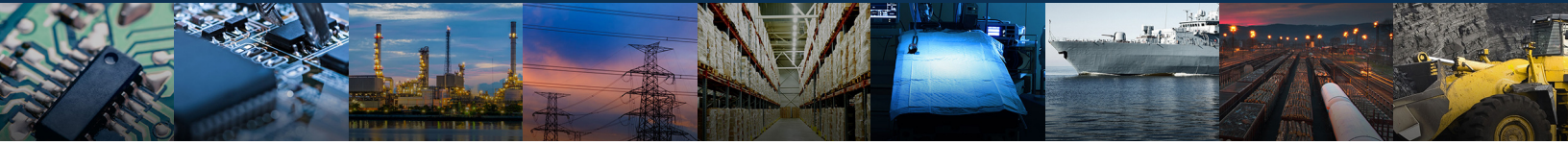




Wall Industries, Inc.



# Thermal Considerations when Using DC-DC Converters in Mobile Based Ground Equipment

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## Introduction

Accurately specifying a dc/dc converter for mobile-based ground equipment presents unique design challenges. Satisfying system requirements and leveraging performance improvements requires a comprehensive understanding of their capabilities and their requirements. Since thermal design plays a key role in optimizing converter performance, the proper assessment of associated parameters is critical to selecting a dc/dc converter. The intent here is not to understate the full complexity of thermal design, but to use the information provided by the manufacturer to arrive at a workable solution. Here we review the thermal considerations that system design engineers should weigh when selecting the optimal dc/dc converter for mobile-based ground systems.

# Budgeting for Heat Dissipation

Mobile environments are particularly harsh on electronics, and for heat generating power converters they can be catastrophic. As operating temperatures increase, the MTBF decreases. It only makes sense to consider thermal capabilities as early in the design cycle as possible.

Even highly efficient converters still dissipate power in the form of heat. Early in system design stages the total power requirements and overall mechanical package data are often unknown, making it difficult to budget for total heat dissipation. Without this information the appropriate converter cannot be specified easily. Efficiency values, thermal impedance, and derating data are necessary in order to define the cooling requirements. In this situation an option is to make reasonable system power requirement predictions, choose a brick converter model at the predicted power levels and work with the average thermal performance characteristics of that series. At the very least, this allows the mechanical designer to budget for the required cooling. Too often the converters and their associated cooling components are added as an afterthought resulting in sub-optimal or uneconomic performance characteristics. This issue is particularly predominant in hot vehicular environments that provide neither a thermally conductive infrastructure (chassis) nor a consistent airflow.

## A Thermal Example

With a baseline chosen, the cooling requirements can be determined easily so that the design can proceed with confidence. Let's assume that we require 65 watts of output power from a converter that exhibits:

- 100-Watt Capability
- 90% Average Efficiency ( $\eta$ )
- Max temperature rating of 100°C case, based on worst-case semiconductor junction temperatures within the converter
- Thermal impedance ( $\theta_{ca}$ ) of 6.75°C/watt
- Derating curves as shown in Figures 1A and 1B

Manufacturers provide derating curves in several forms, but all forms are governed by one key factor pertaining to the converter's case...its temperature rises above ambient ( $\Delta T_{rise}$ ). Figure 1A shows output power versus case temperature while Figure 1B reveals % of output current versus case temperature. Since output current is directly proportional to output power, these curves are identical. If the system requirements are known in terms of max ambient temperature ( $T_{amb}$ ), the conversion factor ( $T_{amb}$ ) is determined by the thermal impedance.

$$\Delta T_{rise} = T_{case} - T_{amb}$$

$$\eta = \frac{P_{out}}{P_{in}} \Rightarrow P_{in} = \frac{P_{out}}{\eta} \Rightarrow P_{in} = \frac{65 \text{ Watts}}{0.9} \cong 72 \text{ Watts}$$

$$P_{diss} = P_{in} - P_{out} \Rightarrow P_{diss} = 72 - 65 \text{ watts} \cong 7 \text{ Watts}$$

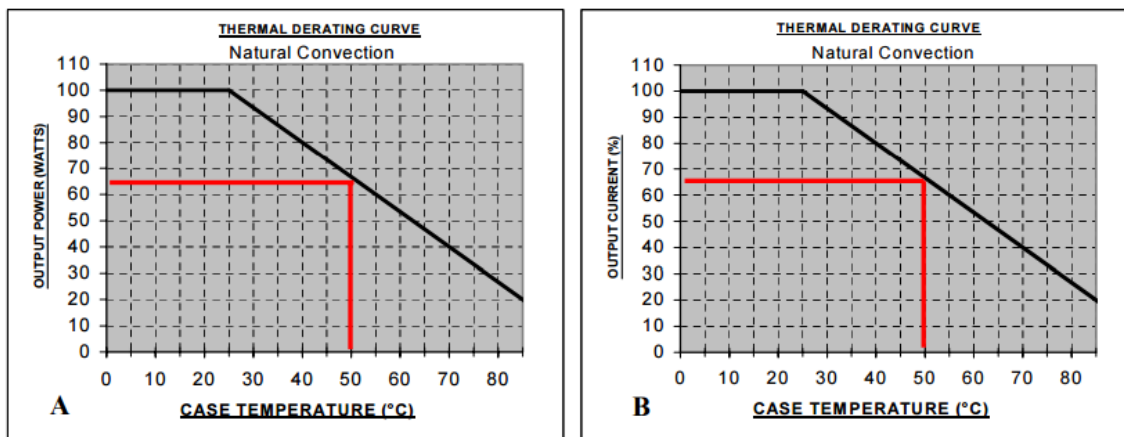
$$P_{diss} = \frac{\Delta T_{rise}}{\theta_{ca}} \Rightarrow \Delta T_{rise} = P_{diss} \times \theta_{ca} = 7 \text{ watts} \times 6.75 \text{ }^\circ\text{C/watt} \Rightarrow \Delta T_{rise} = 47.25 \text{ }^\circ\text{C}$$

As the converter is rated to operate to 100°C, the maximum ambient temperature=100°C-47.25°C or 52.75°C (≅53°C). This is called the free air (natural convection) max ambient temperature.

Now assume our maximum system ambient temperature (Tambmax) is 75°C. This means the converter temperature must be reduced by 17°C (75°C - 53°C= 17°C) in order for the converter to operate at 65 watts out in a 100°C ambient temperature. Keep in mind general component derating. The converter is a component and should be de-rated from both a temperature standpoint as well as from a power distribution standpoint.

Calculating the heatsink properties required to reduce the case temperature by 17°C can be accomplished in the same manner as above. About 7 watts must still be dissipated, but the temperature rise must be kept within 17°C.

The new thermal impedance required=( $\theta_{has}$ ) = 17°C/7 watts=2.5°C/watt. This means that the heat sink must be capable of 2.5°C/watt maximum including any junction impedance between the converter and the heat sink. Hence thermal interface materials such as grease or thermal pads are used.



**Figure 1. Thermal derating curves for 100W converter, (A) Pout vs. Case Temperature or (B) Percent Output Power vs. Case Temperature**

## Conclusion

DC/DC converters have a lot to offer in the form of tightly regulated output voltages, efficiencies that make battery management feasible, and reduced size allowing an overall compact system design. The market for devices demanding extremely low source voltages is growing. While using low input voltages is not a new technology, it raises strikingly different challenges than those exhibited by higher voltage sources. By carefully assessing the thermal parameters of prospective DC/DC converters', the power design engineer is one step closer to selecting the optimal converter for their system designs.

## How can we help you?

To speak with our power supply and conversion specialists, contact us any time at 888-597-9255 or [sales@wallindustries.com](mailto:sales@wallindustries.com). We can't wait to power your success.

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