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Air Quality Monitoring System

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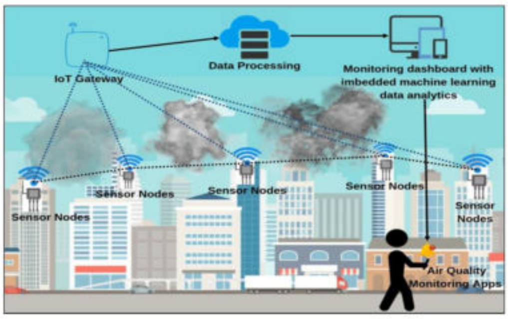
Introduction:

- Air pollution is one of the biggest emerging problems in India with PM as one of the major pollutants.
- To tackle the PM problem, we need to find the precise source of PM which is currently monitored by a sparse network of sensors.
- We have proposed an IoT enabled MQTF based air quality monitoring system, which can be connected via mobile app for personal usage.
- Since our proposed system is low-cost, we can create a large network of these sensors to get accurate AQI data at the location of the user.



Literature:

- *Particulate matter* (PM) is micro-scale particle suspended in ambient air. PM can be classified into two groups according to their size: PM10 and PM2.5. Along with ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead, PM has been listed as one of the six criteria air pollutants.
- More and more evidences have proved that PM has adverse health effects and the health issues are directly related to the size of PM [1]–[4].
- The commonly used methods for PM monitoring include TEOM, QCM, SAW, and FBAR. Although each of the method shows its own advantage, there are great challenges to miniaturize these sensing platforms for wearable and reliable personal exposure monitoring.
- We propose, a PM sensor using the micro quartz tuning fork as a transducer with use of an "adhesive" coating layer for PM capture, and specially designed and positioned "nozzle" for efficient sample delivering, both of which contribute to the high sensitivity of the PM sensor.

Methods:

- As shown in the schematic, the pump will initially be turned on and air-suction will start through the $PM_{2.5}$ impactor.
- Air will be passed to the purging channel where $PM_{2.5}$ particles present in the air will get deposited on the MQTF module due to it is coated repositionable polymer glue.
- MQTF frequency will decrease due to this deposition of $PM_{2.5}$ particles. This change in frequency can be tracked with the help of a simple ADC circuit.
- The received data will be further processed and manipulated to draw useful conclusions and can be sent over cloud to user's device.

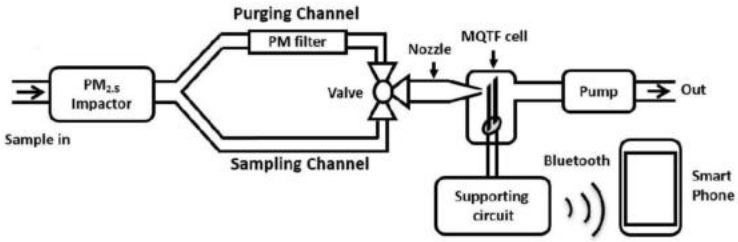


Figure 1. *MQTF Based Sensor*

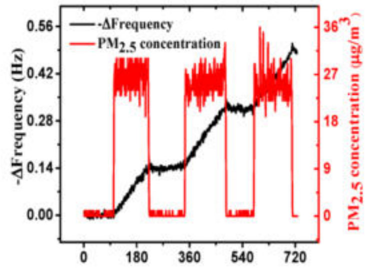
Analysis:

- The resonant frequency of the tuning fork is determined by the following equation: $f = \frac{1}{2\pi}\sqrt{k/m}$
- When PM2.5 is captured by the glue on the MQTF module, the effective mass will be changed, which results in a resonant frequency downward shift.
- This resonant frequency shift can be monitored and recorded by the detection circuit, from which the PM2.5 concentrations can be calculated by doing necessary calibration.

Results:

- We can clearly see from the plot that the slope of $\Delta Frequency$ vs time increases on increase of $PM_{2.5}$ concentration and decreases on decrease in $PM_{2.5}$.
- Hence, we can conclude that the frequency of MQTF module decreases as the mass of deposited $PM_{2.5}$ increases and so as the frequency according to the relation:

$$f = \frac{1}{2\pi}\sqrt{k/m}$$



Conclusions:

- In summary, a highly sensitive $PM_{2.5}$ sensor with capability of continuous monitoring has been proposed by using the mass-sensitive MQTF as the transducer.
- The sensor can be developed by integrating glue-coated MQTF sensing element, detection circuit and wireless communication module for connecting it to cloud and sending data to user's mobile app.
- Because of the low cost of the MQTF, the simple fabrication procedure, and the miniaturized size of the sensor, this sensor could be a promising candidate for personal exposure assessment.

Important References:

[1] S. Boussaad and N. J. Tao, "Polymer wire chemical sensor using a microfabricated tuning fork," Nano Lett., vol. 3, no. 8, pp. 1173–1176, Aug. 2003

[2] F. Tsow et al., "A wearable and wireless sensor system for real-time monitoring of toxic environmental volatile organic compounds," IEEE Sensors J., vol. 9, no. 12, pp. 1734–1740, Dec. 2009.

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