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ADI rolls out single-chip converters for precise capacitance and impedance measurements

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Norwood, Mass. — Analog Devices, Inc.'s new families of capacitance-to-digital converters (CDCs) and impedance-to-digital converters (IDCs) simplify instrumentation and sensor design in industrial, automotive, and medical applications.

These converters are the world's first high-precision, fully integrated converters that address the complex and difficult signal processing challenges of direct capacitance-to-digital and impedance-to-digital conversion.

Combining advanced signal processing techniques with high levels of integration, ADI's CDC and IDC devices attain a level of precision previously only possible with conventional analog voltage-to-digital converters aided by a significant number of discrete components. ADI's devices provide designers significant advantages over existing discrete solutions for capacitance- and impedance-sensing applications that have historically lacked precision and proven difficult and expensive to design.

The devices are ideal for a wide range of high-performance instrumentation and sensing applications, from blood pressure monitors and glucose analyzers to position sensors for automobiles and industrial corrosion analysis systems.

"Designers of instrumentation equipment have long recognized the benefits of using capacitive and impedance techniques for applications requiring highly accurate measurements, but up until now they were constrained by complexities in implementation and by the significant design cost involved," said Mike Britchfield, product line director, precision converters, Analog Devices. "Our advanced CDC and IDC technologies solve these design challenges by delivering the optimal performance levels within an easy-to-use, fully-integrated one-chip solution significantly reducing time to market."

More about Analog Devices' CDC Products

Capacitive sensors, which are used to enable high-precision measurements in space-constrained and power-sensitive applications — such as pressure monitoring and remote keyless entry — are extremely robust, accurate, and sensitive, but can be costly and difficult to implement. Traditional capacitance sensor signal processing solutions are either limited to lower accuracy applications or require an expensive, multichip capacitance-to-voltage front-end. ADI's CDCs eliminate these constraints by enabling higher accuracy and delivering complete on-chip analog functionality, while reducing design effort and external component costs.

Because changes in the physical environment can change sensor parameters, the AD7745 is software configurable, eliminating the need for multiple customer product models and expensive hardware reconfiguration, and easing qualification and inventory management. The software programmable output data rate can be varied from 5 Hz to 90 Hz. At 16.6 Hz, simultaneous rejection of 50 Hz and 60 Hz signals is achieved.

The first three devices in ADI's CDC family — the AD7745, AD7746 and AD7747 — leverage ADI's expertise in high-precision sigma-delta technology and system integration by combining 24-bit

resolution, low noise of 5 atofarads (aF) $10^{1}8$; per root hertz, and low power (1 mA max) with a complete range of on-chip analog functions.

More about Analog Devices' IDC Products
Impedance measurement is a complex and difficult signal processing challenge, traditionally accomplished using discrete solutions.

The AD5933 and AD5934 combine state-of-the-art digital and analog signal processing techniques to provide a compact integrated solution for impedance measurement. Using a DDS to provide a fine-frequency sweep capability combined with an A/D converter and sophisticated digital signal processing these devices allow an external complex impedance (range 100Ω to 10 MΩ) to be excited with a known frequency of up to approximately 100 kHz. The response signal from the impedance is sampled by the on-board A/D converter and discrete fourier transform (DFT) processed by an on-board DSP engine. The DFT algorithm returns a real (R) and imaginary (I) data word at each frequency point (in the case of a sweep) allowing impedance to be conveniently calculated based on an initial calibration.

Availability and Pricing
All devices are currently sampling with production quantities of the CDCs (AD7745 and AD7746) and the IDCs (AD5933: 12-bit, 1 Megasamples/s; and AD5934: 12-bit, 250 Kilosamples/s) slated for May. The AD7747 CDC is currently sampling with production quantities planned for August. The devices are available in small 16-lead TSSOP and 16-lead SSOP with prices ranging from $4.60 to $4.95 (CDC) and $4.35 to $6.65 (IDC) per unit in 1,000-piece quantities.Click here for the CDC data sheet.

Analog Devices, 1-800-262-5643, www.analog.com.

ADI has developed a new converter breed for high precision measurement in response to a rising number of capacitance and impedance-based sensor applications. "Traditionally it's been extremely difficult to precisely measure capacitance and impedance values without significant design effort," said Conor Power, product marketing manager of ADI's precision converter group.

The only way to accomplish this task previously was to implement a multichip solution that could involve up to nine discrete chips with extra resistors and capacitors, Power said. The multichip version would include an A/D converter, a temperature sensor, a programmable gain amplifier (PGA), multiplexer, a voltage regulator and other devices. Consequently, the AD7745 represents a more cost-effective solution — 35% of the cost of a multichip solution, he said.

ADI's AD7745 devices aren't the only CDCs in town. However, these are the first devices of this kind aimed at high precision measurement applications, Power said. Existing CDCs, which are crude and lack precision, are used exclusively for proximity sensing, he said. Previously, there was no single chip solution for high precision applications. "With these products, customers don't have to build and qualify expensive and difficult discrete converter solutions for their capacitance sensing applications," Power said. "The AD7745 family simplifies and speeds the design phase, saves board space, and leads to products with improved manufacturability," Power added.

There are countless industrial applications that require capacitance to sense presence such as touch screens likes the ones you see in elevators that sense the presence of your finger and then change capacitance accordingly, said Morry Marshall, VP of strategic technologies at Semico Research Corp. (Phoenix, Ariz.). "I worked with a similar product 10 years ago that required 20 chips to do the same thing. There is nothing like this device in the market today. It will provide a tremendous advantage to designers," he added.

Some key features of the AD7745 CDC family include 2 femtofarad (fF) accuracy and ±0.01% linearity of full-scale reference (FSR). The one-chip device offers direct conversion from capacitive sensor to digital code, an auxiliary differential voltage channel, and on-chip voltage reference and

on-chip clock. The on-chip temperature sensor provides 0.1°C resolution and ±1°C accuracy. These capacitance converters are insensitive to parasitic capacitances on their inputs as a result of their front-end architecture, which also protects the converters from input leakage current.

These capacitance converters are guaranteed to operate within the specified automotive temperature range. For automotive applications that don't require such high resolution, ADI can trade off resolution for power and speed, Power said. For applications operating in extreme operating conditions, such as automotive applications, customers can add extra protection circuitry at the inputs of the device without worrying about parasitic effects on measurement.

Regarding ADI's impedance converters, impedance conversion is becoming more important to many sensor and diagnostic related applications. Again, as with capacitance converters, this task is traditionally accomplished via several discrete solutions, and usually requires a high level of analog design skill to extract frequency responses of the unknown impedance, said James Caffrey, product marketing manager for ADI's precision converter group.

ADI's single chip device offers a way to analyze complex impedance at a 50% cost savings over a multichip solution, Caffrey said. "This is the way it works. The device generates a frequency sweep, which is applied to the unknown impedance or sensor. Then, the frequency response is captured and the real and imaginary coefficients extracted allow impedance to be conveniently calculated," he explained.

Key features of the AD5933 family of impedance converters include a DDS to create a predefined frequency profile, on-chip gain stages allowing a broad impedance range to be measured, and a ±1°C temperature sensor. The AD5934 is the same as the AD5933 except it's a 250 Kilosample/s A/D converter, without an on-chip oscillator and no temperature sensor.