WHITEPAPER

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DOING THE NUMBERS FOR POWER CONVERSION

The math of power conversion used to be simple. The byproduct of AC-to-DC power conversion is heat. Need more power? Then deal with more heat. For years we've found a lot of ways to manage that heat – and the design challenges and output inefficiencies that heat creates.

Place an AC-to-DC power supply unit (PSU) on a circuit board or inside a piece of electronic equipment from servers and networking gear to manufacturing equipment and even automatic teller machines (ATMs) and power engineers are forced to use tools from fans and heatsinks to air-cooling and even liquid-cooled designs to off-set the debilitating effects of heat.

Today, however, with new demands on expanding, always-connected, always-mobile, data and content-hungry applications, the electronics that drives these advances need not only more power but more power, in more locations, in more and smaller devices. And that drives the demands on traditional power conversion heat mitigation and power density design approaches.

Some PSUs do have temperature protection capabilities that, in ambient temperatures above 65 degrees Celsius, protect a power supply by shutting down the power and the overall system. This is not an ideal option. So, power supplies are often run at maximum output, and heat, creating stress on the overall device and degrading the overall quality and life of the power supply. Again, this is not ideal for remote or hard-to access power devices.

MANAGING HEAT – CONVECTION AND CONDUCTION

For years, power designers have battled the excessive heat of power conversion using a variety of techniques to cool or transfer heat – via both airflow heat convection or heat-conducting materials to improve power efficiency and power output performance (Figure 1).

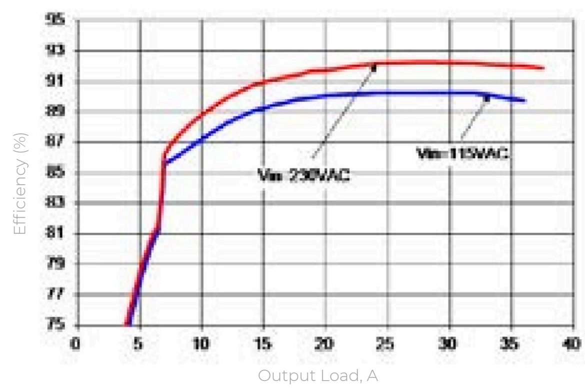

FIGURE 1. Power Supply Efficiency versus Output Current

In many applications fans can be used to increase air flow over hot surfaces to remove heat via forced air convection. However, fans are not appropriate for all applications since they tend to have a lower mean time between failure (MTBF) rate and are therefore less reliable than the electronics they cool.

For applications where fans are not feasible, conduction cooling is a likely solution. Conduction cooling, which is sometimes referred to as fanless cooling, dissipates heat from a PSU with heat sinks, cold plates or other similar techniques.

The heat removal medium can be air, water, oil, metal or special liquids. Examples of a conduction-cooled fanless front end AC-DC PSU is OmniOn Power's CCR0512 and the full line of CLP (compact low power) open frame PSUs which dissipate heat via either a heat sink or cold plate.

In OmniOn's line of CLP PSUs, for example, components producing higher heat levels are placed on the bottom of the printed circuit board where, put in contact with thermally conductive materials, the heat is conducted to the metal exterior of the equipment cabinet, which acts like a heat sink (Figure 2).

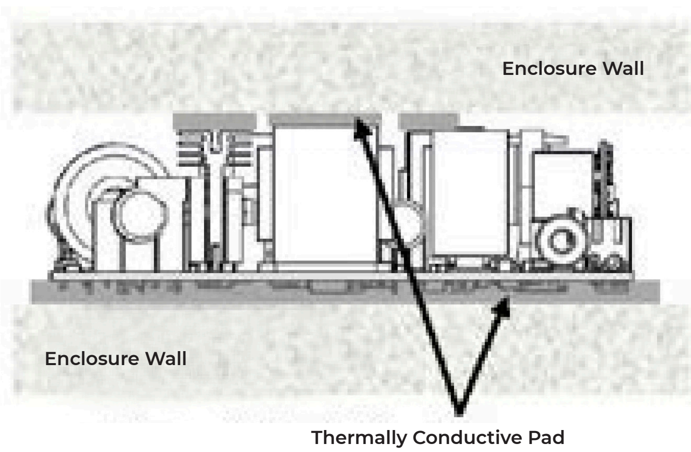

FIGURE 2. Example arrangement of the CLP0412 for sealed enclosure applications

These options can create thermal reductions that help achieve 90 percent energy efficiency, at a range of power loads from 50 to 100 percent. Yet these efficiency levels can be even more challenging when designing power supply solutions in small and confined enclosures. This is especially true in remote or harsh environments like remote wireless devices or in industrial settings.

HOW HEAT DERATES POWER OUTPUT

One of the standard "work-arounds" is not just reducing heat by cooling or dissipating the heat, but actually "accommodating" the inefficiency heat creates by derating the output capacity of the power supply. If, for example, a 100 watt (W) power supply is only operating at 60 percent efficiency, with 40 percent lost to wasted heat, then that device might be derated to, 60W or 50W output.

Think of this analogy. Imagine the inefficiency of a home heating furnace, for example, if 50 percent of the out-put or heat was escaping from the furnace into the basement and away from heating the home (the load). In theory, if you could afford to pay for the fuel (power) then the furnace is doing its job albeit inefficiently.

So, if a power supply can be situated in an open, air-cooled environment, or if designers have room and power to run a small fan to dissipate heat, then the inefficiencies of mitigating thermal dissipation is less of a problem. But what about in smaller, tight and enclosed environment such as a remote wireless or networking equipment, where long-term damage from heat to equipment and systems is a major design challenge.

Going back to the furnace example. If all that wasted heat raises the temperature of the ambient air in the basement, then the basement gets too hot. Too hot makes the space unusable, compounded by the wear and tear on the furnace and surrounding equipment from the excessive heat. A hypothetical, but impractical, solution is to only use half the furnace's heating capacity, operating, for example, three of the six burners, to cut back on excessive heat.

Derating a power supply's rated output is like that furnace's 3-burner solution. The heat is forcing the designer to cut the power output rating and usefulness of the PSU. It not only robs the power capacity of the device but wastes precious circuit board real estate or enclosure space and lowers the overall OpEx value of the device.

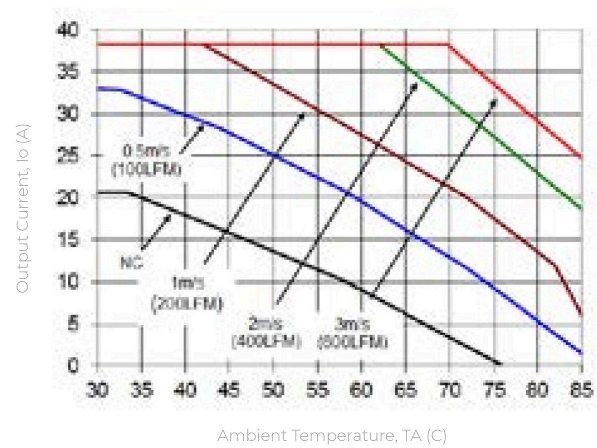

FIGURE 3. Thermal Data shown for CLP0412FP model

Take, for example the cost of a 450W driver rated at 320W. This derating essentially discards approximately 30 percent of the component's function and, of course, cost. It's like you're paying to install three lightbulbs but getting to use only two. You're paying more money for less light.

The way to counter this derating conundrum is to use a PSU rated for high efficiency across a range of operating temperatures. OmniOn's CLP line of PSUs offer a 90 percent power efficiency across variable loads at conditions up 50 degrees Celsius (122 degrees Fahrenheit) (Figure 3.)

POWER DENSITY - BIG POWER IN SMALL SPACES

A central equation in managing power conversion especially in smaller, high power output applications is the power density of the PSU. Traditional open frame power supplies, for example, have been restricted to a 3 x 5 inch wide, 1.4 inch high form factor. These dimensions enable air-flow and fan cooling, but restrict the power-to-dimension, or power density, as shown in the chart below.

W (in)	L (in)	H (in)	Vol (in^3)	Power (W)	Density (W/in^3)
2	4	1.4	11.2	150	13.4
2	4	1.4	11.2	200	17.9
3	5	1.38	20.7	450	21.7
3	6	1.38	24.84	550	22.1

FIGURE 4. PSU form factors match and power densities

Newer approaches, such as OmniOn's CLP power conversion units pack equivalent power output into a smaller, higher density form factor (Figure 4). This fanless, open frame PSU creates a power density of $18W/in^3$ for 200W applications, allowing equipment designers to put smaller, high-density power options into small and constricted spaces.

Typical applications include compact systems such as small cell wireless devices, small form communications equipment such as routers, test and measurement instruments or medical devices.

Beyond thermal management and conductive cooling, power density can be achieved by dispersing, or spreading out, some of the heat producing components across the circuit board. Additionally, low power components can be placed onto secondary boards, which are either placed off the main board, or mounted vertically, in a low profile, 90 degrees to the main board.

Power designers can also use a new class of small active and passive components that deliver equivalent performance. Increasing "feature" density can also be accomodated in some PSUs, including OmniOn's line of CLPs, by putting some of the power-related components or increased functionality on the 2 x 4 inch board, such as stand-by output, current sharing, Level 4 surge protection and remote on-off. This reduces the number of additional system components, saving both space and improving power density.

Putting new or expanded capabilities "on-board" also boosts space and power density. One example of this involves the EMI (Electromagnetic Interference) that some power supplies can generate, which can disrupt critical circuitry or conflict with regulatory guidelines. This burdens the overall system by requiring an additional component to clean up EMI noise effectively eroding power density of the PSU.

To counter this issue, OmniOn's CLP series PSUs integrate a Class B EMI filter that mitigates this noise, maximizing system space for critical networking or computing circuitry.

To further increase overall power capacity and output, several of these CLP units can be used in parallel to power larger devices, such as an outdoor lighted billboard or newer wireless radio head systems where one or more PSUs are needed to power multiple antennas or to provide added redundancy.

POWER IN CHALLENGING ENVIRONMENTS

In our data-centric, mobile app-driven business and personal lives, getting access to data, content and applications means putting power at and into smaller, remote, challenging and environmental challenging locations.

Powering a wireless modem in an office or home is simple compared to powering a small cell, or new 5G wireless node affixed to a remote, hard-to-access utility pole. Locating power conversion units closer to loads in demanding manufacturing settings requires PSUs to perform in hot, dusty or vibration-prone shop floor locations.

The key to managing environmental conditions is to ensure consistent, quality power efficiency levels at less than optimum operating conditions. OmniOn's line of CLP PSUs operate across a broad range of temperatures, from minus 40 degrees Celsius up to 70 degrees Celsius.

As stated earlier, these PSUs deliver greater than 90 percent power efficiency at full load output at temperatures up to 50 degrees Celsius (122 degrees Fahrenheit).

Certainly, managing thermal output in AC-to-DC power conversion has been an ongoing challenge for electronic system designers. This challenge is, expanded, today by new demands for increased power capacity in smaller, more confined and remote data and communications devices.

Power designers do, however, have access to a range of new compact and low power supplies that meet the most rigorous requirements for both thermal management and power density for these new and expanding applications.

RESOURCES

See the full line of product and data sheets for OmniOn Power's CLP Open Frame Power Supplies

6 Reasons to Use the CLP Family of Open Frame Power Supplies

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