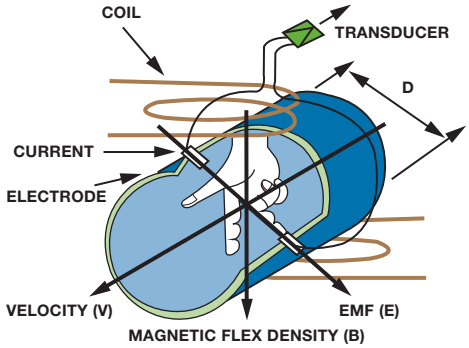
ADI Electromagnetic Flow Meter Solutions

System Theory and Typical Architecture of Industrial Electromagnetic Flow Meters

The operating principle of the electromagnetic flow meter is based on Faraday's law of electromagnetic induction. When the magnetic field direction perpendicular to the conductor cutting magnetic line is speed V, both ends of the conductor will be induced by a certain force E, and the liquid flow rate change can be calculated by detecting the value of the force.

The features of electromagnetic flow meters are no pressure loss and no impact from viscosity, fluid density, temperature, pressure, or conductivity, making it suitable for measuring pulp, slurry, and sewage with high accuracy.

An electromagnetic flow meter system consists of power supplies, magnetic excitation, signal conditioning, analog-to-digital conversion, processor, display, keyboards, logic I/Os, and multiple communication protocols such as 4 mA to 20 mA, HART, PROFIBUS,® RS-485/RS-422/RS-232, Modbus, and Foundation.



$E = K \times B \times V \times D$
K is instrument constant
B is magnetic flex density
V is average fluid velocity across the pipe
D is diameter of measurement pipe

System Design Considerations and Major Challenges of Industrial Electromagnetic Flow Meters

To appropriately design an electromagnetic flow meter system, designers must consider many different system requirements, including accuracy, bandwidth, and magnetic excitation frequency.

- Electromagnetic flow meter sensor output ranges can be as small as several tens of μV with a certain common voltage. The output impedance is often higher than the MΩ range. The front-end precision operational amplifier or instrumentation amplifier requires ultrahigh input impedance, very low leakage current, and excellent CMRR.
- An electromagnetic flow meter's maximum measurement range can be as wide as 1500:1, and the range for the corresponding flow rate is 0.01 m/s to 15 m/s.
- Measurement accuracy can be as high as 0.2% of reading, which often requires a 16-bit to 24-bit analog-to-digital converter.
- Connectivity to different fieldbus protocols, such as HART, PROFIBUS, Modbus, Foundation, RS-485/RS-422/RS-232, and wireless HART.
- Isolation needed between system power supply, central logic unit, communication, and I/Os. Isolation grade varies from 1 kV to 2.5 kV.
- Portable electromagnetic flow meters require ultralow power MCU, amp, and ADC components.
- Higher frequency square wave excitation improves the flow of mud and noise immunity, but needs to be balanced with zero stability.

A low temperature drift coefficient and low power consumption are important for electromagnetic flow meters to withstand a wide working temperature range in industrial environments. ADI offers a complete portfolio such as precision amplifiers, precision references, precision analog-to-digital converters, and ARM core microprocessors.

EMC interference immunity, such as for ESD, EFT, and surge, is a considerable challenge for electromagnetic flow meters. The high level ESD immunity components offered by ADI greatly help to improve reliability and robustness.

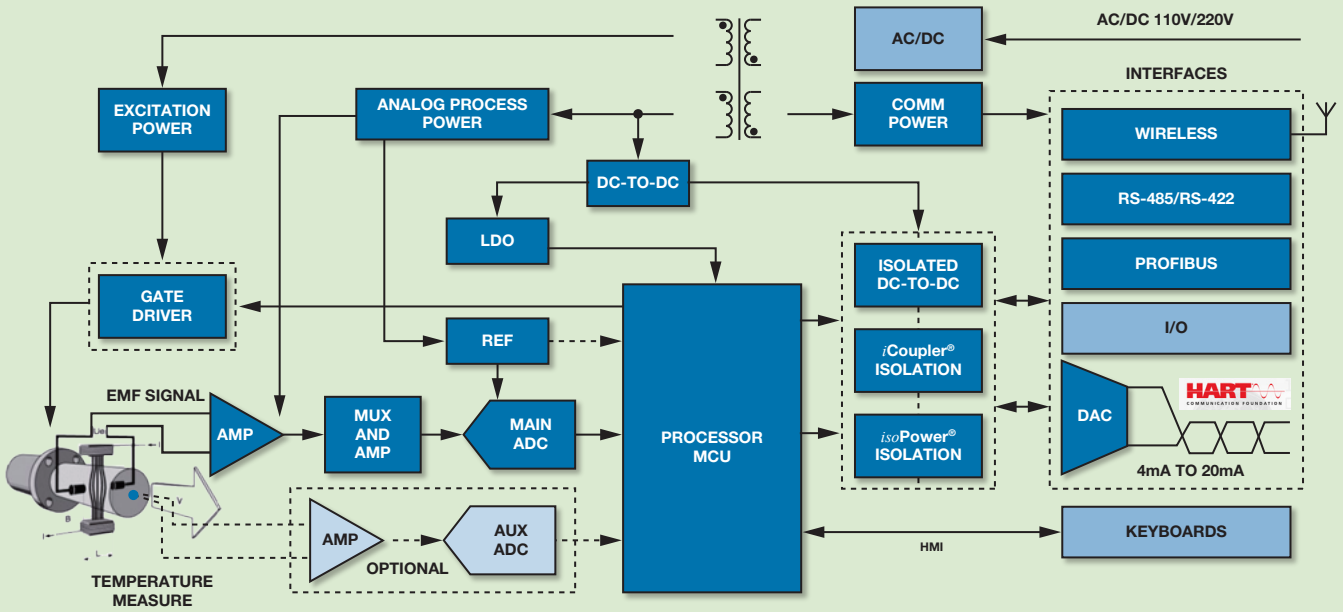
In addition, the limited space inside electromagnetic flow meters requires dense systems. Therefore, the form factor has to be reduced to accommodate this. Recently, advances in integration have allowed system designers to migrate to smaller, lower power, lower cost solutions, with performance approaching that of larger systems. The challenge moving forward is to continue to drive the integration of these solutions while increasing their performance and diagnostic capabilities.

ADI offers market tailored solutions to aid in the design process. These solutions feature our industry-leading technologies and offer a range of design options: from implementation of discrete components to fully integrated solutions and everything in between.

Total Solutions from ADI

Leverage ADI amplifier, data conversion, signal processing, communications, and power technology and expertise to design high resolution, low noise industrial electromagnetic flow meter systems.

Main Signal Chain



Main Product Introduction

Device	Description	Key Features	Benefits
ADC			
AD7173-8	24-bit, 31.25 kSPS, Σ-Δ ADC	17.5 noise free bits at 31.25 kSPS; INL ±3 ppm of FSR; 85 dB rejection of 50 Hz and 60 Hz with 50 ms settling	Multichannel high precision ADC
AD719x	Multichannel, 4.8 kHz, ultralow noise, 24-bit Σ-Δ ADC	RMS noise: 11 nV at 4.7 Hz (gain = 128), up to 22 noise free bits (gain = 1) programmable gain (1 to 128) output data rate: 4.7 Hz to 4.8 kHz	Ultralow noise, internal PGA, high precision Σ-Δ ADC; 2 differential/4 pseudo differential, 8 differential/16 pseudo differential input channels
AD7793/ AD7794/ AD7795/ AD7796	16-bit to 24-bit, 3 differential to 6 differential channels, Σ-Δ ADCs with PGA	4.7 Hz to 470 Hz, embedded 2 switchable current sources, reference, PGA, low noise	Low power consumption and dedicated design for RTD/thermocouple temperature measurement
Processor/MCU			
ADSP-BF504F	Blackfin® embedded processor	Blackfin processor core with 400 MHz (800 MMACS) performance and 68 kB L1 memory; ADC control module for glueless interface to an external ADC with synchronized sampling; 12 peripheral DMA channels and two memory-to-memory DMA channels; two SPI, two SPORT, two UART, and one PPI interface; industrial temperature grades	Abundant resources with competitive cost
ADuCM360/ ADuCM361	ARM Cortex®-M3 microcontroller	Integrated dual/single 24-bit Σ-Δ ADC; UART, I²C and 2 × SPI serial I/O; 16-bit PWM controller; 19-lead multifunction GPIO ports; 128 kB Flash/EE memory, 8 kB SRAM	ADuCM360/ADuCM361 is designed for direct interfacing to external precision sensors in both wired and battery-powered applications
ADSP-CM4xx	Mixed-signal control processors with ARM Cortex-M4	The ADSP-CM40xF family of mixed-signal control processors is based on the ARM® Cortex-M4 processor core with floating-point units operating at frequencies up to 240 MHz and integratingup to 384 kB of SRAM memory, 2 MB of flash memory, accelerators, and peripherals; analog module consisting of two 16-bit SAR-type ADCs and two 12-bit DACs	This family of mixed-signal control processors offers low static power consumption and is produced with a low power and low voltage design, delivering world class processors and ADC performance with lower power consumption
ADSP-BF70x	ADSP-BF70x belongs to the Blackfin processor family, a high performance DSP series	ADSP-70x delivers a class-leading 800 MMACS of processing power at less than 100 mW—double the performance or half the power of competing devices; it includes up to 1 MB of internal SRAM, eliminating external memory in many applications, while a second configuration features an optional DDR memory interface	The ADSP-BF70x family offers designers' unparalleled flexibility and functionality through an array of advanced connectivity options (including USB, SDIO, CAN, ePPI, SPORT, quad SPI)

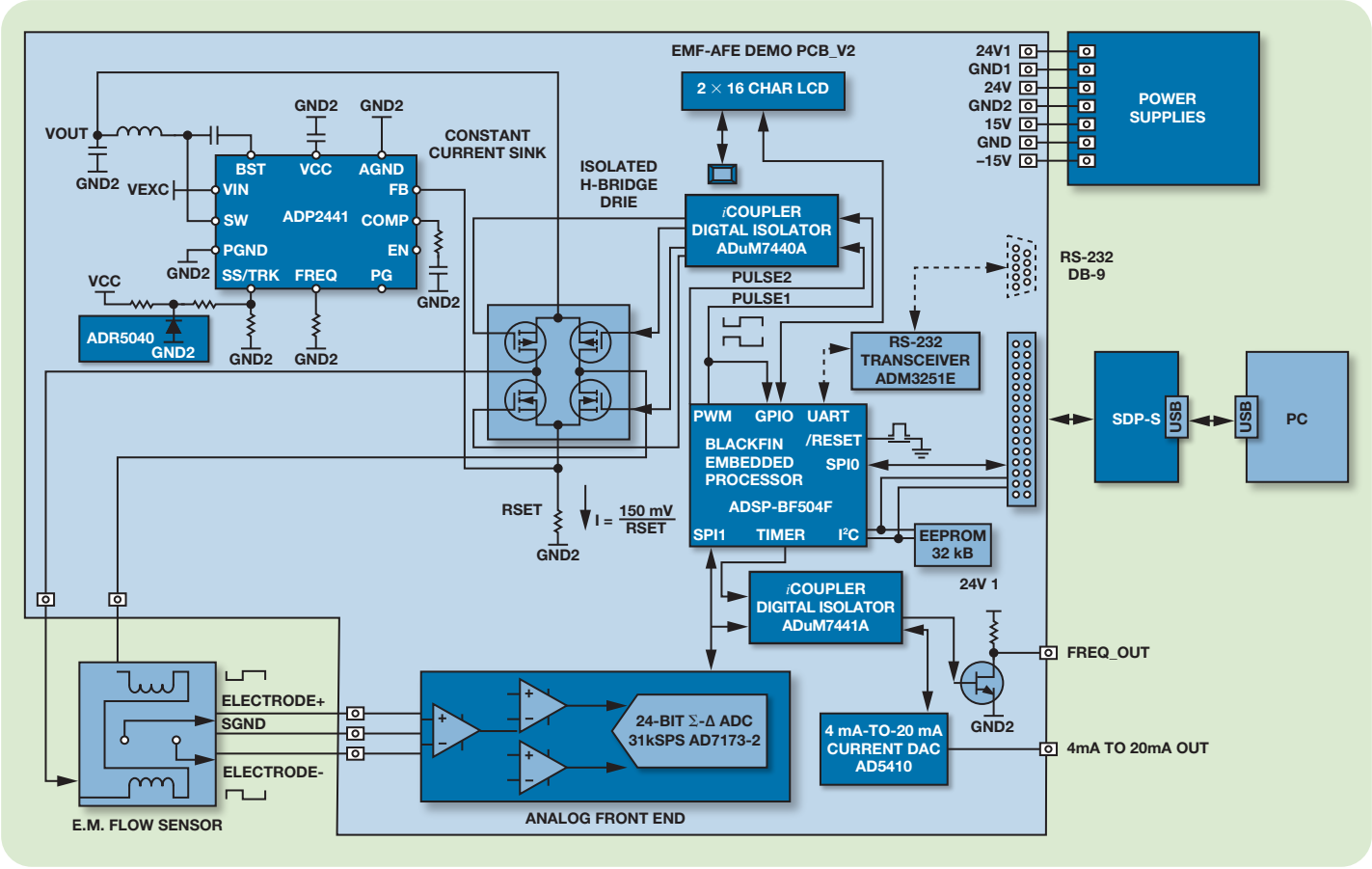
Main Product Introduction (Continued)

Device	Description	Key Features	Benefits
Amps			
AD8667	Low noise op amp	Bandwidth = 520 kHz; V_{NOISE} density = 21 nV/$\sqrt{Hz}$; I_B = 0.3 pA; I_{SY} = 570 μA	Extremely low leakage current, battery powered
ADA4051-1	Micropower and autozero op amp	Bandwidth = 125 kHz; V_{NOISE} density = 95 nV/$\sqrt{Hz}$; I_B = 20 pA; I_{SY} = 20 μA	Perfect buffer for battery supply, competitive price
AD8220	Instrumentation amp	Bandwidth= 1.5 MHz; V_{OS} = 1 mV; V_{NOISE} density = 90 nV/$\sqrt{Hz}$; I_B= 25 pA; gain control interface = resistor	New generation for replacing classic AD620
AD8226	Instrumentation amp	Bandwidth = 1.5 MHz; V_{OS} = 1.2 mV; V_{NOISE} density = 2 μV/$\sqrt{Hz}$; I_B = 27 nA; gain control interface = resistor	Good performance and competitive price
AD8228	Instrumentation amp	Bandwidth = 650 kHz; V_{OS} = 50 μV; V_{NOISE} density = 15 nV/$\sqrt{Hz}$; I_B = 600 pA; gain control interface = pin strap	Excellent temperature drift, low noise
AD8231	Instrumentation amp	Bandwidth = 2.7 MHz; V_{OS} = 15 μV; V_{NOISE} density = 66 nV/$\sqrt{Hz}$; I_B= 500 pA; gain control interface= digital	Digital gain control with low offset voltage
AD8276	Difference amp	Wide input range beyond supplies; bandwidth: 550 kHz; low offset voltage drift: ±2 μV/°C maximum; low gain drift: 1 ppm/°C maximum	Low cost solution for current source and RTD measurement
AD8221	Precision instrumentation amp	Gain from 1 to 1000; in contrast, the AD8221 maintains a minimum CMRR of 80 dB to 10 kHz for all grades at G = 1	Low voltage offset, low offset drift, low gain drift, high gain accuracy, high CMRR
AD8422	Precision instrumentation amp	Low noise and distortion: 8 nV/$\sqrt{Hz}$ maximum input voltage noise at 1 kHz; 0.15 μV p-p RTI noise (G = 100); 0.5 ppm nonlinearity with 2 kΩ load (G = 1); 150 dB minimum CMRR (G = 1000); 3.6 V to 36 V single supply; input overvoltage protection: 40 V from opposite supply	High performance, low power, rail-to-rail
AD8236	Micropower instrumentation amp	40 μA supply current (maximum); 1 pA input bias current; high CMRR: 110 dB CMRR, G = 100	High input impedance, low input bias current, high CMRR, small size, and low power
DAC			
AD5410/ AD5420	Current source DAC	12-/16-bit resolution; 0 mA to 24 mA ±0.01% FSR TUE; ±3 ppm/°C typical output drift; on-chip reference (10 ppm/°C maximum)	Universal output DAC and support HART communication
AD5421	Current source DAC	16-bit resolution; 3.2 mA to 24 mA; NAMUR compliant alarm; TUE error: 0.05% maximum; on-chip reference TC: 4 ppm/°C maximum loop voltage range: 5.5 V to 52 V	Loop-powered universal output DAC, and support HART
AD5660	*nano*DAC®	Single 16-bit, 5 ppm/°C on-chip reference; tiny 8-lead SOT-23/ MSOP packages	Tiny package and high performance
REF			
ADR34XX	Voltage references	Initial accuracy: ±0.1% (maximum) maximum temperature coefficient: 8 ppm/°C	Sink low quiescent current: 100 μA (maximum); low dropout voltage
ADR44x	Voltage references	Initial accuracy: ±0.04% (maximum), temperature coefficient: 3 ppm/°C; voltage noise: 2.25 μV p-p type in 0.1 Hz to 10 Hz	Ultralow noise, high initial accuracy, excellent temperature drift
Gate Driver			
ADuM7440	Isolated gate driver	1000 V rms isolation rating, low power operation; bidirectional communication, up to 25 Mbps data rate (NRZ),3 V/5 V level translation	Low power operation, competitive price
Isolator			
ADuM140x	Quad-channel digital isolators	2.5 kV rms; low power operation, 3 V/5 V level translation; high data rate: dc to 90 Mbps (NRZ), output enable function	High data rate: dc to 90 Mbps (NRZ), low power operation
ADuM144x	Quad-channel digital isolator, 3.75 kV rms	1.8 V/3.3 V level translation, high-temp operation: 125°C, high data rate: dc to 10 Mbps (NRZ)	Bidirectional communication, low power operation

Main Product Introduction (Continued)

Device	Description	Key Features	Benefits
Interface			
ADM2587E	Isolated RS-485/RS-422	Half- or full-duplex, 500 kbps, 5 V or 3.3 V operation	Integrated isolated dc-to-dc; ±15 kV ESD
ADM2483	Isolated RS-485 transceiver	Half-duplex, 500 kbps data rate, 5 V or 3 V operations (VDD1), low power operation: 2.5 mA max, 2.5 kV isolation	Low power operation, competitive price
Power			
ADP2441	DC-to-DC regulator	Synchronous step down dc-to-dc converter, with wide input voltage range of 4.5 V to 36 V; up to 1 A output current	High efficiency of up to 94%
ADP2300/ ADP2301	DC-to-DC regulator	Single, nonsynchronous, step-down dc-to-dc converter, 1.2 A output, 0.7 MHz/1.4 MHz frequency, input voltage range from 3.0 V to 20 V	Small 6-lead SOT23 package, few components, small and small solution size
ADP1720	Linear regulator	Wide input voltage range: 4 V to 28 V, max output current: 50 mA, accuracy over line, load, and temperature: ±2%, fixed 3.3 V and 5.0 V output voltage options	Wide input voltage range: 4 V to 28 V
ADP1612/ ADP1613	DC-to-DC regulator	Voltage input 1.8 V to 5.5 V, output voltage V_{IN} to 20 V; pin-selectable 650 kHz or 1.3 MHz PWM frequency	Boost dc-to-dc
ADP125	Linear regulators	5.5 V input, 500 mA maximum output current 1% initial accuracy, up to 31 fixed output voltage options available from 1.75 V to 3.3 V; low quiescent current: 45 µA	Excellent load/line transient response
ADP2323	DC-to-DC regulator	Input voltage: 4.5 V to 20 V; ±1% output accuracy; integrated 90 mΩ typical high-side MOSFET; flexible output configuration dual output: 3 A/3 A; parallel single output: 6 A; programmable switching frequency: 250 kHz to 1.2 MHz	Dual output, step-down dc-to-dc regulator
ADP710x	Lower noise LDO	3.3 V to 20 V and provides up to 500 mA of output current; 15 µV rms for fixed output versions; PSRR performance of 60 dB at 10 kHz, V_{OUT} = 3.3 V	Small package CMOS LDO
HART			
AD5700/ AD5700-1	Half-duplex HART modem/ half-duplex HART modem with internal oscillator	HART compliant fully integrated FSK modem, 1200 Hz and 2200 Hz sinusoidal shift frequencies, 115 µA maximum supply current in receive mode, integrated receive band-pass filter, minimal external components required, 1.71 V to 5.5 V power supply/0.5% precision internal oscillator	Lowest power consumption; smallest package; high integration; high driver capability

ADI Latest EM Flow Meter Solution Block Diagram



Circuits from the Lab®

- *Complete High Speed, High CMRR Precision Analog Front End for Process Control* (CN0213)—www.analog.com/CN0213
- *4 mA-to-20 mA Loop-Powered Temperature Monitor Using the ADuC7060/ADuC7061 Precision Analog Microcontroller* (CN0145)—www.analog.com/CN0145
- *16-Bit Fully Isolated Output Module Using the AD5422 Single Chip Voltage and Current Output DAC and the ADuM1401 Digital Isolator* (CN0065)—www.analog.com/CN0065
- *Fully Isolated Input Module Based on the AD7793 24-Bit Σ-Δ ADC and the ADuM5401 Digital Isolator* (CN0066)—www.analog.com/CN0066

Application Notes

- *AN-1203 Application Note, Simplified 16-Bit, 4 mA-to-20 mA Output Solution Using the AD5420*—www.analog.com/AN-1203

For more information about electromagnetic flow meters, please contact ADI.

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What ADI Can Provide to Customers

- **ADC:** ADIsimADC™; Σ-Δ ADC register configuration assistant
- **DAC:** ADIsimDAC™
- **AMP:** ADIsimOpAmp™; ADIsimDiffAmp™
- **Power:** EVB ADIsimPower
- **Processor:** EVB emulation tools

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