ADI Gas Detector Solution Based on NDIR and PID

Application Introduction

This is the second article on gas detectors from ADI, which contains the NDIR (non-dispersive infrared) gas detector solution and the PID (photoionization) gas detector solution. The first article describes a micro-power toxic gas detector based on an electrochemical sensor (see Design Resources at end of this article for additional information).

The NDIR sensor is based on absorption spectroscopy theory—a specific gas absorbs a specific wavelength in the infrared (IR) spectrum, and the gas concentration is proportional to the amount of IR light absorbed. The advantages of an NDIR detector are high sensitivity, long operating life, reduced maintenance, safety, and reliability. The main disadvantage of NDIR is its high price. NDIR gas detectors are commonly employed in the detection of methane and carbon dioxide, which can be used in applications for the mining, agriculture, oil, and chemical industries.

The PID sensor is mainly made up of ultraviolet (UV) light and an ion chamber. UV light excites gas molecules resulting in electrons and ions that produce current relating to the gas concentration in the ion chamber. The advantages of PID gas detectors are high sensitivity, fast response, high accuracy, safety, and reliability. However, the cost of PID detectors is also high and the selectivity of PID detectors is not good. Thus, PID gas detectors are commonly employed in the detection of volatile organic compounds (VOC) like aromatics, ketones, and aldehydes. These applications are suitable in the chemical industry, oil and gas, and airlines.

System Design Considerations

Reliability

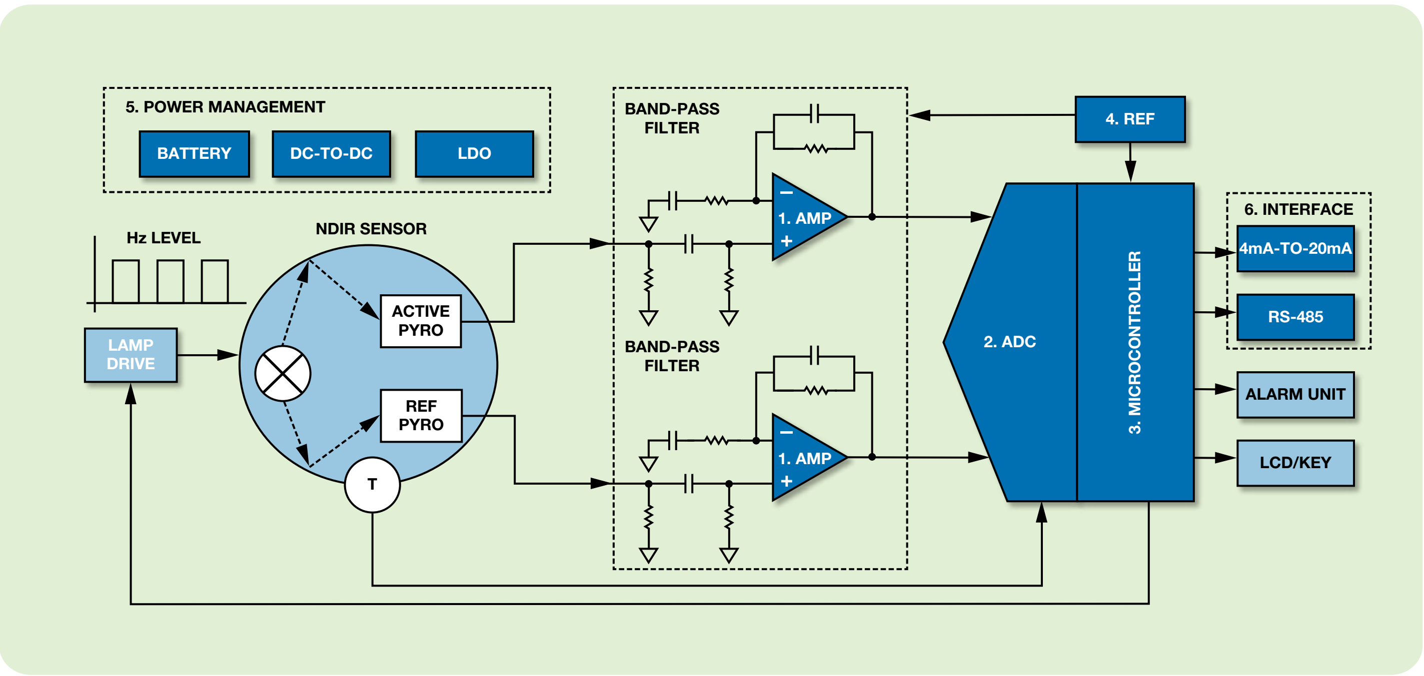
Accuracy, interference immunity, and good long-term stability are important factors during NDIR and PID detector design. To achieve this object, low drift and an accurate signal chain are needed for a reliable gas detector.

Resolution

To take full advantage of sensor dynamic range, the low noise and high resolution should be taken into consideration during signal chain and power design both for NDIR and PID detectors.

NDIR Solution from ADI

Below is the system block diagram of an NDIR gas detector, including NDIR sensor, band-pass filter, microcontroller (ADC integrated), power management, and communication interface.



Note: The signal chains above are representative of the system block diagram of a toxic gas detector design. The technical requirements of the blocks vary, but the products listed in the table below are representative of ADI's solutions that meet some of those requirements.

1. Amplifier	2. ADC	3. Microcontroller	4. Reference	5. Power Management	6. Interface
AD8629/ ADA4528-1	AD7798	ADuCM361	ADR423/ ADR4533	ADP2503/ ADP2370/ ADP160	AD5420/ ADM2483/ AD5749

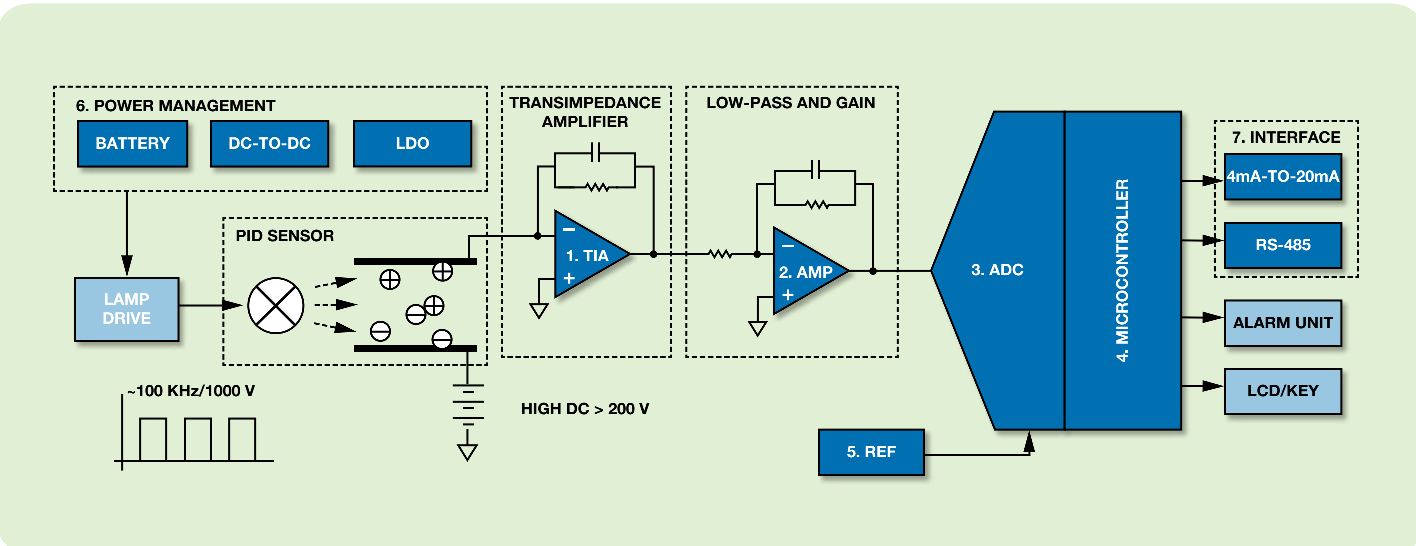
The NDIR gas sensor contains a lamp, which is driven at low frequency by a lamp drive circuit. The small pyro (pyroelectric sensor) output signals are approximately sawtooth in shape and must be amplified and filtered. A band-pass amplifier is applied to pass only the fundamental frequency and reduce noise at other frequencies. The amplifier outputs are roughly sinusoidal in shape. The ADC gets the amplitude of active and reference channels whose ratio is related to the gas concentration.

Reliability: ADI is committed to providing accurate and low drift signal chain products like zero-drift amplifiers, low noise and drift references, and highly accurate ADCs, all of which help designers build an accurate and stable system. The ADC could be independent or integrated with the MCU depending on the detailed application.

Resolution: Since the output voltage of an NDIR sensor is a level of mV, the noise at the input stage of signal condition should be around 1 μV to achieve 0.1% resolution. The common bandwidth of the signal chain is less than 10 Hz, so the 1/f noise (0.1 Hz to 10 Hz) from the amplifier dominates. The ADI zero-drift amplifier with ultralow 1/f noise can help the designer achieve high resolution.

PID Solution from ADI

Below is the system block diagram of the PID gas detector, including PID sensor, transimpedance amplifier (TIA), low-pass filter, microcontroller (with integrated ADC), power management, and communication interface.



1.TIA	2. Amplifier	3. ADC	4. Microcontroller	5. Reference	6. Power Management	7. Interface
AD549/ AD8605	ADA4528-1/ AD8629	AD7190	ADuCM361	ADR423/ ADR4533	ADP2503/ ADP160/ ADP2370	AD5420/ ADM2483/ AD5749

The PID gas sensor contains an ultraviolet (UV) lamp, which is pulsed at about 100 kHz frequency by a lamp drive circuit. Ionization occurs when a molecule absorbs high energy UV light and ionizes in electrons and ions. The high voltage across the ionization chamber forces a weak current flowing through the transimpedance amplifier to transfer to voltage. After going through the low-pass filter with gain, the voltage signal goes to the 24-bit sigma-delta ADC.

Reliability: Similar to NDIR system, the ultralow bias current of the TIA, low drift of the zero-drift amplifier, and the high performance ADC can benefit the designer with an accurate and stable signal chain.

Resolution: The ADI TIA not only offers ultralow bias current but also ultralow current noise. With a 24-bit sigma-delta ADC integrated with MCU, the designer can implement a PID system with very high resolution. An independent ADC should be considered if the designer needs more resolution.

Main Products

Part Number	Description	Benefits
Amplifier		
ADA4528-1	Zero drift 15 nV/°C @ max, ultralow noise 97 nV p-p @ 0.1 Hz to 10 Hz	Zero drift and low noise contribute to a very accurate system
AD8629	Zero drift 20 nV/°C @ max, very low noise 0.5 μV p-p @ 0.1 Hz to 10 Hz, dual in one package	Zero drift and low noise contribute to a very accurate system, dual in one package helps channel consistency
TIA		
AD549	Ultralow bias current 60 fA @ max, ultralow current noise 0.16 fA/$\sqrt{Hz}$	High reputation in precision TIA measurement
AD8605	Low bias current 1 pA @ max, low current noise 10 fA/$\sqrt{Hz}$	Low cost for TIA measurement
ADC		
AD7798	140 μA @ max quiescent current, up to 470 Hz output update rate, 3-channel 16-bit peak-to-peak resolution at any output data rate	Low power Σ-Δ ADC, high resolution and high accuracy
AD7190	24-bit Σ-Δ ADC, 23-bit peak-to-peak resolution @ max, programmable output data rate from 4.7 Hz to 4.8 kHz, 2 differential inputs or 4 pseudo-differential inputs	Very high resolution and very high accuracy
Reference		
ADR423	3 V reference, very low drift: 3 ppm/°C (max), low noise: 2 μV p-p @ 0.1 Hz to 10 Hz, long time stability: 50 ppm/$\sqrt{1000}$ hr	Low drift, good stability and low noise reference, many other choices for output voltage in ADR42x family
ADR4533	3.3 V reference, very low drift: 2 ppm/°C (max), low noise: 2.1 μV p-p @ 0.1 Hz to 10 Hz, long time stability: 25 ppm/$\sqrt{1000}$ hr	Low drift, very good stability and low noise reference, many other choices for output voltage in ADR45xx family
Microcontroller		
ADuCM361	Precision analog microcontrollers, ARM Cortex™-M3 32-bit processor, 6 differential channels, single (24-bit) ADCs, single 12-bit DAC, power consumption 1.0 mA, 290 μA/MHz, 19-pin GPIO, 128 kbytes Flash/EE memory, 8 kbytes SRAM	Low power consumption, ultrahigh precision 24-bit Σ-Δ ADC
Power Management		
ADP2503	38 μA quiescent current; 2.5 MHz buck-boost dc-to-dc converters, has ability to operate at input voltages greater than, less than, or equal to the regulated output voltage	Low power consumption to achieve long battery life, small package and few external parts reduce PCB space.
ADP2370	3.0 V to 15 V input , 800 mA, 1.2 MHz or 600 K PWM frequency, low quiescent current 14 μA, high efficiency larger than 90%, current-mode control architecture	Small 3 mm × 3 mm LFCSP package, few peripheral components, and small solution size
ADP160	2.2 V to 5.5 V input, 150 mA maximum output current, 1% initial accuracy, up to 15 fixed-output voltage options available from 1.2 V to 4.2 V; low quiescent current: 42 μA	Low power consumption, integrated output discharge resistor, small package with only two 1 μF external capacitor
Interface		
AD5420	16-bit resolution; current output ranges: 0 mA to 24 mA, 0.01% FSR typical total unadjusted error; 3 ppm/°C typical output drift; on-chip reference (10 ppm/°C maximum)	16-bit resolution and monotonicity, supports HART communication
ADM2483	Half-duplex, 500 Kbps data rate, 5 V or 3 V operations, low power operation: 2.5 mA max, 2.5 kV isolation	Low power operation and competitive price
AD5749	4 mA to 20 mA driver, current output ranges: 0 mA to 24 mA or 4 mA to 20 mA, 0.03% FSR typical total unadjusted error (TUE), 5 ppm/°C typical output drift	Low cost, precision 4 mA to 20 mA driver

Design Resources

Design Tools/Forums

- ADuCM361 Design Tools: —*ftp.analog.com/pub/MicroConverter*
- Analog Filter Wizard™: ADI Active Filter Design Tool —*www.analog.com/AnalogFilterWizard*
- ADIsimPower™: ADI Voltage Regulator Design Tool—*www.analog.com/adisimpower*
- ADIsimOpAmp™: ADI OpAmp Design Tool—*www.analog.com/adisimopamp*
- EngineerZone®: Online Technical Support Community—*ez.analog.com*

Reference

- ADI Micropower Toxic Gas Detector Solutions Based on Electrochemical Sensors—*www.analog.com/ECGasDetector*

To View Additional Signal Generator Resources, Tools, and Product Information, Please Visit *instrumentation.analog.com*

Customer Interaction Center

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