The First PWM Device

Opening the Gates for the Power Management Industry

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It's easy to improve on a product technology when you know there is a market for it. However, it's much more difficult to take an original idea and develop it into a product when you're not too sure about the market's acceptance.

That's what we at Silicon General faced when we developed the first pulse width modulation (PWM) control chip in 1975—at least that's what our marketing manager told me. He thought we were wasting our time developing a PWM to implement switching technology for power supply control. At the time, I wondered if he was right. I knew we would have a market at least for what would become the SG1524 in military applications. Little did we know that the first integrated PWM controller would open the gates for the many generations to come of switching regulators and switch-mode power supplies (SMPS).

Right Place, Right Time!

In the 1950s, switching technology was used as a control algorithm to regulate the output of a switching power supply. Military and aerospace companies used switching power supplies, or "switchers" as we called them, because they were smaller and lighter weight than traditional transformer-based linear power supplies. Switchers had low internal losses, but were complex to design and used a large number of discreet components that made them costly.

Back then, a lot of analog ICs were available from companies like Motorola, Fairchild and Signetics. Many designed specifically for PWM control. However, discrete designs for switchers were not available and few had the experience to successfully create a SMPS. More importantly, no one as yet had put together all of the blocks on a single chip. When a customer came to us seeking a solution for a single-chip PWM controller, we took the plunge.

Teletype Corp. wanted to convert its old mechanical teletype equipment into smaller, quieter electronic machines. They believed that a switcher was part of the answer, but even a discrete implementation of a SMPS was too big. So they asked us to design a single-chip controller.

At the time, all of the functional blocks were known and could be integrated—except that no one had actually put together both analog and digital circuitry on the same silicon. Digital logic was made from gold-doped silicon, which is incompatible with analog circuitry.

Eventually, we turned to the first logic gate design that launched the semiconductor industry, a variation on the digital circuit developed years before by Jack Kilby of Texas Instruments. This design lead to resistor-transistor logic (RTL). This combination allowed us to implement both digital and analog circuits. To my knowledge, this was probably the first integrated, mixed-signal semiconductor ever produced.

It was a challenge and took us about a year, but eventually we designed a 16-pin, dual in-line package. The SG1524 was unique in many ways. It included an analog error amplifier and voltage reference, a fixed frequency oscillator, a pulse-width defining comparator, gating circuitry for dual outputs, and the protection of pulse-by-pulse current limiting. Of course, later devices and topologies improved upon this technique, but the SG1524 set the foundation.

Opening the Gates

As soon as we introduced the SG1524, we began improving it. Our efforts led to more capabilities and better performance in the SG1525 and

SG1526 devices. Eventually, many new families of control circuits evolved from the SG1524 as improvements or equivalents from other competing suppliers were developed.

The next major advancement in power occurred in the 1980s after I moved to Unitrode. This was the advent of current-mode control. I didn't come up with the ideas behind current-mode control, although I wish I had. When Digital Equipment suggested it to us, we grasped the idea and turned it into silicon. Current-mode control had better dynamic response and ease of compensation, along with the ability to easily incorporate over-current protection.

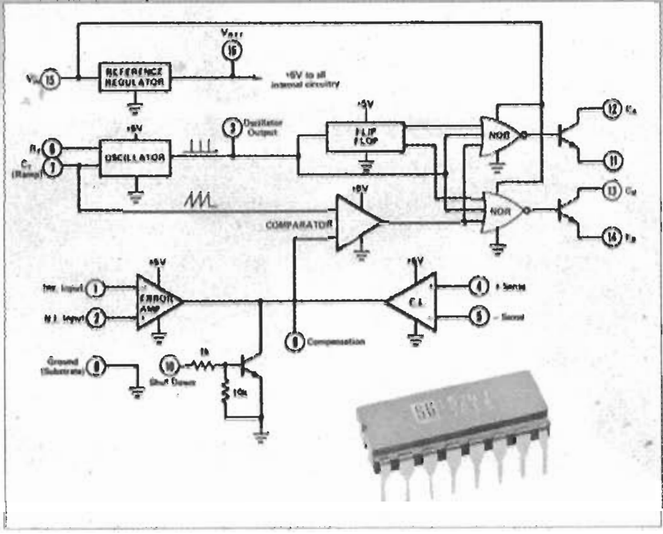
Current-mode control was first implemented in the UC1846, a 16-pin device which proved to be readily accepted by power supply designers. However, recognizing that an 8-pin version could be both more desirable and cost-effective, we immediately followed with the UC1842 family as the first 8-pin devices. It wasn't long before the UC1842 surpassed the SG1524 in volume sales.

In the early 2000s, supply voltages dipped to 2.2 V or lower, with demands for higher current on the upswing. Now the pendulum is swinging back towards greater use of voltage-mode control as it becomes more difficult to efficiently sense current at low voltages.

Throughout the '80s, other power management technologies and topologies were developed. Some more successful than others. At one point, we had high hopes for resonant-mode control that produced a sine wave instead of a square pulse of current. We thought this would minimize switching losses. However, we found what we saved on pulse transitions we lost due to higher peak values. The '80s and '90s were a time of exploring new ideas and concepts. We continually developed new technologies, hoping to make life easier for our customers, so they could make better products for their customers. In the '90s, many of these developments were more evolutionary versus major breakthroughs, such as quasi-resonant and phase-shift control, and power factor correction.

Processing the Future

In addition to new circuit designs being invented by the industry during the '80s and '90s, we were fortunate to have a major breakthrough with the development of BiCMOS process technology. The effects of BiCMOS on power management have been far-reaching.



Block diagram of the SG1524.

Before the mid-90s, power management was fabricated using bipolar processes. Introducing the BiCMOS process made it easier to combine power devices on the same piece of silicon along with control circuitry. Added benefits include higher switching speeds, fewer parasitics, lower quiescent current—and the ability to take advantage of the reduced geometry of digital processes, a trend that continues today.

Smaller geometries are important to the future of the power management industry because it is one of the key factors that keep driving down the cost of many devices. This is especially true for consumer electronics, today's fastest growing market segment. Unlike the computer and telecom industries that were simply cost-conscious, the consumer electronics industry places extreme pressure on cost where the lowest price carries the day. After Texas Instruments (TI) acquired Unitrode, I realized that TI's efficient fabrication technique would play a huge role in keeping our costs down and product quality up.

When I think about where I started in the power management industry, it's truly amazing what I see being invented today. Blurring the lines between analog and digital process technologies is just one example. You can see how this is leading to the integration of power management technology into systems-on-a-chip (SOC) devices. This is already happening in the wireless industry, and there's no reason why it won't apply to other industries as well. In my estimation, we're not done yet with breakthroughs in power management. ■