

# REFERENCE DESIGN

**IRDCiP1001-A**

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

## **IRDCiP1001-A, 200kHz, 20A, 3.3V<sub>IN</sub> to 4.5V<sub>IN</sub> Single Phase Synchronous Buck Converter using iP1001**

### Overview

In this document, Table 1 and Figure 1 are provided to enable engineers to easily evaluate the iP1001 in a single phase configuration that is capable of providing up to 20A in a lab environment without airflow. Figures 3, 4, 5 and 6 and the complete bill of materials in Table 2 are provided as a reference design to enable engineers to very quickly and easily design a single phase converter. In order to optimize this design to your specific requirements, refer to the iP1001 data sheet for guidelines on external component selection and user adjustable limits and specifications. Custom designs may require layout modifications.

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| IRDCiP1001-A Demoboard Operating Conditions |           |      |
|---------------------------------------------|-----------|------|
|                                             | Min       | Max  |
| V <sub>IN</sub>                             | 3.3V      | 4.5V |
| V <sub>OUT</sub>                            | 0.925V    | 2.5V |
| I <sub>OUT</sub>                            | See Fig.1 |      |

### Demoboard Quick Start Guide

#### **Initial Settings:**

- The output is set to 2V, but can be adjusted from 0.925V to 2.0V by setting SW1 according to the VID codes provided in Table 1. The output voltage can also be adjusted to allow up to 2.5V<sub>OUT</sub> for 3.3V<sub>IN</sub>, by adding R3 & R4 with the DAC set to 2V<sub>OUT</sub>. Refer to equation 1 for R3 & R4 values. R4 should be removed for output voltages below 2V, and R3 should be set to zero ohms (see Table 2).
- The switching frequency is centered around 200kHz for <5V<sub>IN</sub> applications with the FREQ pin connected to V<sub>DD</sub>.
- The input voltage range can be increased to allow operation between 5V<sub>IN</sub> and 12V<sub>IN</sub>. Refer to IRDCiP1001-B reference design documentation for direction on changing the configuration of the demo board.

#### **Procedure for Connecting and Powering Up Demoboard:**

1. Apply input voltage (3.3V-4.5V) across V<sub>IN</sub> and PGND. Note that this demo board has a mini-boost circuit provided in order to provide the 5V<sub>DD</sub> internal logic for the iP1001. This boost circuit can be used to provide power for up to 5 x iP1001 devices simultaneously.
2. Apply load across VOUT pad and PGND pad.
3. Make sure Jumpers JP2 and JP3 are connected.
4. Remove jumper JP1 to turn on the boost circuit and pull iP1001 ENABLE pin high. The ENABLE pin is controlled via switch 8 on SW1. This pin is supplied in low state, once pulled high the output is enabled.
5. Adjust load accordingly.

### IRDCiP1001-A Recommended Operating Conditions

(refer to the iP1001 datasheet for maximum operating conditions)

Input voltage: 3.3 - 4.5V (V<sub>DD</sub> provided by mini boost circuit)

Output voltage: DAC selectable between 0.925V - 2.0V (with extended operating range to 3.3V with R3 & R4)

Output current: Up to 20A depending on duty factor (refer to recommended operating area Fig.1).

Switching Freq: 200kHz or 300kHz selectable.

# IRDCiP1001-A

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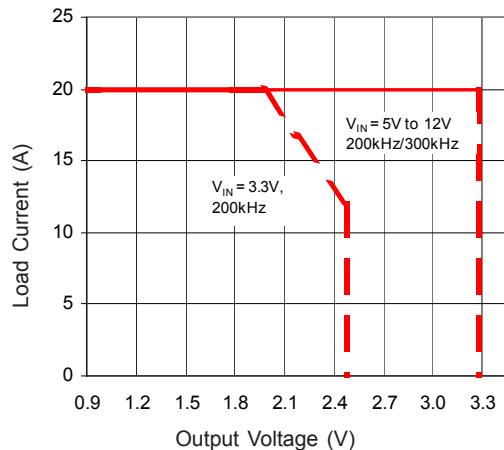


Fig. 1 - Recommended Operating Area

| D4 | D3 | D2 | D1 | D0 | Output Voltage (V) | D4 | D3 | D2 | D1 | D0 | Output Voltage (V) |
|----|----|----|----|----|--------------------|----|----|----|----|----|--------------------|
| 0  | 0  | 0  | 0  | 0  | 2.00               | 1  | 0  | 0  | 0  | 0  | 1.275              |
| 0  | 0  | 0  | 0  | 1  | 1.95               | 1  | 0  | 0  | 0  | 1  | 1.250              |
| 0  | 0  | 0  | 1  | 0  | 1.90               | 1  | 0  | 0  | 1  | 0  | 1.225              |
| 0  | 0  | 0  | 1  | 1  | 1.85               | 1  | 0  | 0  | 1  | 1  | 1.200              |
| 0  | 0  | 1  | 0  | 0  | 1.80               | 1  | 0  | 1  | 0  | 0  | 1.175              |
| 0  | 0  | 1  | 0  | 1  | 1.75               | 1  | 0  | 1  | 0  | 1  | 1.150              |
| 0  | 0  | 1  | 1  | 0  | 1.70               | 1  | 0  | 1  | 1  | 0  | 1.125              |
| 0  | 0  | 1  | 1  | 1  | 1.65               | 1  | 0  | 1  | 1  | 1  | 1.100              |
| 0  | 1  | 0  | 0  | 0  | 1.60               | 1  | 1  | 0  | 0  | 0  | 1.075              |
| 0  | 1  | 0  | 0  | 1  | 1.55               | 1  | 1  | 0  | 0  | 1  | 1.050              |
| 0  | 1  | 0  | 1  | 0  | 1.50               | 1  | 1  | 0  | 1  | 0  | 1.025              |
| 0  | 1  | 0  | 1  | 1  | 1.45               | 1  | 1  | 0  | 1  | 1  | 1.000              |
| 0  | 1  | 1  | 0  | 0  | 1.40               | 1  | 1  | 1  | 0  | 0  | 0.975              |
| 0  | 1  | 1  | 1  | 0  | 1.35               | 1  | 1  | 1  | 0  | 1  | 0.950              |
| 0  | 1  | 1  | 1  | 0  | 1.30               | 1  | 1  | 1  | 1  | 0  | 0.925              |
| 0  | 1  | 1  | 1  | 1  | Shutdown*          | 1  | 1  | 1  | 1  | 1  | Shutdown*          |

\* Shutdown : Upon receipt of the shutdown code (per VID code table above), both FETs are turned OFF and the output is discharged as it enters UVP fault mode.

Table 1 - iP1001 VID Code

For output voltages above the DAC maximum setting of 2V, refer to Equation 1 below to calculate the required resistor values for R3 & R4 (needed in order to achieve the extended output voltage range).

$$\text{Equation 1 : } V_{\text{out}} = V_F \cdot \{1 + R3/R4\}$$

where  $V_F$  is equal to the DAC setting

and R4 is recommended to be  $\sim 1\text{k}\Omega$

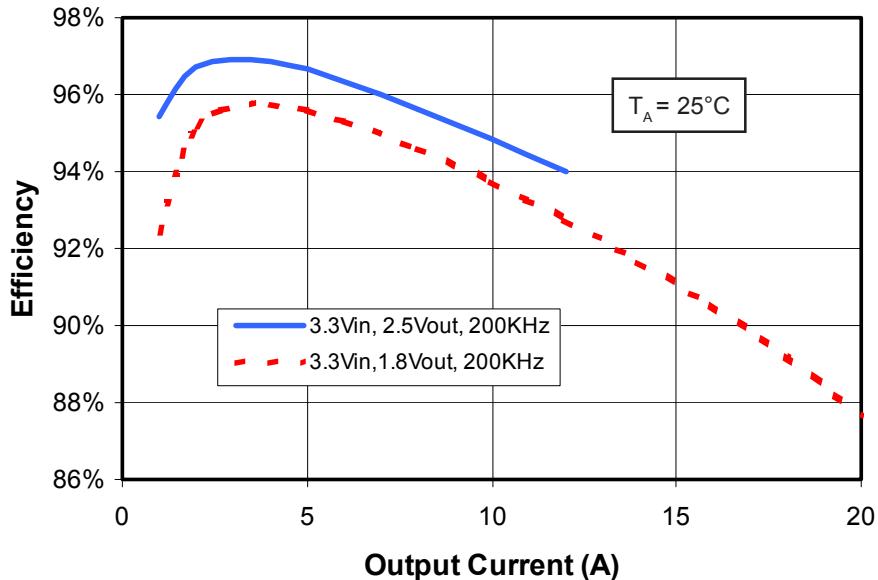


Fig. 2 - Typical Efficiency vs. Current

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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.

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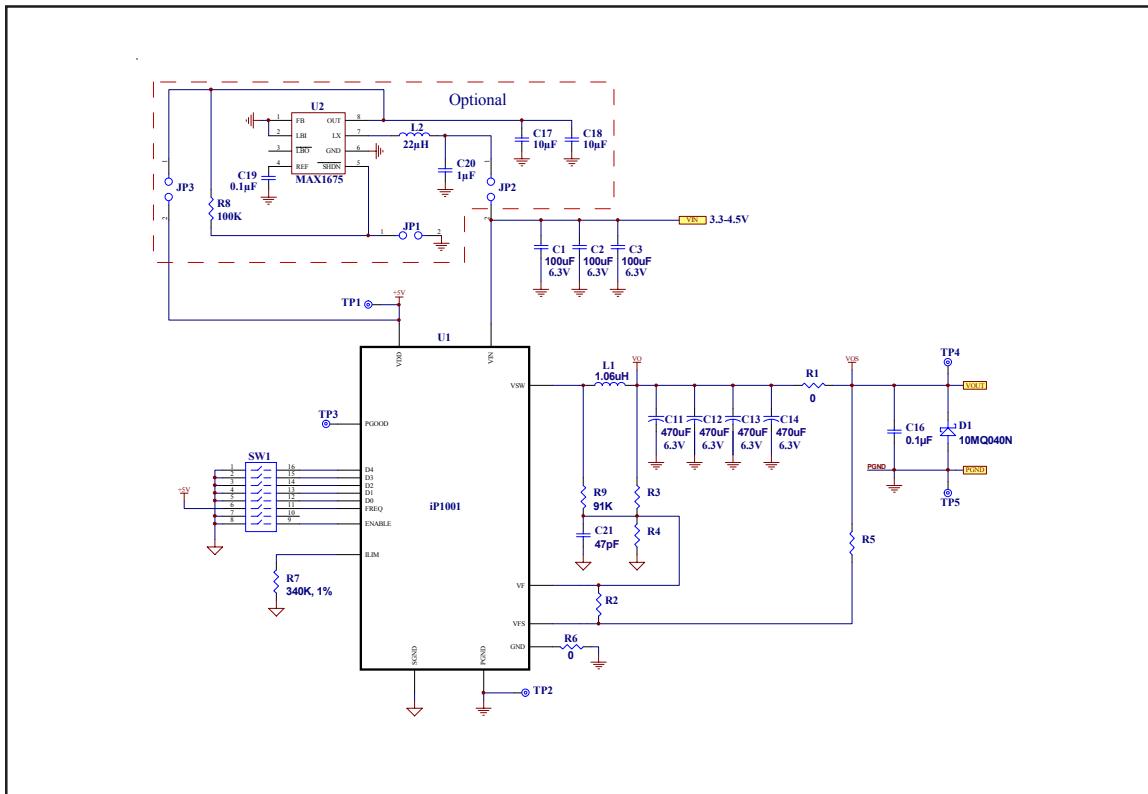
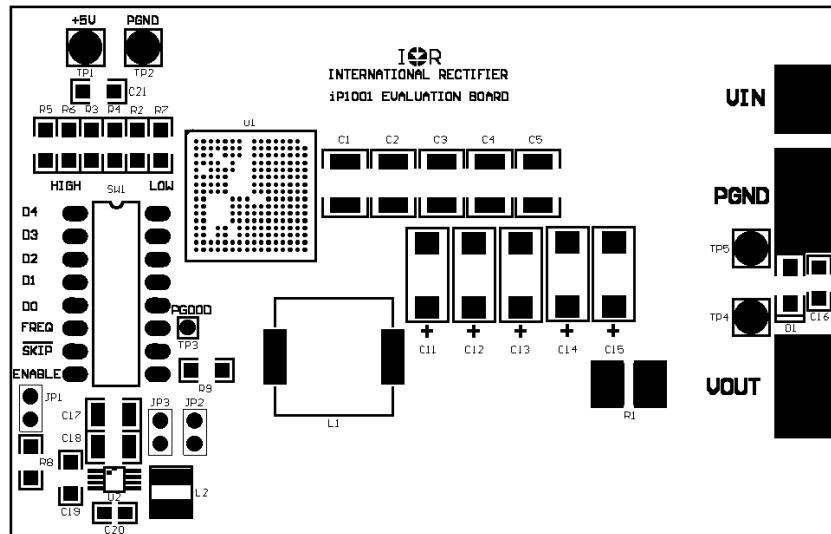
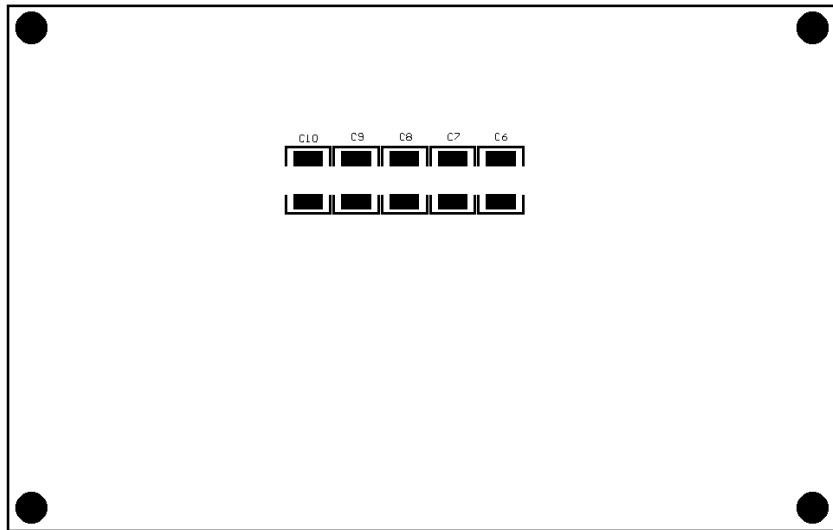


Fig. 3 - Reference Design Schematic



**Fig. 4 - Component Placement (Top View)**



**Fig. 5 - Component Placement (Bottom View)**

# IRDCiP1001-A

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## IRDCiP1001-A (For operation $<4.5V_{IN}$ )

| Designator                       | Value   | Part Type                                                                             | Footprint          | Mfr.                    | Mfr. P/N           |
|----------------------------------|---------|---------------------------------------------------------------------------------------|--------------------|-------------------------|--------------------|
| C1, C3, C5                       | 100uF   | Capacitor, 6.3V, 20%, X5R                                                             | 1812               | TDK                     | C4532X5R0J107MT    |
| C2, C4, C6, C7, C8, C9, C10, C15 | -       | Not Installed                                                                         | -                  | -                       | -                  |
| C11, C12, C13, C14               | 470uF   | Capacitor, 6.3V, 20%, Tantalum                                                        | 7343               | Sanyo                   | 6TPB470M           |
| C16, C19                         | 0.100uF | Capacitor, 50V, 10%, X7R                                                              | 1206               | Novacap                 | 1206B104K500N      |
| C17, C18                         | 10.0uF  | Capacitor, 16V, 10%, X5R                                                              | 1210               | TDK                     | C3225X5R1C106KT    |
| C20                              | 1.00uF  | Capacitor, 10V, 10%, X7R                                                              | 0805               | MuRata                  | GRM40X7R105K010    |
| C21                              | 47.0pF  | Capacitor, 50V, 5%, C0G                                                               | 1206               | MuRata                  | GRM42-6C0G470J050A |
| D1                               | 40V     | Schottky Diode, 40V, 2.1A                                                             | D-64               | International Rectifier | 10MQ040N           |
| JP1, JP2, JP3                    | -       | Test Point                                                                            | -                  | Samtec                  | TSW-102-07-LS      |
| JP1-1, JP2-1, JP3-1              | -       | Shunt                                                                                 | -                  | Samtec                  | SNT-100-BKT        |
| L1                               | 1.06uH  | Inductor, 16A, 20%, Ferrite                                                           | SMT                | Panasonic               | ETQP6F1R1BFA       |
| L2                               | 22uH    | Inductor, 0.68A, 20%, Ferrite                                                         | SMT                | Sumida                  | CR43-220           |
| R1                               | 0Ω      | Resistor, 0Ω Jumper                                                                   | 2716               | Isotek Corp             | SMT-R000           |
| R2                               | -       | For <2Vout, Not installed<br>For >2Vout, Resistor, 0Ω Jumper                          | SMT                | -                       | -                  |
| R3                               | -       | For <2Vout, Resistor, 0Ω Jumper<br>For >2Vout see formula for value                   | SMT                | -                       | -                  |
| R4                               | -       | For <2Vout, Not installed<br>For >2Vout recommend 1kΩ<br>see formula for detail       | SMT                | -                       | -                  |
| R5                               | -       | For <2Vout, Resistor, 0Ω Jumper<br>For >2Vout, Not installed                          | 1206               | Panasonic               | ERJ-8GEY0R00       |
| R6                               | 0Ω      | Resistor, 0Ω Jumper                                                                   | 1206               | -                       | -                  |
| R7                               | 340kΩ   | Resistor, 340kΩ, 1%<br>340kΩ sets for 20A limit.<br>See ILIM formula for other values | 1206               | ROHM                    | MCR18EZH3403       |
| R8                               | 100kΩ   | Resistor, 100kΩ, 5%                                                                   | 1206               | ROHM                    | MCR18EZHJ104       |
| R9                               | 91kΩ    | Resistor, 91kΩ, 5%                                                                    | 1206               | ROHM                    | MCR18EZHJ913       |
| SW1                              | -       | 8-position DIP switch                                                                 | SMT                | C&K Components          | SD08H0SK           |
| TP1, TP3                         | -       | Not Installed                                                                         | -                  | -                       | -                  |
| TP2, TP4, TP5                    | -       | Test Point                                                                            | -                  | Keystone                | 1502-2             |
| U1                               | -       | Power Block                                                                           | SSBGA<br>14mmx14mm | International Rectifier | iP1001             |
| U2                               | -       | IC, Step-Up DC-DC Converter, 0.5A                                                     | 8uMAX              | Maxim                   | MAX1675EUA         |

Table 2 - Reference Design Bill of Materials

## Adjusting the Current Limit

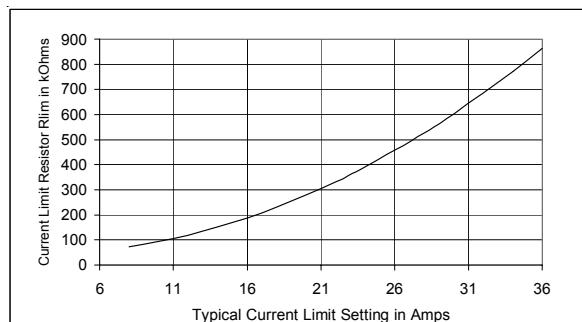


Fig. 6 Current Limit Adjustment using  $R_{LIM}$

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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