

REFERENCE DESIGN IRDCiP2005A-A

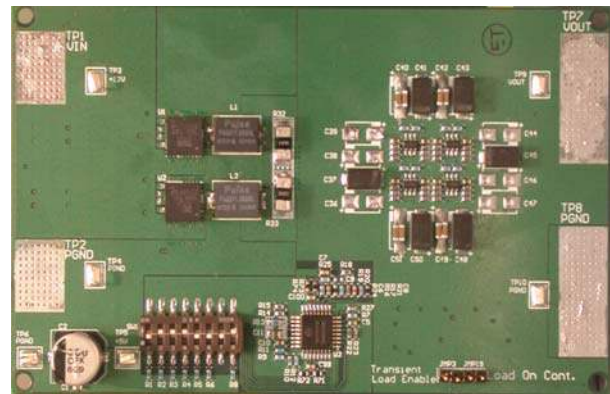
International Rectifier • 233 Kansas Street, El Segundo, CA 90245 USA

**IRDCiP2005A-A: 1MHz, 65A DC, 80A Peak,
Dual Phase, Sync Buck Converter using iP2005**



Overview

This reference design is capable of delivering a current of 65A DC or 80A peak (with heatsink) at an ambient temperature of 45°C and airflow of 300LFM. Figures 1–19 provide performance graphs, thermal images, and waveforms. The shunt resistors are added for load line preciseness and can be changed to DCR sensing for higher efficiency. Figures 19-23, and Table 1 are provided to engineers as design references for implementing a dual phase iP2005 solution. The components installed on this demo board were selected based on operation at an input voltage of 12V and at a switching frequency of 1MHz. Changes from these set points may require optimizing the control loop and/or adjusting the values of input/output filters in order to meet the user's specific application requirements. Refer to the iP2005 datasheet for more information.



Demo board Quick Start Guide

Initial Settings:

V_{OUT} is set to 1.25V, but can be adjusted from 0.8375V to 1.6V by changing the settings of VID0 through VID5 according to the OnSemi data sheet of NCP5318.

Power Up Procedure:

1. Apply drive power supply across V_{dd} and PGND.
2. Apply input voltage across V_{IN} and PGND.
3. Turn on the enable signal through the DIP switch (SW1-pin 8).
4. Apply load and adjust to desired level. See recommendations below.
5. Install/uninstall a jumper to JMP3 to turn on and turn off current transient load (65A step)*

* Note: the transient current load is a resistive load and the voltage across it is measured instead of current due to ESL limitations. For more details, please refer to figure 11 through 15.

IRDCiP2005A-A Recommended Operating Conditions

(refer to the iP2005 datasheet for maximum operating conditions)

Input voltage:	9.5 – 13.2V
Output voltage:	0.8375 -1.6V
Switching Freq:	1MHz

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Output current: This reference design is capable of delivering a continuous current of 65A (with heatsink) or 80A repetitive pulse current load (50A DC + 10% duty 30A DC) at an ambient temperature of 45°C and an airflow of 300LFM.

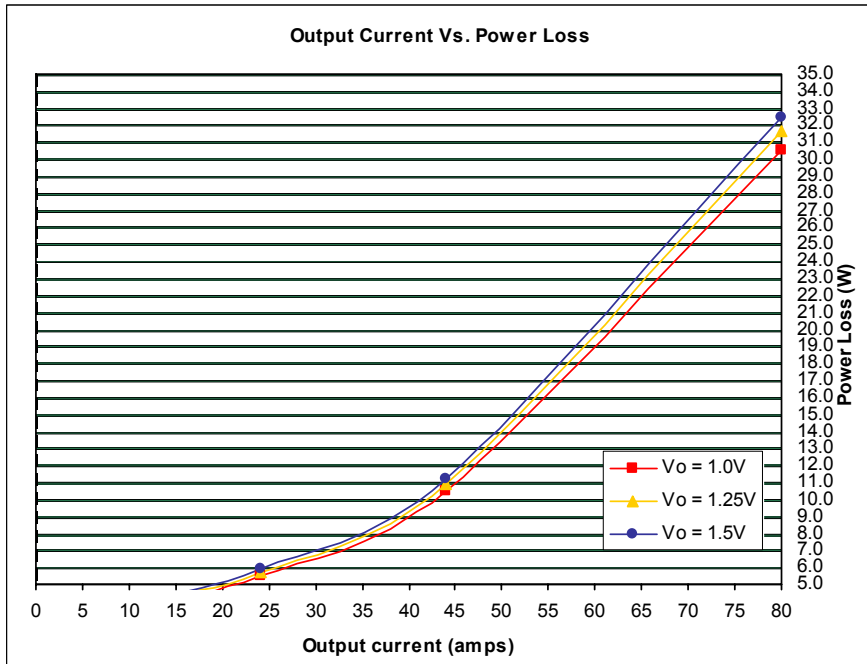


Fig. 1 Power Loss vs. Output Current for Vin=12V

Fsw=1MHz, Vdd=5V, Ta=45dgC, Airflow=300LFM, with Heat Sink

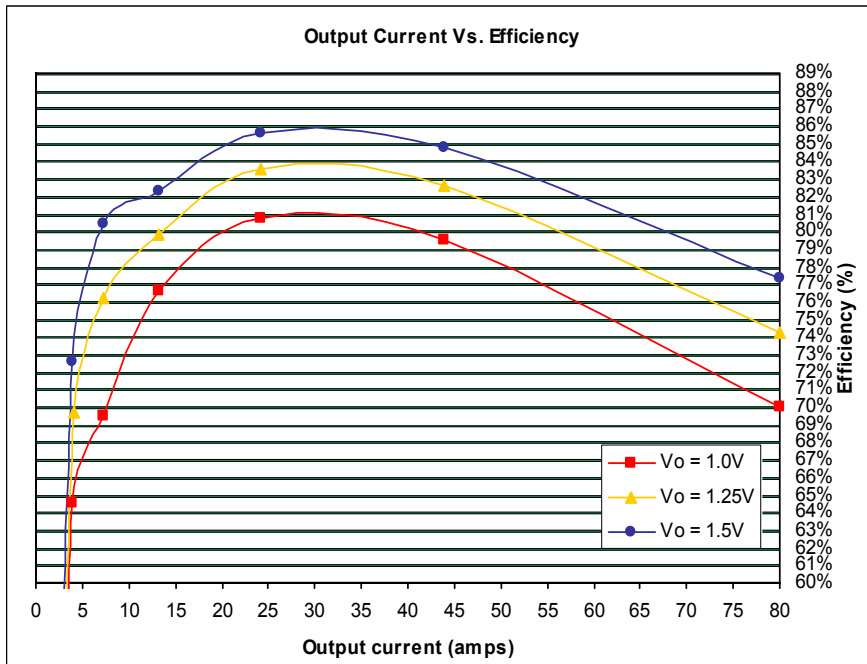


Fig. 2 Efficiency vs. Output Current for Vin=12V

Fsw=1MHz, Vdd=5V, Ta=45dgC, Airflow=300LFM, with Heat Sink

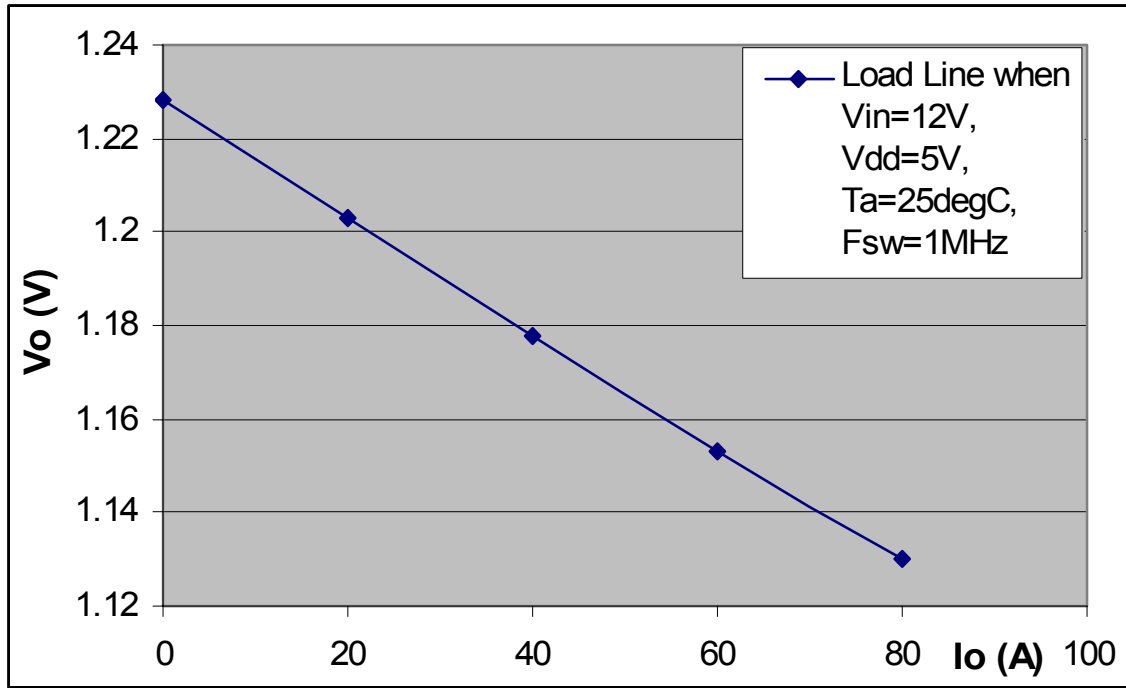


Fig. 3 Load Line $R_{LL} = 1.2 \text{ m}\Omega$

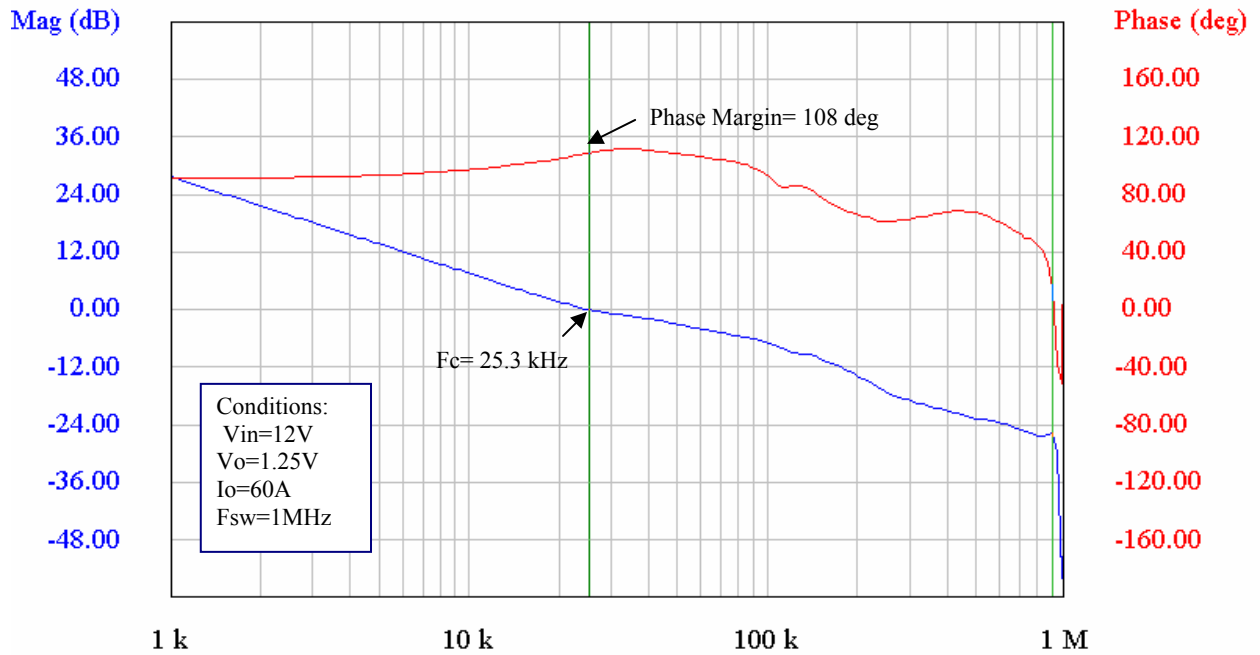


Fig. 4 Bode Plot

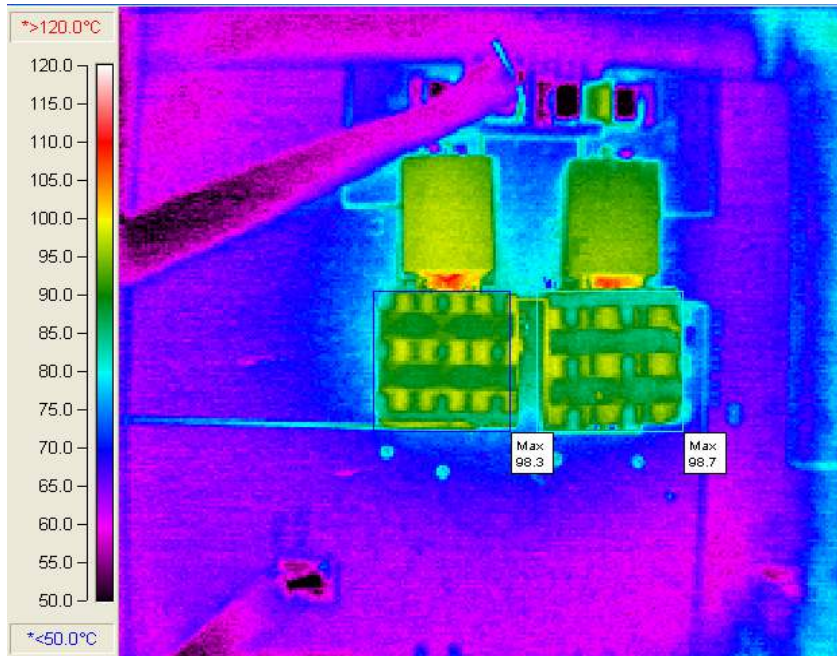


Fig. 5 Thermal Graph 1

**Fsw=1MHz, Vdd=5V, Ta=45 °C,
Airflow=300LFM, Vin=12V,
Vo=1.25V, Io=65A, with heat sink**

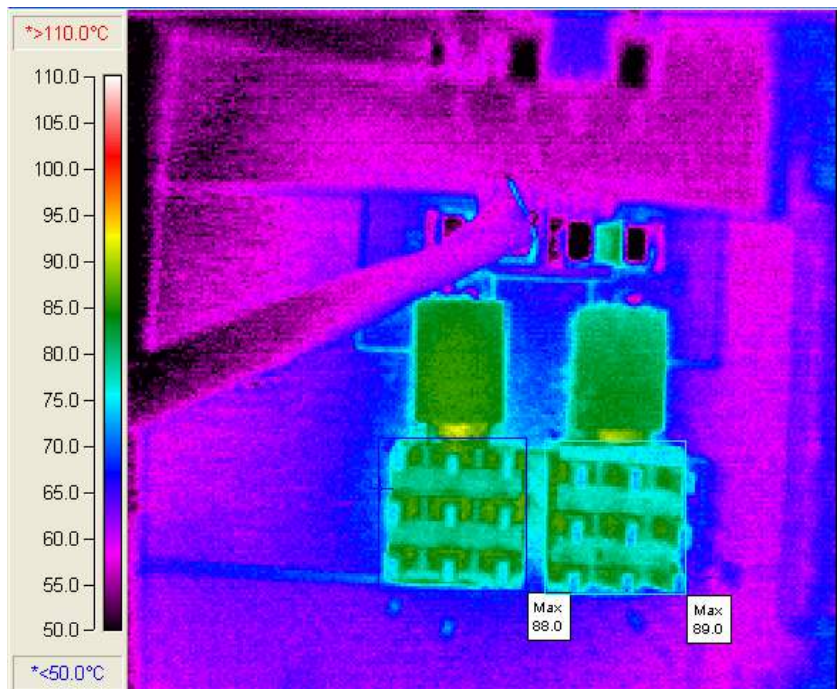


Fig. 6 Thermal Graph 2

**Fsw=1MHz, Vdd=5V, Ta=45 °C,
Airflow=300LFM, Vin=12V,
Vo=1.25V, Io=50A+30A (pulse),
with heat sink**

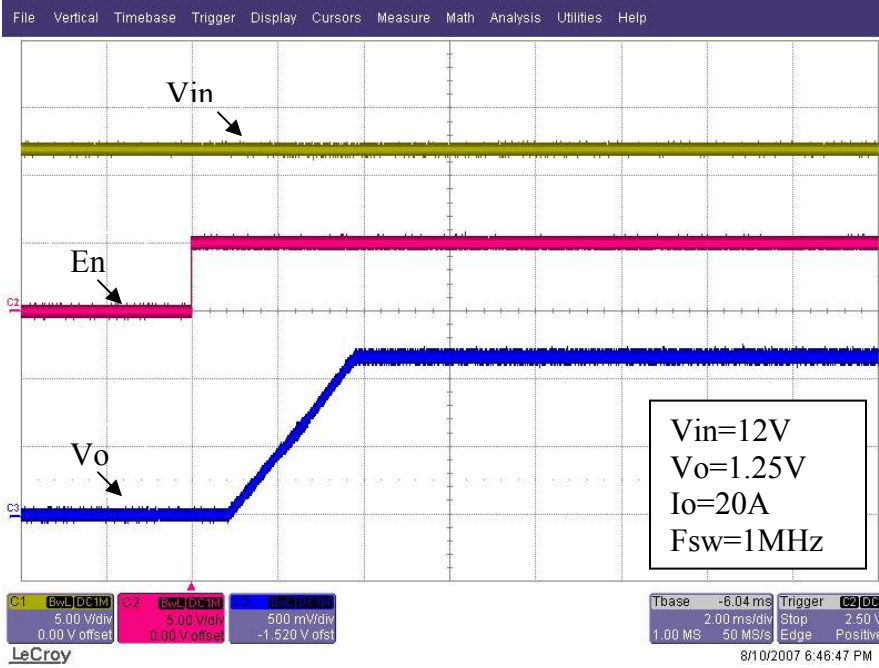


Fig. 7 Power-Up Sequence



Fig. 8 Power-Down Sequence

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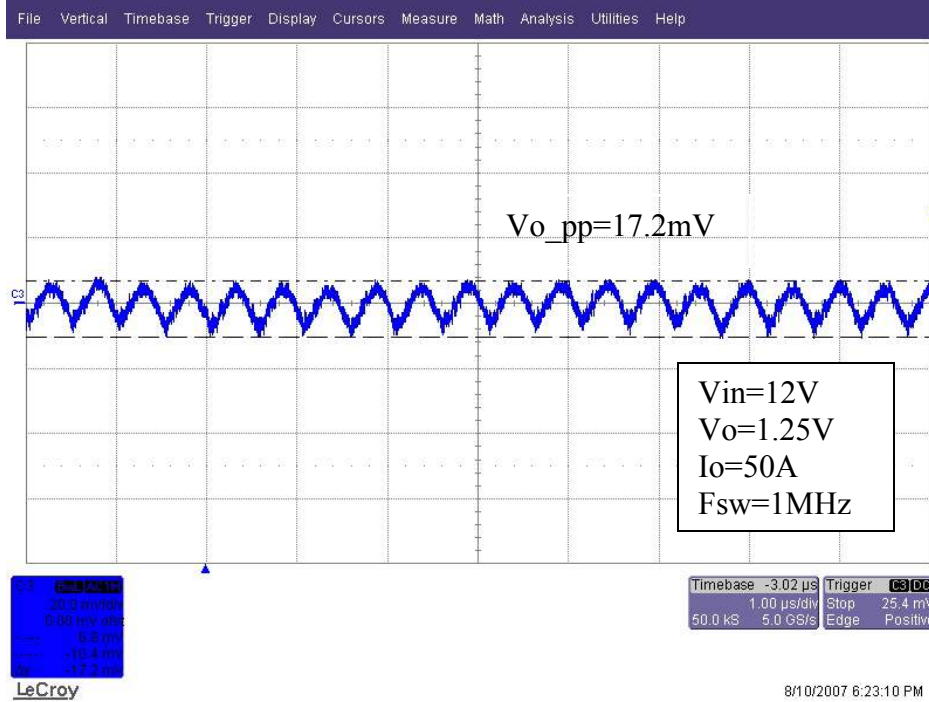


Fig. 9 Output Voltage
Ripple

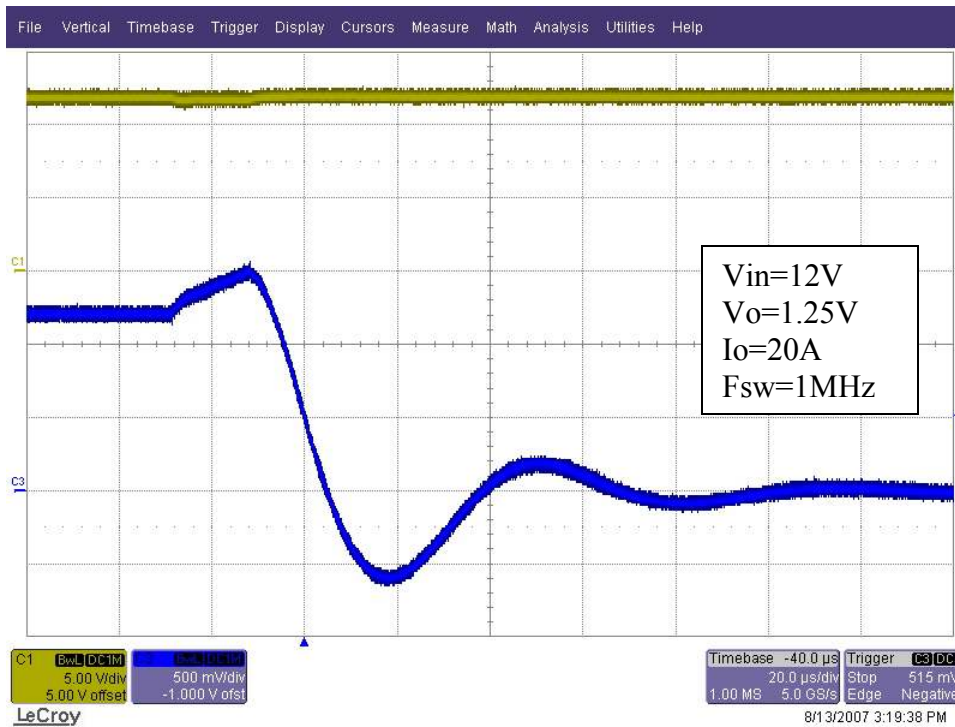


Fig. 10 Over-Voltage
Protection

Transient Load Overview

Many of today's high performance CPU's can easily draw transient currents with slew rate greater than 1000A/μs. Unfortunately, replicating and demonstrating such a load event with such a high current slew rate on an evaluation board is not a trivial task. The smallest amount of stray inductance can quickly limit the slew rate of your load design and cause large voltage spikes. For example, a stray inductance of 30pH will create 30mV of over/undershoot for a given transient event with a slew rate of 1000A/μs. Such an over/undershoot may already exceed the amount of voltage variation allowed in your design. A new approach over a traditional load design needs to be implemented.

This reference design has an embedded load that is capable of delivering a 65A current step at slew rate of 1000A/μs. The load design uses a parallel network of very small, low charge MOSFETs, 0402 capacitors, and 0603 load resistors (see Figure 1). This new approach greatly minimizes the parasitic inductance through the use of low ESL components and by distributing the switching current amongst many high speed switching MOSFETs. The pulsed current is run at a duty cycle of less than 2% which results in very little power dissipation and minimal device temperature rise. The net result closely replicates the dynamic load response of a high performance CPU.

Validating the current waveform could only be done by measuring the voltage drop differentially across the load resistors during the switching event. Placing a current probe is not an option due to the ESL adder. Since the resistive load is a passive element, current flowing through the resistor is in phase with the voltage across the resistor. If the voltage across the resistive element changes at a rate of 1000V/μs, one can assume the current is changing at the same rate (1000A/μs).

Figures 12, 14 & 15 show the validation of the load design for this particular demonstration tool. Four MOSFETs stages were used to create a 65A load step at a minimum of slew rate of 1000A/μs. The parallel network of load resistors in this design creates an equivalent impedance of 9mΩ. Differentially measuring the voltage drop across the load resistors of each MOSFET stage yields a voltage change of approximately 0.575V. Using Ohm's law we approximately get 65A of total load current (see Figure 12). Zooming in at the rising and falling edges of the load step, we can then measure the slew rate of the load step. In this particular design, we are achieving about 40ns rise and fall times for 40A change which translate to about 1000A/μs (see Figures 14 & 15).

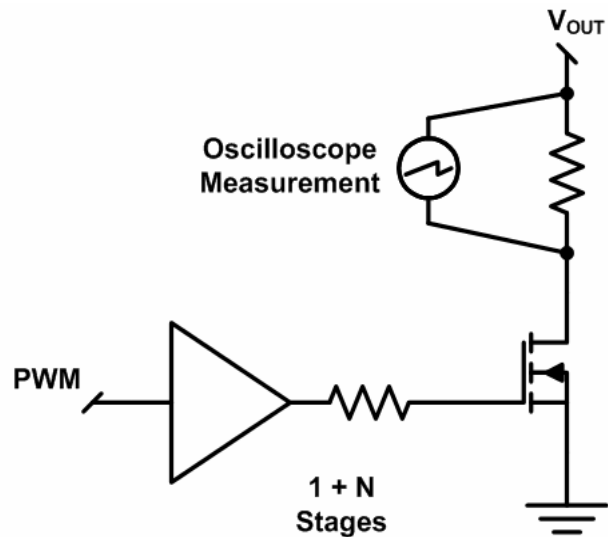
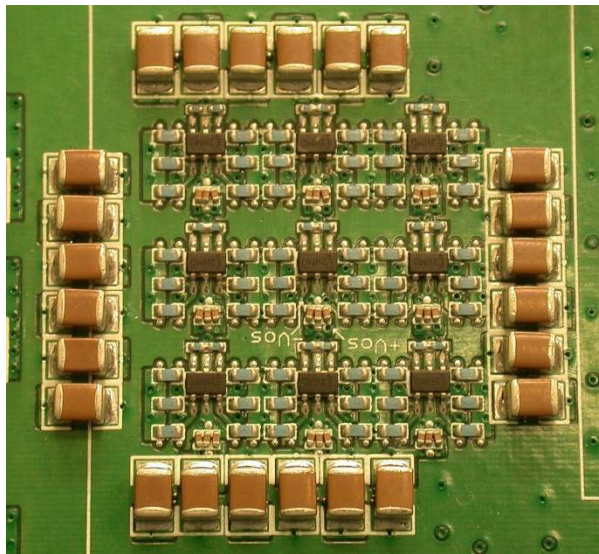


Fig. 11 Embedded High Slew Rate Load Design

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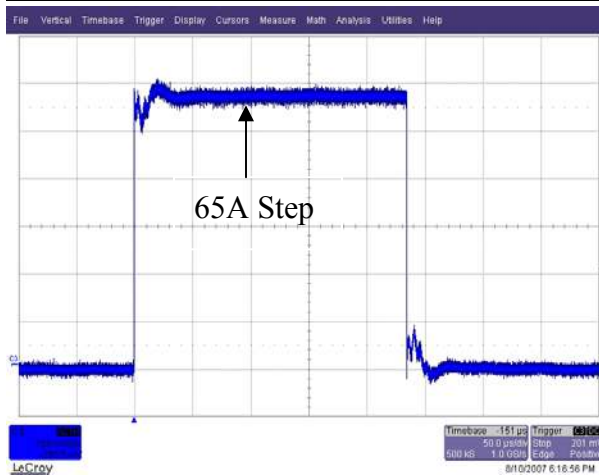


Fig. 12 Transient Load Current

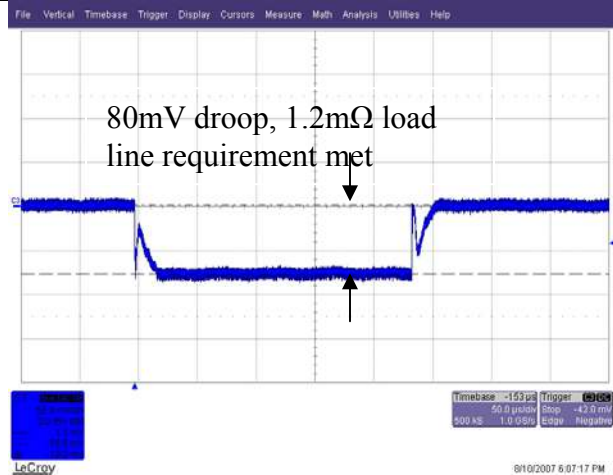


Fig. 13 Vout under Transient Load

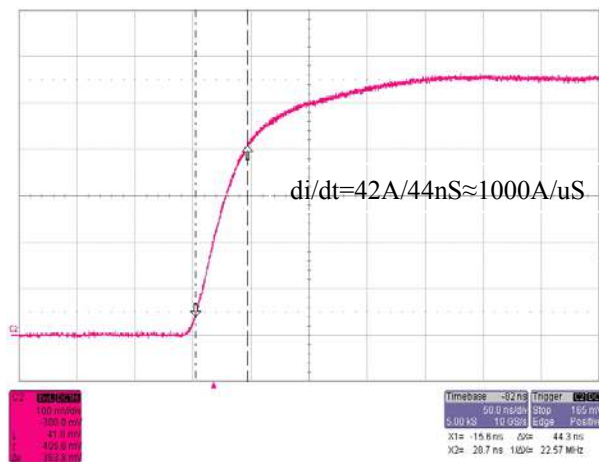


Fig. 14 Zoom-in rising edge of load

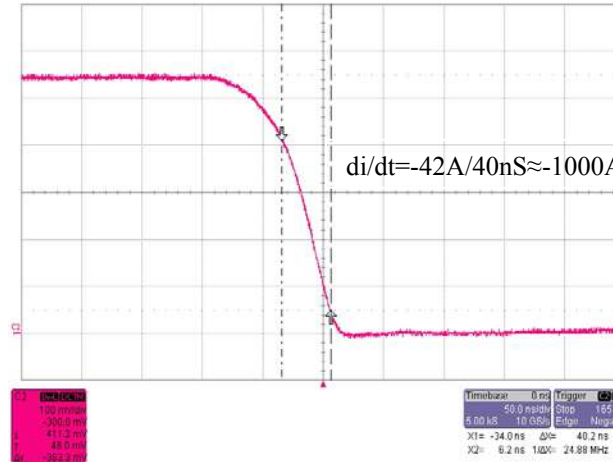


Fig. 15 Zoom-in falling edge of load

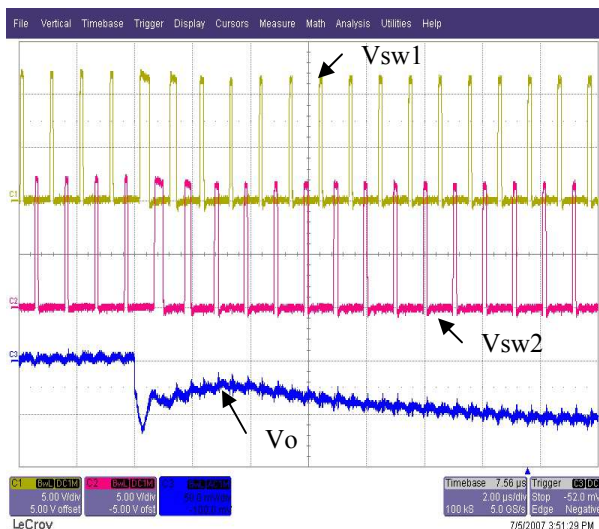


Fig. 16 Transient load step-up

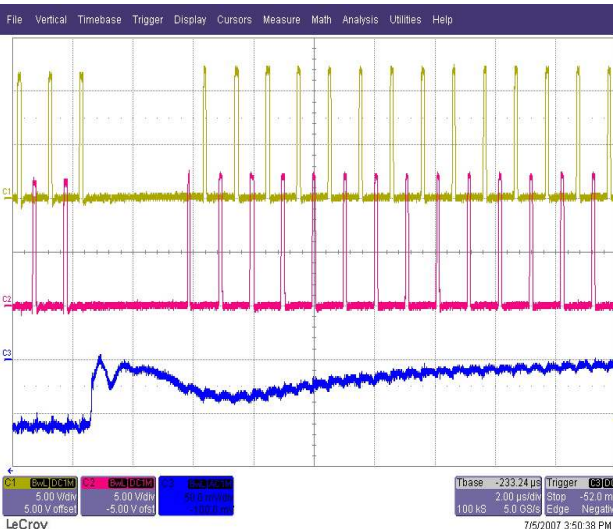


Fig. 17 Transient load step-down

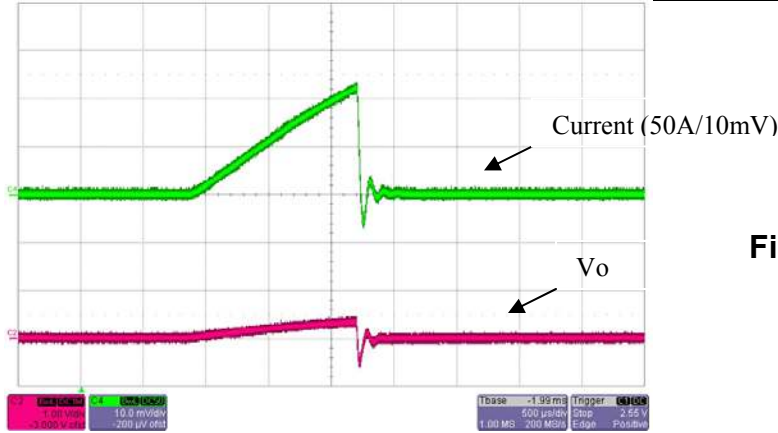


Fig. 18 Over-Current Protection

Adjusting the Over-Current Limit

R10 and R12 are the resistors used to adjust the over-current trip point. The trip point corresponds to the peak inductor current, refer to equation below to determine R10 and R12 values given the over current limit:

$$R10+R12 = (70.5 \times I_{Limit} - 90) \text{ ohm}$$

More details can be found in On-Semi data sheet of NCP5318.

Mechanical Drawings



Fig. 19 Heat Sink Photo

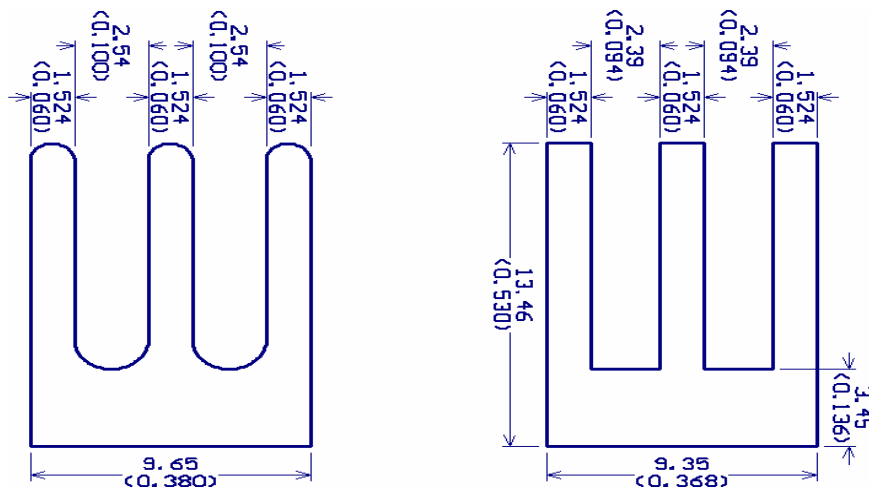


Fig. 20 Mechanical Outline Drawing of Heatsink

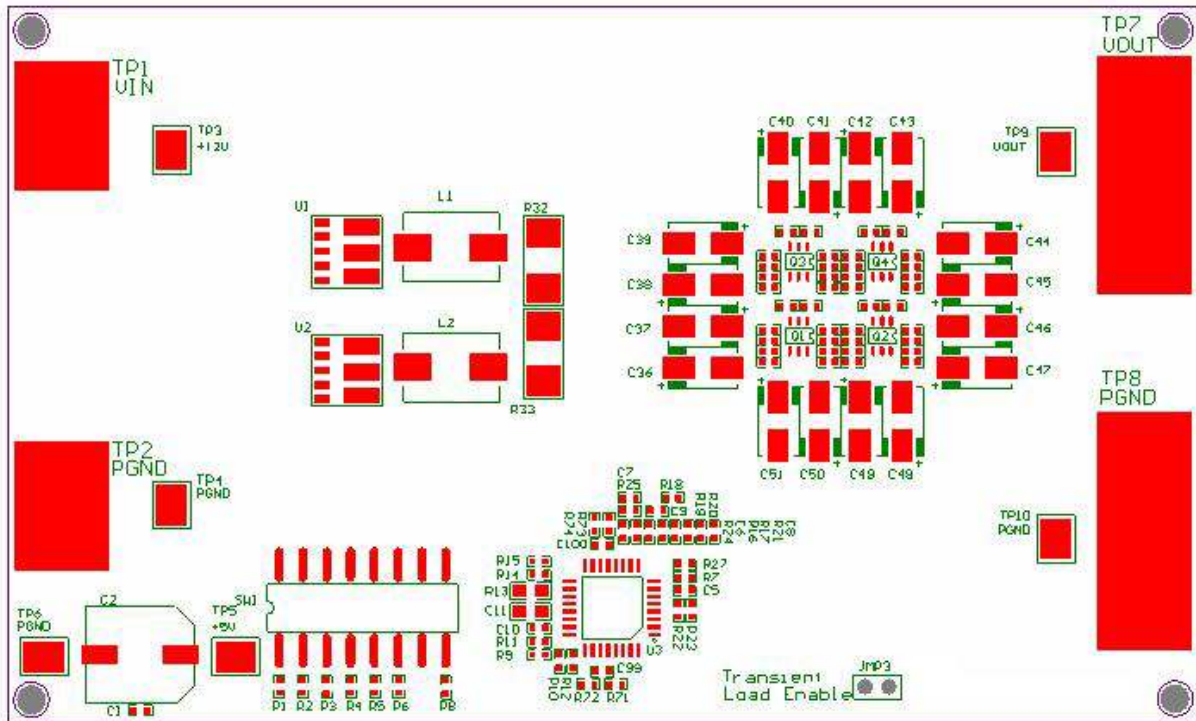


Fig. 21 Top Layer View

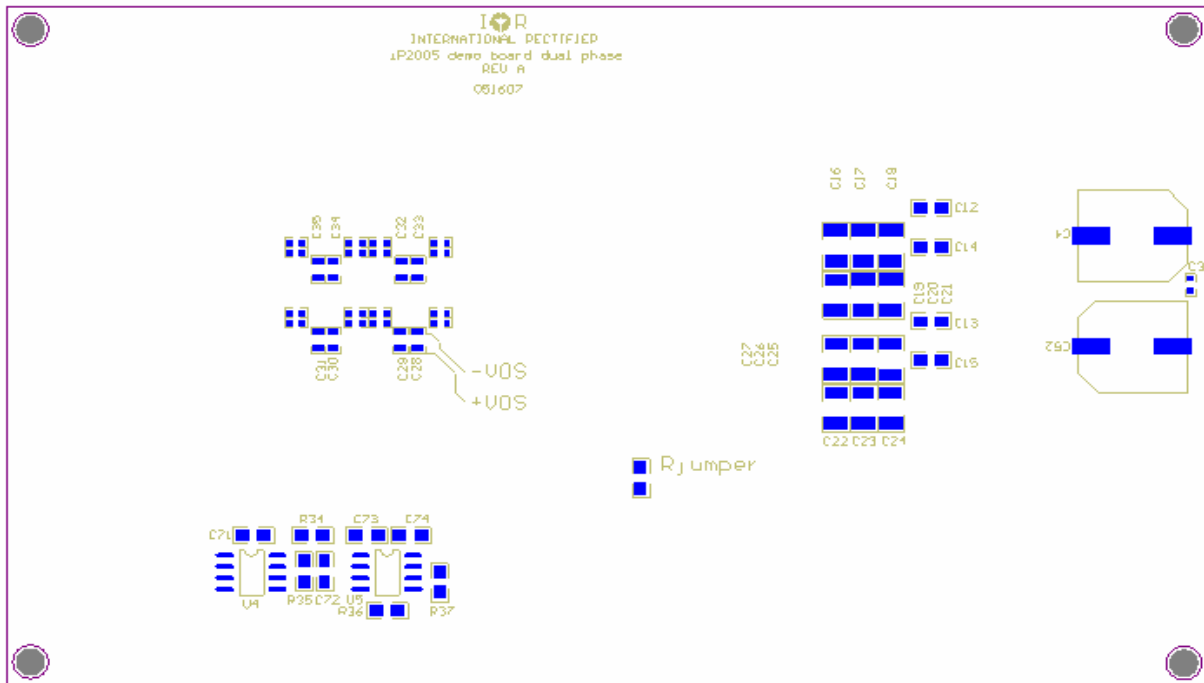


Fig. 22 Bottom Layer View

Refer to the following documents for more details and guidelines detailed guidelines for design:

iP2005A datasheet: Specifications and user guides about International Rectifier's integrated power modules used in this reference design

NCP5318 datasheet: Specifications and user guides about the On-Semi multiphase buck controller used in this reference design

AN-1028: Recommended Design, Integration and Rework Guidelines for International Rectifier's iPowIR Technology BGA and LGA and Packages

This paper discusses optimization of the layout design for mounting iPowIR BGA and LGA packages on printed circuit boards, accounting for thermal and electrical performance and assembly considerations. Topics discussed includes PCB layout placement, and via interconnect suggestions, as well as soldering, pick and place, reflow, inspection, cleaning and reworking recommendations.

AN-1030: Applying iPOWIR Products in Your Thermal Environment

This paper explains how to use the Power Loss and SOA curves in the data sheet to validate if the operating conditions and thermal environment are within the Safe Operating Area of the iPOWIR product.

AN-1047: Graphical solution for two branch heatsinking Safe Operating Area

Detailed explanation of the dual axis SOA graph and how it is derived.

Use of this design for any application should be fully verified by the customer. International Rectifier cannot guarantee suitability for your applications, and is not liable for any result of usage for such applications including, without limitation, personal or property damage or violation of third party intellectual property rights.

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