ADI DEMO SYSTEM FOR pH METERS AND CONDUCTIVITY METERS

Application Introduction

This is the second article for pH meter and conductivity meter applications. In the first article, water analysis applications, a theory of operation, circuit architecture, and design considerations were discussed. In this article, a related Analog Devices demo system will be introduced. For the first article, please refer to the link to the APM (Application Per Month) listed at the end of this article.

System Design Considerations

Stability

Drift with time and temperature are very important factors during pH meter and conductivity meter design. Analog Devices excels at achieving the low drift and accuracy in signals chains that designers require.

Resolution

To take full advantage of a sensor's dynamic range, low noise and high resolution should be taken into consideration during signal chain and power design, especially for laboratory instruments.

Low Power Consumption

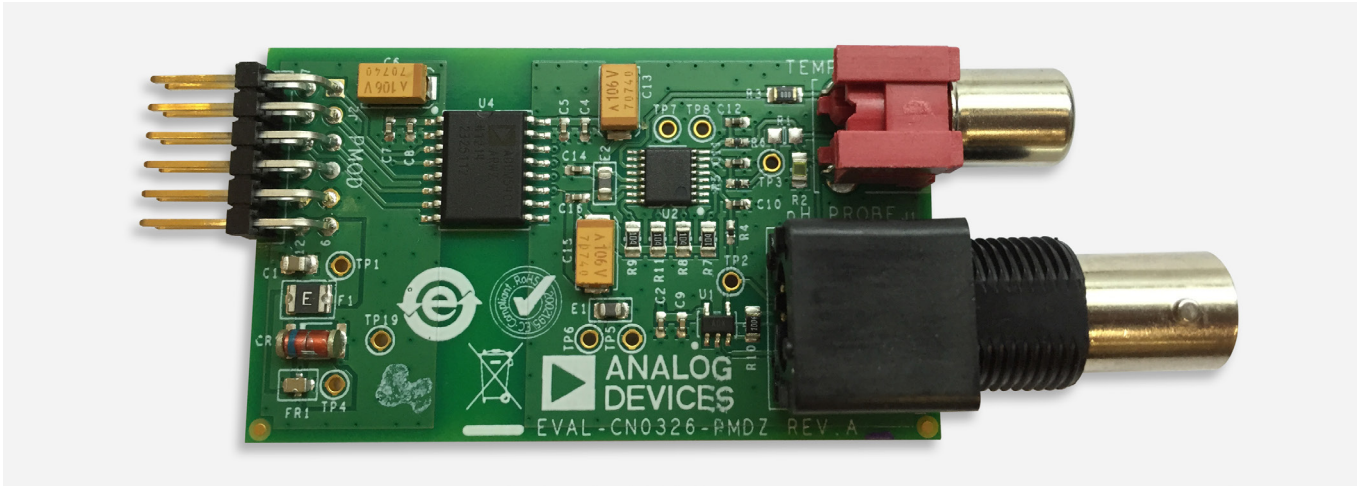
Portability is a key feature in modern day instrumentation. Creating portable pH meters and conductivity meters with long-term functionality requires a low power design suited for limited battery resources.

pH Meter Demo System from ADI

CN0326: Isolated Low Power pH Monitor with Temperature Compensation

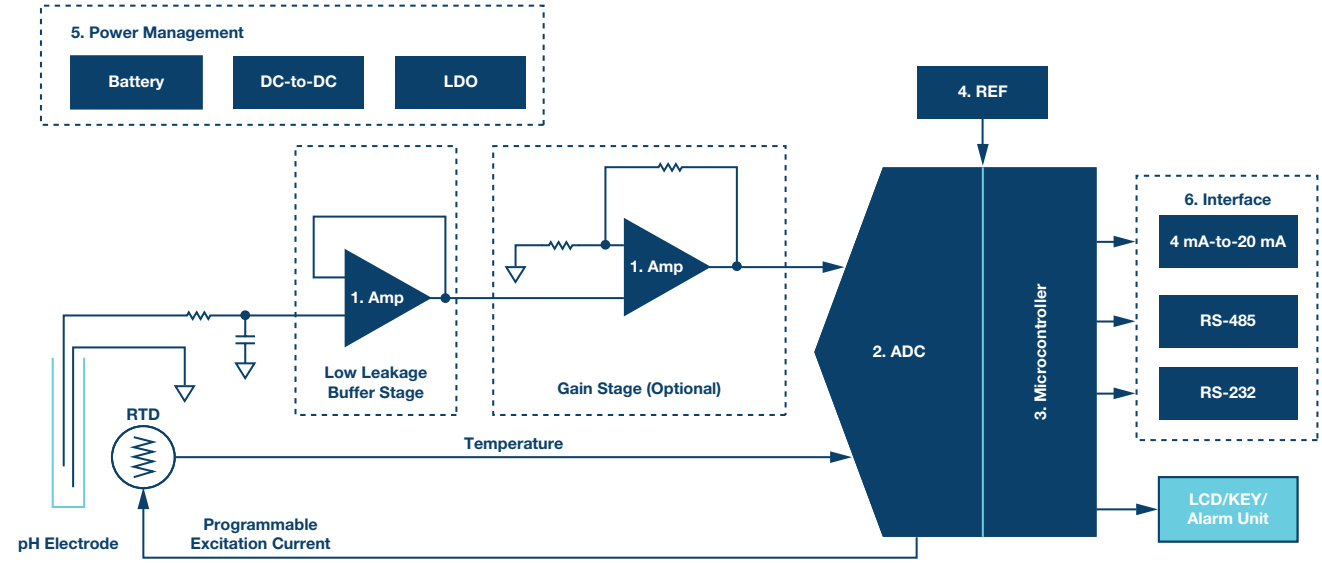
The circuit shown in the following figure is a completely isolated, low power pH sensor signal conditioner and digitizer with automatic temperature compensation for high accuracy.

CN0326 gives 0.5% accuracy readings for pH values from 0 to 14 with greater than 14 bits of noise-free code resolution and the circuit is suitable for a variety of industrial applications such as chemical, food processing, water, and wastewater analysis.



System Block Diagram

1. Below is the system block diagram for a pH meter, including pH electrodes, a low leakage input stage, a gain stage (optional), a microcontroller (ADC and reference integrated), power management, and a communication interface.



System block diagram and signal chain representative of a pH meter. The technical requirements of the blocks vary, but the products listed in the table are representative of ADI solutions that meet some of those requirements.

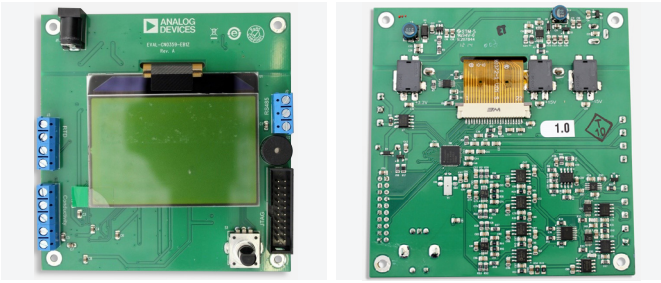
1. Amplifiers	2. ADCs	3. Microcontrollers	4. References	5. Power Management	6. Interfaces
AD8626/AD8641/ ADA4665-2/ADA4692-2/ AD8603	AD7792/AD7793	ADuCM361/ADuC7061	ADR4525/ADR3425/ ADR291	ADP2503/ADP2370/ ADP166/ADP7102/ ADP5310	AD5412/AD5422/ ADM2484E/ADM3251E/ ADuM5401

Conductivity Meter Demo System from ADI

CN0359: Fully Automatic High Performance Conductivity Measurement System

The CN0359 is a completely self-contained, microprocessor controlled, highly accurate conductivity meter. Due to its small size and high accuracy, it not only supports portable instruments but can also support bench instruments. It is ideal for measuring the ionic content of liquids, water quality analysis, industrial quality control, and chemical analysis.

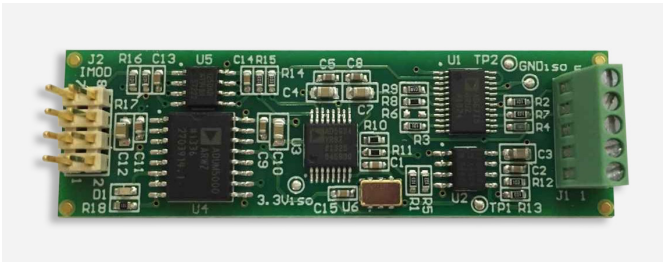
A carefully selected combination of precision signal conditioning components yields an accuracy of better than 0.3% over a conductivity range of 0.1 µS to 10 S (10 MΩ to 0.1 Ω) with no calibration requirements. Automatic detection is provided for either 100 Ω or 1000 Ω platinum (Pt) resistance temperature devices (RTDs), allowing the conductivity measurement to be referenced to room temperature.



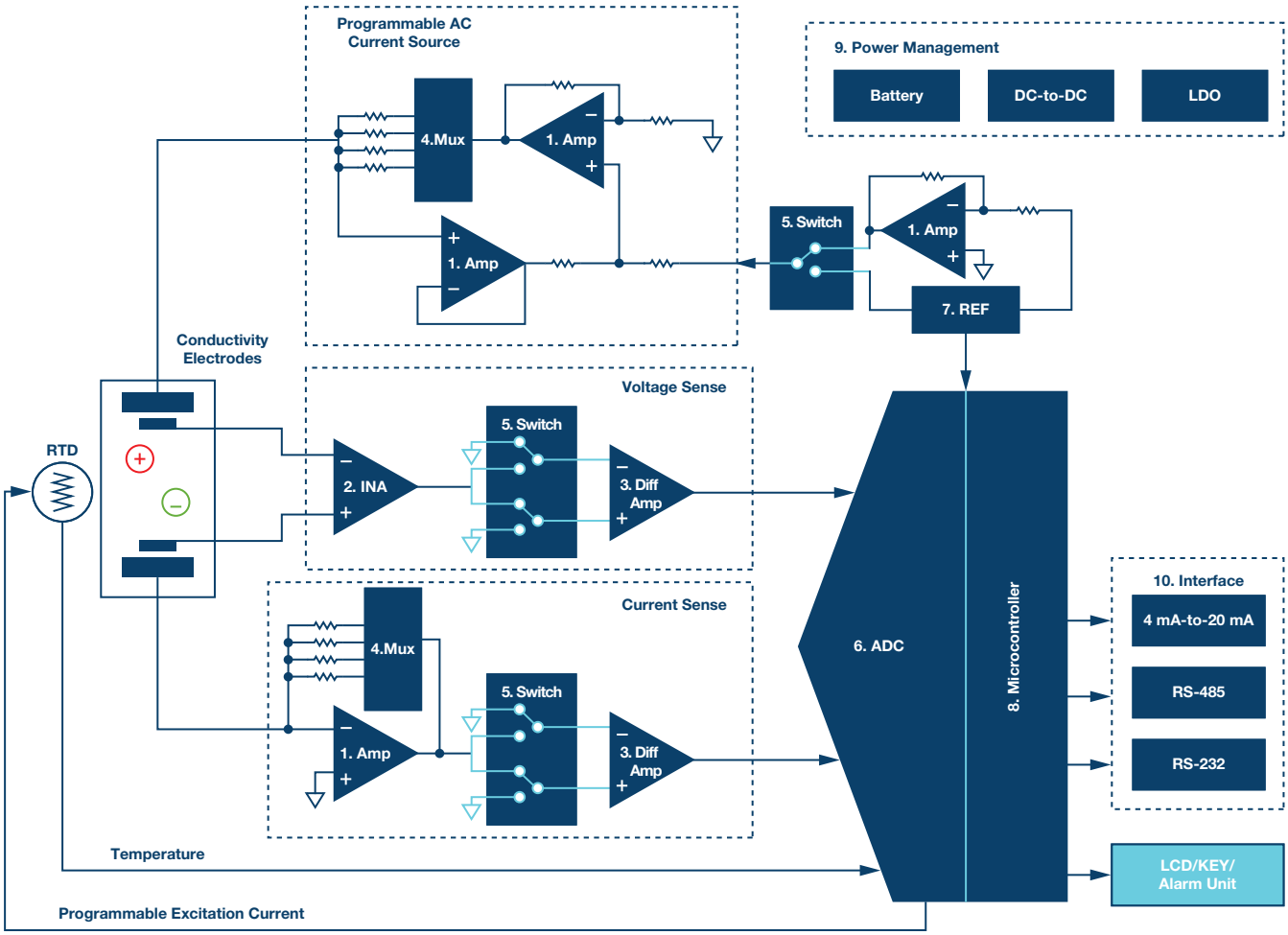
CN0349: Fully Isolated Conductivity Measurement Data Acquisition System

The CN0349 is a highly accurate, isolated, and highly integrated solution for conductivity meters.

This design solution is implemented with the integrated analog front end IC AD5934. The circuit has a total error of less than 1% FSR after calibration. The small footprint of all the components make the circuit ideal for applications where printed circuit board (PCB) real estate is at a premium. The digital output of the circuit is fully isolated; therefore, the ground loop interference is eliminated, making it ideal for harsh industrial environments.



2. Below is the general system block diagram of a conductivity meter, including conductivity electrodes, a programmable ac current source, voltage sense, current sense, a microcontroller (ADC and reference integrated), power management, and a communication interface.



System block diagram and signal chain representative of a conductivity meter. The technical requirements of the blocks vary, but the products listed in the table are representative of ADI solutions that meet some of those requirements.

1. Amplifiers	2. INAs	3. Difference Amplifiers	4. Muxes	5. Switches
AD8626/ADA4692-2/ ADA4627-1	AD8220/AD8422/AD8228/ AD8421/AD8253	AD8271/AD8278	ADG704/ADG708/ADG1609	ADG733/ADG1636
6. ADCs	**7. References**	**8. MCUs**	**9. Power Management**	**10. Interfaces**
AD7792/AD7793	ADR4525/ADR3425/ADR291	ADuCM361/ADuC7061	ADP2503/ADP2370/ ADP160/ADP7102	AD5412/ADM2484E/ ADuM5000/ADuM1250

Main Products

Part Number	Description	Benefits
Operational Amplifiers		
AD8626	0.25 pA bias current @ typ room temperature, >2 pA bias current @ typ 50°C, low offset drift 2 µV/°C, up to ±13 V power supply, high bandwidth 5 Mhz, rail-to-rail output	Wider power supply range, low bias current @ 0°C to 50°C, low offset drift, suitable for pH meters, high bandwidth for ac sources
ADA4665-2	0.1 pA bias current @ typ room temperature, 0.2 pA bias current @ typ 50°C, low offset drift 3 µV/°C, up to ±8 V power supply, rail-to-rail input/output	Wider power supply range, low bias current @ 0°C to 50°C, low offset drift, suitable for pH meters
AD8603	1 pA max @ 25°C, Micropower: 50 µA, Low offset voltage: 50 µV max, Rail to Rail Input/Output	Low bias current, low power, and low offset op amp
Instrumentation Amplifiers		
AD8220	JFET input, low bias current 10 pA @ typ, high bandwidth 1.5 Mhz @ G = 1, gain range 1 to 1000	Low bias current, suitable for conductivity meters
AD8228	Low bias current 0.5 nA, low gain drift 1 ppm/°C, low noise 15 nV/$\sqrt{Hz}$	Fixed gain with internal resistor, low cost, and improved gain accuracy
Difference Amplifiers		
AD8271	Gain = ½, 1, 2, gain drift 10 ppm/°C, 15 MHz, and 30 V/µs slew rate	Low gain drift and high speed, suitable for ADC drivers in conductivity applications
AD8278	Low power consumption 100 µA, G = ½ or 2, bandwidth 1 MHz	Low power consumption
Muxes		
ADG704	4-channel multiplexer, low on resistance 2.5 Ω @ typ, low leakage current 10 pA @ typ, low power consumption 1 µA	Low leakage and low on resistance help to build high accuracy systems
ADG1609	4-channel multiplexer, ±8 V power supply, low on resistance 4.5 Ω @ typ, low leakage current 20 pA @ typ, low power consumption 1 µA	Wider power supply range, low leakage, and low on resistance help to build high accuracy systems
Switches		
ADG733	Double SPDT switch, low on resistance 2.5 Ω @ typ, low leakage current 10 pA @ typ, low power consumption 1 µA	Low leakage and low on resistance help to build high accurate system
ADG1636	Double SPDT switch, ±8 V power supply low on resistance 2.5 Ω @ typ, low leakage current 10 pA @ typ, low power consumption 1 µA	Wider power supply range, low leakage, and low on resistance help to build high accuracy systems
ADCs		
AD7792	400 µA quiescent current, 3-channel, 16-bit peak-to-peak resolution, up to 470 Hz output update rate, on-chip reference, internal bias voltage, internal current excitation	Low power consumption and highly integrated Σ-Δ ADC, high resolution and high accuracy, suitable for precision measurement especially temperature
AD7793	400 µA quiescent current, 3-channel 24-bit Σ-Δ ADC, up to 470 Hz output update rate, on-chip reference, internal bias voltage, internal current excitation	Low power consumption and highly integrated Σ-Δ ADC, high resolution and high accuracy, suitable for precision measurements such as for temperature
References		
ADR4525	2.5 V reference, very low drift: 2 ppm/°C (max), low noise: 1.25 µV pp @ 0.1 Hz to 10 Hz, long-term stability: 25 ppm/$\sqrt{1000}$ hr, hysteresis: 50 ppm	Low drift, very good stability and low noise reference, low hysteresis, multiple options for output voltage in ADR45xx family
ADR3425	2.5 V reference, low drift 8 ppm/°C (max), long-term stability 30 ppm/$\sqrt{1000}$ hr, 100 µA max quiescent current, small size 6-lead SOT-23 package	Low drift, good stability, multiple options for output voltage in ADR34xx family
ADR291	2.5 V reference,12 µA quiescent current	Low power consumption, good drift and stability
Microcontrollers		
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 kB Flash/EE memory, 8 kB SRAM. Small package, low drift internal reference 5 ppm typical, integrated programmable current source	Low power consumption, high precision 24-bit Σ-Δ ADC, 4 mA to 20 mA loop applications, small package
ADuC7061	A precision Analog microcontroller based on a 10 MHz ARM7 and a highly precise dual sigma-delta ADC front-end, 24-bit of resolution and 16-bit ENOB and sub-100 Hz output rates; memory footprint includes a 32 kB flash and 4 kB SRAM; other key specs includes sub-3 mA operation (with MCU core at 1 MHz) making the part suitable for 4 mA to 20 mA loop applications, a 12-bit DAC and small packaging, 5 × 5mm 32-pin LFCSP	Low power consumption, low cost 24-bit Σ-Δ ADC, 4 mA to 20 mA loop applications, small package
Power Management		
ADP2503	38 µA quiescent current; 2.5 MHz buck-boost dc-to-dc converters, operates between 2.3 V and 5.5 V	Low power consumption to achieve long battery life, small package, and few external parts
ADP166	2.2 V to 5.5 V input LDO, 150 mA maximum output current, ultralow quiescent current: 10 µA when output 10 mA, up to 15 fixed-output voltage options available from 1.2 V to 4.2 V	Low power consumption, integrated output discharge resistor, small package with only two 1 µF external capacitor
ADP7102	20 V input LDO, 300 mA output current, low noise 15 µV rms, 7 fixed output voltage options, and an adjustable output voltage option.	High input voltage, low noise LDO

Main Products (Continued)

Part Number	Description	Benefits
Interfaces		
AD5422	Current output ranges: 0 mA to 24 mA, voltage output range: 0 V to 5 V, 0 V to 10 V, ±5 V, ±10 V, 16-bit resolution, 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
ADM2484E	Full/half-duplex isolated RS-485/RS-422 transceiver, 500 kbps data rate, 256 nodes, 5 V or 3.3 V operations, 15 kV ESD protection 5 kV isolation	Highly integrated isolated RS-485 transceiver
ADM3251E	Isolated RS-232 transceiver, 460 kbps data rate, 5 V or 3.3 V operations, 15 kV ESD protection, 2.5 kV isolation	Highly integrated isolated RS-232 transceiver

Design Resources

APM Article

- APM: ADI Water Analysis Solution for pH Meters and Conductivity Meters—*www.analog.com/apm/adi-water-analysis-solution_en.pdf*

Circuits from the Lab®

- CN0326: Isolated Low Power pH Monitor with Temperature Compensation—*www.analog.com/en/CN0326*
- CN0359: Fully Automatic High Performance Conductivity Measurement System—*www.analog.com/en/CN0359*
- CN0349: Fully Isolated Conductivity Measurement Data Acquisition System—*www.analog.com/en/CN0349*
- CN0312: Dual-Channel Colorimeter with Programmable Gain Transimpedance Amplifiers—*www.analog.com/en/CN0312*

Application Notes/Articles

- Programmable-Gain Transimpedance Amplifiers Maximize Dynamic Range in Spectroscopy Systems—*www.analog.com/ad-47-05/pgtia.pdf*

Design Tools/Forums

- ADuCM361 Design tools—*www.analog.com/en/CN0185*
- Analog Filter Wizard™: ADI Active Filter Design Tool —*www.analog.com/FilterWizard*
- 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*

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