LEADING inside

A series on engineering better performance and lower costs in new designs, by Analog Devices.

A Whole New Value Equation for Industrial Designs

State-of-the-art analog and mixed signal ICs, particularly those manufactured on submicron CMOS, have brought significant size, cost, and power advantages to a wide variety of applications, with one notable exception—industrial. The high voltage requirements of sensors and actuators cannot be affordably met with most of today's ICs. The continual decrease in smaller geometry CMOS power supplies and the shift to single supplies have caused industrial engineers to add more discrete circuitry around new state-of-the-art ICs, adding board area and costs to each design. However, breakthrough technology has finally brought submicron innovation to the ±10 V world.

A new process from Analog Devices called *i*CMOS™, for industrial CMOS, changes all that. It combines the performance and cost advantages of low and high voltage CMOS, high voltage bipolars, and DMOS processes in a submicron technology. This process allows users to put as much as 30 V across a chip. Analog Devices' researchers concluded that there was a need to combine the cost benefits of submicron CMOS with a suite of high voltage, high performance analog devices on a single chip to achieve breakthroughs in accuracy, power, signal chain integration, and associated cost benefits that were previously unattainable using existing IC processes.

Process Engineering

The developers of *i*CMOS wanted to create a truly modular process that would produce both high and low voltage devices for a wide variety of applications, requiring that they develop specialized epitaxy and photolithographic masks that would work seamlessly together in many different configurations. This challenge was especially acute for the bipolar transistors, which have requirements that ordinarily influence the surrounding devices. But the designers of *i*CMOS were able to overcome this obstacle in such a way that the overall performance of the devices was not compromised.

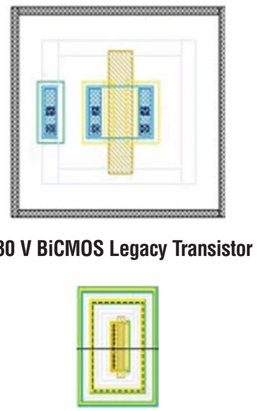

Figure 1. The iCMOS process enables more functionality and multiple voltages on-chip with submicron geometry.

Crucial to *i*CMOS was the development of a manufacturing process that would enable the growth of thicker gate oxide. This breakthrough permitted tooling switches capable of handling high voltages that can be fabricated in close proximity to conventional 5 V devices. Thus, multiple supply voltages, whether they are 5 V, 16 V, 24 V, or 30 V, can be isolated from the substrate and from each other.

Smaller Sizes, More Integration

As depicted in Figure 1, the real estate has diminished considerably—a major contributor to placing the numerous components available on the chip. *i*CMOS is a completely modular manufacturing process, meaning the performance and robustness of each of its large suite of available devices are not simply the result of traditional trade-offs to achieve integration.

Here is what this new process brings to each of the devices that are the basis of industrial applications:

With regard to both converters and amplifier products, the process has been optimized for noise, matching, linearity, and stability. In addition, specific to amplifiers, it improves noise/power ratio and reduces offset and offset drift. It also reduces 1/f noise and output settling time. As for references, they are now fully bipolar, which means higher accuracy and lower temperature coefficients.

Submicron advantages have come to the ±10 V world.

*i*CMOS enables analog-to-digital converters (ADCs) with software-selectable inputs allowing wide input ranges from ±2.5 V to ±10 V, while providing 85% less power consumption than existing solutions. *i*CMOS digital-to-analog converters (DACs) can provide industry-leading performance in packages that are 30% smaller. In addition, *i*CMOS multiplexers exhibit low R_{ON} and R_{ON} variation (5 Ω maximum), in 16-lead TSOP (thin small outline packages).

Products Announced

The first 15 *i*CMOS products have been announced, and there are more on the way. They are emerging as breakthrough products in their own right, thanks to significant improvements over the competition in accuracy, power, footprint, and total cost.

Examples of Specific Products Tooled in this Technology:

- DAC: The AD5764 quad 16-bit DAC offers three times more accuracy while using 50% less board space. Some of the features included are an on-chip precision reference as well as reference buffers, a precision amplifier, temperature sensor, and an extended programmable output range. (See Figure 2.)

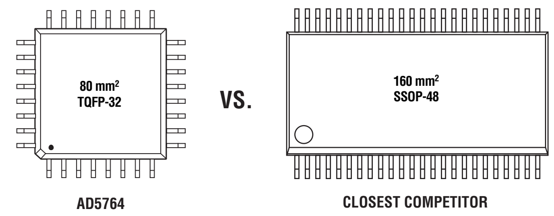

Figure 2. The quad 16-bit DAC (AD5764) cuts board space in half, and has triple the accuracy of the closest competitor.

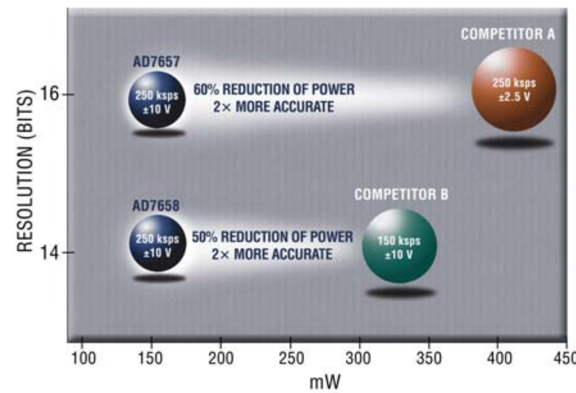

Figure 3. A comparison of a 14-bit ADC (AD7657) and a 12-bit ADC (AD7658) demonstrating up to a 60% power reduction and up to twice the accuracy of the competition.

- ADCs: The AD7328 1 MSPS, 8-channel, 12-bit ADC reduces power consumption by 60%, as compared to competitive products. The AD7656 16-bit ADC offers simultaneous sampling on six channels and twice the accuracy of comparable devices. (See Figure 3 for more ADCs.)
- Amplifier: The AD8661 precision rail-to-rail amplifier features the lowest offset voltage, noise, and input bias current in its class. Available in a 3 mm × 3 mm LFCSP and a narrow SOIC-8, it is 70% smaller than the competition.
- Digital Potentiometer: The AD5290 delivers an unbeatable combination of features and performance in a compact MSOP-10 package and can be operated from a single-supply up to 30 V or dual-supply up to ±15 V.
- Switches and Multiplexers: These devices operate at ±15 V while delivering industry-leading performance in very small packaging. For example, the ADG1408, 8:1 mux exhibits an on resistance that is 85% lower than its closest competitor.

Value Proposition

Individually and collectively, the analog and mixed-signal ICs made on the innovative *i*CMOS process enable new value metrics for high voltage, industrial ICs.

- Dramatic Power Reduction: The capability to employ multiple voltages on a single substrate enables direct sampling onto a high impedance capacitive array. Accompanied by the integration of on-chip, low noise amplifiers capable of driving high voltage outputs, these features combine to reduce component power consumption by as much as 85%.
- Smaller Footprint: *i*CMOS ICs are typically 30% to 75% smaller than other high voltage parts. In addition, the inclusion of auxiliary components, such as on-chip memory and on-chip signal conditioning, reduces board space even further while equaling the performance level of off-chip, standalone components.
- Less Complexity, in Much Less Time: The integration of high voltage components onto *i*CMOS products eliminates the need to surround low voltage components with complex external circuitry, resulting in simplified design and shorter design time.

In summary, the submicron geometry, in concert with all the other attributes of *i*CMOS described above, enables the integration of more of the signal chain without compromising performance. Finally, state-of-the-art IC technology is available for applications such as factory automation, process control, and instrumentation. The newly available size, cost, and power advantages enables an entirely new value standard for the ±10 V world.

Author Profile: Leo McHugh has been with Analog Devices for 18 years, and as marketing manager, has been a contributor to numerous product and technology introductions. He can be reached at leo.mchugh@analog.com.