

UNDERSTANDING THE BASICS OF *POWERCASSETTE*®

PowerCassette® is very similar to many other multiple-output, switching power supplies in its basic building blocks - in the same way that most automobiles or television sets are functionally similar yet offer markedly different user benefits. Those differences result from hundreds of advanced technology refinements. The following is a brief description of those basic building blocks and some of the considerations which led to *PowerCassette*'s most important features and attributes.

The following represent the principal distinct areas of technical discipline, and all but no. 3 could easily be applicable to 90% of the multi-output, mains-operated power supplies rated above 250 watts.

- 1. Power Entry Section**
- 2. Power Factor Correction Section**
- 3. Two Separate High Power DC-DC Converters and One Medium Power, Triple Output DC-DC Converter**
- 4. Low-Power Standby Supply**
- 5. Supervisory and Fault Protection Circuits**
- 6. Cooling System**
- 7. Packaging and Connector System**

Power Entry Section

This section takes the nominal input voltage such as 115/230VAC, passes it through an EMI filter (typically having a combination of inductors and capacitors), and then full wave rectifies and filters it to remove most of the line voltage ripple. The filter capacitors in this section also store energy, allowing the power supply to function for at least 16 milliseconds after a power failure, sufficient time for a signal to be sent to outside equipment to allow orderly switchover to backup power.



Power Factor Correction

Power factor was taught to engineering students as the phase relationship between voltage and current, particularly when the load was inductive (such as a motor) or capacitive (such as a very large electroluminescent display). For example, fluorescent lamp ballasts (essentially an autotransformer) and many large motors have for 40 years employed “power factor correction” capacitors to offset their high inductance and thereby present a more proper load to the electric utility. New “electronic ballasts” are a variation of a switching power supply and are “high power factor” to begin with, not needing an auxiliary component.

Virtually all off-line switching power supplies are fundamentally “low power factor” to begin with, but not in the way engineers have for a century defined it. The power supply definition means that the input AC current waveform is very distorted in comparison with the input voltage waveform because of the effect of the large capacitors in the power entry section. That distortion has many undesirable consequences (not discussed here for simplicity). Suffice it to say that a decade ago the industry decided that a technique should be employed to “correct” that distortion. That technique has today become quite standard and is in one form or another called a “boost” converter. The result is that the input AC current is quite close to being a perfect sine wave like the voltage, i.e., “bad” distortion is no longer present.

The power correction section consists of a “chopper” circuit (a high speed on/off switch) with an on/off ratio according to a relationship to the instantaneous input voltage sine wave. The power factor correction circuit causes the large filter capacitors in the power entry section to be charged to a nominal, fixed 380VDC regardless of the instantaneous AC line voltage—whether that is 10 volts or 250 volts. The 380 volts then becomes a DC input for the main DC-DC converters.

DC-DC Converters

The purpose of the DC-DC converters is to take the rectified and filtered AC voltage (or today, the rectified, filtered and power factor corrected voltage), which is now 380VDC, and send it to another “chopper” circuit, turning it into a pulsed DC which is fed to a transformer, where it is typically stepped down to a low voltage. That low voltage is then filtered and becomes the output voltage, such as 12V, 5V, 3.3V, etc. The transformer also serves to provide electrical isolation for safety purposes.

In the *PowerCassette* there are several such DC-DC converters, one of them with multiple windings on the secondary of its transformer, allowing a main output and a pair of auxiliary, lower power outputs. A “smart circuit” allows the auxiliaries to deliver power even when there is no demand on the main output.



Standby Supply

The standby supply is a low power section, acting like a little independent DC-DC converter driven directly from the 380VDC. Its purpose is to power the fans and provide a 5V, 1 ampere output for external monitoring or supervisory circuits. This standby supply voltage is always present, even if the power supply is inhibited (in the “sleep” mode). In high power radar systems such a power supply is called a “keep alive” voltage so that very high-power transmitter tubes will require no system warm-up time before being activated.

Supervisory Circuits

Within the overall power supply are control circuits which form the “brains” of the unit. These circuits monitor line voltage and output load variations and then cause power switching circuits to change pulse width to maintain a precise output voltage in the face of those variations. The supervisory circuits provide signals to the outside world on the status of several important operating conditions. They also detect various fault conditions such as excessive voltage, short circuits, excessive temperatures, etc. and then either shut down the power supply or generate alarm signals.

Cooling System

All of the main power semiconductors, transformers and chokes dissipate substantial heat. Typically 20 to 30% of the power coming into and going out of the supply is lost in heat. Therefore, all the components must be chosen, rated and positioned or mounted so that air flow can cool them directly or indirectly in accordance with fairly precise criteria (not simply “blowing air” across the elements). The complete system, choice of fans, overall packaging, air exit area, etc. becomes a “total design” consideration.

Packaging and Connector System

The unit is designed to be 1U-high to fit within standard industry enclosure guidelines. It also is designed so that all input and output voltages are on a single plug-in connector so that the power supply can be quickly plugged into, or removed from, a backplane like a cartridge or video cassette. The choice of connector is important because it must not obstruct the exiting cooling air.

General Considerations.

In the design of a power supply, the most fundamental decision is the choice of “topology” such as forward converter, half bridge, full bridge, resonant, quasi-resonant, flyback, etc. Each has its place, and choice can be influenced by the overall objective of size, cost efficiency, operating frequency, desired features, power, number of outputs and versatility.



In developing a “recipe” for a multi-output supply, one must decide on an approach such as individual DC-DC converters, mag-amp outputs, single transformer with multi-winding, etc.

In the *PowerCassette*, before the first design decision was made, the following objectives were established

- 1U high profile
- Up to six outputs
- Two high-power channels
- Very high density
- Hot pluggable
- 600W total power
- Cost effective in volume
- Extremely easy to create hundreds of variations using a mass-produced standard PCB set with virtually identical bill of materials for all variations—in other words, the advantages of customization without the manufacturing variations associated with them.

In the final analysis, the design of *PowerCassette* required the use of proven topologies such as a forward converter, in ways not typically expected, to achieve efficiencies normally associated with more exotic topologies. Similarly, ways had to be found, using principles of air turbulence and heat distribution, to make a small amount of air flow (from small fans) remove more heat than one would expect. The driving model for the design has been the same as that now used by automakers—a standard platform which can be quickly “morphed” into a myriad of configurations while not affecting the continuous flow of manufacturing.