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How Analog Engineers Bring Digital Designs to Life

The "digital revolution" has changed the way we communicate, work and travel by reshaping our relationship with the world around us. The digitization of electronics has transformed our world by enabling a vast network of portable, accessible interconnected communications media. The ability to quickly and accurately collect images, voice and audio data from the environment around us and manage and manipulate it in the digital domain has given rise to anytime, anywhere communication and higher performance computing. It has yielded more reliable and affordable medical electronics. It has brought exciting, interactive multimedia content to a diversity of consumer devices. Collectively, advances like these have placed the world we live in quite literally at our fingertips.

However, the promised advantages of digital technology are only as good as the ability of the analog technologies that faithfully reproduce the digital language of 1's and 0's into analog signals that can be heard, seen, felt, or perceived by human beings.

The impact of the digital revolution would have been muted without significant and simultaneous analog technology innovation. The more of our world we capture digitally, the more of it we must convert and reconstruct - whether into real-time voice transmissions, audio signals or video images. The shrinking footprint and increasing feature set of today's cell phones, the audio quality of high-end automotive sound systems and the high-definition images broadcast to digital televisions are a product not only of smart circuit design, advanced manufacturing and high-performance digital processing, but of an ongoing revolution in analog design.

Indeed, the profusion of digital products in thousands of end markets and applications has triggered a similar, and often proportionately larger, need for high-quality analog technology. A faster digital signal processor (DSP), for example, enables a digital audio receiver to improve its performance by adding multiple audio channels. Each new channel, however, requires a separate power amplifier to drive the signal output in a manner that is familiar and pleasing to the human ear. In fact, market research firm DataBeans estimates that for every dollar of digital content added to an electronic end-product design as much as \$1.40 in analog technology also is required.

The proliferation of digital electronics is actually doing much more than driving demand for analog content. In many cases, new digital products require new levels of highly integrated, high-performance analog circuitry that is able to convert, condition and regulate the signal, control and power chains that define today's advanced system functions. In fact, some end users might be surprised to learn that many of the features of their most favorite digital products are differentiated more by analog innovation than digital circuitry. Consider the following application trends and the ways in which analog technology is enabling and defining the digital landscape:

- Digital still cameras:** When they were introduced to the consumer market more than 15 years ago, digital still cameras set out to meet - and exceed - the quality of 35 mm film stock. While advances in DSP and microcontroller processing technology have created the bandwidth necessary to rapidly process images digitally, the quality of those images depends on the ability of high-performance data converters in the camera's analog front end (AFE) to lower noise and increase dynamic range. Advances in data conversion technology also have enabled the AFE to address other conventional performance issues such as lowering power to extend battery life, raising conversion sample rates to increase camera shutter speed and boosting the light sensitivity of the image sensor to reduce the need for flash in higher resolution cameras. Such features have increased the analog semiconductor content in a typical digital still camera from less than \$2 a few years ago to more than \$5 today. Next generation cameras may require as much as \$15 of analog circuitry.

Moreover, analog innovation isn't just improving digital camera performance; it is helping differentiate new camera designs. The combination of analog and microelectromechanical systems (MEMS) devices, for example, is being used to compensate for camera "shake" by adding a gyroscope and data conversion technology to eliminate blurred photographic images.

- Audio processing:** Whether processing Dolby 5.1-channel Surround Sound in a home theater application or 12-channel audio in a high-end automotive system, today's audio signal chain is increasingly digital. In reality, however, the signal chain is "all-digital" in name only as the profusion of multi-channel audio is placing new performance demands on analog technology. The digital signal processing challenges inherent in a multi-channel digital audio topology, for instance, require designers to use multiple high-performance analog power amplifiers to drive speakers and audio codecs capable of converting analog audio signals without compromising, or "washing out", the performance of the DSP.

And in many applications, multi-channel audio is being designed into smaller and smaller systems, requiring lower power and lower cost analog components capable of operating at higher efficiencies. Even high volume consumer audio systems require best-in-class audio converters to ensure the high performance and precision needed to maximize the performance of the digital processor.

- Cellular Handsets:** As the cellular infrastructure migrates from 2G and 2.5G to higher performance 2.75G and 3G services, it is driving the development of a new generation of more intelligent, function-rich phones. The rapid convergence of voice, video and data is allowing designers to add such exciting features to next generation handsets as MP3 music and broadcast TV. Already, the market is expanding in a variety of directions as manufacturers segment their product lines to address the needs and habits of distinct user groups. But the features in these "digital" cell phones are also driving the need for new analog capability. The trend to integrate higher resolution cameras into the wireless handset demands better analog image processing, image stabilization and focus/zoom control - as well as the data converters and amplifiers required to support those functions. New, more user-friendly phones featuring easier-to-read color displays require advanced LCD backlight power devices. And as designers integrate new voice, video and data features into these

platforms and attempt to manage up to 20 different regulated voltages, advanced power management and battery-charging ICs are required to ensure that camera performance doesn't come at the cost of battery life. These changes, combined with the challenges involved with implementing the advanced multi-band, multimode RF and analog interface functions required in the basic communications engine of a 3G phone, will drive up the average analog content of a wireless handset from approximately \$8 today to more than \$15 per unit in the near future.

- **Medical Imaging:** In the healthcare arena, the availability of larger amounts of digital resources and the transformation of stationary systems to portable formats is driving demand for a range of new, higher performance analog components. In medical imaging applications, for example, high-speed digital computation allows physicians to review higher resolution CT scans and ultrasound images to more quickly and accurately assess the condition of vital organs or blood vessels. But to take advantage of those new capabilities, designers must improve the signal acquisition capabilities of their products by increasing channel density and improving the performance of the AFE.

New advances in variable gain amplifiers and analog-to-digital converters are increasing dynamic range and improving image quality, while I/Q demodulator and phase-shifter ICs are enhancing the performance of Doppler ultrasound systems. Furthermore, by integrating multiple functions and channels into a single device, these high performance analog components can help designers build smaller, more portable systems by dramatically reducing product footprint and power consumption. Analysts now estimate that 2-D and 3-D medical imaging applications will represent a \$1.5 billion market for analog components.

- **Advanced TV:** Ask the average person on the street and you'll hear that while the history of TV has been analog, the future is digital. While the advent of high-definition TV and theater-quality sound are attributed to the digital revolution, the development of advanced TV is being driven as much by the adoption of new analog technology as innovations in digital design. Even in the era of digital broadcasting, TVs require dual interfaces - both digital and analog - to support legacy VCRs, DVD players and camcorders. Highly integrated interface ICs that support multiple interface standards - from standard analog to the emerging High-Definition Multimedia Interface (HDMI) - will be required to couple analog and digital inputs to state-of-the-art flat panel displays. High performance audio processors will help engineers migrate analog sound processing tasks to the digital domain. And new highly integrated post processing ICs will boost audio performance by compensating for the design limitations of thin flat-panel TVs. Indicative of this growing reliance on high performance analog circuits, the approximately \$20 of analog content used in the average digital TV today will grow to almost \$60 per unit over the next several years.

Analog Devices understands that data conversion technology and the front end signal processing required to manipulate and manage real-world phenomena, such as light, sound, motion, pressure and temperature, are essential ingredients to creating a rewarding end-user experience.

That's a lesson ADI has learned through more than 40 years of designing and developing analog, digital and mixed-signal technology and cultivating a deep knowledge of our customers' applications requirements. ADI offers best-in-class performance for a given application--and that translates into the optimum user experience. ADI's innovation also is lowering system costs through increased integration, smaller sizes, less power. This is key to meeting mass market cost structures that enable digital designs to be so popular.

This proven expertise, an extensive product portfolio, and a growing array of support tools allow ADI engineers to add performance where it matters most. By ensuring the right components are available for customers' applications, Analog Devices enables engineers to bring the full potential of their digital designs to life.

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