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## PI2003-EVAL1 Active ORing Evaluation Board User Guide

### Contents

Introduction .....	Page 1
PI2003 Product Description .....	Page 2
Evaluation Board Terminal Description .....	Page 2
Evaluation Board Schematic .....	Page 3
Bill of Materials .....	Page 3
Test Procedure .....	Page 4
PCB Layouts .....	Page 7
Evaluation Board Mechanical Drawing .....	Page 7



Cool-ORing™ Series

PI2003-EVAL1 Evaluation Board featuring the Cool-ORing PI2003 Active ORing controller.

The PI2003-EVAL1 Evaluation Board is intended to acquaint the user with the benefits and features of the Cool-ORing™ PI2003 full function Active ORing solution. It is not designed to be installed in end-use equipment.

**Please read this document before setting up the PI2003-EVAL1 Evaluation Board and refer to the PI2003 product data sheet 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 PI2003-EVAL1 allows the user to test the basic principle and operational characteristics of a low side Active ORing function in a redundant power architecture, while also experiencing the benefits and value of the PI2003 solution versus conventional Active ORing solutions. The PI2003-EVAL1 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 PI2003 controller and an 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 6 A.

The PI2003-EVAL1 evaluation board is designed with optimized PCB layout and component placement to represent a realistic high density final design for an embedded low side Active ORing solution for -48 Vbus applications requiring up to 6 A. This evaluation board is intended as an easy and

simple way to test the electrical and thermal performance of the PI2003 Active ORing controller.

Both dynamic and steady state testing of the PI2003 can be completed on the PI2003-EVAL1 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 PI2003 can be found in the PI2003 product data sheet.

# Cool-ORing™ PI2003 Product Description

The Cool-ORing PI2003 with an external industry standard 100V N-channel MOSFET provides a complete Active ORing solution designed for use in -48 Vbus redundant power system architectures. The PI2003 controller with an N-channel MOSFET enables extremely low power loss with fast dynamic response to fault conditions, critical for high availability systems.

The PI2003 controller with a low Rds(on) N-channel MOSFET provides very high efficiency and low power loss during steady state operation. The PI2003 controller provides an active low fault flag output to the system during excessive forward current, light load, or reverse current.

Figure 1 shows a photo of the PI2003-EVAL1 evaluation board, with two PI2003 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 PI2003 universal Active ORing controller.



### Terminals Rating

Vin1+ to Vin1-,	60 V / 8 A
Vin2+ to Vin2-	60 V / 8 A
VC1, VC2	-0.3 V to 17.3 V / 40 mA
FT1, FT2	-0.3 V to 17.3 V / 10 mA

Figure 1 – PI2003 -EVAL1 Evaluation Board (1.8" x 1.8")

Terminal	Description
Vin1+ and Vin1-	<b>Power Source Input #1:</b> or bus input designed to accommodate up to 60 V and 6 A continuous current.
Vin2+ and Vin2-	<b>Power Source Input #2:</b> or bus input designed to accommodate up to 60 V and 6 A continuous current.
VC1	<b>Optional Auxiliary Input Voltage #1:</b> to supply PI2003 VC power. VC1 should be 10 V or higher to fully enhance the MOSFET.
VC2	<b>Optional Auxiliary Input Voltage #2:</b> to supply PI2003 VC power. VC2 should be 10 V or higher to fully enhance the MOSFET.
FT1	<b>PI2003 (U1) Fault Pin:</b> Monitors U1 fault conditions
FT2	<b>PI2003 (U2) Fault Pin:</b> Monitors U2 fault conditions
Vout +	<b>Output +:</b> connected to input return
Vout-	<b>Output -:</b> connected to MOSFETs sources

Table 1 – PI2003-EVAL1 Evaluation Board terminals description

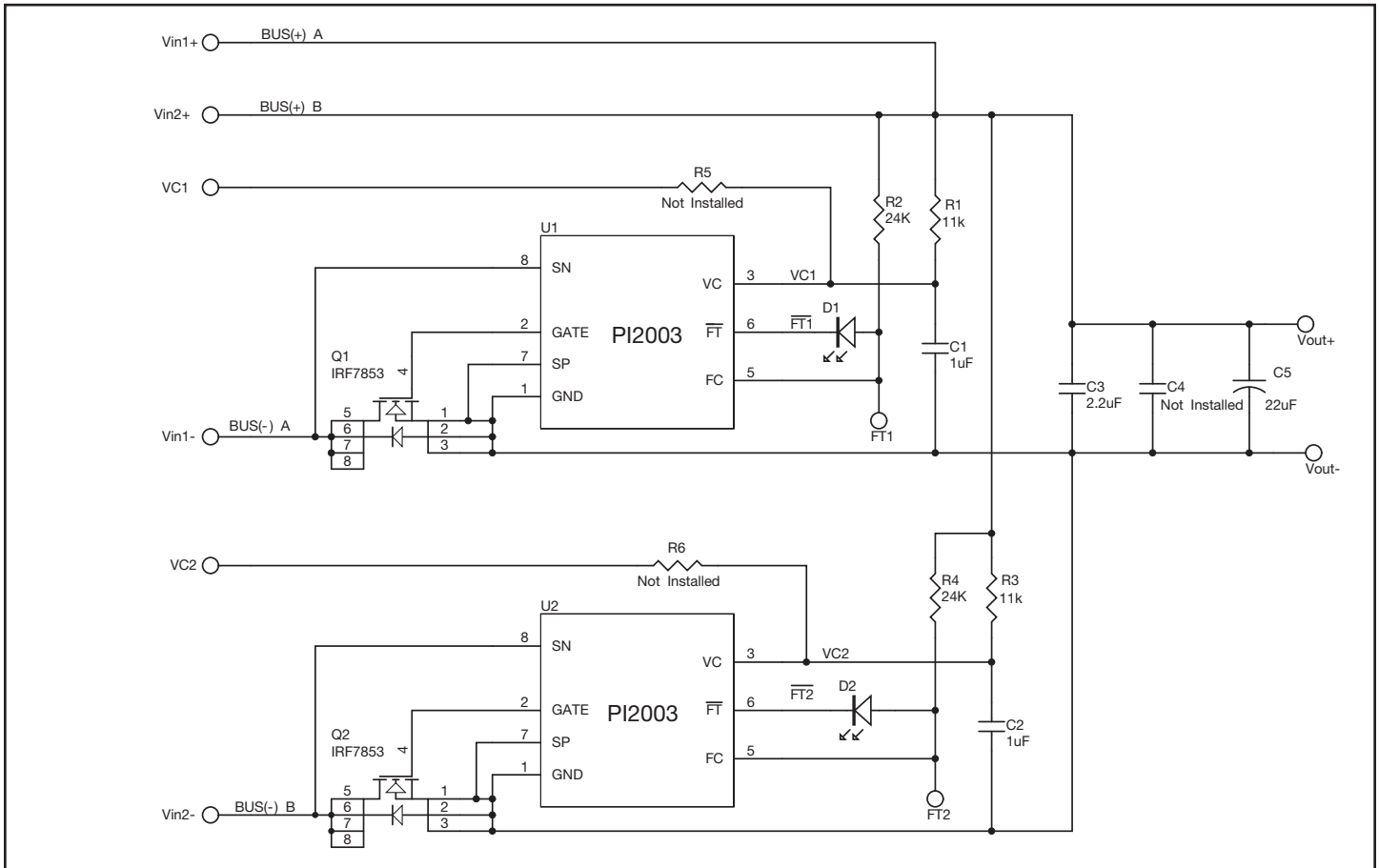


Figure 2 – PI2003-EVAL1 Evaluation Board schematic.

Item	QTY	Reference Designator	Value	Description	Footprint	Manufacturer
1	2	C1, C2	1 $\mu$ F	Capacitor, MLCC X5R, 1 $\mu$ F, 16 V	0603	
2	1	C3	2.2 $\mu$ F	Capacitor, MLCC X7R, 2.2 $\mu$ F, 100 V	1812	
		C4	Not installed		1812	
		C5	22 $\mu$ F	Capacitor, Electrolytic, 22 $\mu$ F 100 V		
4	2	D1, D2		LED, Super Red	THIN 0603	Lite-On, Inc.,
5	4	FT1, FT2, VC1, VC2		Turret Test point	TURRET-1528	Keystone Electronics
6	6	Vin1+, Vin1-, Vin2+, Vin2-, Vout+, Vout-		Turret Test point	TURRET-1502	Keystone Electronics
9	2	Q1, Q2	IRF7853	100 V, 8.3 A, N-MOSFET	SO-8	International Rectifier
10	2	R1, R3	11 K $\Omega$	Resistor, 11 K $\Omega$ , 1/4 W, 5%	0805	
11	2	R2, R4	24 K $\Omega$	Resistor, 24 K $\Omega$ , 1/8 W, 5%	0805	
12	2	R5, R6	Not Installed		0805	
16	2	U1, U2	PI2003	Picor Active ORing Controller	3mmx3mm; 10-TDFN	PICOR

Table 2 – PI2003-EVAL1 Evaluation Board bill of materials

Reference Designator	Value	Functional Description
C1, C2	1 $\mu$ F	VC Bypass Capacitor
C3, C4, C5,		Output (Load) Capacitor
D1, D2	LED	To indicate a fault exists when it is on
Q1, Q2	N-MOSFET	ORing MOSFET
R1, R3	11 K $\Omega$	VC Bias resistor
R2, R4	24 K $\Omega$	LED current limit resistor
R5, R6	Not Installed	Optional to connect VC to separate source
U1, U2	PI2003	Picor Active ORing Controller

Table 3 – Component functional description

# Initial Test Set Up

Baseline Test Procedure (Refer to Figure 3)

## 1.0 Recommended Equipment

- 1.1 Two Isolated DC power supplies - 0 – 60 V; 10 A
  - 1.1.1 If the DC power supply outputs are not isolated, two 10 A 100 V Schottky diodes are required, as shown in Figure 4.
- 1.2 DC electronic load - 10 A minimum.
- 1.3 Digital Multimeter
- 1.4 Oscilloscope.
- 1.5 Appropriately sized interconnect cables.
- 1.6 Safety glasses.
- 1.7 PI2003 Product Data sheet.

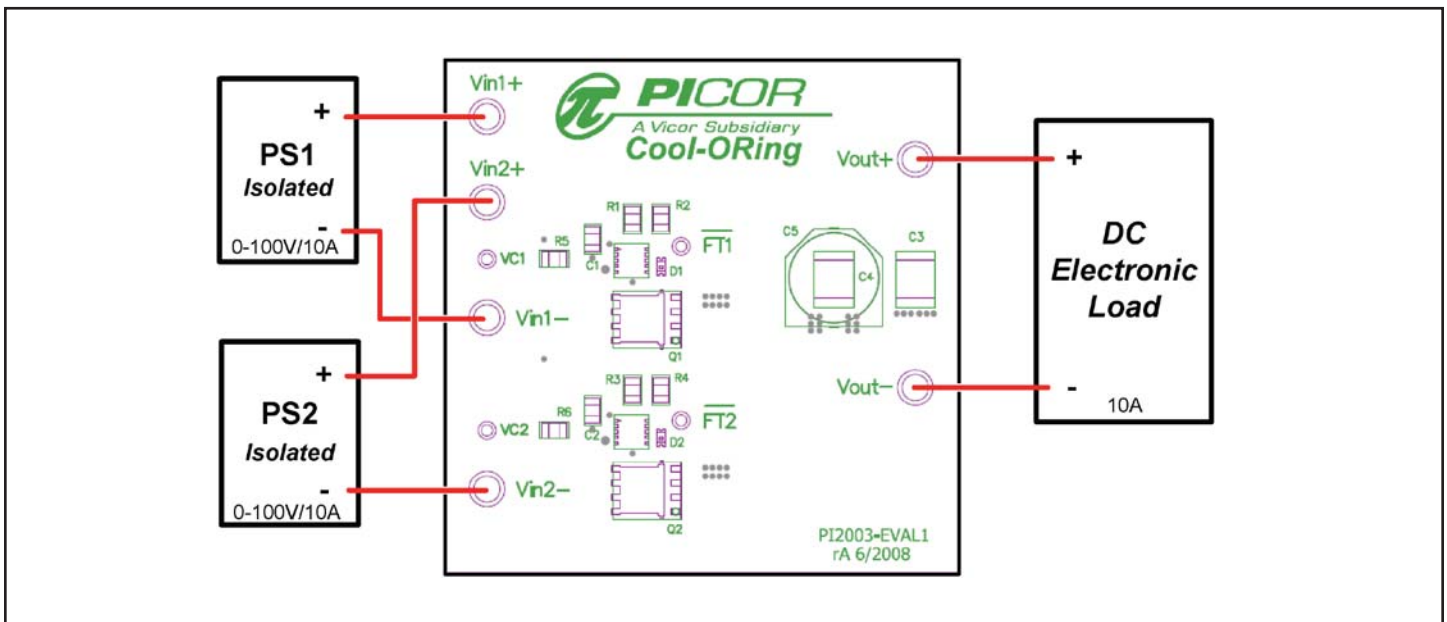


Figure 3 – Layout configuration for a typical redundant power application, using isolated power supplies.

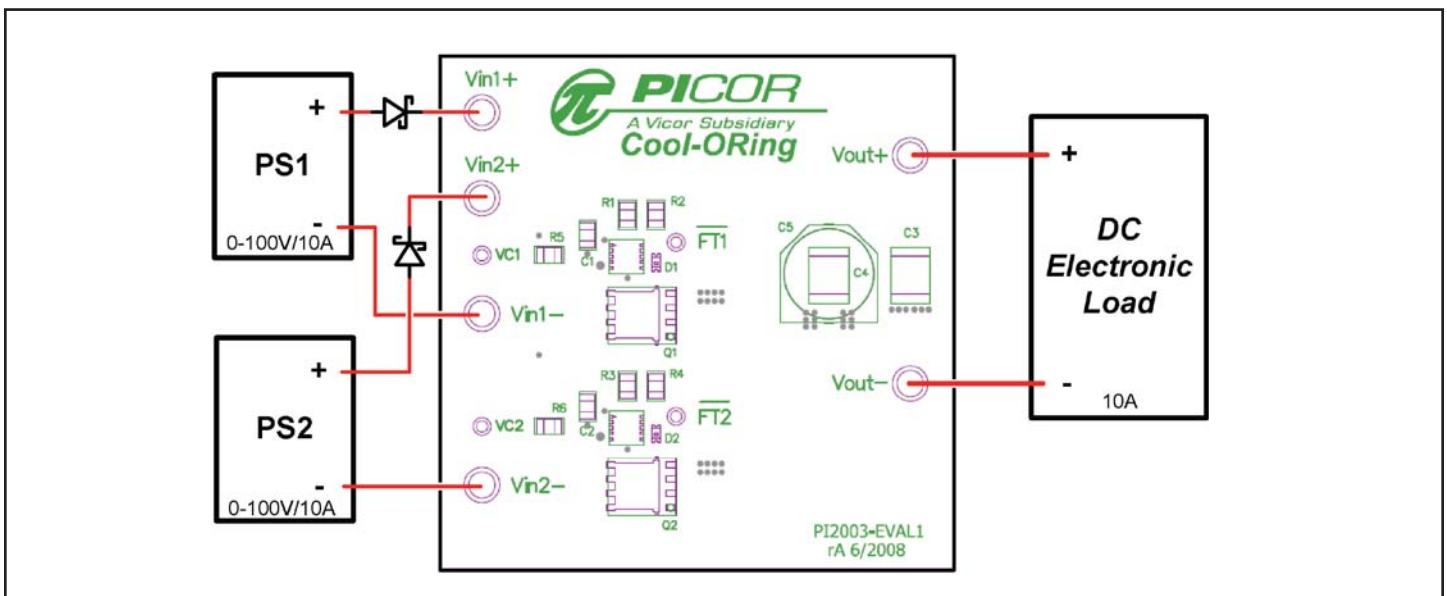


Figure 4 – Layout configuration for a typical redundant power application, using non-isolated power supplies.

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

## 2.0 Controller Bias Voltage (VC):

2.1 The PI2003 Controller has a separate input (VC) that provides power to the control circuitry and the gate driver. An internal voltage regulator (VC) clamps the VC voltage to 11 V typically. PI2003 EVAL1 is configured to bias the controllers directly from the bus voltage (Vin1 and Vin2). Two bias resistors (R1 and R3: 11 kΩ, 1/4 W, 0805) are connected from the return input (Vin1+ and Vin2+) to each controller VC pin, see schematic in figure 2. The bias resistors are selected to support -48 V bus voltage (36 V to 60 V).

2.2 If the bus voltage (Vin1 and Vin2) range is different from 36 V to 60 V and higher than the Clamp voltage, 11 V typical, the Rbias value has to be changed using the following equations:

2.2.1 Select the value of Rbias using the following equations:

$$R_{bias} = \frac{V_{busmin} - VC_{clampMAX}}{I_{Cmax}}$$

2.2.2 Calculate Rbias maximum power dissipation:

$$P_{DR_{bias}} = \frac{(V_{busmax} - VC_{clampMIN})^2}{R_{bias}}$$

Where:

Vbusmin : V(bus) minimum voltage

Vbusmax : V(bus) maximum voltage

VCclampMAX : Maximum controller clamp voltage, 12 V

VCclampMIN : Minimum controller clamp voltage, 10 V

ICMAX : Controller maximum bias current, use 2.0 mA

2.2.3 For example, if the minimum V(bus) = 36 V and the maximum V(bus) = 60 V

$$R_{bias} = \frac{V_{busmin} - VC_{clampMAX}}{I_{Cmax}}$$

$$R_{bias} = \frac{36 V - 12 V}{2.0 mA} = 12 K\Omega$$

Rbias maximum power dissipation is at maximum input voltage.

$$P_{DR_{bias}} = \frac{(V_{busmax} - VC_{clampMIN})^2}{R_{bias}} = \frac{(60 V - 10 V)^2}{12 K\Omega} = 208 mW$$

2.3 The PI2003-EVAL1 is configured to allow the customer to use a direct bias voltage to the controller VC pin independent of the bus input. VC1 and VC2 terminals can be connected directly to the controller VC pins after removing R1 and R3 and populating R5 and R6.

## 3.0 Hook Up of the Evaluation Board, refer to Figures 3 and 4.

3.1 If isolated power supplies are used, Figure 3.

3.1.1. Connect the positive terminal of PS1 power supply to Vin1+. Connect the negative terminal of PS1 Vin1-. Set the power supply to 48 V. Keep PS1 output disabled (OFF).

3.1.2. Connect the positive terminal of PS2 power supply to Vin2+. Connect the negative terminal of PS2 Vin2-. Set the power supply to 48 V. Keep PS2 output disabled (OFF).

3.2 If non-isolated power supplies are used, Figure 4.

3.2.1. Connect the positive terminal of PS1 power supply to Vin1+ through a Schottky diode. Connect the negative terminal of PS1 Vin1-. Set the power supply to 48 V. Keep PS1 output disabled (OFF).

3.2.2. Connect the positive terminal of PS2 power supply to Vin2+ through a Schottky diode. Connect the negative terminal of PS2 Vin2-. Set the power supply to 48 V. Keep PS2 output disabled (OFF).

- 3.3 Connect the electronic load to the output between Vout and Gnd. Set the load current to 1 A.
  - 3.4 Enable (turn ON) PS1 power supply output.
  - 3.5 Turn on the electronic load.
  - 3.6 Measure the voltage across Q1, connect a voltmeter between Vout- and Vin1-, the voltmeter should read less than 30 mV to assure that the MOSFET is fully enhanced.
  - 3.7 LED D1 should be off indicating that controller U1 has no fault. LED D2 should be on indicating that U2 is in a fault mode and the controller Gate pin output is low.
  - 3.8 Disable (turn OFF) PS1 power supply output.
  - 3.9 Enable (turn ON) PS2 power supply output.
  - 3.10 Measure the voltage across Q2, connect a voltmeter between Vout- and Vin2-, the voltmeter should read less than 30mV to assure that the MOSFET is fully enhanced.
  - 3.11 LED D2 should be off indicating that controller U2 has no fault. LED D1 should be on indicating that U1 is in a fault mode and the controller Gate pin output is low.
  - 3.12 Enable (turn ON) PS1 and PS2.
  - 3.13 Increase output load to 5 A. The power source, PS1 and PS2, should share the load current equally if there output voltages are equal. Both LEDs, D1 and D2, should be off indicating that both controllers Gate pin output is high.
- #### 4.0 Input short circuit test
- 4.1 Apply a short at one of the inputs (Vin1 or Vin2). The short can be applied electronically using a MOSFET connected between low side off the source (Vin1- or Vin2-) and the return (Vin1+ or Vin2+) or simply by connecting Vin- to the return. Measure the response time between when the short is applied and the MOSFET Gate turns off. An example for PI2003 response time to an input short circuit is shown in Figure 5.

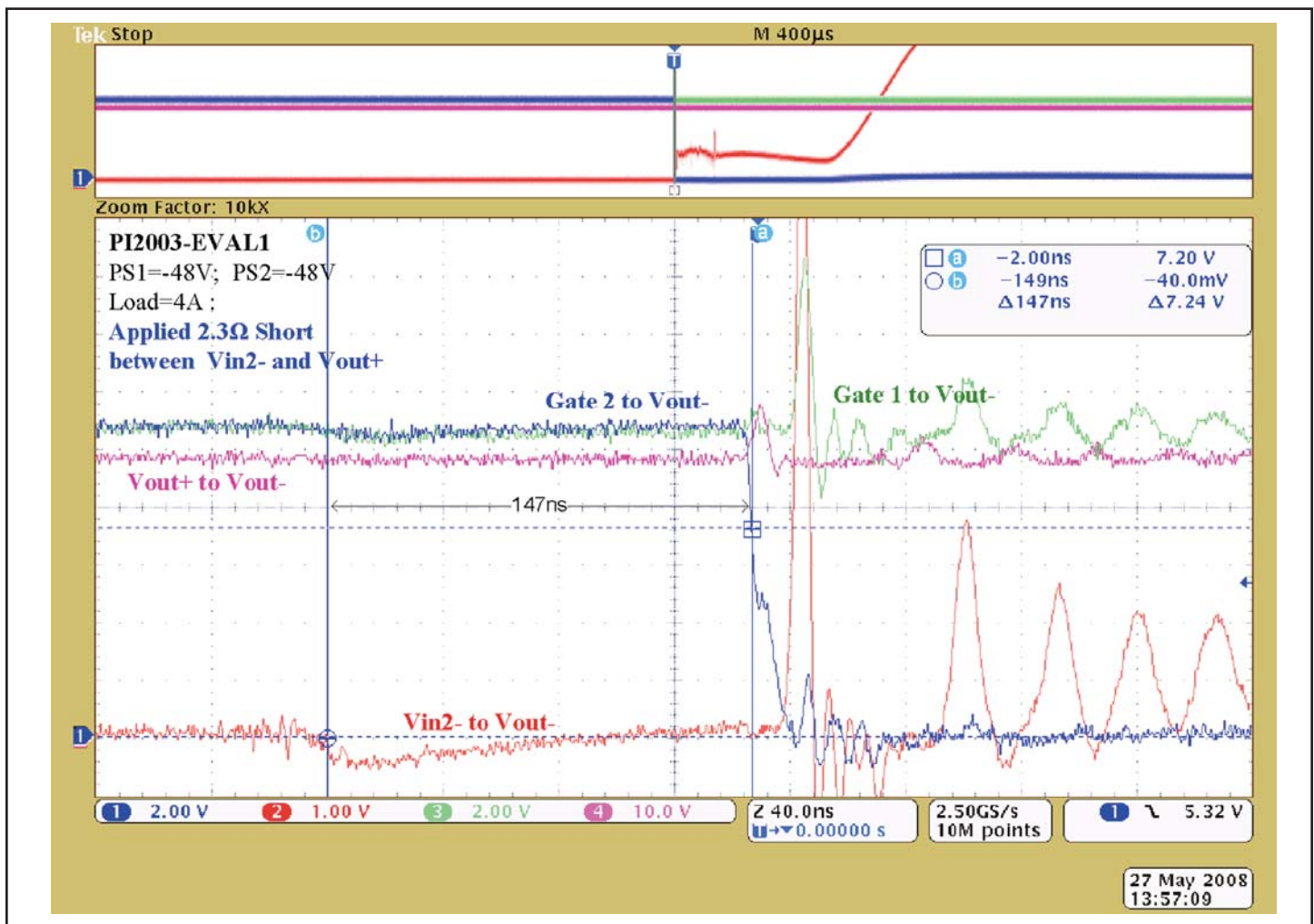


Figure 5 – Plot of PI2003 response time to reverse current detection

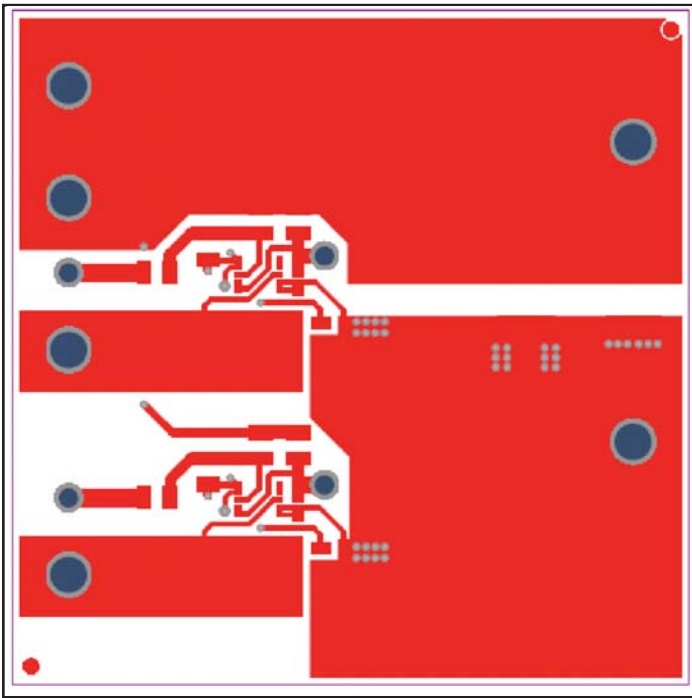


Figure 6a – PI2003-EVAL1 layout top layer. Scale 2.0:1

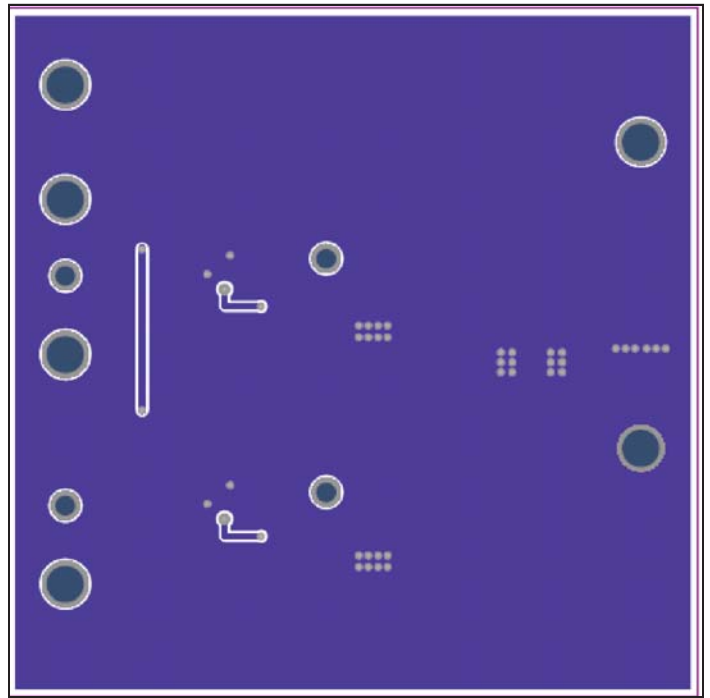
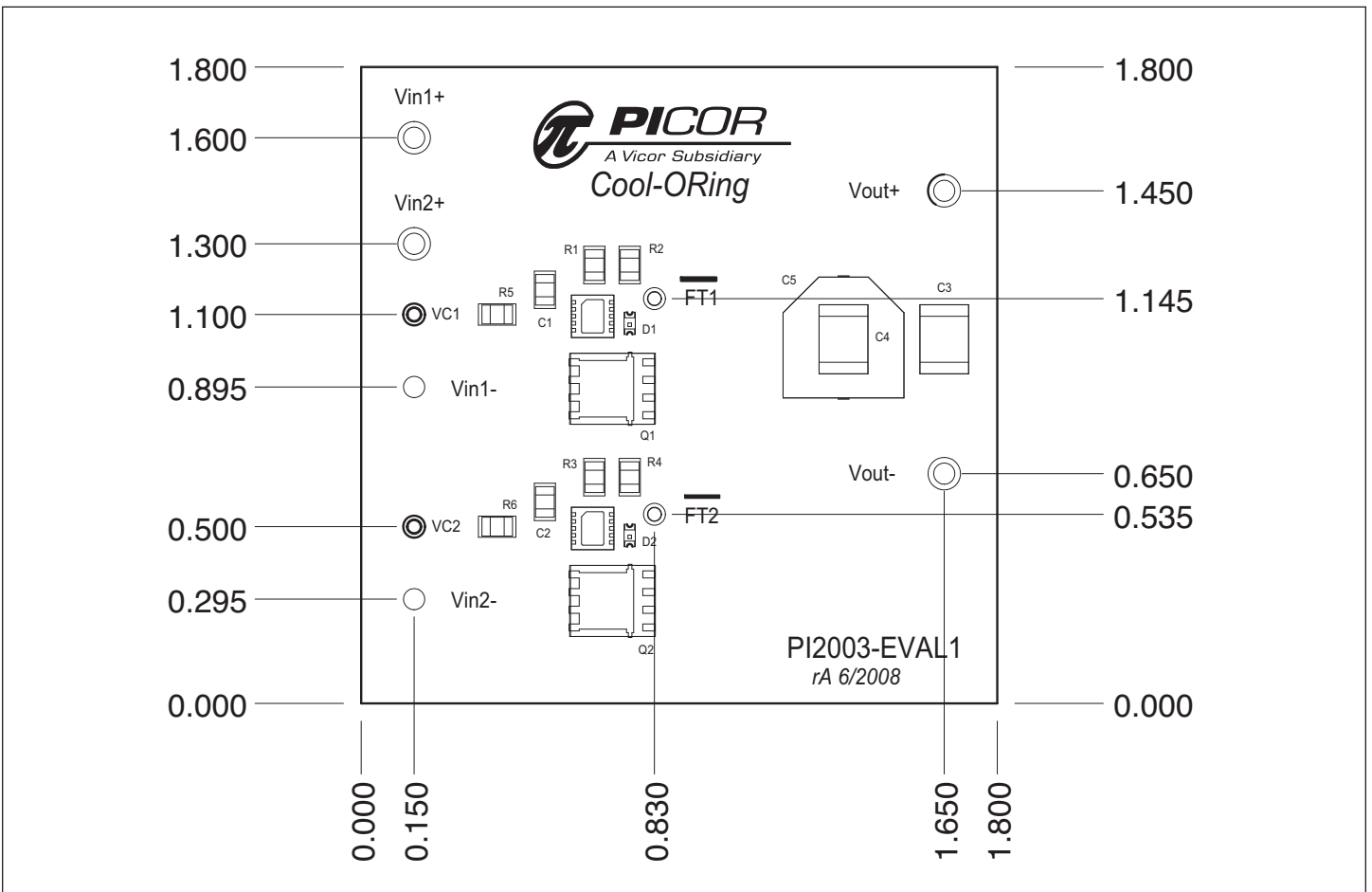


Figure 6b – PI2003-EVAL1 layout Bottom layer. Scale 2.0:1

## Mechanical Drawing





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