GURU GOBIND SINGH INDRAPRASTHA UNIVERSITY, NEW DELHI

INTERNSHIP PROJECT ON CONVERSION OF ANALOG SIGNAL TO DIGITAL SIGNAL TO DETECT THE HARMFULLNESS OF A GAS

Submitted in partial fulfillment for the session (2021-2025) for the award of the degree in Bachelor of Technology in Department of Electronics and Communications Engineering

SUBMITTED AT:

UNIVERSITY SCHOOL OF INFORMATION, COMMUNICATION & TECHNOLOGY, DWARKA, DELHI – 110078

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SIGNATURE	**YEAR**	II Year
	College	University School of Information, Communication and Technology

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CERTIFICATE OF INTERNSHIP

This is to certify that Bhavdeep Singh Nijhawan of University School of Information, Communication and Technology, Guru Gobind Singh Indraprastha University has successfully completed an internship under the project titled "Conversion of Analog Signal to Digital Signal to Detect the Harmfulness of a Gas". Duration: [Start Date] to [End Date]

During the internship, Bhavdeep Singh Nijhawan actively participated in the design, development, and implementation of a project focused on converting analog signals from gas sensors into digital data for the purpose of detecting and assessing the harmfulness of gases. He demonstrated a high level of dedication, technical expertise, and problem-solving skills throughout the internship.

Bhavdeep singh Nijhawan played a significant role in the following aspects of the project:

- Selection and integration of gas sensors to measure harmful gases.
- Implementation of analog-to-digital conversion techniques for signal processing.
- Calibration and testing of the sensor system to ensure accurate measurements.
- Data analysis and interpretation to assess gas concentration levels and potential risks.
- Collaborating with the project team to achieve project milestones and goals.

Given this [Date] day of [Month], [Year].

[Signature]

[Name of Project Supervisor] [Title of Project Supervisor] [Company/Organization Name]

[Seal of Company/Organization]

DECLARATION

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to all those who contributed to the successful completion of my internship project titled "Conversion of Analog Signal to Digital Signal to Detect the Harmfulness of a Gas." This project aimed to explore the crucial field of environmental monitoring by converting analog signals from gas sensors into digital signals for the detection of harmful gases. The insights gained from this endeavor have been invaluable, shaping my understanding of both analog-to-digital conversion and the environmental impacts of gas pollutants.

I extend my heartfelt thanks to my mentor, Professor P. Mathur, whose guidance, expertise, and unwavering support were instrumental in guiding me throughout this project. Their insightful feedback and patient mentoring played a pivotal role in the development of this work.

I would also like to express my appreciation to the University School of Information, Communication and Technology, Guru Gobind Singh Indraprastha University for providing me with the necessary resources, access to equipment, and a conducive environment for conducting my research.

I am grateful to my family and friends for their constant encouragement, patience, and belief in my abilities. Their unwavering support provided me with the motivation to overcome challenges and achieve milestones during this internship.

Finally, I would like to thank the academic institution that facilitated this internship opportunity and provided the platform for me to expand my knowledge and skills. The experience gained from this project will undoubtedly contribute to my personal and professional growth.

In conclusion, this internship project has been a significant learning experience that has enriched my understanding of analog-to-digital conversion techniques and their applications in environmental monitoring. The knowledge gained from this project will undoubtedly serve as a strong foundation for my future endeavours in the field of engineering and environmental sciences.

Thank you to everyone who contributed to this project in various ways, and I am truly grateful for your support.

Thanking You
Yours Sincerely
Bhavdeep Singh Nijhawan
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ABSTRACT

Air Quality Index is one of the prime issues in metropolitan areas and cities where the health of the people is determined by the air they breathe. Many issues related to lung and throat arise from the poor quality of the air. In this project, we will be majorly discussing the topic and quality of air index that the people from industries related to mining, gas stations and various other hazardous places breathe.

The main motive of this project and thesis is to develop an electronic device accompanied and integrated with programming to convert a continuous signal, that is any gas to a discrete signal, that is a numerical value to measure the extent of harm of the gas.

The project emphasis on design and implementation of a smart air quality monitoring device along with a data analysis system for real-time measurement, analysis, and visualization of air pollutants, thereby aims to raise awareness about air quality among community and provide valuable insights for potential environmental improvements.

Benefits and Outcomes

- Enhanced awareness of air quality among the B.Tech. campus community.
- Practical experience in sensor integration, hardware development, and software programming.
- Contribution to environmental sustainability efforts on campus.
- Insights for potential policy changes or initiatives to improve air quality.
- Integration of real-world applications into B.Tech. coursework.

- Opportunity for collaborative research and data analysis projects.

This project offers a learning experience that combines electronics, software development, data analysis, and environmental science, making it an excellent choice for an internship in the B.Tech. program.

INTRODUCTION

PROJECT OVERVIEW

Sensor Integration and Hardware Development

Integrate sensors capable of measuring key air pollutants such as particulate matter (PM2.5 and PM10), carbon monoxide (CO), nitrogen dioxide (NO2), sulphur dioxide (SO2), and ozone (O3) into a compact, portable device. Design the hardware to ensure accurate data collection and real-time communication capabilities.

Data Acquisition and Transmission

Develop the device to collect air quality data from the integrated sensors and transmit it wirelessly to a central database or server. Choose suitable communication protocols for data transfer.

Data Processing and Analysis

Implement algorithms to process raw sensor data, calculate the air quality index (AQI), and categorize pollution levels. Consider using established AQI calculation methods to ensure accurate and consistent results.

Web-Based Dashboard and Mobile App

Create an interactive web-based dashboard and, if feasible, a mobile app that displays real-time air quality data and trends. Users should be able to view current AQI levels, pollutant concentrations, historical data, and receive alerts based on predefined thresholds.

Alerts and Notifications

Integrate an alert system that sends notifications to users when air quality reaches or exceeds certain predefined levels. Users should be able to receive alerts through email, SMS, or app notifications.

Historical Data Analysis

Implement tools for users to analyse historical air quality data, identify patterns, and draw insights. Provide visualization options such as graphs, charts, and maps for data representation.

Educational Resources

Include educational materials within the dashboard or app to inform users about the importance of air quality, potential health effects of different pollutants, and tips for minimizing exposure.

User-Friendly Interface and Accessibility

Design an intuitive and user-friendly interface for both the web dashboard and mobile app, ensuring that users of varying technical backgrounds can easily understand and interact with the data.

Sustainability and Scalability

Plan for the device's long-term maintenance, including sensor calibration and hardware updates. Consider the potential for expanding the network of monitoring devices across different areas of the campus.

Documentation and Training

Prepare comprehensive documentation detailing device setup, operation, maintenance, and troubleshooting. Conduct training sessions for users to ensure effective utilization of the system.

BENEFITS AND OUTCOMES

- Enhanced awareness of air quality among the B.Tech. campus community.
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- Contribution to environmental sustainability efforts on campus.
- Insights for potential policy changes or initiatives to improve air quality.
- Integration of real-world applications into B.Tech. coursework.
- Opportunity for collaborative research and data analysis projects.

THEORY

In the context of mining processes and hazardous places in India, several factors contribute to the degradation of air quality and the potential health risks associated with poor air quality. Here are some theoretical points related to AQI in mining processes and hazardous places in India:

Particulate Matter Emissions

Mining processes often involve activities that generate significant amounts of dust and particulate matter, which can contribute to elevated levels of PM2.5 and PM10. These particles are tiny and can penetrate deep into the respiratory system, leading to respiratory and cardiovascular health issues.

Heavy Metal Contamination

Mining activities can release heavy metals such as lead, mercury, and cadmium into the air. These metals are toxic and can have serious health effects, especially when inhaled or ingested.

Sulphur Dioxide and Nitrogen Dioxide Emissions

In areas with mining operations, the combustion of fossil fuels and other industrial processes can lead to increased emissions of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). These gases can exacerbate respiratory problems and contribute to the formation of acid rain.

Carbon Monoxide Exposure

Carbon monoxide (CO) is another pollutant that can be emitted from mining equipment and machinery. High levels of CO can interfere with oxygen transport in the body and lead to symptoms like headaches, dizziness, and even death in extreme cases.

Ozone Formation

While ozone (O_3) is typically associated with urban air quality, it can also form as a secondary pollutant through reactions between precursor pollutants in the presence of sunlight. Ozone can have negative effects on respiratory health and plant life.

Health Impacts

Poor air quality in mining areas can lead to a range of health problems, including respiratory diseases (e.g., asthma, chronic obstructive pulmonary disease), cardiovascular issues, and increased susceptibility to infections. Vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions are at higher risk.

Regulatory Measures

The Indian government has established air quality standards and guidelines to regulate pollutant emissions from various industries, including mining. However, enforcement and monitoring challenges can sometimes result in inadequate air quality management in these areas.

Mitigation Strategies

To address air quality concerns in mining processes and hazardous places, measures such as improved ventilation, dust suppression techniques, use of cleaner fuels and technologies, and proper waste management are essential to reduce emissions and protect human health.

It's important to note that the specific AQI levels and pollution sources can vary depending on the type of mining activity, location, and prevailing environmental conditions. Local regulations and monitoring efforts play a crucial role in ensuring that air quality is managed effectively in mining and hazardous areas to safeguard both human health and the environment.

INSTANCES OF GAS TRAGEDIES

Bhopal Gas Tragedy (1984)

One of the most infamous industrial disasters in history, the Bhopal Gas Tragedy occurred on the night of December 2-3, 1984, in Bhopal, Madhya Pradesh. A pesticide plant operated by Union Carbide India Limited (UCIL) leaked around 40 tons of toxic methyl isocyanate (MIC) gas into the atmosphere, leading to the immediate deaths of thousands of people and causing long-term health issues for countless others. The exact death toll remains disputed, but estimates suggest it could be in the thousands, and the aftermath of the tragedy had far-reaching consequences on the affected community.

Visakhapatnam Gas Leak (2020)

On May 7, 2020, a gas leak occurred at a chemical plant in Visakhapatnam, Andhra Pradesh. The plant, owned by LG Polymers India Pvt. Ltd., released a toxic gas, styrene, into the surrounding residential areas, leading to several fatalities and causing injuries to hundreds of people. The incident raised concerns about safety measures in industrial plants and their proximity to residential areas.

Delhi Carbon Monoxide Leak (2021

In January 2021, a tragic incident occurred in a factory in Delhi's Mundka area where a carbon monoxide leak resulted in the deaths of six people. The incident highlighted the importance of proper ventilation and safety protocols in industrial facilities.

Kanpur Factory Gas Leak (2020)

In July 2020, a gas leak incident occurred at a factory in Kanpur, Uttar Pradesh, which led to several workers falling unconscious. Prompt action by authorities helped prevent further casualties, but it emphasized the importance of workplace safety and emergency response measures.

These gas tragedies highlight the importance of strict safety regulations, proper maintenance of industrial facilities, and the need for better disaster preparedness and response mechanisms. They also serve as reminders of the importance of ensuring the safety and well-being of communities living in the vicinity of industrial sites.

FLOW CHART DEPICTING THE MODEL


Start: Initiating the process of analog-to-digital signal conversion for gas detection.
Sensor Data Acquisition: Reading analog signals from gas sensors and amplifying and conditioning the sensor signals for accurate measurement.
Analog-to-Digital Conversion: Converting the conditioned analog signal to digital form using an ADC (Analog-to-Digital Converter).
Data Processing: Processing the digital data to extract gas concentration values and applying calibration factors to convert digital values to gas concentration levels.
Threshold Comparison: Comparing the detected gas concentration levels to predefined threshold values for harmfulness.
Decision Making: Deciding whether the gas concentration is within safe limits or exceeds harmful thresholds. Activating alerts or warnings if harmful levels are detected.
Alert Generation: Generating alerts or notifications to inform relevant stakeholders about detected harmful gas levels.
Data Logging: Logging the processed digital data along with timestamp and sensor information for further analysis.
Data Visualization: Displaying real-time gas concentration levels and alerts on a user interface (dashboard or mobile app).
Historical Data Analysis: Storing historical gas concentration data for trend analysis and pattern recognition.
User Interaction: Allowing users to interact with the system, view real-time data, access historical data, and adjust settings.

PROCESS

ANALOG TO DIGITAL CONVERSION (ADC)

Analog-to-Digital Conversion (ADC) is the process of converting an analog signal into a digital representation that can be processed and stored by digital systems such as computers or microcontrollers. The conversion involves several steps, and here's a general overview of the process:

Sampling

The first step in ADC is sampling, where the continuous analog signal is sampled at regular intervals to obtain discrete data points. The analog signal is measured at specific time intervals, and each measurement represents the amplitude of the signal at that instant.

Quantization

After sampling, the analog voltage levels are quantized into discrete digital values. The range of analog values is divided into a finite number of discrete levels. The number of levels is determined by the bit resolution of the ADC. For example, an 8-bit ADC can represent the analog signal using 2^8 (256) discrete levels.

Encoding

The quantized analog values are then encoded into binary digits (bits) based on the quantization levels. Each discrete level is assigned a unique binary code. For example, in an 8-bit ADC, the analog value corresponding to each level will be represented using an 8-bit binary number.

Digital Output

The final step is to output the digital representation of the analog signal. The binary codes obtained in the encoding step are sent as digital signals to a digital system (e.g., microcontroller, computer) for further processing or storage.

ACCURACY

The accuracy of the digital representation depends on the sampling rate (how frequently the analog signal is sampled) and the bit resolution (the number of bits used to represent the quantized levels).

Higher sampling rates and higher bit resolutions result in more accurate digital representations of the original analog signal, but they also require more processing power and memory.

It's important to note that the ADC process introduces quantization error, which is the difference between the original analog value and the quantized digital value. This error can be minimized by using higher bit resolutions and appropriate signal processing techniques.

ADCs are fundamental components in various electronic systems, from simple applications like audio processing to complex systems in communications, control systems, and data acquisition.

They allow digital devices to interface with the real world by converting continuous analog signals into discrete digital data that can be processed, stored, and manipulated.

EQUIPMENTS

Gas Sensors

Gas sensors capable of detecting the specific harmful gases you are targeting (e.g., carbon monoxide, methane, ozone, nitrogen dioxide, sulphur dioxide). Choose sensors with analog voltage output proportional to gas concentration.

Microcontroller or Microprocessor

An Arduino board, Raspberry Pi, or similar microcontroller/microprocessor for signal processing, data conversion, and communication.

Analog-to-Digital Converter (ADC)

An external ADC module (if not integrated into the microcontroller) to convert the analog sensor output into digital form.

Amplification and Conditioning Circuitry

Op-amps or signal conditioning circuits to amplify and condition the analog signals from gas sensors.

Power Supply

Appropriate power supply for the microcontroller, sensors, and other components.

Display Interface

LED displays, OLED screens, or LCD screens to display real-time gas concentration levels or alerts.

Communication Interface

Components for data communication, such as Wi-Fi module (ESP8266, ESP32) or Bluetooth module (HC-05, HC-06).

Prototyping Board

Breadboard or prototype board for building and testing circuits before soldering components.

Wires and Connectors

Jumper wires, cables, and connectors for interconnecting components.
Enclosure

A casing or enclosure to protect the components and ensure safety.

Computer/Device

A computer or device for programming and interfacing with the microcontroller.

Software Tools

Integrated Development Environment (IDE) for programming the microcontroller (e.g., Arduino IDE).
Circuit simulation software (optional) to model and test circuits before implementation.

Gas Calibration Equipment (Optional)

Calibration gases and equipment to calibrate and validate sensor readings.

Data Storage (Optional)

Storage device (SD card or cloud storage) to log and save historical data.

Mobile Device (Optional)

For testing and interfacing with the developed system through a mobile app.

SENSORS

Gas Sensors for Carbon Monoxide (CO)

- MQ-7 Gas Sensor: Detects carbon monoxide and has high sensitivity and fast response time.
- Figaro TGS5042: Specifically designed for CO detection with low power consumption.

Gas Sensors for Methane (CH_4)

- MQ-4 Gas Sensor: Detects methane gas and is commonly used in gas leak detection systems.
- Figaro TGS2611: Sensitive to methane and other hydrocarbons.

Gas Sensors for Hydrogen Sulphide (H_2S)

- MQ-136 Gas Sensor: Sensitive to hydrogen sulphide gas and often used in industrial applications.
- Winsen ME3-H_2S: High sensitivity to hydrogen sulphide gas.

Gas Sensors for Ammonia (NH_3)

- MQ-137 Gas Sensor: Sensitive to ammonia gas and used in applications such as agriculture and industrial safety.
- Figaro TGS2600B: Detects ammonia and other gases.

Gas Sensors for Nitrogen Dioxide (NO_2)

- MQ-136 Gas Sensor: Besides hydrogen sulphide, this sensor is also sensitive to nitrogen dioxide.
- Alphasense NO_2-B4: Highly sensitive to nitrogen dioxide and commonly used in environmental monitoring.

Gas Sensors for Ozone (O_3)

- MQ-131 Gas Sensor: Sensitive to ozone gas and often used in air quality monitoring devices.
- Alphasense O_3-B4: Specifically designed for ozone detection with high accuracy.

Gas Sensors for Sulphur Dioxide (SO_2)

- MQ-136 Gas Sensor: In addition to detecting hydrogen sulphide and nitrogen dioxide, this sensor can detect sulphur dioxide.
- Winsen ME4-SO2: Highly sensitive to sulphur dioxide gas.

ANALOG TO DIGITAL SIGNAL CONVERSION

Gas Sensing Principle

Gas sensors are devices designed to detect the presence and concentration of specific gases in the environment. They operate based on various sensing principles, such as:

1. **Chemical Reactions**: Gas molecules interact with a sensing material, causing changes in electrical conductivity, resistance, or other electrical properties.

2. **Catalytic Oxidation/Reduction**: Certain gases trigger reactions on the sensor surface, changing its electrical characteristics.

3. **Electrochemical Reactions**: Gases cause electrochemical reactions, resulting in measurable current or potential changes.

Analog Signal Generation

When the target gas interacts with the gas sensor, it produces a change in the sensor's electrical property (e.g., resistance, voltage, current). This change generates an analog electrical signal that varies with the concentration of the detected gas.

Signal Conditioning

The analog signal from the gas sensor is often weak and susceptible to noise. Signal conditioning involves amplification, filtering, and sometimes modulation to enhance the signal quality, improve signal-to-noise ratio, and prepare it for analog-to-digital conversion.

Analog-to-Digital Conversion (ADC)

The conditioned analog signal is converted into a digital signal using an analog-to-digital converter (ADC). ADC quantizes the continuous analog signal into discrete digital values. The resolution of the ADC determines the smallest detectable change in the analog signal.

Calibration and Compensation

Calibrating the gas sensor involves relating the digital values to actual gas concentrations using known reference gases. Compensation accounts for environmental factors, such as temperature and humidity, that can influence sensor performance.

Microcontroller/Processor Interface: The digital signal is processed by a microcontroller or processor. Signal processing techniques, such as averaging, smoothing, and noise filtering, can be applied to further improve signal quality. The microcontroller also manages calibration, compensation, and data interpretation.

Data Analysis and Interpretation

The digital signal is analysed to determine the gas concentration. This may involve linearization based on the sensor's characteristics and calibration curve. Thresholds or predefined limits are set to determine whether the detected gas concentration is harmful.

Display and Communication

Results can be displayed on a user interface, such as an LCD display or LED indicators. Communication interfaces (e.g., UART, I2C, SPI) can transmit data to external devices, controllers, or cloud platforms for remote monitoring and analysis.

Alarm and Control

If the detected gas concentration exceeds safe limits, the system can trigger alarms or safety mechanisms. Additionally, the information can be used to control other systems, such as ventilation or air purification systems.

Data Logging and Storage

For historical analysis and regulatory compliance, the system may log and store gas concentration data over time. This data can provide insights into trends, potential hazards, and system performance.

User Interaction and Feedback

User interfaces can provide real-time feedback, notifications, and warnings about gas concentration levels, allowing users to take appropriate actions.

C++ PROGRAMS

C++ PROGRAM TAKING INPUT FROM SENSOR

```
#include<bits/stdc++.h>
using namespace std;
int main() {
   int input;
   cout<<"Please Enter the Gas Leaked:"<<endl;
   cin>>input;
   if (input == 0) {
      cout<<"No Gas is Leaked."<<endl;
   } else if (input>1000) {
      cout<<"The Gas is Leaking."<<endl;
   } else {
      cout<<"The Gas is Fatal."<<endl;
   }
   return 0;
}
```

C++ PROGRAM CONVERTING ANALOG SIGNAL TO DIGITAL SIGNAL

```
#include<bits/stdc++.h>
using namespace std;
const double PI = 3.14159265358979323846;
std::vector<double> generateAnalogSignal(double frequency, double amplitude, double duration,
double samplingRate) {
   std::vector<double> analogSignal;
   for (double t = 0; t < duration; t += 1.0 / samplingRate) {
      double value = amplitude * std::sin(2 * PI * frequency * t);
      analogSignal.push_back(value);
   }
   return analogSignal;
}
std::vector<int> analogToDigitalConversion(const std::vector<double>& analogSignal, int
bitResolution) {
   double maxAnalogValue = *std::max_element(analogSignal.begin(), analogSignal.end());
   double minAnalogValue = *std::min_element(analogSignal.begin(), analogSignal.end());
   double analogRange = maxAnalogValue - minAnalogValue;
   int quantizationLevels = 1 << bitResolution;
   double stepSize = analogRange / quantizationLevels;
   std::vector<int> digitalSignal;
   for (double value : analogSignal) {
      int digitalValue = static_cast<int>((value - minAnalogValue) / stepSize);
      digitalSignal.push_back(digitalValue);
   }
   return digitalSignal;
}
int main() {
   double samplingRate = 1000;  // Samples per second
   double duration = 1.0;       // Duration of the analog signal in seconds
   double frequency = 10.0;     // Frequency of the analog signal in Hz
   double amplitude = 50.0;     // Amplitude of the analog signal
   int bitResolution = 8;       // Number of bits in the digital representation
    std::vector<double> analogSignal = generateAnalogSignal(frequency, amplitude, duration,
samplingRate);
    std::vector<int> digitalSignal = analogToDigitalConversion(analogSignal, bitResolution);
    std::cout << "Analog Signal:" << std::endl;
   for (double value : analogSignal) {
      std::cout << value << std::endl;
   }

   std::cout << "\nDigital Signal ("
         << bitResolution << "-bit ADC):" << std::endl;
   for (int value : digitalSignal) {
      std::cout << value << std::endl;
   }
   return 0;
}
```

SOURCES

1. www.google.com
2. www.chatgpt.com