International Rectifier

REFERENCE DESIGN

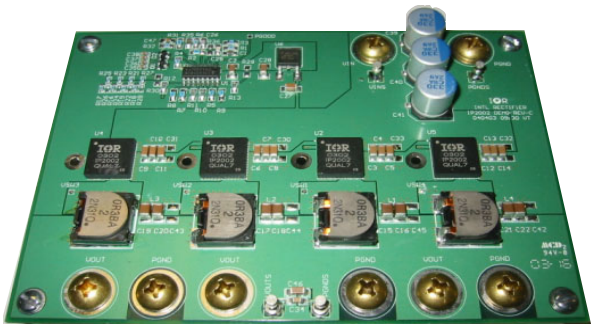
IRDCiP2002-C

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

IRDCiP2002-C: 1MHz, 120A, 4-phase Synchronous Buck Converter using iP2002

Overview

This reference design is capable of delivering up to 120A at an ambient temperature of 45°C if the enclosed heatsink is attached and 250LFM of airflow is provided. Performance graphs and waveforms are provided in figures 1 - 9. The figures and table in pages 4 - 7 are provided as a reference design to enable engineers to very quickly and easily design a 4-phase converter. Refer to the data sheet for the controller listed in the bill of materials in order to optimize this design to your specific requirements. A variety of other controllers may also be used, but the design will require layout and control circuit modifications.



Demoboard Quick Start Guide

Initial Settings:

The output is set to 1.3V, but can be adjusted from 0.8V to 3.3V by changing the values of R3 and R32 according to the following formula:

$$R3 = R32 = (24.91k * 0.8) / (V_{OUT} - 0.8)$$

The switching frequency per phase is set to 1MHz with the frequency set resistor R4. This creates an effective output frequency of 4MHz. The graph in figure 11 shows the relationship between R4 and the switching frequency per phase. The frequency may be adjusted by changing R4 as indicated; however, extreme changes from the 1MHz set point may require redesigning the control loop and adjusting the values of input and output capacitors. Refer to the SOA graph in the iP2002 datasheet for maximum operating current at different conditions.

Procedure for Connecting and Powering Up Demoboard:

1. Apply input voltage (+12V) across VIN and PGND
2. Apply load across VOUT pads and PGND pads
3. Adjust load to desired level. See recommendations below.

iP2002 Recommended Operating Conditions

(refer to the iP2002 datasheet for maximum operating conditions)

Input voltage:	6.5 - 12V
Output voltage:	0.8 - 3.3V
Switching Freq:	1MHz per phase, 4MHz effective output frequency.
Output current:	The reference design is capable of delivering up to 120A at an ambient temperature of 45°C if the enclosed heatsink is attached and 250LFM of airflow is provided. With a heatsink and no airflow, the reference board is capable of delivering 110A at 25°C ambient. With 250LFM and no heatsink, the reference board is capable of delivering 100A at 25°C ambient.

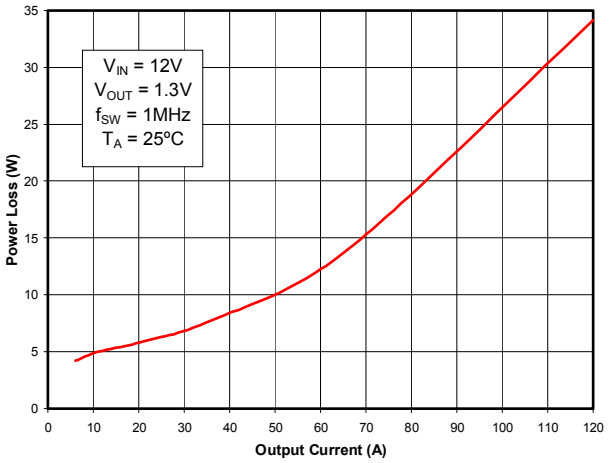


Fig. 1: Power Loss vs. Current

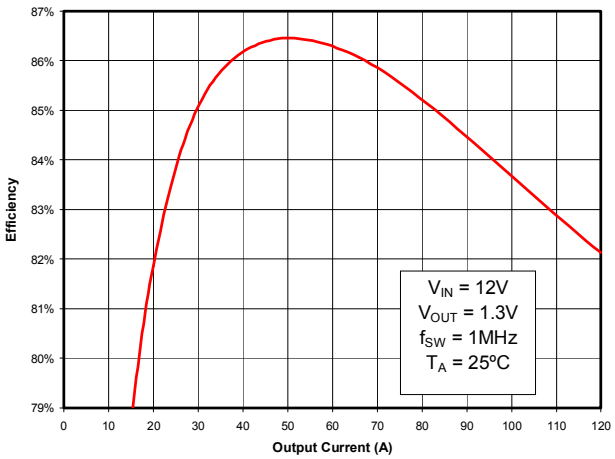


Fig. 2: Efficiency vs. Current

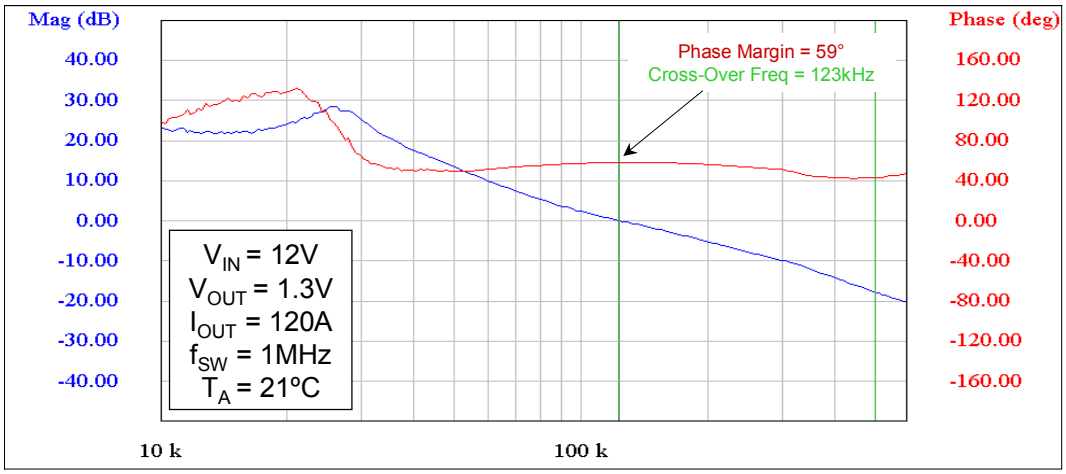


Fig. 3: Bode Plot

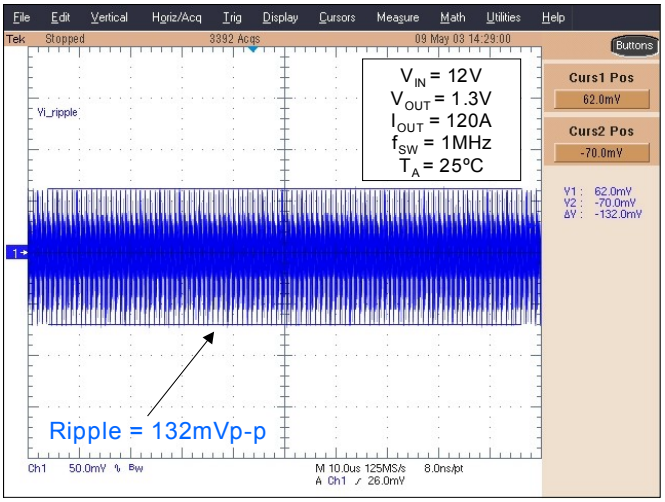


Fig: 4: Input Voltage Ripple Waveform

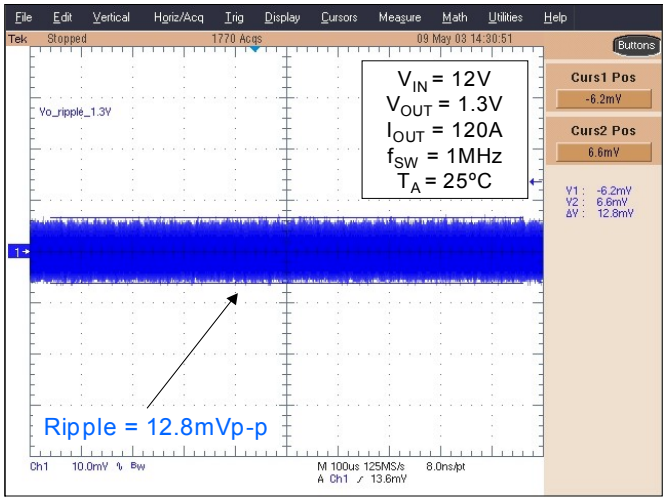


Fig. 5: Output Voltage Ripple Waveform

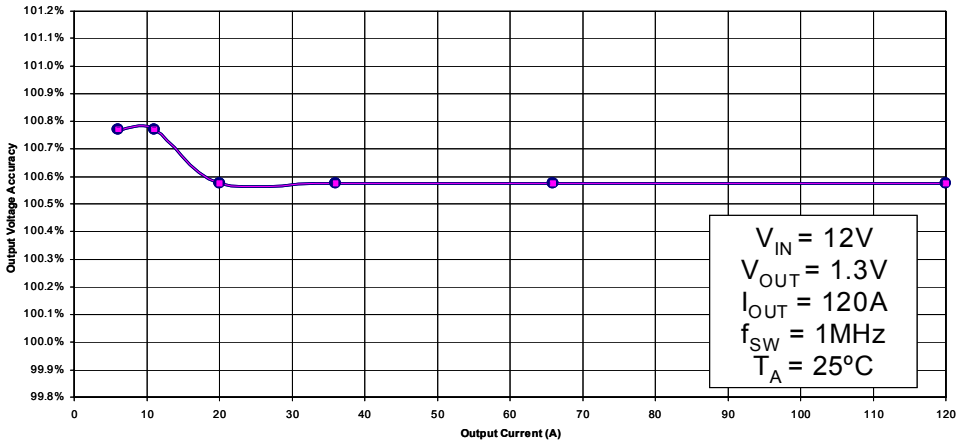


Fig. 6: Output Voltage Accuracy vs. Current

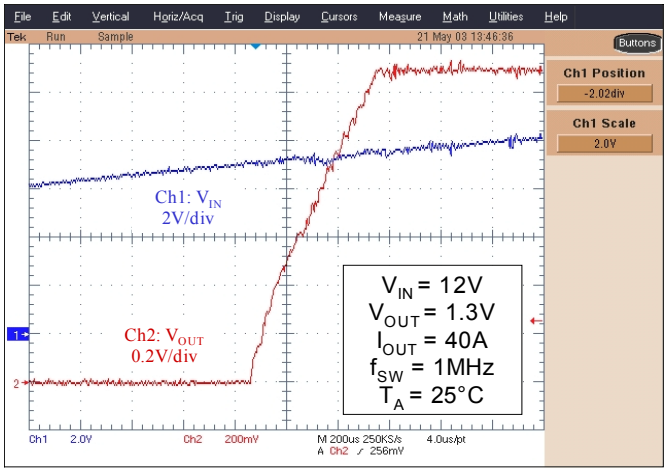


Fig. 7: Power Up Waveform

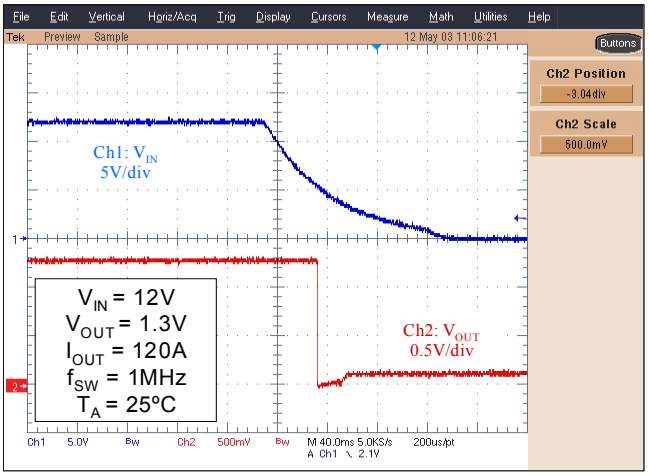


Fig. 8: Power Down Waveform

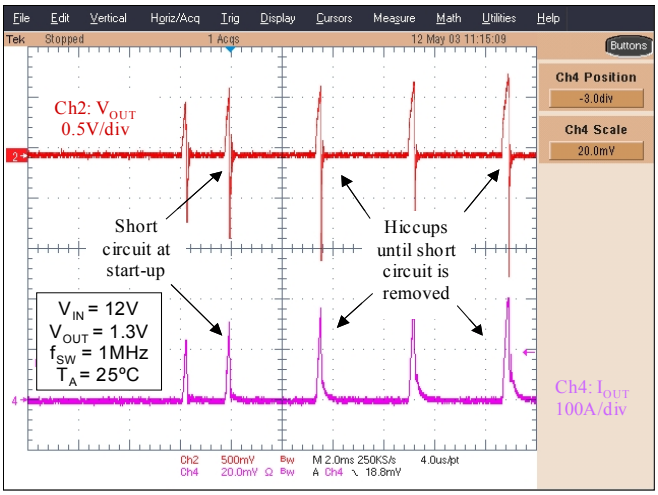


Fig 9: Short Circiut Condition Waveform

Adjusting the Over-Current Limit

R5, R7, R8 & R9 are the resistors used to adjust the over-current trip point. The trip point is a function of the controller and corresponds to the per phase output current indicated on the x-axis of Fig. 10. For example, selecting 2.7k resistors will set the trip point of each phase to 49.5A. (Note: Fig. 10 is based on iP2002 T_{BLK} = 125°C. The trip point will be higher than expected if the reference board is cool and is being used for short circuit testing.)

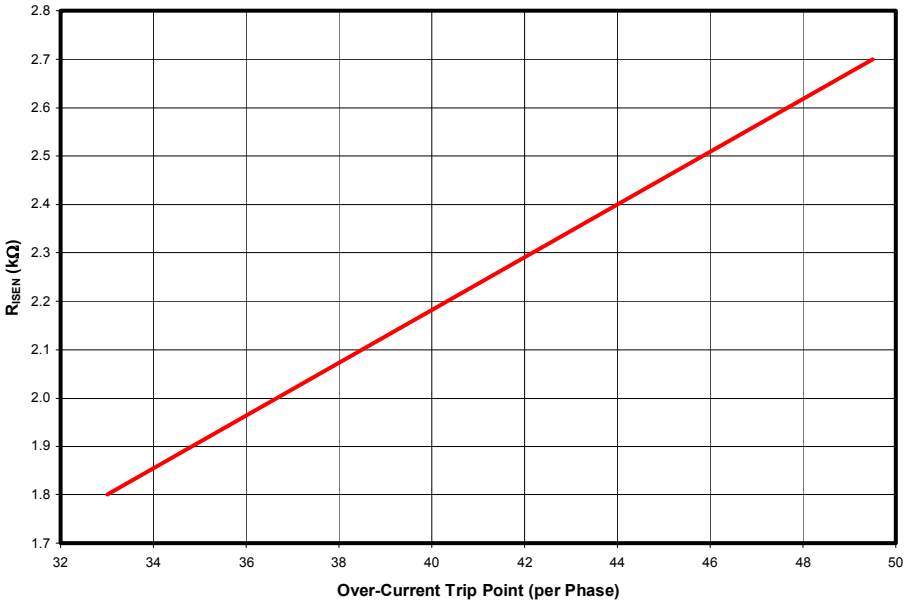


Fig. 10: R_{ISEN} vs. Current (per Phase)

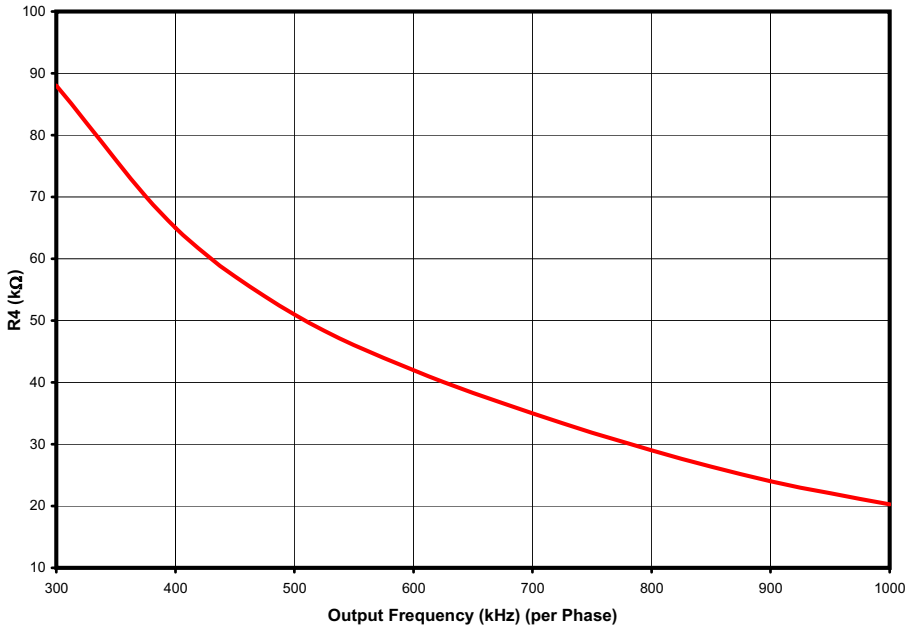


Fig. 11: R4 vs. Frequency (per Phase)

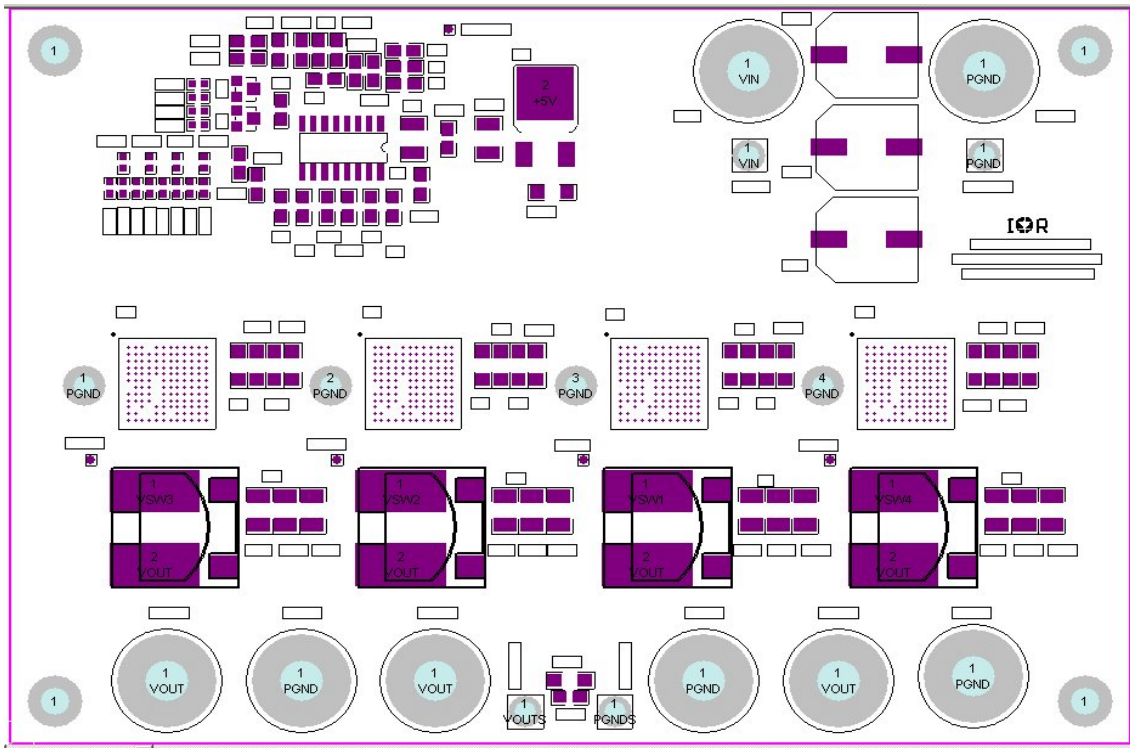
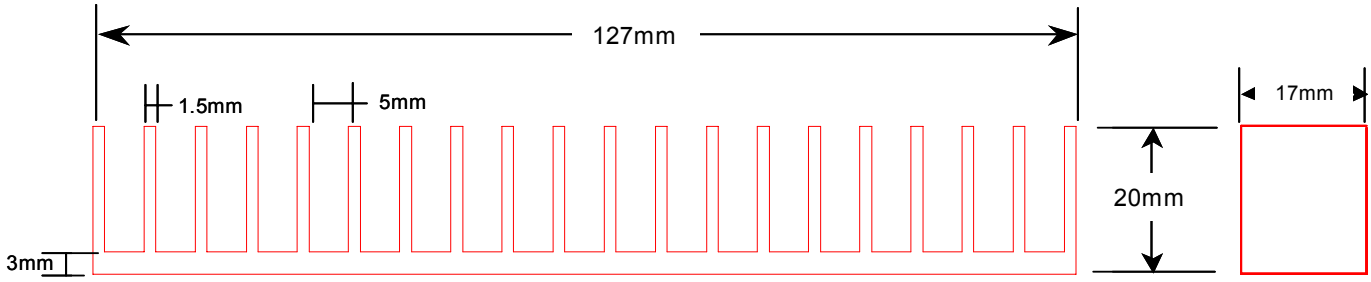


Fig. 12: Component Placement Top Layer



Heatsink Notes:

1) Always use the supplied Bergquist Gap Pad™ A2000 thermal interface material with heatsink.
2) Torque 4 x #2-56 machine screws to 15 ±1 in-oz.
3) The heatsink is optimized for 250 LFM with unconfined airflow. Performance will improve with more airflow or confined airflow.
4) Airflow direction should be parallel to fins for maximum performance.

Fig. 13: Heatsink Specificationss

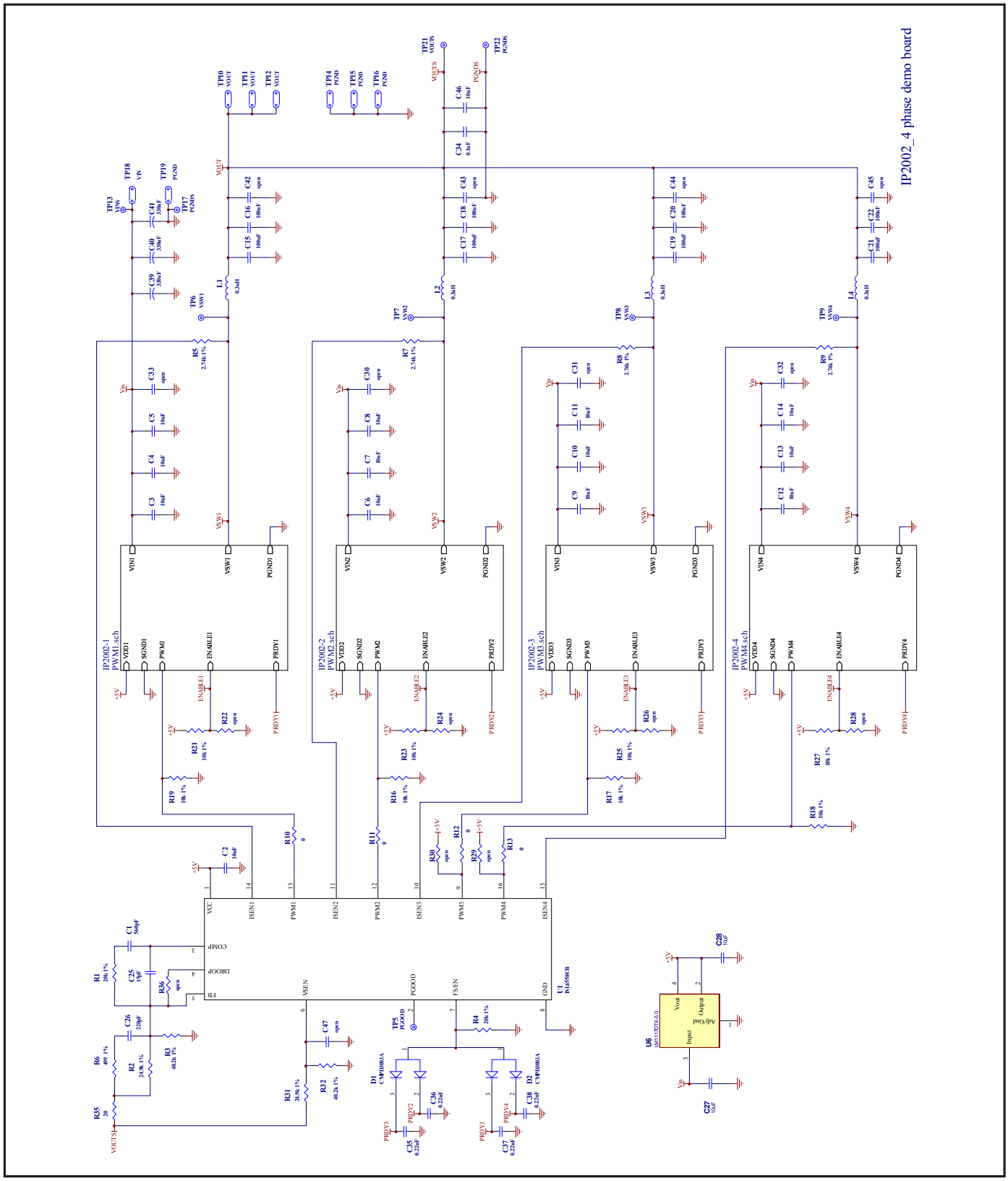


Fig. 14: Reference Design Schematic

Quantity	Designator	Type 1	Type 2	Value 1	Value 2	Tolerance	Package	Manufac 1
1	C1	capacitor	NPO	560pF	50V	5%	0805	ROHM
14	C10, C11, C12, C13, C14, C27, C3, C4, C46, C5, C6, C7, C8, C9	capacitor	X5R	10.0uF	16V	10%	1206	Murata
8	C15, C16, C17, C18, C19, C20, C21, C22	capacitor	X5R	100uF	6.3V	20%	1210	TDK
2	C2, C28	capacitor	X5R	10.0uF	6.3V	10%	1206	TDK
1	C25	capacitor	NPO	15.0pF	50V	5%	0805	ROHM
1	C26	capacitor	NPO	220pF	50V	5%	0805	Phicomp
31	C30, C31, C32, C33, C42, C43, C44, C45, C47, R22, R24, R26, R28, R29, R30, R36, SHORT, SHORT1,	open	-	-	-	-	-	-
1	C34	capacitor	X7R	0.100uF	50V	10%	0805	ROHM
4	C35, C36, C37, C38	capacitor	X5R	0.22uF	6.3V	10%	0603	TDK
3	C39, C40, C41	capacitor	polymer	330uF	16V	20%	SMD	Panasonic
2	D1, D2	diode	general purpose	200V	600mA	-	sot23	Central semiconductor
4	HN1, HN2, HN3, HN4	hardware	hexnut	4-40	-	-	-	Building Fasteners
4	L1, L2, L3, L4	inductor	ferrite	0.30uH	36A	20%	SMT	Panasonic
2	R1, R4	resistor	thick film	20.0K	1/8W	1%	0805	KOA
4	R10, R11, R12, R13	resistor	thick film	0	1/8W	<50m	0805	ROHM
8	R16, R17, R18, R19, R21, R23, R25, R27	resistor	thick film	10.0K	1/10W	1%	0603	KOA
2	R2, R31	resistor	thick film	24.9K	1/8W	1%	0805	KOA
2	R3, R32	resistor	thick film	40.2K	1/8W	1%	0805	KOA
1	R35	resistor	thick film	20	1/8W	1%	0805	KOA
4	R5, R7, R8, R9	resistor	thick film	2.74K	1/8W	1%	0805	KOA
1	R6	resistor	thick film	499	1/8W	1%	0805	KOA
8	SC1, SC2, SC3, SC4, SC5, SC6, SC7, SC8	hardware	hexnut	10-24	-	-	-	McMaster Carr
4	ST1, ST2, ST3, ST4	hardware	stand off	4-40	2	-	alumininum	Keystone
8	TC1, TC2, TC3, TC4, TC5, TC6, TC7, TC8	hardware	machine screw	10-24	3/4	-	-	McMaster Carr
1	U1	ISL6558	PWM controller	4.5 - 5.5V	0.8 - 5V	-	16 Ld SOIC	Intersil
4	U2, U3, U4, U5	iP2002	BGA unit	5 - 12V	30A	-	11mm x 11mm	International Rectifier
1	U6	LM1117	LDO linear regulator	5.0V	800mA	-	TO-252	National Semiconductor

Table 1: Reference Design Bill of Materials

Refer to the following application notes for detailed guidelines and suggestions when implementing iPOWIR Technology products:

AN-1028: Recommended Design, Integration and Rework Guidelines for International Rectifier's iPOWIR Technology BGA Packages
This paper discusses the assembly considerations that need to be taken when mounting iPOWIR BGA's on printed circuit boards. This includes soldering, pick and place, reflow, inspection, cleaning and reworking recommendations.

AN-1029: Optimizing a PCB Layout for an iPOWIR Technology Design
This paper describes how to optimize the PCB layout design for both thermal and electrical performance. This includes placement, routing, and via interconnect suggestions.

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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