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INDUSTRIAL ULTRASONIC FLOW METER SOLUTIONS

Industrial Ultrasonic Flow Meter System Theory

Ultrasonic flow meters are volumetric flow meters that are used to measure the flow rate of liquids, gases, or steam. They are commonly found in oil and gas, pharmaceutical, and food and beverage industries. Flow meters use time of flight or doppler techniques to measure flow rate.

Flow meters that use the time of flight principle have a pair, or multiple pairs, of transducers. The transmit time of the ultrasonic waves is measured in both directions and from this the flow rate can be calculated. This technique typically requires a relatively pure medium, with <5% particles. Accuracies of <1% are achievable.

Using the doppler approach, ultrasonic pressure waves are reflected off of moving particles in the flow. The velocity of these particles creates a doppler shift in the echo signal, which is used to determine the flow rate. This measurement approach is typically limited to 3% accuracy in real-world implementations.

An ultrasonic flow meter consists of power supplies, transducer excitation, signal conditioning, ADCs, processing, a display, a keypad, and multiple communication options, such as 4 mA to 20 mA, HART, RS-485, and wireless.

Industrial Ultrasonic Flow Meter System Design Considerations and Major Challenges

This solutions guide will focus on ultrasonic flow meters based on the time of flight principle. The signal chain below is best suited for applications requiring higher performance, especially those with multiple pairs of transducers. As well as the need to achieve high measurement accuracy, these designs often have significant space constraints.

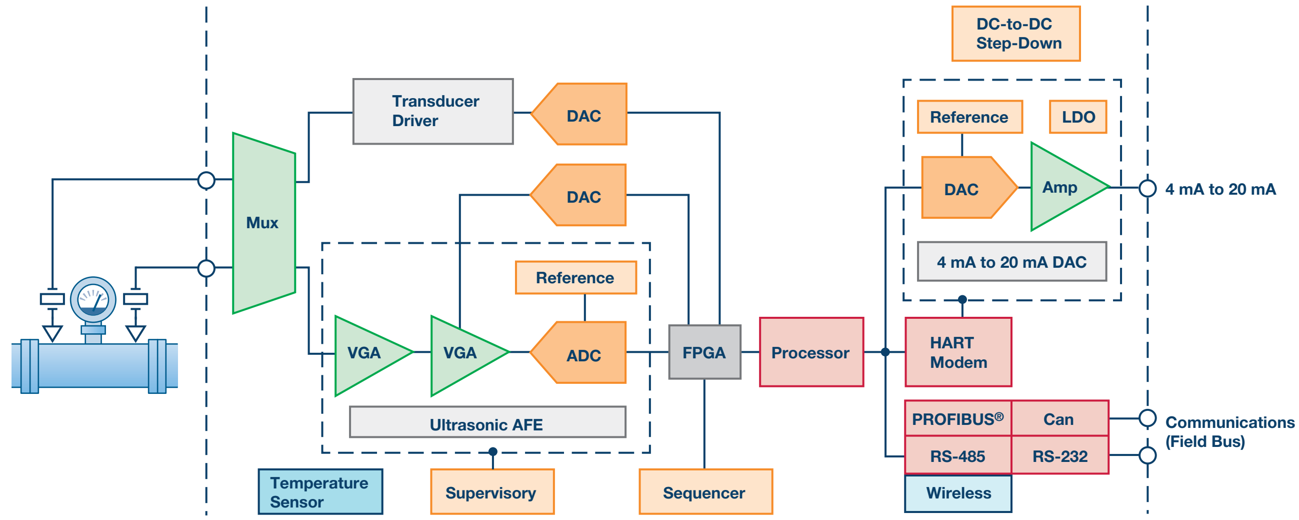
In liquid ultrasonic flow meters, a 1 MHz ultrasonic frequency is common. The accuracy of the system is directly related to the relative accuracy of the upstream and downstream time of flight measurements. For this reason, an FPGA is generally used to control the timing of the transmit and receive pulses. Careful attention must also be paid to any possible variations in latency of the transmit and recieve signal paths.

Another important aspect is the high gain required by the receive signal chain. This gain needs to be dynamically adjustable for different flow conditions and pipe sizes, typically in the range of 60 dB or higher, thus requiring a low noise receive signal chain path.

The transducer excitation can be either be on/off or a waveform generator may be used. A waveform generator typically adds cost and complexity, but provides greater control of the output signal allowing for an even more accurate and robust flow meter design.

The signal processing requires considerable filtering and FFT analysis to determine a precise time-stamp for the receive signal, which can be done using a DSP processor that can also support the required interface protocols.

Main Signal Chain



Main Products Introduction

Function Block	Part Number	Description	Key Features and Benefits
Transmit	*High Speed DAC/Waveform Generator*		
	AD9106	Quad-channel, 12-bit, 180 MSPS arbitrary waveform generator	Enables enhanced flow meter performance by accurately controlling the transmit signal. It also enables significant space saving for multipath flow meters, and offloads waveform generation from the FPGA.
	AD9705	Single-channel, 10-bit, 175 MSPS TxDAC	Enables enhanced flow meter performance by accurately controlling the transmit signal.
Multiplexer	ADG5412F	Quad, ±55 V fault protected switch, 10 Ω ON resistance	Can be used to protect low voltage receive circuitry from higher voltage transmit signals.
Receive	*Fully Integrated Multichannel Receive Solution*		
	AD9670	Highly integrated octal ultrasound AFE	Enables significant space saving and performance advantages for multipath flow meters.
	VGA		
	AD8338	Single-channel VGA with 80 dB gain range, 4.5 nV√Hz at 80 dB	Highest dynamic range with low noise, to accurately gain low level receive signals. This can allow the meter to operate over a wider range of pipe diameters and turbulent flows.
	AD8332	Single-channel VGA with 48 dB gain range, including 0.74 nV√Hz LNA	High dynamic range with lowest noise, to accurately gain low level receive signals. This can allow the meter to operate over a wider range of pipe diameters and turbulent flows.
	Precision DAC for VGA Gain Control		
	AD5681R	Single-channel, 12-bit *nano*DAC+®, 2.5 V internal reference	Small solution size with integrated reference.
	Pipeline ADC		
	AD9629	Single-channel, 12-bit pipeline ADC with 20 MSPS/40 MSPS/80 MSPS sampling rate	Well defined latency and high linearity enable accurate time of flight measurement. This results in improved accuracy of the flow measurement.
	Temperature Sensor		
	ADT7320	Fully integrated digital temperature sensor, 0.25°C max error	Simple, accurate temperature measurement for temperature compensation.
Processing	*DSP*		
	ADSP-BF70x	400 MHz Blackfin®+ core, up to 1 MB SRAM, cryptography accelerators on-chip, <100 mW at 400 MHz	Low power DSP solution minimizes system power as well as self-heating in the flow meter housing. Supports multiple industrial interfaces.
Communications	*4 mA to 20 mA and HART*		
	AD5420	16-bit/12-bit DAC and 4 mA to 20 mA driver, HART compatible, integrated reference and LDO	Fully integrated, HART-compatible, 4 mA to 20 mA solution.
	AD5700-1	HART modem with integrated <1% precision oscillator	Industry's smallest HART modem—requiring minimal external components aids in smaller system design. Registered with the HART communications foundation.
	RS-485		
	ADM2582E ADM2587E	Fully integrated signal and power isolation, ±15 kV HBM ESD	Fully isolated RS-485 solution with high ESD rating.
	Wireless <1 GHz Transceiver		
	ADF7023	Ultralow power, resilient to interferers, data rates up to 300 kSPS	Superior interference blocking for increased wireless reliability.
	Wireless 2.4 GHz Transceiver		
	ADF7242	Maintains robust range in ultraharsh spectrum by superior blocking	Superior interference blocking for increased wireless reliability.

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