Title	**Preliminary Reference Design Report 50 W Flyback Converter with Two Independently Regulated Outputs Using InnoMux™2-EP IMX2378F-H415**
Specification	90 VAC – 265 VAC Input; 12 V / 1.67 A and 24 V / 1.25 A Outputs
Application	Multi-Output PSU for Appliance and Industrial
Author	Applications Engineering Department
Document Number	RDR-1043
Date	31 May 2024
Revision	1.0

Summary and Features

Unique single-stage multi-output, flyback architecture enabling:-

- High efficiency across wide-input line voltage
- Independently regulated 12 V and 24 V outputs
  - Both output voltages are regulated to ±1% accuracy
- Low no-load consumption
  - Less than 50 mW across line
- Comprehensive protection features
  - Output overvoltage (OVP)
  - Output power limit set independently for each output
  - Accurate thermal protection with hysteretic overtemperature shutdown
  - Input voltage monitor with accurate brown-in/brown-out and overvoltage

PATENT INFORMATION
The products and applications illustrated herein (including transformer construction and circuits external to the products) may be covered by one or more U.S. and foreign patents, or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at www.power.com. Power Integrations grants its customers a license under certain patent rights as set forth at https://www.power.com/company/intellectual-property-licensing/.

Power Integrations, Inc.
5245 Hellyer Avenue, San Jose, CA 95138 USA.
Tel: +1 (408) 414-9200 Fax: +1 (408) 414-9201
www.power.com

Introduction

This document is an engineering report describing a flyback offline power supply intended for appliance, industrial and smart meter applications, utilizing the IMX2378F-H415 from the InnoMux2-EP family of ICs.

The power supply has two Constant Voltage (CV) outputs: 1.67 A, 12 V and 1.25 A, 24 V. It can deliver a total maximum output power of 50 W, with universal mains input (from 90 VAC to 265 VAC). This design shows the high efficiency and accurate output regulation that is possible due to the controller's multiplexing power control algorithm and high level of integration.

This report is a preliminary summary. To receive additional information including bill of materials, printed circuit board (PCB) layout, computer performance data and test setup, contact your local PI representative.

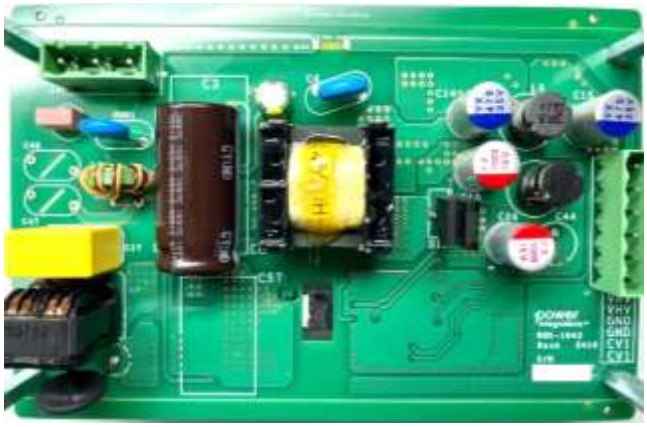


Figure 1 – Populated Circuit Board Photograph, Top.

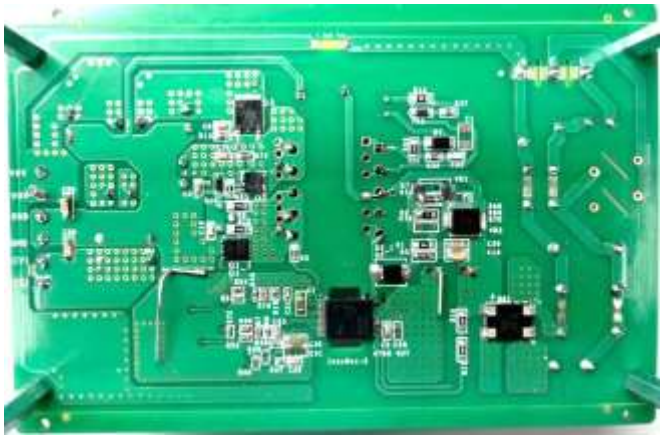


Figure 2 – Populated Circuit Board Photograph, Bottom.

1 Power Supply Specification

The table below represents the minimum acceptable performance of the design.

Description	Symbol	Min	Typ.	Max	Units	Comment
Input						
Voltage	V_{IN}	90		265	VAC	3 Wire Input
Frequency	f_{LINE}	47	50/60	64	Hz	
Output						
Output Voltage 1	V_{OUT1}	11.8	12	12.2	V	±5%
Output Ripple Voltage 1	$V_{RIPPLE1}$			240	mV	±1%, 20 MHz Bandwidth
Output Current 1	I_{OUT1}	0		1.67	A	
Output Voltage 2	V_{OUT2}	23.7	24	24.3	V	±5%
Output Ripple Voltage 2	$V_{RIPPLE2}$			480	mV	±2%, 20 MHz Bandwidth
Output Current 2	I_{OUT2}	0		1.25	A	
Total Output Power						
Output Power	P_{OUT}		50		W	
Efficiency						
Full Load	η		90		%	Measured at 230 VAC, 25 ºC
Standby Input Power				<0.3	W	Measured at 230 VAC 25 ºC, 5 V 30 mA
Environmental						
Ambient Temperature	T_{AMB}	0		40	ºC	Free Convection, Sea Level

Table 1 – Power Supply Specifications

2 Simplified Schematic

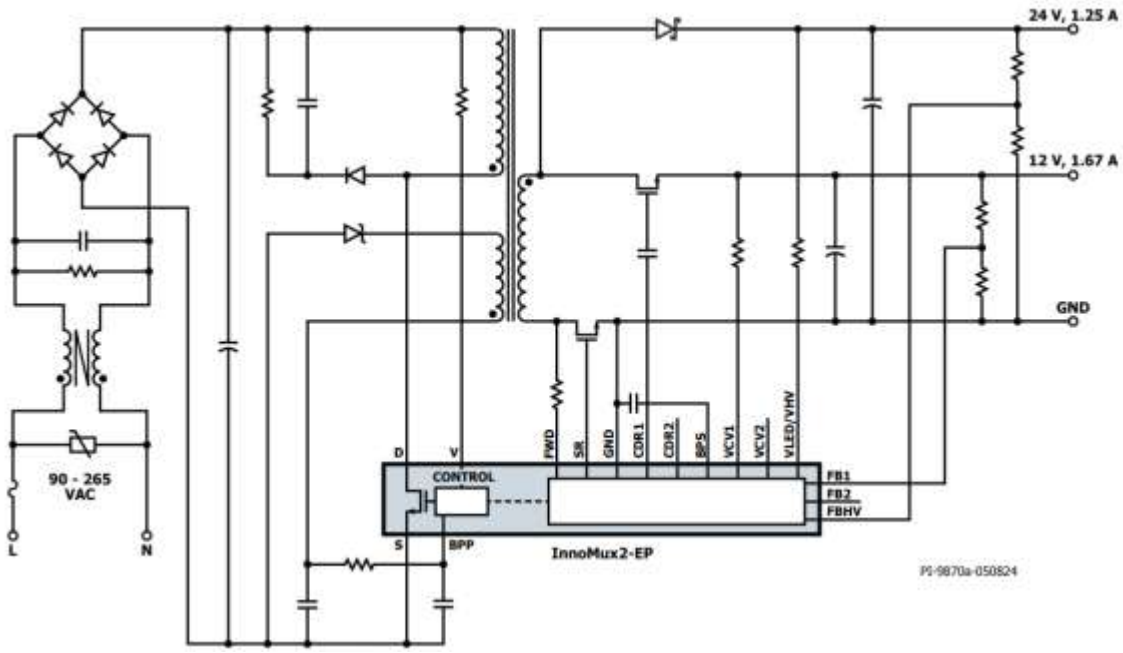


Figure 3 – Simplified Schematic Showing Key Circuit Elements

3 Preliminary Performance Information

Full Load Efficiency vs. Line

Full load efficiency vs. line voltage is shown below. Nominal line voltages (90 VAC, 115 VAC, 230 VAC, 265 VAC).

- CV1 = 12 V @ 1.67 A
- CVHV = 24 V @ 1.25 A
- NTC resistor is shorted

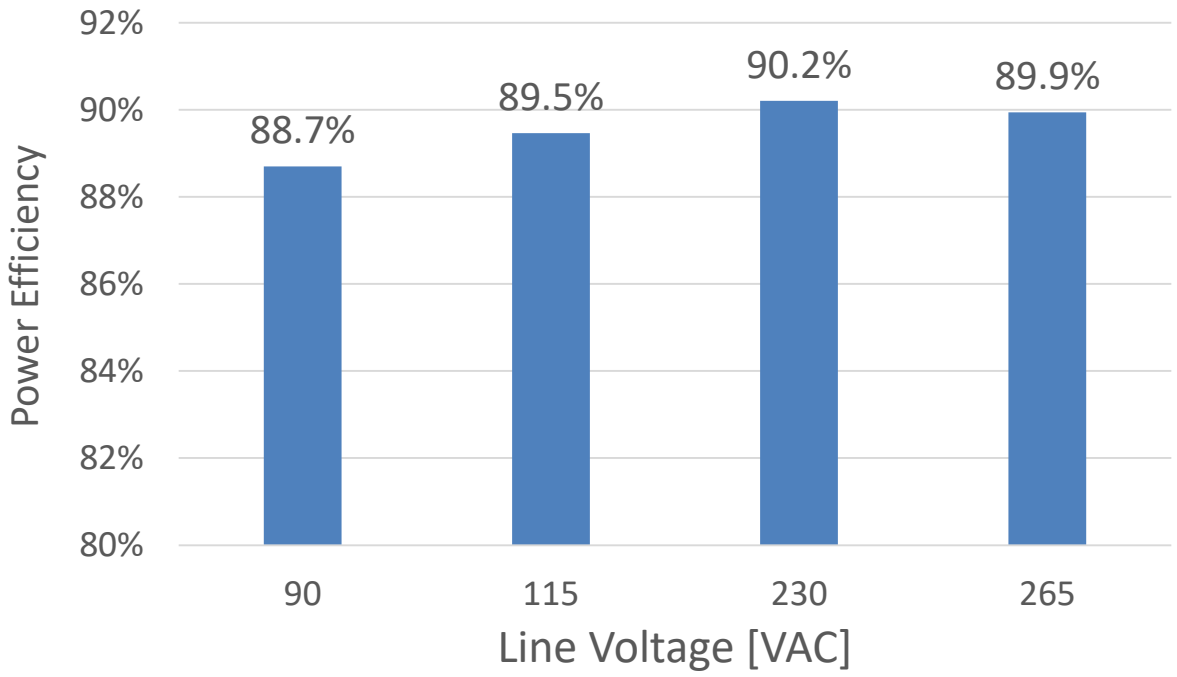


Figure 4 – Full Power Efficiency vs. Line Voltage at Room Temperature

4 Efficiency vs. Load

- Tests performed at nominal line voltages (90 VAC, 115 VAC, 230 VAC, 265 VAC).
- CV1 = 12 V @ 1.67 A (0 to 100% with 5% load increment)
- CVHV = 24 V @ 1.25 A (0 to 100% with 5% load increment)
- NTC resistor is shorted

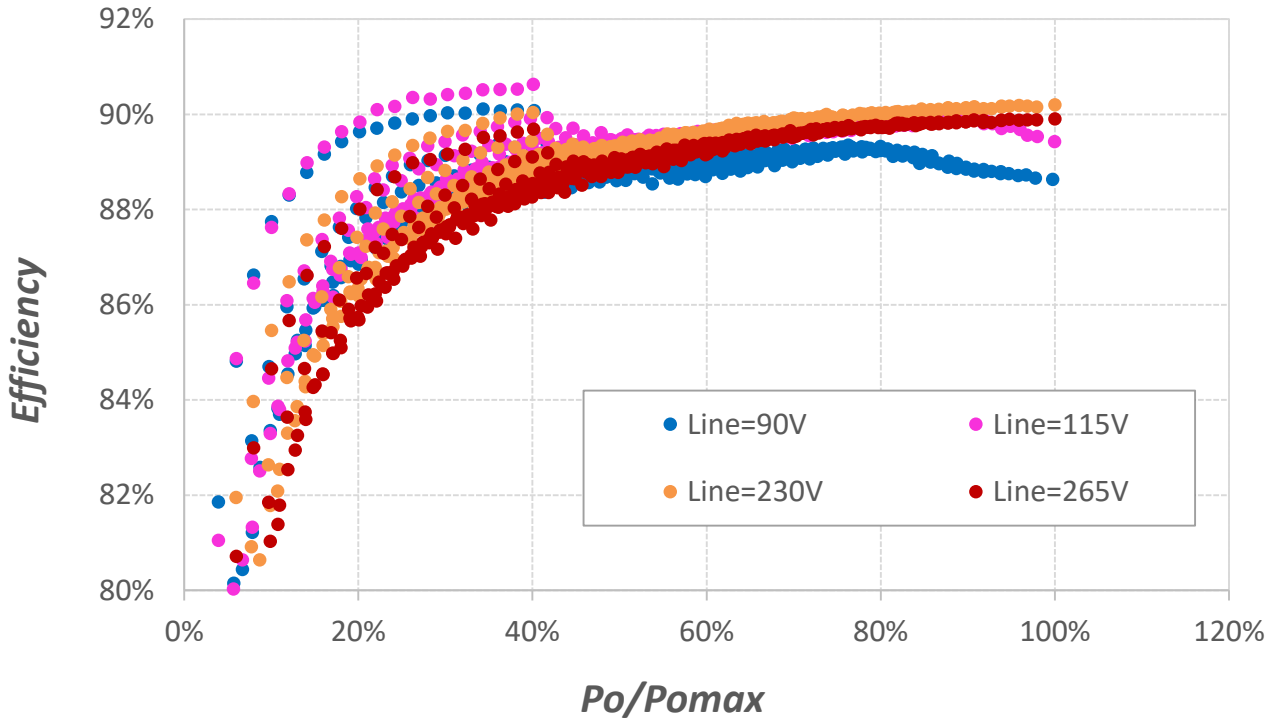


Figure 5 – Efficiency vs. Load for All Line Inputs, Room Temperature

5 Output Load Regulation

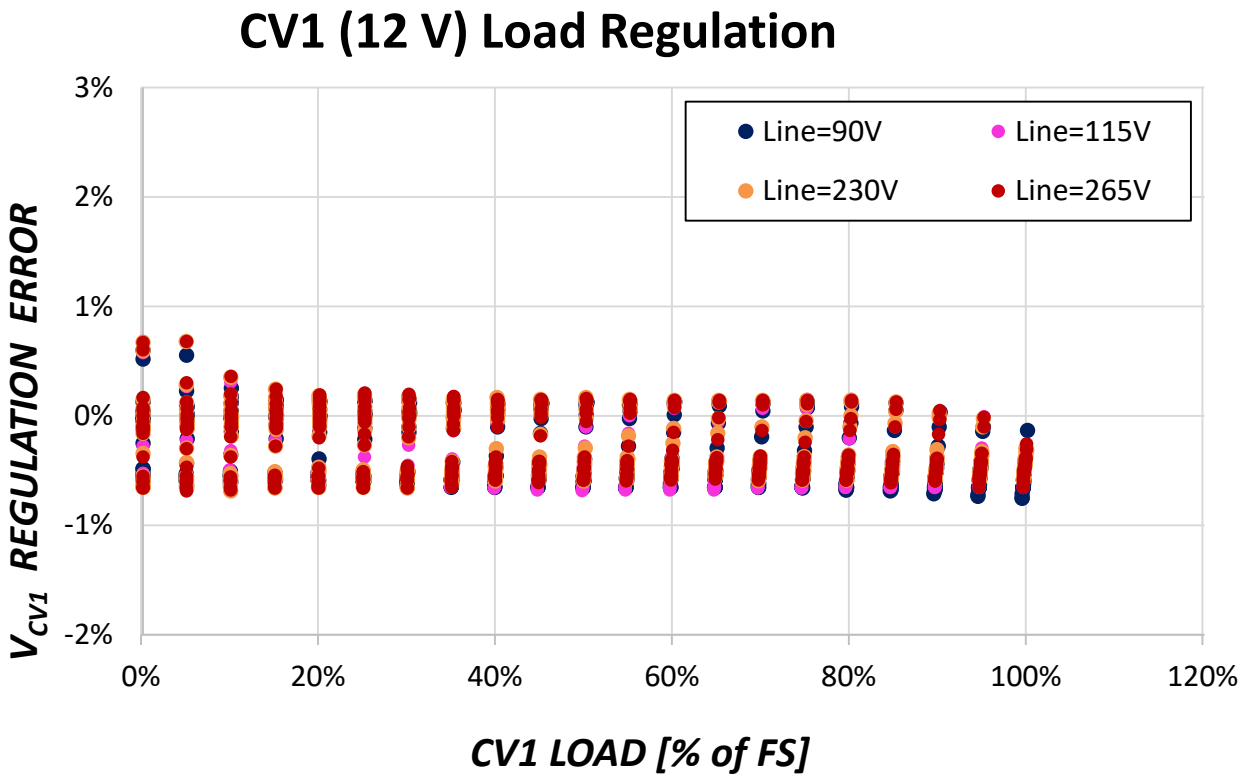


Figure 6 – CV1 Output Voltage Error vs. Output Load, Room Temperature

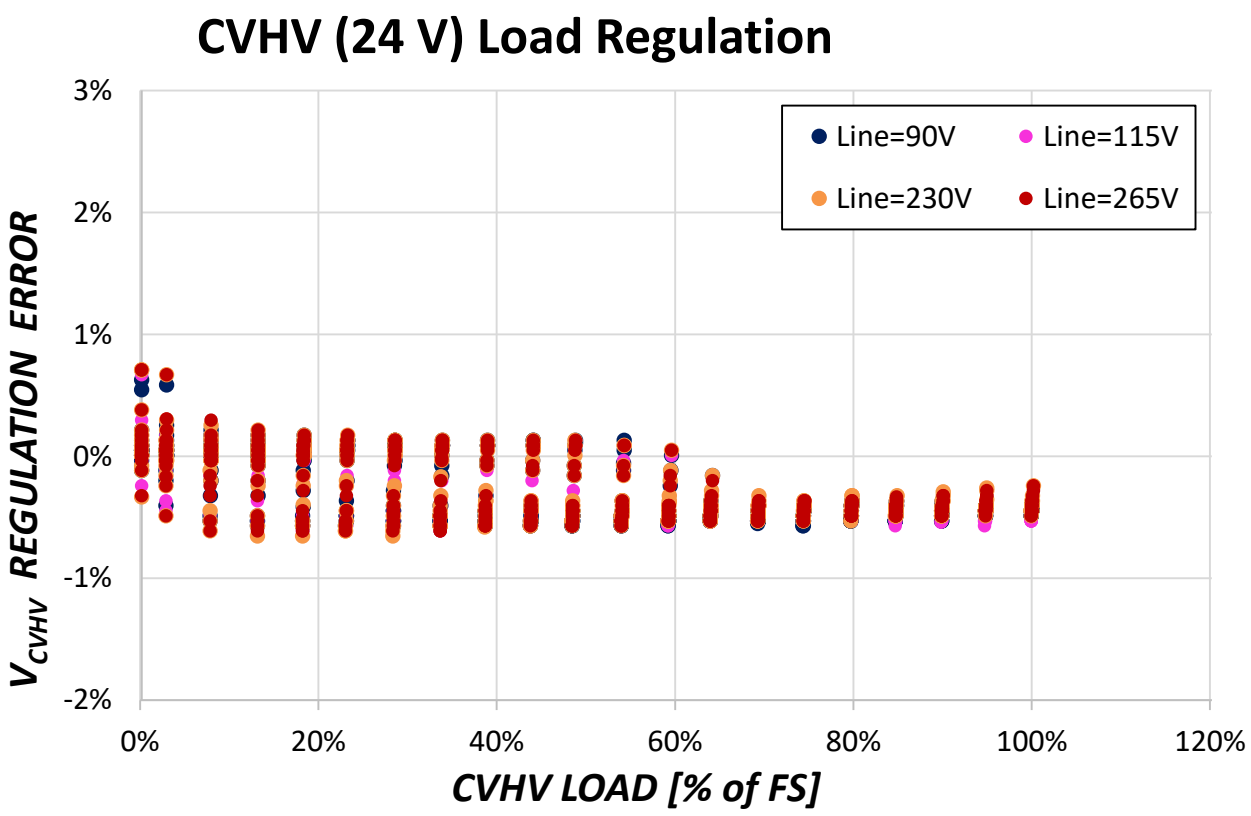


Figure 7 – CVHV Output Voltage Error vs. Output Load, Room Temperature

6 No-Load and Standby Input Power (ICVHV = 0 A)

The output power vs. input power at standby mode measurements are shown below. These were obtained for all combinations of:

- All nominal line voltages (90 V, 115 V, 230 V, 265 V)
- CVHV output = 0 A
- CV1 output = 0 mW to 350 mW

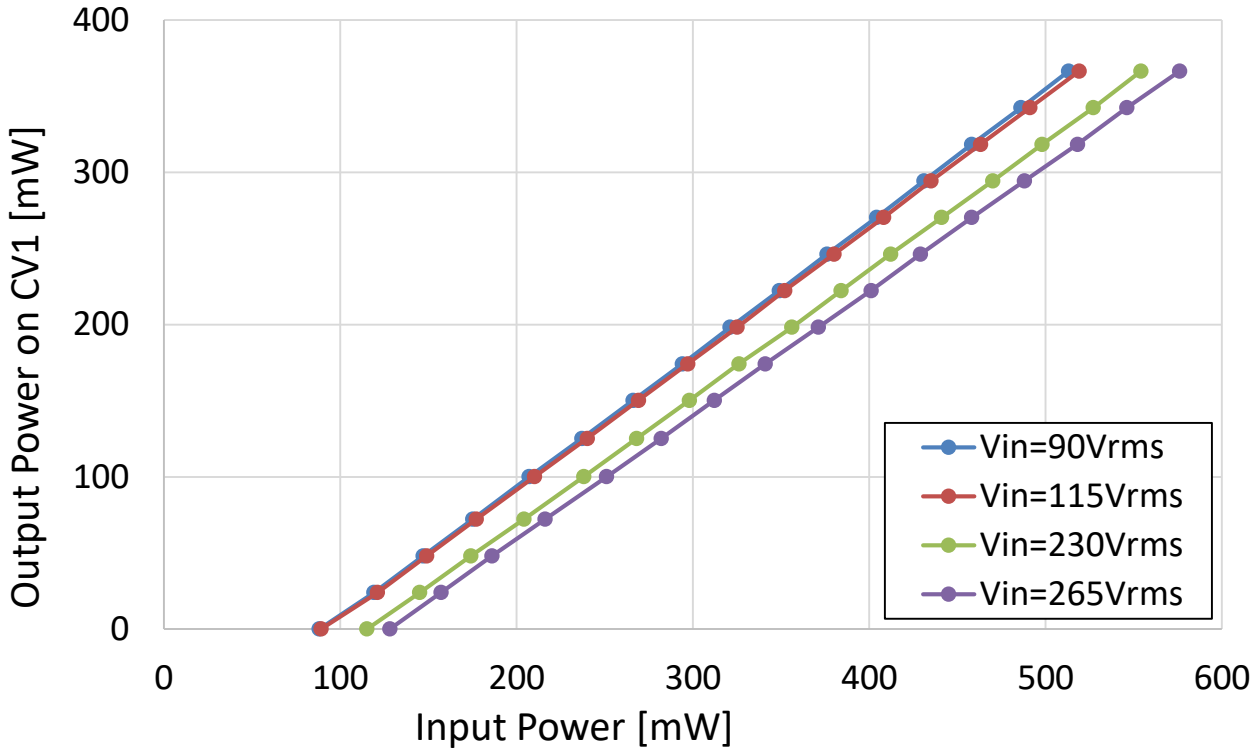
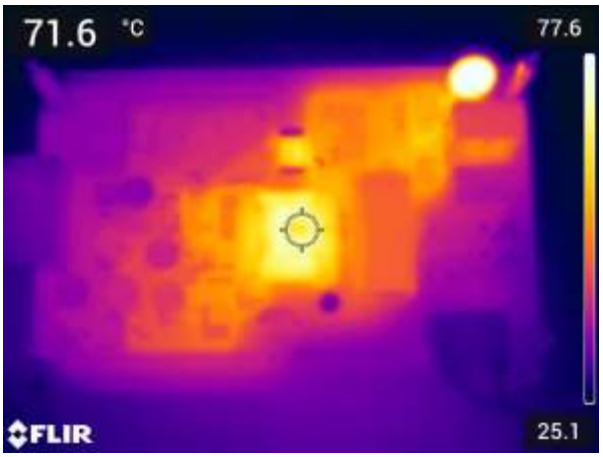


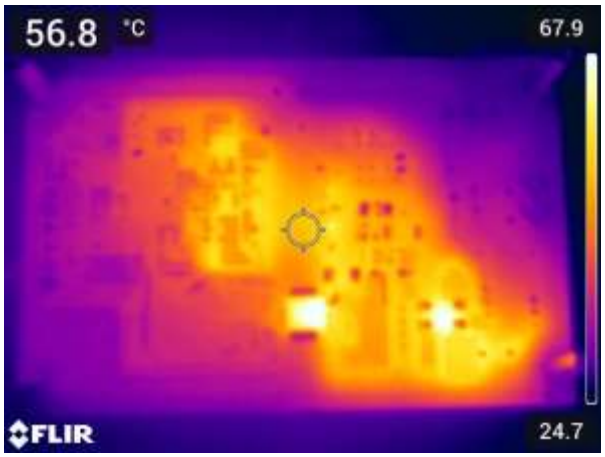
Figure 8– Standby Power Availability vs. Input Line Voltage, Room Temperature

7 Thermal Performance

No heatsinks are required for the power supply. Copper PCB area is used for cooling the InnoMux2-EP IC. No forced air-cooling was required during any test. Temperatures of the hottest components in the assembly are shown below.

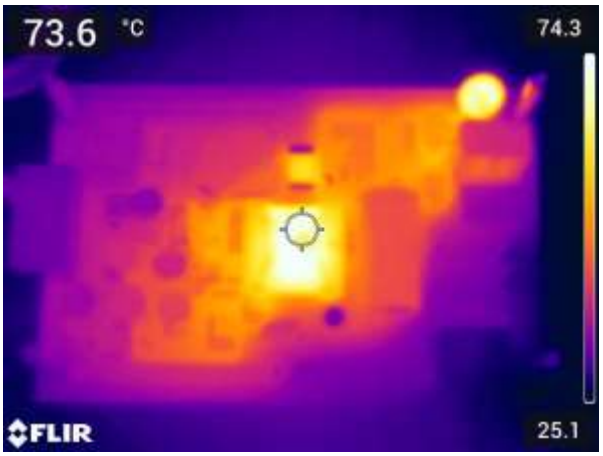


(a) Top View

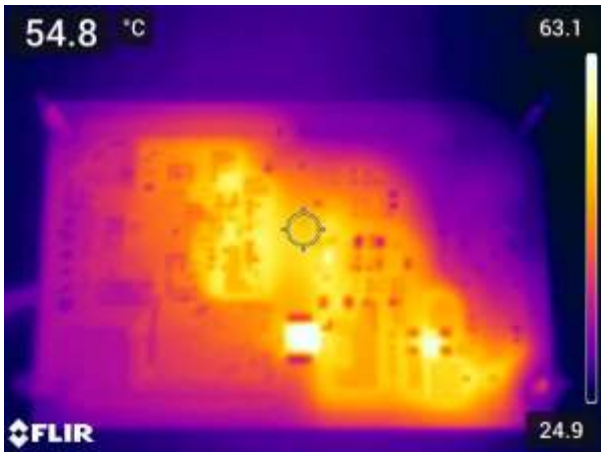


(b) Bottom View

Figure 9– Thermal Image, 90 VAC, Full Power

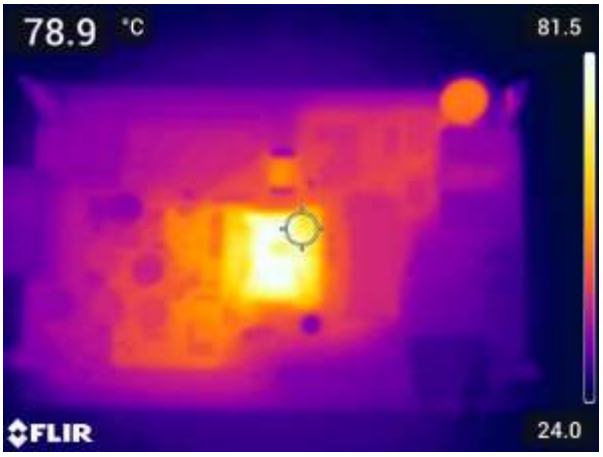


(a) Top View

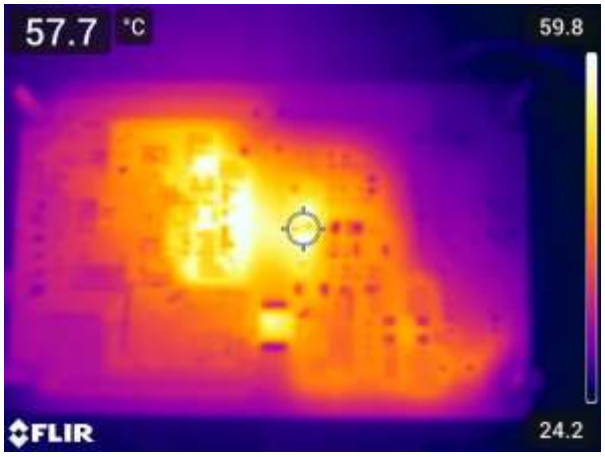


(b) Bottom View

Figure 10 – Thermal Image, 115 VAC, Full Power

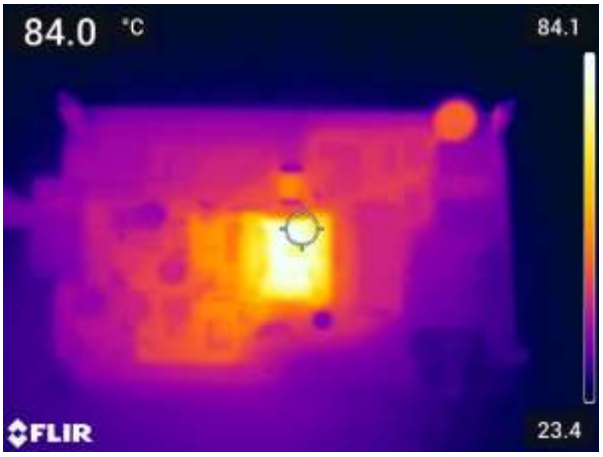


(a) Top View

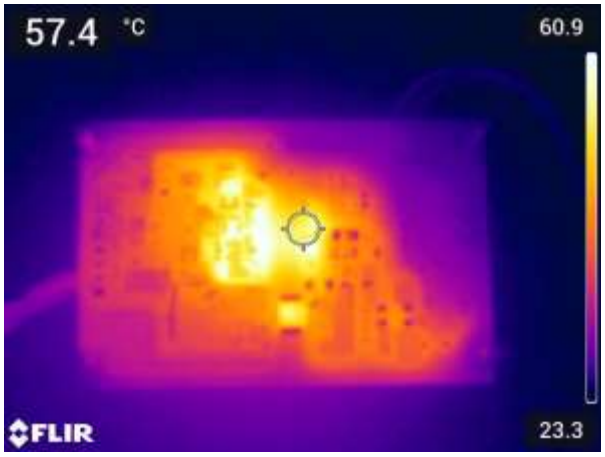


(b) Bottom View

Figure 4 – Thermal Image, 230 VAC, Full Power



(a) Top View



(b) Bottom View

Figure 5 – Thermal Image, 265 VAC, Full Power

Revision History

Date	Author	Revision	Description & Changes	Reviewed
31-May-24	Doc. Team	1.0	Preliminary Release.	Apps & Mktg

For the latest updates, visit our website: www.power.com

Reference Designs are technical proposals concerning how to use Power Integrations' gate drivers in particular applications and/or with certain power modules. These proposals are "as is" and are not subject to any qualification process. Suitability, implementation and qualification are the sole responsibility of the end user. The statements, technical information and recommendations contained herein are believed to be accurate as of the date hereof. All parameters, numbers, values and other technical data included in the technical information were calculated and determined to our best knowledge in accordance with the relevant technical norms (if any). They may be based on assumptions or operational conditions that do not necessarily apply in general. We exclude any representation or warranty, express or implied, in relation to the accuracy or completeness of the statements, technical information and recommendations contained herein. No responsibility is accepted for the accuracy or sufficiency of any of the statements, technical information, recommendations or opinions communicated and any liability for any direct, indirect or consequential loss or damage suffered by any person arising therefrom is expressly disclaimed.

Power Integrations reserves the right to make changes to its products at any time to improve reliability or manufacturability. Power Integrations does not assume any liability arising from the use of any device or circuit described herein. POWER INTEGRATIONS MAKES NO WARRANTY HEREIN AND SPECIFICALLY DISCLAIMS ALL WARRANTIES INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF THIRD PARTY RIGHTS.

Patent Information
The products and applications illustrated herein (including transformer construction and circuits' external to the products) may be covered by one or more U.S. and foreign patents, or potentially by pending U.S. and foreign patent applications assigned to Power Integrations. A complete list of Power Integrations' patents may be found at www.power.com. Power Integrations grants its customers a license under certain patent rights as set forth at http://www.power.com/ip.htm.

Power Integrations, the Power Integrations logo, CAPZero, ChiPhy, CHY, DPA-Switch, EcoSmart, E-Shield, eSIP, eSOP, HiperLCS, HiperPLC, HiperPFS, HiperTFS, InnoSwitch, Innovation in Power Conversion, InSOP, LinkSwitch, LinkZero, LYTSwitch, SENZero, TinySwitch, TOPSwitch, PI, PI Expert, PowiGaN, SCALE, SCALE-1, SCALE-2, SCALE-3 and SCALE-iDriver, are trademarks of Power Integrations, Inc. Other trademarks are property of their respective companies. ©2022, Power Integrations, Inc.

Power Integrations Worldwide Sales Support Locations

WORLD HEADQUARTERS
5245 Hellyer Avenue
San Jose, CA 95138, USA.
Main: +1-408-414-9200
Customer Service:
Worldwide: +1-65-635-64480
Americas: +1-408-414-9621
e-mail: usasales@power.com

CHINA (SHANGHAI)
Rm 2410, Charity Plaza, No. 88,
North Caoxi Road,
Shanghai, PRC 200030
Phone: +86-21-6354-6323
e-mail: chinasales@power.com

CHINA (SHENZHEN)
17/F, Hivac Building, No. 2, Keji
Nan 8th Road, Nanshan District,
Shenzhen, China, 518057
Phone: +86-755-8672-8689
e-mail: chinasales@power.com

GERMANY
(AC-DC/LED/Motor Control Sales)
Einsteinring 24
85609 Dornach/Aschheim
Germany
Tel: +49-89-5527-39100
e-mail: eurosales@power.com

GERMANY (Gate Driver Sales)
HellwegForum 3
59469 Ense
Germany
Tel: +49-2938-64-39990
e-mail: igbt-driver.sales@
power.com

INDIA
#1, 14th Main Road
Vasanthanagar
Bangalore-560052
India
Phone: +91-80-4113-8020
e-mail: indiasales@power.com

ITALY
Via Milanese 20, 3rd. Fl.
20099 Sesto San Giovanni (MI) Italy
Phone: +39-024-550-8701
e-mail: eurosales@power.com

JAPAN
Yusen Shin-Yokohama 1-chome Bldg.
1-7-9, Shin-Yokohama, Kohoku-ku
Yokohama-shi,
Kanagawa 222-0033 Japan
Phone: +81-45-471-1021
e-mail: japansales@power.com

KOREA
RM 602, 6FL
Korea City Air Terminal B/D,
159-6
Samsung-Dong, Kangnam-Gu,
Seoul, 135-728 Korea
Phone: +82-2-2016-6610
e-mail: koreasales@power.com

SINGAPORE
51 Newton Road,
#19-01/05 Goldhill Plaza
Singapore, 308900
Phone: +65-6358-2160
e-mail: singaporesales@power.com

TAIWAN
5F, No. 318, Nei Hu Rd.,
Sec. 1
Nei Hu District
Taipei 11493, Taiwan R.O.C.
Phone: +886-2-2659-4570
e-mail: taiwansales@power.com

UK
Building 5, Suite 21
The Westbrook Centre
Milton Road
Cambridge
CB4 1YG
Phone: +44 (0) 7823-557484
e-mail: eurosales@power.com