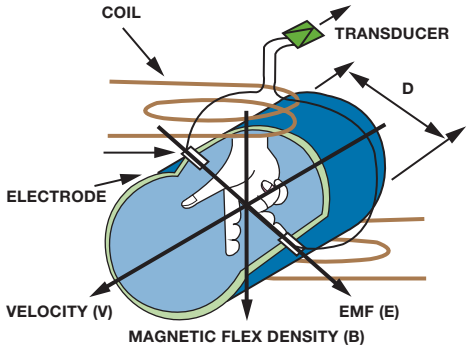
ADI Electromagnetic Flow Meter Solutions

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 communications like 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.
- Electromagnetic flow meter product maximum measurement range can be as wide as 1500:1, and the range for 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.

Industrial site temperature environments are quite complex and sometimes even extremely adverse. Low temperature drift coefficient and low power consumption are very important for electromagnetic flow meters to withstand a wide working temperature range. ADI offers a complete portfolio such as precision amplifiers, precision references, precision analog-to-digital converters, and ARM core microprocessors.

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

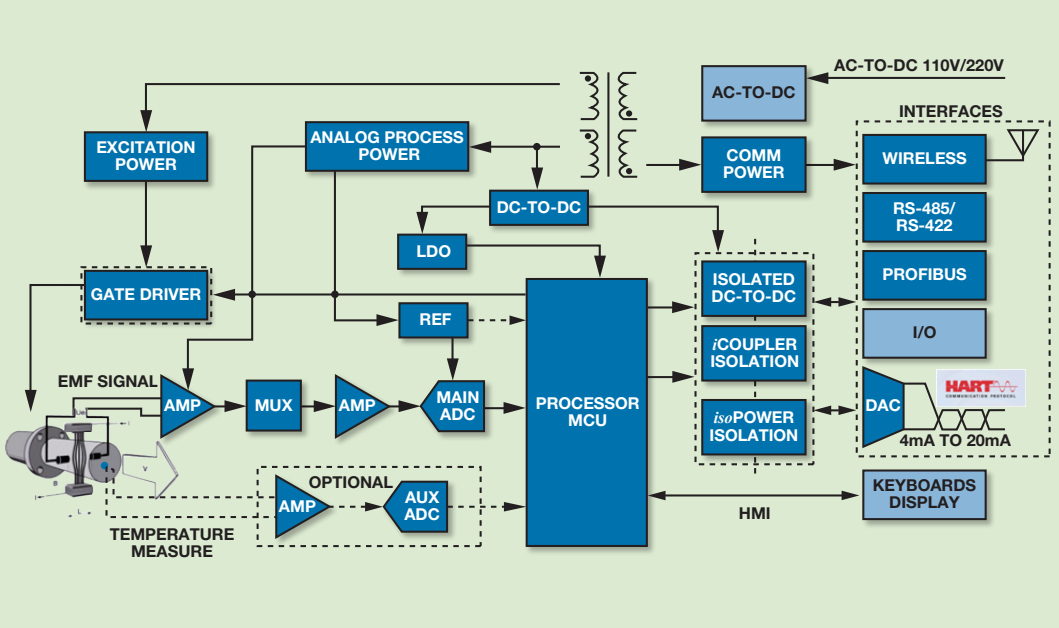
In addition, the limited space inside electromagnetic flow meters requires dense systems. Therefore, the form factor has to be reduced to accommodate this. Recently, advances in integration have allowed system designers to migrate to smaller, lower power, lower cost solutions, with performance approaching 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



Note: The signal chain above is representative of a typical EM flow meter system. The technical requirements of the blocks vary, but the products listed in the table are representative ADI's solutions that meet some of those requirement.

Main Product Introduction

Part Number	Description	Key Features	Benefits
ADC			
AD7663	16-bit, 250 kSPS CMOS ADC	35 mW @ 5 V, 16-bit no missing code, INL = 3 LSB, S/(N + D): 90 dB type @ 100 kHz	Fast throughput, serial or parallel interface
AD7685	16-bit, 250 kSPS PulSAR® ADC	16-bit 250 kSPS no missing code, INL = ±2 LSB max, 4 mW @ 5 V/100 kSPS	Low power, internal conversion clock, high throughput rate
AD7682	16-bit, 4-channels, 250 kSPS, PulSAR ADC	16-bit 250 kSPS no missing code, INL = ±1.5 LSB max, 12.5 mW @ 5 V/250 kSPS	Unipolar single-ended and differential, low power, single power with bipolar input, competitive price
AD7192	24-bit 2 differential/4 pseudo channels, Σ-Δ ADC with PGA	4.8 kHz, ultralow noise, rms noise: 11 nV @ 4.7 Hz (gain = 128), 15.5 noise-free bits @ 2.4 kHz (gain = 128), differential inputs	Ultralow noise, internal PGA, high precision Σ-Δ ADC
Main ADC/Aux ADC			
AD7792/AD7793/ AD7794/AD7795	16-bit to 24-bit, 3 differential to 6 differential channels, Σ-Δ ADC with PGA	4.7 Hz to 470 Hz, embedded 2 switchable current sources, reference, PGA, low noise	Low power consumption and designed for RTD/thermocouple temperature measure
Processor/MCU			
ADUC7060	Analog microcontroller (ARM7TDMI core)	24-bit, 8 kSPS Σ-Δ ADC up to 10 ADC channels; 1-channel 14-bit voltage DAC outputs; 16-bit, 6-channel PWM; on-chip voltage reference, ±10 ppm/°C and temperature sensor; programmable sensor excitation current sources, 200 μA to 2 mA; up to 14 GPIO pins	High resolution, low power, and abundant resources

Main Product Introduction (continued)

Part Number	Description	Key Features	Benefits
AMP			
AD8622	Low power and precision op amp	Bandwidth = 540 kHz; V_{NOISE} density= 11 nV/√Hz; I_B = 45 pA; I_{SY} = 350 µA	Very low noise and low leakage current
AD8667	Low noise op amp	Bandwidth = 520 kHz; V_{NOISE} density = 21 nV/√Hz; I_B = 0.3 pA; I_{SY} = 355 µA	Extremely low leakage current, battery powered
ADA4051-1	Micropower and auto-zero op amp	Bandwidth = 125 kHz; V_{NOISE} density = 95 nV/√Hz; I_B = 20 pA; I_{SY} = 20 µA	Perfect buffer for battery supply, competitive price
AD8220	Instrumentation amplifier	Bandwidth = 1.5 MHz; V_{OS}= 1 mV; V_{NOISE} density = 90 nV/√Hz; I_B= 25 pA; gain control interface = resistor	New generation for replacing classic AD620
AD8226	Instrumentation amplifier	Bandwidth = 1.5 MHz; V_{OS} = 1.2 mV; V_{NOISE} density = 2 µV/√Hz; I_B= 27 nA; gain control interface = resistor	Good performance and competitive price
AD8228	Instrumentation amplifier	Bandwidth = 650 kHz; V_{OS}= 50 µV; V_{NOISE} density = 15 nV/√Hz; I_B= 600 pA; gain control interface = pin strap	Excellent temperature drift and low noise
AD8231	Instrumentation amplifier	Bandwidth = 2.7 MHz; V_{OS}= 15 µV; V_{NOISE} density = 66 nV/√Hz; I_B= 500 pA; gain control interface = digital	Digital gain control with low offset voltage
AD8276	Difference amplifier	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
DAC			
AD5410/ AD5420	Current source DAC	12-bit/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, supports 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, supports 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, and perfect temp drift
Gate Driver			
ADuM322x	Isolated gate driver	Dual-channel isolated, 2.5 kV rms; 4 A peak output current, 4.5 V to 18 V output drive, output shoot-through logic protection; dc to 1 MHz	Output shoot-through logic protection, enhanced system-level ESD performance
ADuM7234	Isolated gate driver	Dual-channel isolated, 1 kV rms; 4 A peak output current, high frequency operation: 1 MHz maximum, narrow-body, 16-lead SOIC, 1 kV rms input-to-output withstand voltage	1 kV rms input-to-output withstand voltage with competitive price
Isolator			
ADuM320x	Dual channel Digital isolators	2.5 kV rms; low power operation, 3 V/5 V level translation; high data rate: dc to 25 Mbps (NRZ) enhanced system-level ESD performance per IEC 61000-4-x	Dual dc-to-25 Mbps (NRZ) signal isolation channels, low power operation
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
ADuM744x	Quad channel digital isolators	1 kV rms isolation rating, low power operation; bidirectional communication, up to 25 Mbps data rate (NRZ),3 V/5 V level translation	Low power operation and competitive price
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 (V_{DD}1), low power operation: 2.5 mA max, 2.5 kV isolation	Low power operation and competitive price
Wireless			
ADF7023	ISM band FSK/GFSK/OOK/ MSK/GMSK transceiver IC	Frequency bands: 862 MHz to 928 MHz, 431 MHz to 464 MHz; ultralow power; ISM band, data rates supported, 1 kbps to 300 Kbps, single-ended and differential PAs	ISM band, data rate: 1 kbps to 300 kbps, very low power consumption
MUX			
ADG1408	Multiplexers	4-channel/8-channel, ±15 V supply; 4.7 Ω maximum on resistance, up to 190 mA continuous current, rail-to-rail operation	Fully specified at ±15 V/+12 V/±5 V
ADG5408	Multiplexers	Latch-up proof construction, 4-channel/8-channel; 8 kV ESD rating, low on resistance (13.5 Ω typical),	Fully specified at ±15 V, ±20 V, +12 V, and +36 V, high switching speed, break-before-make switching action

Main Product Introduction (continued)

Part Number	Description	Key Features	Benefits
Power			
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 SOT23-6 package, few peripheral components, 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 regulator	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

Circuits from the Lab™ Reference Circuits for Electromagnetic Flow Meter Solutions

- *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*
- *Simplified 16-Bit, 4 mA-to-20 mA Output Solution Using the AD5420* (CN0098)—*www.analog.com/CN0098*
- *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*

What ADI Can Provide to Customers

- **ADC** ADIsimADC; Σ-Δ ADC register configuration assistant
- **DAC** ADIsimDAC
- **AMP** ADIsimOpAmp, ADIsimDiffAmp
- **Power** EVB and ADIsimPower
- **Processor** EVB emulation tools and some software

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