. They are also known as photocells, photoconductors, or photoconductive cells.

The semiconductor material used to make them has a high resistance. A widely used notation for the photoresistor, also known as an LDR, is displayed below.

Incident light is represented by the direction arrow.

Fig 3. LDR SENSOR

C. MQ-135 SENSOR

Numerous dangerous gases, such as ammonia, NOx, alcohol, benzene, smoke, and CO2, can be detected by the MQ-135 gas sensor. It has heightened sensitivity to smoke and fumes of benzene, ammonia, and sulfide. The MQ-135 sensor chip and an LM393 comparator are combined in this module, making it easy to integrate into various gas sensing projects. It has both analog (0–4V) and digital (0–1) outputs and operates on a 5V power source. Upon

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detection of no gas, the digital output is LOW (0); when gas concentrations surpass a predetermined threshold, it becomes HIGH (1). The analog output ranges from 4V, which indicates high concentration, to 0V, which indicates low concentration.

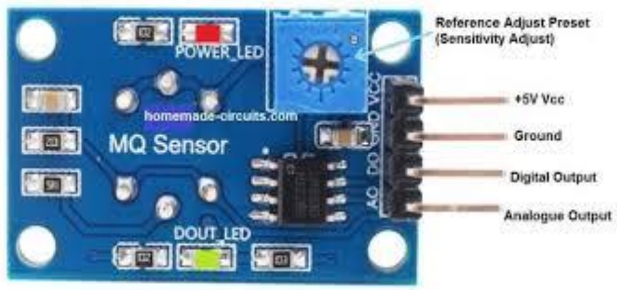

Fig 4. MQ-135 SENSOR

D. BUZZER

An audible signaling device, such as a buzzer or beeper, can be piezoelectric, mechanical, or electromechanical. Buzzers and beepers are frequently used for timers, alarm devices, and verifying user inputs such as mouse clicks or keystrokes. Computers, printers, copiers, alarms, electronic toys, automobile electronics, telephones, timers, and other electronic devices for sound all make considerable use of buzzers,which areintegrated electronic transducer structures with DC power supplies. 5V active buzzer With the help of the board and a specific sensor expansion module, rated power may be directly connected to a continuous sound, resulting in a straightforward circuit design that is "plug and play."

Fig 5. BUZZER

E. LCD

LCDs are less power-consuming than LED or gas-plasma screens since they trap light rather than emit light and are, therefore, thin and efficient.

LCDs process two categories of signals: **data** and **control**, based on the **RS (Register Select)** pin. When RS = 1, the display mode will be in data mode, and RS = 0 will put the display in command mode. Data is held in the **information register** in ASCII code format.

In order to read off the LCD, drive the **R/W (Read/Write)** pin high, pulse the **E (Enable)** pin, and immediately read off the data on the trailing edge of the pulse.

Commands and data are given in a specific sequence to decide how the screen displays are refreshed.

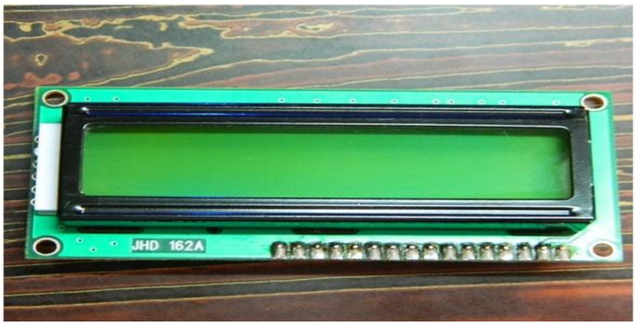

Fig 6. LCD

F. RELAY MODULE

Relays are electromagnetic switches that can be used to control numerous circuits with a single signal or to turn a circuit on and off with a low power signal. Relays are essential to the effective operation of any high-end industrial application equipment. Relays are simple switches that can be controlled both electrically and mechanically. An electromagnet and even a collection of contacts are components of relays. The electromagnet is responsible for the switching mechanism. Its operation is even based on a variety of operating concepts. However, they differ according to their uses. Relays are used in most pieces of equipment.

Fig 7. RELAY MODULE

G. NODEMCU

The NodeMCU, which is powered by the ESP8266 chip, allows energy monitoring and control in home appliances via Wi-Fi. It interfaces with sensors such as PZEM-004T to monitor voltage, current, power, and energy consumption and sends data to IoT platforms such as Blynk or ThingSpeak. It has low power consumption, which guarantees long-term usage. NodeMCU can also be used to control appliances using relays, maximizing energy utilization and minimizing wastage. It offers remote monitoring and control via apps or web interfaces and sends real-time alerts. Simple programming using Arduino IDE or Lua makes it a cost-effective and effective smart energy management, cost-saving, and home automation solution.[10-25]

H. SOFTWARE USED

Arduino IDE is a free source code application that is mostly used for writing and compiling code for Arduino modules. Even a non-technical individual can begin learning how to use it because it is official Arduino software and the code compilation is so easy. It runs on the Java Platform, which provides built-in features and

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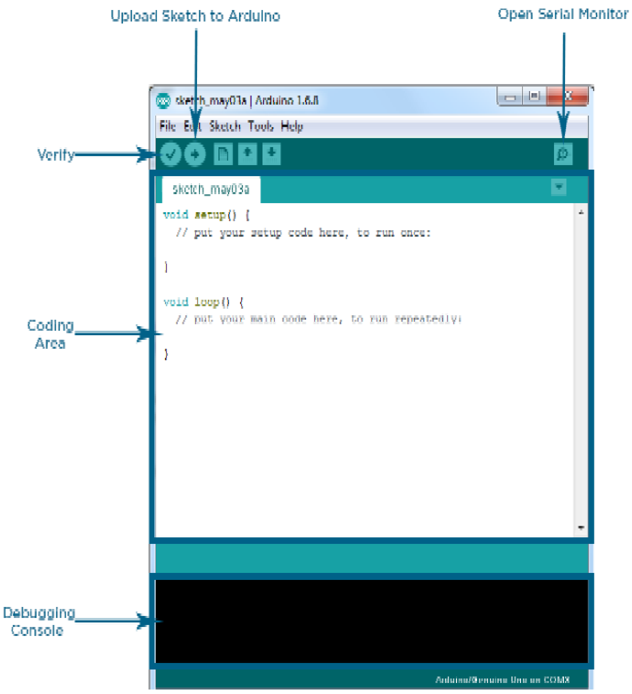
instructions that are crucial for debugging, changing, and compiling the code in the environment. It is easily accessible on operating systems including MAC, Windows, and Linux.

The Arduino Uno, Arduino Mega, Arduino Leonardo, and Arduino Micro are just a few of the many different Arduino modules that are available.

A microcontroller that is pre-programmed to carry out instructions in the form of code is included on the boards of both items.The code—also known as a sketch—written on the IDE platform will ultimately result in a Hex File, which is uploaded and transmitted to the board's controller.

The two primary components of an IDE environment are an editor and a compiler. The editor is used to code the program of interest, while the compiler compiles and uploads the code to the specified Arduino Module.



IV. SIMULATION RESULTS

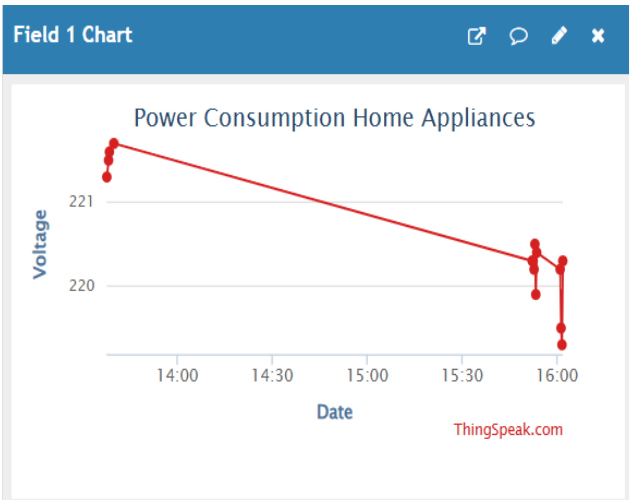


Fig.1 Output Voltage Diagram

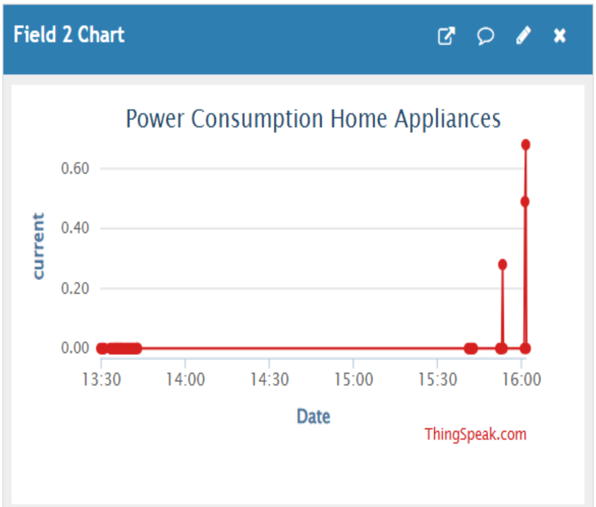


Fig. Output Current Diagram

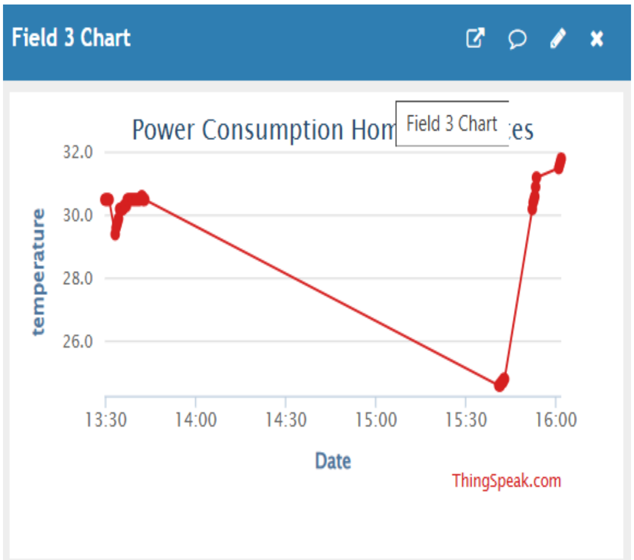


Fig.3 Output Temperature Diagram

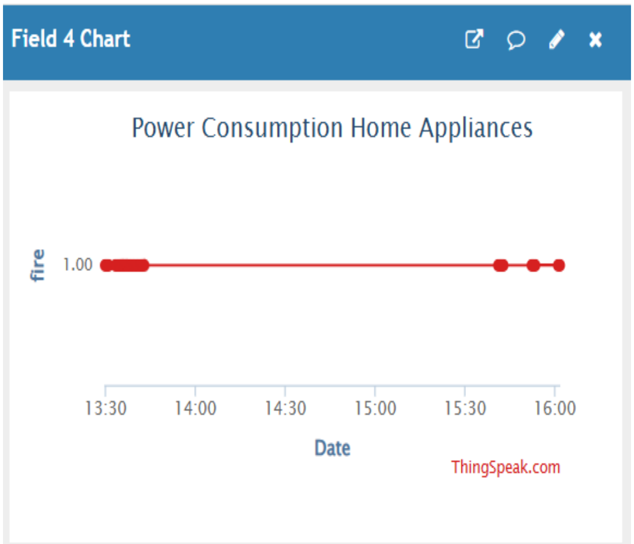


Fig.4 Output Fire Diagram

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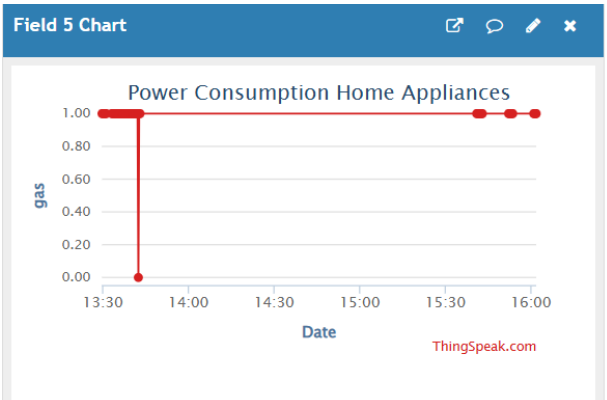

Fig.5 Output Gas Diagram

A SCADA home energy management system is an Internet of Things-based system that combines new-generation sensors, smart appliances, and a control center to monitor and monitor energy usage in real time. It simplifies it for homeowners to monitor their energy usage, streamline appliance usage, and automate wastage saving. The system offers data analytics, smart meters, and IoT sensors through which information concerning consumption patterns is gained, and, therefore, efficient and cost-effective decisions can be made by the users. Automatic behavior adjustment also occurs with adjustments of the thermostats from the information based on the present occupancy or adjusting the devices from peak consumption levels, and money is saved from electricity bills. Fault detection to avoid failure within equipment also aids through predictive functions. In totality, the SCADA system based on the IoT not only increases energy efficiency and cost-effectiveness in operation but also ensures environmental sustainability in terms of decreasing carbon prints.

V. CONCLUSION

Finally, IoT-based power and safety monitoring system is a new solution to improve energy efficiency, convenience, and safety in industries and residential places. With the incorporation of sensors such as fire sensor, LDR, MQ135, DHT11, and PZEM 004T, the system provides real-time environmental conditions and electrical parameters monitoring. It not only optimizes the energy consumption by ensuring automatic day/night cycle and temperature-based adjustment of appliances but also promotes safety through fire hazard and air quality pre-detection. NodeMCU integration for cloud monitoring and control gives a system an extra feature by enabling users to control and monitor devices remotely. This project shows how IoT can design intelligent, secure, and energy-efficient areas for living and working, and hence it is a rich asset for homes and industries in the modern world.

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