WHITE PAPER

Next-Generation, Miniature High Voltage Power Modules

The first generation of high voltage power modules changed the way designers could use high voltage, and the next-generation is pushing the envelope further.

Synopsis

XP EMCO next-generation, miniature high voltage power modules provide designers and end-users ever-expanding choices for off-the-shelf, drop-in miniature solutions to meet their high voltage needs.

The next-generation of high voltage power modules features more watts per cubic inch, reduced power consumption with the addition of smart features for control and safety. As the number of applications requiring high voltage grows, reliable operation with size and weight limits present tough challenges. This white paper describes XP EMCO's solution to these challenges.

Table of Contents

The Low Voltage Revolution

The wide availability of miniature low voltage power modules inspired a sea change in the architecture of power distribution. Small, lightweight modules could be mounted right at the devices they were energizing. No longer was it necessary to build a main power supply outputting the different voltages and power levels required by the wide variety of subsystems and circuits. This required long runs of power wire sized for the total needs of the system, one set for each voltage. The modularized approach enabled using a single isolated DC bus with a standard supply feeding each circuit.

High Voltage Faces the Same Challenge

High voltage quickly moved to modular localized solutions also, but high voltage has to be treated very differently. A high voltage power supply designer faces the same problems as low voltage designers, plus the additional constraints of physics, chemistry, and topology. In the past, this task was left to specialists who usually had to create a new design for each application — there was very little standardization. High voltage supplies tended to be oversized for their power rating in order to allow for extra spacing of the internal wiring and components. Then there was the problem of safely routing the high voltage output to its load. As the number of applications requiring high voltage grew, there was pressure to change this early design strategy.

To meet this challenge, high voltage power supply manufacturers designed proprietary methods to build off-the-shelf modules in very small standard packages that could be used in much the same way as low voltage power modules. Producing high voltage requires a transformer plus rectifiers and capacitors. At 60 Hz, these components have to be large. The first generation high voltage module designers therefore understood that the key to significantly reducing size was to work at relatively high frequencies rather than 60 Hz. Their approach was to start with low voltage DC, typically in the range of 12 to 28 VDC, and then to use an oscillator-based inverter circuit to produce a low voltage, high-frequency input for the transformer.

High frequency enabled extreme reductions in size, especially for the transformers and capacitors. However, high voltage engineers were still faced with a serious problem that low voltage engineers didn't have to worry about — the possibility of arcing between high voltage points and between high voltage and ground. This meant that there were limits to how small these supplies could be made, and still ensure reliable operation. High voltage never stops looking for, and creating, pathways to escape being confined; therefore unique topologies were developed to achieve the long-term reliability demanded by end users. Another part of the solution to that problem was in developing encapsulation techniques that enabled the spacing for high voltages to be significantly reduced, while at the same time allowing for adequate heat dissipation.

The First Generation Arrives

Armed with these tools, XP EMCO and others developed families of reliable, miniature, small-footprint standard modules which they built in large numbers, thus enabling users to count on their availability for new designs. The modules are generally available in two basic types:

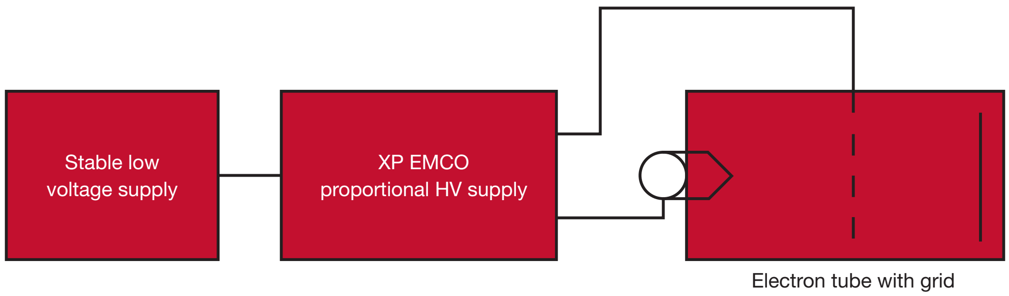
- Proportional Supply
- Regulated Supply

Proportional Supply Modules

Less expensive and providing more power per cubic inch, proportional supply modules are used in various ways where the output voltage varies as a function of the input:

- If the voltage required by the load is not critical — for example, for electrostatic air cleaners — a proportional supply can be used without special control circuits. The output voltage can be adjusted by varying the input.

- If the high voltage needs to be constant and the load current doesn't vary widely, it may be sufficient to use a stable low voltage for the input.



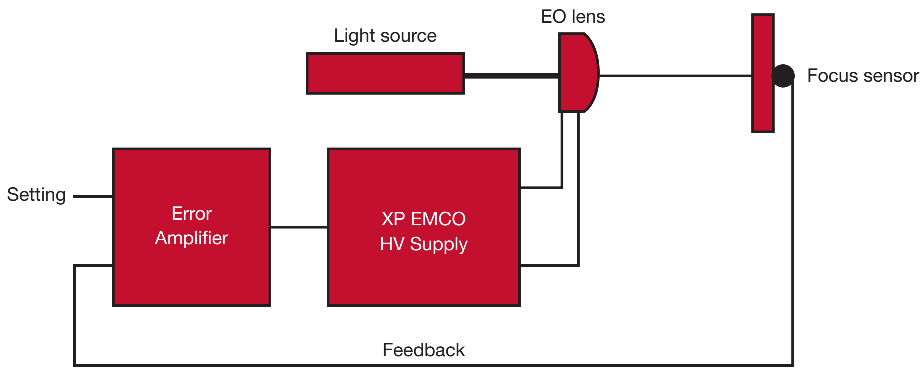
Application Example #1: Grid Biasing

Application Example #1 shows a proportional high-voltage supply applying bias to the grid of a photomultiplier tube. Since the grid draws virtually zero load current, the high voltage bias can easily be kept at a constant level because its low-voltage input is taken from a regulated source.

Regulated Supply Modules

Regulated supplies are used where the output is stabilized and controlled by internal components, as in the following examples

- To regulate extremely stable output against variations of load current, input voltage, temperature, and drifting over time. Sampling the output voltage and feeding it to an error amplifier that controls the DC input is one way to accomplish this.
- To feed high-voltage supply into a device that is part of a manufacturing or instrumentation process. Taking the feedback for the error amplifier from a process variable, rather than directly from the high-voltage output, is one way to accomplish this.



Application Example #2: High Voltage Controlled by a Process Variable

Application Example #2 illustrates a high-voltage supply controlling an electro-optic lens. The system as a whole is kept stable because the feedback signal that controls the high voltage is taken from an optical focus sensor. This technique regulates the entire process rather than just the high voltage.

The Next-Generation is Here

Over the past ten years, DC-to-DC high voltage converters have proven themselves to be effective, efficient, and reliable. Next-generation technology is retaining those qualities and is further pushing the boundaries of watts per cubic inch, reduced power consumption, and the addition of smart features for control and safety. Comparing the present generation of several XP EMCO high voltage power supplies with the models that they have replaced provides a good illustration of these trends.

FS Series

The following table compares the current generation FS series 10-watt power supplies with its predecessor, the F series.

	FS	F	Change
Volume	1.27 cubic inches	4 cubic inches	68% smaller
Weight	1.6 oz	5 oz	68% smaller
Watts per cubic inch	7.9	2.5	More than triple
Input power	15 watts	18 watts	17% less
Height	0.5 inches	0.85 inches	42% less
Footprint	2.5 square inches	4.8 square inches	48% less

Important new smart features added to the FS module:

- A host-controlled TTL high on pin 8 disables the output.
- A TTL high alarm on pin 6 signals the host that an excess temperature or overvoltage fault has occurred.
- Clearing the fault condition automatically restores output (the alarm signal remains until reset).

Q Series

The industry-standard, ultra-miniature Q series has several new models and optional features. Constant product evolution ensures continued status as the industry standard well into the future.

- The QH series has 2.5x the output power in the same package, up through 5 kV.
- An optional center tap provides plus and minus symmetrical outputs with respect to ground, up through ±450VDC.
- A custom 0.400" height version is available.
- An optional high-input impedance control pin can be used (up through 5 kV) for:
  - Controlling the high voltage output from an error amplifier for use in a closed-loop regulator circuit.
  - On/Off control from a logic circuit.

A Series

The ultra-miniature A series takes miniaturization even further; based on the Q series topology, it provides more output power, but is significantly smaller and lighter.

Standard Power

	A (through 2 kV)	Q
Output watts	1 W	0.5 W
Volume	0.1 cubic inches	0.125 cubic inches
Weight	0.2 oz	0.2 oz
Watts per cubic inch	10	4
Height	0.25 inches	0.5 inches
Footprint	0.4 square inches	0.25 square inches

Higher Power

	AH (through 2 kV)	QH
Output watts	1.5 W	1.25 W
Volume	0.1 cubic inches	0.125 cubic inches
Weight	0.2 oz	0.2 oz
Watts per cubic inch	15	10
Height	0.25 inches	0.5 inches
Footprint	0.4 square inches	0.25 square inches

ULP Series

The ULP series of miniature regulated and programmable high voltage supplies is designed for battery powered portable equipment. Mobile and airborne applications use the ULP series where consideration for light weight, small payload size, and long periods of operation are required. Providing up to 2 watts of output power, the ULP series can operate no-load for up to 4500 hours from 2 lithium AA batteries.

	ULP
Output watts	4 W
Volume	2.1 $in.^3$
Weight	2 oz
Watts per cubic inch	1.9 $W/in.^3$
Height	0.5 in.
Footprint	4.6 $in.^2$

External Connections

- Input: +5.4 to 7.4v
- Input: shut down -TTL - active high
- Output: voltage monitor: 0 to +2.5v
- Output: voltage reference: +2.5v
- Input: programming: 0 to +2.5v

State of the Art

The trends described here demonstrate that high voltage suppliers are continually seeking ways to provide end-users an increasing number of choices for off-the-shelf, drop-in miniature solutions to their high voltage needs.

www.xppower.com

About XP EMCO

XP EMCO is an innovative, industry-leading developer of high voltage power supplies. During the past 40+ years, XP EMCO has received many prestigious accolades and awards including:

"Product of the Year" (2 times) from Electronic Products Magazine
"Key Partner Award" from the University of Wisconsin for Project ICECUBE
"Most Innovative New Product of the Year" from the University of California, Davis
"Product Technology Award" from ECN Magazine
"Runner-Up Product of the Year" from Electronic Engineering Product News
"Editor's Choice Awards" (6 times) from Electronic Products Magazine

XP EMCO Main Office
1 EMCO Court
Sutter Creek, CA 95685
Main: (800) 546-3680 (209) 267-1630
Head Offices: Sales
Web: www.xppower.com