

A REVIEW OF DC/DC CONVERTER DE-RATING PRACTICES

By

Tim Powers

As a power design engineer the most commonly asked questions by far are related to thermal performance of dc-dc converters. At issue are many factors, such as power and temperature de-rating, thermal measurement techniques, correlation of case temperature to ambient temperature, heat sink selection, required airflow, and the list goes on. Max operating case temperature is the most commonly used parameter that converter manufacturers use to rate their products. But this value does not readily relate to how a converter will operate within a system, which makes these questions difficult to answer. A converter's case temperature can vary widely under the same electrical conditions within different systems as the overall environments are seldom the same. When a converter is selected based solely on its power capability, other suitable products may be overlooked. The theory that converter reliability can be assured by simply de-rating the power used by 50% is unsound. This may be a good practice for most passive components such as resistors where using a .25 watt part at .125 watts or less is considered to be the safe operating area. But when this approach is applied to a converter it may actually cause more stress leading to higher cooling costs and lower MTBF.

Most dc-dc manufacturers have design de-rating guidelines. Design engineers also may use guidelines that they have developed themselves. In a system requiring 100 watts of power these guidelines often call for a 200-watt converter. This sounds safe and

practical, right? Maybe not. As engineers we de-rate components to improve their reliability by decreasing component stress. The key to optimizing converter selection is to understand the properties of the converter and to choose the one that exhibits the least stress within the intended application.

The author suggests using the term “useable power”. Useable power is the amount of rated output power a converter can generate without requiring an unrealistic amount of cooling. As the design of a system unfolds, the available means of cooling and mounting become pre-defined. Space provided dictates whether a heat sink can be used and if so, its size. As engineers we would like to start with the power dissipation and temperature, design the required heat sink based on its thermal impedance in °C/watt and design the system around it. The fact is that available space ultimately dictates this decision. Most systems have fan requirements with little room for negotiation. Even with airflow, the location set aside for the converter is usually determined by electrical layout parameters, not convenience based on cooling. The converter will be subjected to the system’s max ambient temperature, which is a function of where the system will be used, the power dissipated from the converter and it’s neighboring components, and the effort made to remove the heat. Here again, the constraints begin with the initial system parameters and the design must accommodate these constraints. With all of this imposed on the system design engineer, it is more important than ever to select the right converter.

Why is de-rating a converter by 50% based on power wrong? It isn't necessarily wrong and there are cases where it will work out fine. A common mistake design engineers make is overlooking suitable converters (which very well may be better solutions) because of a misconceived design guideline.

Let's look at an example where a converter was selected based on de-rated power. In this scenario, perfectly appropriate converter solutions were improperly rejected because the "required" power level was not specified in the desired package.

There are many factors to consider when searching for a converter, but for our example we will compare thermal aspects alone, as most other parameters are very similar.

Under worst-case loads consider a power requirement of roughly 100 watts and a half brick package size. The first inclination may be to select a converter rated for 200 watts at the appropriate output voltage and input voltage range. Cost may confine our selection to a mid-level performance converter in that power range. A converter rated at 87% efficient seems sufficient for these purposes, especially since we would be using it at $\frac{1}{2}$ load worst case or lower. From the curve in Fig.1 the efficiency at 100 watts (50%) is about 84% and at 70 watts the efficiency is about 80%. At very light loads the efficiency of a converter is generally low. As the load increases the efficiency follows to the point where it nears its nominal value. Then the increasing efficiency becomes less linear. After this knee in

the curve, the efficiency will generally peak at some point and then begin to decline.

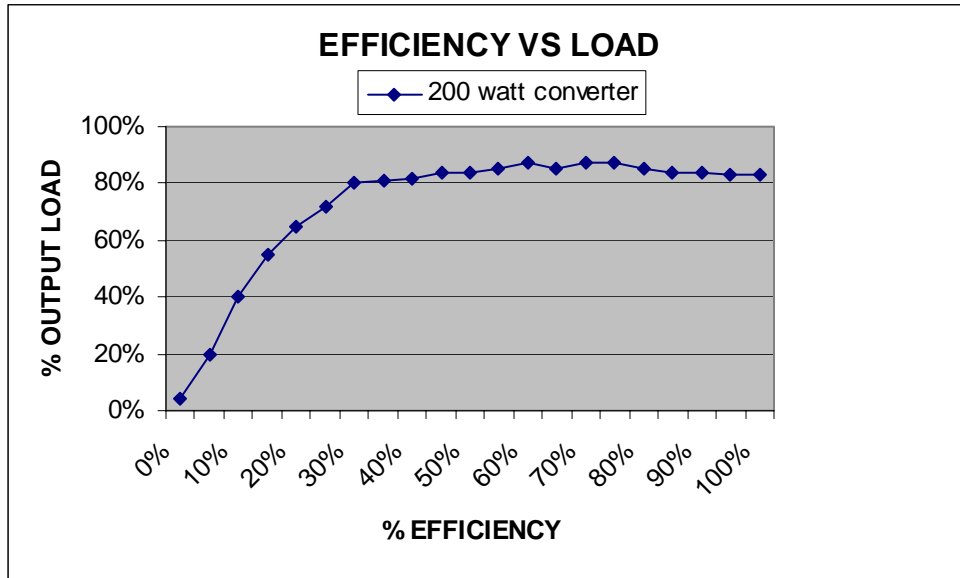


FIG. 1

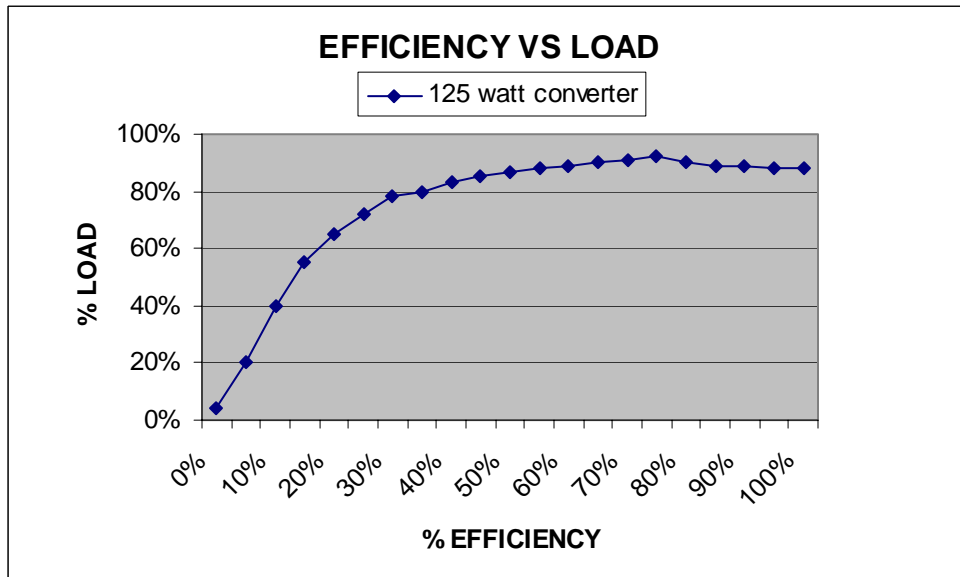


FIG. 2

The power dissipated at these points follows:

100 watts: $(100 / .84) - 100 = 19$ watts dissipated

70 watts: $(70 / .8) - 70 = 17.5$ watts dissipated

By placing the normal operating load point near the knee on the efficiency curve the power dissipated increases dramatically.

The converter we chose was 125 watts. Most parameters were relatively equal, but the efficiency was dramatically improved. Lowering the power requirements increased our choices allowing us to consider higher performance models.

From the curve in Fig.2 the basic shape of the curve is very similar with higher overall efficiencies. At 100 watts we have 92% efficiency, and at 70 watts we have 91.2%.

Comparing the power dissipated we observe:

100 watts: $(100 / .92) - 100 = 8.7$ watts dissipated

70 watts: $(70 / .912) - 70 = 6.75$ watts dissipated

The difference is more than 50% in favor of the lower power converter, As a bonus, lower power converters actually run cooler without a heat sink than the higher power units run with a heat sink!

It's always difficult to discern a converter's capabilities from initial manufacturer claims. Questionable marketing practices may add to the confusion. As advertised a converter may be capable of 200+ watts in that package, but it also may require an inordinate amount of cooling. The obvious question which results is why can't the higher performance/lower power converter be made to deliver 200 watts? The answer relates to component robustness. Larger semiconductor packages like D and D2 packages are tough and have more volume to absorb thermal transients. Smaller packages like SO8 are less capable of withstanding sudden thermal transients and don't always offer sufficient means of transferring the heat. FET's in these small packages offer smaller die's with less parasitic capacitance's and lower RDS ON ratings. Though this reduces losses, there are practical limits to their capabilities.

Conclusion

Though de-rating values are useful indications of a converter's performance, design engineers must exercise caution when relying on these values to select the proper dc-dc converter. By carefully considering the combination of parameters that contribute to an understanding of the complete thermal picture, the design engineer can confidently select the most suitable candidates for their design.