REFERENCE DESIGN | RD:701

NBM2317 YAMUNA2

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Introduction

This document describes the application system used for the Non-Isolated Bus Converter NBM™ products, specifically the NBM2317 in a 22.83 x 17.34 SM-ChiP package. Vicor offers the NBM2317 products listed below in Table 1 along with the respective evaluation board numbers used in the system.

Refer to the user guide UG:702 to learn how to operate the NBM2317 evaluation board.

Table 1
NBM2317 family

Evaluation Board Number	Product Number	Low-Side Current Rating
NBM2317E60D1580T0R	NBM2317S60D1580T0R	80A

Application System Description

The application system (YAMUNA2) includes an evaluation board intended to be an electrical reference design for the application of the NBM2317 products. The system incorporates forced convection cooling using a heat sink and other components available from Vicor; the heat sink kit is Vicor part number MB-EVAL-NBM2317-1X, and includes Items A through D listed in Table 2 below. Figure 1 below shows the assembled YAMUNA2 system.

Figure 1
YAMUNA2 application system assembly

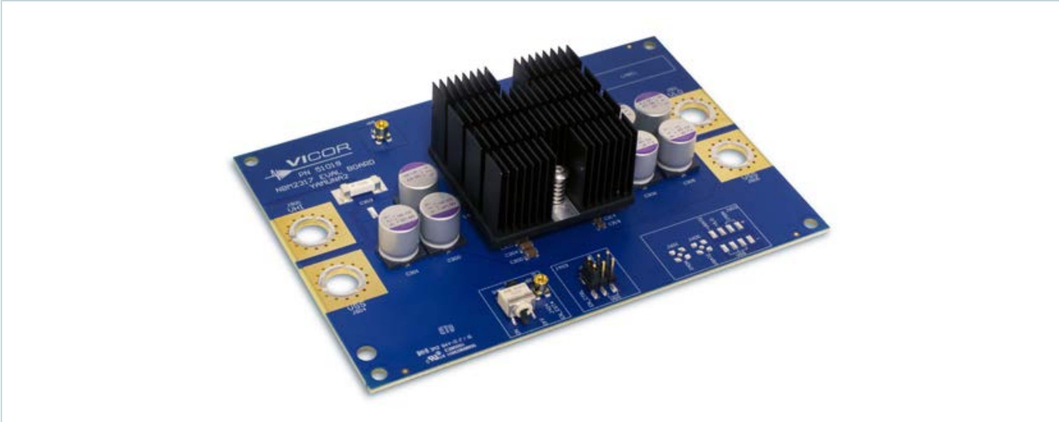


Figure 2 below shows an exploded view of the same system with individual parts referenced and listed below in Table 2. These parts are part of the application system offered from Vicor. The evaluation board comes with the heat sink mounting holes and the pre-installed PEM nuts, which makes the heat sink installation easy. Refer to the user guide UG-702 section on the heat sink installation to learn how to install the heat sink.

Figure 2
Exploded view of YAMUNA2 application system assembly

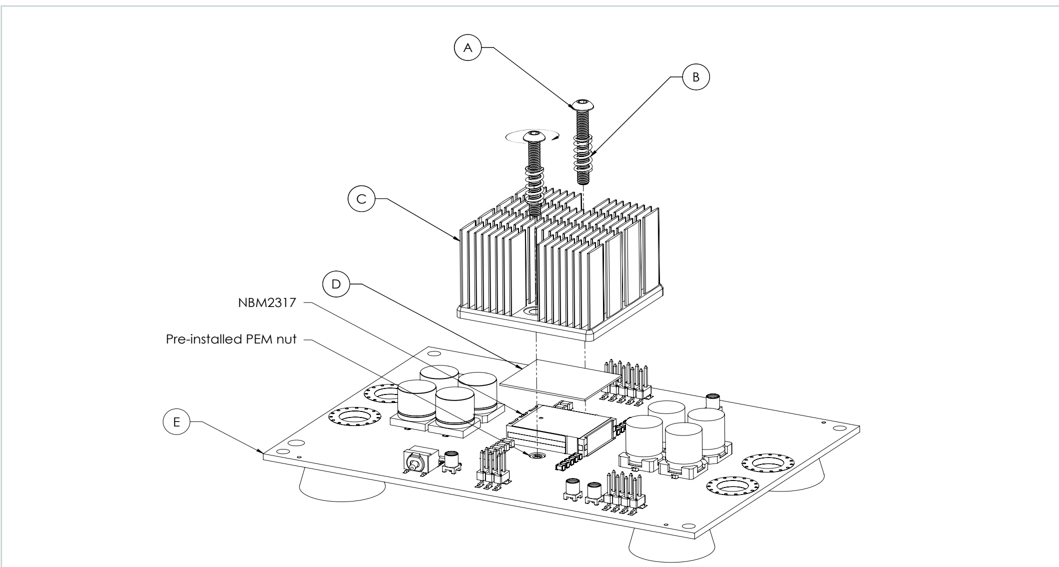


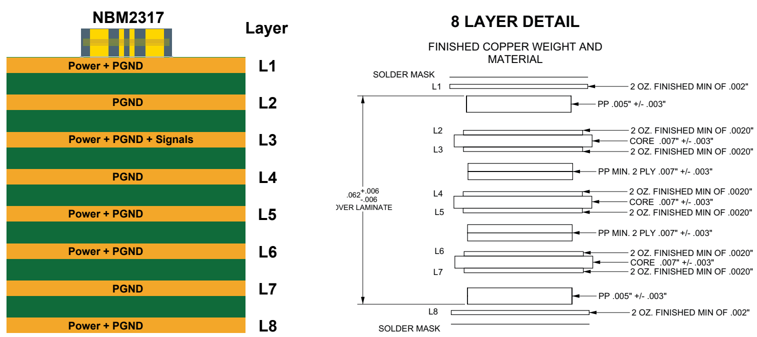
Table 2
YAMUNA2 application system part numbers

<table>
<tr><th>Reference Designator</th><th>Name</th><th>Description</th><th>QTY</th><th colspan="2">Part Number Vicor / MFR</th></tr>
<tr><td>A</td><td>Screw</td><td>M3 x 0.50mm thread, 22mm long, button head hex drive, passivated 18-8 stainless steel; McMaster-Carr</td><td>2</td><td>50326-22 / 92095A473</td><td rowspan="4">MB-EVAL-NBM2317-1X</td></tr>
<tr><td>B</td><td>Spring</td><td>Standard compression series, passivated stainless steel; Lee Spring</td><td>2</td><td>51052 / LC 026BB 03S</td></tr>
<tr><td>C</td><td>Heat Sink</td><td>HS 40 x 40 x 25 26CTC LONGITUDINAL MNT HOLE</td><td>1</td><td>51455</td></tr>
<tr><td>D</td><td>Thermal Interface Material (TIM)</td><td>SILTEL TIM PAD 25 x 20 x 0.5 THK; TIMTEL</td><td>1</td><td>50810 / SG-TC6.0</td></tr>
<tr><td>E</td><td>Evaluation Board</td><td>NBM2317 Application PCB</td><td>1</td><td colspan="2">51018</td></tr>
</table>

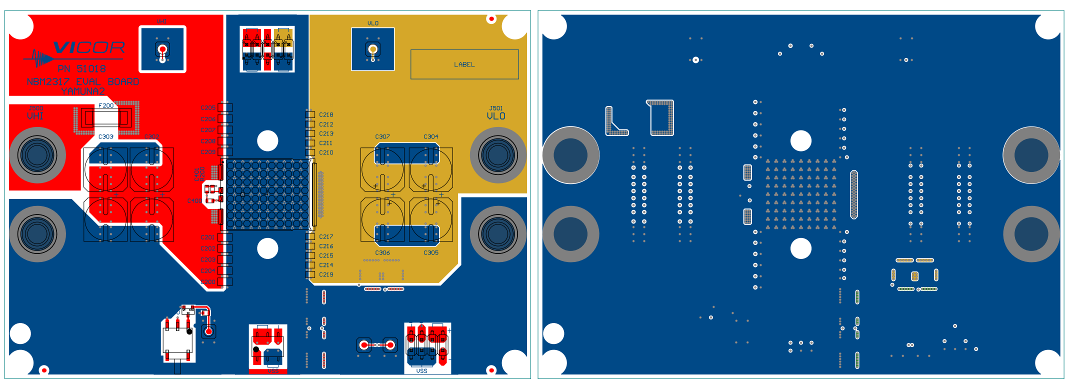
Application PCB

The YAMUNA2 Application System utilizes Evaluation Board number 51018 that is a printed circuit board (PCB) specifically designed for the NBM2317 product needs. It is a multi-layer board with a total of 8 layers. All the layers utilize 2 oz copper to provide high-current-carrying capability and also to help dissipate the heat generated by the NBM2317. Figure 3a shows the PCB layer stack up. Layers with the same net names are stitched with the through-hole vias to provide electrical connection between the same nets and also to improve the heat transfer. The area underneath the NBM product is the PGND power plane from Layer 1 through 8. Shown below in Figure 3b are Layer 1 and 2. Layers 3 through 8 are alternates of Layer 1 and Layer 2. These copper planes are interconnected using multiple vias in a pattern shown in Figure 3c that allows using the maximum number of vias underneath the NBM while allowing soldering the NBM module. Vias that are closer to the +VHI and +VLO pins essentially provide the same functionality as the PGND vias.

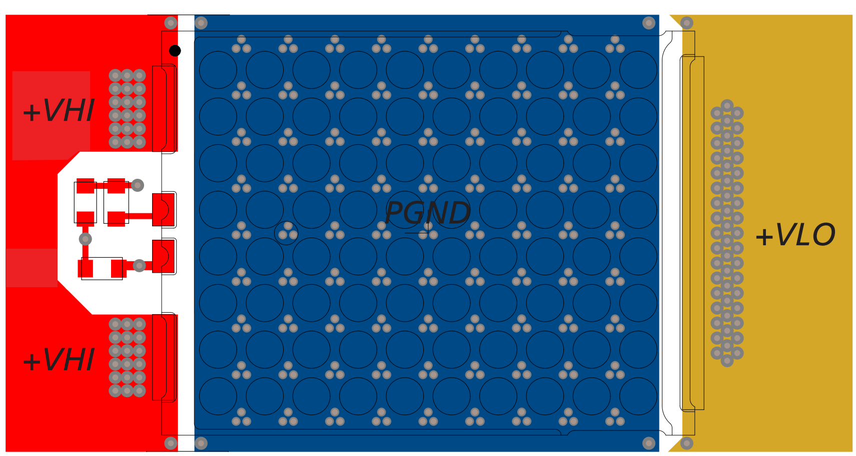
Figure 3
YAMUNA2 PCB information



(a) PCB stackup and layer detail



(b) PCB layer 1 (left), layer 2 (right)

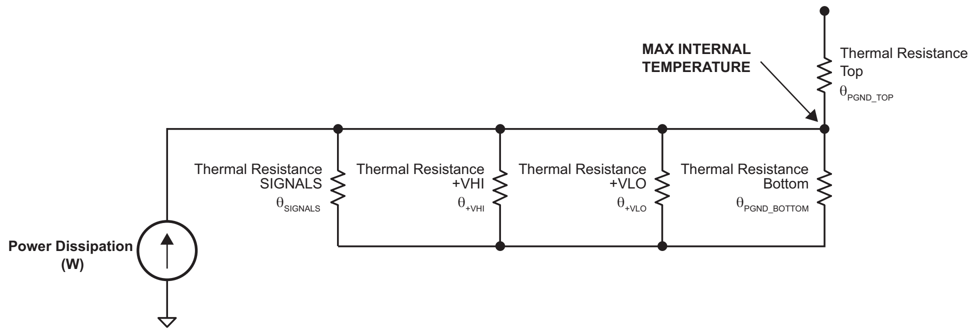


(c) Detail of vias

Application System Thermal Analysis

Application system thermal analysis was performed using the YAMUNA2 application system with evaluation board NBM2317E60D1580T0R, which utilizes the NBM2317S60D1580T0R product. Thermal analysis of the system is built on the NBM2317S60D1580T0R thermal circuit model, shown below in Figure 4 with the thermal resistances of the NBM2317S60D1580T0R. The thermal circuit model and the thermal resistances of the product are available in the product data sheet.

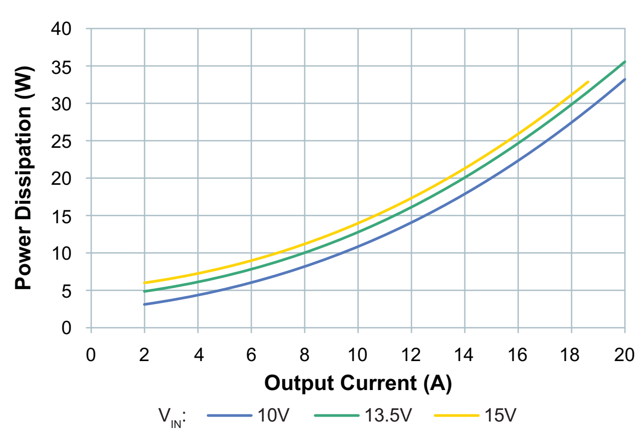
Figure 4
Thermal circuit model of NBM2317S60D1580T0R



Symbol	Thermal Impedance (°C / W)	Definition of Estimated Thermal Resistance
$\theta_{SIGNALS}$	57	from the hottest component junction inside the NBM to the circuit board it is mounted on at SIGNALS
θ_{+VHI}	19	from the hottest component junction inside the NBM to the circuit board it is mounted on at +VHI
θ_{+VLO}	7.2	from the hottest component junction inside the NBM to the circuit board it is mounted on at +VLO
θ_{PGND_BOTTOM}	2.0	from the hottest component junction inside the NBM to the circuit board it is mounted on at PGND_BOTTOM
θ_{PGND_TOP}	1.6	from the hottest component junction inside the NBM to the circuit board it is mounted on at PGND_TOP

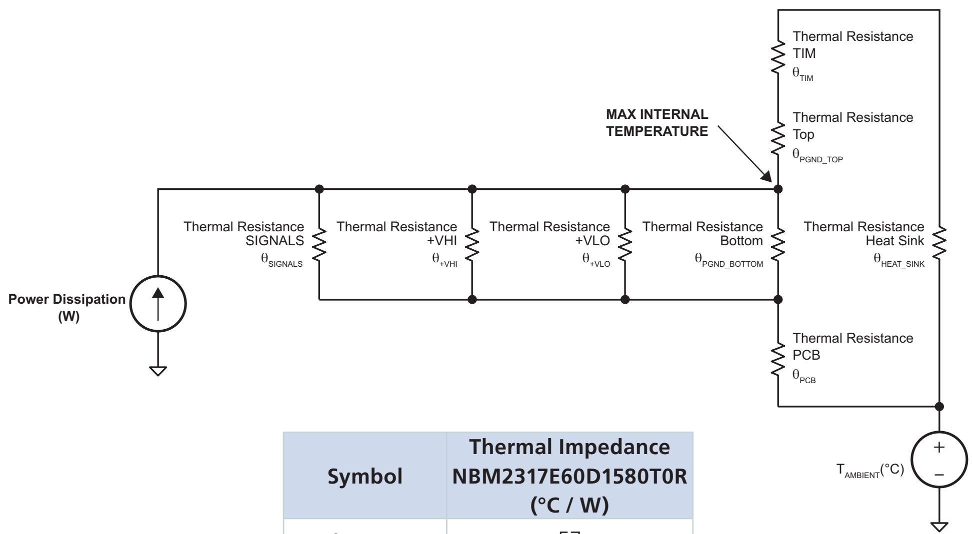
The product data sheet will also show the product power dissipation (W) that is utilized in the thermal circuit model as a function of output current and input voltage to the NBM2317.

Figure 5
Power dissipation vs. output current chart from NBM2317S60D1580T0R data sheet



Adding the heat sink (Item C from Figure 2), the thermal interface pad (TIM – Item D from Figure 2), and the evaluation board (Item E from Figure 2) to the thermal circuit model of the NBM2317S60D1580T0R results in the thermal circuit model shown in Figure 6 below.

Figure 6
Complete thermal circuit model of the evaluation board



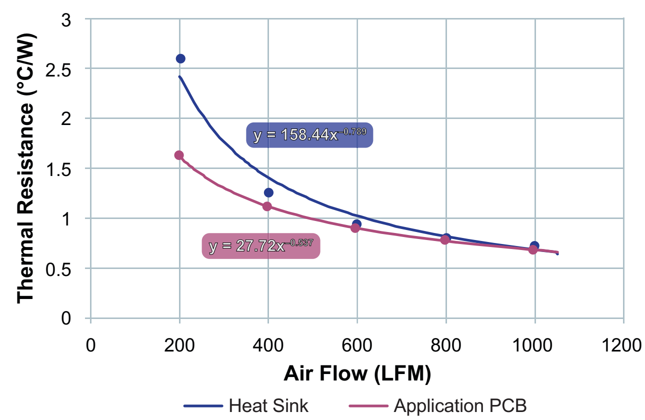
Symbol	Thermal Impedance NBM2317E60D1580T0R (°C / W)
$\theta_{SIGNALS}$	57
θ_{+VHI}	19
θ_{+VLO}	7.2
θ_{PGND_BOTTOM}	2.0
θ_{PGND_TOP}	1.6
θ_{TIM}	0.21

In this depiction of an analogous electrical system, resistances are in °C/W, electrical potential is in °C and the electrical source is the power dissipation of the NBM2317S60D1580T0R in watts. MAX INTERNAL TEMPERATURE in the circuit model is the maximum internal temperature of the NBM2317S60D1580T0R.

NOTE: For this NBM2317 only in the thermal cooling environment provided by the YAMUNA2 application system, the TM-reported temperature of the NBM2317S60D1580T0R can be used as an indication of the maximum internal temperature of the NBM2317.

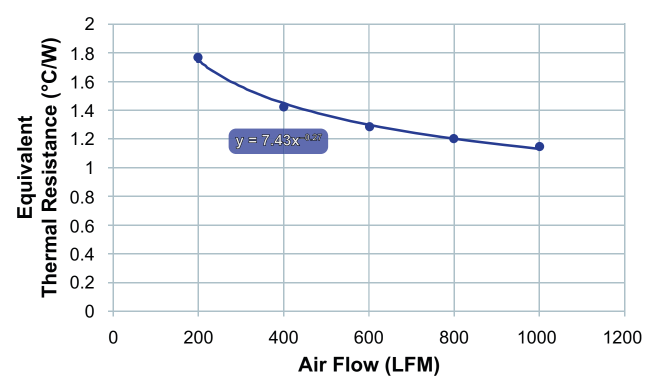
The YAMUNA2 is a forced convection cooled system that utilizes a customer-provided external fan to provide a flow of ambient temperature air across the heat sink and both sides of the evaluation board. As such, the thermal resistance of the evaluation board (θ_{PCB} in Figure 6) and the heat sink (θ_{HEAT_SINK} in Figure 6) are direct functions of the approach air velocity to the system as provided by the external fan. The thermal resistance in °C/W of both the evaluation board and the heat sink are shown in Figure 7 as a function of approach air velocity in linear feet per minute (LFM). These two resistance values at the appropriate LFM as provided by the customer-supplied external fan would be used for θ_{PCB} and θ_{HEAT_SINK} respectively in the complete thermal circuit model in Figure 6. The thermal interface pad (TIM) provides a thermal resistance value of 0.21°C/W. Thermal resistances of the application PCB and heat sink at other approach air velocities can be determined by the graph in Figure 7 below. The thermal resistance of the thermal interface pad will not change with changing approach air velocities.

Figure 7
Thermal resistance of YAMUNA2 application PCB (51018) and heat sink (51455)



The overall thermal circuit of the YAMUNA2 system can be further simplified to one equivalent thermal resistance as a function of approach air velocity. In this simplification, the YAMUNA2 equivalent thermal resistance is the difference between the maximum internal temperature of the NBM2317 and the ambient temperature in °C, divided by the total power dissipation of the NBM2317 in watts as determined by its operating line and load condition. Figure 8 below shows this equivalent thermal resistance as a function of the approach air velocity.

Figure 8
Equivalent thermal resistance of YAMUNA2 application system (NBM2317E60D1580T0R) vs. approach air velocity



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