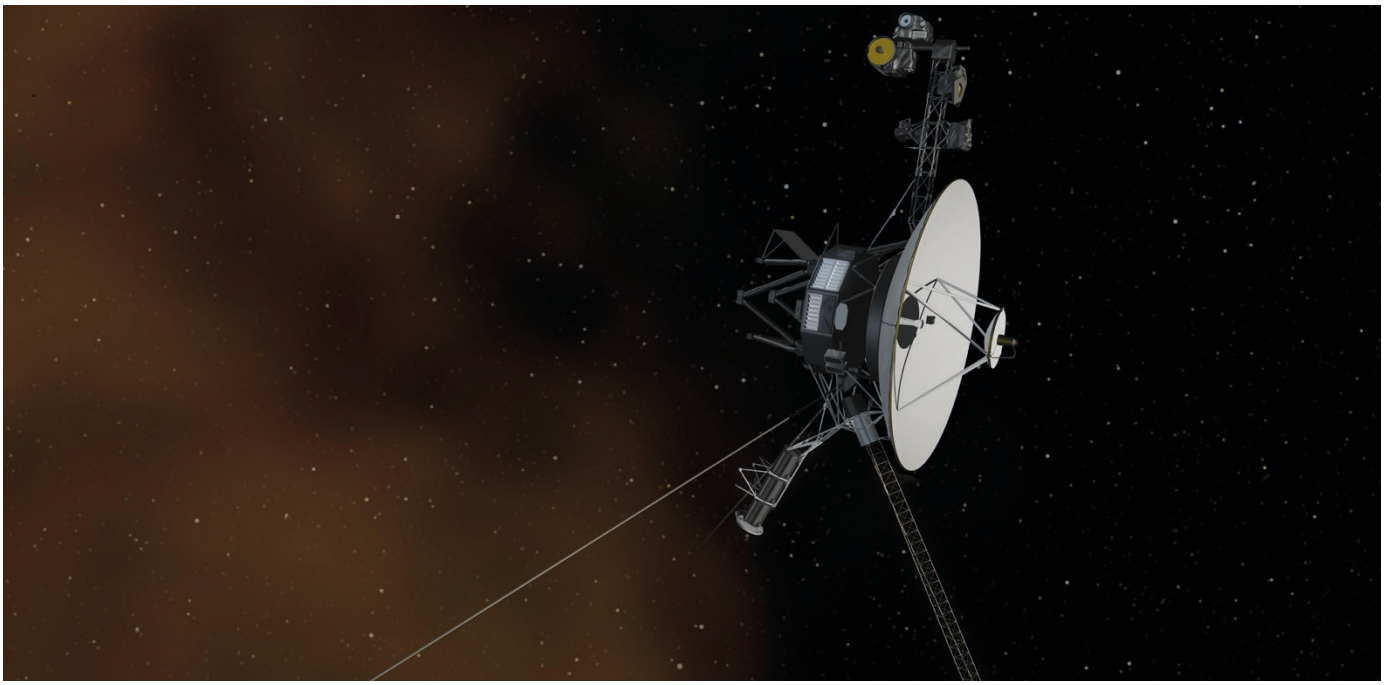


1980 - a pivotal point in the power industry!

October 29, 2020, after seven months of silence due to a major upgrade of the 70 meter wide radio antenna located in Camberra, NASA sent a set of commands to the 43 year-old spacecraft, Voyager 2 that has travelled billions of miles from earth since its launch in 1977. Voyager 2 acknowledged it had received the call and executed the commands without any issue. Interesting for sure - but what is the significance of this to power engineers?

Although often considered as the last cog in the wheel by system designers, in truth the power supply is probably one of the most important parts of their equipment. From the thyratron tubes used in the type REC-30 power rectifier to supply HV power to teletype teleprinters in 1930 [1], through to the latest Wide Band Gap semiconductors, without their curiosity and passion, power designers would not have made a lot of things possible. Voyager 2 is a good example of that, but who remembers what happened in the late seventies and early eighties within the power industry and how leading power engineers changed the face of our industry?

Back in time to the battlefield!
Launched on August 20, 1977, Voyager 2 was powered by a Radioisotope Thermoelectric Generator (RTG) that turns heat from the decay of a radioactive material into electricity. The generated voltage is regulated and distributed to the 14 scientific equipments and to the master control board. The overall power system has been designed to accommodate the RTG and despite the schematic being kept secret, a brand new technology was mentioned called ‘switching power supply’!

Known since 1930, switching power supply principles have been explored by power designers for decades with the aerospace industry with NASA being the driving force in research and development. Considering the astronomical cost of a launch, and also the lifetime of space probes and satellites, space power designers sought for lower weight, higher energy efficiency and

compactness. In the sixties NASA had already used switching power systems in a number of satellites e.g. Telstar in 1962.
In parallel with secret research conducted by aerospace and military organizations to miniaturize embedded power systems, power designers in the civil industry also considered alternative solutions to the old, heavy, bulky conventional architecture of transformer, rectifier, and linear regulation. Who launched the first commercial switching power supply is up for debate, but we can mention RO Associates who in 1967 introduced a 20Khz power solution, followed by a wave of products e.g. 1970 NEMIC Japan, 1973 HP 500W.

For leading power designers it was obvious that switching power technology was the future. But at that time linear power supplies were the reference and 'switching' was considered to be a suspicious technology and some were predicting that the interference field generated by switching could cause major damage to the final application.

We should remember that in the seventies linear power supplies were the norm, and despite Lambda introducing a line of 'standardized' linear power supplies, the launch of Power-One's 'H' series is considered by many as the first 'off the shelf' power solution, first in USA and then in Europe. Based on a genius level concept of a folded aluminum plate used as case and power dissipater, Power-One launched an amazing number of variants offering systems designers a ready to use power supply (Figure 01).

Simultaneously in Japan - with very little information coming out from that country – power supplies manufacturers not only launched a complete range of linear power supplies but only few years after, a range of switching power solution. One example is the company ELCO/COSEL, which launched the linear "G" series in 1975, followed in 1977 by a complete range of switching power supplies, the "H" series (Figure 02)! In truth, Japan was really ahead of the curve. Another example being SONY who in 1960 at the time when the TV industry used electronics tubes (valves), were the first to use transistors

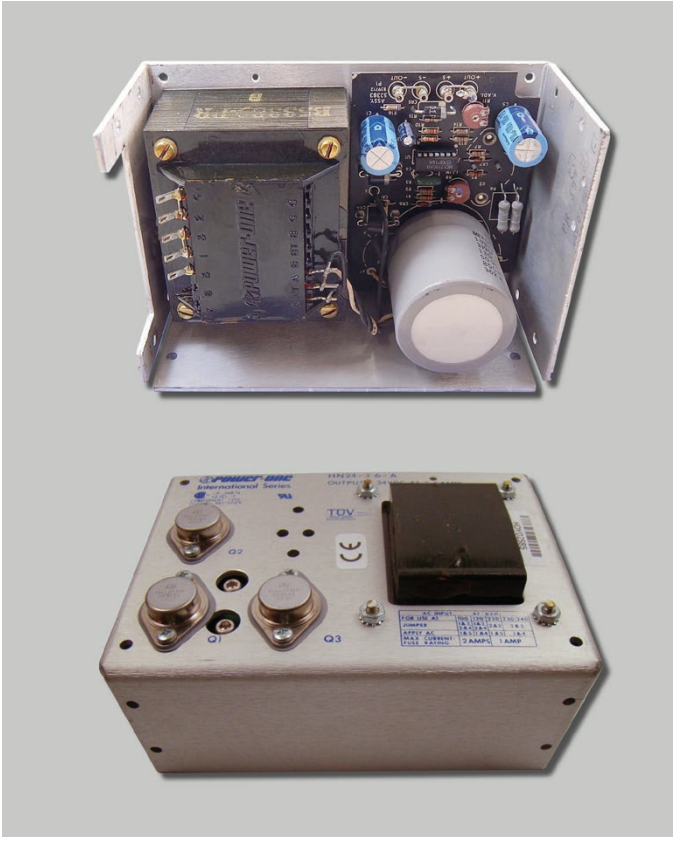


Figure 01 – Power One Linear power supplies "H" series

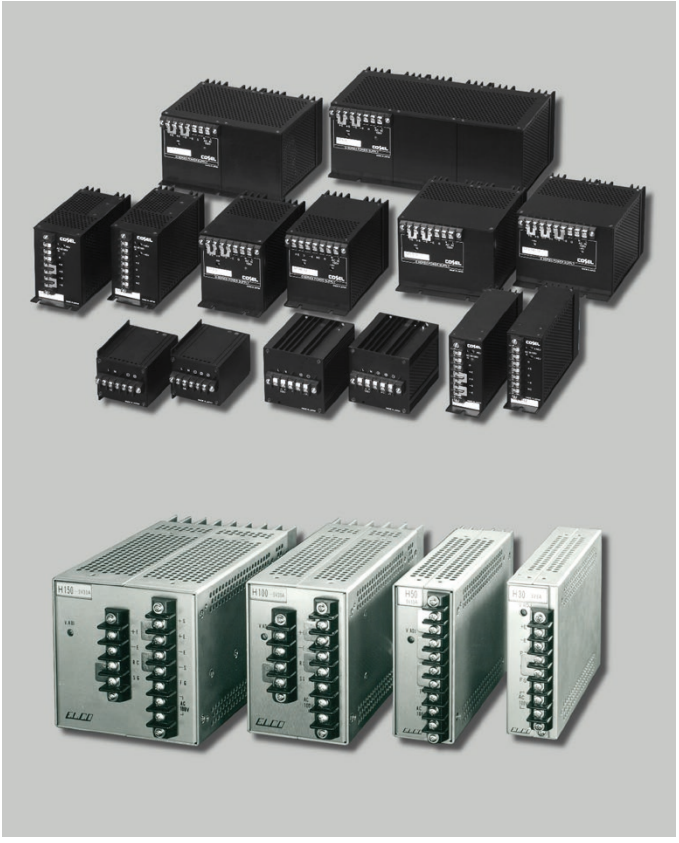


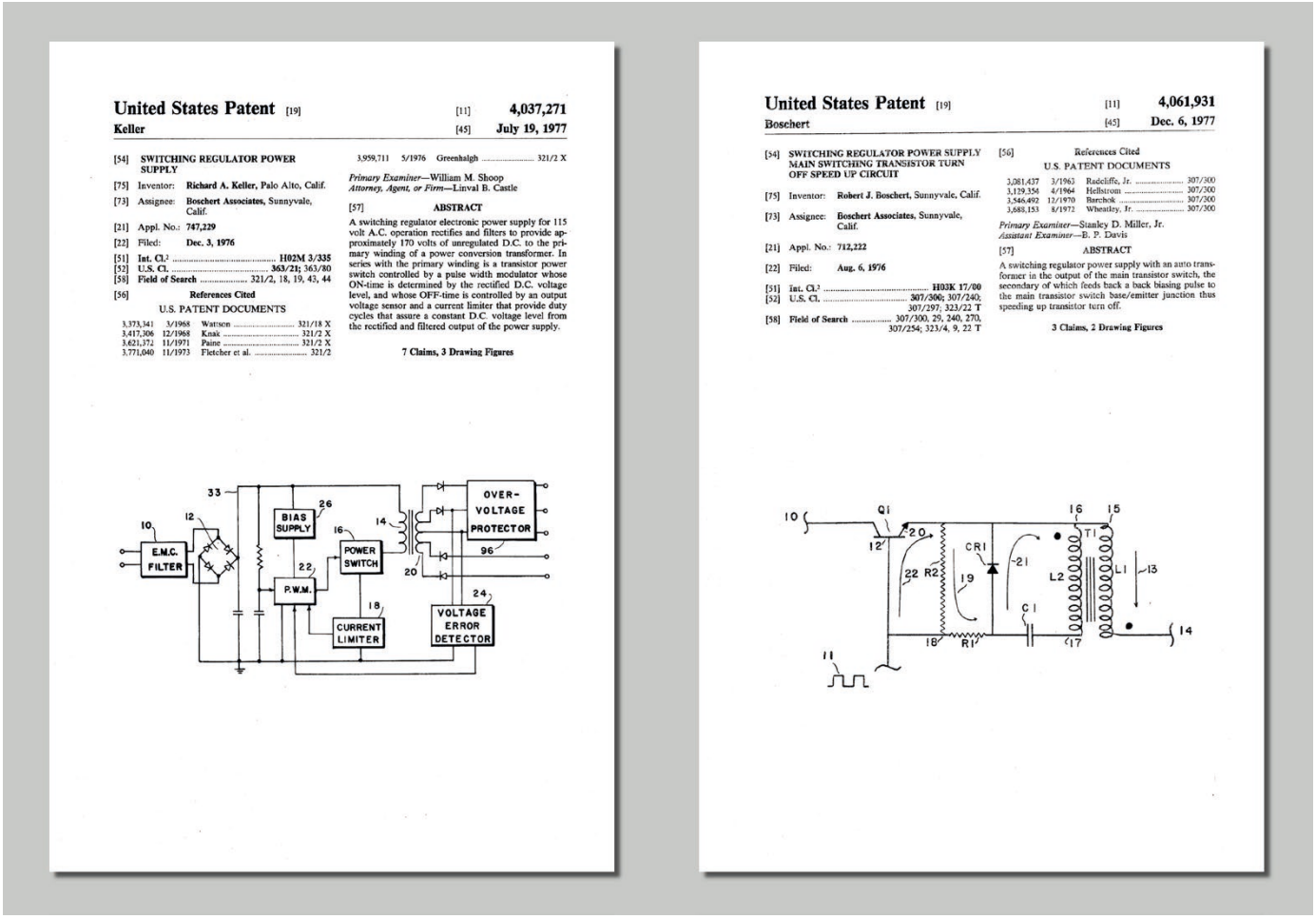
Figure 02 – ELCO/COSEL 1975 Linear "G" series (Top) and 1977 Switching "H" series (Bottom)

in their TVs and were probably the first to implement a switching power supply in TV equipment in the early seventies.

We should also remember that in the late seventies and early eighties, the vast majority of companies developing electronics equipment had their own in-house power departments designing dedicated power solutions for their applications. Not surprisingly, for many in-house power designers the launch of the Power-One 'H' series was perceived as a threat. Many equipment manufacturers adopted standardized 'off the shelf' power supplies, refocusing their internal power department's R&D to the emerging switching power technology in order to stay ahead of their competitors.

With passion, talent and curiosity!
The seventies was full of talented engineers researching enhanced switching power solutions and it would require a dedicated article to name them all. Among all of them, to me it is interesting to mention two 'power gurus', Robert J. Boschert (Boschert Associates) and Frederick Rod Holt (Apple), both working at the same time on more efficient power solutions. In both cases, as it was in the aerospace industry, they aimed to make the power supplies smaller, lighter and more efficient.

According to legend in his kitchen, in 1970, Robert Boschert started to develop a more cost effective, competitive and lighter power supply as an alternative to the bulky transformer and linear regulation model. He focused on developing a switching power supply for wheel and band printers that he produced in volume in 1974. In 1976 he launched one of the first 'off the shelf' switching power supplies and applied for patents 4,037,271 and 4,061,931 to protect its IPR (Figure 03).



United States Patent [19]
Keller
[11] 4,037,271
[45] July 19, 1977

[54] SWITCHING REGULATOR POWER SUPPLY
[75] Inventor: Richard A. Keller, Palo Alto, Calif.
[73] Assignee: Boschert Associates, Sunnyvale, Calif.
[21] Appl. No.: 747,229
[22] Filed: Dec. 3, 1976
[51] Int. Cl.² H02M 3/335
[52] U.S. Cl. 363/21; 363/80
[58] Field of Search 321/2, 18, 19, 43, 44

[56] References Cited
U.S. PATENT DOCUMENTS

3,373,341	3/1968	Watson	321/18 X
3,417,306	12/1968	Knak	321/2 X
3,621,372	11/1971	Paine	321/2 X
3,771,040	11/1973	Fletcher et al.	321/2
3,959,711	5/1976	Greenhalgh	321/2 X

Primary Examiner—William M. Shoop
Attorney, Agent, or Firm—Linval B. Castle

[57] ABSTRACT

A switching regulator electronic power supply for 115 volt A.C. operation rectifies and filters to provide approximately 170 volts of unregulated D.C. to the primary winding of a power conversion transformer. In series with the primary winding is a transistor power switch controlled by a pulse width modulator whose ON-time is determined by the rectified D.C. voltage level, and whose OFF-time is controlled by an output voltage sensor and a current limiter that provide duty cycles that assure a constant D.C. voltage level from the rectified and filtered output of the power supply.

7 Claims, 3 Drawing Figures

United States Patent [19]
Boschert
[11] 4,061,931
[45] Dec. 6, 1977

[54] SWITCHING REGULATOR POWER SUPPLY MAIN SWITCHING TRANSISTOR TURN OFF SPEED UP CIRCUIT
[75] Inventor: Robert J. Boschert, Sunnyvale, Calif.
[73] Assignee: Boschert Associates, Sunnyvale, Calif.
[21] Appl. No.: 712,222
[22] Filed: Aug. 6, 1976
[51] Int. Cl.² H03K 17/00
[52] U.S. Cl. ..... 307/300; 307/240; 307/297; 323/22 T
[58] Field of Search ..... 307/300, 25, 240, 270, 307/254; 323/4, 9, 22 T

[56] References Cited
U.S. PATENT DOCUMENTS

3,081,437	3/1963	Radcliffe, Jr.	307/300
3,129,356	4/1964	Hellstrom	307/300
3,546,492	12/1970	Barchok	307/300
3,688,153	8/1972	Wheatley, Jr.	307/300

Primary Examiner—Stanley D. Miller, Jr.
Assistant Examiner—B. P. Davis

[57] ABSTRACT

A switching regulator power supply with an auto transformer in the output of the main transistor switch, the secondary of which feeds back a back biasing pulse to the main transistor switch base/emitter junction thus speeding up transistor turn off.

3 Claims, 2 Drawing Figures

Figure 03 – Boschert Associates switching regulators patents 4,037,271 and 4,061,931

The two patents were granted in less than a year, followed by the commercial success of the OL25 switcher that received high profile coverage in the press and media e.g. “Flyback converters: solid-state solution to low-cost switching power supplies” published 21 December, 1978 in Electronics. Robert Boschert was also a pioneer in selling licenses of its IPR and in 1977 Boschert Inc. had more than 600 employees and was certified to design switching power solutions for space and military aircrafts.

At the same time Steve Jobs, known for his curiosity in new technology, considered switching power technology as being of interest, but due to lack of time the Apple I launched in April 1976 featured a conventional linear power supply. Never mind, working on the Apple II Rob Holt designed a 38W multi-output off-line flyback switching power supply (Figure 04) for which he filled a patent in February 1978 and got it granted in December (4,130,862). Apple II was a success and with volume levels increasing, Apple outsourced the manufacturing of the power supply to ASTEC, beginning the long history of OEM power supplies for computers.

Figure 04 - Apple II 38W multi-output off-line flyback switching power supply designed by Rob Holt

Perhaps anecdotal but nonetheless illustrating the competitive landscape within the power industry which suffered a number of IPR disputes, in Walter Isaacson’s Steve Jobs biography it is written that Jobs said: “Instead of a conventional linear power supply, Holt built one like those used in oscilloscopes. It switched the power on and off not sixty times per second, but thousands of times; this allowed it to store the power for far less time, and thus throw off less heat. That switching power supply was as revolutionary as the Apple II logic board was.” Jobs later added: “Rod doesn’t get a lot of credit for this in the history books, but he should. Every computer now uses switching power supplies, and they all rip off Rod Holt’s design.”

For sure, as a good marketer Steve Jobs would like APPLE to enjoy the accolade of implementing switching power supplies in PCs, though many others e.g. IBM and HP followed the same path at the same time, all aiming for higher performance and reduced costs.

However, despite the huge benefits of that technology, its implementation and market adoption has been relatively slow and market analysts have estimated that only 8% of the power supplies manufactured in 1978 were based on switching topology.

Make my Teletype smaller, lighter and faster!
In the introduction I mentioned the thyratron power rectifier type REC-30 powering a 1930 Teletype teleprinter [1]. Few know that, in those days, Teletypes used to be state of the art telecommunication machines and long before the introduction of 1, 2, 3, 4 and 5G, a communication system that motivated power designers to invent and innovate.

Besides topologies, one major evolution in the switching power supply industry occurred in 1976 when Robert Mammano, cofounder of Silicon General Semiconductors introduced the first control IC dedicated to switching power supply. The launch of the SG1524 was a major step forward within the power supply community, and its first application was a new generation of Teletype machines marketed as being ‘smaller, lighter and faster’.

Originally developed to solve a Teletype manufacturing problem, the introduction of the SG1524 became the kick-off of modern switching power supplies, opening the way to inventions and innovations that we all benefit from today.

The race for switching power is open!
With the development of the personal computer and IT equipment, the demand for high efficiency and low weight increased the demand on power designers to improve performance further. Despite Steve Jobs' perception, computer leaders such as IBM had impressive power departments and the launch of the IBM 5150 Personal Computer set the tempo for the design of a dedicated power supply using the NE5560 and later the SG3524 chip. Unique to the PC industry, switching power supplies are specific to a motherboard and are not as such 'off the shelf' for common applications use, although the snowball effect on contracted manufacturers contributed to boost their own products' development, launching complete ranges of commercial products.

On the industrial side it is impossible to name all the products and innovations but since we mentioned the Power-One 'H' series, it is fitting to mention a young engineer who joined Power-One in the early eighties named Steve Goldman who led the team that designed the new generation of switching power supplies, the MAP series. Anecdotally, MAP stands for the name of Power-One's Chief Engineer/Designer at that time, Michael Archer (Michael Archer Product).

Simultaneously the computing and industrial industries moved towards switching power architectures and although it took years before that technology prevailed over the well-established linear solution, a number of power electronics conventions started all around the world, providing a forum for power engineers to learn and share knowledge about new technologies.

1980, the pivotal point in the power industry!
At the end of the seventies and the beginning of the eighties the power industry forged the foundations of where we are today. Despite the IEEE Power Electronics Specialist Conference (PESC) starting in 1970, power designers and industry leaders considered a different type of forum to share technology knowledge, new ideas and best practices. POWERCON took place in Beverly Hills, Calif., March 20 to 22, 1975, followed in 1978 by a conference primarily focused on telecommunications called INTELEC. Unfortunately, after nine years POWERCON ceased in 1984 leaving the power community as an orphan.

Back in days when the grandfather of the internet, ARPANET had just adopted the TCP/IP protocol (January 1983), power engineers were still miles away from chatting and blogging, and with the growing demand for tighter cooperation within the power industry the need for a 'one place to share' became obvious. In 1983 the China Power Supply Society (CPSS) was founded [2], and in 1985 the Power Sources Manufacturers Association was incorporated (PSMA) [3]. Both organizations aimed to share knowledge and to facilitate communication within their respective power communities, and 35 years later both are still supporting power engineers.

At the same time that PSMA was formed, a group of eight passionate engineers, Bill Hazen (Prime Computer) ; Don Drinkwater (DEC) ; Phil Hower (Unitrode) ; Jonathan Wood (Data General) ; Marty Schlecht (MIT) ; Jack Wright (GE) ; Trey Burns (Data General) and John Kassakian (MIT) had an idea to create a power conference which would embrace research, applied electronics, and serve to connect electronics engineers to a larger community including industry, and the provision of an exhibition. It was to be called the Applied Power Electronics Conference and Exposition (APEC) [4], and the first edition took place on 28 April to 1 May, 1986 in New Orleans.

And the story continues..
The power electronics industry has been through many periods of evolution, disruption and revolution. If the introduction of the Bipolar Junction Transistor was arguably the 'first' technological revolution, there is no doubt that the migration from linear power conversion to switching technology was the second, and the beginning of a long evolutionary path.

43 years after it was the launched, Voyager 2 has travelled 14 billion miles into deep space and the power supplies that pioneers designed in the early seventies are still doing their jobs. This is what makes all of us excited by what we do in the power industry and thanks go to all the genius power designers that I have been unable to name in this article that have contributed to make the transition from linear to switching technology possible.

Note:
This paper was first presented in December 2020 by Electronica AZI (Romanian and European editions)

References:
[1] Teletype Model 19 Thyratron Power Supply - https://youtu.be/WX74GoHuwHk
[2] China Power Supply Society (CPSS) - http://www.cpss.org.cn/en/
[3] Power Sources Manufacturers Association was incorporated (PSMA) - https://www.psma.com/
[4] Applied Power Electronics Conference and Exposition (APEC) - https://apec-conf.org/

POWERBOX (PRBX): https://www.prbx.com

About Powerbox
Founded in 1974, with headquarters in Sweden and operations in 15 countries across four continents, Powerbox serves customers all around the globe. The company focuses on four major markets - industrial, medical, transportation/railway and defense - for which it designs and markets premium quality power conversion systems for demanding applications. Powerbox's mission is to use its expertise to increase customers' competitiveness by meeting all of their power needs. Every aspect of the company's business is focused on that goal, from the design of advanced components that go into products, through to high levels of customer service. Powerbox is recognized for technical innovations that reduce energy consumption and its ability to manage full product lifecycles while minimizing environmental impact. Powerbox a Cosel Group Company.

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Chief Marketing and Communications Officer for Powerbox, Patrick Le Fèvre is an experienced, senior marketer and degree-qualified engineer with a 35-year track record of success in power electronics. He has pioneered the marketing of new technologies such as digital power and technical initiatives to reduce energy consumption. Le Fèvre has written and presented numerous white papers and articles at the world's leading international power electronics conferences. These have been published over 250 times in media throughout the world. He is also involved in several environmental forums, sharing his expertise and knowledge of clean energy.

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