Electronic Nose

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Abstract

To detect trace amount of various abnormal gases in the air, the electronic nose uses an array of eight highly sensitive metal-oxide semiconductor (MOS) gas sensors that change resistance when exposed to volatile chemical compounds. The previous iteration of the nose supported a single-chamber testing system which took one hour to complete analysis and required every sample to be prepared manually between tests. Our work builds upon the prior team's work by implementing multi-chamber support that will greatly reduce the amount of manual monitoring operation required.

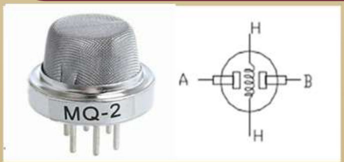
Introduction

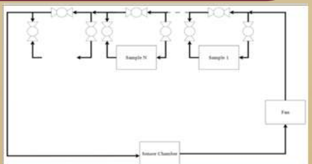
The electronic nose system emulates the biological function of scent by using an array of eight highly sensitive metal-oxide semiconductor (MOS) gas sensors that exhibit a change of internal resistance when exposed to volatile chemical compounds. This variation allows the array to detect the presence and relative concentration of gases in the parts-per-million (ppm) range. To communicate this data into recognizable trends, microcontrollers are utilized to process the data over time and present it on a graph [1]. Practical use cases include food-quality assessment, environmental monitoring, medical diagnostics (e.g., disease detection through volatile biomarkers), and hazardous gas identification. Our contribution to the project is the design and implementation of a solenoid system that, utilizing object-oriented programming, achieves the original team's goal of multi-chamber support and enables further development toward fully autonomous testing.

Sensors To be Used

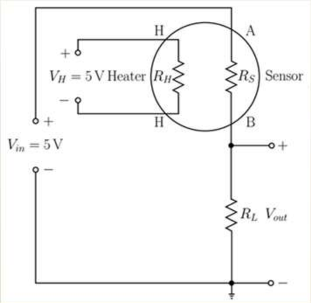
MQ-2	Methane, Butane, LPG, Smoke
MQ-3	Alcohol, Ethanol, Smoke
MQ-4	Methane, CNG Gas
MQ-5	Natural gas, LPG

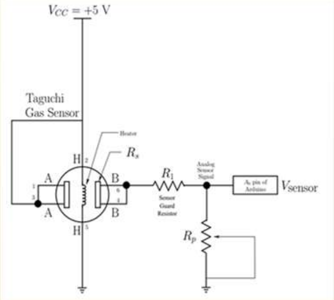
MQ-6	LPG, butane
MQ-7	Carbon Monoxide
MQ-8	Hydrogen Gas
MQ135	Air Quality



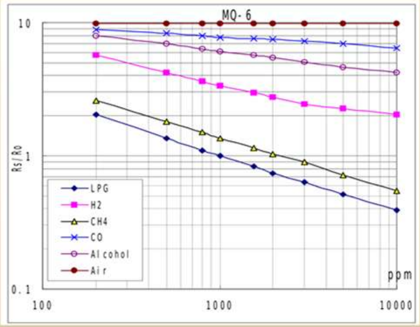


Circuit Diagram - One Sensor



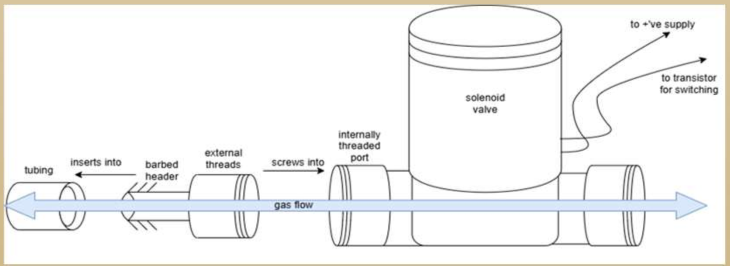


Sensitivity Curve



The x-axis shows the log gas concentration in Parts Per Million (ppm), and y-axis is the ratio of R_S which is the resistance of the MQ-6 Sensor for the sample, and R_o which is the resistance when measuring gas concentration at 1,000 ppm at a temperature (20° C and 65 % humidity).

Solenoid Assembly



Discussion

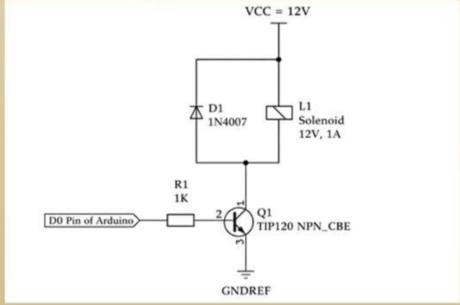
Overview: The electronic nose array consists of eight sensors, each of different specificity and selectivity types to particular gases. Each sensor contains a heating element (model: H pins) and a material between pins A and B whose resistance depends on the concentration of gases present around it when heated. This internal resistance (R_S) can be measured in open air, as well as its new resistance when it encounters gas from a sample (R_O). This ratio is used to determine the ppm of the gas present in the sample. The value of R_S is derived from the voltage obtained across the load resistance R_L by using the Analog to Digital Converter (ADC) in the Arduino. The collected data is handed off to the Raspberry Pi and compiled for further processing.

Procedure: Samples are placed in a closed environment (sampling chamber). The sensor array is mounted in a separate (sensing) chamber. The air inside is circulated from the sampling chamber to the sensing chamber in a closed loop. The V_{RL} of each sensor is measured every second as it encounters volatile organic compounds (VOCs). Each test is approximately 30 minutes. This data can be further interpreted to derive the ppm of gas sampled. When one chamber test completes, the system undergoes a purge cycle to rid the system of the sample and clear the sensing chamber. The system then cycles to the next sampling chamber for testing.

Contribution: The prior solenoids were replaced with electrically-accentuated, normally closed valves that operate at zero pressure. The implementation meets current system specifications (i.e., tube width, material considerations, and power constraints). These solenoids are controlled by TIP120 transistors that switch on upon receiving a high signal from the Arduino. This capability greatly reduces the manual operation required, as each testing cycle is now programmable. A 700W power supply is introduced to meet the solenoid power requirements. The original fan was replaced by a much stronger one, the speed of which will be controlled by PWM. This improved the circulation inside the loop immensely.

Future Work: The data processing will be improved via software in a manner that enables further implementation of a machine-learning model that can predict the classification of the VOCs the nose detects from samples.

Circuit Diagram - One Solenoid



References

1. J. Morrison, "Human nose can detect 1 trillion odours," *Nature*, Mar. 2014, doi: https://doi.org/10.1038/nature.2014.14904.

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