

48V
Input
7.3V
Output
60A
Current
2250V dc
Isolation
Half-Brick
DC-DC Converter

The PQ50073HZB60 PowerQor Zeta half-brick converter is a next-generation, board-mountable, isolated, fixed switching frequency DC/DC converter. The Zeta series converters offer industry leading power density for standard isolated DC/DC converters with a tightly regulated output. This 7.3Vout module provides 2,250Vdc isolation, tolerance of output current transients up to 85A, and more available power and higher efficiency than most competitive bus converters. RoHS compliant (see last page).

PowerQor®



PQ50073HZB60

Operational Features

- High efficiency, 93% at full load
- Delivers up to 440W of output power with minimal derating
- Operating input voltage range: 44-52 Vdc
- Fixed frequency switching provides predictable EMI
- Output voltage trim range of -50%, +10%

Mechanical Features

- Industry standard half-brick pin-out configuration
- Size 2.3" x 2.4" (58.4 x 61.0mm)
- Total height only 0.50" (12.7mm)
- Total weight: 4.3oz (123g)

Safety Features

- 2250V, 30MΩ input-to-output isolation
- UL 60950-1:2003 , Basic Insulation
- CAN/CSA-C22.2 No. 60950-1:2003
- EN60950-1:2001
- RoHS compliant (see last page)

Protection Features

- Input under-voltage lockout
- Output current limit and short circuit protection
- Active back bias limit
- Output over-voltage protection
- Thermal shutdown

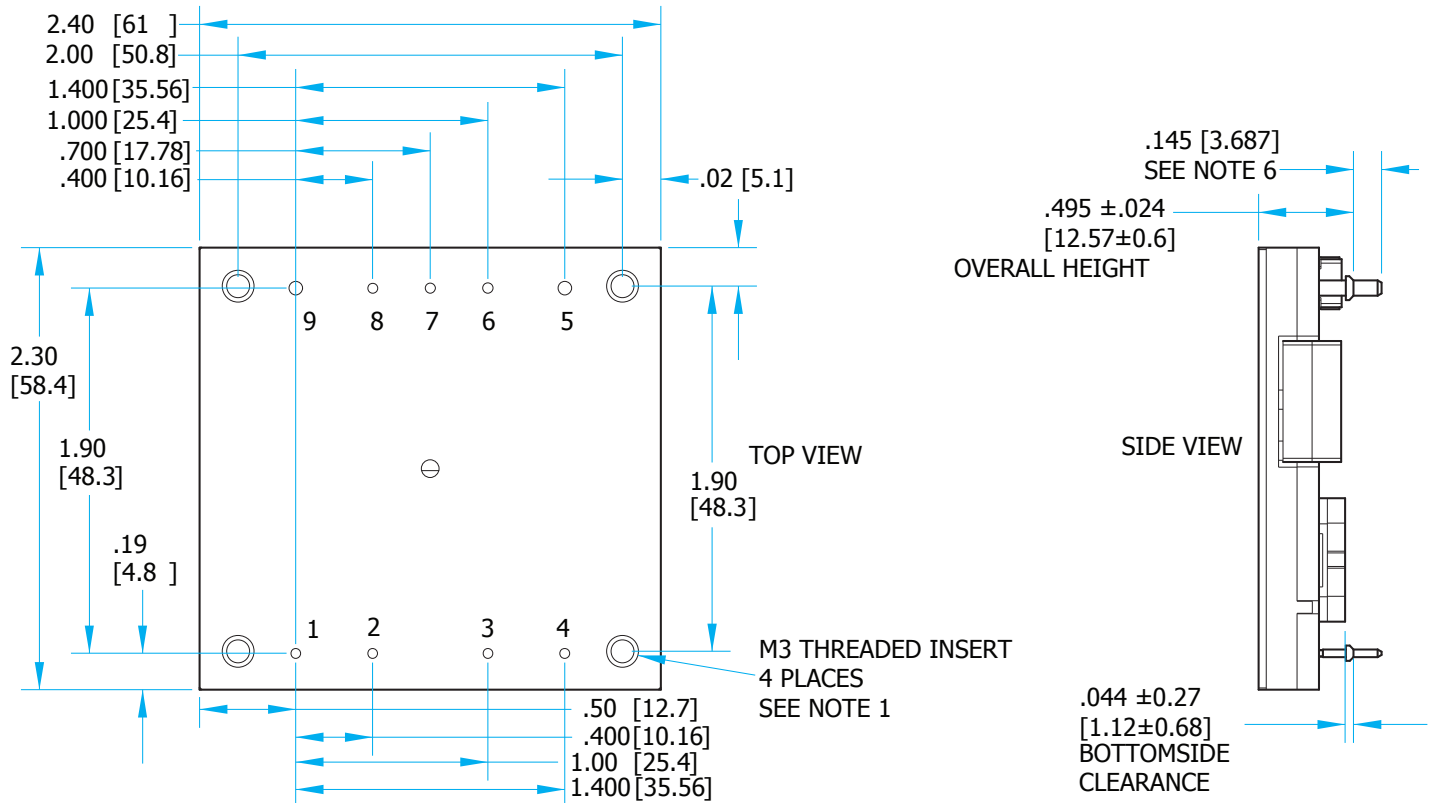
Control Features

- On/Off control referenced to input side

Contents

	Page No.
MECHANICAL DIAGRAM (base-plated)	2
ELECTRICAL CHARACTERISTICS	3-4
Standards and Qualifications	5
Figures	6-8
Application Section	9-12
Ordering Information	13

MECHANICAL DIAGRAM (base-plated)



NOTES

- 1) M3 screws used to bolt unit's baseplate to other surfaces (such as heatsink) must not exceed 0.100" (2.54 mm) depth below the surface of the baseplate.
- 2) Applied torque per screw should not exceed 6in-lb. (0.7 Nm)
- 3) Baseplate flatness tolerance is 0.004" (.10mm) TIR for surface
- 4) Pins 1-4, 6-8 are 0.040" (1.02mm) diameter, with 0.080" (2.03mm) diameter standoff shoulders.
- 5) Pins 5 and 9 are 0.080" (2.03 mm) diameter with 0.125" (3.18mm) diameter standoff shoulders.
- 6) Other pin extension lengths available. Recommended pin length is 0.03" (0.76mm) greater than the PCB thickness.
- 7) All Pins: Material: Copper Alloy
Finish (RoHS 6/6): Matte Tin over Nickel plate
- 8) Undimensioned components are shown for visual reference only.
- 9) Weight: 4.3oz (123g)
- 10) All dimensions in inches (mm) Tolerances: x.xx +/-0.02 in. (x.x +/-0.5mm) x.xxx +/-0.010 in. (x.xx +/-0.25mm)
- 11) Workmanship: Meets or exceeds IPC-A-610C Class II
- 12) The flanged pins are designed to permit surface mount soldering (allowing to avoid the wave soldering process) through the use of the flanged pin-in-paste technique.

PIN DESIGNATIONS

Pin	Name	Function
1	Vin(+)	Positive input voltage
2	ON/OFF	TTL input to turn converter on and off, referenced to Vin(-), with internal pull up.
3	Reserved	Not connected
4	Vin(-)	Negative input voltage
5	Vout(-)	Negative output voltage
6	SENSE(-)	Negative remote sense; see note 1
7	TRIM	Output voltage trim; see note 2
8	SENSE(+)	Positive remote sense; see note 3
9	Vout(+)	Positive output voltage

Notes:

- 1) SENSE(-) should be connected to Vout(-) either remotely or at the converter.
- 2) Leave TRIM pin open for nominal output voltage.
- 3) SENSE(+) should be connected to Vout(+) either remotely or at the converter.

PQ50073HZB60 ELECTRICAL CHARACTERISTICS

Ta = 25 °C, airflow rate = 300 LFM, Vin = 48V dc unless otherwise noted; full operating temperature range is -40 °C to +100 °C baseplate 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			80	V	Continuous
Operating			60	V	Continuous
Isolation Voltage					
Input to Output			2250	V dc	Input to output
Operating Temperature	-40		100	°C	Baseplate temperature
Storage Temperature	-55		125	°C	
Voltage at ON/OFF input pin	-2		18	V	
INPUT CHARACTERISTICS					
Operating Input Voltage Range	44	48	52	V	
Input Under-Voltage Lockout					
Turn-On Voltage Threshold	34.0	35.5	37.0	V	
Turn-Off Voltage Threshold	32.5	34	35.5	V	
Lockout Voltage Hysteresis		1.5		V	
Maximum Input Current			19.5	A	In Current Limit, Vin min, nominal Vout
No-Load Input Current		210		mA	
Disabled Input Current		50		mA	
Input Terminal Ripple Current		225		mA	RMS
Input Reflected Ripple Current		5		mA	RMS thru 4.7µH inductor
Recommended Input Fuse			30	A	
Input Over-Voltage Shutdown		90		V	
Recommended External Input Capacitance		330		µF	Typical ESR 0.1-0.2 Ω
Input Filter Component Values (L/C)		0.5/11.0		µH/µF	
OUTPUT CHARACTERISTICS					
Output Voltage Set Point	7.23	7.3	7.36	V	
Output Voltage Regulation					
Over Line		±0.20/14		%mV	
Over Load		±0.20/14		%mV	
Over Temperature		60	90	mV	
Total Output Voltage Range	7.17		7.43	V	Over sample, line, load, temperature & life
Output Voltage Ripple and Noise					20 MHz bandwidth; See Note 1
Peak-to-Peak		80		mV	Full load; 5mF Electrolytic capacitance
RMS		15		mV	Full load; 5mF Electrolytic capacitance
Operating Output Current Range			60.0	A	Subject to thermal derating; See Note 2
Output DC Current-Limit Inception	90	100	110	A	Output Voltage 10% Low
Output DC Current-Limit Shutdown Voltage		3.0		V	See Note 3
Back-Drive Current Limit while Enabled		5.2		A	Peak negative current drawn from output
Back-Drive Current Limit while Disabled		3	5	mA	Negative current drawn from output
Maximum Output Capacitance			12	mF	Vout nominal at full load (resistive load)
EFFICIENCY					
100% Load		93		%	
50% Load		93		%	

Note 1: For applications requiring reduced output voltage ripple and noise, consult SynQor applications support (e-mail: support@synqor.com)

Note 2: Unit can withstand output current transients below the current limit threshold for up to 10ms. Subject to thermal derating.

Note 3: If the output voltage falls below the Output DC Current Limit Shutdown Voltage for more than 50ms, then the unit will enter into hiccup mode, with a 500ms off-time.

PQ50073HZB60 ELECTRICAL CHARACTERISTICS

Ta = 25 °C, airflow rate = 300 LFM, Vin = 48V dc unless otherwise noted; full operating temperature range is -40 °C to +100 °C baseplate 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)		150		mV	50% to 75% to 50% Iout max; Figure 7
Step Change in Output Current (5 A/μs)		775		mV	0% to Max Transient Load; Figure 8
Settling Time		3		ms	25% of Full load transient, to within 1% Vout nom
Turn-On Transient					
Turn-On Time	43	47	51	ms	Full load, Vout=90% nom.
First Startup Delay:		2		ms	
Output Voltage Overshoot		0		%	Max output capacitance and full load
ISOLATION CHARACTERISTICS					
Isolation Voltage (dielectric strength)		2250			
Isolation Resistance		30		MΩ	
Isolation Capacitance (input to output)		1000		pF	See Note 1
TEMPERATURE LIMITS FOR POWER DERATING CURVES					
Semiconductor Junction Temperature			125	°C	Package rated to 150 °C
Board Temperature			125	°C	UL rated max operating temp 130 °C
Transformer Temperature			125	°C	
Baseplate Temperature			100	°C	See Figure 3 for derating curve
FEATURE CHARACTERISTICS					
Switching Frequency (Isolation Stage)		125		kHz	
Switching Frequency (Regulation Stage)		500		kHz	
ON/OFF Control (Option P)					
On-State Voltage	2.4		18	V	
Off-State Voltage	-2.0		0.8	V	
ON/OFF Control (Option N)					
On-State Voltage	-2.0		0.8	V	
Off-State Voltage	2.4		18	V	
ON/OFF Control (Either option)					Figure A
Pull-Up Voltage	4.5	5	5.5	V	
Pull-Up Resistance		10		kΩ	
Output Voltage Trim Range	-50		+10	%	Measured across Pins 8 & 4; Figure B
Output Voltage Remote Sense Range			10	%	Measured across Pins 8 & 4
Output Over-Voltage Protection	8.1	8.4	8.7	V	Over full temp range
Over-Temperature Shutdown OTP Trip Point		125		°C	Average PCB Temperature; Auto Recovery
Over-Temperature Shutdown Restart Hysteresis		10		°C	
RELIABILITY CHARACTERISTICS					
Calculated MTBF (Telcordia) TR-NWT-000332		2.1		10 ⁶ Hrs.	TR-NWT-000332; 80% load, 300LFM, 40°C Ta
Calculated MTBF (MIL-217) MIL-HDBK-217F		1.9		10 ⁶ Hrs.	MIL-HDBK-217F; 80% load, 300LFM, 40°C Ta
Field Demonstrated MTBF				10 ⁶ Hrs.	See our website for details

Note 1: Higher values of isolation capacitance can be added external to the module.

Standards and Qualifications

Parameter	Notes & Conditions
STANDARDS COMPLIANCE	
UL 60950-1:2003	Basic Insulation
CAN/CSA-C22.2 No. 60950-1:2003	
EN60950-1:2001	
IEC 61000-4-2	ESD test, 8 kV - NP, 15 kV air - NP (Normal Performance)
Note: An external input fuse must always be used to meet these safety requirements. Contact SynQor for official safety certificates on new releases or download from the SynQor website.	

Parameter	# Units	Test Conditions
QUALIFICATION TESTING		
Life Test	32	95% rated Vin and load, units at derating point, 1000 hours
Vibration	5	10-55 Hz sweep, 0.060" total excursion, 1 min./sweep, 120 sweeps for 3 axis
Mechanical Shock	5	100g minimum, 2 drops in x and y axis, 1 drop in z axis
Temperature Cycling	10	-40 °C to 100 °C, unit temp. ramp 15 °C/min., 500 cycles
Power/Thermal Cycling	5	Toperating = min to max, Vin = min to max, full load, 100 cycles
Design Marginality	5	Tmin-10 °C to Tmax+10 °C, 5 °C steps, Vin = min to max, 0-105% load
Humidity	5	85 °C, 85% RH, 1000 hours, continuous Vin applied except 5 min/day
Solderability	15 pins	MIL-STD-883, method 2003

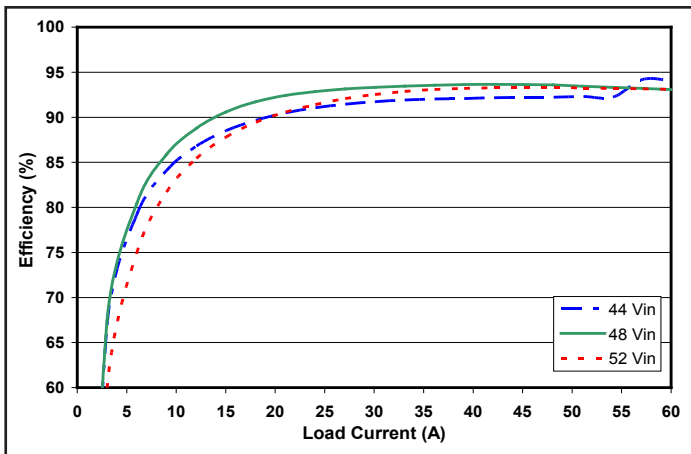


Figure 1: Efficiency at nominal output voltage vs. load current for minimum, nominal, and maximum input voltage at 25°C.

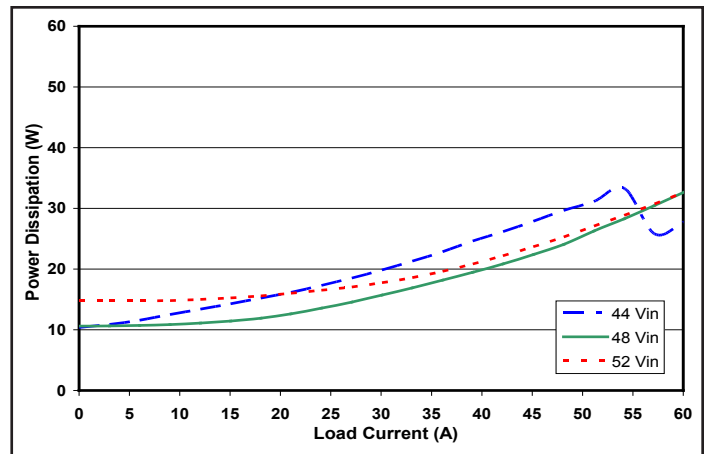


Figure 2: Power dissipation at nominal output voltage vs. load current for minimum, nominal, and maximum input voltage at 25°C.

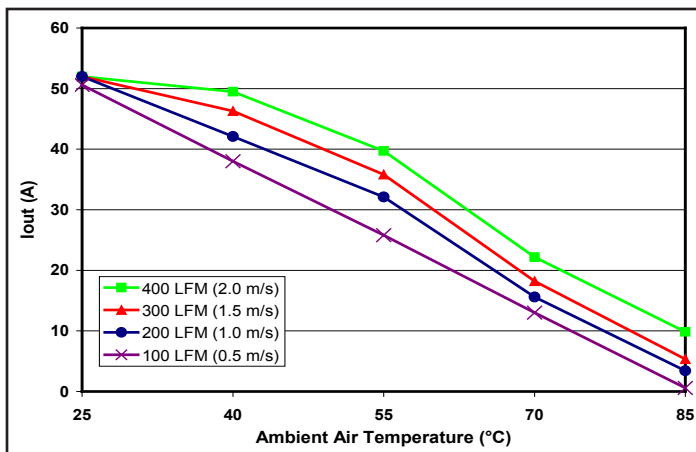


Figure 3: Maximum output power derating curves vs. ambient air temperature for airflow rates of 100 LFM through 400 LFM with air flowing from pin 4 to pin 1 (nominal input voltage).

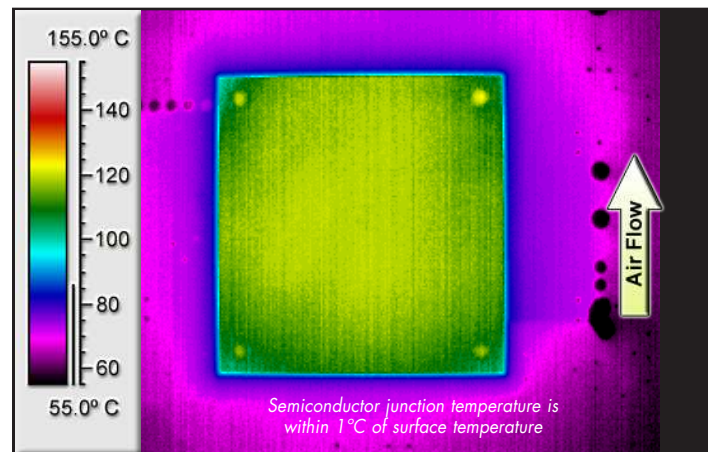


Figure 4: Thermal plot of converter at 32.1 amp load current (234W) with 55°C air flowing at the rate of 200 LFM. Air is flowing from pin 4 to pin 1 (nominal input voltage).

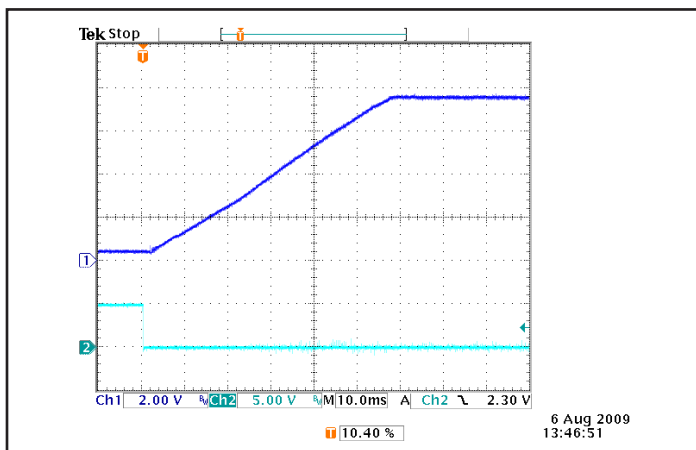


Figure 5: Turn-on transient at full load (resistive load) (10 ms/div). Input voltage pre-applied. Top Trace: V_{out} (2V/div). Bottom Trace: ON/OFF input (5V/div)

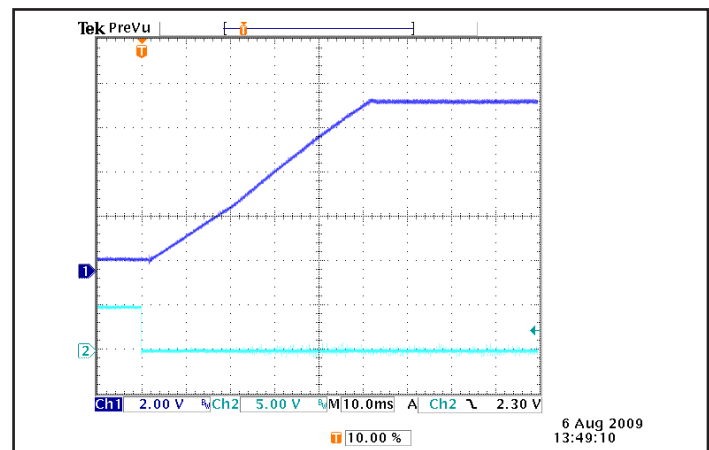


Figure 6: Turn-on transient at zero load (10 ms/div). Top Trace: V_{out} (2V/div). Bottom Trace: ON/OFF input (5V/div)

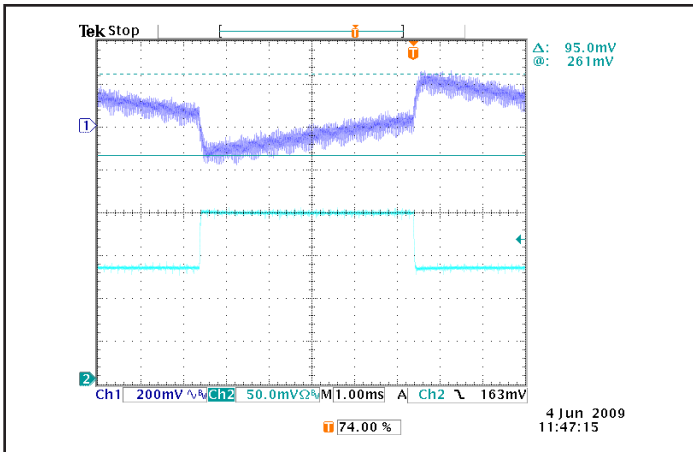


Figure 7: Output voltage response to step-change in load current (50%-75%-50% of $I_{out(max)}$; $dI/dt = 0.1A/\mu s$). Load cap: 5000 μF , ceramic output capacitance. Top trace: V_{out} (200mV/div). Bottom trace: I_{out} (10A/div).

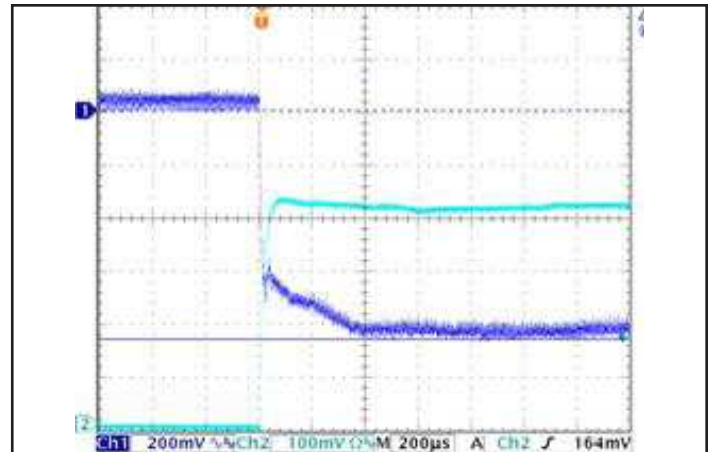


Figure 8: Output voltage response to step-change in load current (0% - 100% of $I_{out(max)}$; $dI/dt = 5A/\mu s$). Load cap: 5000 μF , electrolytic output capacitance. Top trace: V_{out} (200mV/div). Bottom trace: I_{out} (20A/div).

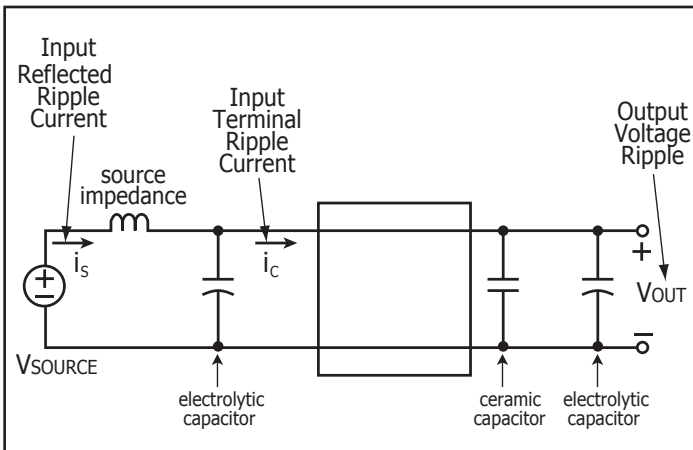


Figure 9: Test set-up diagram showing measurement points for Input Terminal Ripple Current (Figure 10), Input Reflected Ripple Current (Figure 11) and Output Voltage Ripple (Figure 12).

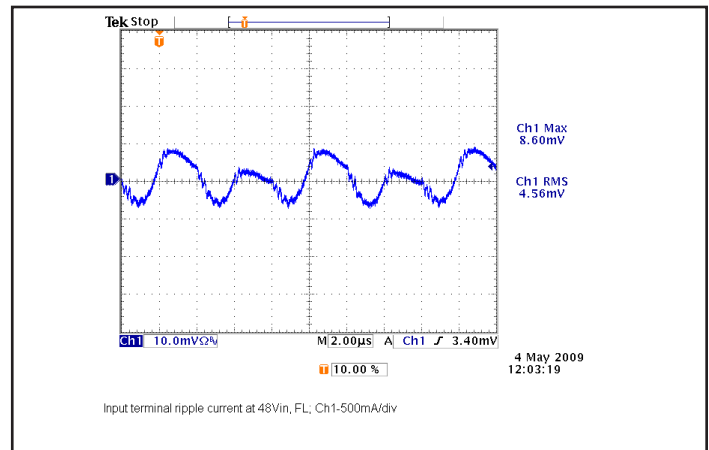


Figure 10: Input Terminal Ripple Current, i_c , at full rated output current and 55V input voltage with 4.7 μH source impedance and 330 μF electrolytic capacitor (Ch1 500mA/div). (See Figure 9).

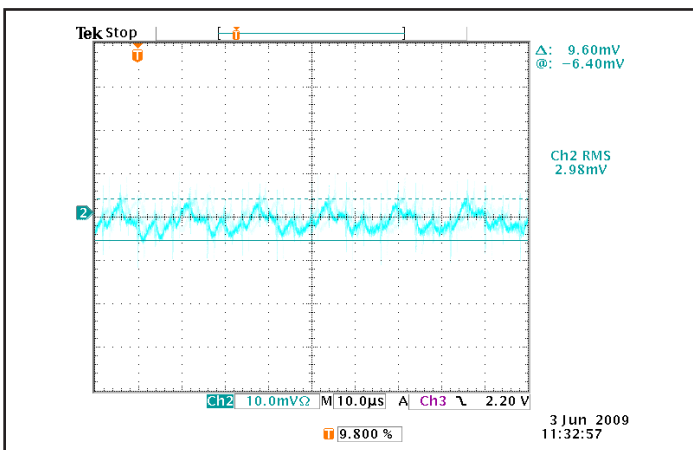


Figure 11: Input reflected ripple current, i_s , through a 4.7 μH source inductor at 55V input voltage and rated load current (20 mA/div). (See Figure 9).

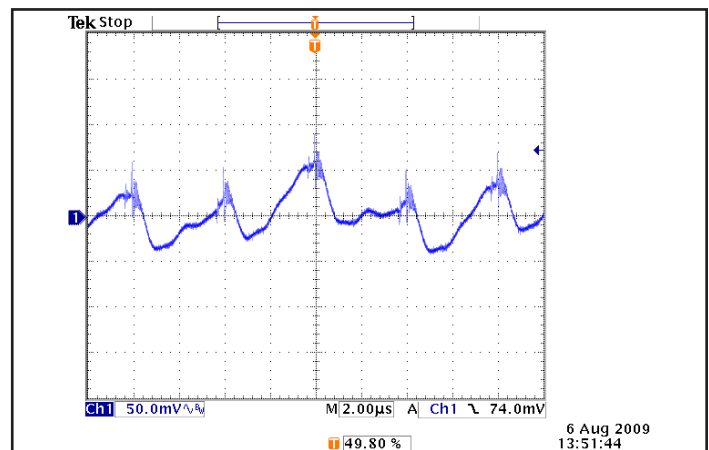


Figure 12: Output voltage ripple at nominal input voltage and rated load current (200 mV/div). Load capacitance: two 1.0 μF ceramic capacitors and 5000 μF electrolytic capacitor. Bandwidth: 20 MHz. (See Figure 9).

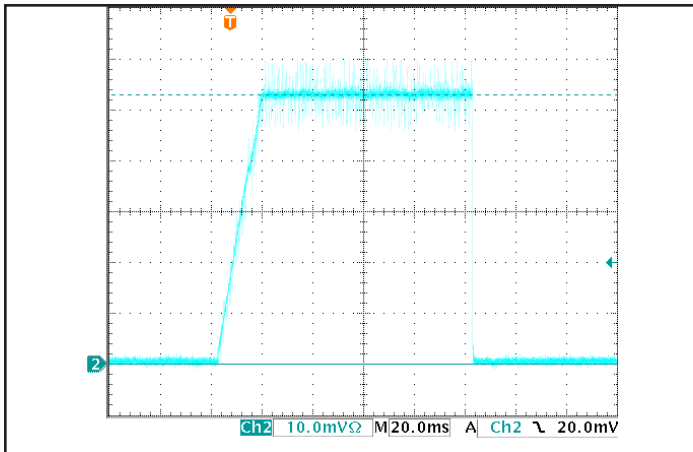


Figure 13: Load current (20A/div) as a function of time when the converter attempts to turn on into a 1 mΩ short circuit.

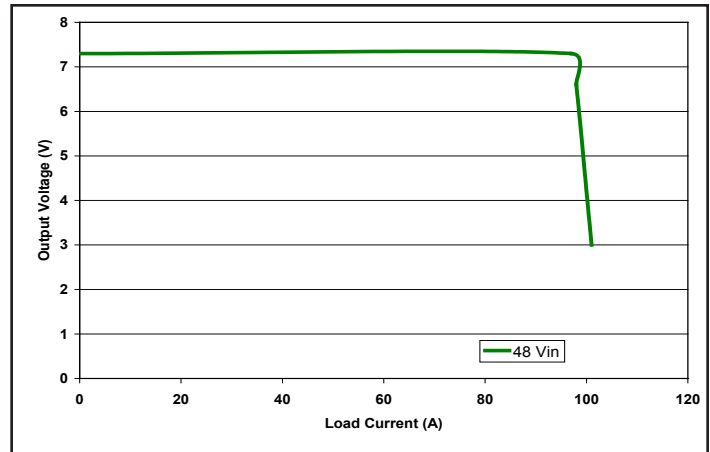


Figure 14: Output voltage vs. load current showing typical current limit curve and converter shutdown point.

BASIC OPERATION AND FEATURES

The *PowerQor* Zeta series converter uses a two-stage power conversion topology. The first stage keeps the output voltage constant over variations in line, load, and temperature. The second stage uses a transformer to provide the functions of input/output isolation and voltage step-down to achieve the low output voltage required.

Both the first stage and the second stage switch at a fixed frequency for predictable EMI performance. Rectification of the transformer's output is accomplished with synchronous rectifiers. These devices, which are MOSFETs with a very low on-state resistance, dissipate significantly less energy than Schottky diodes, enabling the *PowerQor* converter to achieve high efficiency.

The *PowerQor* series of half-brick, quarter-brick and eighth-brick converters uses the industry standard footprint and pin-out configuration.

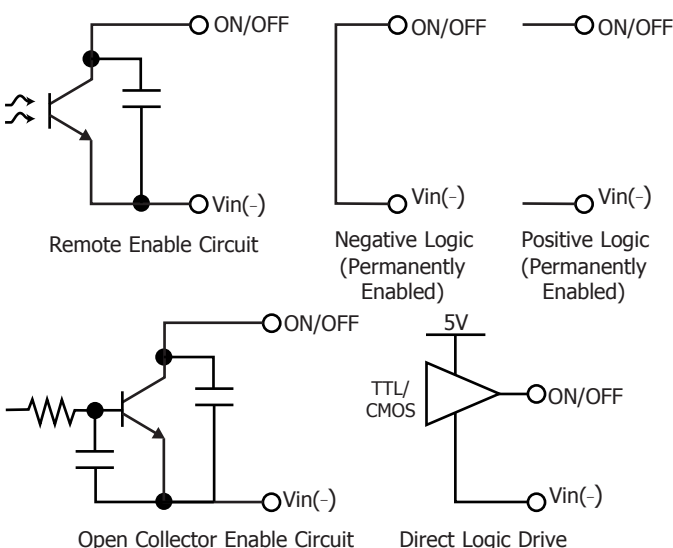


Figure A: Various circuits for driving the ON/OFF pin.

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(-). The converter is available with either positive or negative logic used for the ON/OFF input.

In the positive logic version, the ON/OFF input is active high (meaning that a high voltage turns the converter *on*). In the negative logic version, the ON/OFF signal is active low (meaning that a low voltage turns the converter *on*). Figure A details five possible circuits for driving the ON/OFF pin.

REMOTE SENSE(±) (Pins 7 and 5): The SENSE(±) inputs correct for voltage drops along the conductors that connect the converter's output pins to the load.

Pin 7 should be connected to Vout(+) and Pin 5 should be connected to Vout(-) at the point on the board where regulation is desired. If these connections are not made, the converter will deliver an output voltage that is slightly higher than its specified value.

Note: The output over-voltage protection circuit senses the voltage across the sense leads (pins 7 and 5) to determine when it should trigger, not the voltage across the converter's output pins (pins 8 and 4).

OUTPUT VOLTAGE TRIM (Pin 6): The TRIM input permits the user to adjust the output voltage across the sense leads up or down according to the trim range specifications. SynQor uses industry standard trim equations.

To decrease the output voltage, the user should connect a resistor between Pin 6 (TRIM) and Pin 5 (SENSE(-) input). For a desired decrease of the nominal output voltage, the value of the resistor should be:

$$R_{\text{trim-down}} = \left(\frac{100\%}{\Delta} \right) - 2 \text{ k}\Omega$$

where

$$\Delta\% = \left| \frac{V_{\text{nominal}} - V_{\text{desired}}}{V_{\text{nominal}}} \right| \times 100\%$$

To increase the output voltage, the user should connect a resistor between Pin 6 (TRIM) and Pin 7 (SENSE(+) input). For a desired increase of the nominal output voltage, the value of the resistor should be

$$R_{\text{trim-up}} = \frac{\left(\frac{V_{\text{nominal}}}{1.225} - 2 \right) \times V_{\text{DES}} + V_{\text{NOM}}}{V_{\text{DES}} - V_{\text{NOM}}} \text{ k}\Omega$$

Figure B graphs the relationship between the trim resistor value, Rtrim-up and Rtrim-down, showing the total range the output voltage can be trimmed up or down.

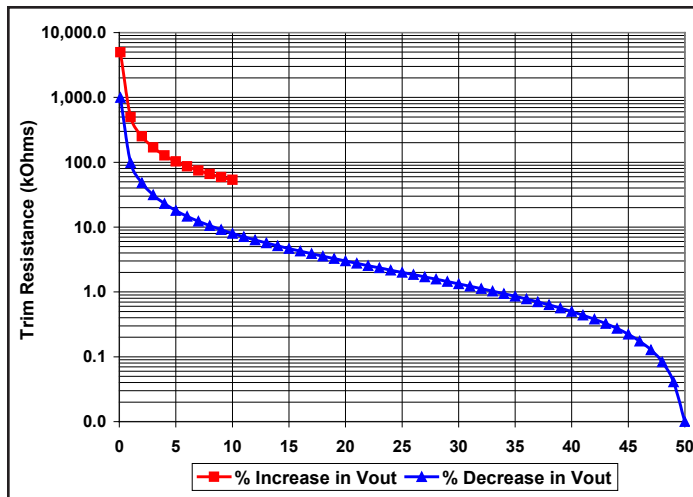


Figure B: Trim Graph for 7.3Vout module

Note: The TRIM feature does not affect the voltage at which the output over-voltage protection circuit is triggered. Trimming the output voltage too high may cause the over-voltage protection circuit to engage, particularly during transients.

It is not necessary for the user to add capacitance at the Trim pin. The node is internally filtered to eliminate noise.

Total DC Variation of Vout: For the converter to meet its full specifications, the maximum variation of the DC value of Vout, due to both trimming and remote load voltage drops, should not be greater than that specified for the output voltage trim range.

PROTECTION FEATURES

Input Under-Voltage Lockout: The converter is designed to turn off when the input voltage is too low, helping to avoid an input system instability problem, which is described in more detail in the application note titled "Input System Instability" on the SynQor website. 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* 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.

Output Current Limit: If the output current exceeds the "Output DC Current Limit Inception" point*, then a fast linear current limit controller will reduce the output voltage to maintain a constant output current. If as a result, the output voltage falls below the "Output DC Current Limit Shutdown Voltage"* for more than 50ms, then the unit will enter into hiccup mode, with a 500ms off-time. The unit will then automatically attempt to restart.

Back-Drive Current Limit: If there is negative output current of a magnitude larger than the "Back-Drive Current Limit while Enabled" specification*, then a fast back-drive limit controller will increase the output voltage to maintain a constant output current. If this results in the output voltage exceeding the "Output Over-Voltage Protection" threshold*, then the unit will shut down. The full I-V output characteristics can be seen in Figure 17.

Output Over-Voltage Limit: If the voltage directly across the output pins exceeds the "Output Over-Voltage Protection" threshold*, the converter will immediately stop switching. This shutdown is latching; unlike other shutdown types, the converter will not restart unless the input power is cycled or the ON/OFF input is toggled.

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*.

* See Electrical Characteristics page.

APPLICATION CONSIDERATIONS

Input System Instability: This condition can occur because any DC/DC converter appears incrementally as a negative resistance load. A detailed application note titled "Input System Instability" is available on the SynQor website which provides an understanding of why this instability arises, and shows the preferred solution for correcting it.

Application Circuits: Figure C below provides a typical circuit diagram which details the input filtering and voltage trimming.

Input Filtering and External Input Capacitance: Figure D below shows the internal input filter components. This filter dramatically reduces input terminal ripple current, which otherwise

could exceed the rating of an external electrolytic input capacitor. The recommended external input capacitance is specified in the Input Characteristics section on the Electrical Specifications page. More detailed information is available in the application note titled "EMI Characteristics" on the SynQor website.

Output Filtering and External Output Capacitance: Figure D below shows the internal output filter components. This filter dramatically reduces output voltage ripple. However, some minimum external output capacitance is required, as specified in the Output Characteristics section on the Electrical Specifications page. No damage will occur without this capacitor connected, but peak output voltage ripple will be much higher.

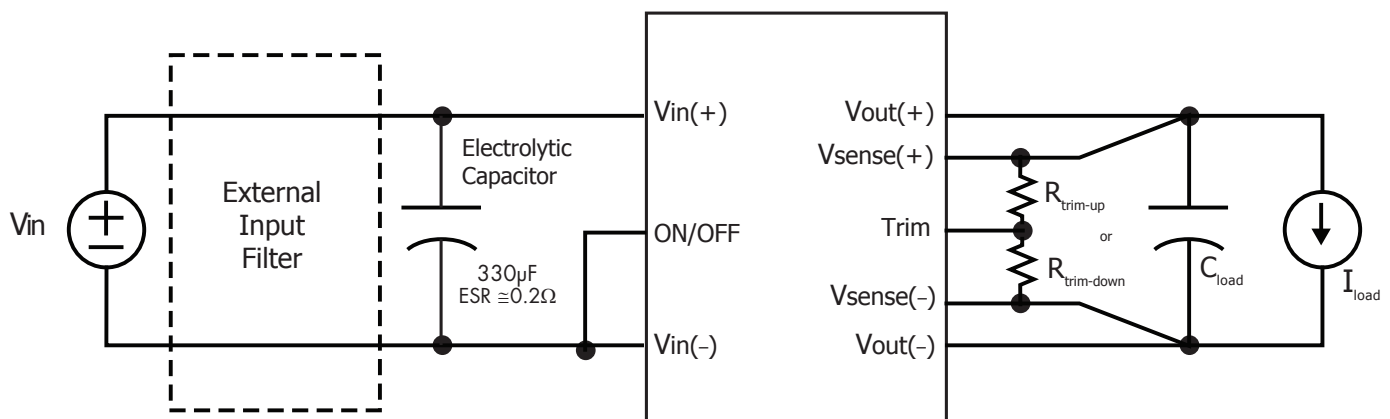


Figure C: Typical application circuit (negative logic unit, permanently enabled).

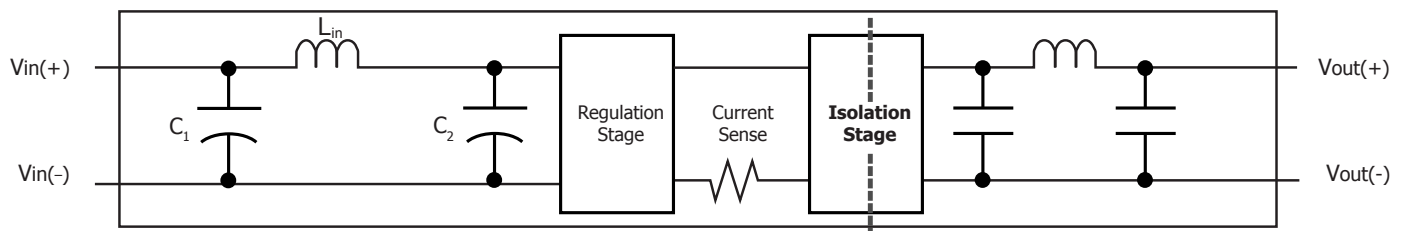


Figure D: Internal Input and Output Filter Diagram (component values listed on specifications page).

Thermal Considerations: The maximum operating base-plate temperature, T_B , is 100 °C. As long as the user's thermal system keeps $T_B \leq 100$ °C, the converter can deliver its full rated power.

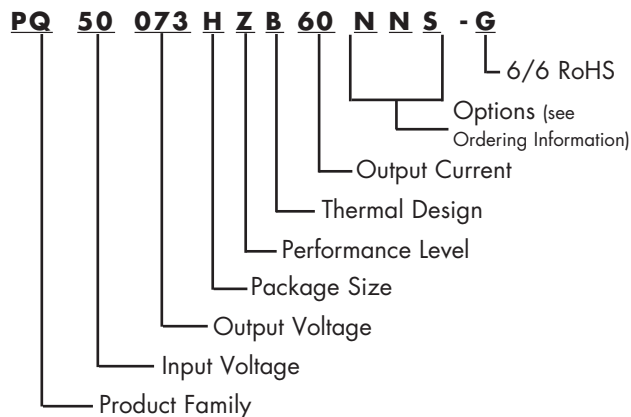
A power derating curve can be calculated for any heatsink that is attached to the base-plate of the converter. It is only necessary to determine the thermal resistance, R_{THBA} , of the chosen heatsink between the base-plate and the ambient air for a given airflow rate. This information is usually available from the heatsink vendor. The following formula can be used to determine the maximum power the converter can dissipate for a given thermal condition if its base-plate is to be no higher than 100 °C.

$$P_{diss}^{max} = \frac{100\text{ °C} - T_A}{R_{THBA}}$$

This value of power dissipation can then be used in conjunction with the data shown in Figure 2 to determine the maximum load current (and power) that the converter can deliver in the given thermal condition.

PART NUMBERING SYSTEM

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



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.

Contact SynQor for further information:

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

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 3 characters for options. Add "-G" to the model number for 6/6 RoHS compliance.

Model Number	Input Voltage	Output Voltage	Max Output Current
PQ50073HZB60NNS	44-52 V	7.3V	60A

Options Description: w x y z			
Thermal Design	Enable Logic	Pin Style	Feature Set
B - Baseplated	N - Negative	N - 0.145"	S - Standard

Not all combinations make valid part numbers, please contact SynQor for availability. See the [Product Summary web page](#) for more options. Many operational functions of this converter are programmable. Contact the factory regarding customizing.

PATENTS

SynQor holds the following U.S. patents, one or more of which apply to each product listed in this document. Additional patent applications may be pending or filed in the future.

5,999,417	6,222,742	6,545,890	6,577,109	6,594,159
6,731,520	6,894,468	6,896,526	6,927,987	7,050,309
7,072,190	7,085,146	7,119,524	7,269,034	7,272,021
7,272,023	7,558,083	7,564,702		

Warranty

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

Information furnished by SynQor is believed to be accurate and reliable. However, no responsibility is assumed by SynQor for its use, nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of SynQor.