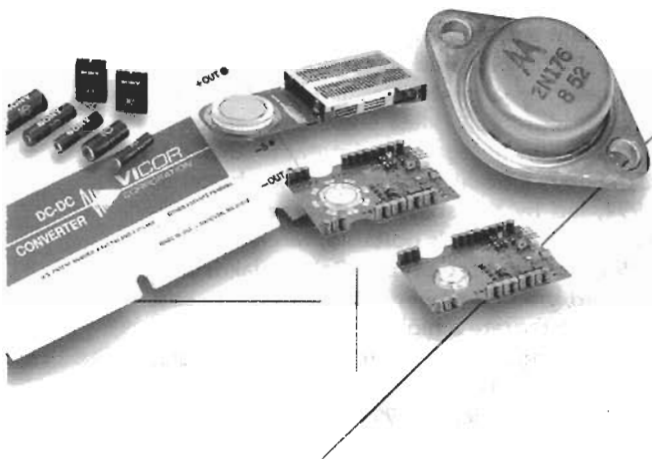


# MILESTONES THAT MATTERED

By Jeremiah Bryant



**P**ower electronics improvements, have enabled nearly every electronics innovation of the last 50 years. Of the thousands of steps forward, we selected 17 events that stand out as key power Milestones that Mattered. To count as a milestone, the event needed to be a revolutionary step forward that triggered an industry-wide new product category, not just simply an extension of an existing technology. Additionally, only products that have matured at least ten years were considered, so that an invention's long run impact could be evaluated. Of the 17 milestones identified, no attempt was made to rank them other than by product introduction date.

In 1954, Motorola's Dan Noble brought the first **germanium power transistor to market**. It marked one of power electronics' first steps into solid state. The germanium power transistor was the power transistor in Motorola's first transistor radio.

The **silicon-controlled rectifier (SCR)** was the original building block in power electronics with uses ranging from dimmable ballasts to motor controls. Although Bell Labs and General Electric referred to this product as an SCR, it is now more commonly known as a thyristor. The original SCR/thyristor was developed by Gordon Hall at Bell Labs in 1956. Detailed information about the early days of transistors can be found at the Transistor Museum run by long-time industry member Jack Ward.

GE's **SCR Manual**, the seminal 1960s era power electronics design text, was the original "how-to-book" of design notes in the industry. The first several editions of the SCR manual were written by Bill Gutzwiller. Additionally, Mr. Gutzwiller was instrumental in the development of the **Triode for Alternating Current (TRIAC)**. A TRIAC is an electronic component approximately equivalent to two SCRs/thyristors joined in inverse parallel and with their gates connected together. This results in a bidirectional electronic switch that can conduct current in either direction when it is triggered. The TRIAC was invented at GE in 1963 by Finis Gentry, a colleague of Mr. Gutzwiller.

Fairchild Semiconductor dates back to the early days of Silicon Valley. Dr. Jean Hoerni was one of the "Traitorous Eight" that left Shockley Semiconductor to form Fairchild in 1957. While at Fairchild, Dr. Hoerni developed the **planar process**, which is the manufacturing process used to build individual components of a transistor (collector, base and emitter) all on one plane.

Three California Institute of Technology (CalTech) professors contributed milestones that mattered, with the earliest stemming from the work of Dr. Carver Mead. Although better known for his work with very-large-scale integration (VLSI), Dr. Mead also discovered the Schottky barrier gate, which is the basis of the **Schottky diode**. Today, the Schottky diode remains one of the basic building blocks for lower-power ac-dc power supplies and dc-dc converters. Dr. David Middlebrook has been instrumental in switch-mode power supply design through his development of **PWM Loop Stability Theory/Analysis**, which is the mathematical principle that underlies switching regulation by developing a framework for directly expressing the important features of a feedback system in terms of recognizable physical paths in the circuit model. Dr. Slobodan Cuk was instrumental in the development of **Integrated Magnetics**. The Integrated Magnetic Cuk Converter features zero current ripple at both input and output and is well suited for use as a dc transformer, which is fed back in such a

way as to maintain a constant turn ratio, both at dc and at ac frequencies.

Bob Mammano, widely regarded as "the father of the PWM controller IC," brought switching regulators and switch-mode power supplies to commercial life with the introduction of the SG1524 in 1975. This watershed moment in the power electronics industry occurred at Silicon General, which was later acquired by Texas Instruments.

Current-mode control has been a staple of power supply design for the last 30 years. Although several individuals worked on current-mode control, Cecil W. Deisch of Bell Laboratories is generally regarded as the primary developer. His paper, "Simple switching control method changes power converter into a current source," presented at the 1978 Power Electronics Specialists Conference, is one of the most cited papers related to early current-mode control.

The power Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) has been one of the most commercially successful power semiconductors of all time. Although the DMOS power MOSFET was originally developed by Dr. John Moll at Hewlett-Packard Labs in 1976, the more significant milestone was commercializing the MOSFET. This was accomplished by Dr. Alex Lidow at International Rectifier in 1979.

The Insulated Gate Bipolar Transistor (IGBT) combines the simple gate drive characteristics of the MOSFET with the high current and low saturation voltage capability of bipolar transistors in a single device. Dr. Nathan Zommer and Dr. Jayant Baliga developed the IGBT at General Electric Corporate Research and Development Center in 1982. Dr. Zommer went on to commercially develop the IGBT at IXYS, while Dr. Baliga has become a preeminent power electronics academician.

Vicor's high-density dc-dc converter brick, developed by Dr. Patrizio Vinciarelli in 1984, has become the basic isolated dc-dc converter module building block. Today's standardization, found in both the isolated and non-isolated dc-dc converter markets started with the intro-

duction and adoption of Vicor's dc-dc converter brick.

When the Institute for Electrical and Electronics Engineers (IEEE) formed the Power Electronics Society (PELS) in 1988, it recognized for the first time the power electronics industry as an important and separate entity.

The 1990s delivered three significant power milestones: rechargeable lithium-ion batteries; the first integrated off-line power conversion IC and the integrated gate commutated thyristor (IGCT). Sony's introduction of lithium-ion batteries in 1991, led by Keizaburo Tozawa, was the primary enabler of today's portable, wireless world. In 1994, Power Integrations' Balu Balakrishnan developed the first power conversion IC to cost effectively integrate a high-voltage power switch and low-voltage control circuitry on a single, monolithic chip. The IGCT, developed by ABB's design team in Zurich in 1997, can be turned on and off by a gate signal. It also has low conduction losses and can withstand higher rates of  $dv/dt$ .

While over the last 50 years there have been countless power innovations, these 17 milestones were delivered by industry giants, whose shoulders we will stand on as we make the milestones of the future. ■

## LAST YEAR... 2006 TOP TEN\* NEW POWER PRODUCTS

1. National Semiconductor Introduces Synchronous, Monolithic, 1.5A Buck Regulator
2. External Battery Pack Runs iPod for 20 Hours
3. LEM Introduces Compact Split-Core Transducers for High AC and DC Currents
4. Valence Delivers on New Lithium-ion Battery Line
5. Entry-Level Handsets Targeted by austriamicrosystems
6. Delta Intros S36SE Board Mounted DC/DC Power Converters
7. Emerson Releases AC-Powered DC UPS
8. TDI Offers New Power Solutions for WiMAX Technology
9. IR's iMOTION™ Platform Enables Cool Running Air Conditioners
10. MTL-Relcom Launches the F800 Family of Fieldbus Power Systems

\*Items shown reflect most frequently accessed New Power Product "announcements" (press release, article, etc.) as posted on PowerPulse.Net during 2006.

Access postings at [www.PowerPulse.Net/TopTen2006.php](http://www.PowerPulse.Net/TopTen2006.php)