IoT Based Air Pollution Monitoring System

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ABSTRACT

In a country like India, air pollution is increasing day by day at the alarming rate. The main reason for increasing of pollution level are crop's remaining burning, emission from the motor vehicle, open defecation of smoke in atmosphere from the industries and burning of garbage openly. Internet of Things (IoT) based pollution system is used to detect the current level of hazardous gases in the atmosphere. In our daily lives the quality of air determines the most because every human being needs fresh air to live. The IoT based pollution system will help us to fetch the data from any location where device is installed. All the data is visible in the smart phone app. In this project we have used the Blynk app. By using the concept of IoT we can use multiple pollution devices at different locations and fetch the data to the smartphone app.

Keywords

Internet of Things (IoT), Gas sensor, Smoke sensor, Humidity sensor, Aruino Uno, Blynk, Smart phone app.

1. INTRODUCTION

Air pollution occurs when harmful or excessive quantities of substances including gases, particulates, and biological molecules are introduced into earth's atmosphere. It may cause diseases, allergies and also death of humans; it may also cause harm to other living organisms such as animals and food crops and may damage the natural environment. Human activity and natural processes can both generate air pollution. Basically, there are two types of air pollution exits; visible air pollution and invisible air pollution. The sustainment of all things living is due to a combination of gases that collectively form the atmosphere; the imbalance caused by the increase or decrease of the percentage of these gases can be harmful for survival. The ozone layer considered crucial for the existence of the ecosystems on the planet is depleting due to increased pollution. Global warming, a direct result of the increased imbalance of gases in the atmosphere is the biggest challenge that world has to overcome for better survival. Several divisions are made to understand the causes of air pollution,. Primarily air pollutants can be caused by primary sources or secondary sources. The pollutants that are a direct result of the process can be called primary pollutants. A classic example of a primary pollutant would be the sulphur-dioxide emitted from factories. Secondary pollutants are the ones that are caused by the inter mingling and reactions of primary pollutants. Smog created by the interactions of several primary pollutants is known to be as secondary pollutant. Pollution emitting from vehicles causes immense amount of pollution. Sulphur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution. Carbon monoxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant. The effects of air pollution are alarming. They are known to create several respiratory and heart problems along with cancer, among other threats to the body. Several millions are known to have died due to direct or indirect effects of air pollution. Children in areas exposed to air pollutants are said to commonly suffer from pneumonia and asthma. Another direct effect is the immediate alterations that the world is witnessing due to global warming. With increased temperatures worldwide, increase in sea levels and melting of ice from colder regions and icebergs, displacement and loss of habitat have already signalled an impending disaster if actions for preservation and normalization are not undertaken timely. Harmful gases like nitrogen oxides and sulphur oxides are released into the atmosphere during the burning of fossil fuels. When it rains, the water droplets combine with these air pollutants becomes acidic and then falls on the ground in the form of acid rain. Acid rain can cause great damage to human, animals and crops. Eutrophication is a condition where high amount of nitrogen present in some pollutants gets developed on sea's surface and turns itself into algae and adversely affects fish, plants and animal species. The green coloured algae that is present on lakes and ponds is due to presence of this chemical only. Just like humans, animals also face some devastating effects of air pollution. Ozone exists in earth's stratosphere and is responsible for protecting humans from harmful ultraviolet (UV) rays. Earth's ozone layer is depleting due to the presence of chlorofluorocarbons, hydro chlorofluorocarbons in the atmosphere. As ozone layer will go thin, it will emit harmful rays back on earth and can cause skin and eye related problems. UV rays also have the capability to affect crops. Gartner estimated the total number of IoT devices in use to have reached 8.4 billion in 2017. Intel projected internet-enabled device penetration to grow from 2 billion in 2006 to 200 billion by 2020. A little more conservative, IHS Markit said the number of connected devices will be 75.4 billion in 2025 and 125 billion by 2030. Gartner estimated the total spend on IoT devices and services at nearly $2 trillion in 2017, with IDC projecting spending to reach $772.5 billion in 2018, 14.6% more than the $674 billion it estimated to be spent in 2017, with it hitting $1 trillion in 2020 and $1.1 trillion in 2021. The internet is continuously changing and evolving. The main communication form of present internet is human-human. IoT can be considered as the future evaluation of the internet that realizes machine-to-machine (M2M) learning. Thus, IoT provides connectivity for everyone and almost everything. The IoT embeds some intelligence in internet-connected objects to communicate, exchange information, take decisions, invoke actions and provide amazing services. An indoor air quality meter is used to monitor CO2 levels, or to

detect gas leaks. Whether portable or fixed, handheld or wall mounted, air quality monitoring equipment is essential for air quality meter overview ensuring health and safety. We will find air quality monitoring devices are used for personal safety and are used to detect, measure and monitor relative humidity, ambient temperature and / or levels of CO2, volatile organic compounds (VOCs), formaldehyde (HCHO) and other refrigerants (CFC / HFC), phosphine (PH3), hydrogen sulphide (H2S), carbon monoxide (CO), nitrogen dioxide (NO2), oxygen (O2), ozone (O3) and other flammable, hazardous or toxic gases. This IoT pollution system is used to monitor air quality on the smartphone using Blynk application and Arduino board. Blynk is an IoT platform to control Arduino, Raspberry Pi and the like over the internet. In this project Blynk provides a digital dashboard on the smartphone that displays real-time air quality readings for the immediate surroundings. It will get us online and ready for the IoT, irrespective of whether Arduino or Raspberry Pi is linked to the internet over Wi-Fi, ethernet or an ESP8266 chip. Arduino Uno is used as a control and measuring unit and Arduino Uno Ethernet shield for connection to the Blynk Cloud. The sensors include hazardous gas sensor, smoke sensor, and temperature and humidity sensor. Additional alarm indication and control through relays RL1 and RL2 have been provided. The two appliances (light, fan, bulb, etc) can be connected to connectors, but we can add more as per our requirement. Connector is used for connecting 230V AC mains to drive the lamp and fan connected at relay board. An LCD display is also connected to see the data which is being transmitted to the Blynk server (Fig.1) [6,10].

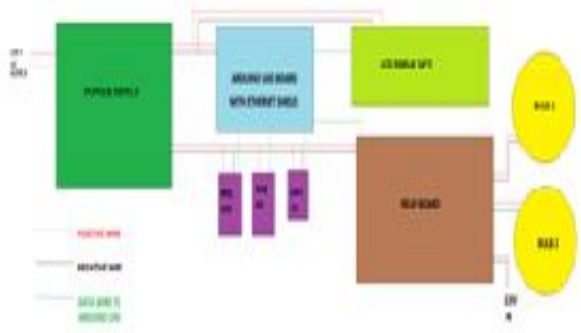

Fig.1: Block diagram of IoT based air pollution monitoring system.

The interconnection of traditionally dumb devices raises a number of questions in relation to security and privacy. IoT involves extending internet connectivity beyond standard devices, such as desktops, laptops, smart phones and tablets, to any range of traditionally dumb or non-internet-enabled physical devices and everyday objects. Embedded with technology, these devices can communicate and interact over the internet, and they can be remotely monitored and controlled. Researchers have already shown remote hacks on pacemakers, cars, and, in October 2016, a large distributed denial-of-service attack dubbed Mirai affected DNS servers on the east coast of the United States, disrupting services. Although, safeguarding IoT devices and the networks is challenging due to the variety of devices and vendors, as well as the difficulty of adding security to resource-constrained devices. Strong passwords, authentication/authorization and identity management, network segmentation, encryption, and cryptography are all suggested IoT security measures. In August 2017, the U.S. Senate introduced the IoT Cyber Security Improvement Act, a bill addressing security issues associated with IoT devices [2, 6, 10, 23-26].

2. MODULES AND MAIN COMPONENTS

2.1 Gas Sensor (MQ 135)

Fig.2: Gas sensor (MQ 135)

The MQ-135 is used to measure air quality. The MQ series of gas sensors use a small heater inside with an electrochemical sensor. They are sensitive to a range of gasses and are used indoors at room temperature. The output is an analog signal and can be read with an analog input of the Arduino. Also, the sensitivity can be adjusted by the potentiometer. The MQ-135 alcohol sensor consists of a tin dioxide (SnO2), a perspective layer inside aluminium oxide micro tubes and a heating element inside a tubular casing. The end face of the sensor is enclosed by a stainless-steel net and the back side holds the connection terminals. Ethyl alcohol present in the breath is oxidized into acetic acid passing through the heater element. With the ethyl alcohol cascade on the tin dioxide sensing layer, the resistance decreases. By using the external load resistance, the resistance variation is converted into a suitable voltage variation. It has high sensitivity to ammonia, sulphide and benzene steam, also sensitive to smoke and other harmful gases [28].

2.2 Smoke Sensor (MQ – 2)

MQ-2 module is used in gas leakage detecting equipment's in family and industry, are suitable for detecting of LPG, i-butane, propane, methane, alcohol, hydrogen and smoke. Due to its high sensitivity and fast response time, measurement can be taken as soon as possible. The sensitivity of the sensor can be adjusted by potentiometer. The MQ2 has an electrochemical sensor, which changes its resistance for different concentrations of varied gasses. The sensor is connected in series with a variable resistor form a voltage divider circuit and the variable resistor is used to change sensitivity. When one of the above gaseous elements comes in contact with the sensor after heating, the sensor's resistance change. The change in the resistance changes the voltage across the sensor, and this voltage can be read by a microcontroller. The voltage value can be used to find the resistance of the sensor by knowing the reference voltage and the other resistor's resistance. The sensor has different sensitivity for different types of gasses [27].

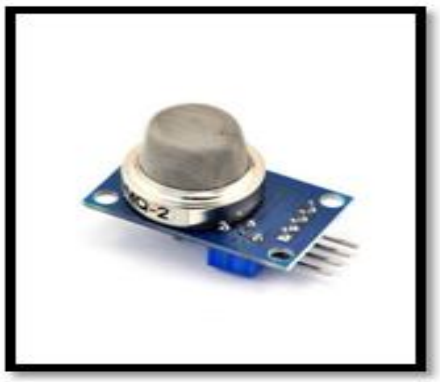

Fig.3: Smoke sensor (MQ–2)

2.3 Humidity Sensor (DHT 11)

DHT11 is a humidity and temperature sensor, which generates calibrated digital output. It can be interface with any microcontroller like Arduino, Raspberry Pi, etc. and get instantaneous results. It is a low-cost humidity and temperature sensor which provides high reliability and long-term stability. The DHT11 humidity and temperature sensor consists of 3 main components. A resistive type humidity sensor, an NTC thermistor and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. Humidity sensor has two electrodes with moisture holding substrate between them. As the humidity changes, the conductivity of the substrate changes or the resistance between these electrodes changes. This change in resistance is measured and processed by the IC which makes it ready to be read by a microcontroller. On the other hand, for measuring temperature these sensors use a NTC temperature sensor or a thermistor. A thermistor is actually a variable resistor that changes its resistance with change of the temperature. These sensors are made by sintering of semi conductive materials such as ceramics or polymers in order to provide larger changes in the resistance with just small changes in temperature. The term NTC means negative temperature coefficient, which means that the resistance decreases with increase of the temperature [29].

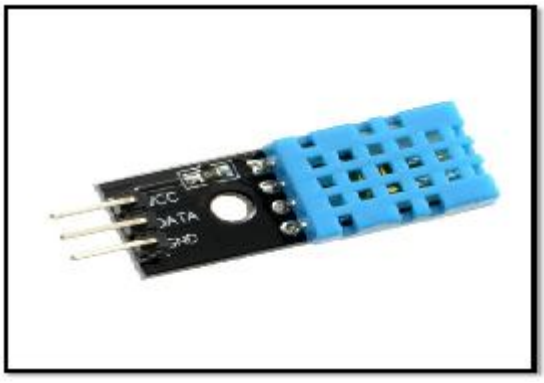

Fig.4: Humidity sensor (DHT 11)

2.4 Arduino Uno

The Arduino UNO is a widely used open-source microcontroller board based on the ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits [1]. The board features 14 digital pins and 6 analog pins. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. A 3.3-volt supply generated by the on-board regulator and it draw a maximum current of 50 mA. The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM [3, 4].

Fig.5: Arduino Uno

2.5 Arduino Ethernet Shield

Fig.6: Ethernet shield

The Arduino ethernet sehield allows us to easily connect our Arduino to the internet. This shield enables our Arduino to send and receive data from anywhere in the world with an internet connection. We can use it to do fun stuff like control robots remotely from a website or ring a bell every time we get a new twitter message. This shield opens up endless amounts of possibility by allowing us to connect to the project to the internet in no-time flat. It has a connection speed of up to 10/100Mb. This is not the fastest connection but better serves the purpose. It relies on the Arduino Ethernet library, which comes bundled with the development environment[3, 4].

2.6 Capacitor, Resistors, Relay, LED, Transformer and Voltage Regulators

Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal

capacitor does not dissipate energy. Here, electrolytic capacitors of 1 µf, 10µf, and 1000 µf are used. Similarly, circuit uses variety different resistors.

Relays are necessary when there must be electrical isolation between controlled and control circuits, or when multiple circuits need to be controlled by a single signal. Relays are most commonly used switching device in electronics. 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. A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable current is applied to the leads, electrons are able to recombine with holes within the device, releasing energy in the form of photons. A mains transformer has 240V primary windings and centre tapped secondary winding. The transformer has flying coloured insulated connecting leads (Approx. 100 mm long). It is AC - 240V to AC - 12V. It is soft iron core, 3Amp. Its output voltage is 12V and 24V. Two different voltage regulators 7805 & 7812 are used for 5 VDC and 12VDC supplies [1-5].

2.7 Pin Header, Bulb & Holder Potentiometer, PCB

A pin header is a form of electrical connector. It consists of one or more rows of male pins typically spaced 2.54 millimetres (0.1 in) apart, but common sizes also include 5.08 millimetres (0.2 in), 5.00 millimetres (0.197 in), 3.96 millimetres (0.156 in), 2.00 millimetres (0.079 in), 1.27 millimetres (0.05 in) and 1.00 millimetre (0.04 in). The distance between pins is commonly referred as pitch in the electronic community. Pin header connectors comprise several different means of connection. Incandescent bulbs are much less efficient than other types of electric lighting; incandescent bulbs convert less than 5% of the energy they use into visible light, A bulb holder is a device that holds a bulb. It is made of bakelite or plastic. The bulb holder is where the bulb fits. The bulb fits into the bulb holder, the bulb holder holds the bulb. The bulb holder contains the electrical connection from the supply to the bulb. The metal end of the bulb comes into contact with the supply when the bulb is screwed into the bulb holder. A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor. The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric voltage. A single pole single throw (SPST) switch is a switch that only has a single input and can connect only to one output. This means it only has one input terminal and only one output terminal. A SPST switch serves in circuits as on-off switches. When the switch is closed, the circuit is on. When the switch is open, the circuit is off. PCB is a copper laminated and non-conductive Printed Circuit Board, in which all electrical and electronic components are connected together in one common board with physical support for all components with base of board [2, 12].

2.8 Diode and Transistor (BC547)

A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low (ideally zero) resistance in one direction, and high (ideally infinite) resistance in the other. In this project we use 1N5408 semiconductor diode. Here, we have used a BC547 transistor NPN transistor. The BC547 is a bipolar junction transistor (BJT) [2, 12].

2.9 2X16 LCD Display

LCD stands for liquid crystal display. Since their interface serial/parallel pins are defined so it's easy to interface them with many microcontrollers. The 16×2 LCD display is a very basic module commonly used in DIYs and circuits. The 16×2 translates to a display 16 characters per line in 2 such lines. In this LCD each character is displayed in a 5×7 or 5x8 matrix. Where 5 represents number of columns and 7/8 represents number of rows. Maximum size of the matrix is 5x8. We cannot display character greater then 5x8 dimension matrix. Normally we display a character in 5x7 matrix and left the 8th row for the cursor. If we use the 8th row of the matrix for the character display, then there will be no room for cursor.

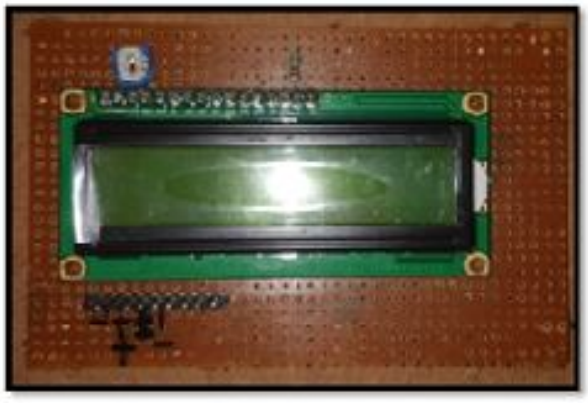

Fig.7: LCD Display

3. CIRCUIT DIAGRAM AND TESTING

The Circuit Diagram

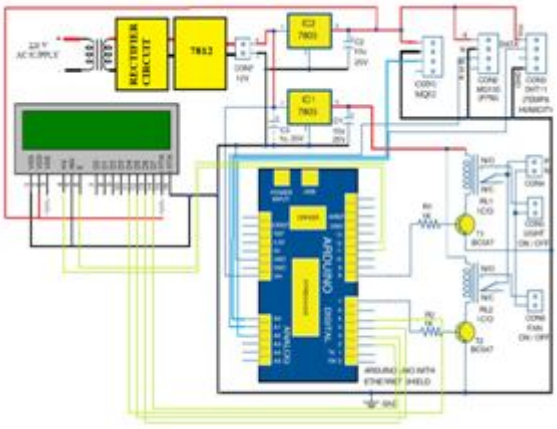

Fig. 8: Circuit diagram of the IoT based air pollution monitoring system

At the heart of the circuit is Arduino Uno board with Arduino shield. Other major components used are temperature and humidity module DHT11 connected to connector CON3, gas sensor MQ135 connected to connector CON2, MQ02 sensor connected to connector CON1 and a few others. Smoke sensor (MQ02) is for particle pollution, also called particulate matter, is a mixture of solid particles and liquid droplets floating in the air. Some particles are released directly from a

specific source, while others are formed in complicated chemical reactions in the atmosphere. The data pin is connected to A1 of Arduino Uno. The normal reading of sensor is below 100 points [7, 9, 14, 20]. Gas sensors (MQ135) sensitive material of the sensor is tin-dioxide, whose conductivity increases with the concentration of gas. Change in conductivity is converted into output voltage signal, which varies corresponding to the concentration of combustible gas. MQ135 is highly sensitive to ammonia, sulphide and benzene steams, smoke and other harmful gases. It is a low-cost sensor, suitable for different applications. Output of the gas sensor is connected to analogue input pin A1 of Arduino Uno board through connector CON2. The normal reading for this sensor is between 150-300 points. Temperature and humidity sensor (DHT11) is composite sensor contains calibrated digital signal outputs of temperature and humidity. Connected to connector CON3, it includes a resistive-type humidity measurement component and an NTC temperature-measurement device. Its output pin is connected to digital pin 6 of Arduino Uno board. It is a relatively inexpensive sensor. Additional alarm indication and control through relays RL1 and RL2 have been provided. The two appliances (light and fan) can be connected to connectors CON5 and CON6, but we can add more as per the requirement. Connector CON4 is used for connecting 230V AC mains to drive the lamp and fan connected at CON5 and CON6, respectively.

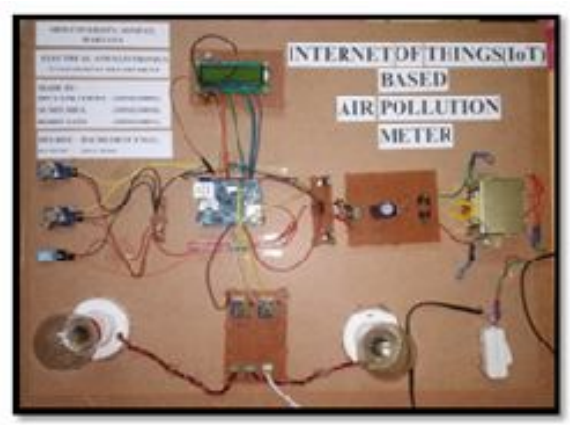

Fig.9: The project component with connection

Arduino Ethernet shield easily connect Arduino to the Internet. This shield enables Arduino to send and receive data from anywhere in the world, with an Internet connection. A 2*16 LCD display is also connected to show the readings of MQ2, MQ135, DHT11 when the device is working without the internet. It is done by the manual programming [7, 9, 14,20].

4. CONCLUSIONS

The proposed IoT based air pollution system is a good device to measure the air quality in outdoors and indoors. This device can be useful to measure the level of gases in a highly dense area like markets hospitals, railway station, bus stand etc from the remote-control room. If data is stored, we can use the data for further experiments which can conclude a significant result. This system is IoT based so it can be used in the smart home for the purpose of cooling, ventilation and other purposes. IoT will enhance the artificial intelligence in the world, so the system can be used in automated systems in factories and industries. This device can be used to understand the flow of wind in different condition and can be helpful to understand their effects on the environment and human life. These systems can become very helpful for the society as the respiratory health conditions are increasing day by day. Due to their high sensitivity these systems can be used in chemical industries. These can be also used by defence agencies to detect any chemical attack. The efficiency of these instruments can be increase by attaching the number of sensor to it. Due to the compatibility to multiple sensors the use of system will be also increased. In early stage meter is powered by the source, but it can be powered by the solar power. In metropolitan cities system can be fitted on the top of the traffic signals due to their compact design. A number of systems can be operated from one control room, without any special arrangement.

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