QPI-8

QUIETPOWER®

AdvancedTCA™ Hot-Swap SiP With Active EMI Filter

Description

The QPI-8 is the industry's first System-in-a-Package (SiP) designed to integrate a total Hot-Swap function with an active EMI filter. The product aligns with the AdvancedTCA™ PICMG® 3.0, requirements for hot insertion and board level conducted noise limitations. The EMI filter provides active conducted common-mode (CM) and differential-mode (DM) noise attenuation from 150 kHz to 30 MHz. The QPI-8 is designed for use on a 48 or 60 Vdc bus (36 – 76 Vdc). The in-rush current limit and circuit breaker are designed to satisfy the 200 W per board PICMG® 3.0 limit up to 70°C PCB temperature around the QPI-8.

The undervoltage and overvoltage thresholds can be trimmed separately via the UVEN and OV inputs using external series resistors. The Powergood active-high output provides opto-coupler drive for a converter's active-low enable (see Figure 9a) or active-high by connecting the diode in series with the Powergood output (see Figure 9b).

The QPI-8 is available in a 25 x 25 x 4.5 mm SiP (System-in-a-Package) with LGA mounting. QPI-8-EVAL1 kits are available for testing the QPI-8. The eveluation board has a mounted QPI-8 with screw terminals for quick in-circuit testing. Check **picorpower.com** for the QPI-8-EVAL1 evaluation board and the QPI-AN1 Application Note.

Features

- **>40 dB CM attenuation at 250 kHz**
- **>70 dB DM attenuation at 250 kHz**
- **80 Vdc (max input)**
- **100 Vdc surge 100 ms**
- **1,500 Vdc hipot hold off to shield plane**
- **-48 V and -60 V Telecom/ATCA BUS capability**
- **Provides safe powered backplane board insertion**
- **6 A Breaker with delay plus 12 A limiter**
- **25 x 25 x 4.5 mm SiP (System-in-a-Package)**
- **Low profile LGA package**
- **-40° to +100°C PCB temperature (see Figure 5)**
- **Hot-Swap and filter combination saves space**
- **Efficiency >99%**
- **Connects between OR'ing diodes and power converter input hold-up capacitors**
- **Patents pending**
- **TÜV Approved**

Application

- **ATCA PICMG® 3.0 boards**

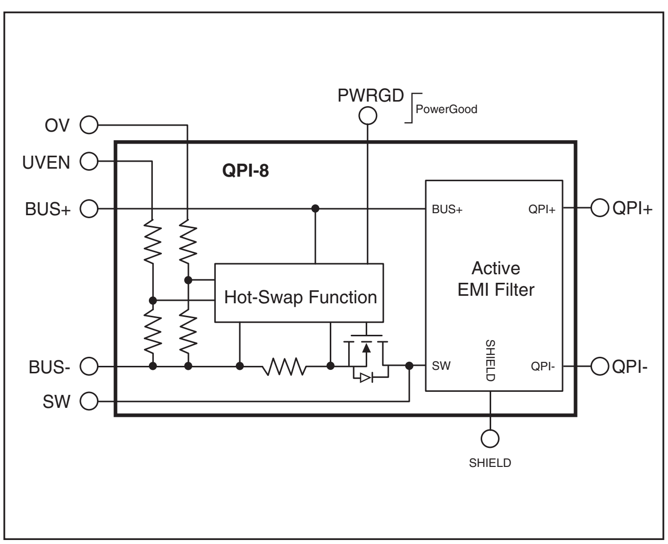


Figure 1 *– Block diagram, EMI filter and Hot-Swap*

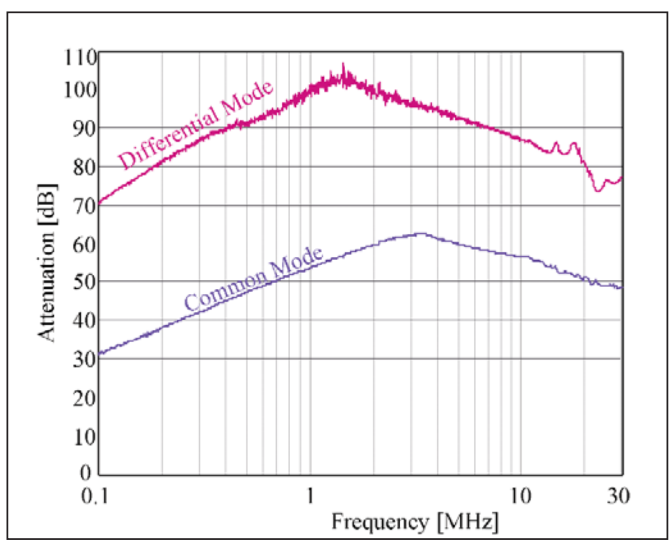


Figure 2 *– Typical attenuation; QPI-8 network analyzer attenuation curves.*

Absolute Maximum Ratings – *Exceeding these parameters may result in permanent damage to the product.*

Pins	Parameter	Notes	Min	Typ	Max	Units
BUS+, SW, PWRGD to BUS-	Input voltage	Continuous	-0.5		80	Vdc
BUS+, SW, PWRGD to BUS-	Input voltage	100 ms transient			100	Vdc
BUS+/BUS- to Shield	BUS inputs to shield hipot				+/-1500	Vdc
QPI+ to QPI-	Load current	Pulsed limit @ 25°C		12		Adc
Package	Power dissipation	VBUS = 48 V, 6 Adc @ 25°C			3.0	W
Package	Operating temperature	PCB to QPI Interface	-40		100	°C
Package	Thermal resistance θja	Free Air			50	°C/W
Package	Junction temperature	Tb = 100°C; Pd = 3 W @15 °C/W			145	°C
Package	Thermal resistance	PCB layout dependent(1)			15	°C/W
Package	Storage temperature		-40		125	°C
Package	Re-flow temperature	20 s exposure(2)			212	°C
All pins	ESD	HBM			+/-2	kV

Note 1: *Refer to Figure 15 and QPI application note QPI-AN1 for general PCB layout guidelines to achieve this thermal resistance when reflowed onto the PCB.*
Note 2: *RoHS compliant product maximum temperature peak is 245°C*

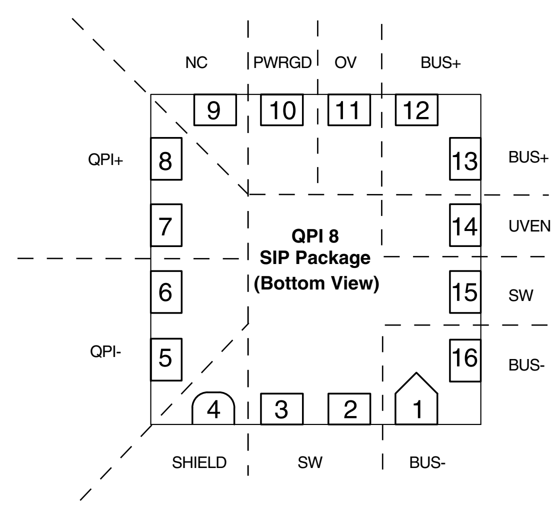
Electrical Characteristics – *Parameter limits apply over the operating temp. range unless otherwise noted.*

Symbol	Parameter	Notes	Min	Typ	Max	Units
V_{b+b-}	BUS+ to BUS- input range	Measured at I_{Load} = 5 A(3)	UV		80	Vdc
V_{+oi}	BUS+ to QPI+ voltage drop	Measured at I_{Load} = 5 A @ 100°C(3)		100		mVdc
V_{-oi}	BUS- to QPI- voltage drop	Measured at I_{Load} = 5 A @ 100°C(3)		-250		mVdc
CMA	Common-mode attenuation	VBUS = 48 V; Frequency = 250 kHz		45		dB
DMA	Differential-mode attenuation	VBUS = 48 V; Frequency = 250 kHz		75		dB
I BUS+ to BUS-	Input bias current at 80 Volts	Input current from BUS+ to BUS-		15		mA
IPG QPI+ to QPI-	Load current prior to PWRGD	Critical maximum DC load			25	mA
UV	Undervoltage threshold rising	Controller disabled to enabled		34		V
UVHYS	Undervoltage hysteresis falling	Controller enabled to disabled		UV – 2 V		V
OV	Overvoltage threshold rising	Controller enabled to disabled		76		V
OVHYS	Overvoltage hysteresis falling	Controller disabled to enabled		OV – 4 V		V
PWGSAT	Powergood low voltage	IPWG = 1 mA		0.2	0.6	V
PWGLK	Powergood high leakage	VPWG = 90 V			1	µA

Note 3: *Refer to Figure 5 for current derating curve.*

Pad Description

Pin Number	Name	Description
1, 16	BUS-	Negative bus potential
2, 3, 15	SW	Negative rail controlled by hot insertion function.
4	SHIELD	Shield connects to the converter shield and Y-capacitor common point via RY. See Figures 9a and 9b.
5, 6	QPI-	Negative input to the converter
7, 8	QPI+	Positive input to the converter
10	PWRGD	Open collector output that asserts low when power is NOT good.
12, 13	BUS+	Positive bus potential
14	UVEN	High side of UV resistor divider
11	OV	High side of OV resistor divider
9	Not Used	No connection



Applications – EMI

The QPI-8 is an active EMI filter providing conducted common-mode and differential-mode attenuation from 150 kHz to 30 MHz. Designed for the telecom and ITE bus range, the QPI supports the PICMG® 3.0 specification for filtering system boards to the EN55022 Class B limit.

The QPI-8 attenuates conducted noise and provides the Hot-Swap function required in redundant systems, minimizing design time compared to using discrete approaches while minimizing the uncertainty that the system will pass the compliance requirements.

The plots in Figures 3 and 4 were taken using the standard 50| /50µH LISN and measurement conditions with the peak detection mode of the spectrum analyzer for a conducted EMI test. The results show the total noise spectrum for a particular converter and load compared to the CISPR22 EN 55022 Class B Quasi-peak detection limit.

The plot in Figure 4 shows the effect of inserting a QPI-8 filter between the DC bus and the converter input under the same operating conditions as in Figure 3. The resulting plot shows the QPI-8 is effective in reducing the measured prefiltered total noise spectrum to well below the EN55022 Quasi-peak detection limit. Using the Quasi-peak detection measurement mode would result in lower amplitudes by the error factor this method introduces.

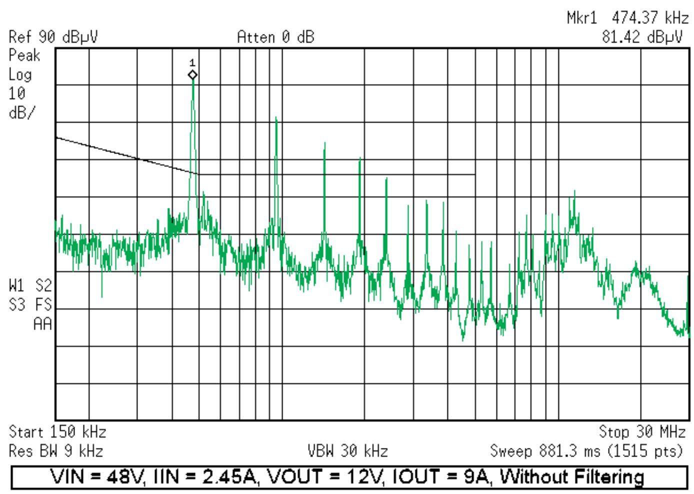


***Figure 3** – Conducted EMI profile of a DC-DC converter.*

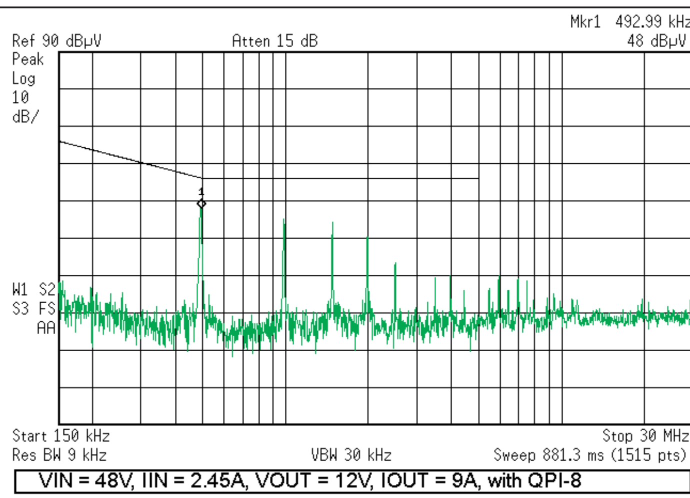


***Figure 4** – Conducted EMI profile of a DC-DC converter with QPI-8.*

Applications – Hot-Swap

The QPI-8 6 Amp rating provides filtering for up to 288 Watts of power from a 48 V bus with a 70°C PCB temperature. It is well suited for the 200 Watt per board limit in the PICMG® 3.0. The 25 x 25 x 4.5 mm surface mount LGA package provides ease of manufacturing by eliminating through-hole assembly. The current derating curve shown in Figure 5 should be used when the PCB temperature that the QPI-8 is mounted to exceeds 70°C.

The QPI-8 is designed to have an undervoltage range of 32 V to 34 V set points when the UVEN pin is tied directly to the BUS+ pin. The QPI-8 becomes enabled when the input voltage exceeds 34 V and continues to work down to 32 V before being disabled.

The QPI-8 overvoltage range is designed to be 72 V to 76 V when the OV pin is tied directly to the BUS+ pin. The QPI-8 remains functioning until the input voltage surpasses 76 V, where the QPI-8 will shutdown until the input voltage falls below 72 V.

External resistors can be added (see Figures 9a and 9b) to trim the UV and OV trip points higher. The graph in Figure 6 shows the trimming effect for a range of external series resistors. The equations in Figure 7 can be used to calculate the UV and OV thresholds.

Note: *It is critical to keep the load current on the converter's input capacitor to less than 25 mA during the initial power-up phase. This limit is set by the current limit level and the duty cycle of the circuit breaker timer. Once Powergood has been asserted the full load can be enabled.*

An external capacitor CE, shown in Figures 9a and 9b, will provide the required UVEN hold-up filtering during the ATCA's 5 ms, zero-volt BUS transient requirement. Figure 8 shows the effects of CE during a BUS transient event. Using a 2.2 µF CE capacitor and 1 mF of converter input capacitance will enable this circuit to support a 42 W load for the 5 ms transient. The Powergood state of the QPI-8 remains unchanged during this transient, allowing the converter to maintain its output power to the load. If the CE capacitor is used, a minimum value of 1K should be used for RUVEN to prevent damaging the enable diodes.

To prevent the QPI-8 from going into a fault mode and deasserting the Powergood signal after the transient, the converter's input capacitors must be sized so that they can be completely restored in the time of one 12 A current pulse, about 1 ms, and still maintain the required input current of the converter. If greater bulk capacitance is required for higher loads, then the circuit in Figure 9c could be used to slowly charge the capacitors. To reduce bulk capacitance and take advantage of the V^2 energy relationship, a boost circuit with a switch-over function can be used to charge fewer bulk storage capacitors to a higher voltage.

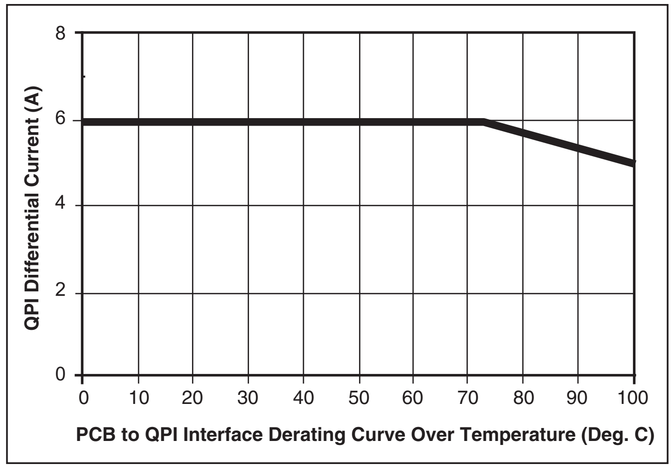


Figure 5 *– QPI-8 current derating curve over temperature.*

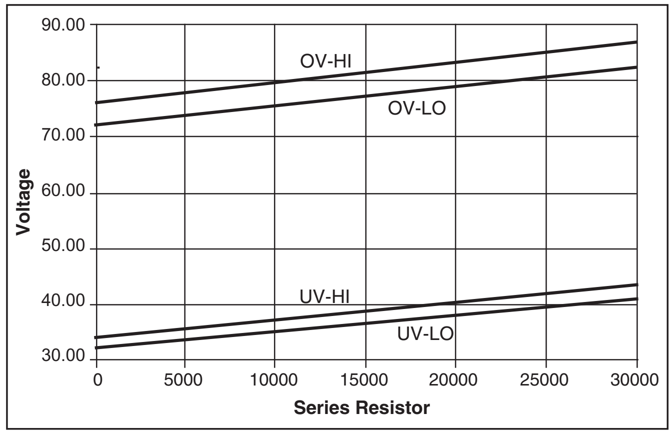


Figure 6 *– Trimming UV/OV with external series resistor.*

$$UVEN_{LO} = \frac{2.5\ (RUVEN + 108{,}450)}{8450}$$

$$UVEN_{HI} = 2.5\ V + (RUVEN + 100{,}000)(316\ \mu A)$$

$$OV_{LO} = 2.5\ V + (ROV + 200{,}000)(348\ \mu A)$$

$$OV_{HI} = \frac{2.5\ (ROV + 206{,}800)}{6800}$$

Figure 7 *– UVEN and OV resistor equations.*

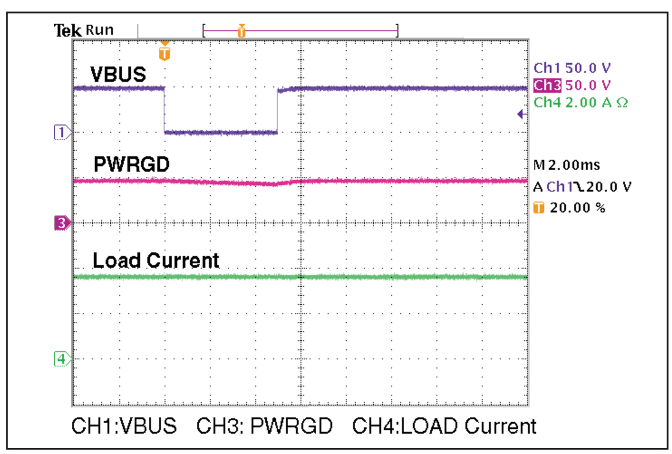


Figure 8 *– 5 ms BUS transient, 42 W load*

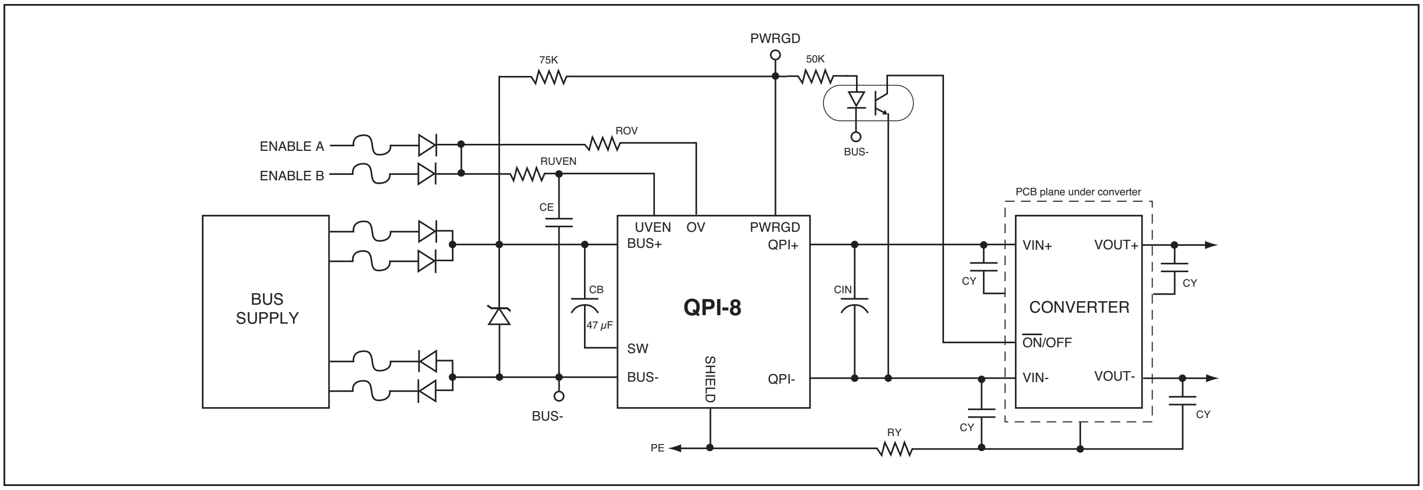


Figure 9a *– Typical ATCA System with QPI-8 with active-low enable input*
(Refer to Figure 15 and QPI-AN1 application note for general PCB layout guidelines).

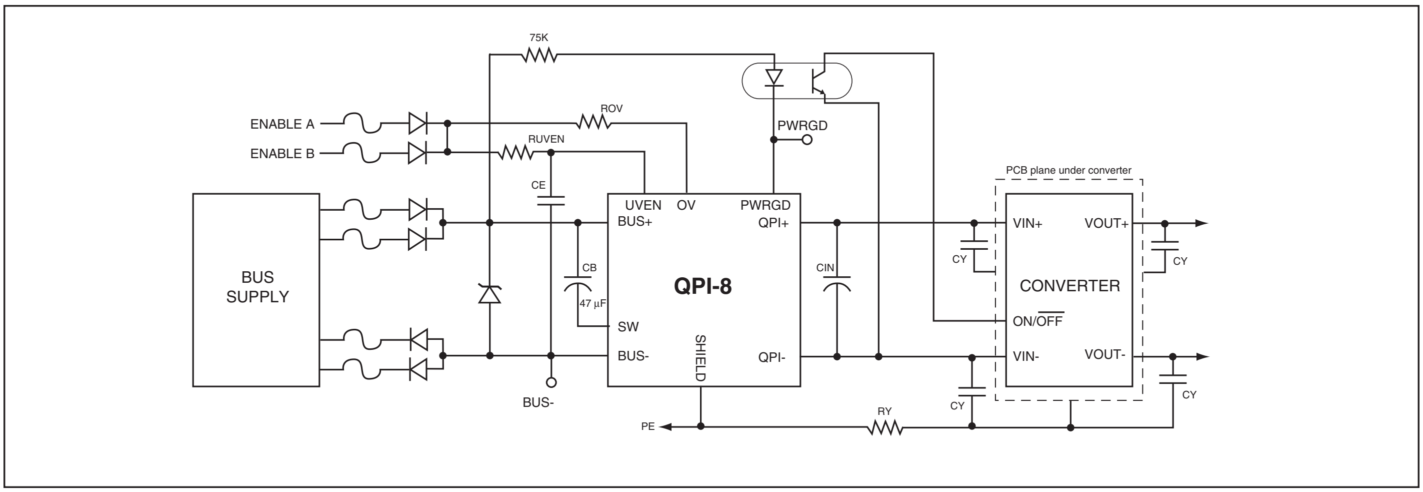


Figure 9b *– Typical ATCA System with QPI-8 with active-high enable input*
(Refer to Figure 15 and QPI-AN1 application note for general PCB layout guidelines).

$$C_{HOLD\text{-}UP} = \frac{2 * E}{(V_{PT}^2 - V_{UVLO}^2)}$$

where:

- E = Hold-up energy
- V_{PT} = Pre-transient voltage
- V_{UVLO} = Converter's UV limit

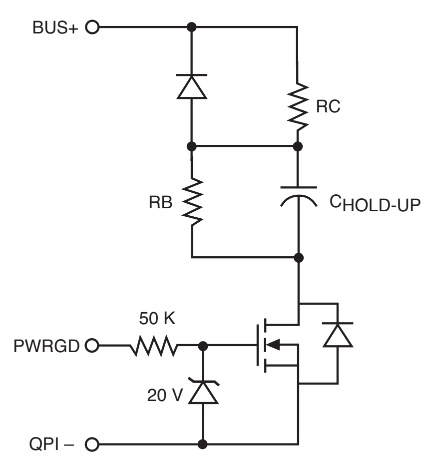


Figure 9c *– Powergood controlled, auxiliary bulk storage capacitor charging circuit.*

Start-up

The following oscilloscope pictures show the Hot-Swap BUS- current, QPI- to Bus- voltage and PWRGD (Powergood) to BUS- output voltage of the QPI-8 during operation. Figures 10 and 11 are the QPI-8's in-rush characteristics under two load capacitance conditions.

In Figure 10 a 470 µF capacitor required roughly 170 ms to completely charge from a 48 V bus voltage. The QPI-8 can drive large amounts of bulk capacitance, as shown in Figure 11 with a 4700 µF load capacitance. Under this condition the PWRGD signal takes about 8.7 seconds to go high after the UVEN input is pulled high upon the completed insertion of the board into the shelf. Figure 11's time-scale is too long to show the current pulses that charge the bulk capacitance.

After insertion, when the UVEN voltage exceeds 34 V the UV detection fault is cleared, the QPI-8 goes through a delay cycle (~15 ms) to allow for system de-bounce and stabilization. After this time, the QPI- to BUS- path is turned on and current is allowed to pass, monitored by the current sense function. Initially the current level exceeds the 6 A circuit breaker limit, the event timer starts and the Powergood state is not valid. The sense function and linear control loop will allow twice the circuit breaker current to pass. If the current does not drop below the circuit breaker level prior to reaching the timer limit, typically 275 µs, the QPI- to BUS- path will open. The effective duty cycle under the current limit condition is approximately 1%. Once the load capacitors are fully charged to the input bus potential, the load condition falls below 6 A and the PWRGD pin is asserted high, providing that the bus supply is still within the UV and OV range.

Transient Protection and Recovery

Figures 12 and 13 show the QPI-8's ability to handle low resistance shorts (<2 |) at the load terminals to emulate fast and slow blown fuse events. In Figure 12, the transient short is 2 seconds long and the QPI- to BUS- path is opened within 400 µs of this occurrence. The QPI-8 remains in a low duty cycle mode until the short is removed, then restarts normally.

Figure 13 demonstrates the QPI-8's performance with a short circuit on its output.

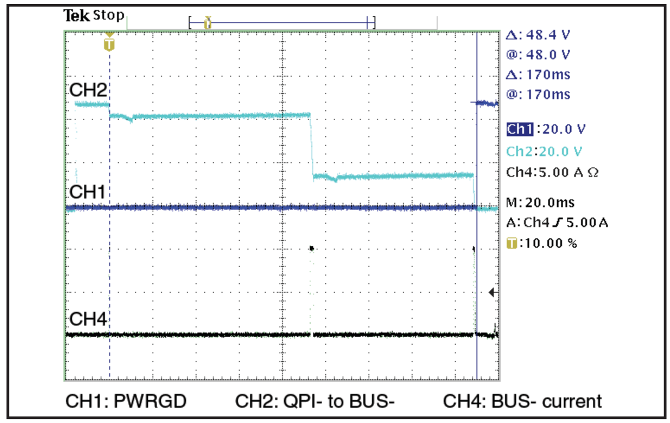


Figure 10 *– 470 µF capacitor @ 48 V*

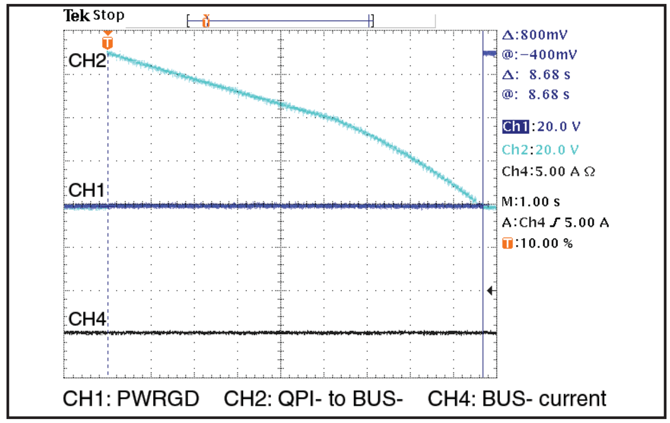


Figure 11 *– 4700 µF capacitor @ 72 V*

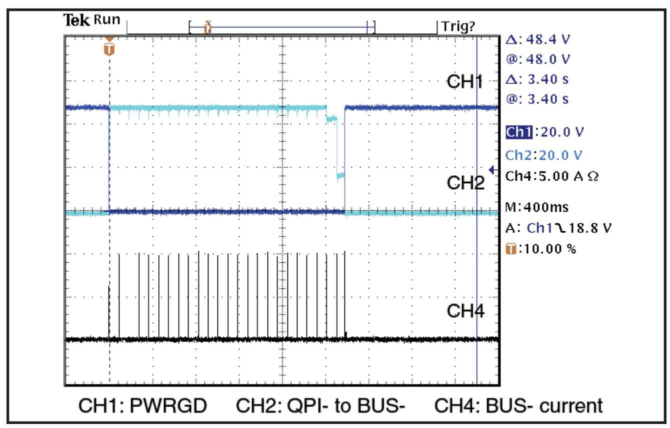


Figure 12 *– 2 second short circuit*

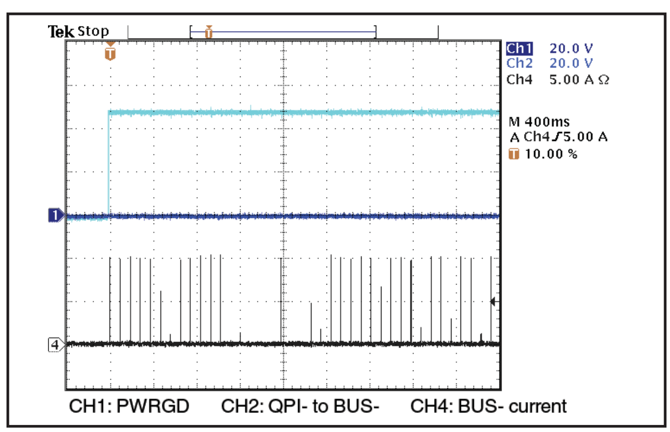


Figure 13 *– Start-up into short circuit*

QPI-8 PCB Layout Considerations

For optimal QPI-8 filtering performance, care must be taken when routing the signal paths of RY (see Figures 9a and 9b) and the shield connections on the PC board. The RY resistor must connect between the converter's shield plane and the shield pin of the QPI-8. The connection to the chassis or protective earth, if required, should be taken directly from the QPI-8 shield pin as shown in Figures 9a and 9b.

Figure 15 shows how this can be accomplished by using the QPI-8's shield pin to bridge the connection between RY and PE without allowing any parasitic paths that might circumvent the QPI-8 and degrade filtering performance. Reference can be made to the QPI-AN1 application note for critical PCB layout recommendations regarding filter performance, but use the QPI-8 pin/pad locations. Some systems may require the converter's positive or negative input or output 'terminal' to be connected to PE (Protective Earth) ground for safety or other considerations.

When using the QPI in this situation this 'terminal' must be connected to the converter shield plane created in the PCB layout under the converter. Because the PE path may pass excessive current under a fault condition the resistance of this path may be limited to a low resistance value. To meet the resistance requirement without degrading filter performance RY can be replaced by a 4.7 µH inductor rated for the fault current condition maintaining low power dissipation during a fault until the protection device clears. The shield return PCB traces must be sized to handle this current as well.

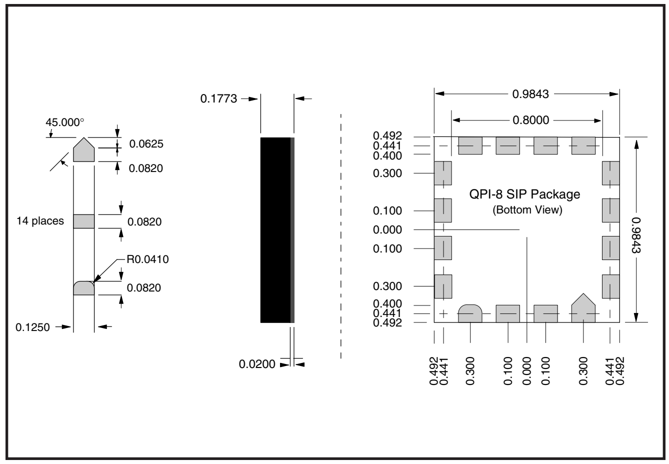


***Figure 14** – LGA Pad, package height and pad location dimensions in inches.*

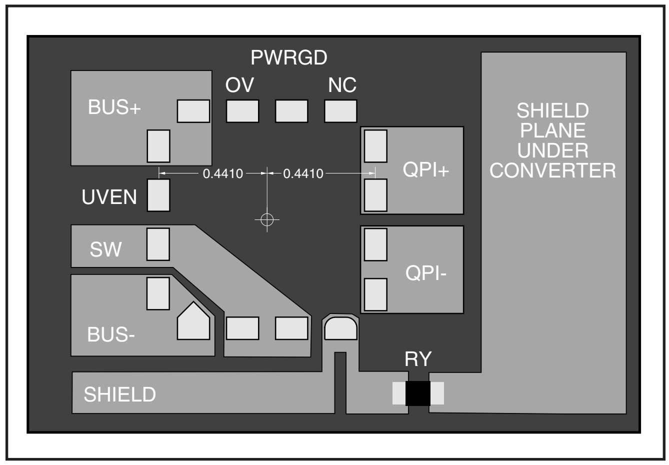


***Figure 15** – Recommended PCB layout pattern.*

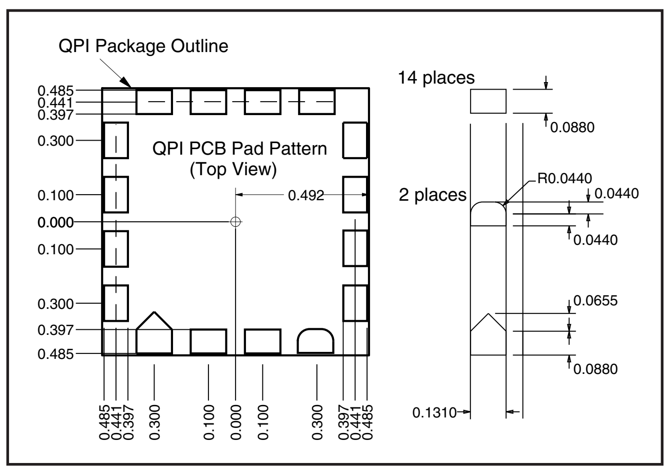


***Figure 16** – Recommended PCB receiving footprint.*

Post Solder Cleaning

Picor's Z version QP SIPs are not hermetically sealed and must not be exposed to liquid, including but not limited to cleaning solvents, aqueous washing solutions or pressurized sprays.

When soldering, it is recommended that no-clean flux solder be used, as this will insure that potentially corrosive mobile ions will not remain on, around, or under the module following the soldering process.

Ordering Information

Part Number	Description
QPI-8L	QPI-8 Land Grid Array Package
QPI-8LZ	QPI-8 Land Grid Array Package, RoHS Compliant

Vicor's comprehensive line of power solutions includes high-density AC-DC & DC-DC modules and accessory components, fully configurable AC-DC & DC-DC power supplies, and complete custom power systems.

Specifications are subject to change without notice.

Vicor Corporation
25 Frontage Road, Andover, MA, USA 01810
Tel: 800-735-6200 Fax: 978-475-6715

Email
Vicor Express: vicorexp@vicr.com
Technical Support: apps@vicr.com