Inselkammerstraße 10
D-82008 Unterhaching
Tel: +49 (0)89 614 503 10
Fax +49 (0)89 614 503 20
E-Mail: power@hy-line.de
URL: www.hy-line.de

Gründenstrasse 82
CH-8247 Flurlingen
Tel: +41 (0)52 647 42 00
Fax +41 (0)52 647 42 01
E-Mail: power@hy-line.ch
URL: www.hy-line.ch

# Thermal Management Design Resources

for Vicor ChiP Products

Written by: Gary Gill
Director, VI Chip Product Line
March 2014

VICOR

## Overview

Two key factors in maximizing power converter performance and successful power system design are thermal environment and heat management. Power densities are increasing faster than power converter efficiency; thus increased performance from thermal management solutions is required.

Products based on Vicor's new ChiP packaging technology are optimized for both electrical and thermal performance. ChiP products are:

- Designed with power components on both sides of the PCB to reduce losses due to parasitics, to spread heat evenly throughout the whole package, and to take advantage of both top and bottom surfaces for heat removal
- Encapsulated in a thermally enhanced molding compound which reduces temperature differentials and provides flat module top and bottom surfaces for ease of use with thermal management accessories (heat sinks, cold plates, heat pipes, etc.). This approach also offers increased thermal management flexibility as either the top or bottom surfaces of the module can be used for thermal management. For maximum performance, both surfaces can be utilized resulting in the industry's highest power density.

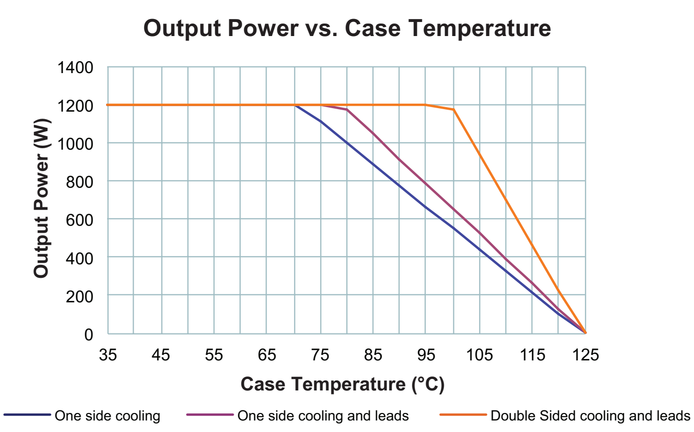
To help power system designers fully leverage the thermal management benefits of the ChiP packaging technology, Vicor offers product, online design tools, and thermal management accessories which simplify a customer's thermal design process.

## Product Data

For every ChiP product, Vicor provides thermal de-rating curves. These curves provide thermal de-rating guidelines for thermal management configurations in which the top of the converter is cooled, the top plus the leads are cooled, or the top, bottom and leads are all cooled. For example, below is the de-rating curve for Vicor's recently announced BCM380P475T1K2A30 380 V to 48 V BCM® (Bus Converter Module).

Figure 1.

BCM380P475T1K2A30 derating guidelines (see datasheet)



These curves indicate that the full rated power of the BCM (1200 W) can be processed provided that the top, bottom, and leads are all held below 95°C. Similarly, if only the top surface is thermally managed, then the top must be held below 70°C in order for the BCM to process full power without derating. These curves highlight the benefits of dual sided thermal management, but also demonstrate the flexibility of the Vicor ChiP platform for customers who are limited to cooling only the top or the bottom surface. In addition to de-rating curves, Vicor also provides estimates for the thermal resistance between the ChiP power modules hottest internal point and the three primary thermal interfaces (top, bottom, and leads). Again, using the BCM380P475T1K2A30 as an example, the following thermal resistances are provided in the data sheet:

Table 1.

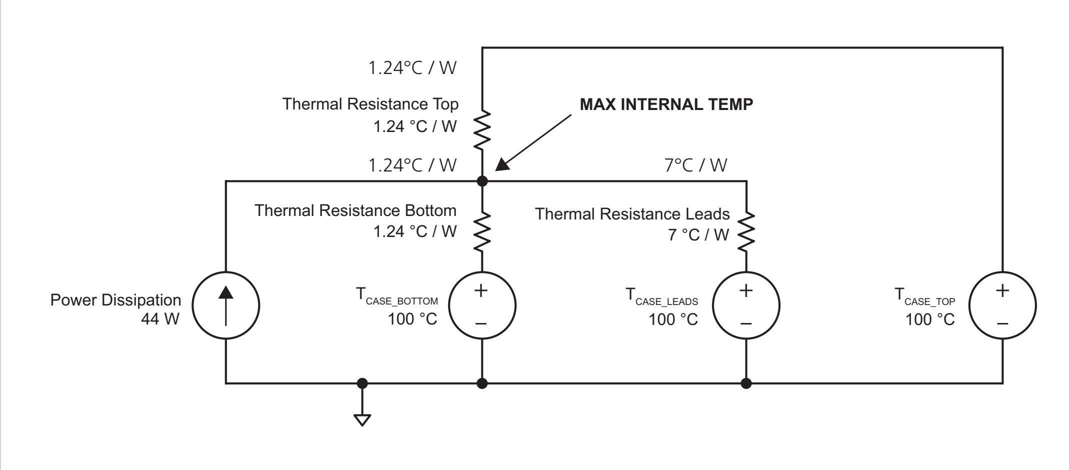
BCM380P475T1K2A30 thermal resistances (see datasheet)

| Attribute | Symbol | Condition / Notes | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Thermal resistance top side | $\phi_{INT\text{-}TOP}$ | Estimated thermal resistance to maximum temperature internal component from isothermal top | | 1.24 | | °C/W |
| Thermal resistance leads | $\phi_{INT\text{-}LEADS}$ | Estimated thermal resistance to maximum temperature internal component from isothermal leads | | 7 | | °C/W |
| Thermal resistance bottom side | $\phi_{INT\text{-}BOTTOM}$ | Estimated thermal resistance to maximum temperature internal component from isothermal bottom | | 1.24 | | °C/W |

These thermal resistances can be used in the equivalent circuit model shown below to estimate heat flows and the BCM's internal temperature.  Please see the ChiP product's data sheet for further details and examples.

Figure 2.

ChiP equivalent circuit thermal model (see datasheet)

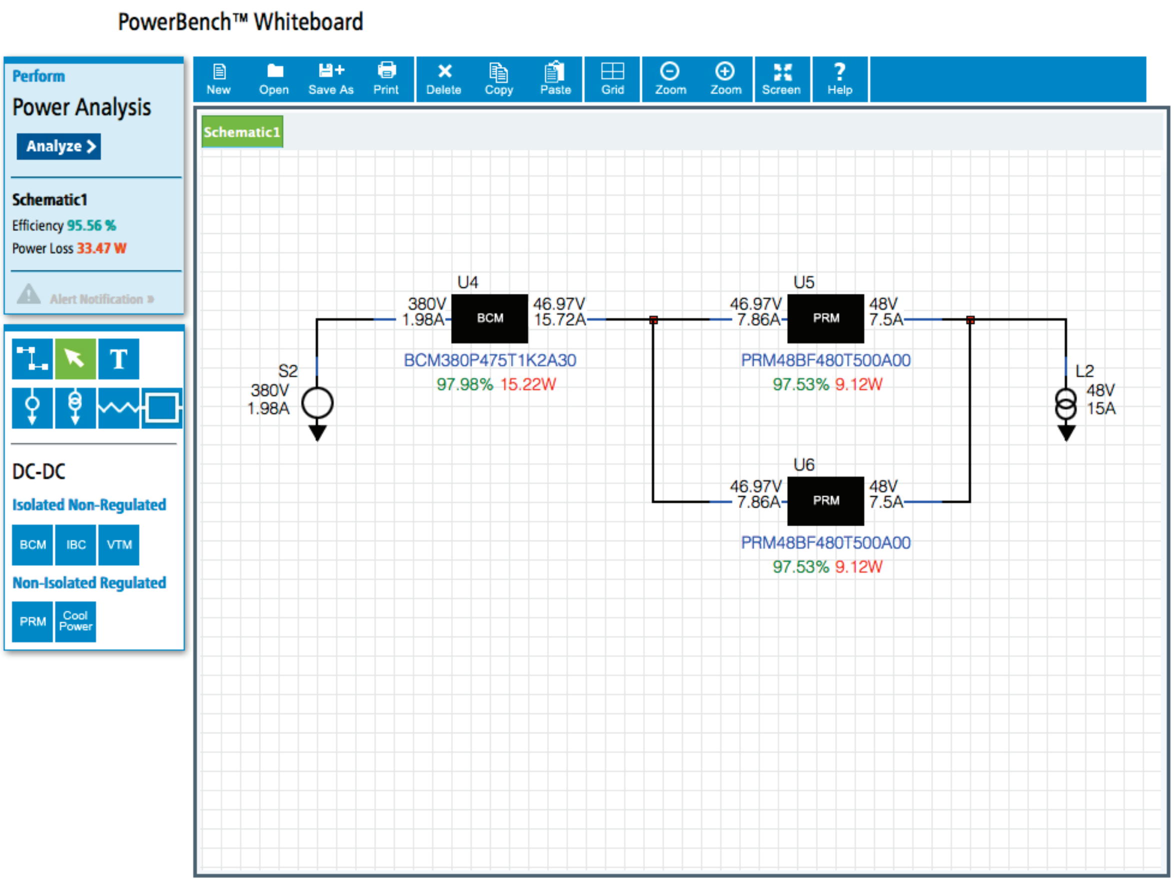


## Online Design Tools

In addition to the data described above, Vicor also offers online tools to help customers evaluate and design in ChiP products. For power system architecture planning, Vicor's PowerBench™ Whiteboard offers an intuitive and easy to use tool for evaluating the power dissipation and efficiency of a multi-converter power system. With a simple and familiar schematic capture interface, the user can construct a power system, using Vicor products, with sources, loads and distribution resistances to determine expected power dissipations of each converter which can then be used for thermal management planning. Below is an example of a power system architected with multiple Vicor power modules evaluated with the PowerBench Whiteboard.

Figure 3.

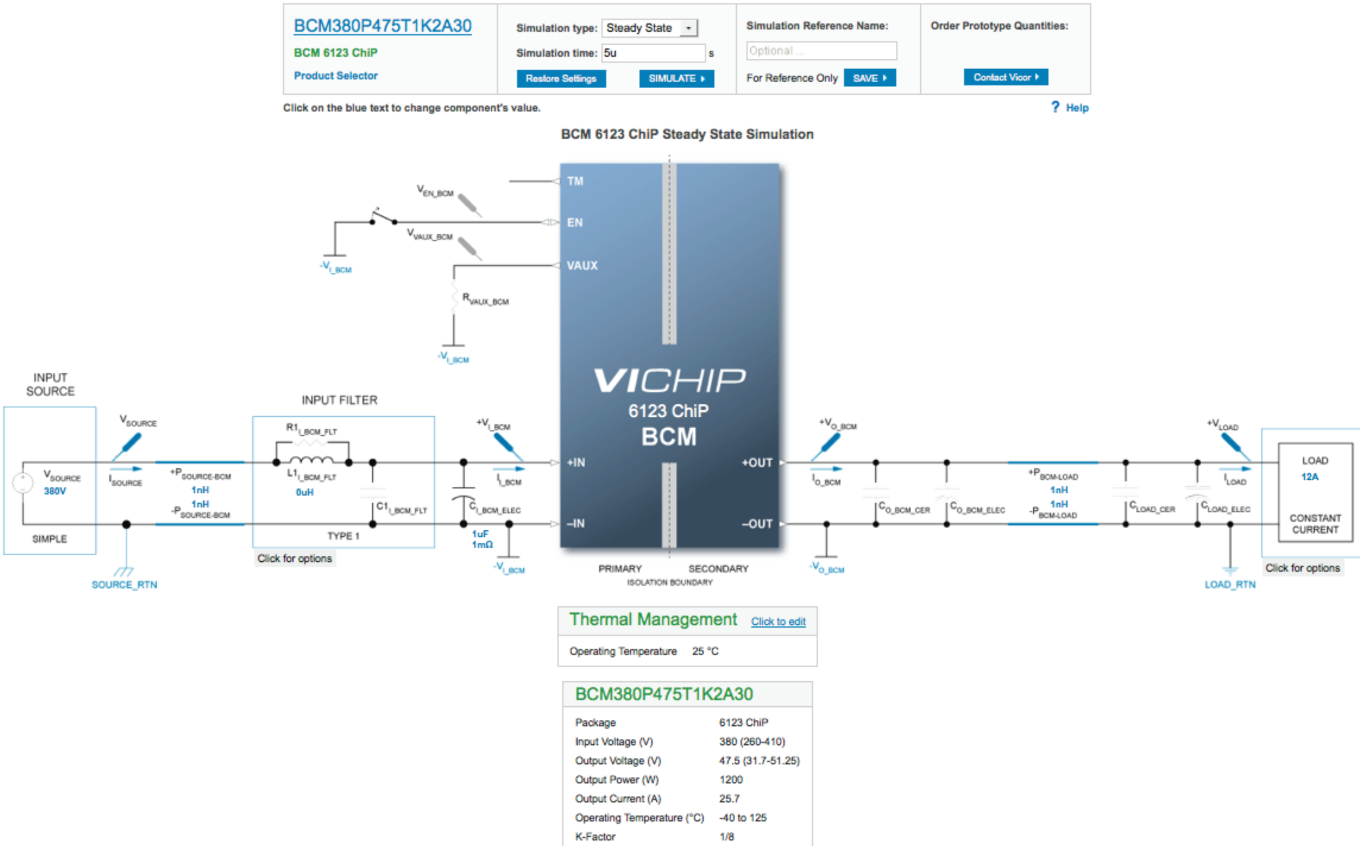
Vicor PowerBench Whiteboard Example




While the PowerBench Whiteboard is an excellent tool for quickly architecting a power system design, Vicor also offers a full featured online simulator which allows a customer to evaluate a component's electrical and thermal performance. The PowerBench Simulator analyzes the converter under a range of situations (startup, steady state, $V_{IN}$ or load steps) in a typical reference design. Figure 4 shows the simulation tool with the BCM380P475T1K2A30 displayed.

Figure 4.

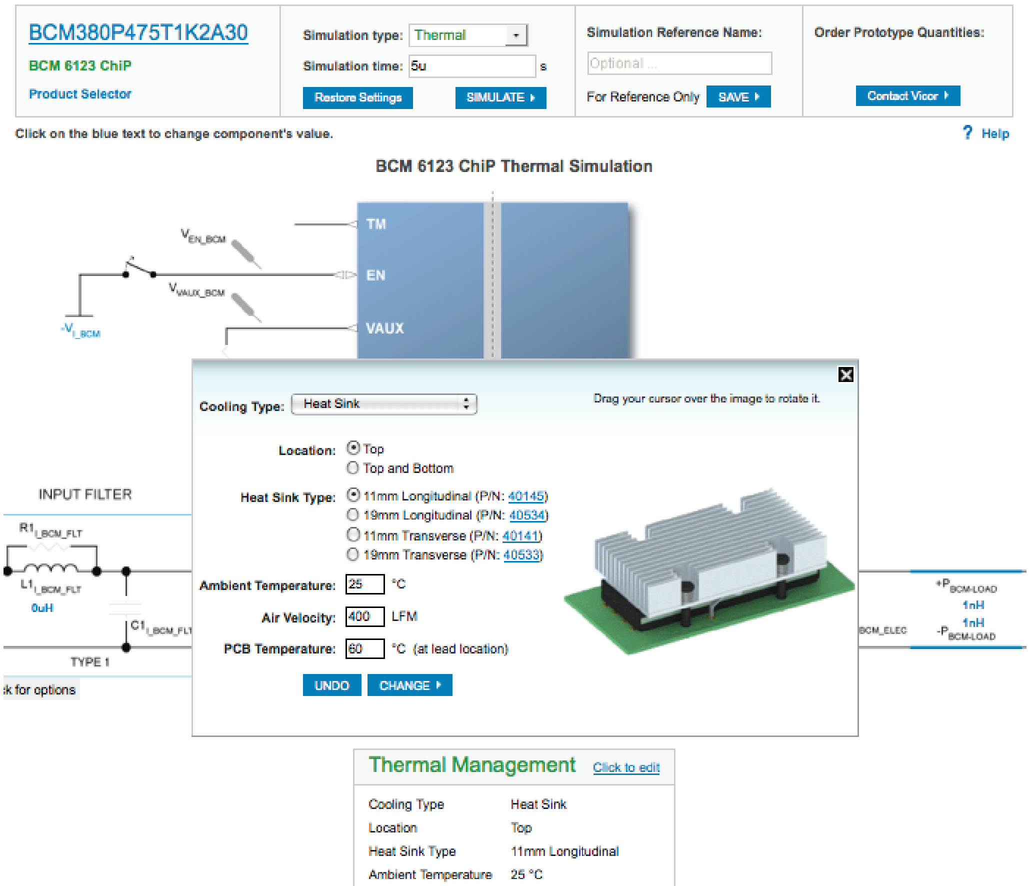
Vicor PowerBench Simulator

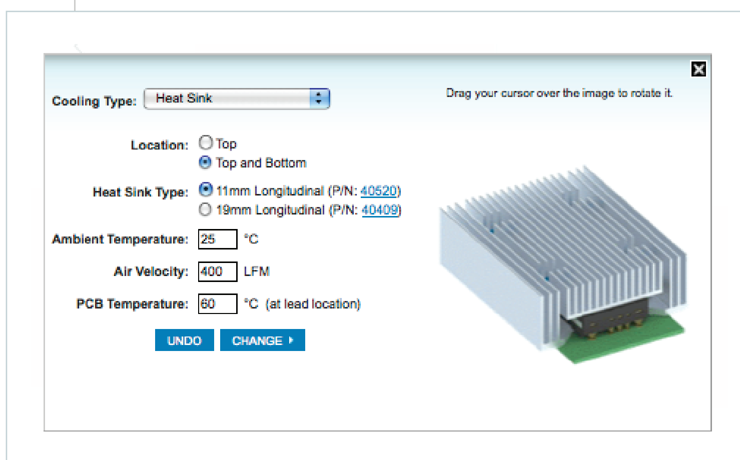



In the simulation tool, the input source, output load, input filter, output filter, as well as various parasitic effects can be modified by the customer to reflect actual design conditions. For thermal simulation, the tool allows the user to select from a range of recommended thermal management options including top side heat sink, top and bottom side heat sinks, or a cold plate. The user can also specify the thermal environment by selecting ambient temperature, air velocity, and thermal interface conductivity.

Figure 5.

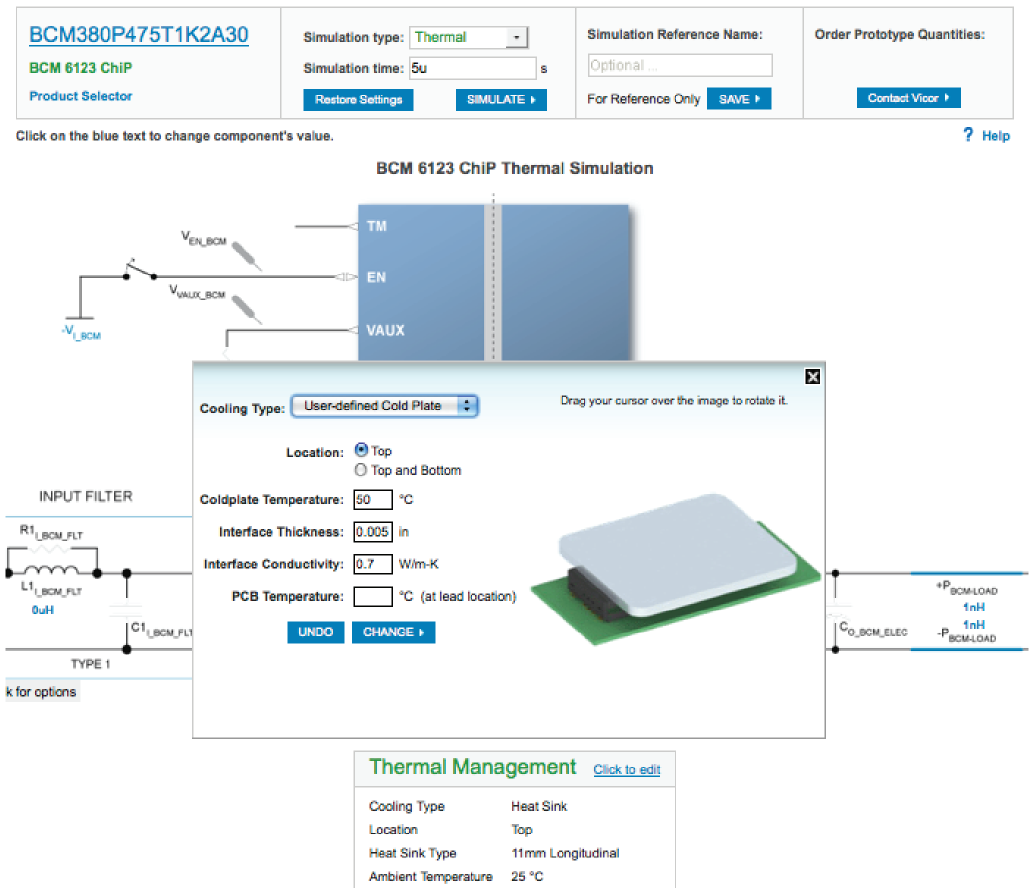
PowerBench Simulator Thermal Management Configurator (with top side heat sink selected)




PowerBench Simulator Thermal Management Configurator (with dual-sided heat sink selected)

Figure 6.
PowerBench Simulator Thermal Management Configurator (with cold plate selected)




Finally, in order to simplify customer thermal management design and evaluation, the recommended heat sinks modeled in the simulator are available for order (along with any associated hardware) from both Vicor and our distribution partners. Vicor provides mechanical drawings and assembly recommendations for these accessories as well.

## Summary

Vicor's new generation of power components based on the ChiP packaging platform offer levels of efficiency, power density and thermal management flexibility that were previously unavailable. To assist customers in realizing the full potential of this exciting new family of power converter modules, Vicor also offers an unmatched collection of product data, online design tools and thermal accessories which enable customers to quickly evaluate and implement designs built around Vicor's power component offerings.

## Converter housed in Package (ChiP) Platform

Vicor's ChiP platform sets best-in-class standards for a new generation of scalable power modules. Leveraging advanced magnetic structures integrated within High Density Interconnect (HDI) substrates with power semiconductors and control ASICs, ChiPs provide superior thermal management supporting unprecedented power density. Thermally-adept ChiPs enable customers to achieve low cost power system solutions with previously unattainable system size, weight and efficiency attributes; quickly and predictably. The advent of ChiPs www.vicorpower.com/promotions/Innovations-In-Power/ChiP_Technology/lp.php, embodies a modular power system design methodology enabling designers to achieve high performance, cost-effective power systems from AC or DC sources to the Point of Load using proven building blocks.