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TECHNOLOGY; A Digital World With Analog As Its Workhorse

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Phonograph records are relics. Traditional cameras sit in closets gathering dust. Clocks with hands? How quaint.

Digital technology, as every marketer knows, is synonymous with speed, precision and the future.

The challenge, though, for those designing digital products is that no human experiences reality as a pattern of 1's and 0's. The natural world is, in engineering terms, a thoroughly analog realm of endlessly variable waves of sound and light, temperature and pressure fluctuations, and shifting magnetic fields.

So it turns out the digital revolution is driving strong demand for advances in analog electronics, an arcane realm in which tens of thousands of products translate reality into 1's and 0's for computers and retranslate digital results into forms humans can perceive.

In a digital camera, for example, analog chips translate wavelengths and intensities of light into digital code and, if the photographer wants to check the image, they retranslate the code into a visual display. Analog or mixed analog-digital chips also manage timing functions, signal filtering and amplification and battery performance.

Few companies understood the interplay better than Texas Instruments Inc., which in the late 1990's decided to invest heavily in analog devices along with its higher-profile digital products. Last year, it moved past STMicroelectronics of France to become the global leader in the $26.8 billion analog chip market, according to Databeans, a market research firm in Reno, Nev.

"Most people think that the world has gone digital and analog is old and not hip," said Gregg A. Lowe, the senior vice president who oversees most of Texas Instruments' analog business. "On average, there's probably 15 analog chips needed for every digital processor you use."

In fact, analog semiconductors have become Texas Instruments' biggest business, generating about 40 percent of its $8.36 billion in semiconductor revenue in 2003.

"The only thing exciting about analog electronics is the results," said Richard K. Templeton, who has been at the company for 20 years and became its chief executive in May.

Of course, when executives at Texas Instruments show off their products by popping open cellphones, digital cameras and hand-held music and video players, the first thing they point to is usually a digital signal processor. Such digital processors, which manage images and sounds while consuming 30 times less power than a standard desktop microprocessor operating at the same speed, made up 35 percent of the company's semiconductor business last year.

But while digital signal processors and microprocessors are the rock stars of information technology, executives at Texas Instruments are making the number of analog devices surrounding the signal processors a feature of their show-and-tell sessions.

Texas Instruments' history with analog technology goes back to 1930 when it was created to help oil companies explore for oil fields using sound waves. It later developed an expertise in radar, another analog technology, making equipment for the military in World War II.

Analog semiconductors have been part of Texas Instruments' business since the 1950's. But it was not until the company began concentrating on electronics for communications in the 1990's that the role of analog electronics became central to its business strategy.

Over the course of that decade, Texas Instruments sold its original oil services unit to Halliburton; its missiles and defense electronics business to Raytheon; its computer operations to Hewlett-Packard and Acer; and the memory-chip business, which had at one time been its biggest unit, to Micron Technology.

Then it began acquiring companies to expand its analog semiconductor operations and to increase its ability to build single silicon chips with both analog circuits and digital signal processors. The acquisitions included a $7.6 billion takeover of Burr-Brown in 2000 that still stands as the largest acquisition in the semiconductor business.

No company, not even a longtime semiconductor giant like Texas Instruments, can expect to produce a home-run product in analog electronics.

Success in digital processors and memory chips boils down to recognizing accurately and rapidly whether a circuit is on or off. That simplicity makes measuring performance and cost relatively straightforward and has even allowed the industry to predict fairly accurately how fast digital technology will improve. But the more variable world of analog data defies the emergence of a blockbuster analog design that fits many products.

"The average analog product does $1 million to $2 million in sales," said Gary Grandbois, principal analyst in the Santa Clara, Calif., office of iSuppli, a market research firm. "You need to have a huge number of products."

Thus, while Texas Instruments controls nearly half the digital signal processor market with a small portfolio of chips that it regularly prunes and updates with more powerful designs, keeping up its 12.9 percent share of the analog market requires maintaining its ability to produce more than 15,000 different analog chips and expanding that portfolio by about 500 chips each year.

While it has the overall market lead, the market is so fragmented that Texas Instruments trails others in many segments of it. In the important analog-to-digital data converter market, for instance, Texas Instruments is a distant second to Analog Devices.

There is not much total profit in many types of analog chips because the volumes are so low, but the profit margins per chip can dwarf those in other sectors of the semiconductor business. As a result, specialists in the most demanding analog components like Linear Technology and Maxim Integrated Products routinely report profit margins that other semiconductor companies envy.

"Anybody who knows anything about analog is sitting on a money-making proposition," said Robert H. Swanson Jr., chairman and chief executive of Linear, which is based in Milpitas, Calif. Even when the end of the telecommunications and Internet bubbles sent Linear's annual sales plummeting from $972 million to $507 million in the fiscal year that ended June 30, 2001, its operating profit margins never fell below 38 percent.

Analog Devices, based in Norwood, Mass., has "extraordinarily high gross margins" similar to Linear's for its converter and analog amplifier segments, according to a presentation by Jerald G. Fishman, Analog's chief executive, to investors in New York in June.

It helps that analog chip makers can generally get all the precision they need from manufacturing equipment viewed as obsolete by the leading manufacturers of digital chips.

Texas Instruments makes digital processors in its newest factories or outsources production to foundry companies that regularly modernize their equipment. But, with modest equipment changes, it produces analog chips internally on older production lines that cannot make circuits small enough for today's digital processors.

But the varied tasks for analog chips present huge design challenges. While some analog chips are sold for pennies apiece as commodities, others that are designed to produce peak performance in specialized research or medical equipment can cost hundreds of dollars. Buyers of analog chips are often more concerned about

availability and reliable performance than price, said Kevin P. March, Texas Instruments' chief financial officer.

Because digital technology is considered the leading edge of electronics, new analog electronics engineers are hard to find at universities. And because analog products are less standardized, engineers who have worked with analog designs and production processes at a particular company cannot easily transfer their expertise.

"It takes six to nine months for a college graduate with training in digital engineering to be contributing to our products," Mr. Lowe said. "In analog, we have to go to a few top universities, get Ph.D.'s and train them for four years before they can help us."

Experts with feet in both realms are especially valuable.

One of the most successful strategies Texas Instruments and others have applied to improving analog microchips has been to integrate them with digital monitoring and control circuits. Just as digital controls get higher efficiency out of an automobile engine, tiny digital circuits on such mixed signal chips can fine-tune the performance of the analog portion of the chip or help it avoid damage.

"The line between pure digital and pure analog chips is rapidly blurring, with both incorporating a little bit of the other," said Kevin Hawkins, a business development manager for the company.

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