Defining an Intelligent Pin-Out for High Amperage DC/DC Converters

A Technical White Paper by SynQor

SynQor's high amperage half-brick and quarter-brick converters feature an alternative pin-out solution that offers significant performance advantages.

Introduction

As the power voltage for digital circuits falls to the 1.0-1.5V range, and as the power consumed on a load board increases, dc/dc converter modules are being asked to deliver very high output currents. For example, while 5 years ago a half-brick converter could deliver only 30A, today's highest amperage half-brick converters deliver 100A. Similarly, 5 years ago quarter-brick converters delivered 15A; now they can deliver 60A. To handle this very high level of current, the number of output power pins needs to be doubled.

The question remains: where should the extra pins be located? Ideally, the chosen locations should be both optimal for the user and a standard for the converter industry. Unfortunately, several manufacturers have already released products with incompatible extra pin locations. It is therefore up to the consumers to decide which pin location will become the new standard. The purpose of this article is to provide some technical guidance for this decision.

Why do I need to double the power pins?

First, it is important to understand that the need to double the number of power pins is not due to the pin's electrical resistance. An 80 mil diameter copper pin has a resistance of about 20μΩ. When this pin carries 100A, its power dissipation is 0.2W. Since the 100A flows out of the V+ pin and back into the Return (or Ground) pin, a total of 0.4W is lost. By doubling the number of power pins, a savings of only 0.2W is realized. To put this in perspective, a 1.2Vout, 100A converter operating at 83% efficiency dissipates about 25W.

Instead, the reason to double the power pins is to reduce the dissipation that occurs on the load board as the output current spreads outward from the pin in

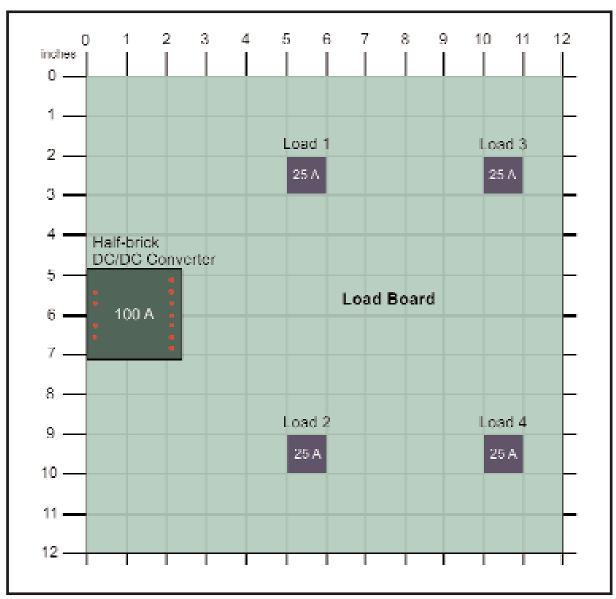

Figure 1: *An example load board with a 100A half-brick converter supplying four 25A loads through 1 oz. power planes.*

the board's power plane. To understand this point, consider a load board that is 12 inches on a side. Assume that the board has four loads, each drawing 25A of current, distributed around the board as shown in Figure 1, and that a 100A half-brick converter is mounted near one edge of the board. Further assume that the power plane connecting the converter to the loads is made from 1 oz. copper and has a resistance per square of 1mΩ (which takes into account the many vias that generally interrupt it).

Measuring the Voltage Drop

Figure 2 shows the voltage profile across the power plane when only one power pin is used for each terminal of the converter. Note that in this figure, the converter's pin is the V+ pin (current is flowing out of it), but the nominal dc voltage at this pin (e.g. 1.2V) has been removed from the scale so that we can focus entirely on the voltage drop from the pin to the load. Note also that the simulation includes thermal relief spokes around the pin, although they cannot be seen at this scale.

From this simulation we can see an 80 mV drop at a distance of about 6 inches from the pin. This large drop occurs because the current has to first spread out from a small point (the pin) before it can take full advantage of the width of the power plane. The resistance of this "spreading" region is high. At 100A, the 80 mV results in 8W of dissipation, and that number is again doubled when you take into account the dissipation caused when the current returns to the converter at the Return pin. Both the 16W of dissipation, and the 160mV of voltage drop (13.3% of 1.2V), are too large.

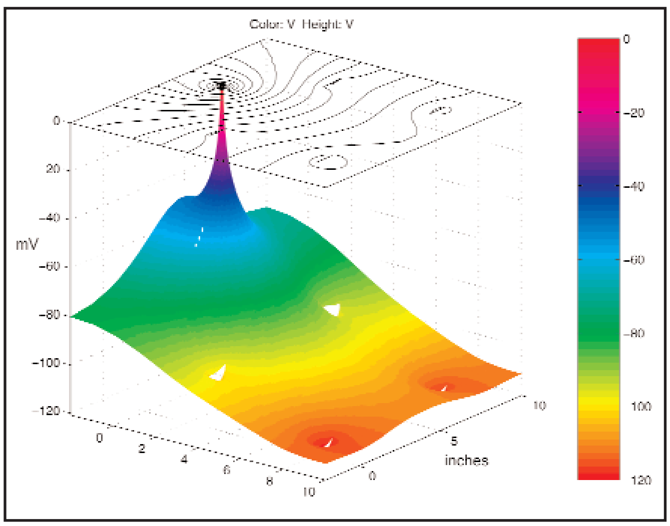

Figure 2: *The voltage profile across the V+ power plane for the case where the converter has only one pin for each terminal. (The nominal dc voltage has been removed from the scale.)*

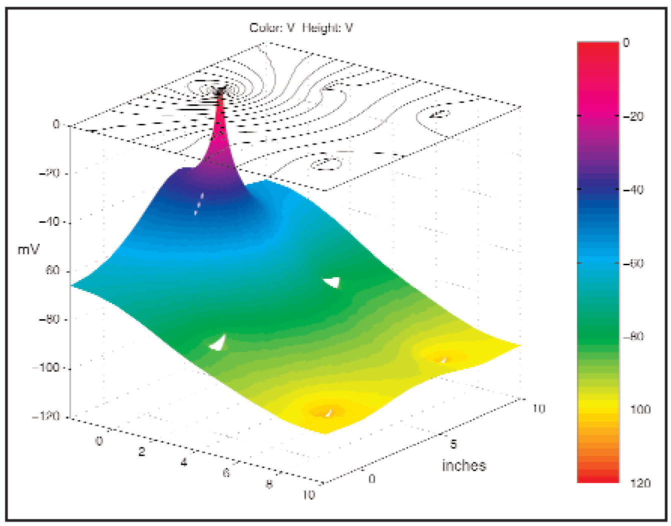

Figure 3: *The voltage profile across the V+ power plane for the case where the converter has two pins for each terminal located adjacent to each other. (The nominal dc voltage has been removed from the scale.)*

Now consider the voltage profile of Figure 3, in which a second power pin has been added for the V+ terminal. The location of this pin is 0.2 inches inside of (and inline with) the original pin (see Fig. 5a). (Note that with the scale of Figure 3 it is not possible to discern the second pin from the first.) This adjacent pin location may be convenient for the layout of the converter, but it does very little to correct the problem for the user. The voltage drop at a comparable point 6 inches away from the converter is about 10mV less than the case where only one terminal pin is used. The total power savings is therefore only 2W out of the 16W.

The reason for this marginal improvement can be understood by examining how the current spreads out from the pin. As the simulations show, it takes several inches for the current to spread out enough to take advantage of the width of the power plane. But since the two pins are located only 0.2 inches apart (see Figure 5a), their currents quickly overlap, and it is as though there were just one pin. The advantage of having two pins is limited to the region immediately surrounding the pins, and that region contributes only a small part of the total spreading resistance.

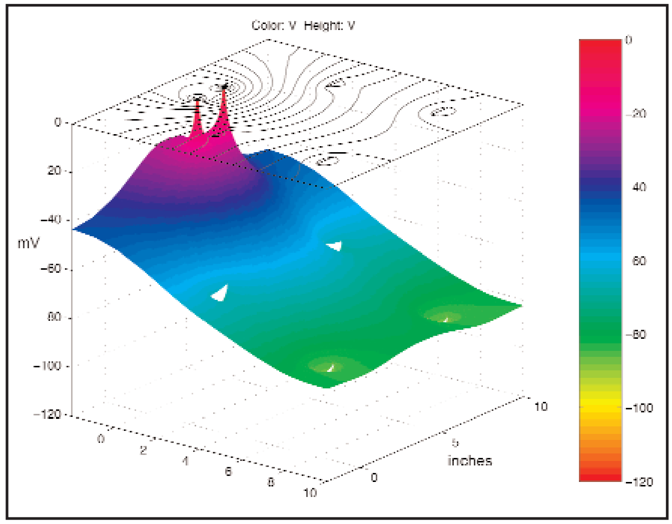

Figure 4: *The voltage profile across the V+ power plane for the SynQor solution where the converter has two pins for each terminal located on opposite sides of the converter. (The nominal dc voltage has been removed from the scale.)*

However, now look what happens when the extra pin is located on the other side of the half-brick converter, 0.2 inches outside of (and inline with) the *pin of the opposite polarity* as in the SynQor converter (see Figure 5b). As the voltage profile in Figure 4 shows, the voltage drop at a comparable point 6 inches away from the converter is about 40 mV lower than the case where only one terminal pin is used. The total power savings in this case is 8W out of the 16W

This substantial improvement occurs because the two pins, in this case, are 1.6 inches apart instead of 0.2 inches. As such, the current from each pin nearly finishes its spreading before it overlaps with the other current, and the effective spreading resistance is nearly cut in half due to the two parallel paths. Clearly, the extra pin location shown in Figure 5b is superior to the location shown in Figure 5a from the users point of view.

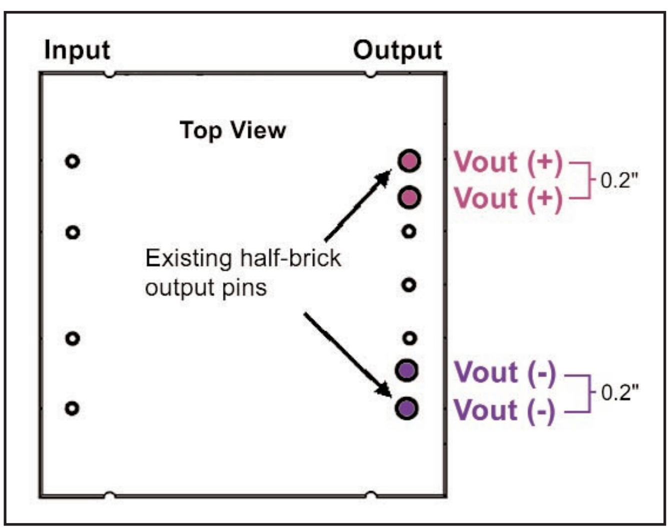

Figure 5a: *Extra pin location where the same terminal pins are located adjacent to each other.*

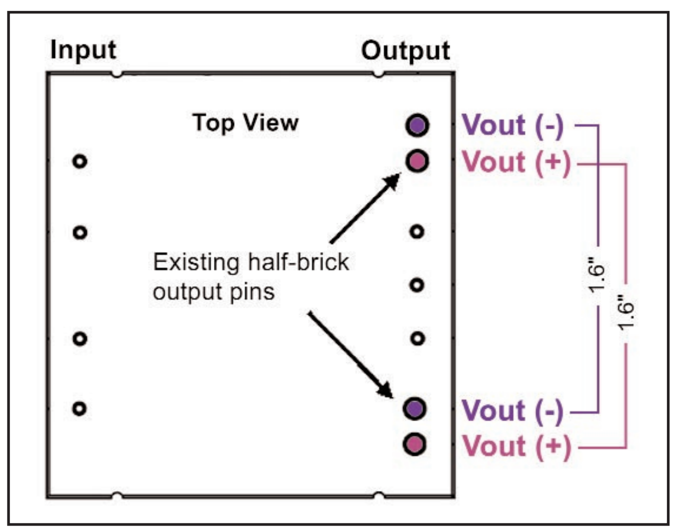

Figure 5b: *SynQor extra pin location where same terminal pins are located on opposite sides of the converter.*

A similar statement can be made for the preferred location of the extra pins on a quarter-brick converter. Figure 6 shows this approach where the extra pins are located 0.15 inches outside of (and inline with) the original pins, with opposite terminals adjacent to each other. Although the distance between the two pins of a given terminal is now only 0.75 inches for this smaller converter, much of the spreading still occurs before the two currents overlap, and the design is therefore superior to one in which the two pins of a given terminal are adjacent and only 0.15 inches or less apart.

As a final point, the preferred extra pin locations shown in Figures 5b and 6 do more than simply reduce power dissipation in the load board. Some of the heat that a converter creates travels down the pins and spreads out onto the load board. How much heat flows this way depends on how hot the load board is from other sources of dissipation. In our half-brick example above, we saw that the power dissipated in the power plane in the vicinity of the converter was reduced by 8W by using the preferred pin locations. This reduction makes the load board in the region of the converter that much cooler, and allows more heat to flow down the pins from the converter. This results in a cooler and therefore more reliable converter.

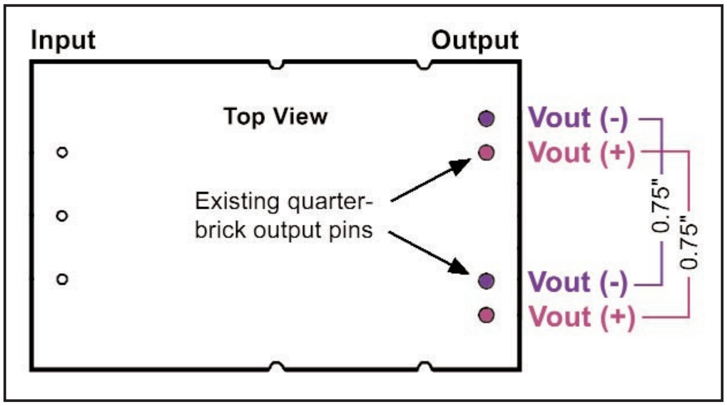

Figure 6: *The preferred location of the extra pins for a high amperage quarter-brick.*

Conclusion

Design engineers have much at stake with any new standards that are adopted in the industry. Their voice should be heard as to which pin-out design provides the best overall solution. Any decision on standardization for the high current brick pin-out should take into consideration the technical merits of competing solutions.

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