CHAPTER 43
IOT Based
Forest Fire Alarm System

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ABSTRACT

Fire Detection Systems are now widely used in various safety and security applications. The major amount of fire starts due to the electric short circuit. It leads to damage to property and also loss of life. To avoid that or to minimize the damage caused by fire outbreaks due to electric short circuits an IoT technology is used to control such a kind of risk. Traditional fire detection systems are not that effective and quick to alert the owner about fire, in case no one is present on the location. To overcome this problem in this paper we present the design and development of IoT based Fire Detection System. A system that combines qualities for fire, temperature and smoke detection, sending alert Text Message about the fire to the user along with onsite alarm(buzzer), updating temperature, humidity and smoke on BLynk cloud every 15 seconds, and it also moves manually with the help of Android Application. The Fire Detection System consists of four main parts: Multiple sensors, communication system motion planning (Manual patrolling), and Android application for manual patrolling of the system. This Fire Detection system can be used in college, school, office, and industry for safety purposes.

Keywords: Fire Detection Systems , IoT technology , BLynk cloud etc.

INTRODUCTION

IoT devices are used in our day-to-day life to monitor and control the electrical, electronic, and mechanical systems used in homes, commercial places, industries, and buildings. IoT stands for " Internet of Things" which means connecting the physical things or objects to the digital world by using various sensors and software connected to a central hub that measures the boundary of the real world as they change time-tot-time and can make a database of the readings or values gathered. When the data gets to the cloud, software processes the data, and then it decides to act, such as sending an alert message without the help of a human.

The Internet of Things inter-connect and inter-relate objects, devices, and people through the wireless network [5].readings or values gathered. When the data gets to the cloud, software processes the data, and then it decides to act, such as sending an alert message without the help of a human. The Internet of Things inter-connect and inter- relate objects, devices, and people through the wireless network [5]. The requirement of placing a smart fire detection system is important within buildings especially in the buildings where many people are inside or valuable belongings. Fire detection systems are important to avoid the loss of personal items caused by both man-made and induced fire. The fire detection system is essential to alert people in time before fire engulfs the building.

They help in the early detection and early warning of fire so that we can extinguish the fire quickly and avoid great disaster and property loss. However, FDS, requires a lot of wiring and labor to install. Hence, we have planned to make an IoT- based wireless fire detection system that is very easy to use. Arduino board is the main controller board that interacts with GSM module, smoke sensor and temperature sensor. For communication purposes it uses a GSM. Through the project codes, the alert message and the phone number of the recipient are given by the user. Due to fire, when temperature and smoke sensor will detect increase in room temperature above certain temperature limit , alert SMS will be sent to the recipient's phone number from the SIM card . inserted into the GSM module [1].

FDS will also alert the people in the room and building with buzzer. The buzzer keeps going on till the temperature is high. It stops buzzing on its own when the temperature of room falls to ordinary value and amount of smoke decreases. This system is very useful whenever the user is not present in the proximity of the affected area. The main concern of this project is, when fire starts due to electric short circuit it will alarm the owner by sending text Message and the people present on site by buzzer. Having said that, the Fire Detection System is purposely designed to alert the owner of the property or any authorized person or security guard whenever any possibilities for having fire disaster prompted in the institute or hospitals or industrial area due to electric short circuit.

LITERATURE SURVEY

Among all the occurred disasters, fires have been known as the dangerous tragedy that could cause damage to the property, also dangerous to the human life. In many disasters, fires have become destructive, recurrent, and most influential disasters if compared to others hazards [1]. Fire outbreak is the third- biggest risk to business operations, according to India Risk Survey (IRS) 2018. In IRS 2016, fire outbreak was ranked eighth-biggest risk to businesses [2]. Almost every day some fires are reported across the country.

These fires not only resulted in the loss of many precious lives and injuries to many but also inflicted heavy property loss [3]. In 2019, fire accidents due to electrical short circuits are marginally higher than the accidents relating to other causes. The fire due to the electrical short circuit has consistently increased year over year. The majority of fire accidents have occurred due to electrical short circuits in residential and commercial buildings [4].

When the monitored temperature increases above 40 degrees Celsius, it is considered a fire situation. There are many types of sensors for fire detection such as heat sensors and smoke sensors; Heat sensors are classic options when the temperature reaches a particular level. Heat sensors have a low false alarm rate, but it is slow in response because the temperature rises slowly in case of fire. Smoke alarms will detect fires before it really starts because in the initial stage of fire smoke will be in large quantity than heat.

Also, we cannot place smoke sensors in frozen areas. If one sensor fails to detect fire in the above condition another will detect the fire. Therefore, we have used both sensors for accurate results [6]. For monitoring of room temperature, we have used ThingSpeak cloud. Bluetooth is used to communicate between the FDS and mobile phone application [7]. When user turn on the Bluetooth we need to turn on the battery of FDS. After Bluetooth is turned on, we need to connect android app to FDS by clicking on the connect button in the app. When it shows connected in the app, click on the start button and user can move the robot manually with the help of forward, reverse, left, right buttons.

EXISTING SYSTEM

The old system of agriculture protection and monitoring primarily relied on manual labor and physical barriers such as fences or scarecrows to protect crops from animals. Farmers would have to manually patrol their fields to check for animal intrusion and scare them away using noise or other means. The old system had several disadvantages, including: High Labor Costs: The old system required a significant amount of manual labor, which could be time-consuming and costly for farmers. Ineffective: Physical barriers such as fences or scarecrows may not always be effective in deterring animals from entering the field, resulting in damage to crops. Reactive: The old system was reactive, meaning that farmers would only respond to animal intrusion after it had already occurred, rather than proactively preventing it. Inefficient: The old system could be inefficient, with farmers spending a lot of time and resources monitoring their fields, which could be better spent on other farm activities. Limited Monitoring: The old system provided limited monitoring of crop growth and health, making it difficult for farmers to make informed decisions about irrigation, fertilization, and harvest.

PROPOSED SYSTEM

A fire system IoT, as you have described it, is a system that incorporates various electronic components such as a NodeMCU, LCD, fire sensor, IoT, relay, and pump to detect and respond to the presence of fire. Here are some details about each component and the advantages of using such a system

ADVANTAGES OF USING A FIRE SYSTEM IOT:

Early detection: By using sensors and IoT, a fire system IoT can detect fires early, which can help prevent them from spreading and causing extensive damage.Remote monitoring: By using IoT, a fire system IoT can be monitored remotely, which can help reduce response times in case of a fire. Automated response: By using relays and pumps, a fire system IoT can automatically respond to the presence of a fire, which can help contain the fire and minimize damage. Cost-effective: By using low-cost microcontrollers and sensors, a fire system IoT can be built relatively inexpensively, making it accessible to a wider range of users. Scalable: A fire system IoT can be scaled up or down depending on the needs of the user, making it suitable for both small and large applications.

NODEMCU:

Development Board NodeMCU is an Open Source Firmware Development Board that helps to mainly build IoT projects with the help of few LUA Scripts. Usually the development board consists of a pre-loaded LUA scripting language, but it is also compatible with Arduino IDE and can be programmed in a fashion similar to that of Arduino. It is analogous to Arduino Hardware with a built in Input / Output pins, it possesses a chip with built in Wi-Fi that enables direct connectivity to internet, thereby facilitating easy control of things from online. It accelerates the Internet of Things projects by providing simplistic and easy development environment for the programmers. The Development Board is based on ESP8266 Chip, integrated GPIO (General Purpose Input Output), PWM (Pulse with Modulation), IIC (Interconnected Integrated Circuit), and ADC (Analog to Digital Converter). It supports a wide variety of libraries, including those for HTTP, UDP, MQTT, and normal GPIO controls. 1.3.2 ESP8266 The ESP8266 chip is the primary component of the development board, it works on 3V logic. It is the chip that is chiefly responsible for the board's ability to connect to Wi-Fi. The early models possess a self-contained System on Chip, and a full TCP/IP stack thereby providing any microcontroller connected to it, the ability to access the Wi-Fi networks. Owing to the technological developments, the recent models have microcontroller ability integrated with the Wi-Fi chip. It has a powerful on-board processing unit and the storage capability is sound enough to allow integration with sensors and other applications via the GPIO pins.

The reduction in the size of the device has placed immense constraints on the power consumption and memory availability. The yester year protocols were too heavy and complex, providing minimal optimization for the presented hardware. Therefore a new protocol with light and simple architecture was long overdue and so MQTT was framed. MQTT (Message Queuing Telemetry Transport) is a message oriented machine-to-machine (M2M) connectivity protocol. Designed as an extremely lightweight publish/subscribe messaging transport, it is useful for connections with remote locations. The striking feature is the protocol's ability to be employed even along with hardware which can comply only with small code footprint. It is also employed in areas when the bandwidth is limited and premium. For instance, it has been used in sensors communicating to a broker via satellite link and small device scenarios where there is a constraint on the bandwidth availability and necessity to reduce the excess processing capability in the hardware. The latest version is MQTT Version 3.1 It is also ideal for mobile applications because of its small size, low power usage, minimized data packets, and efficient distribution of information to one or many receivers. Yet another point worth highlighting is the fact that the protocol is very energy efficient and draws minimal power for operation. Though invented as early as 1999, the full potential of the protocol has been unleashed owing to the drastic improvement and technological advancement in the field of electronics. Currently the protocol is undergoing the process of Standardization and the port 1883 has been designated as the standard port. MQTT layers

Web Server General Any web page that is accessible or viewable over the internet is inherently hosted by a Web Server. In other words, without Web Servers there will not be any Web pages to browse over the Internet. The images, videos, GIF or any text document or PDF that is available on a remote computer must be served and made accessible to the users via Web pages hosted by the Web Servers. Web servers mainly respond to requests initiated by the user anywhere in the world accessed via the World Wide Web. They generally process the HTTP requests that are made by the client via the various and numerous network protocols. It is responsible for serving the web pages to the users on their demand, storing the web pages and also processing the same. The entire communication between the clients and the server is based on the Hyper Text Transfer Protocol. Most times the pages that are delivered or served are HTML documents, which can comprise data ranging from text, images, scripts, etc. The clients communicate with the web servers using web browsers in most cases. The request for a particular page is initiated by the web browser and the server delivers the same. Though the primary purpose of the web server is to serve web pages and user requested data, it is also capable of receiving data from the user, for instance, uploading a file. This is owing to the ability of the HTTP protocol. Web servers also support scripting languages such as PHP, java script, etc. This facilitates the user to control the server's behavior using a

set of scripts. Servers need not necessarily be accessed via the World Wide Web; they can also be deployed to be accessed only through the local networks which can be used for printers and other devices. Multiple servers can be employed in case of heavy traffic requests. Flask It is quite difficult for someone to create a web server from the very scratch moreover it is time consuming, and so many vendors set up a basic frame layout that serves as a guideline in order to ease the process of creating a web server. Many such vendors facilitate creating and hosting of a custom web server catering to our specific needs. Some of the vendors are apache, njinx, etc. Flask, like the other vendors is used to create our custom web servers but with a slight variation from the others. Flask is mainly a web framework that can be written using the python language. Web framework is used for development of web applications such as web servers, web APIs, etc. Flask is mainly server- side web framework, enabling us to display our web pages and applications over the server. Flask doesn't force the users to use a particular set of library or tools, thereby enabling easy and fast development of web applications. Like any other web server development tool, Flask can serve up static files, scripts, regular HTML documents, images, etc.

It has the functionality of creating a developmental web servers for dry run purpose and can has an option of running the server in debug mode, if the user wants to make a log of the crash details. Major advantage of Flask is the fact that it is compatible with many extensions that caters specific needs and purpose and it can process RESTful request. As it is a micro-framework there are little or no dependencies on external libraries. WebScokets When visiting a typical web page, each resource like image, css, javascript file, etc. that the browser comes across when interpreting the document creates a new request to the server using the HTTP protocol.

This includes requests made using Javascript and HTTP Requests. 1.6.1 What is WebSocket? WebSocket is a protocol providing full-duplex communication channels over a single TCP connection. WebSocket is designed to be implemented in web browsers and web servers, but it can be used by any client or server application. Being an independent TCP-based protocol its only relationship to HTTP is that its handshake is interpreted by HTTP servers as a request that can be upgraded. 1.6.2 Conventional protocol "Protocol" is an established set of conventions. In the case of a HTTP protocol, it is a convention for connecting, transmitting, receiving, and disconnecting. WebSockets use a different protocol from HTTP, one that makes a connection and then keeps it open until you leave the page.

Though WebSockets use a different protocol, they initiate communication over HTTP and then transparently change to the special WebSockets protocol. Communication over this connection is not the same as the HTTP GET/POST/etc. it's a special protocol that supports simultaneous data transfer in both directions. 1.6.3 Difference between HTTP and WebSocket Consider a server and client has established connectivity over traditional HTTP by handshake process. Each time when the client requires some data from the server, it has to initiate a full-fledged HTTP request.

 This process is time consuming and if the request takes long time to process the user will have to reset the connection by initiating the handshake again. Sometimes the server may deliberately send the data slowly to avoid such handshake process. But WebSockets are more like a two-way communication between the server and client. Once a handshake has been established for transferring the data it ensures that the channel/connection is kept open in case the client needs any other data form the server.

The connection is kept open until any one of the two initiates a release. This enables simultaneous communication and transfer of any format of data even user defined data. Fig. 1.4-WebSocket communication The server pushes the data to the web browser; the transmission and reception of data occur simultaneously. Since the channel is kept open throughout the entire conversation, the exchange of data doesn't suffer any connection loss as in HTTP protocol.

LCD

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

The potential transformer will step down the power supply voltage (0- 230V) to (15-0-15) level. If the secondary has less turns in the coil then the primary, the secondary coil's voltage will decrease and the current or AMPS will increase or decreased depend upon the wire gauge. This is called a STEP- DOWN transformer. Then the secondary of the potential transformer will be connected to the rectifier. When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.

The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

The path for current flow is from point B through D1, up through Load, through D3, through the secondary of the transformer back to point B.

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through Load, through D2, through the secondary of transformer, and back to point A. Across D2 and D4. The current flow through Load is always in the same direction. In flowing through Load this current develops a voltage corresponding to that. Since current flows through the load during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional half-wave circuit.

This bridge rectifier always drops 1.4Volt of the input voltage because of the diode. We are using 1N4007 PN junction diode, its cut off region is 0.7Volt.

So any two diodes are always conducting, total drop voltage is 1.4 volt.

The unregulated AC/DC power supply part of the circuit consists of a transformer that steps down 230VAC to 15 volts across a center tapped secondary winding 15V AC individually across the two halves of the secondary winding with opposite polarities, diodes (D1) to (D4) that rectify the AC appearing across the secondary with (D1) and (D3) providing 'full wave rectification to produce a positive output, (D2) and (D4), providing full wave rectification to produce a negative output, capacitors (C1) and (C2) providing the filtering action. 7812 is a fixed output positive three terminal regulator whereas

If a Capacitor is added in parallel with the load resistor of a Rectifier to form a simple Filter Circuit, the output of the Rectifier will be transformed into a more stable DC Voltage. At first, the capacitor is charged to the peak value of the rectified Waveform. Beyond the peak, the capacitor is discharged through the load resistor until the time at which the rectified voltage exceeds the capacitor voltage. Then the capacitor is charged again and the process repeats itself.

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

A fixed three-terminal voltage regulator has an unregulated dc input voltage , applied to one input terminal, a regulated dc output voltage, from a second terminal, with the third terminal connected to ground.

The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts.

This is a regulated power supply circuit using the 78xx IC series. These regulators can deliver current around 1A to 1.5A at a fix voltage levels. The common regulated voltages are 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, and 24V. It is important to add capacitors across the input and output of the regulator IC to improve the regulation. In our power supply circuit we get 12 and -12Volt output.

COMPONENT DESCRIPTION

This circuit is designed to control the load. The load may be motor or any other load. The load is turned ON and OFF through relay. The relay ON and OFF is controlled by the pair of switching transistors (BC 547). The relay is connected in the Q2 transistor collector terminal. A Relay is nothing but electromagnetic switching device which consists of three pins. They are Common, Normally close (NC) and Normally open (NO).

The relay common pin is connected to supply voltage. The normally open (NO) pin connected to load. When high (5 Volt)pulse signal is given to base of the Q1 transistors, the transistor is conducting and shorts the collector and emitter terminal and zero (0 Volt)signals is given to base of the Q2 transistor. So the relay is turned OFF state.

When low pulse is given to base of transistor Q1 transistor, the transistor is turned OFF. Now 12v is given to base of Q2 transistor so the transistor is conducting and relay is turned ON. Hence the common

terminal and NO terminal of relay are shorted. Now load gets the supply voltage through relay. relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil.

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. The picture shows a working relay with its coil and switch contacts. You can see a lever on the left being attracted by magnetism when the coil is switched on. This lever moves the switch contacts. There is one set of contacts (SPDT) in the foreground and another behind them, making the relay DPDT. The relay's switch connections are usually labeled COM, NC and NO

One-half cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through Load, through D2, through the secondary of transformer, and back to point A. Across D2 and D4. The current flow through Load is always in the same direction. In flowing through Load this current develops a voltage corresponding to that. Since current flows through the load during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

FIRE DETECTION

The flame sensor is used to detect the flame occurrence. When the sensor detects the fire then it became short-circuit. When there is no fire the sensor become open circuit.

CIRCUIT DESCRIPTION

The flame sensor is like a small module and it is connected with resistor. This connection formed the voltage divider network which is connected with inverting input terminal of the comparator. The reference voltage is given to non inverting input terminal. The comparator is constructed with inbuilt operational amplifier.

When there is no fire, the flame sensor became open circuit. So the inverting input terminal voltage is grater than non inverting input terminal (reference voltage). Now the comparator output is 0V. Hence zero voltage is given to microcontroller.

When there is fire occurred, the flame sensor became short circuit. So the inverting input terminal voltage is less than non inverting input terminal (reference voltage). Now the comparator output is +5V. Hence +5v voltage is given to microcontroller. In the microcontroller we can detect the fire with the help of software.

CONCLUSION AND FUTURE SCOPE

The cost of actual implementation is also considerably less compared to other designs, due to the availability of low-priced sensors. Future work will look into the actual implementation of the system and recording of results. The system can be further improvised by adopting an Fire alarm IOT

A fire system IoT is a highly advanced system that incorporates various electronic components such as sensors, microcontrollers, and relays to detect and respond to the presence of fire. By using IoT, remote monitoring and response become possible, while the automation of the response to the fire can help minimize damage and prevent the fire from spreading. The use of low-cost components also makes this system a cost-effective solution for both small and large applications. With the scalability of the system, it can be customized to meet the specific needs of the user, making it an excellent choice for a wide range of scenarios. Overall, the fire system IoT provides a highly efficient and advanced solution for detecting and responding to fires, and it has significant advantages over traditional fire alarm systems.

REFERENCES

[1]. N N Mahzan, N I M Enzai, N M Zin and K S S K M Noh, "Design of an Arduino-based home fire alarm system with GSM module", 1st International Conference on Green and Sustainable Computing (ICoGeS), 2017.

[2]. Rajit Sengupta, Kiran Pandey, "20 Indian cities saw 80% of building fire deaths", www.downtoearth.org.in, 15 February 2019.

[3]. R. R. Nair, "Fire Safety Regulations in India", www.isrmag.com, May 15, 2018.

[4]. Barath Kancharla, "Number of Fire Accidents in the country reduced over time, Deaths still above 10,000 a year", factly.in, JANUARY 30, 2021.

[5]. Jenil Dosani, Nikunj Makwana, Archana Chaugule, "NodeMCU based Fire Detector System", HBRP Publication, Recent Trends in Cloud Computing and Web Engineering Volume 2 Issue 3, 2020.

[6]. Hamood Alqourabah, Amgad Muneer, Suliman Mohamed Fati, " A Smart Fire Detection System using IoT Technology With Automatic