PI2007-EVAL2 12V/15A High Side Active ORing Evaluation Board User Guide

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Cool-ORing® Series



PI2007-EVAL2 Evaluation Board featuring the Cool-ORing PI2007 Active ORing controller.

The PI2007-EVAL2 Evaluation Board is intended to acquaint the user with the benefits and features of the *Cool-ORing®* PI2007 full function Active ORing solution. It is not designed to be installed in end-use equipment.

Please read this document before setting up the PI2007-EVAL2 Evaluation Board and refer to the PI2007 product datasheet for device specifications, functional description and characteristics.

During operation, the power devices and surrounding structures can be operated safely at high temperatures.

- Remove power and use caution when connecting and disconnecting test probes and interface lines to avoid inadvertent short circuits and contact with hot surfaces.
- When testing electronic products always use approved safety glasses. Follow good laboratory practice and procedures.

Introduction

The PI2007-EVAL2 allows the user to test the basic principle and operational characteristics of an Active ORing function in a redundant power architecture, while also experiencing the benefits and value of the PI2007 solution versus conventional Active ORing solutions. The PI2007-EVAL2 evaluation board is configured to receive two independent power source inputs, per a typical redundant power architecture, through two Active ORing channels that are combined to form a redundant power output. Each channel contains a PI2007 controller and a 25V N-channel power MOSFET. The MOSFET foot print can take an SO-8 or Power SO-8 MOSFET package. Each channel is capable of up to 15A.

The PI2007-EVAL2 evaluation board is designed with optimized PCB layout and component placement to represent a realistic high density final design for an embedded high side Active ORing solution for 12V Bus (10V to 14V) applications requiring up to 15A. This evaluation board is intended as an easy and simple way to test the electrical and thermal performance of the PI2007 Active ORing controller.

Both dynamic and steady state testing of the PI2007 can be completed on the PI2007-EVAL2 evaluation board, in addition to using the key features of the product. Dynamic testing can be completed under a variety of system level fault conditions to check for response time to faults.

This document provides basic instructions for initial start-up and configuration of the evaluation board. Further information on the functionality of the PI2007 can be found in the PI2007 product data sheet.

Cool-ORing® PI2007 Product Description

The Cool-ORing PI2007 with an external industry standard 25V N-channel MOSFET provides a complete Active ORing solution designed for use in 12V Bus (10V to 14V) redundant power system architectures. The PI2007 controller with an N-channel MOSFET enables extremely low power loss with fast dynamic response to fault conditions, critical for high availability systems.

The PI2007 controller with a low $R_{DS(on)}$ N-channel MOSFET provides very high efficiency and low power loss during steady state operation. The PI2007 controller provides an active low fault flag output to the system during excessive forward current or reverse current, or under VC under voltage condition.

Figure 1 shows a photo of the PI2007-EVAL2 evaluation board, with two PI2007 controllers and two N-channel MOSFET used to form the two Active ORing channels. The board is built with two identical Active ORing circuits with options and features that enable the user to fully explore the capabilities of the PI2007 Active ORing controller.



Terminals Maximum Rating

Vin1, Vin2,	25V/15A
Vout	25V/30A
$\overline{FT}1$, $\overline{FT}2$	-0.3V to 17.3V / 10mA
VL1, VL2 (R5=R6=1.5kΩ)*	5.5V
* VL1, VL2 voltage can be higher than 5.5V, but R5 and R6 values have to be increased to accommodate the LEDs	

Figure 1: PI2007-EVAL2 Evaluation Board (1.8" x 1.8")

Terminal	Description
Vin1	**Power source Input #1** or bus input designed to accommodate up to 15A continuous current.
Vin2	**Power source Input #2** or bus input designed to accommodate up to 15A continuous current.
$\overline{FT}1$	**PI2007 (U1) Fault pin:** Monitors U1 fault conditions.
$\overline{FT}2$	**PI2007 (U2) Fault pin:** Monitors U2 fault conditions.
VC1	**PI2007 (U1) VC input:** Leave this pin unconnected unless an alternative controller bias voltage.
VC2	**PI2007 (U2) VC input:** Leave this pin unconnected unless an alternative controller bias voltage.
VL1	**Fault pin $\overline{FT}1$ LED supply**
VL2	**Fault pin $\overline{FT}2$ LED supply**
Vout	**Output:** Q1 and Q2 MOSFETs drain connection, connect to the load high side.
Rtn	**Return Connection:** Three Rtn connections are available and are connected to a common point, the Ground plane. Input supplies Vin1, Vin2, and the output load at Vout should all be connected to their respective local Rtn connection.

Table 1: PI2007-EVAL2 Evaluation Board Terminals Description

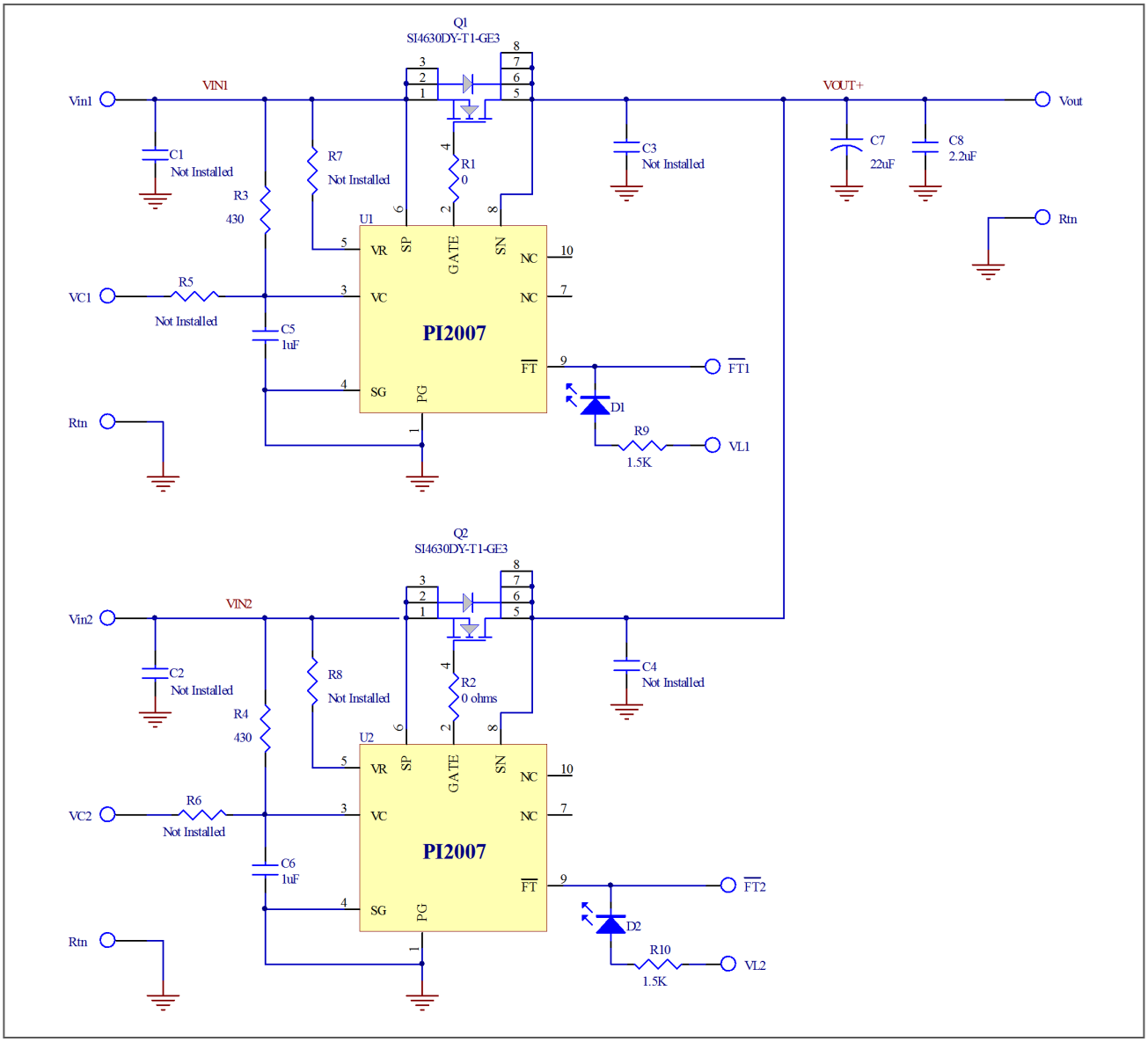


Figure 2: PI2007-EVAL2 Evaluation Board schematic.

Item	QTY	Ref. Designator	Value/Part NO.	Description	Footprint	Manufacturer
1	2	C1, C2, C3, C4	Not Installed	MLCC Capacitor, X7R, 1uF,50V	1206	
2	2	C5, C6	1µF	MLCC Capacitor, X7R, 1uF,50V,	805	
3	1	C7	22µF	Electrolytic Capacitor, 22uF,100V	Panasonic _E/F	Panasonic
4	1	C8	Not Installed	MLCC Capacitor, 10uF,25V	1812	
5	2	D1, D2	LTST-C191CKT	LED, Red	0603 LED	Lite-On
6	6	$\overline{FT}$1, $\overline{FT}$2, VC1, VC2, VL1, VL2	1528	Turret Test point	TURRET - 1528	Keystone Electronics
7	6	Rtn, Rtn, Rtn, Vin1, Vin2, Vout	1502	Turret Test point	TURRET - 1502	Keystone Electronics
8	2	Q1, Q2	SI4630DY-T1-GE3	N-MOSFET,25V,40A	PPAK SO-8	Siliconix
9	1	R1, R2	0Ω	Resistor,0 Ω,1%,0.1W	0603	
10	1	R3, R4	430Ω	Resistor,430Ω, 1%, 0.125W	0805	
11	1	R5, R6, R7, R8	Not Installed			
12	2	R9, R10	1.5K	Resistor,1.5K,1%,0.1W	603	
13	2	U1, U2	PI2007-00-QEIG	Picor Cool ORing Controller IC	3x3mm 10L TDFN	PICOR

Table 2: PI2007-EVAL2 Evaluation Board Bill of Materials

Ref. Designator	Value/Part NO.	Functional Description
C1, C2, C3, C4	Not Installed	Snubber to reduce voltage ringing when the device turns off Add the capacitors if a long harnesses are used to connect the power source or load to the board.
C5, C6	1uF	VC Bypass Capacitor
C7	22uF	Output (Load) Capacitor
C8	Not Installed	Output (Load) Capacitor, this capacitor can be installed if instead of C7 if the user requires a ceramic load capacitor, 1812 package can accommodate a high ceramic capacitors value at 25V rating.
D1, D2	LTST-C191CKT	To indicate a fault exists when it is on
Q1, Q2	SI4630DY-T1-GE3	ORing switch
R1, R2	0Ω	Gate resistor, optional to slow gate turn off time, higher value resistor will reduce gate pull down peak current
R3, R4	430Ω	VC bias resistor
R5, R6,	Not Installed	Optional to use PI2007 external VC bias voltage, removing R3 and R4 when external bias voltage is used.
R7, R8	Not Installed	Optional to use PI2007 internal VC bias resistor (VR) by placing 0Ω resistor and removing R3 and R4
R15, R16	1.5K	LED current limit resistor, selected to operate at 3.3V and 5.0V logic voltage. Replace R15 and R16 with the proper resistor value for different logic voltage.
U1, U2	PI2007	Cool ORing Controller

Table 3: Component functional description

Test Procedure:

Initial Test Set Up

PI2007-EVAL2 is designed with two bias circuit options, bias via 1% external resistor (R3 and R4) or via internal resistor (VR input). R3 and R4 resistors are installed (430Ω, 1%).

Baseline Test Procedure – PI2007 (Refer to Figure 3)

1. Recommended Material

1.1. Material Needed-Picor supplied

1.1.1. PI2007-EVAL2

1.1.2. PI2007 Product Datasheet

1.2. Recommended Users Supplied Equipment

1.2.1. Two DC power supplies: 0-20V; 20A each.

1.2.2. One low power logic voltage power supply

1.2.3. Load: electronic Load, Power resistors or actual load.

1.2.4. Multimeter.

1.2.5. Oscilloscope.

1.2.6. Appropriately sized interconnect cables.

1.2.7. Safety glasses.



Figure 3: Layout configuration for a typical redundant power application using PI2007.

Before initial power-up follow these steps to configure the evaluation board for specific end application requirement:

Note that PI2007 will not turn off the MOSFET unless it senses current in the reverse direction through the MOSFET. This means that if both input power source are turned on and both MOSFET are in on condition, then one off the power source is turned off, the associated PI2007 will not turn off the MOSFET unless the power source sinks current from the output when it turns off and cause a reverse current in the MOSFET that generates negative voltage equal or greater than 6mV.

2. Control Circuitry Bias:

PI2007 control circuitry and the gate driver for the MOSFET are biased through the VC pin. An internal regulator clamps VC pin voltage with respect to PG pin (V_{VC-PG}) to 11.7V typically. In a 12V application the input voltage can vary between 10V and 14V which is higher than the VC clamp voltage. A bias resistor between VC pin and input voltage is required to accommodate VC clamp.

PI2007-EVAL2 has two options for the bias resistor. A 420Ω internal resistor connected between VC pin and VR pin, or 430Ω 1% external resistor (R3 and R4). R3 and R4 installed in PI2007-EVAL2. If the internal resistor is desired for the test, remove R3 and R4, and install 0Ω resistor (jumper) for R7 and R8 to connect PI2007 VR pin to its input.

3. Hook Up of the Evaluation Board

3.1. Connect the positive terminal of PS1 power supply to Vin1. Connect the ground terminal of PS1 to its local Rtn. Set the power supply to 12V. **Keep PS1 output disabled, off.**

3.2. Connect the positive terminal of PS2 power supply to Vin2. Connect the ground terminal of PS2 to its local Rtn. Set the power supply to 12V. **Keep PS2 output disabled, off.**

3.3. Connect the logic power supply PS3 positive terminal to VL1 and VL2. Connect the ground terminal of this power supply to a Rtn terminal. Set the power supply to the desired logic voltage level, 3.3V or 5V. **Keep PS3 output disabled, off.**

3.4. Connect the electronic load to the output between Vout and its local Rtn. Set the load current to 5A.

3.5. Enable (turn on) PS1 power supply output.

3.6. Enable (turn on) PS3 power supply output.

3.7. Turn on the electronic load.

3.8. Verify that the load voltage (Vout) is few millivolts below 12V. This verifies that the Q1 MOSFET is in conduction mode.

3.9. Verify that Vin2 is low. This verifies that Q2 MOSFET is off.

3.10. Enable (turn on) PS2 output.

3.11. Verify that both PS1 and PS2 are sharing load current evenly by looking at the supply current. *Power supplies output may need adjustment to set current sharing between the supplies.*

3.12. Disable (turn off) PS1, PS2, and PS3 outputs.

3.13. Enable (turn on) PS2 output then Enable and PS3 outputs.

3.14. Verify that Vout is few millivolts below 12V. This verifies that the MOSFET Q2 is in conduction mode.

3.15. D2 should be off. This verifies that there is no fault condition.

3.16. Verify that Vin1 is low. This verifies that the MOSFET (Q1) is off.

4. Input short circuit test:

PI2007 has a very fast response (80ns) to a reverse current (Input short) fault condition. Measuring a short period event requires attention to the test set-up. Before proceeding, consider the following:

4.1. To emulate a real application, the BUS supplies for this test should have a solid output source such as a DC-DC converter that supplies high current and can be connected very close to the evaluation board to reduce stray parasitic inductance. Or use the prospective supply sources of the end application where the PI2007 will be used. Typical bench power supplies have slow response to output load change. In this test when the power supply output is shorted and then released, the bench power supply may produce high output voltage with high current capability that may damage the device under test.

4.2. Do not install Input capacitors (C1 and/or C2) in this test.

4.3. Output capacitor (C7) should be installed.

4.4. Place the scope probes very close to the MOSFET drain and source to measure Vout and Vin, and

make sure that the scope ground leads are very short. You may use a close by ground pad for the scope probe return, such as C1, C2, C3 and C4 Rtn pads.

4.5. Apply a short at one of the inputs (Vin1 or Vin2) when both controllers (U1 and U2) are on, PS1 and PS2 are enabled. The short can be applied electronically using a MOSFET connected between Vin and Rtn or simply by connecting Vin to Rtn. Then measure the response time between when the short being applied and the MOSFET being disconnected (or turned off). An example for PI2007 response time to an input short circuit is shown in Figure 4.

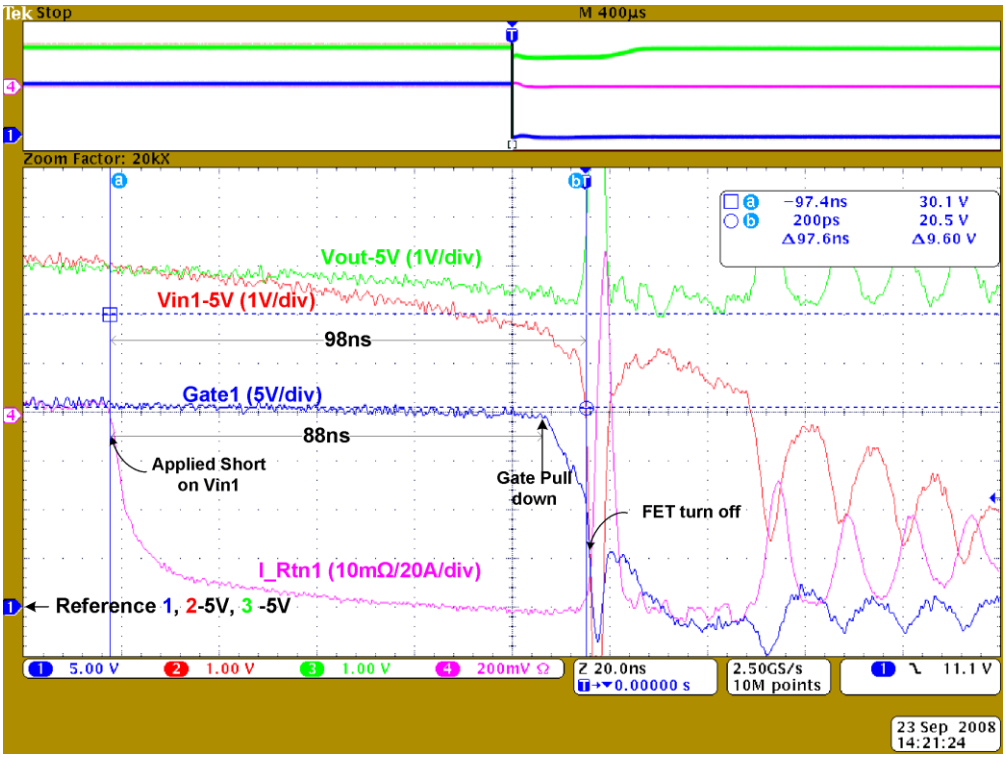


Figure 4: Plot of PI2007 response time to reverse current detection

Test Setup:
DUT: PI2007-EVAL2
Vin1 = 12V
Vin2 = 12V
Output Load = 6A

Test:
Both input sources are turned on and sharing the load current, then applied a short for **1ms** with fast turn on 1mΩ MOSFET between Vin1 and Rtn.

Test purpose:
To show the PI2007 response to a fault condition, where the output of the input source is shorted or tried to source current from the load (Vout)

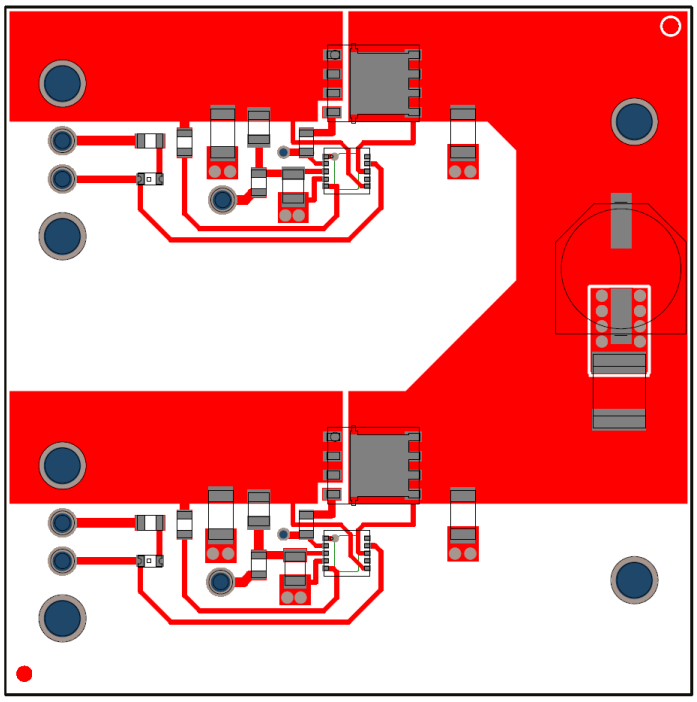


Figure 5: PI2007-EVAL2 layout top layer. Scale 2.0:1

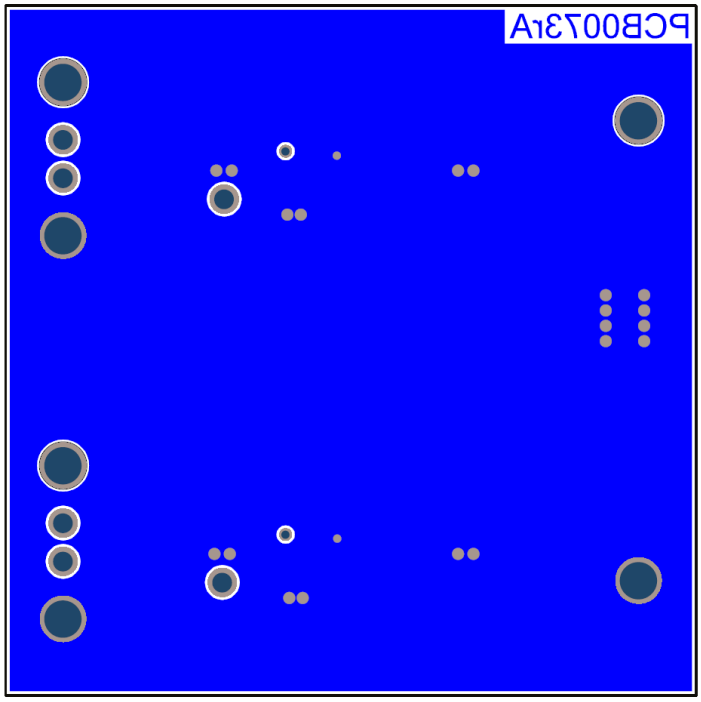


Figure 6: PI2007-EVAL2 layout bottom layer 2. Scale 2.0:1

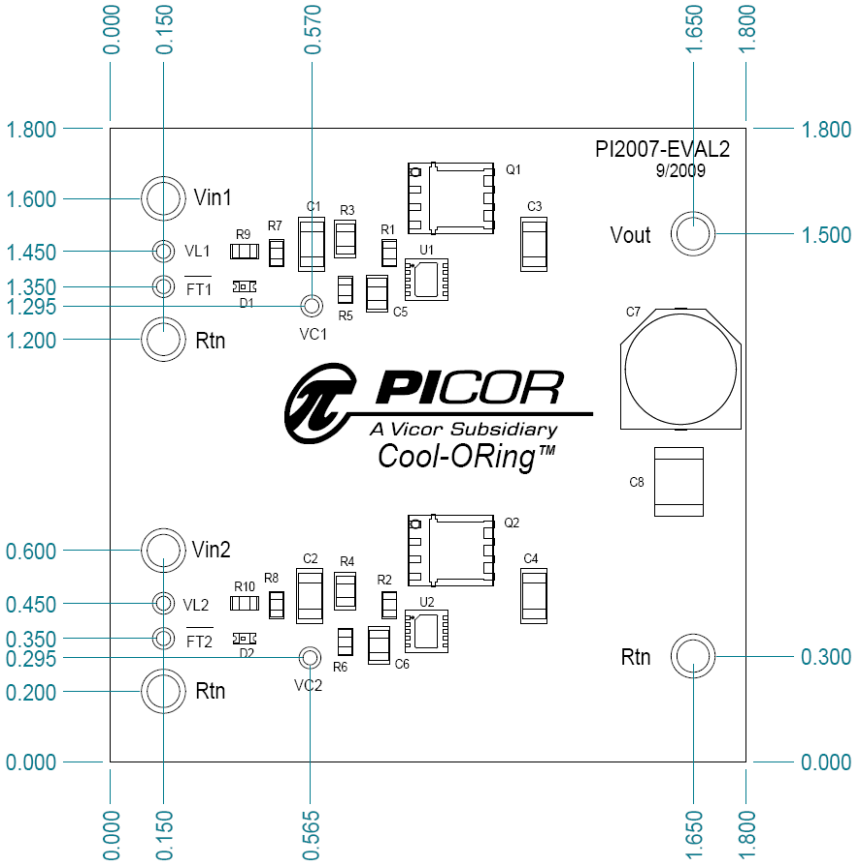


Figure 7: PI2007-EVAL2 evaluation board mechanical drawing

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