

QPO-1-EVAL1 User's Guide

**Description:**

The QPO-1-EVAL1 is designed to allow full testing of the QPO-1LZ, along with its various performance options, to fully optimize a final system design. The board offers two terminal options for vertical or horizontal mounting. The user must select the required values for the  $R_{HR}$ ,  $R_{SCSET}$  and  $R_{SA}$  resistors and solder them in the designated positions before applying power to the EVAL1. Please refer to the QPO-1LZ product data sheet, schematics and the following pages for the proper application of this board.

The QPO-1 output ripple attenuator SiP uses active filtering to reduce output ripple and noise (PARD) over 30 dB from 500 Hz to 500 kHz and can be extended down to 50 Hz with additional capacitance added to the VREF pin. The QPO-1LZ operates over a voltage range from 3 to 30  $V_{DC}$  and supports load currents as high as 10A. Output regulation is maintained with remote sense or trim adjustment of the power supply. The closed loop architecture improves transient response and ensures quiet point-of-load regulation when used in conjunction with the power supply's control loop or trim node.

**Features:**

- > 30 dB PARD attenuation, 1 kHz to 500 kHz
- 3 - 30  $V_{DC}$  operating range
- 10A rating
- Supports precise point-of load regulation through use of remote sensing or converter trimming.
- Optional Start-up circuit included.
- User selectable performance optimization for attenuation, power dissipation, and transient response
- Horizontal or vertical mounting options.
- Evaluation board includes a Johnson Jack for low-noise measurement of the QPO's filtering performance.

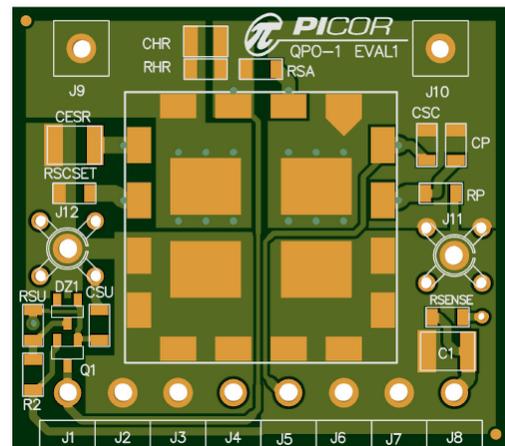


Figure 1 – Top View of Evaluation Board.

**QPO-1 Performance:**

The waveforms in Figure 2 high-light the QPO-1's ability to both filter a converter's output ripple and maintain a constant output voltage during a load transient. The input voltage of the QPO-1 (dark blue) shows varying amplitude and frequency PARD before and during the load transient, but the QPO-1 output voltage (light blue) remains relatively unaffected. The load transient is a 1A to 10A load step (green).

The converter used is a Vicor Mini, 48V to 5V converter (Model number: V48B5C200BN)

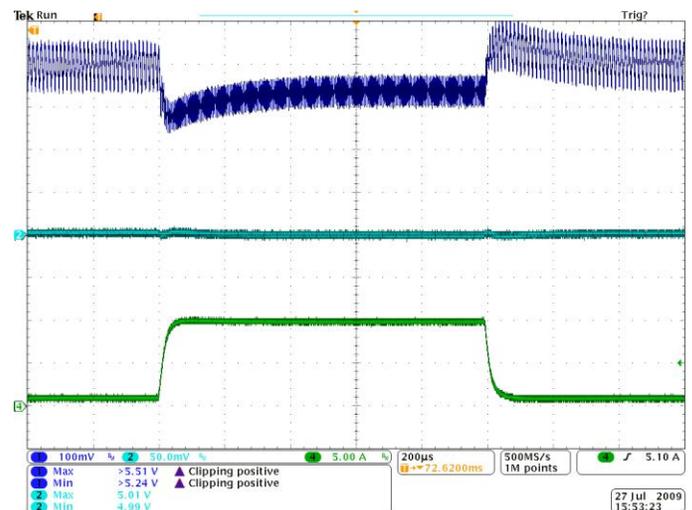


Figure 2 - PARD and Transient Attenuation

**QPO-1-EVAL1 SCHEMATIC:**

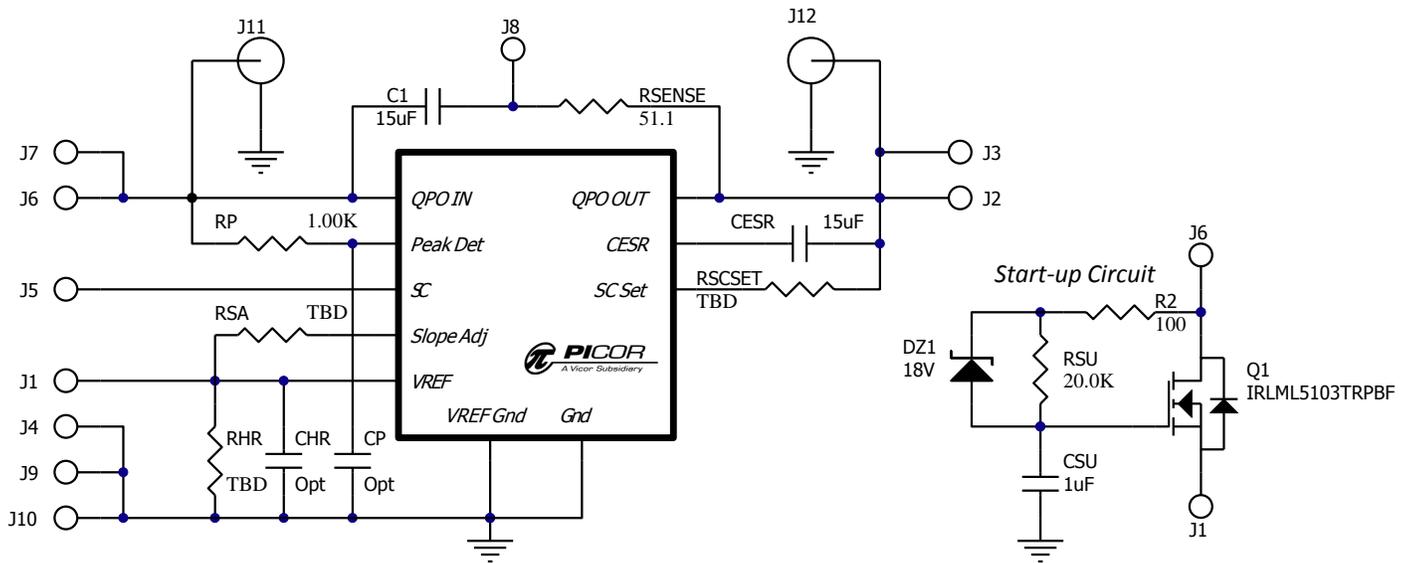


Figure 3 – Evaluation board schematic.

**QPO-1-EVAL1 BOM:**

Qty	Description	Value	Designator	Vendor	Vendor Part Number
2	Capacitor,X7R Ceramic,15uF,25V,1812	15uF	C1, CESR	TDK	C4532X7R1E156MT
1	Capacitor,X7R Ceramic,1uF,50V,1206	1uF	CSU	TDK	C3216X7R1H105K
1	Diode,Zener,12V,0.15W,SOT-23	18V	DZ1	ON Semi	BZX84C18LT1G
8	Samtec,0.2", Rt Angle Header		J1, J2, J3, J4, J5, J6, J7, J8	Samtec	FWS-08-02-T-S-RA
2	Connector,Johnson Jack	Johnson Jack	J11, J12	Tektronix	131503100
1	Transistor,PFET,30V,0.6A	IRLML5103TRPBF	Q1	International Rectifier	IRLML5103TRPBF
1	QPO-1LZ	QPO-1LZ	QPO-1	PICOR	QPO-1LZ
1	Resistor,5%,0.25W,1206	100	R2	Rohm	MCR18EZPJ101
1	Resistor,1%,0.25W,1206	1.00K	RP	Rohm	MCR18EZHf1001
1	Resistor,1%,0.25W,1206	51.1	RSENSE	Rohm	MCR18EzPF51R1
1	Resistor,1%,0.25W,1206	20K	RSU	Rohm	MCR18EZHf2002

**INSTALLED COMPONENTS:**

The QPO-1-EVAL1 board comes with the following components pre-stuffed:

- Remote Sense Components: C1, R<sub>SENSE</sub>
- Start-up Assist Circuit: C<sub>SU</sub>, R<sub>SU</sub>, DZ1, R2, Q1
- Peak Detector: R<sub>p</sub>
- CESR: C<sub>ESR</sub>

**USER DEFINED COMPONENTS:**

The QPO-1-EVAL1 board comes with the following components not installed; values to be determined by customer:

- Headroom Resistor: R<sub>HR</sub> (not optional, must be installed for proper operation)
- Headroom Capacitor: C<sub>HR</sub> (optional)
- Slope Adjust: R<sub>SA</sub> (optional)
- SC Function: C<sub>SC</sub>, R<sub>SCSET</sub> (optional)
- Peak Detector: C<sub>p</sub> (optional)

**FUNCTION DESCRIPTIONS:**

**Slope Adjust:**

The slope adjust function allows the user to modify the voltage drop across the QPO-1 (headroom voltage) dependent on the current passing through the QPO-1. This function is used to maintain a constant power across the QPO-1 over a varying range of load currents. The R<sub>SA</sub> resistor can be calculated by using the following equation:

$$R_{SA} = \frac{0.05V}{A} * \frac{\Delta I_{OUT}}{\Delta V_{HR}} * 2.5k\Omega$$

Where;  $\Delta I_{OUT}$  = Maximum change in load current (A)  
 $\Delta V_{HR}$  = headroom voltage change over load range (V)  
 R<sub>SA</sub> = slope adjust resistor ( $\Omega$ )

The slope adjust feature can be disabled by either using a large resistor value (100k or greater) for R<sub>SA</sub> or by omitting this resistor entirely.

**Headroom Adjust:**

The R<sub>HR</sub> resistor is used to program the desired voltage drop across the QPO-1. This voltage must be greater than the ripple voltage that the QPO-1 is to filter, with additional voltage added for the voltage drops in the attenuation path. Like the R<sub>P</sub> resistor, **the R<sub>HR</sub> resistor must always be installed for proper operation.** The value of RHR can be calculated using this equation:

$$R_{HR} = \frac{QPO_{OUT} * 2.5k\Omega}{V_{HR}}$$

Where; R<sub>HR</sub> = headroom setting resistor value ( $\Omega$ )  
 QPO<sub>OUT</sub> = the voltage on the QPO's output (V)  
 V<sub>HR</sub> = the target headroom voltage (V)

If this resistor is omitted, then the reference pin will be at the same voltage as the input pin, forcing the output pin to be the same voltage as the input pin.

**SC Function:**

The function of the SC circuit is to use a converter's trim or SC (secondary control) pin to compensate for the voltage drop across the QPO-1, thereby maintaining the desired output voltage on the QPO's output.

The R<sub>SCSET</sub> resistor (listed as R<sub>SC</sub> in the datasheet) determines the amount of current the SC pin of the QPO-1 will source. The current is calculated by dividing the headroom voltage (the voltage drop from QPO\_IN to QPO\_OUT) by R<sub>SCSET</sub>.

$$R_{SCSET} = \frac{R_{IN} * V_{OUT}}{V_{RPT}}$$

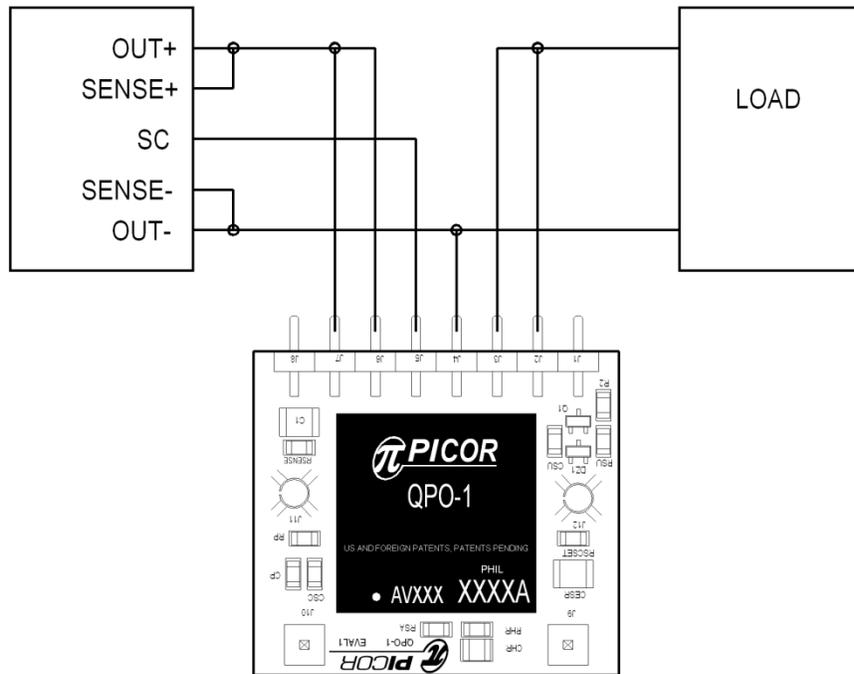
Where; V<sub>OUT</sub> = Nominal converter output voltage (V)  
 V<sub>RPT</sub> = internal reference voltage (V)  
 R<sub>IN</sub> = internal series resistor. ( $\Omega$ )

When using one of Vicor's Micro, Mini or Maxi converters, the R<sub>IN</sub> = 1k $\Omega$  and the V<sub>RPT</sub> = 1.23V.

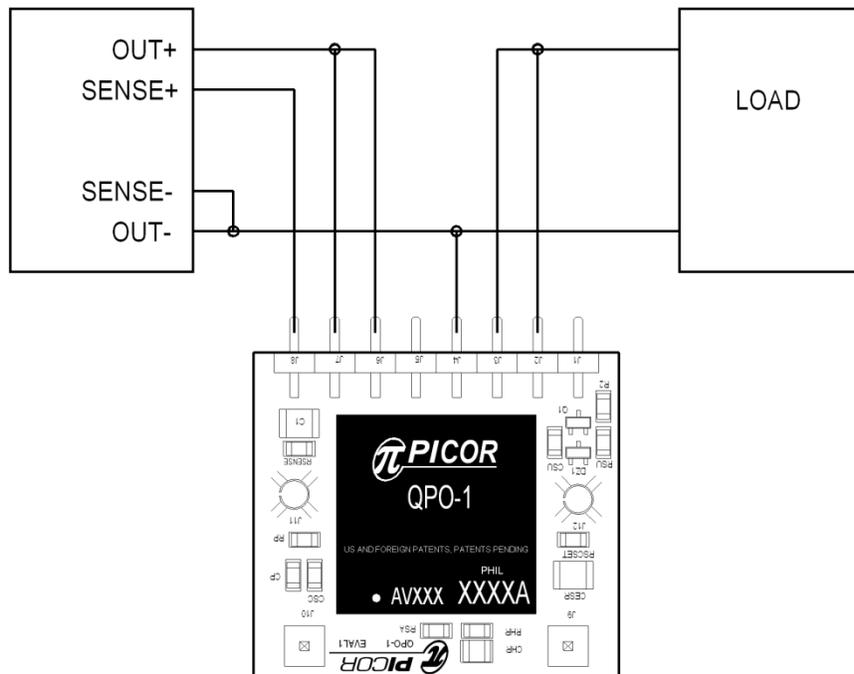
Figure 4 shows the QPO-1-EVAL1 board connected so as to use the SC function to compensate for the QPO-1's voltage drop.

**Remote Sense:**

Compensation for the QPO-1's voltage drop can be done using the converter's remote sense pins, if available. The on-board sensing network can be attached as is shown in Figure 5.



**Figure 4** – Evaluation board in SC configuration.



**Figure 5** – Evaluation board in Remote Sense configuration.

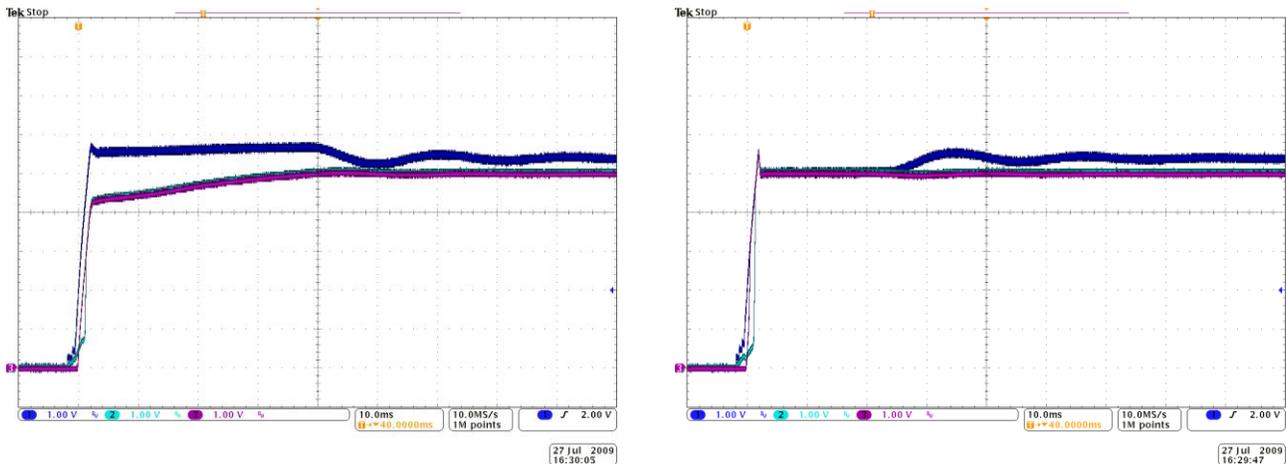


Figure 6 - Start-up waveforms; without (left) and with (right) the optional Startup circuit.

#### Start-up Circuit:

The start-up circuit (Figure 3) on the evaluation board is used to connect the QPO-1's reference pin to its input pin during start-up. In both waveform pictures of Figure 6, the Output Voltage (light blue) follows the  $V_{REF}$  voltage (purple) of the QPO-1.

In the picture to the left in Figure 6, without the optional start-up circuit, the QPO-1 input voltage (the converter's output voltage) can be seen to be greater than the nominal 5V output of the converter. This is due to the QPO-1's SC circuit having greater headroom voltage during start-up and therefore over-driving the SC of the converter. After about 40ms, the  $V_{REF}$  voltage reaches its 5V pre-set limit and the converter's output voltage starts to drop, eventually steadying out at 5.35V, the nominal output voltage plus the QPO-1's headroom voltage.

The potential problem with this start-up is that the converter could fault due to its output being forced to be greater than 110% of the nominal value. For converters with lower nominal output voltages, this could be very serious condition.

The waveforms to the right are the same converter with the optional start-up circuit enabled. Here, the  $V_{REF}$  is forced to follow  $V_{IN}$ , so  $V_{OUT}$  follows as well. After about 25ms, the start-up circuit releases the  $V_{REF}$  pin and it adjusts its value down to generate the proper headroom voltage across the QPO-1. Using this method, there is no possibility of over-driving the converter and causing a fault.

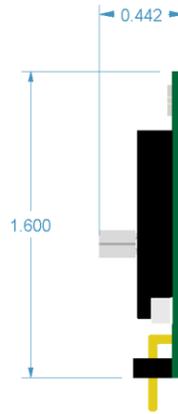
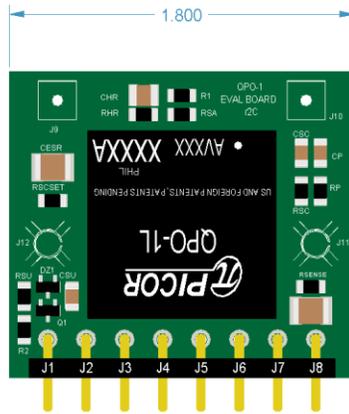
#### Peak Detector:

The QPO-1 peak detector is used to adapt the headroom voltage in response to increasing converter ripple. The greater the ripple on the QPO-1's input, the greater the headroom voltage across the QPO-1. This feature can be disabled by adding the  $C_p$  capacitor to the evaluation board. The addition of this capacitor creates an RC filter network that filters out the converter's ripple to the peak detector.

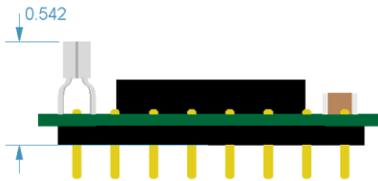
**The  $R_p$  resistor must always be installed for proper operation.** The peak detector creates the internal reference voltage rail that gets divided down by the headroom resistor  $R_{HR}$ .

**Mounting Options:**

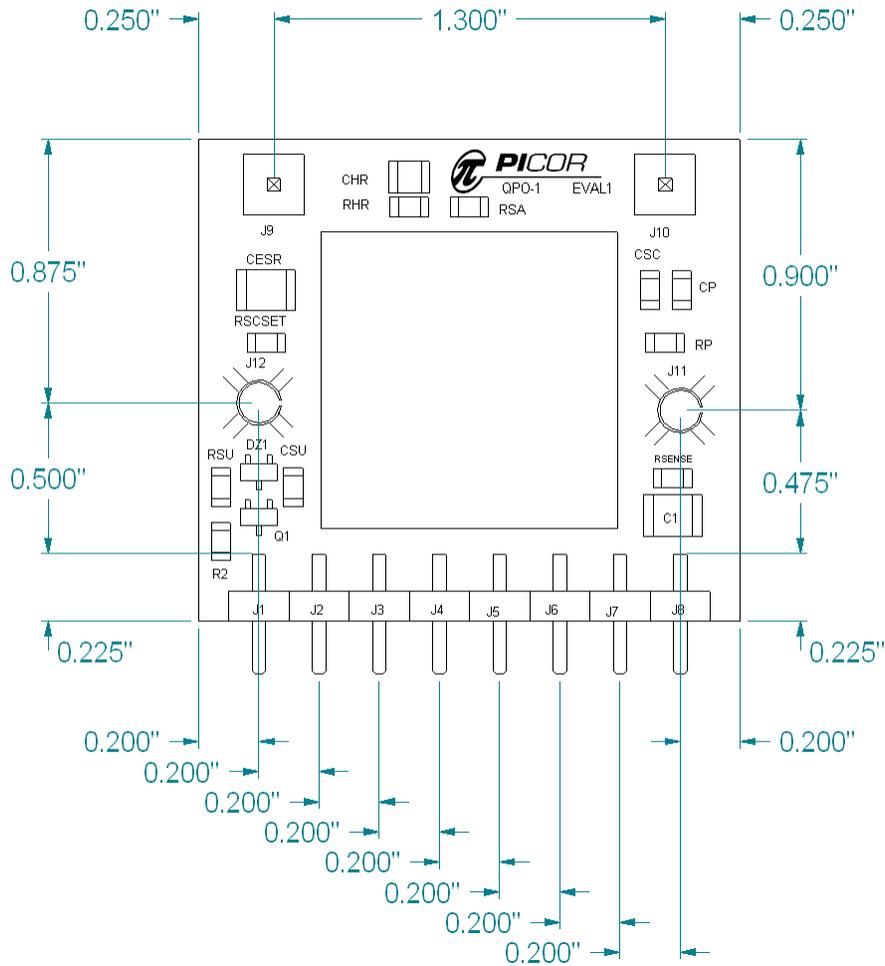
**Vertical Mount**



**Horizontal Mount**



Mechanical Drawing:



Ordering Information

Part Number	Description
QPO-1-EVAL1	Evaluation Board for QPO-1L

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