Technical Specification

BQ35211EEC60

330-365V	11V	60A	600W	4250V	Extended-Eighth Brick
Input	Output	Current	Power	Isolation	DC-DC Converter

The BQ35211EEC60 bus converter is a next-generation, board-mountable, isolated, fixed switching frequency DC-DC converter that uses synchronous rectification to achieve extremely high conversion efficiency. The Bus Qor series provides an isolated step down voltage from 352V to 11V intermediate bus with no regulation in a extended eighth-brick module. The BQ35211EEC60 converter is ideal for creating the mid-bus voltage required to drive standard DC-DC non-isolated converters.

BusQor®

BQ35211EEC60 Model

Operational Features

- High efficiency, 95% at full rated load current
- Delivers 60A full power with no derating up to 100°C case
- Operating input voltage range: 330-365V
- Fixed frequency switching provides predictable EMI
- No minimum load requirement

Control Features

- On/Off control referenced to input side
- Inherent current share (by droop method) for high current and parallel applications.

Safety Features

Pending

- UL 60950-1
- EN60950-1
- CAN/CSA-C22.2 No. 60950-1

Mechanical Features

- Extended Eighth-brick package
- Industry standard Eighth-brick pin-out configuration
- Size: .92"x2.62" (23.4x66.5 mm), height: 0.52" (12.7 mm)
- Total Encased weight: 2.2oz (63g)

Protection Features

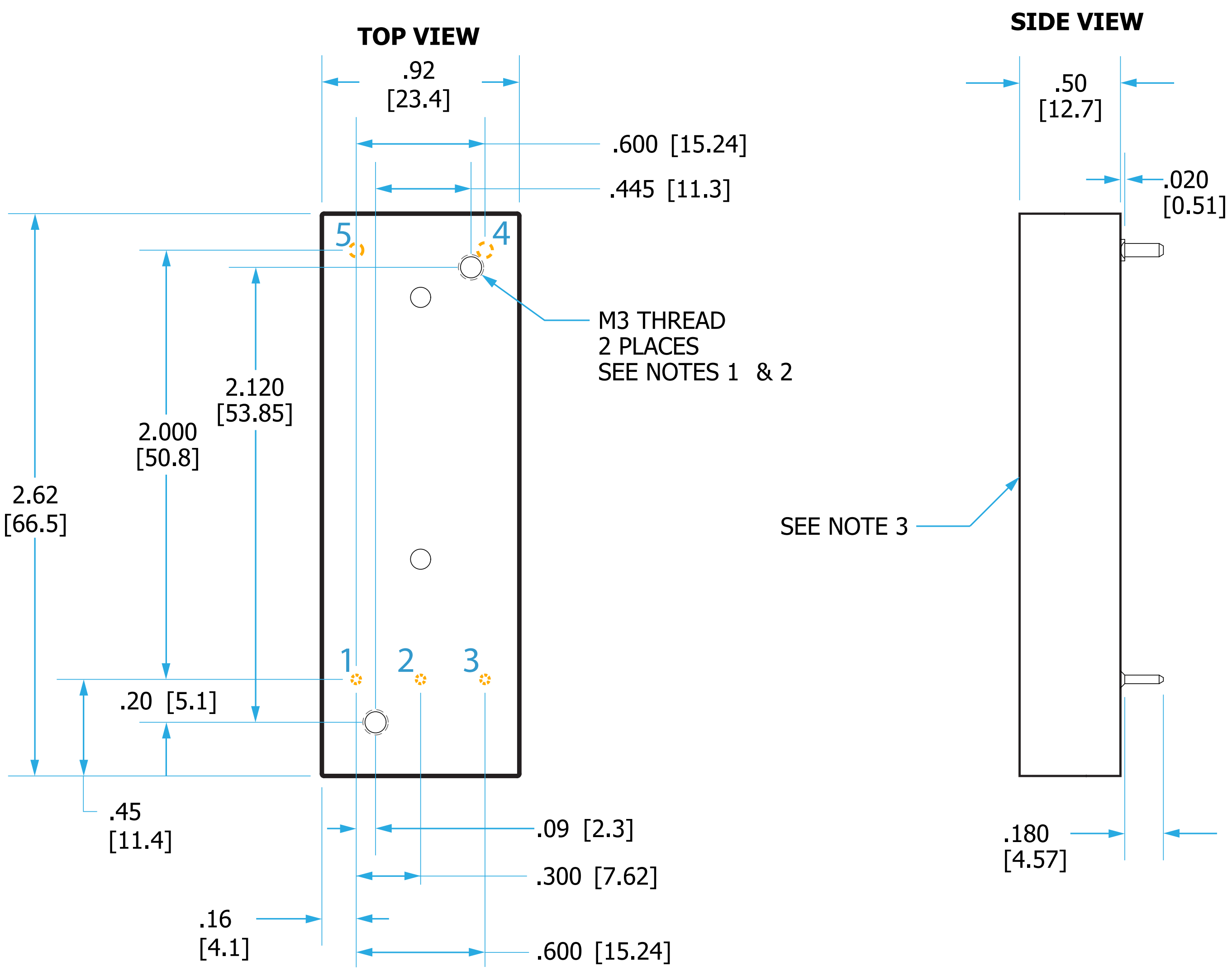
- Input under-voltage and over voltage lockout protection against abnormal input voltages
- Output current limit and short circuit protection (auto recovery)
- Thermal shutdown (auto recovery)

Contents

SynQor®

Encased Mechanical Diagram

Input: *330-365V*
Output: *11V*
Current: *60A*
Package: *EXT-Eighth Brick*



NOTES

1) M3 SCREWS USED TO BOLT UNIT'S BASEPLATE TO OTHER SURFACES SUCH AS HEATSINKS MUST NOT EXCEED 0.10" (2.54mm) DEPTH BELOW THE SURFACE OF THE BASEPLATE.
2) APPLIED TORQUE PER SCREW SHOULD NOT EXCEED 5in-lb (0.7Nm)
3) BASEPLATE FLATNESS TOLERANCE IS 0.004" (.10mm) TIR FOR SURFACE
4) PINS 1-3 ARE 0.040" (1.02mm) DIA. WITH 0.080" (2.03mm) DIA. STANDOFF SHOULDERS
5) PINS 4 & 5 ARE 0.062" (1.57mm) DIA. WITH 0.100" (2.54mm) DIA. STANDOFF SHOULDERS
6) ALL PINS: MATERIAL: COPPER ALLOY
FINISH: MATTE TIN OVER NICKEL PLATE
7) UNDIMENSIONED COMPONENTS ARE SHOWN FOR VISUAL REFERENCE ONLY
8) ALL DIMENSIONS IN INCHES (mm)
TOLERANCES: X.XX IN +/-0.02 (X.X mm +/-0.5 mm)
X.XXX IN +/-0.010 (X.XX mm +/-0.25 mm)
9) WEIGHT: 2.2oz (63g) TYP.

PIN DESIGNATIONS

Pin	Name	Function
1	Vin(+)	Positive input voltage
2	ON/OFF	Logic control ON/OFF
3	Vin(–)	Negative input voltage
4	Vout(–)	Negative output voltage
5	Vout(+)	Positive output voltage

BQ35211EEC60 Electrical Characteristics

Ta = 25 °C, airflow rate = 800 LFM, Vin = 352V dc unless otherwise noted; full operating temperature range is -40 °C to +100 °C base plate temperature with appropriate power derating. Specifications subject to change without notice.

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
ABSOLUTE MAXIMUM RATINGS					
Input Voltage					
Non-Operating	-0.5		600	V	Continuous
Operating			450	V	Transient, 100 mS; dV/dt < 0.5 V/µs
Isolation Voltage					
Input to Output			4250	Vdc	See Note 4
Input to Base-plate			2300	Vdc	See Note 4
Output to Base-Plate			2300	Vdc	See Note 4
Operating Temperature (Baseplate)	-40		100	°C	
Storage Temperature	-55		125	°C	
Voltage at ON/OFF input pin	-2		18	V	
INPUT CHARACTERISTICS					
Operating Input Voltage Range	330	352	365	V	Continuous
	330	352	410	V	Transient, 100 ms; dV/dt < 0.5 V/µs
Input Under-Voltage Lockout					
Turn-On Voltage Threshold		320		V	
Turn-Off Voltage Threshold		310		V	
Lockout Voltage Hysteresis		10.0		V	
Input Over-Voltage Shutdown				V	
Turn-On Voltage Threshold		410		V	
Turn-Off Voltage Threshold		420		V	
Maximum Input Current			2.0	A	Vin = 330 V
No-Load Input Current		25		mA	
Disabled Input Current		1.0		mA	
Input Reflected-Ripple Current		15	30	mA	RMS through 10µH inductor
Input Terminal-Ripple Current		250		mA	RMS, full load
Recommended Input Fuse (see Note 1)			10	A	Fast blow external fuse recommended
Recommended External Input Capacitance		2		µF	Typical ESR 0.1-0.2 Ω
Input Filter Component Values (L\C)		4.7\0.22		µH\µF	Internal values
OUTPUT CHARACTERISTICS					
Output Voltage Set Point		10.9		V	Vin = 352 V, Io = 0 A
Output Voltage Regulation					
Over Line		10.3\1.1		%\V	
Over Load		5.6\600		%\mV	
Over Temperature		2.8\300		%\mV	
Total Output Voltage Range	9.300		11.400	V	Over sample, line, load, temperature & life
Output Voltage Ripple and Noise					20 MHz bandwidth; see Note 2
Peak-to-Peak		250	400	mV	Full load
RMS		90		mV	Full load
Operating Output Current Range	0		60	A	Subject to thermal derating; Vin = 352 V
Output DC Current-Limit Inception		68		A	Vin = 352 V
Output DC Current-Limit Shutdown Voltage		8.5		V	Vin = 352 V
Back-Drive Current Limit while Disabled		20		mA	Negative current drawn from output
Maximum Output Capacitance			2,500	µF	10.4 Vout at 30 A Resistive Load
EFFICIENCY					
100% Load		95.0		%	
50% Load		95.9		%	

BQ35211EEC60 Electrical Characteristics (continued)

Ta = 25 °C, airflow rate = 800 LFM, Vin = 352V dc unless otherwise noted; full operating temperature range is -40 °C to +100 °C base plate temperature with appropriate power derating. Specifications subject to change without notice.

Parameter	Min.	Typ.	Max.	Units	Notes & Conditions
DYNAMIC CHARACTERISTICS					
Output Voltage during Load Current Transient					
Step Change in Output Current (0.1 A/µs)		250		mV	50% to 75% to 50% Iout max
Settling Time		100		µs	To within 1% Vout nom
Turn-On Transient					
Turn-On Time (with 2.5 mF output capacitance)		2.5	5	ms	Half load (resistive), Vout=90% nom.
Fault Inhibit Time		250		ms	Figure E
Output Voltage Overshoot		0		%	2.5 mF load capacitance
ISOLATION CHARACTERISTICS					
Isolation Voltage (dielectric strength)			4250	V	See Absolute Maximum Ratings; Note 4
Isolation Resistance		100		MΩ	
Isolation Capacitance (input to output)		N/A		pF	Note 3
Semiconductor Junction Temperature			125	°C	Package rated to 150 °C
Board Temperature			125	°C	UL rated max operating temp 130 °C
Transformer Core Temperature			125	°C	
Maximum Base-Plate Temperature, Tb			100	°C	
FEATURE CHARACTERISTICS					
Switching Frequency	240	250	260	kHz	
ON/OFF Control					
On-State Voltage	-1		0.4	V	
Off-State Voltage	2		18	V	
ON/OFF Control					Application notes Figure B
Pull-Up Voltage		5		V	
Pull-Up Resistance		82.5		kΩ	
Over-Temperature Shutdown OTP Trip Point	140		150	°C	Average PCB Temperature
Over-Temperature Shutdown Restart Hysteresis		10		°C	
RELIABILITY CHARACTERISTICS					
Calculated MTBF (Telcordia) TR-NWT-000332		TBD		10^6 Hrs.	80% load, 200LFM, 40 °C Ta
Calculated MTBF (MIL-217) MIL-HDBK-217F		TBD		10^6 Hrs.	80% load, 200LFM, 40 °C Ta

Note 1: Pending certification tests were carried out using 10A fast blow fuse. Fuse interruption characteristics have to be taken into account while designing input traces. User should ensure that Input trace is capable of withstanding fault currents

Note 2: For applications requiring reduced output voltage ripple and noise, consult SynQor applications support (e-mail: support@synqor.com)

Note 3: Isolation capacitance can be added external to the module (recommended).

Note 4: 1 minute for qualification test and less than 1 minute in production.

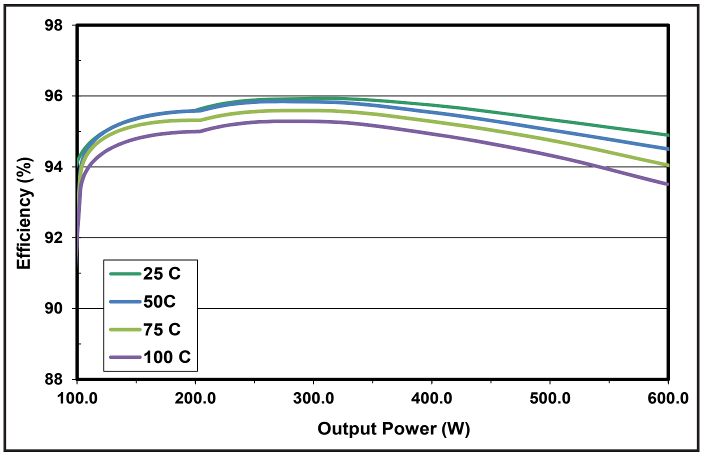


Figure 1: *Efficiency at nominal output voltage vs. output power for nominal input voltage at different case temperatures.*

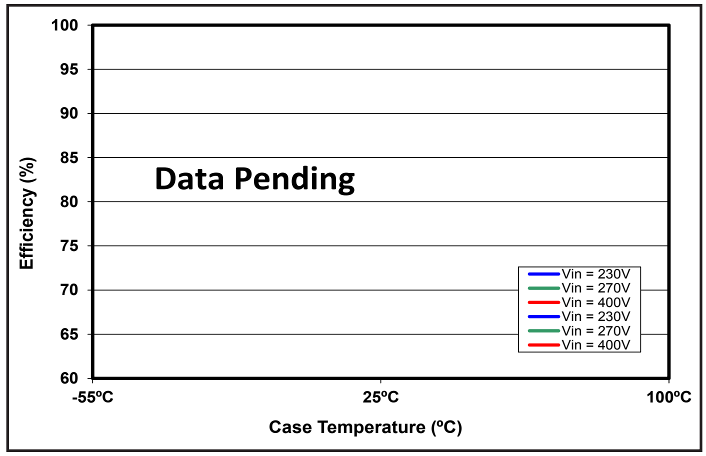


Figure 2: *Efficiency at nominal output voltage and 60% rated power vs. airflow rate for ambient air temperatures of 25°C, 40°C, and 55°C (nominal input voltage).*

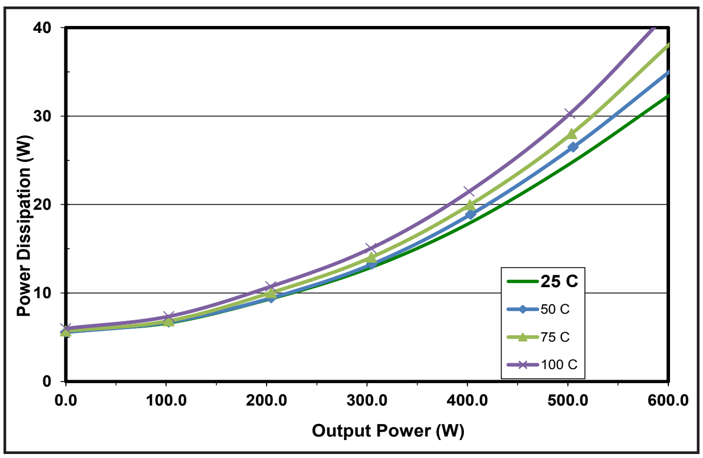


Figure 3: *Power dissipation vs. output power for nominal input voltage at different case temperatures.*

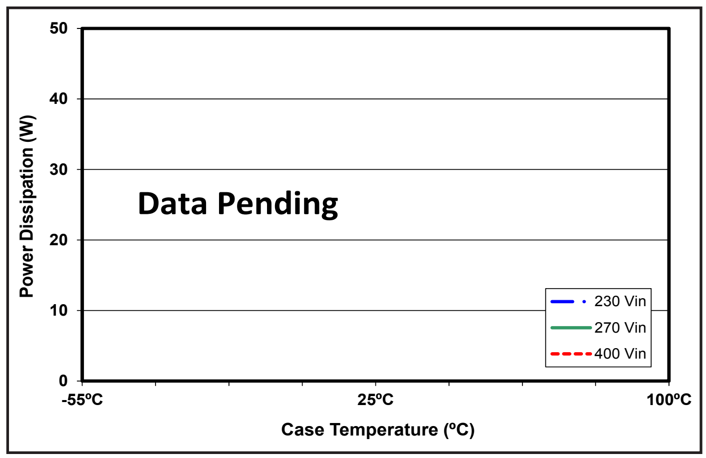


Figure 4: *Power dissipation at nominal output voltage and 60% rated power vs. airflow rate for ambient air temperatures of 25°C, 40°C, and 55°C (nominal input voltage).*

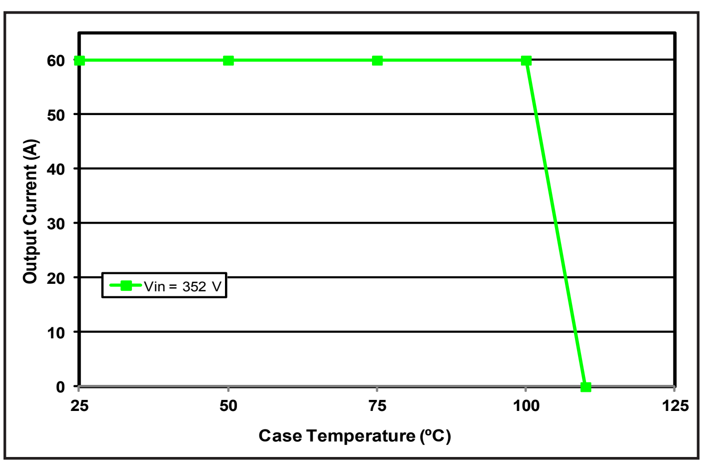


Figure 5: *Maximum output power vs. case temperature at nominal input voltage.*

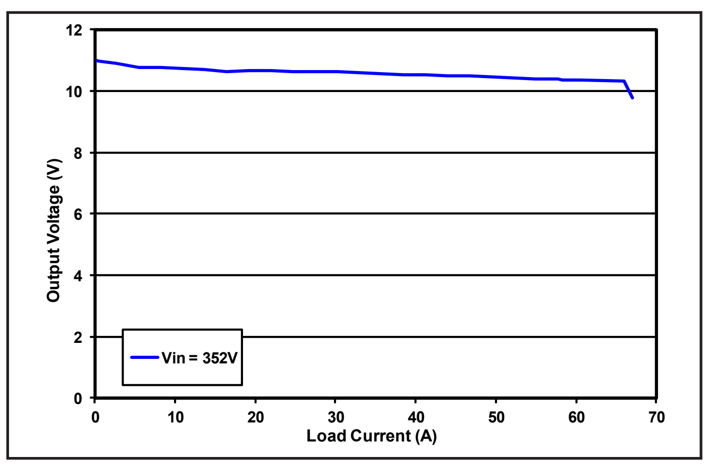


Figure 6: *Output voltage vs. load current, current limit curve for nominal input voltage at TCASE=25°.*

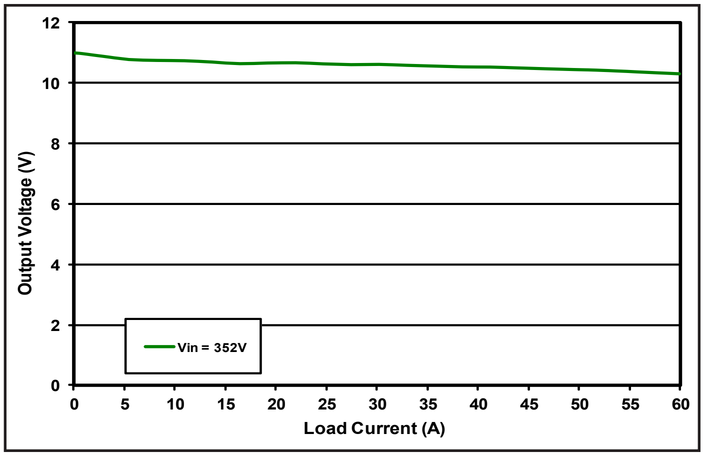


Figure 7: *Output voltage vs. load current, regulation curves for nominal input voltage at TCASE=25°C.*

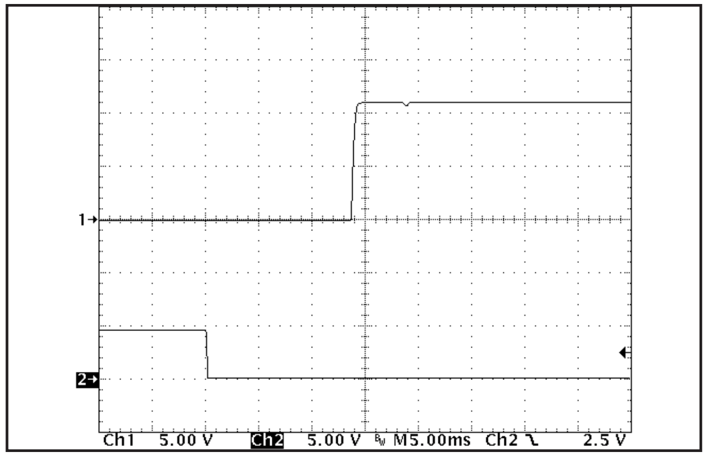


Figure 8: *Turn-on transient at no load and zero output capacitance initiated by ENA. Input voltage pre-applied. Ch 1: Vout (5V/div). Ch 2: ENA (5 V/div).*

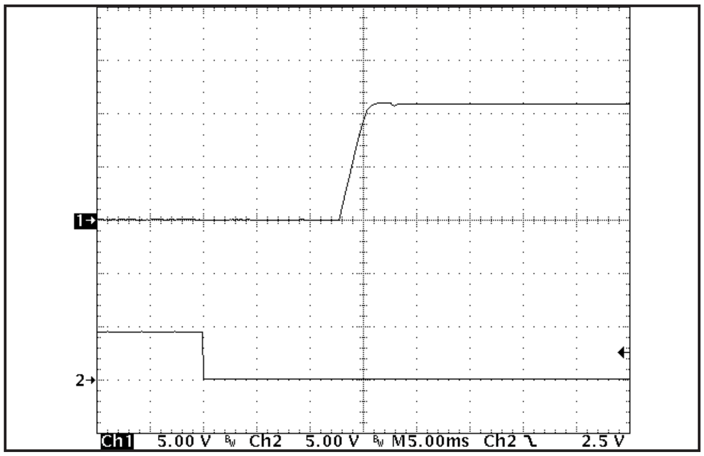


Figure 9: *Turn-on transient at no load and 2.5 mF output capacitance initiated by ENA. Input voltage pre-applied. Ch 1: Vout (5V/div). Ch 2: ENA (5 V/div).*

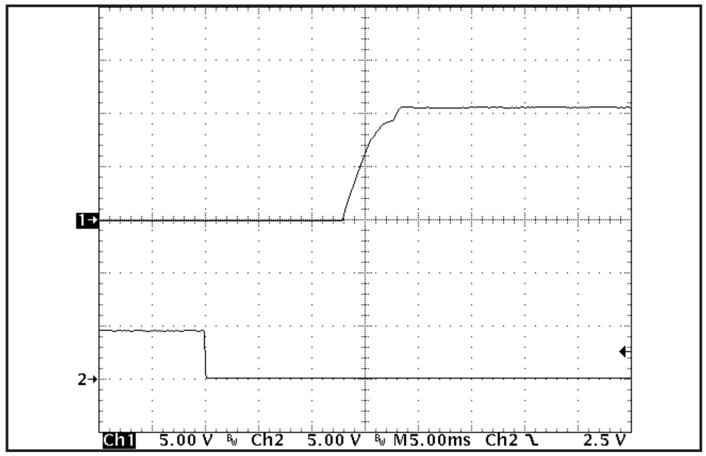


Figure 10: *Turn-on transient at half resistive load and 2.5 mF output capacitance initiated by ENA. Input voltage pre-applied. Ch 1: Vout (5V/div). Ch 2: ENA (5 V/div).*

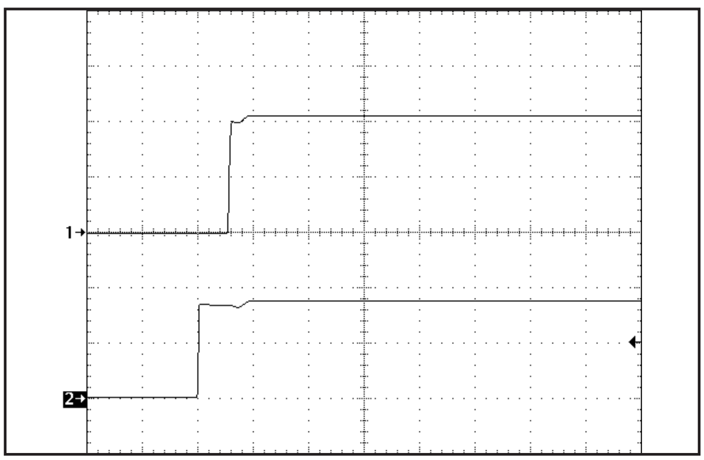


Figure 11: *Turn-on transient at half resistive load and 2.5 mF output capacitance initiated by Vin. ENA previously high. Ch 1: Vout (5V/div). Ch 2: Vin (200 V/div).*

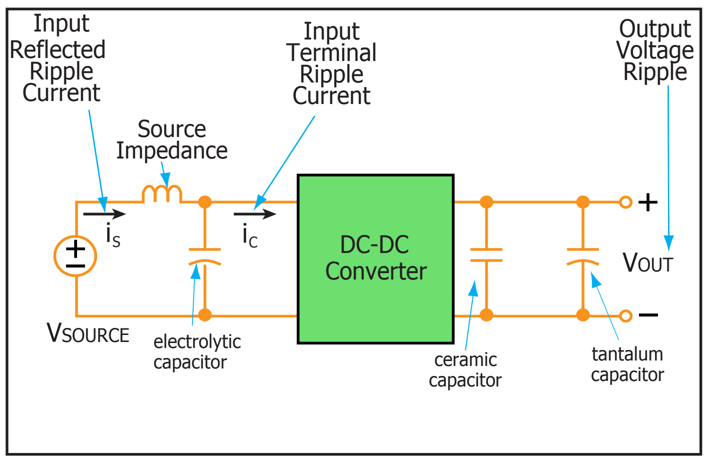


Figure 12: *Test set-up diagram showing measurement points for Input Reflected Ripple Current (Figure 15), Input Terminal Ripple Current (Figure 16) and Output Voltage Ripple (Figure 17).*

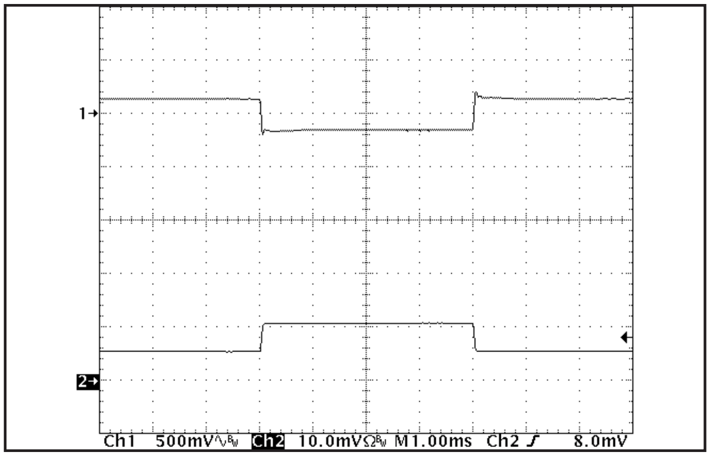


Figure 13: *Output voltage response to step-change in load current 50%-100%-50% of Iout (max). Load capacitance: 1uF ceramic and 10uF 100mΩ ESR tantalum. Ch1: Vout (500mV/div). Ch 2: Iout (50A/div).*

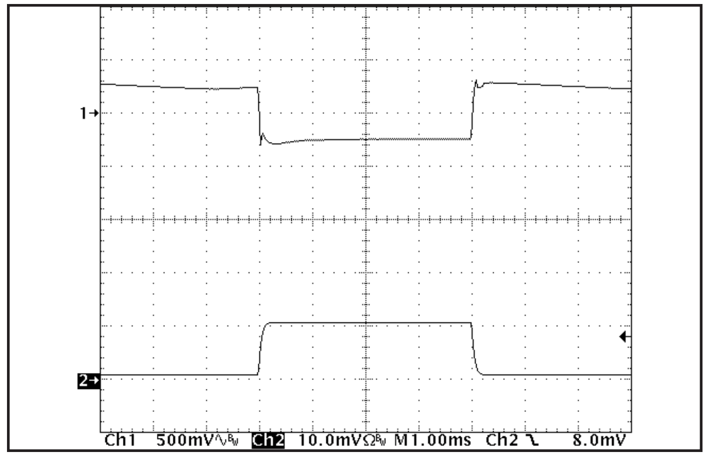


Figure 14*: Output voltage response to step-change in load current 10%-100%-10% of Iout (max). Load capacitance: 1uF ceramic and 10uF 100mΩ ESR tantalum. Ch1: Vout (1V/div). Ch 2: Iout (50A/div).*

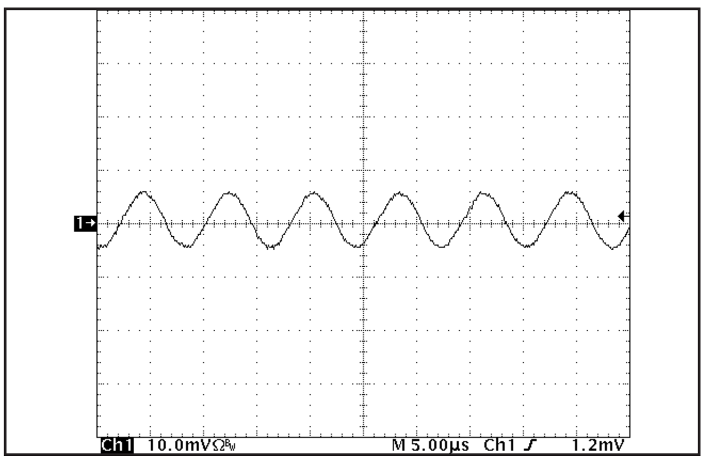


Figure 15: *Input reflected ripple current, is, through a 10 µH source inductor, using a 47µF electrolytic input capacitor (100mA/div). See Figure 12.*

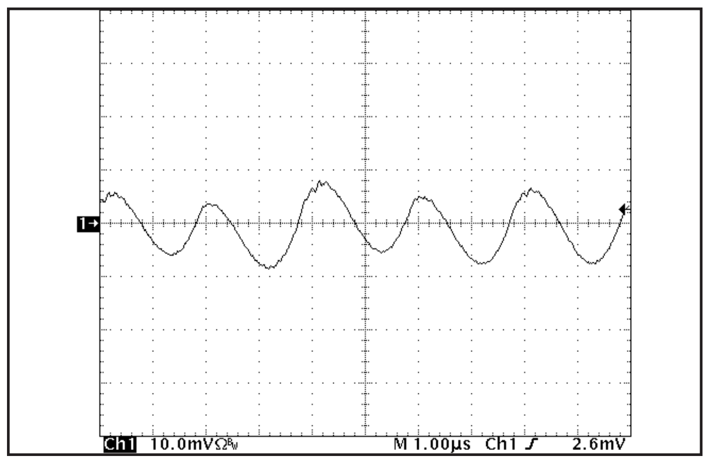


Figure 16: *Input terminal ripple, ic, at nominal input voltage and full load (200mA/div). Bandwidth: 20MHz. Load capacitance: 1uF ceramic and 10µF 100mΩ ESR tantalum capacitor. See Figure 12.*

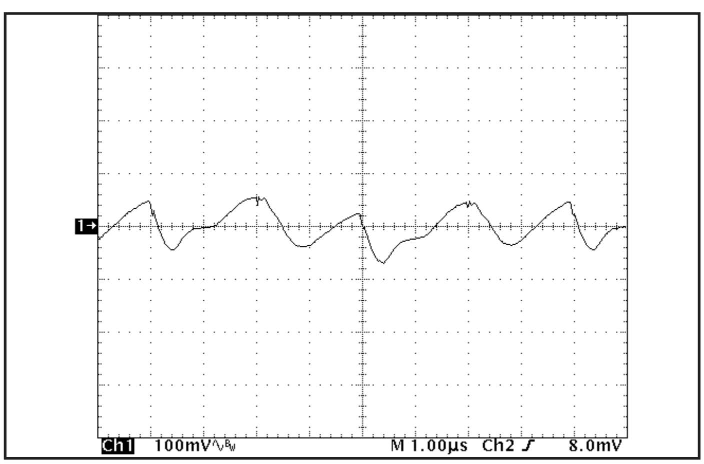


Figure 17*: Output voltage ripple, Vout, at nominal input voltage and full load (100mV/div). Bandwidth: 20MHz. Load capacitance: 1uF ceramic and 10µF 100mΩ ESR tantalum capacitor. See Figure 12.*

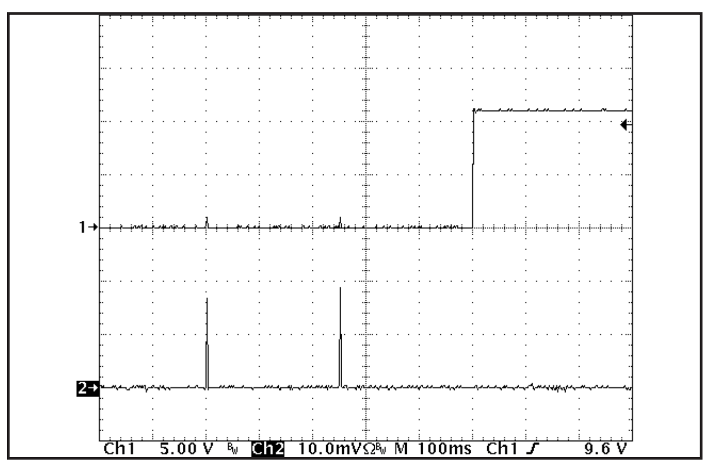


Figure 18*: Rise of output voltage after the removal of a short circuit across the output terminals. Rshort = 5mΩ. Ch1: Vout (5V/div). Ch 2: Iout (50A/div). Bandwidth: 20MHz.*

BASIC OPERATION AND FEATURES

With voltages dropping and currents rising, the economics of an Intermediate Bus Architecture (IBA) are becoming more attractive, especially in systems requiring multiple low voltages. IBA systems separate the role of isolation and voltage scaling from regulation and sensing. The BusQor series bus converter provides isolation and an unregulated voltage step down in one compact module, leaving regulation to simpler, less expensive non-isolated converters.

In Figure A below, the BusQor module provides the isolation stage of the IBA system. The isolated bus then distributes power to the non-isolated buck regulators to generate the required voltage levels at the points of load. In this case, the bucks are represented with SynQor's NiQor series of non-isolated DC-DC converters. In many applications requiring multiple low voltage outputs, significant savings can be achieved in board space and overall system costs

When designing an IBA system with bus converters, the designer can select from a variety of bus voltages. While there is no universally ideal bus voltage, most designs employ one of the following: 12V, 11V, 9.6V, 7.5V, 5V, or 3.3V. Higher bus voltages can lead to lower efficiency for the buck regulators but are more efficient for the bus converter and provide lower board level distribution current. Lower bus voltages offer the opposite trade offs.

SynQor's BusQor modules act as a true dc transformer. The output voltage is proportional to the input voltage, with a specified "turns ratio" or voltage ratio, plus minor drop from the internal resistive losses in the module. When used in IBA systems, the output variation of the BusQor must be in accordance with the input voltage range of the non-isolated converters being employed.

The BusQor architecture is very scalable, meaning multiple bus converters can be connected directly in parallel to allow current sharing for higher power applications.

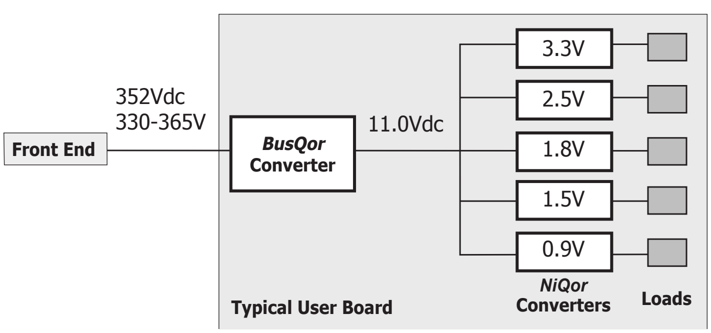


Figure A: *Example of Intermediate Bus Architecture using BusQor bus converter and NiQor non-isolated converters*

CONTROL FEATURES

REMOTE ON/OFF (Pin 2): The ON/OFF input, Pin 2, permits the user to control when the converter is on or off. This input is referenced to the return terminal of the input bus, Vin(-).

In the negative logic version, the ON/OFF signal is active low (meaning that a low turns the converter on). Figure B is a detailed look of the internal ON/OFF circuitry.

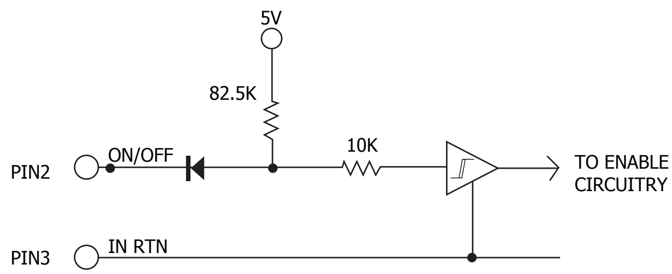


Figure B: *Internal ON/OFF pin circuitry*

PROTECTION FEATURES

Input Under-Voltage Lockout: The converter is designed to turn off when the input voltage is too low, helping avoid an input system instability problem, described in more detail in the application note titled "Input System Instability". The lockout circuitry is a comparator with DC hysteresis. When the input voltage is rising, it must exceed the typical Turn-On Voltage Threshold value (listed on the specification page) before the converter will turn on. Once the converter is on, the input voltage must fall below the typical Turn-Off Voltage Threshold value before the converter will turn off. Also see Figure E.

Output Current Limit: The output of the BusQor module is electronically protected against output overloads. When an overload current greater than the "DC Current-Limit Inception" specification is drawn from the output, the output shuts down to zero volt in a period of 1ms typical (see Figure C). The shutdown period lasts for a typical period of 250ms (Figure D) after which the BusQor tries to power up again (10ms). If the overload persists, the output voltage will go through repeated cycles of shutdown and restart with a duty cycle of 4% (On) and 96% (Off) respectively. The BusQor module returns (auto resetting) to normal operation once the overload is removed. The BusQor is designed to survive in this mode indefinitely without damage and without human intervention.

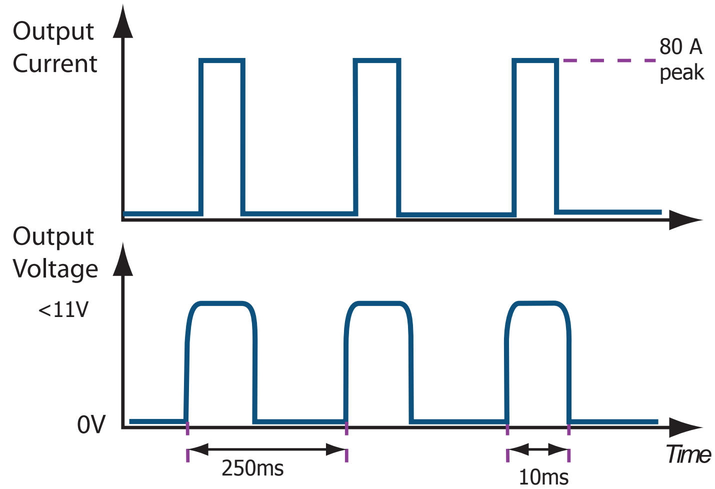


Figure D: Output Short Circuit and Auto-Resetting protection diagram (not to scale)

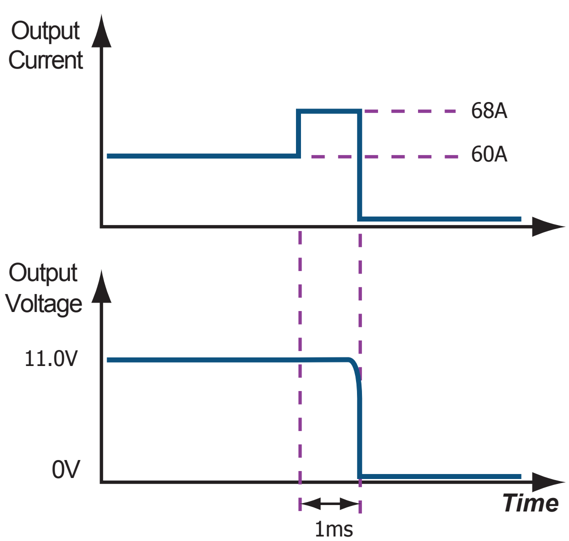


***Figure C:** Output Overload protection diagram (not to scale)*

Output Short Circuit Protection: When the output of the BusQor module is shorted, a peak current of typically 80 A will flow into the short circuit for a period of about 1ms. The output of the BusQor will shutdown to zero for ~ 250mS (Figure D). At the end of the shutdown period the BusQor module tries to power up again. If the short circuit persists, the output voltage will go through repeated cycles of shutdown and restart with a duty cycle of 4% (On) and 96% (Off) respectively. The BusQor module returns (auto resetting) to normal operation once the short circuit is removed. The BusQor is designed to survive in this mode indefinitely without damage and without human intervention.

In the Auto resetting mode, also referred to as "Hiccup" mode, the power drawn from the 352V input is about 5 Watts, most of which is dissipated into the external fault. It is important that copper traces and pads from the output circuit be designed to withstand the short term peaks, although the average input current into the fault may be as low as 0.015A typical. See Figure 18 for appropriate

Over-Temperature Shutdown: A temperature sensor on the converter senses the average temperature of the module. The thermal shutdown circuit is designed to turn the converter off when the temperature at the sensed location reaches the Over-Temperature Shutdown value. It will allow the converter to turn on again when the temperature of the sensed location falls by the amount of the Over-Temperature Shutdown Restart Hysteresis value.

APPLICATION CONSIDERATIONS

Start-Up Inhibit Period: Figure E details the Start-Up Inhibit Period for the BusQor module. At time t0, when Vin is applied with On/Off pin asserted (enabled), the BusQor output begins to build up. Before time t1, when the input voltage is below the UVL threshold, the unit is disabled by the Input Under-Voltage Lockout feature. When the input voltage rises above the UVL threshold, the Input Under-Voltage Lockout is released, and a typical Startup Inhibit Period of 12ms is initiated. The output builds up to 90% of the nominal value of 11.0V in a period of 5ms typical (50 % load).

At time t2, when the On/Off pin is de-asserted (disabled), the BusQor output instantly drops to 0V. Fall time from 11.0V to 0V is dependent on output capacitance and any parasitic trace inductance in the output load circuit.

At time t3, when the On/Off pin is re-asserted (enabled), the BusQor module output begins to build up after the inhibit period of 800 ms typical has elapsed.

Refer to the Control Features section of the data sheet for details on enabling and disabling methods for Bus Qor modules.

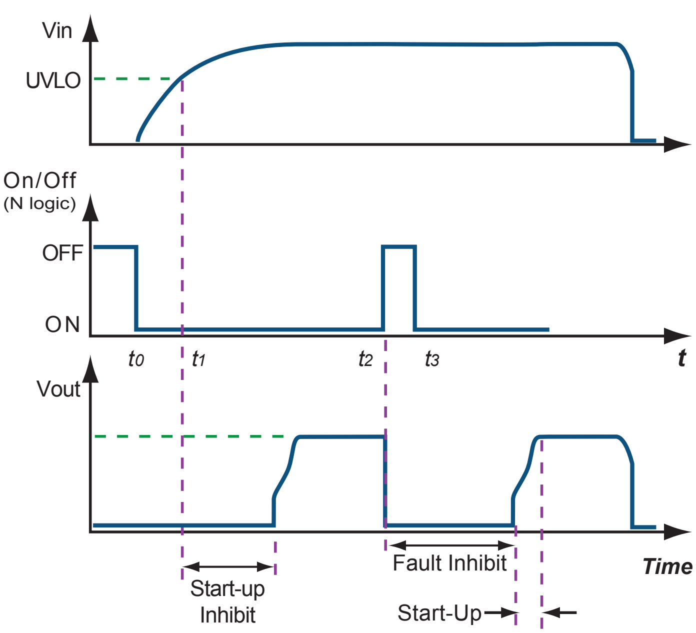


Figure E: *Power Up/Down Diagram (not to scale) showing Start-Up Inhibit Period*

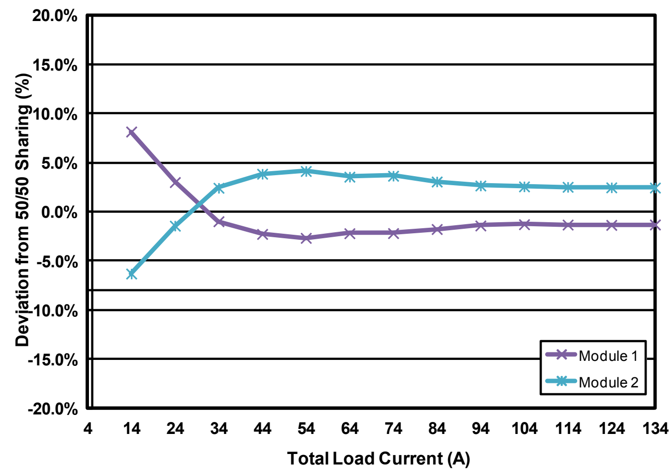


Figure G: *Typical current share performance of 2 paralleled modules*

Current Sharing: BusQor modules are designed to operate in parallel without the use of any external current share circuitry. A typical (recommended) circuit for paralleling two BusQor modules is shown in Figure H. An output capacitor is recommended across each module and located close to the converter for optimum filtering and noise control performance. Dedicated input inductors are recommended but are considered optional. Input capacitors must be located close to the converter module. PCB layout in the input circuit should be such that high frequency ripple currents of each module is restricted to a loop formed by the input capacitors and the input terminals of the BusQor module. See Figure H for details on PCB layout. Contact SynQor application engineering for further assistance on PCB trace design.

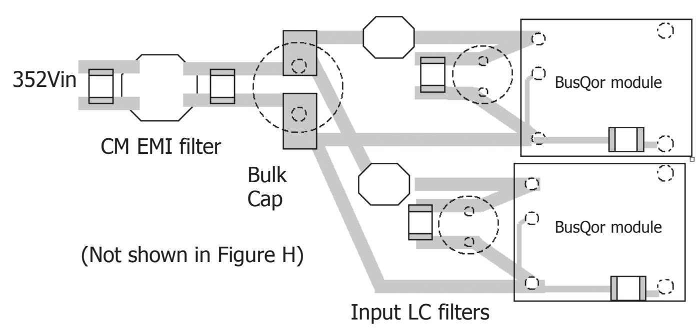


Figure H: *Recommended physical implementation of two Bus Qor's in parallel.*

The current share performance of two paralleled modules is illustrated in the graph in Figure G. In this graph the percent deviation from ideal sharing (50%) is plotted for each module versus the total output load current at 352Vin.

Input: *330-365V*
Output: *11V*
Current: *60A*
Package: *EXT-Eighth Brick*

Part Numbering System

The part numbering system for SynQor's dc-dc converters follows the format shown in the example below.

BQ 352 11 EE C 60 N R S - G

- BQ — Product Family
- 352 — Input Voltage
- 11 — Output Voltage
- EE — Extended Package Size
- C — Thermal Design
- 60 — Output Current
- N R S — Options (see Ordering Information)
- G — 6/6 RoHS

The first 12 characters comprise the base part number and the last 3 characters indicate available options. The "-G" suffix indicates 6/6 RoHS compliance.

Application Notes

A variety of application notes and technical white papers can be downloaded in pdf format from our website.

RoHS Compliance: The EU led RoHS (Restriction of Hazardous Substances) Directive bans the use of Lead, Cadmium, Hexavalent Chromium, Mercury, Polybrominated Biphenyls (PBB), and Polybrominated Diphenyl Ether (PBDE) in Electrical and Electronic Equipment. This SynQor product is 6/6 RoHS compliant. For more information please refer to SynQor's RoHS addendum available at our RoHS Compliance / Lead Free Initiative web page or e-mail us at rohs@synqor.com.

Ordering Information

The tables below show the valid model numbers and ordering options for converters in this product family. When ordering SynQor converters, please ensure that you use the complete 15 character part number consisting of the 12 character base part number and the additional characters for options. Add "-G" to the model number for 6/6 RoHS compliance.

Model Number	Input Voltage	Output Voltage	Max Output Current
BQ35211EEC60xyz-G	330-365V	11V	60A

The following options must be included in place of the ***w x y z*** spaces in the model numbers listed above.

Options Description: w x y z			
Thermal Design	**Enable Logic**	**Pin Style**	**Feature Set**
ENCASED	N - Negative	K - 0.110" N - 0.145" R - 0.180" Y - 0.250"	S - Standard

Not all combinations make valid part numbers, please contact SynQor for availability.

Contact SynQor for further information and to order:
Phone: 978-849-0600 **Toll Free:** 888-567-9596 **Fax:** 978-849-0602
E-mail: power@synqor.com **Web:** www.synqor.com
Address: 155 Swanson Road, Boxborough, MA 01719 USA

WARRANTY
SynQor offers a three (3) year limited warranty. Complete warranty information is listed on our website or is available upon request from SynQor.

PATENTS

SynQor holds numerous U.S. patents, one or more of which apply to most of its power conversion products. Any that apply to the product(s) listed in this document are identified by markings on the product(s) or on internal components of the product(s) in accordance with U.S. patent laws. SynQor's patents include the following:

7,050,309 7,765,687 7,787,261
8,149,597 8,644,027