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A Low Power Reconfigurable Multi-Sensing Platform For Gas Application

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Abstract

Presence of toxic gases and accidental explosions in gas industries have turned the researcher to innovate an electronic nose system which can indicate the nature and the parameters of the gas passing through different vessels. Therefore, in this research we propose a low power Radio Frequency Identification (RFID) based gas sensor tag which can monitor the parameters and indicate the type of gas. The research work is divided in to three main parts. The first two parts cover the design and analysis of low power multi-sensors and processing unit, while the last part focuses on a passive RFID module which can provide communication between the sensor and the processing unit, as shown in Fig. 1.
In passive RFID applications, power consumption is one of the most prominent parameter because most of the power is harvested from the coming RF signal. Therefore a ring-oscillator based low power temperature sensor is designed to measure the gas thermodynamic conditions. The oscillator is designed using the Thyristor based delay element [7], in which the current source present for temperature compensation has been displaced to make the delay element as temperature dependent. The proposed temperature sensor consumes 47nW power at 27 °C, which increases linearly with temperature. Moreover, a 4x4 array of tin-oxide gas sensor based on convex Micro hotplates (MHP), is also utilized to identify the type of gas. The array is designed such that each sensor of an array provide different pattern for the same gas. The power consumption caused by the temperature and gas sensor is in the order of few µW's. The prime advantage of MHP can be visualized by the 950 °C annealed MHP, which exhibit the thermal efficiency of 13 °C /mW. Moreover it requires a driving voltage of only 2.8V to reach 300 °C in less than 5ms, which make it compatible with power supplies required by CMOS ICs.
The gas sensor will provide 16 feature points at a time, which can results in hardware complexity and throughput degradation of the processing unit. Therefore, a principle component analysis (PCA) algorithm is implemented to reduce the number of feature points. Thereafter, a binary decision tree algorithm is adopted to classify the gases. We implemented both algorithms on heterogeneous Zynq platform. It is observed that the execution of PCA on Zynq programmable SoC is 1.41 times faster than the corresponding software execution, with a resource utilization of only 23% .
Finally, a passive ultrahigh-frequency (UHF) RFID transponder is developed for communicating between the sensing block and processing unit. The designed module is responsible to harvest the power from the coming RF signal and accomplish the power requirement of both sensors. The designed transponder IC achieved minimum sensitivity of -17dBm with a minimum operational power of 2.6µW.