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## Examine The Thermal Implications Of Potted Versus Open-Frame Bricks

When I joined Vicor almost 20 years ago, the inventors of the brick told me that the planar surface of a base plate is optimal for removing or transferring heat and that potting provides an outstanding thermal interface around each component. When bricks first came out, in fact, all of them

were encapsulated and fitted with attached base plates. Our philosophy at the time, as it is now, was to be as flexible as possible to enable designers to adapt the brick to many different applications.

High-power-density open-frame converters appeared sometime in the mid-1990s, presumably to produce a simpler, lighter-weight converter at lower cost. The Telecommunications Act of 1996, designed to stimulate local telephone service, coincided with technological advances (such as fiber optics) that kicked off the telecom boom.

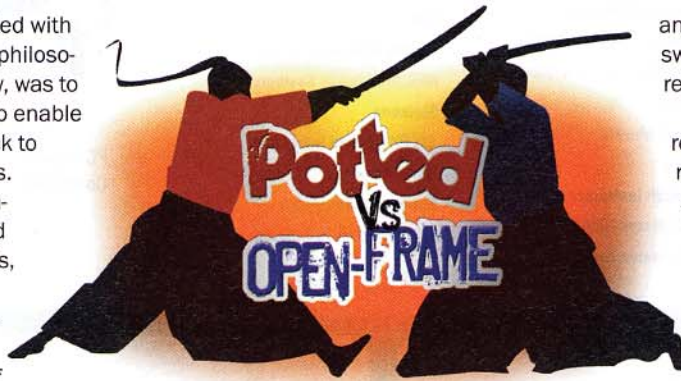
What really drove the open frames, even though some critics make a big deal about their high efficiency, was the telecom racks containing load cards: To maximize the capacity, the pitch (the distance between boards or cards in the rack) was specified. That distance limited the maximum height for a brick.

Open frames, with no base plate, were a perfect fit. The potted brick was not. The overall height of the potted brick was half an inch, but the tighter pitch was around 0.6 in. It was too close for these tighter-pitched applications, and the value of having a base plate that can add a heatsink was negated.

In addition, with the advent of synchronous rectification (not used in some bricks), the open-frame makers were able to claim higher efficiencies on the low voltage outputs. Not to take anything away from the open frame, it found a niche where it excelled, and it benefited from the boom. Unfortunately, the telecom boom went bust by early 2001.

**BY THE SPECS** • Open-frame units with synchronous rectification just reach the 90% efficiency mark at low output voltages. But they lose any significant efficiency advantage over a potted brick at higher output voltages.

Diode rectification typically uses a Schottky diode, which has a low forward voltage drop. So, the dissipated power is roughly proportional to the current through the diode. Synchronous rectification operates a little differently (albeit at additional cost



and complexity) and uses a MOSFET switch or switches to accomplish rectification.

The MOSFET has a low internal resistance ( $R_{DS(ON)}$ ), which is the resistance from the drain to the source when the MOSFET is on. The power dissipated in this case is roughly proportional to the square of the current.


At lower currents, the MOSFET will generate less heat than the diode until output current is reduced to a point where

the switching or ac losses in the FET again exceed the essentially dc losses in the rectifier. After a crossover point, at about 20 A, diode rectification generates less heat loss than the MOSFET, and at no load or light loads ac losses result in lower efficiencies for the MOSFET.

And unlike diodes, whose forward voltage drop decreases as junction temperature increases, when the temperature rises in a MOSFET,  $R_{DS(ON)}$  increases for the same amount of current. The power dissipated in the MOSFET increases, reducing efficiency and increasing the heat generated.

**PROS AND CONS** • Any converter, open-frame or potted, can operate at full rated load only if it doesn't exceed a certain maximum ambient temperature. But high-ambient-temperature environments are a disadvantage for the open frame because they rely on forced convection, which means fans.

In tightly pitched telecom applications, the airflow is forced through and over the components. For applications with more space, though, the airflow takes the path of least resistance and goes over or around the converter, not through the components.

In any case, open frames are prone to localized hot spots. Although the thermal spreading effect of potting is advantageous, the most significant advantage of a potted module versus the open-frame converters is the flexibility of easily adding a heatsink to the base plate if needed. 

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