

Configuring the Vicor BCM with low power ni-POLs

By Johnny Yuen, David Berry, Patrick Kowalyk, Gabe Pietromonaco, Tom Curatolo *Applications Engineering Group*

Introduction

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| <i>Introduction</i> | 1 | This Application Note describes basic design practices for using Vicor’s Bus Converter Module (BCM) as an Intermediate Bus Converter (IBC), providing a bus voltage to non-isolated Point-of-Load converters (niPOLs). The focus of this app note is on power systems of 300 W or less (multiple BCM configurations will accommodate higher power levels). |
| <i>Summary</i> | 2 | Let’s first review the differences between a Distributed Power Architecture and an Intermediate Bus Architecture. |
| <i>Conclusion</i> | 5 | Fig.1 shows a typical distributed architecture in which a 48 V bus provides power to DC-DC converters. Depending on the application, this distribution system may have some drawbacks. Multiple isolated DC-DC converters duplicate the isolation function and consume an excess of valuable PCB real estate. If niPOLs are used, their efficiency in converting 48 V to voltages of 5 V or less is typically in the 70% range. Fig. 2 shows an Intermediate Bus Architecture (IBA) in which the 48 V bus is again used, in this case to power a Vicor 48 V to 12 V (K=1/4) BCM. The K=1/4 refers to the fixed ratio or voltage transformation ratio of the BCM. The IBA approach has some advantages over the 48 V distribution scheme shown in Fig.1, but this advantage can be application dependent. |

Figure 1
Typical Distributed Power Architecture

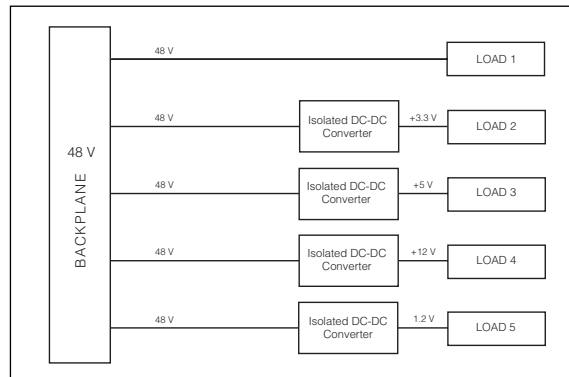
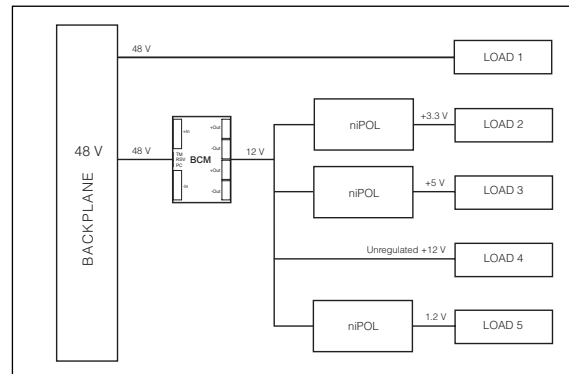


Figure 2
Typical Intermediate Bus Architecture



The niPOLs within IBA forego isolation and high-ratio voltage transformation in order to improve cost effectiveness, and they depend upon a nearby bus converter to supply isolated power at a low voltage.

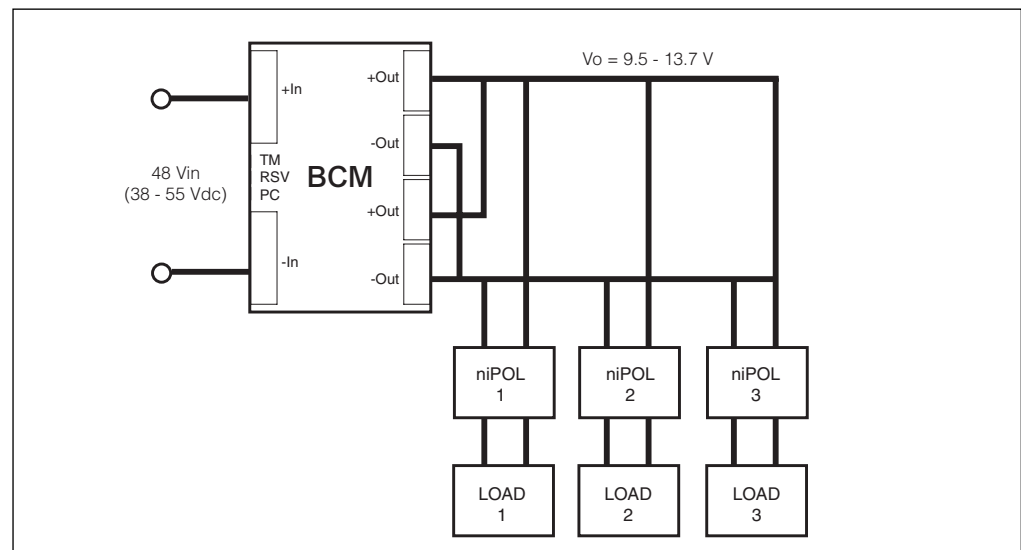
The 48 V to 12 V ($K = 1/4$) BCM can be placed at the power entry point on the board. This will provide safety isolation from the higher 48 V backplane voltage as well as free up board space at the point-of-load.

The system architect needs to take into account the lowest BCM input voltage and the negative impedance of the niPOLs when determining the number of niPOLs a BCM can drive. This precaution is necessary to ensure that the BCM will not be in current limit during startup or low line conditions.

Summary

IBA separates the DC-DC converter functions of isolation, transformation, and regulation and allocates them to two devices. In Fig. 3, the BCM provides voltage transformation and isolation, and the niPOL converter provides the tight load regulation. High system efficiency is maintained because of the exceptionally high conversion efficiency of the BCM along with the reduced step-down ratio required by the niPOL. Efficiency above 95% for the BCM is realized because the BCM does not regulate output voltage, it provides a fixed-ratio output. IBA systems use less board space than an isolated brick converter solution by eliminating multiple isolation barriers included in isolated converters.

Figure 3
The input range to the BCM is 38 – 55 Vdc which corresponds to an output range of 9.5 – 13.7 Vdc.



The small size of niPOL converters complement today's high density packaging designs, with vertical-mount versions presenting a very small footprint while making effective use of forced-air cooling. Fast load transients are handled effectively by the niPOL converters since the niPOL can be placed very close to the load. This also reduces the possibility of noise injection in other circuit functions on the same board.

If appropriate consideration is given when partitioning the system loads for operation from niPOL converters, power up sequencing may be tailored to each circuit section or load device. Additionally, there can be fewer board layers because multiple voltages no longer need to traverse the entire board. BCMs inherently support current-sharing, allowing parallel operation without additional control circuitry or interconnects.

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The BCM uses a new power conversion technology called Sine Amplitude Conversion (SAC), which provides the capability of realizing higher efficiency, greater power density of 1095 W/in³ (compared to 168 W/in³ in a quarter brick), and faster transient response. See the BCM data sheets that are available on the Vicor web page for more information:

vicorpower.com/products/vichip/bcm

To the right is a comparison of a typical open frame Quarter-brick to Vicor's BCM.



Faster transient response means that less energy storage is required downstream. The BCM power train offers a unique capacitance multiplication feature. The effective output capacitance is 16x the input capacitance when a BCM with K of 1/4 is used. This means significantly less capacitance need be added downstream of the BCM. Since energy stored in a capacitor is $1/2 CV^2$, a small amount of capacitance at the 48 V input to the BCM has the same effect as the bulky capacitance typically added to the 12 V input of the downstream niPOLs. This is also complemented by the lower input and output noise of SAC technology, resulting in a significant reduction in filtering.

To observe the effect of the BCM's capacitance multiplication feature and dynamic performance, several niPOLs from different manufacturers were tested to compare the performance with their recommended capacitance versus with the equivalent capacitance placed on the input of the BCM. Figs. 6–9 show typical results. Figs. 4 and 5 define the test set ups.

Figure 4
Test set up 1 with niPOL
and recommended input
capacitance of 680 μ F.

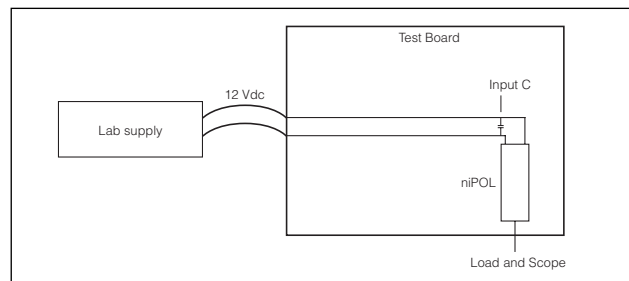
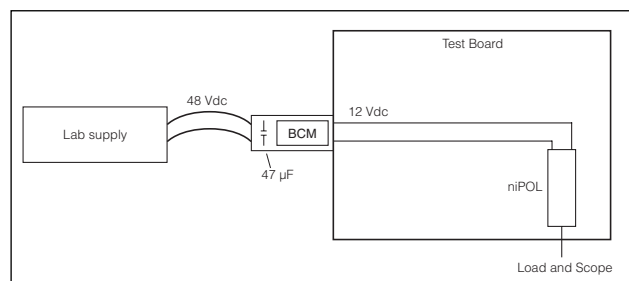


Figure 5
Test set up 2 with BCM and 47
 μ F of input capacitance.



Shown are scope plots of the transient response and output ripple for the niPOL part number S151-1220330-BB from C&D/Celestica Technologies. The load step is from 10% to 90% of the rated current (1.5 A to 13.5 A) at a rate of 0.5 A/ μ S. The output ripple measurement was taken with 330 μ F of output capacitance at full load (15 A).

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As can be observed from the figures, the transient response and output ripple of both systems are nearly identical. This demonstrates the manufacturer's recommended input capacitance for the niPOL can be replaced with significantly less capacitance at the BCM input without degradation of performance. Both set ups do have defined PCB trace impedance from the board edge to the niPOL. Greater trace impedance may even require additional input capacitance at the input of the niPOL. With the capacitance multiplication feature of the BCM, the 47 μF of input capacitance is the equivalent of 752 μF of output capacitance for a K of 1/4.

In many applications, the PCB trace impedance to the niPOL can vary; therefore, it is necessary to evaluate the system with reduced capacitance. The input capacitance of the niPOL can be replaced with an equivalent source impedance. This equivalent source impedance would consist of four parameters: the reduced input C, trace impedance, BCM output impedance, and BCM input capacitance reflected to the output.

Figure 6
Transient response
in set up 1

Top waveform:
niPOL output
Bottom waveform:
load current

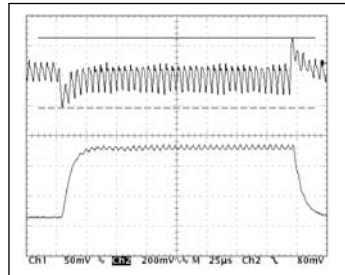


Figure 7
Transient response
in set up 2

Top waveform:
niPOL output
Bottom waveform:
load current

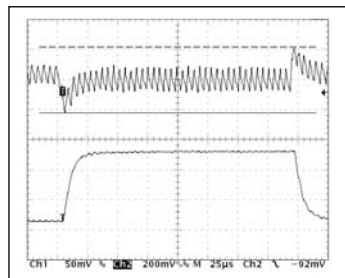


Figure 8
Output ripple in set up 1
with 330 μF of niPOL
output capacitance

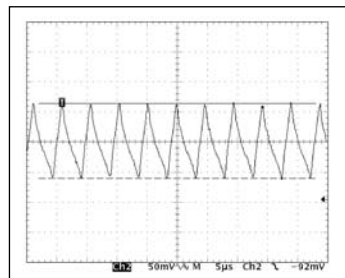
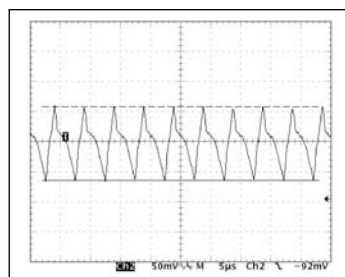


Figure 9
Output ripple in set up 2
with 330 μF of niPOL
output capacitance



Conclusion

Using Intermediate Bus Architecture incorporating Vicor's BCMs and off-the-shelf niPOL converters can be an efficient and cost effective power solution. The high conversion frequencies and fast transient response of Vicor's BCM allow the system architect to take advantage of the capacitance multiplication feature. Any capacitance placed at the input to the BCM will be as effective as $1/K^2$ times this capacitance at the output of the BCM (input to the niPOLs) up to ~800 kHz. In some cases, it may be advantageous to add the input capacitance to the niPOL as well as capacitance on the input of the BCM so the combination of the two reflect the manufacturer's recommended capacitance.

It is important to ensure that the output capacitance of the BCM does not exceed the maximum value listed on the BCM data sheet.

Of course, as in any power system design with dynamic loads, layout and PCB trace impedances must be taken into consideration. Any trace inductance that is realized between the output of the BCM and the input of the niPOL will affect dynamic performance. It is especially important to keep the input impedance to the BCM as low as possible so it can respond quickly to changes in load current.

| Vendor | Part Number | Mounting | Output Range / Current |
|----------|----------------|-------------------------|------------------------|
| National | LM2676-Adj | Thru / surface discrete | 1.2 – 37 @ 3 A max |
| National | LM2678-Adj | Thru / surface discrete | 1.2 – 37 @ 5 A max |
| C&D | S151-122033-BB | Thru hole | 3.3 @ 15 A |
| C&D | LSM-1.8/10-D12 | Surface | 1.8 @ 10 A |
| C&D | LSN-1.8/10-D12 | Thru hole | 1.8 @ 10 A |
| C&D | NEF-0100181BO | Thru hole | 1.8 @ 10 A |
| Artesyn | PTH12010WAS | Surface | 1.2 – 5 @ 12 A |
| Tyco | NXA025ADJ | Thru hole | 0.8 – 5 @ 25 A |
| TI | PTH12010 | Thru hole | 1.2 – 5.5 @ 12 A |
| TI | PTH12050 | Thru hole | 1.2 – 5.5 @ 6 A |
| TI | PTH12060 | Thru hole | 1.2 – 5.5 @ 10 A |

The following is a list of other niPOLs that were tested in similar set ups. Contact Vicor Applications Engineering for the test results. Tel: 800.927.9474 or email: apps@vicor.com