EDITORIAL BACKGROUNDER

Texas Instruments Leadership in Analog Process Technology Drives Product Performance

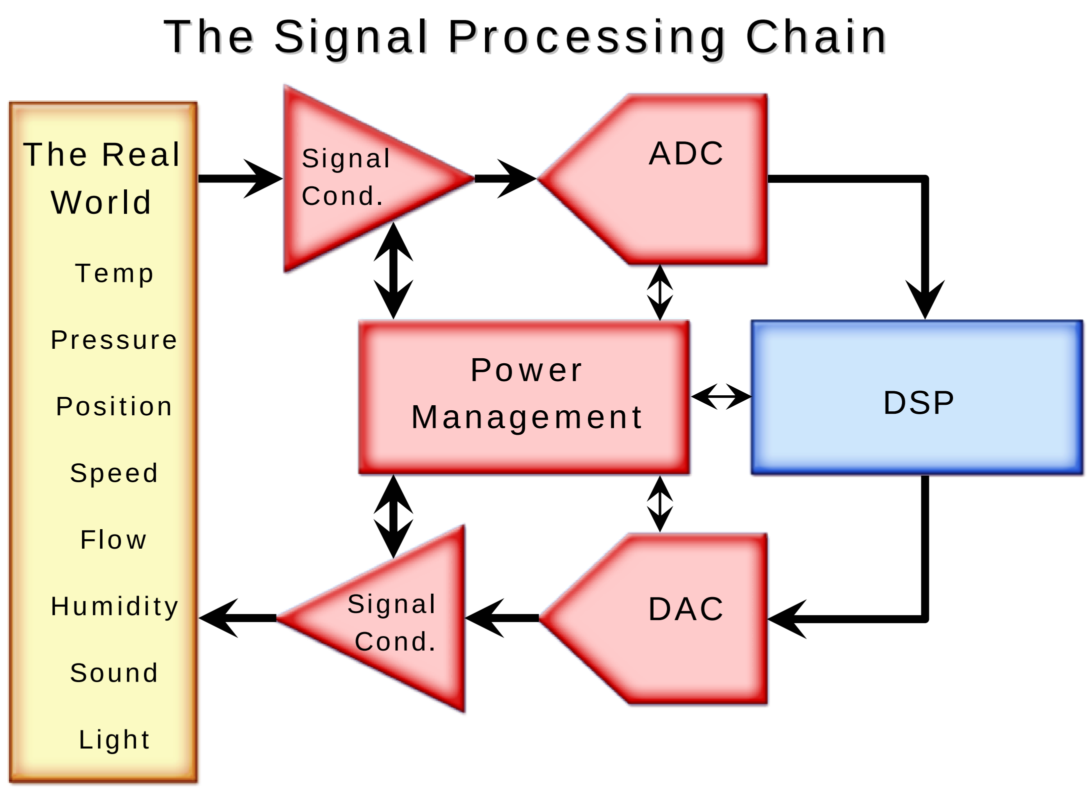
High-performance TI analog products complement state-of-the-art DSPs and other digital logic in making new systems faster, less power-hungry, more robust and more affordable.

In a world where the latest high-speed digital technology advances dominate the news, it is important to remember the key role that analog technology plays. Analog chips connect digital signal processors (DSPs) and other types of logic to the outside world, changing "real world" signals such as light and sound into binary pulses and back again. Without analog technology, there would be no computers, cell phones, PDAs, digital cameras, CDs, DVDs and other digital equipment, not to mention the Internet and a host of digital communications services. And no matter how far digital circuitry advances, it will always need high-performance analog circuitry to complement it. In order to keep pace with the extremely fast digital technology developments, analog technology must also continue to evolve.

Texas Instruments (TI) understands the critical importance of analog chips and continues to invest significantly in analog research and development (R&D). Analog technology and DSPs complement each other as two of the company's core areas of product design and manufacturing. With its industry leadership in these areas, TI is able to maximize its analog expertise to benefit its digital portfolio and vice-versa. Moreover, as the company's digital chip fabrication plants mature, TI will convert them to analog manufacturing and continue to gain substantial extra revenue these facilities. Since new, state-of-the-art digital fabs can cost up to three billion dollars, the re-use of existing facilities for analog manufacturing gives TI tremendous financial leverage on its capital investment and provides an important advantage for the company in analog technology development.

What do analog chips do?

Every system with a DSP or other processor requires analog chips to receive and condition incoming analog signals, then convert them to digital signals for the logic to process. At output, other analog devices re-convert the digital signal back to analog and amplify it for driving system interfaces like visual displays, audio speakers, etc. If the system includes a radio, analog functions designed for radio frequency (RF) operation receive and transmit the wireless signals. Finally all the functions in the system, including the digital logic, are powered by analog chips designed to handle the higher voltages and currents associated with managing power from batteries or the electrical grid.



Depending on system requirements, analog functions may be discrete components; they may be integrated with each other analog functions; or, in some cases, they may be integrated with the DSP or other digital logic. Integration decisions depend on which technologies can be combined cost-efficiently without sacrificing performance or power consumption. These considerations are very different in, for example, a cell phone and a wireless base station. In a cell phone low power and low cost are critical, while a base station demands top performance for greater channel density. TI's analog design teams focus on developing products that meet the systems requirements of all key markets. The job of TI's analog process development teams is to provide the manufacturing technologies that make those products possible.

Analog Components in SoC Designs

Because the requirements vary so much among the different analog functions and the types of systems where they are used, TI's development of analog technologies follows several distinct paths. In some cases TI pursues a strategy of integrating all critical analog and digital functions required to support a specific application in System on Chip (SoC) designs. This approach requires that the same advanced CMOS processes used to create high-performance DSPs, microcontrollers and ASICs, support some analog components. This analog and digital integration capability is found on TI's single-chip Bluetooth and ADSL products, with a single-chip GSM/GPRS device for cell phones available by late 2004. Today, as TI develops its 65-nm CMOS process for next-generation digital products, analog developers are working with digital teams to ensure that analog components will also be ready for integration in the first products that come off the line at this node.

But most analog functionality is not optimized for high-speed digital logic integration. In this case, TI analog product development teams focus on analog-only integration, as well as precision, speed and power. Different processes are devoted to different component requirements. In a cell phone, every signal chain analog component that is not integrated into the digital baseband or RF sections is combined into an analog baseband device to minimize system space, cost and power consumption. In other applications, different analog processes have component characteristics tailored for the needs of signal conditioning, data conversion and power supply in those systems.

Digital design is two-dimensional because it makes complicated logic patterns out of theoretically identical transistors that simply turn on-and-off. By contrast, analog design is multi-dimensional, because it uses transistors and other components over the full working range of their physical characteristics to modify signals in a variety of ways. This multi-dimensional complexity means that designers need time to learn to use an analog process, so high-performance analog processes tend to mature about two CMOS nodes later than high-speed digital processes. In 2005, when TI's 65-nm digital CMOS process is scheduled to go into production, a corresponding 130-nm high-performance analog CMOS process is also scheduled to be turning out its first products. (The "in-between" 90-nm node is being used for today's highest-performing digital products.)

TI's leadership analog processes

TI has three processes in production that illustrate the depth and breadth the company's commitment to analog technology. The HPA07 Precision Analog CMOS and BiCom III High-Speed BiCMOS processes are specialized for signal conditioning and data conversion, while the LBC5 Power BiCMOS process is designed for power supply functions. While high speed and low noise are critical for signal conditioning, handling high voltages and currents reliably are essential for power management. Each of these analog processes is designed to meet a specific mix of these requirements.

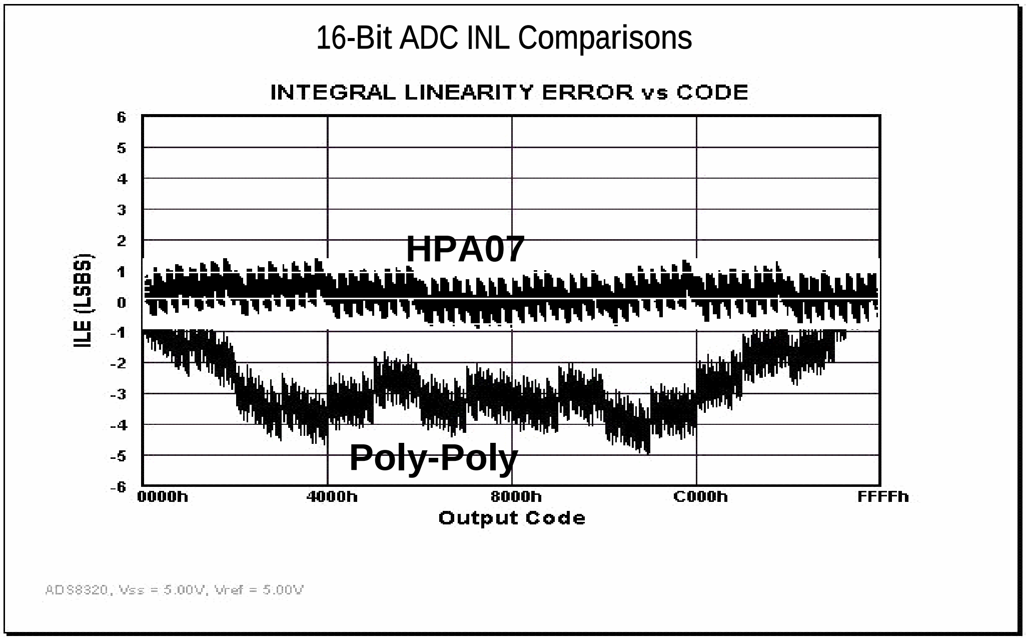
High Precision

The HPA07 Precision Analog CMOS process offers extremely low-noise performance for communications and other systems where analog and high-speed digital functions must co-exist with minimal signal interference. Incorporating the logic and memory of its fundamental 5-V, 0.3-micron digital CMOS process, the HPA07 process then adds specialized transistors and passive components for analog functionality. Isolation shields analog signals from the high-frequency interference of digital circuits, and exceptional component matching promotes precision.

Key components include low-noise transistors with extremely low total harmonic distortion (THD) characteristics. The transistors are created using a buried-channel PMOS technique, which allows tighter noise characteristics control to give the best gain bandwidth/noise ratio for this class of device. Silicon-chromium (SiCr) thin film resistors with very low temperature coefficients provide stability over the entire working temperature range. Metal-insulator-metal (MIM) capacitors with tight alignment and low parasitics reduce size while providing a 4X improvement in voltage coefficients over previous processes. Drain-extended CMOS transistors that handle up to 30 V for driving signals enable the process to extend to higher voltage applications.

HPA07 – World Class Capacitors

4x Improvement in Voltage Coefficient Greatly Improves Analog-to-Digital Conversion

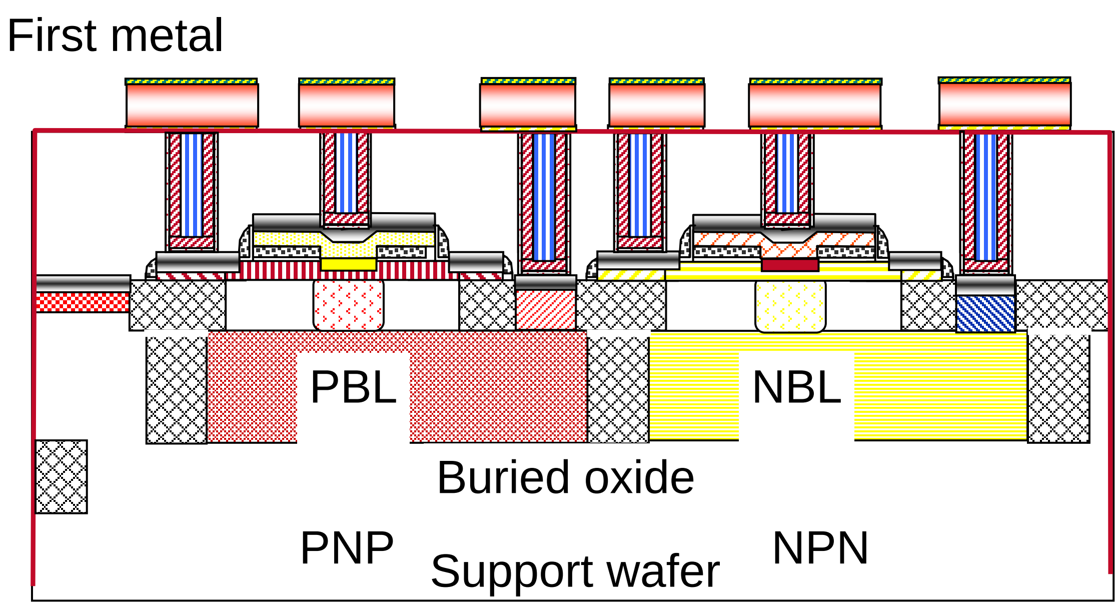


The first IC product available using the HPA07 process is TI’s OPA300 High-Speed, Low-Noise Operational Amplifier. Capable of driving the industry's highest-performing 16-bit analog-to-digital converters (ADCs), the op amp features a high bandwidth of 180 MHz, low noise of 3nV/rtHz, fast settling of 150 ns to 0.0015 percent, and low harmonic distortion of only 0.003 percent. In the OPA300 op amp, system developers have a true 5-V single-supply solution available for driving high-speed Successive Approximation Register (SAR) ADCs without compromising performance or using a negative power supply.

High Speed

The BiCom III High-Speed BiCMOS process is designed for exceptionally high-frequency operation in signal conditioning and data conversion. Adding the speed of silicon-germanium (SiGe) bipolar transistors to 5-V, 0.35-micron CMOS logic, the BiCom III process is designed with the best high performance component set. As the industry's first production process to feature complementary SiGe PNP and NPN transistors, BiCom III offers high Early voltage, high transistor gain, high f_T (maximum unity gain frequency), low capacitance for low THD and low power consumption. All of these features are critical to wireless, as well as other communications equipment. Other features include MIM capacitors, trench isolation for circuit protection, and nickel-chromium-aluminum (NiCrAl) thin-film resistors with low sheet resistance (R_S) to handle high currents. Silicon-on-insulator (SOI) techniques provide low, highly linear capacitance and improve isolation and speed.

BiCOM III Transistors



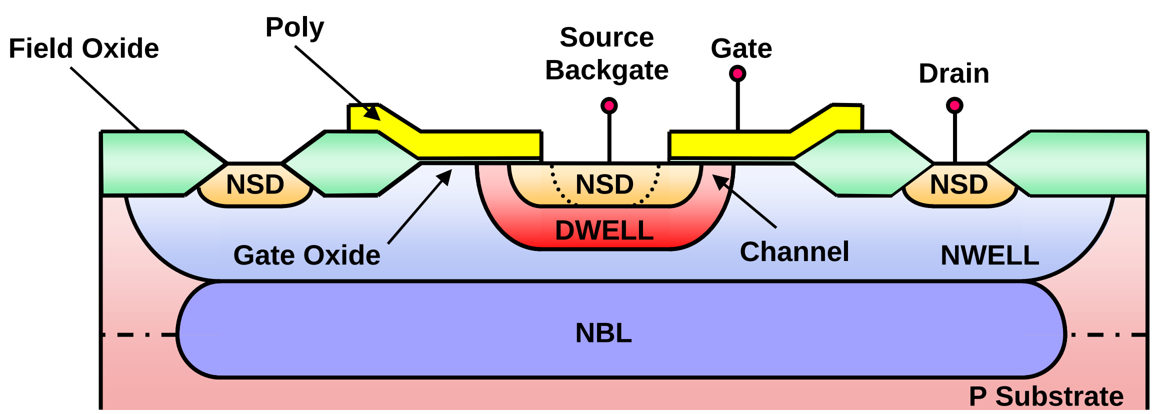
The first product to be developed using the BiCom III process was TI's THS4302 Wideband Fixed-Gain Amplifier. Featuring a bandwidth of 2.4 Gigahertz (GHz) and a fixed gain of +5 V/V, the device is well-suited for driving high-resolution data converters for a wide dynamic range in digital signal processing. The high amplifier bandwidth benefits wireless infrastructure equipment such as base stations and relay stations, providing more channel capacity and wider bandwidth packaged into less space. In addition to being an attractive alternative to radio frequency (RF) amps, the THS4302 class AB op amp allows advanced semiconductor test equipment to keep pace with future generations of high-performance IC products that are now in development.

High Power

TI’s 0.35 micron LBC5 Power BiCMOS process is capable of integrating a wide variety of components, including power transistors, CMOS logic, bipolar transistors and passives, enabling the full range of power, control and protective circuitry used in power management devices. Lateral Double-diffused MOS (LDMOS) transistors support high voltages of up to 60 V with low on-resistance. Thick copper metal significantly reduces resistance for high current capacity, and bonding over active circuitry moves high-current conductors off-chip quickly. The result is a high SOA (safe operational area) figure, which protects the device and improves reliability while supporting high-power operation.

Lateral DMOS Transistor

LDMOS = Lateral Double-Diffused MOS



An example of a product released using a Power BiCMOS process is the TPS54350 SWIFT™ (Switcher with Integrated FET Technology) DC-DC Converter. The device supports a wide input voltage from 4.5 V to 20 V at a continuous output current of 3 A, operating with greater than 90 percent efficiency at up to 700 kHz. With its integrated MOSFET driver, high accuracy and small size, the device is ideal for low-power industrial and commercial systems, liquid crystal display (LCD) monitors and television sets, hard disk drives, video graphics cards and point-of-load regulation off a 9-V or 12-V wall adapter.

Analog enables the future

These high-performance processes, along with analog integration in state-of-the-art digital processes, give TI its leading edge in analog technology. Future developments will push the precision, speed and power of TI’s analog products even further, while new CMOS nodes will increasingly integrate analog and digital functions, leading to cost-effective single-chip systems. While advanced analog technology may not be featured in the headlines as often as the latest digital technology, it is every bit as important to the future of high-performance electronics. With a substantial investment in analog R&D, TI maintains its commitment in analog processes and products in order to complement its leadership in DSPs and enable the ever-more exciting electronic system advancements of the future.