DC/DC Converters For Industrial Applications

Electronic components are designed and manufactured with specific performance characteristics tailored to their target application environments. These environments are segregated based on how harsh they are and what sort of reliability they require.

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The Industrial Environment

The “commercial” space is the least demanding, with temperature ranging from 0° C to 70° C and relatively lax reliability expectations. At the other end of the spectrum are “military” grade components, with temperatures ranging from -55 °C to 125 °C and extremely strict requirements for radiation tolerance, shock, moisture, and the like. In between these two extremes one can find a handful of niche application spaces, among which the “industrial” grade components find their home.

In addition to a -40 °C to 85° C operating temperature range, one of the most important characteristics of industrial components is their voltage tolerance. This is especially important for DC/DC converters, which are required to handle a wide input voltage range and switch it down to the more common 5 V and 3.3 V rails. Typical industrial voltage inputs include 60 V, 48 V, and 24 V. Industrial components also carry specifications for ingress and physical handling. Many are IP67 rated, which specifies a high level of ingress protection against dust and water. Vibration ratings may also specify that a product can be in an environment that moves or shakes and will survive temporary or constant oscillation.

Lastly, an often overlooked feature of many industrial components is a 10-year supply guarantee. Since these components are likely to be deployed into environments that are difficult to service, the overall product lifecycle is generally quite long. Ensuring a plentiful supply of replacement devices provides a competitive advantage by guaranteeing a long serviceable life.

ROHM offers a wide range of DC/DC converters specifically tailored to the requirements of industrial applications. The table below provides an overview of these ICs across their range of input and output voltages.

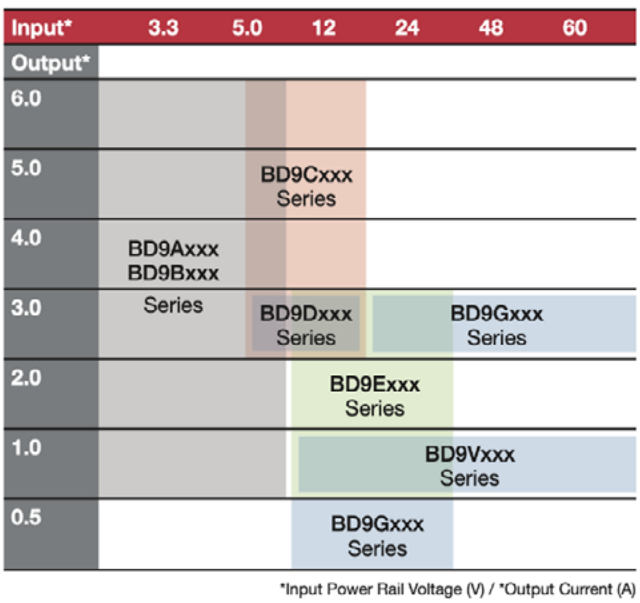

Figure 1: ROHM voltage converters for industrial input/output ranges

ROHM Technology

ROHM’s DC/DC converters employ two proprietary technologies to achieve best-in-class performance -- Nano Pulse Control™ and QuiCur™. Nano Pulse Control is a DC/DC switching technology that offers the industry’s smallest pulse width of only 9 nanoseconds. This is 3-4X faster than the nearest competitor, as shown in the following figure.

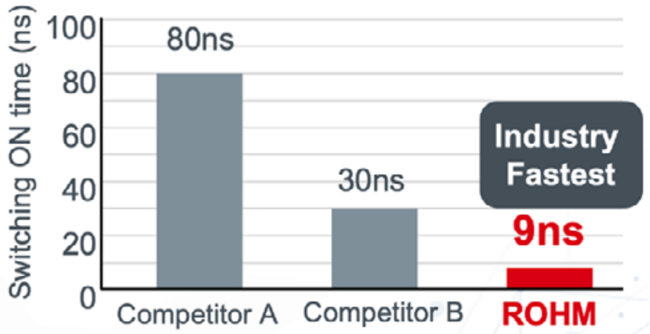

Figure 2: Reduced switching time enables large voltage conversion ratios

This miniscule pulse width allows ROHM’s DC/DC converters to handle large input to output voltage ratios, which is often required for industrial environments. With Nano Pulse Control, these converters can directly buck a 48 V input rail down to a 1 V output in a single stage. Competitive products, on the other hand, require an intermediate step and two separate conversion ICs.

QuiCur is another ROHM technology upon which their industrial DC/DC converters are built. It is a circuit level technique that solves several of the main problems plaguing feedback networks for maximum response performance. As shown in the figure below, this technology relies on introducing two dedicated error amplifiers. In particular, the second stage is critical as it uses a technique whereby its gain is scaled by the overall drive current. The result is

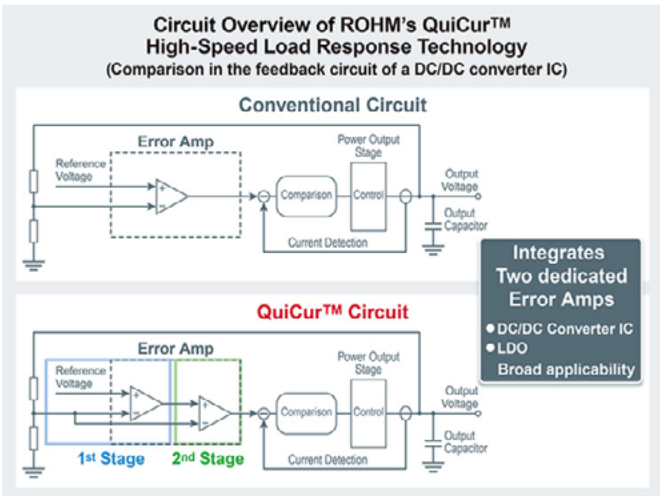

Figure 3: ROHM’s QuiCur circuit topology

a much more flexible frequency response, allowing the designer to choose between optimal stability, minimal undershoot, and reduced physical size.

By using ROHM's Nano Pulse Control and QuiCur technologies, designers can choose from a broad portfolio of DC/DC converters and LDO's for industrial applications ranging from high voltage/high current to space constrained, and everything in between.

High Voltage, High Current Solutions

Several common industrial applications start with high voltage AC mains or battery inputs in the range of 48 V to 60 V. As shown in the example below, EV charging stations often include an AC/DC module to provide a 60 V supply from 380 VAC mains. This 60 V rail must be bucked down to 12 V for both the interface circuitry and the high-voltage control circuitry. ROHM's BD9Gxxx series of regulators is able to reliably deliver this 5:1 conversion ratio in a single stage.

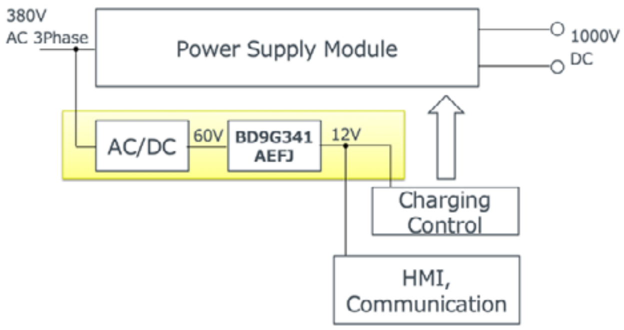

Figure 4: EV Charging Station

Similarly, electric bicycle (eBike) batteries based on Lithium chemistries provide DC outputs in the realm of 60 V. The eBike's supporting circuits, as shown in the figure below, include communication interfaces, high power gate drivers, and battery management modules, which can draw in excess of 3A of current at 5V. Once again, the ROHM BD9Gxxx series of DC/DC converters is the perfect choice for efficiently delivering this type of load current at such a high step down ratio.

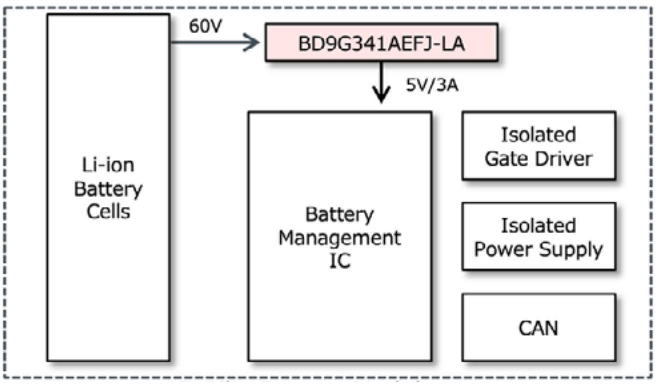

Figure 5: eBike Battery Interface

Space Constrained Solutions

For industrial applications where the input voltage is 24 V or less, but physical space is a premium commodity, ROHM's Nano Pulse Control and QuiCur technologies offer a significant leg up on the competition. This is due to the relative reduction in the size of supporting passives required for these DC/DC converters. The BD9Fxxx series is an excellent example and is compared to the traditional BD9Exxx series in the figure below. The required inductor size and package size yield an area benefit of over 70% while simultaneously offering an increased load current of 67%.

BD9F500QUZ / BD9E303EFJ comparison

	BD9F500QUZ	BD9E303EFJ
Package	VMMP16L3030 3.0 x 3.0 mm	HTSOP-J8 4.9 x 6.0 mm
Iout	5 A	3 A
Frequency	600 kHz / 1 MHz / 2.2 MHz	300 kHz
L value	1.5 µH - 4.7 µH	10 µH - 22 µH
L size	8.0 x 8.0 mm	10.0 x 10.0 mm

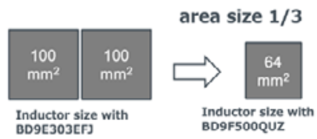

Figure 6: Area reduction due to smaller inductors and smaller IC package

In a similar vein, the improved efficiency of these devices results in less waste heat, in turn reducing the heat sink requirements for reliable operation. As shown in the figure below, the ROHM part operates nearly 35 degrees Celsius cooler than the competitor when pushing 4 A of current. The required heatsink, PCB stackup, and thermal planes will be much less expensive and require significantly less volume.

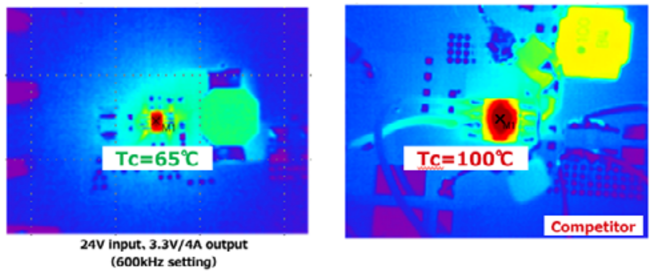

Figure 7: Improved thermal performance eliminates heat sink requirement

When considering QuiCur for improved frequency response, one potential design implication is the reduction of output capacitor size. As shown in the figure below, when stepping from 0.1 A to 3A, the ROHM part exhibits one third of the ripple compared to a competitor switching from a much smaller step. As a result, the designer may choose to reduce the output capacitor size by 70% for the same performance, and save in both space and cost.

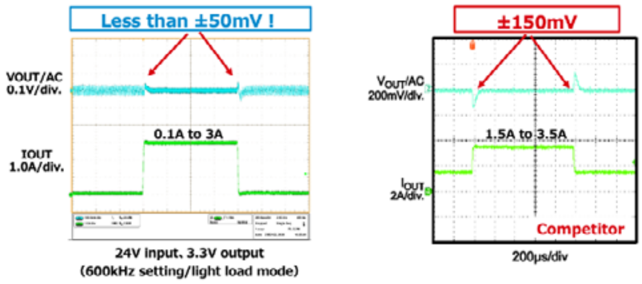

Figure 8: Fast transient response reduces output capacitor requirements

Conclusion

Industrial applications present a unique set of environmental constraints that commercial grade electronics components cannot survive in. Foremost among these are high input voltage and high temperature. ROHM's proprietary Nano Pulse Control and QuiCur technologies are at the heart of a suite of DC/DC converter products that thrive in these environments. They provide large input to output ratios, high performance frequency response, and an overall reduction in physical volume and supporting componentry. As such, these devices find themselves at the front end of many industrial systems and should be on the top of the designer's toolbox when tackling these challenging problems.

To learn more, visit: https://www.rohm.com/support/nano and https://www.rohm.com/documents/11303/9976301/Introduction_NewRelease_QuiCur-e.pdf

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