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Air Pollution Monitoring and Control Using 3D Printed Activated Carbon with Tio2 Filter

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ABSTRACT—

The Emissions of many air pollutants have been shown to have variety of negative effects on public health and the natural environment. Emissions that are principal pollutants of concern include: Hydrocarbons- A class of burned or partially burned fuel, hydrocarbons are toxins. Hydrocarbons are a major contributor to smog, which can be a major problem in urban areas. Prolonged exposure to hydrocarbons contributes to asthma, liver disease, lung disease, and cancer. Regulations governing hydrocarbons vary according to type of engine and jurisdiction. Methane is not directly toxic, but is more difficult to break down in a catalytic converter, so in effect a "non-methane hydrocarbon" regulation can be considered easier to meet. Since methane is a greenhouse gas, interest is rising in how to eliminate emissions of it.This project attempts to develop an effective solution for pollution is monitoring & Controlling by using gas sensor on a real time basis namely real time wireless air pollution controlling system. Commercially available gas sensors for sensing concentration of gases like CO2,CO are calibrated using appropriate calibration technologies.

Keywords: air pollution, hydrocarbons, methane, health hazards, smog, greenhouse gas, real-time monitoring, pollution control

I. Introduction

Air pollution is a growing concern due to its detrimental impact on public health and the environment. A variety of pollutants, including hydrocarbons, significantly contribute to these issues. Hydrocarbons, present in partially burned fuels, act as toxins and are major contributors to smog, particularly in urban areas. Chronic exposure to hydrocarbons poses risks of asthma, liver and lung diseases, and even cancer. Regulations governing these pollutants vary based on engine type and location.

Despite not being directly toxic, methane poses a significant challenge. Its resistance to breakdown in catalytic converters necessitates stricter regulations for "non-methane hydrocarbons" to ensure compliance. Additionally, methane's potent greenhouse gas properties raise concerns and fuel the search for effective mitigation strategies.

This project addresses the critical need for air pollution control by proposing a real-time wireless air pollution monitoring and control system. This system utilizes readily available gas sensors for continuous monitoring of key pollutants like carbon dioxide (CO2) and carbon monoxide (CO). By employing appropriate calibration techniques, the system ensures accurate and reliable data for real-time monitoring and control of air quality.

II. Literature review

Discuss existing methods for air quality monitoring, including stationary and mobile stations, sensor technologies, and data collection methods. Highlight the limitations of these approaches and how your project addresses them.

[1] Review machine learning and statistical techniques used for analyzing air quality data and predicting pollutant levels. Address how your project incorporates these techniques for real-time monitoring and potential control strategies.

[2] Explain the principles of adsorption on activated carbon and photocatalytic degradation by TiO2 for air pollution control. Discuss the advantages and limitations of these materials, focusing on their suitability for your chosen pollutants and filter design.

[3] Explore existing research on 3D printing technologies for air filters, emphasizing the benefits of customization, cost-effectiveness, and potential for complex geometries that your project utilizes.

[4] Review the specific gas sensors you are using and their effectiveness in detecting your target pollutants. Discuss any calibration methods employed to ensure accuracy and reliability.

[5] Describe the control strategies your system will implement based on sensor data. This could involve adjusting filter parameters, activating additional cleaning mechanisms, or integrating with larger air quality management systems.

[6] Analyze similar projects that use 3D-printed filters, activated carbon, TiO2, or real-time control systems for air pollution. Highlight the differences in approach, target pollutants, and performance metrics to clearly demonstrate the novelty of your project.

III. Proposed work

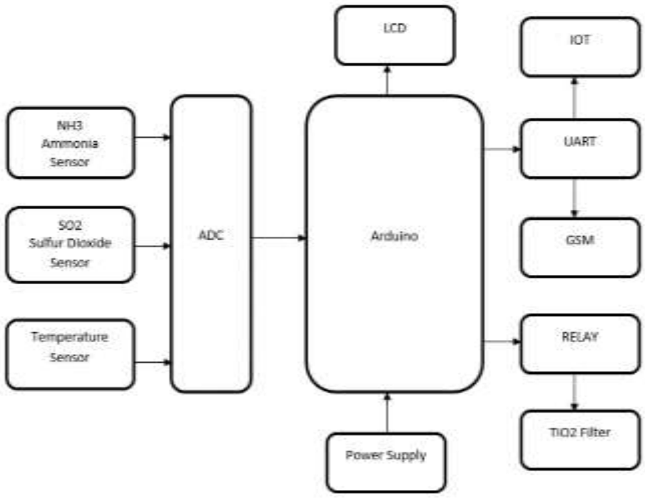
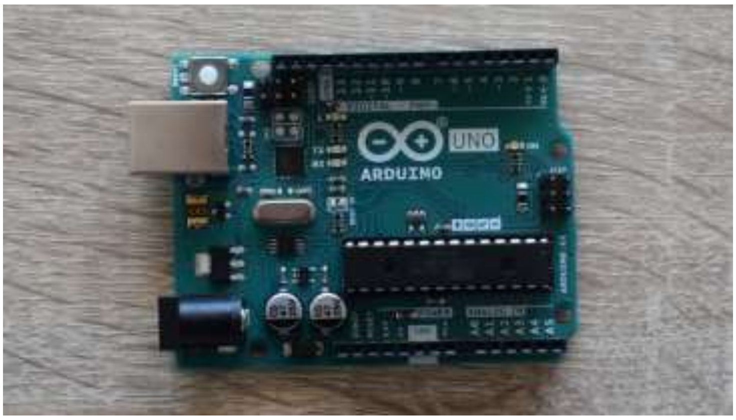


Fig. 1. Systematic Block diagram of Proposed work

The Project aims at designing an air pollution monitoring system which can be installed some other future temperature and gas leakages at particular place specific location and to enhance the system from the previously developed systems. The environment status can be used by anyone to get in live updates about the pollution and gas leakages in their region. It uses microcontroller integrated with individual gas sensors along with temperature & humidity, altitude level, smoke and gas detection sensor which measures the concentration of each gas separately.

A. ARDUINO



Even though there is a large number of different types of microcontrollers and even more programs created for their use only, all of them have many things in common. Here we have used Arduino. Thus, if you learn to handle one of them , you will be able to handle them all. A typical scenario on the basis of which it all functions as follows: Power supply is turned off and everything is still…the program is loaded into the arduino, nothing indicates what is about to come. Power supply is turned on and everything starts to happen at high speed! The control logic unit keeps everything under control.It disables all other circuits except quartz crystal to operate. While the preparations are in progress, the first milliseconds go by.Power supply voltage reaches its maximum and oscillator frequency becomes stable. SFRs are being filled with bits reflecting the state of all circuits within the arduino. All pins are configured as inputs. The overall electronis starts operation in rhythm with pulse sequence. From now on the time is measured in micro and nanoseconds.Program Counter is set to zero. Instruction from that address is sent to instruction decoder which recognizes it,after which it is executed with immediate effect.The value of the Program Counter is incremented by 1 and the whole process is repeated...several million times per second.

B. SENSORS

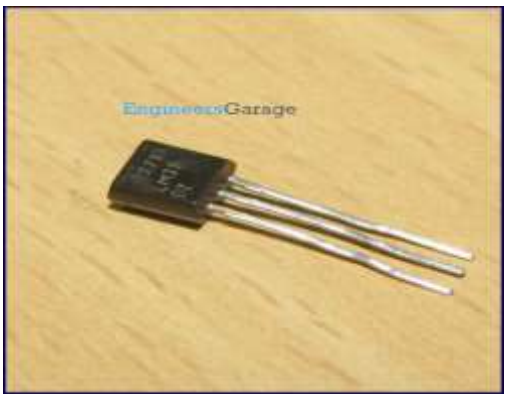
NH3 (AMMONIA SENSOR)

NH3 is a common pollutant emitted from agricultural activities (such as livestock farming and fertilizer use) and industrial processes.NH3 is a common pollutant emitted from agricultural activities (such as livestock farming and fertilizer use) and industrial processes. Connect the sensor to your microcontroller (e.g., Arduino) for data collection. Display NH3 levels on an LCD or web interface.

SO2 (SULFUR DIOXIDE SENSOR)

SO2 is a byproduct of burning fossil fuels (coal, oil, and gas) and industrial processes. Detects harmful levels of SO2, which can cause respiratory issues and acid rain. Helps identify pollution sources (e.g., power plants, vehicles). Calibrate against known SO2 concentrations using reference standards. Integrate SO2 data with your control system for real-time adjustments (e.g., activating air purifiers or adjusting ventilation)

TEMPERATURE SENSOR



The measurement of temperature is one of the fundamental requirements for environmental control, as well as certain chemical, electrical and mechanical controls. Many different types of temperature sensors are commercially available, and the type of temperature sensor that will be used in any particular application will depend on several factors. For example, cost, space constraints, durability, and accuracy of the temperature sensor are all considerations that typically need to be taken into account. Various types of temperature sensors are known including liquid-in-glass (LIG) thermometers, bimetallic thermometers, resistance thermometers, thermocouples, and radiometers. Depending upon the temperature to be measured, the required accuracy of the measurement, and other factors such as durability or cost, one type of temperature sensor may be preferable over another. Some temperature sensors provide a wide range of temperature measurement, whereas other temperature sensors may only provide temperature information for a small temperature range. In addition to the temperature range sensed, the sensitivity and the accuracy of temperature sensors may also vary widely. Additionally, some temperature sensors work at high voltages while others only work at low voltages.

C. 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. Click to learn more about internal structure of a LCD.

D. IOT (INTERNET OF THINGS)

The IOT concept was coined by a member of the Radio Frequency Identification (RFID) development community in 1999, and it has recently become more relevant to the practical world largely because of the growth of mobile devices , embedded and ubiquitous communication, cloud computing and data analytics. A world where billions of objects can sense, communicate and share information, all interconnected over public or private Internet Protocol (IP) networks. These interconnected objects have data regularly collected, analyzed and used to initiate action, providing a wealth of intelligence for planning, management and decision making. This is the world of the Internet of Things. The Internet of Things is much more than machine to machine communication, wireless sensor networks, sensor networks , 2G/3G/4G,GSM,GPRS,RFID, WI-FI, GPS, microcontroller, microprocessor etc. These are considered as being the enabling technologies that make “Internet of Things” applications possible.

Enabling technologies for the Internet of Things are considered in [1] and can be grouped into three categories:

(1) Technologies that enable “things” to acquire contextual information,

(2) Technologies that enable “things” to process contextual information, and

(3) Technologies to improve security and privacy.

IoT Architecture,

It consists of layers that support IoT technologies. At the sensor layer, smart devices with various sensors collect real-time data. These sensors measure temperature, air quality, speed, and more. Connectivity to sensor gateways happens via LAN or PAN. The gateways and networks layer handles communication across diverse protocols and technologies, ensuring seamless data flow for IoT services and applications.

E. UART

A universal asynchronous receiver/transmitter is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with other communication standards such as EIA RS-232.A UART is usually an individual (or part of an) integrated circuit used for serial communications over a computer or peripheral device serial port. UARTs are now commonly included in microcontrollers. A dual UART or DUART combines two UARTs into a single chip. Many modern ICs now come with a UART that can also communicate synchronously; these devices are called USARTs. The Universal Asynchronous Receiver/Transmitter (UART) controller is the key component of the serial communications subsystem of a computer. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Serial transmission of digital information (bits) through a single wire or other medium is much more cost effective than parallel transmission through multiple wires. A UART is used to convert the transmitted information between its sequential and parallel form at each end of the link. Each UART contains a shift register which is the fundamental method of conversion between serial and parallel forms.

F. RELAY

A relay is an electrically operated switch. When current flows through the coil of the relay, it creates a magnetic field that attracts a lever, changing the switch contacts. Relays have two switch positions (double throw or changeover switches). They allow one circuit to control a second circuit, which can be completely separate. For instance, a low-voltage battery circuit can use a relay to switch a 230V AC mains circuit. The connection between the two circuits is magnetic and mechanical, not electrical. The relay coil typically passes a relatively large current (e.g., 30mA for a 12V relay). Most ICs (chips) can't provide this current directly, so a transistor amplifies the small IC current to the required value for the relay coil. Some relays have multiple sets of switch contacts (SPDT, DPDT, or more). While most relays are designed for PCB mounting, you can also solder wires directly to the pins, taking care not to melt the plastic case of the relay.

G. TIO2 FILTER

TiO2 (titanium dioxide) is an oxide of the metal titanium which occurs naturally as a rutile in some acid igneous rocks and metamorphic rocks, and is also in sedimentary rocks and beach sands. TiO2 (titanium dioxide) is found in heavy mineral sand deposits rutile and is often associated with a common titanium mineral, ilmenite, together with zircon, monazite and magnetite.

You will find TiO2in all kinds of paint, printing ink, plastics, paper, synthetic fibers, rubber, condensers, painting colors and crayons, ceramics, electronic components along with food and cosmetics.

IV. Conclusion

The proposed ambient air pollution sensing system can provide real-time measurement of five most important for human health air parameters and transfer it to higher level applications for analysis and forecasting. The system integrates CO, $PM_{1.0}$, $PM_{2.5}$, PM_{10}, CO_2, temperature, and humidity sensors into one compact unit that a controller component. Measured data is bonded together with timestamp and particular result monitor. The device saves data into on-board reading with ability to be transferred to a host computer by direct USB connection or through can be read in-place by LCD display. Mobility is provided by the device compactness and presence of on-board power supply. Such approach gives the ability to implement the low cost flexible mobile air pollution monitoring network in urban areas. Other necessary air pollution parameters could be measured by simple onboard adding of new sensors that support corresponding interface. In comparison with the similar systems developed device is designed to be a complete, ready to use portative measuring system, which can be integrated into different higher level ambient air pollution monitoring applications. The article focuses on the implementation features of developed system. Proposed diagrams with their description bring a practical value.

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