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Application of Semiconductor Sensor Arrays and IEEE 1451 Standard for Air Pollution Monitoring

By

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ACRONYMS AND ABBREVIATIONS

$\mu g/m^3$	:	micrograms per cubic meter
ADC	:	Analog to Digital Converter
bps	:	bits per second
CO	:	Carbon monoxide
DAC	:	Digital to Analog Converter
DDK	:	Driver Development Kit
DGND	:	Digital Ground (Digital Common)
DMA	:	Direct Memory Access
EAPMS	:	Environmental Air Pollution Monitoring System
ECP	:	Extended Capabilities Port
EPA	:	US Environment Protection Agency
EPP	:	Enhanced Parallel Port
Flash/EE	:	electrically erasable programmable nonvolatile flash memory
FTIR	:	Fourier Transform Infrared
GC	:	Gas Chromatography
GUI	:	Graphical User Interface
I/O	:	Input and Output
I^2C	:	Inter Integrated Circuits
IDLH	:	Immediately Dangerous to Life or Health
IEEE	:	Institute of Electrical and Electronics Engineers
IST	:	International Sensor Technology
kBps	:	kilo Bytes per second
kt/y	:	kilotons per year
LCD	:	Liquid Crystal Display
LEL	:	Lower Explosive Limit or Lower Flammable Limit (LFL)
MBps	:	Mega Bytes per second
MCU	:	Microcontroller Unit

mg/m^3	:	milligrams per cubic meter
MMOS	:	Mixed Metal Oxide Semiconductor
NAAQS	:	National Ambient Air Quality Standards
NCAP	:	Network Capable Application Processor
NIOSH	:	National Institute for Occupational Safety and Health
NIST	:	National Institute of Standards and Technology, US
NO_2	:	Nitrogen dioxide
NO_x	:	Oxides of Nitrogen
n-type	:	Negative type semiconductors having more free electrons than intrinsic semiconductors
O_3	:	Ozone
PC	:	Personal Computer
PID	:	Photo Ionization Detector
PM	:	Particulate Matter
PM_{10}	:	Particulate Matter: having particles aerodynamic diameter is 10μm and smaller
$PM_{2.5}$	:	Particulate Matter: having particles aerodynamic diameter is 2.5μm and smaller
ppb	:	parts per billion by volume
ppm	:	parts per million by volume
p-type	:	Positive type semiconductors having more holes than intrinsic semiconductors
PWM	:	Pulse Width Modulator
SO_2	:	Sulfur dioxide
SO_x	:	Oxides of Sulfur
SPI	:	Serial Peripheral Interface
SPM	:	Suspended Particulate Matter
SPP	:	Standard Parallel Port
SRAM	:	Static Random Access Memory
STIM	:	Smart Transducer Interface Module

TEDS	:	Transducer Electronic Data Sheet
THC	:	Total Hydrocarbons: Un-burnt hydrocarbons in the exhaust gas of engines
TII	:	Transducer Independent Interface
TTL	:	Transistor Transistor Logic
UUID	:	Universal Unique Identification
UV	:	Ultra Violet
UVB	:	Ultra Violet Radiation – Range B (wavelengths of 280 – 315 nm)
VOC	:	Volatile Organic Compounds
WHO	:	World Health Organization

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ABSTRACT

An Environmental Air Pollution Monitoring System (EAPMS) which is capable of detecting and measuring of major air pollutant gases has been constructed. This system measures concentrations of major air pollutant gases CO, NO_2, SO_2 and O_3 using semiconductor sensors. The EAPMS was developed to comply with IEEE 1451 standard, especially IEEE 1451.2 standard. It consists mainly of three parts: Smart Transducer Interface Module (STIM) to which a semiconductor sensor array and signal conditioning circuits have been connected, Network Capable Application Processor (NCAP) and Transducer Independent Interface (TII). All key functions of STIM have been implemented using the ADuC812 microconverter (Analog Devices). The STIM and the NCAP were linked by the TII. Three gas sensors were calibrated using the standard calibration methods.

In the EAPMS, the STIM measures the concentrations of pollutant gases and converts into digital data when a request is made by the NCAP. Eventually, this data is fed to the NCAP. A standard PC has been used to simulate the NCAP. Gas concentration levels and information pertaining to the STIM can be seen on the Graphical User Interface (GUI) of the NCAP. The EAPMS is capable of measuring CO concentrations in the range of 0 – 400 ppm, SO_2 in the range of 0 – 10 ppm and O_3 in the range of 0 – 100 ppb. Further, the EAPMS can generate warnings when the pollutant level exceeds predetermined maximum permitted air quality levels.