RUDY SEVERNS

Lifetime Achievement Award Winner

By David Morrison, Editor in Chief

An innovator in power-supply design who anticipated the trend toward higher frequency switching, an illuminator of power-supply topologies, and one who introduced many engineers to the promise and perils of power MOSFETs, Rudy Severns has made diverse contributions to the power electronics field in a career spanning five decades as an engineer, author, instructor and consultant.

On the 50th anniversary of his first jump from a biplane, Rudy Severns went skydiving yet again, pushing his lifetime total to somewhere in the vicinity of 500 jumps. Throughout his career, he took breaks for months-long sailing voyages, which usually necessitated a job change on his return. When it was time to fulfill his military obligation, a young Severns parlayed his experience as a radio operator into a stint with the Army's Special Forces, where he learned the skills of unconventional warfare.

Given his bent for adventure, is it any wonder that Severns' career as an engineer, author, instructor and consultant was marked by a similar sense of adventure? When the early generations of power MOSFETs were helping to propel switch-mode power-supply (SMPS) design into the commercial mainstream, Severns realized that engineers were limiting their power-supply designs to a very narrow set of topologies. In writing the landmark text *Modern DC to DC Switchmode Power Converter Circuits*, which he co-authored with Ed Bloom, Severns set out to introduce engineers to the hundreds of power-supply topologies that were available.

A similarly adventurous spirit may have been at work in the late 1970s when Severns made the then-radical proposal to a PowerCon audience that power-supply designers consider moving to higher switching frequencies for certain applications. His PowerCon 5 paper anticipated what would become an industry trend toward high-frequency switching only a few years later. But that trend was anything but obvious at the time, and the show organizer even suggested for his next paper that he go with something less "blue sky."

Severns was also sailing into uncharted waters when, as a semiconductor applications engineer in the late '70s and early '80s, he began working with power MOSFETs.

Severns not only needed to figure out how to use these new components, he had to teach power-supply designers how to use them. That gave Severns his first foray into teaching power electronics, an activity with which he would become more involved in time.

Working with those early power MOSFETs, Severns was also among those who were discovering their peculiarities and their failure modes. He wrote several papers documenting these problems, worked with customers to address these issues in their designs and then worked with his company's device designers to eliminate some of the early MOSFET weaknesses.

Prior to becoming an applications engineer, Severns worked in industry for many years designing high-voltage, high-power supplies for space, military and science applications. In these assignments, the unforgiving nature of high-voltage design undoubtedly added an element of danger and adventure to his work, while also giving Severns a grounding in SMPS technology and opportunities to innovate.

But before that career started, there would be several adventures that would help shape his later life in ways big and small. As a youngster, Severns would get a taste for electronics and experimentation, beginning his lifelong involvement with amateur radio. He would receive a surprisingly good grounding in math and science at his small country high school.

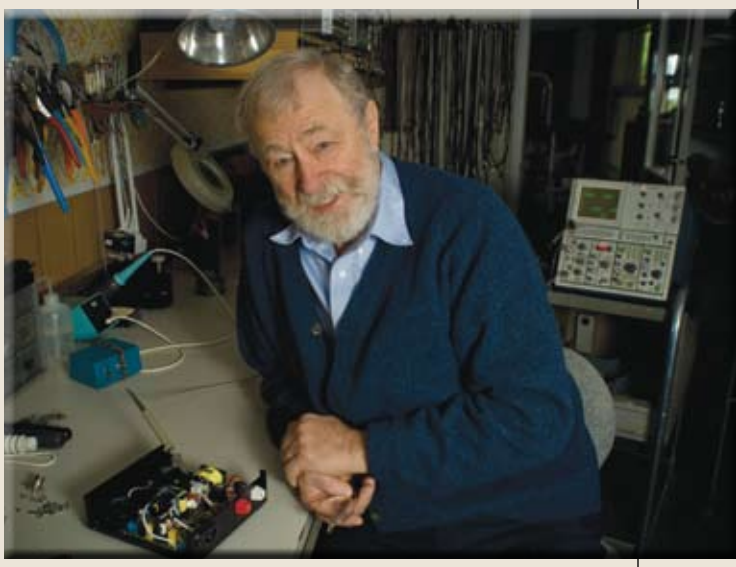
Then after graduation, he would get a chance to mature in the military while undergoing some rather exotic training in an Army Special Forces unit. And finally, he would enroll in a college engineering program, where he would tailor his curriculum to suit his interests, while gaining valuable work experience as a technician in particle accelerator labs.

Abundant Opportunities

Severns' work during his college years with high voltage, high power and RF provided him with good experience for the engineering jobs he would take after graduating from UCLA in 1966. Severns recalls that the job situation at the time for graduating engineers was "wonderful," as a result of the booming aerospace and military industries and the heavy funding of big science.

Upon graduation, he picked up where he left off in his engineering work by taking a position at the Los Alamos Scientific laboratory, where once again he designed high-power RF amplifiers, pulse modulators and high-voltage, high-power power supplies for the lab's linear particle accelerator. That job also gave Severns the opportunity to publish what would be the first of many papers on power and RF topics.

In that first paper, Severns described techniques for transmitting a pulse across a high-voltage interface to RF



pulse modulators that were floating at 50 kV to 100 kV. One of the innovative techniques used light signals transmitted over light pipes using some of the early Hewlett-Packard optoelectronic components.

Severns continued designing pulse modulators and power supplies when he moved to Continental Electronics Corp. in 1968. Another two years later he moved on again to take a job as design engineer at Analog Technology Corp., where he designed power converters for spacecraft physics experiments. Then in 1971, he took a job at Hughes Aircraft Corp. This was followed by stints at Magnavox Research Laboratory from 1974 to 1978 and a short stint in 1978 at TRW, space systems division.

Then as now, job hopping was fairly common among engineers. "In the early '70s, in Southern California, jumping from one company to the next was de rigeur," says Severns, and he did so for various reasons. "But in general, my motivation was to find something interesting to do. I looked at the work that was available and what I was doing today. If I was finishing up a project, and it was getting boring and routine, I'd go off and find a new job."

Fortunately for Severns, there were many interesting jobs in the late '60s and early '70s. At Analog Technology, he worked on deep-space instrumentation for projects such as the Mariner mission to Mars. Then at Hughes, he did design work (using traveling wave tube amplifiers) on some of the early communications satellites. Both jobs were "really fascinating work" that involved developing new circuits.

At Magnavox, he was among those doing the early development work on global positioning systems (GPS). For Severns, the GPS project was his first opportunity to design low-voltage dc power supplies, which would power the GPS receivers.

Chances to Innovate

Nearly all of these power supplies for the spacecraft and GPS systems were SMPSs designed solely with discrete devices including bipolar junction transistors (BJTs or bipolars) for the switches. And all of the magnetic components were designed from scratch. These projects required innovation, which would require Severns to develop new circuit topologies and design techniques.

For example, at ATC, Severns introduced a resonant power-supply design for space at a time when most space applications were using flyback converters. In this case, the resonant approach was motivated by the challenge of delivering high voltage at low power (milliwatts), but with very high efficiency. This work became the subject of his second paper.

In this application, Severns says, "You had to supply 20 mW at 400 V from a 28-V spacecraft bus and you had to do it as efficiently as possible. That's extremely difficult to do with hard switching. So I went with the resonant approach, which required some innovation."

At Hughes, his work with traveling wave tube amplifiers required him to invent circuits that could achieve high efficiency and very light weight. "That's really where I started to invent new circuits and new topologies," says Severns.

The demand for very light weight together with small size would also be a motivating requirement at Magnavox. "That's where I started doing very-high-frequency work," says Severns.

In the late '70s, the standard for switchers was 20 kHz to 25 kHz. At Magnavox, Severns pushed the switching frequency beyond 100 kHz, even developing a tiny (for the time) SMPS running at 600 kHz. That work was the basis for two groundbreaking papers that he presented at PowerCon and the Power Electronics Specialists Conference (PESC) in 1978 and eventually led to Severns' appointment as an IEEE fellow.

The PowerCon paper, "Design of High-Efficiency Off-line Converters Above 100 kHz" was one of the earliest to discuss the possibility of higher-frequency operation.

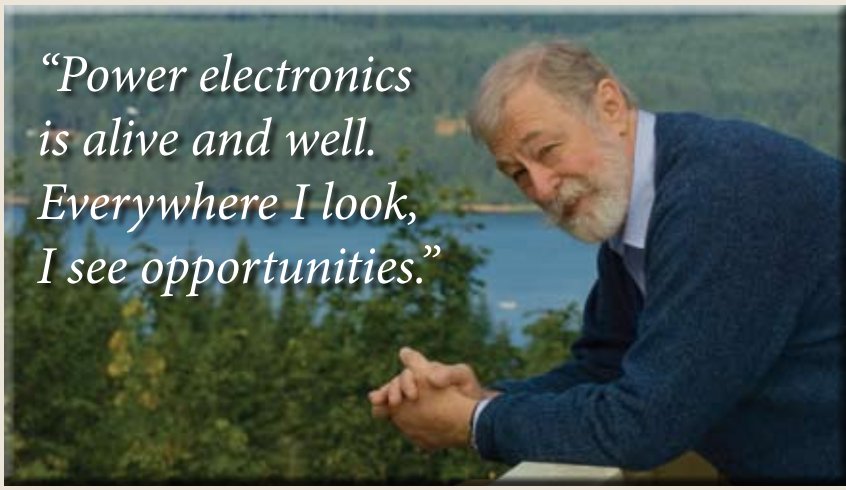
"It was the first real proposal in a large power-supply forum that said, 'Think about much higher switching frequencies.'" The paper was very popular, even receiving a best paper award, but it was also controversial. Severns recalls that Ron Birdsall, the organizer of the event, suggested that Severns write about something less "blue sky" and more practical for his next conference paper. But within two or three years, high-frequency switching wasn't blue sky anymore.

In addressing the PowerCon audience, Severns took care to explain that high-frequency switching was an option, rather than a necessity in all cases. But this message was not heard.

Severns recalls, "When I presented the paper, I was extremely careful to say, I am not telling you that you should operate at these frequencies. I am telling you that in certain situations you can and you may wish to operate at these frequencies. Of course, within months everyone was saying that I was advocating that we all shift to this frequency."

Severns notes that in later years, he went so far as to tell designers to decrease switching frequencies when higher-frequency switching wasn't warranted.

At the time Severns presented his paper, the use of SMPS technology was well established within the military and aerospace industries. However, it had not yet been accepted within the commercial industry. It's frequently said that the arrival of the power MOSFET enabled the adoption of switch-mode technology by commercial power-supply merchants in the late '70s and early '80s.



According to Severns, the power MOSFET also enabled the migration to the higher switching frequencies he was describing in his papers. "Almost immediately after I gave my paper, the power MOSFET came on the scene and designers didn't have to go through the effort I did to make BJTs work at 150 or 200 kHz."

Nevertheless, the transition to higher frequencies did not happen overnight. It would take 10 years before the MOSFETs would become cheap enough that designers would use them en masse and be able to routinely design power supplies to operate at higher frequencies, according to Severns.

Adventures in Semiconductors

When Severns gave his PowerCon paper in San Francisco, the sales manager from Intersil was in the audience. "With some later arm twisting, he dragged me up to go to work for Intersil, because they were simultaneously [along with Siliconix, Hewlett-Packard and International Rectifier] coming out with power MOSFETs.

"Intersil lured me away, but I was easy to lure because it was really different. Developing hardware is one world. The semiconductor industry is another world," says Severns.

At the time he started working at Intersil as a field applications engineer (FAE), the only design he had com-

pleted using a power MOSFET was the 600-kHz switcher described in his PESC paper. "Now I understood the principles, but from principles to writing application notes and giving lectures, it's a long jump."

However, Severns learned quickly about how MOSFETs work, and how their particular characteristics and flaws could lead to failures in the applications. He then had to instruct customers in how to use the new transistors and how to avoid pitfalls.

"For instance, somebody would put two MOSFETs in parallel and they would start oscillating. That's because these things have gain up in the ultrahigh-frequency region. So my job was to figure out how to prevent that. And there were other strange operating modes having to do with dv/dt," says Severns.

"The early MOSFETs, for example, they would switch very fast. But when you started doing that with more than one of them in the circuit, a device would be in the off state and have this tremendous dv/dt applied across it. So, the one that was supposed to be off would be turned on due to intrinsic parasitics," explains Severns.

Severns notes that his counterparts at the other power MOSFET companies were also addressing these problems, though he was among the first to write about dv/dt and other issues such as parasitic oscillation in parallel devices, radiation effects and avalanche-induced turn off. Most of these issues were addressed through semiconductor processing.

"My job was to identify the problem, explain to the world what the problem was and how to avoid it until we fix it right," says Severns. "And at the same time, I had to tell the device designers in the process department, 'Change your design so we don't have to tell the world that we have this problem.'"

In 1980, his work as an FAE also gave him his start as a teacher, which included giving presentations to engineers about MOSFETS. "The MOSFET's a new product. We have to sell the engineering community on how to use this product. That's when I started giving lots and lots of seminar talks."

Though he did this initially for Intersil, he would later present similar seminars for International Rectifier and Siliconix. In time he would expand into teaching power-supply design seminars for Ed Bloom, and for others such as the University of Wisconsin at Madison and Oregon State University.

In Boredom, Inspiration

"In 1980, while working for Intersil, I wrote the first tract on how to invent new topologies. I wrote what's called the kama sutra of power-supply topologies. It's a 40- or 50-page application note full of dozens and dozens of circuits. And a lot of them are new or showing likeness between old ones. The whole idea was here's how you invent power-supply topologies."

"I had given a couple papers before touching on the subject. Topology invention for me really started when I worked at Hughes and I never let that thread go. So for Intersil, I wrote this humongous application note for SMPS people saying here are all the ways you can use it. Of course, all of the models in there use MOSFETs for switches, naturally. Ed Bloom looked at that application note and said, 'Couldn't we write a book on that?'"

After that suggestion, some time passed and Severns embarked on his sailing trip to Mexico and Hawaii. Severns notes that normally he could forget about engineering for several months at a time, but that was more difficult to do on such a long voyage.

"So, I'm on my cruise, and it's about seven or eight months into the cruise. I'm in Kāne'ohe Bay, Hawaii. I'm sitting in paradise absolutely bored to death. So I say, 'Ed, I am going to write a book.' And I sat down with a pencil and a pad of yellow-lined paper on the boat and wrote in longhand everyday for a few hours."

"And then I just kept mailing these packages to Ed Bloom, one chapter at a time. His wife, Joy, is transcribing on an early Apple computer. She is taking all of this chicken scratch on yellow-lined paper and writing this all up. Then Ed goes through and checks everything." Out of this work emerged *Modern DC to DC Switchmode Power Converter Circuits*.

"The book would not have happened without Ed Bloom's efforts. He prodded me to write it. He did a tremendous amount of work, about 80% of the work. And Ed added a chapter 12 on converters with integrated magnetics."

Severns says he was amazed at the reception the book received. "We have sold several thousand copies, and it has been translated illegally into several languages. It's not the world's greatest technical book at all, it's just sort of a show and tell," says Severns. "But the main comment I got back was how easy it was to read and create new ideas from. That was part of the reason for its success. The other part was that there was nothing like it other than the application note I had written at Intersil."

"Engineers working in the field were choosing power-supply topologies from a very, very narrow set at the time, and we just wanted to jog them a little bit. Now, given the experience over the past 25 years since the book was written, having hundreds of circuits has only had a small impact on the field," comments Severns. "People are still using the same relatively small set of topologies for large commercial activities (i.e., high-volume, low-cost products). The book really had its impact in more specialized military, space and medical applications."

At the time he wrote the book on topologies, Severns was well into his career as an independent consultant. In that role, he continued to give seminars, write papers and participate in industry conferences.

New Engineering Challenges

A few years ago, Severns took down his consulting shingle and retired. But for Severns, retirement has given

him an opportunity to pursue his interests in amateur radio more intensively. His involvement with power electronics and amateur radio, he believes, are closely linked.

"Certainly for me, they're one item, a single thread, really. All of my early work stems from being a teenager trying to build a transmitter. That's all analog, and with transmitters you're immediately into high voltage and high power. Today, the theme continues as I'm doing a lot of experimental electromagnetics work in antennas."

Severns has been busy publishing his results in various amateur radio magazines and also on his Web site. But ultimately, he'd like to make a contribution to the amateur radio field by writing a book in which he explains details surrounding the operation of vertical antennas, grounds and ground antennas. Within these topics there are issues that have either been "misexplained, ignored or are matters of contention," says Severns.

To support these endeavors, Severns has gone back to school. For the last four years, he has been taking courses in mathematics and electromagnetics at the University of Oregon to bring himself up to speed on the field.

And despite his attempts to retire from power electronics, just this year he completed a book on snubber design at the urging of Jerrold Foutz, a longtime industry veteran. The book, *Snubber Circuits for Power Electronics*, explores an area of power-supply design that is absolutely critical in high-power applications.

And while he views himself as being out of the power electronics business these days, Severns may yet take some of the knowledge he has "salted away" and write additional books on power design topics. If he does, it will be another opportunity for Severns to influence future generations of engineers working in the power electronics field.

With demands for energy efficiency driving technology development and applications like smart power grids emerging, Severns believes "power electronics is alive and well."

"There's a whole field available to young engineers," says Severns. "Everywhere I look, I see opportunities." **PETech**

Editor's Note

For additional information about Rudy Severns' life and career, please check out the online version of this article at www.powerelectronics.com.

You'll learn about Severns' early experiences in "Small School, Quality Education," "First Steps in Electronics" and "A Quick Start in Engineering." Another influence on Severns' career path was his love of sailing. To read about how his ocean-going adventures took his career in new directions, see "Setting Sail."

A complete list of works by Severns, including those referenced in this article, are also available online.