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**HV96001  
Offline LED Driver  
Evaluation Board  
User's Guide**

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# **HV96001 Offline LED Driver Evaluation Board User's Guide**

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## Preface

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### NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website ([www.microchip.com](http://www.microchip.com)) to obtain the latest documentation available.

Documents are identified with a “DS” number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is “DSXXXXXXXXA”, where “XXXXXXXX” is the document number and “A” is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics to open a list of available online help files.

## INTRODUCTION

This chapter contains general information that will be useful to know before using the HV96001 Offline LED Driver Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Customer Support
- Document Revision History

## DOCUMENT LAYOUT

This document describes how to use the HV96001 Offline LED Driver Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. “Quick Start Instruction”** – Important information about the HV96001 Offline LED Driver Evaluation Board.
- **Chapter 2. “Installation and Operation”** – Includes instructions on installing and using the HV96001 Offline LED Driver Evaluation Board.
- **Appendix A. “Schematic and Layouts”** – Shows the schematic and layout diagrams for the HV96001 Offline LED Driver Evaluation Board.
- **Appendix B. “Bill of Materials (BOM)”** – Lists the parts used to build the HV96001 Offline LED Driver Evaluation Board.
- **Appendix C. “Demo Board Waveforms”** – Describes the various demo waveforms for the HV96001 Offline LED Driver Evaluation Board.

# HV96001 Offline LED Driver Evaluation Board User's Guide

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

Description	Represents	Examples
<b>Arial font:</b>		
Italic characters	Referenced books	<i>MPLAB® IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	<u>File&gt;Save</u>
Bold characters	A dialog button	Click <b>OK</b>
	A tab	Click the <b>Power</b> tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
<b>Courier New font:</b>		
Plain Courier New	Sample source code	#define START
	Filenames	autoexec.bat
	File paths	c:\mcc18\h
	Keywords	_asm, _endasm, static
	Command-line options	-Opa+, -Opa-
	Bit values	0, 1
	Constants	0xFF, 'A'
Italic Courier New	A variable argument	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets [ ]	Optional arguments	mcc18 [options] <i>file</i> [options]
Curly brackets and pipe character: {   }	Choice of mutually exclusive arguments; an OR selection	errorlevel {0 1}
Ellipses...	Replaces repeated text	var_name [, var_name...]
	Represents code supplied by user	void main (void) { ... }

## RECOMMENDED READING

This user's guide describes how to use the HV96001 Offline LED Driver Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **HV96001 Data Sheet – “Secondary-Side, Micro-Interfaced, Flicker-Free LED Controller with Enhanced PWM and Analog Dimming” (DS20006291)**

## THE MICROCHIP WEBSITE

Microchip provides online support via our website at [www.microchip.com](http://www.microchip.com). This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at:  
<http://www.microchip.com/support>

## DOCUMENT REVISION HISTORY

### Revision A (January 2020)

- Initial release of this document.

# **HV96001 Offline LED Driver Evaluation Board User's Guide**

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## Chapter 1. Quick Start Instruction

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### 1.1 INTRODUCTION

This chapter provides an overview of the HV96001 Offline LED Driver Evaluation Board and covers the following topics:

- HV96001 Device – Short Overview
- HV96001 Device – Key Features
- Evaluation Design Kit Contents

### 1.2 HV96001 DEVICE – SHORT OVERVIEW

The HV96001 is an LED driver device that targets offline lighting applications requiring wide range dimming capability. The device provides both linear and Pulse Width Modulation (PWM) dimming capability, the PWM dimming capability having particularly wide dimming range. The driver IC is adapted to a system that consists of:

- a flyback converter, for converting AC power to DC power with high power factor and with galvanic isolation, the output voltage being regulated for optimizing system efficiency,
- a boost converter, for boosting the flyback converter output voltage to the LED load voltage with near zero ripple for a flicker free LED current, and
- a linear load switch, for PWM dimming the LED current with a wide range of the PWM duty.

### 1.3 HV96001 DEVICE – KEY FEATURES

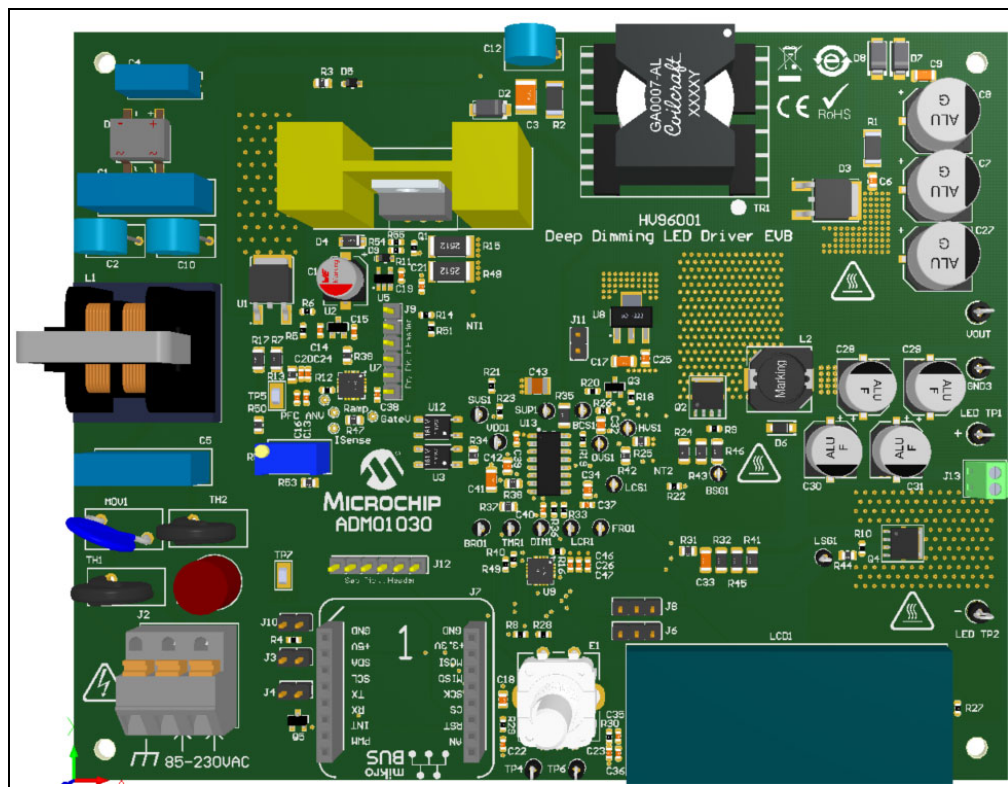
- Linear (analog) dimming with wide range of the amplitude control of the LED current
- PWM (digital) dimming, dims down to 0.01% and lower, with PWM pulse width down to 150 ns
- Flyback converter control with automatic output voltage adjustment for maintaining high system efficiency
- Boost converter with near zero output voltage ripple for ripple free LED current
- $V_{DD}$  internal regulator with 60V input voltage capability/5V output voltage, 10 mA drive for supplying external loads
- Fault recovery with auto-retry delay
- Undervoltage detection of  $V_{DD}$  voltage set using timing capacitor and for supply voltage (flyback output voltage)
- Overvoltage detection of the LED load voltage (boost output voltage)
- Overcurrent detection of the load switch current
- Stuck-at-zero detection of the DIM input signal

# HV96001 Offline LED Driver Evaluation Board User's Guide

## 1.4 EVALUATION DESIGN KIT CONTENTS

The HV96001 Offline LED Driver Evaluation Board Kit includes:

- HV96001 Offline LED Driver Evaluation Board (ADM01030)
- Important Information Sheet



**FIGURE 1-1:** HV96001 Offline LED Driver Evaluation Board (ADM01030).

## Chapter 2. Installation and Operation

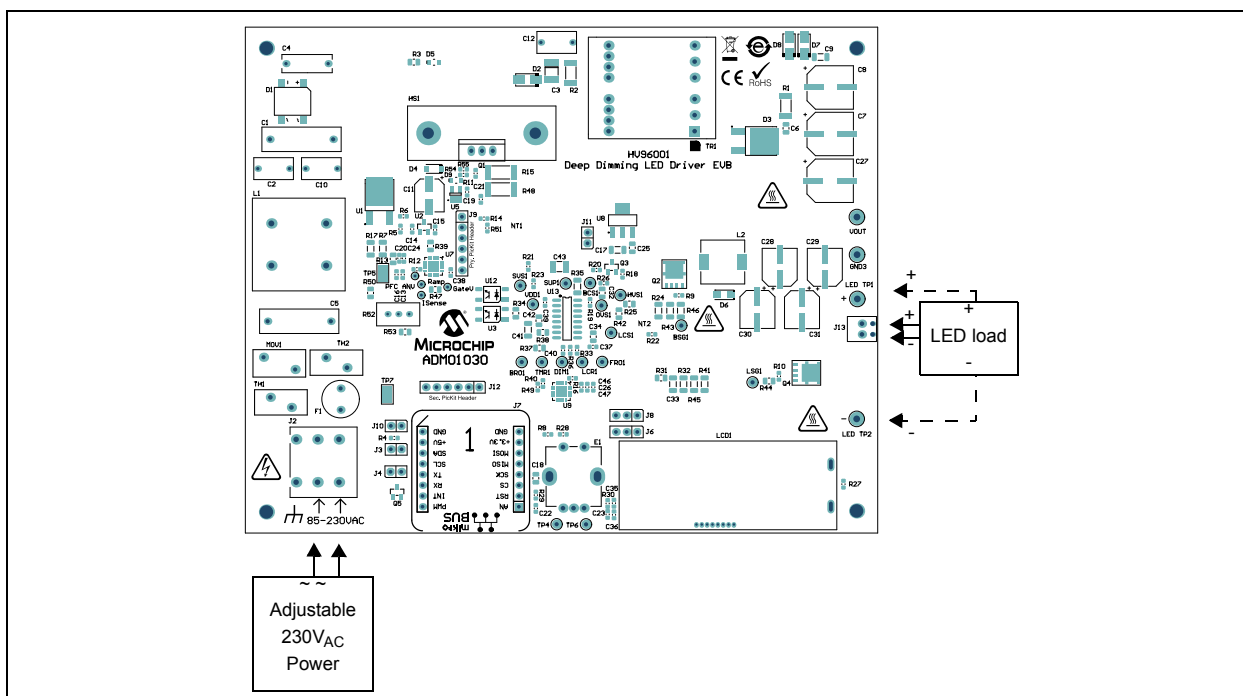
### 2.1 GETTING STARTED

HV96001 Offline LED Driver Evaluation Board is fully assembled and tested to evaluate and demonstrate the HV96001 LED driver. In the primary side, the flyback converter has implemented an active Power Factor Correction (PFC) control algorithm by a PIC controller that commands the switching sequence in such a manner that the input current follows the input voltage envelope, as shown in [Figure C-1](#). Therefore, the power factor of the application is  $PF > 0.9$ , for the entire input voltage range. The power factor value (PF) should be tuned by using R52 potentiometer according to the rated power of the LED load used. The tuning should be done in no dimming conditions. For example, to obtain a power factor PF over 0.9 for a 42W LED load, the value for the R52 resistor will be set to 750Ω. Check if mechanical jumper JP1 (provided) is mounted on the J11 connector.

#### 2.1.1 Powering the HV96001 230V<sub>AC</sub> Offline LED Driver Evaluation Board

The board is connected directly to 230V<sub>AC</sub>. A variable AC power supply is needed for testing and evaluation in the laboratory. The power supply requires an output capability of at least 1A and a voltage range of 80 to 265V<sub>AC</sub>. This can be obtained from an autotransformer supplied from the mains or an electronic AC/AC power supply (for example, Chroma ATE Inc.'s 61500 series).

The LED Load is not provided but the output of the driver can supply a LED load of 20-45 V<sub>DC</sub> rated and current up to 0.8A. Do not use a LED load bigger than 45V since the overvoltage protection, OVP, would become active, causing light interruption at the output.



**FIGURE 2-1:** Connection Diagram.

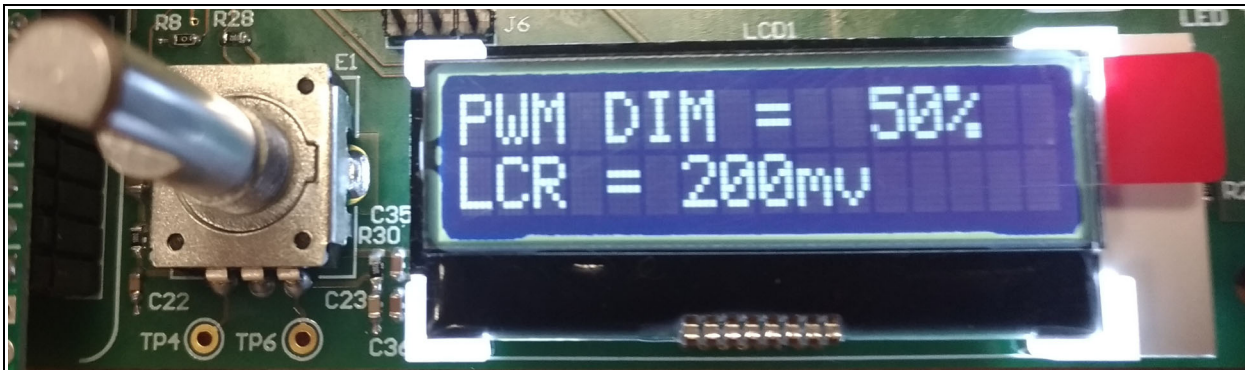
# HV96001 Offline LED Driver Evaluation Board User's Guide

## 2.2 SETUP/CONFIGURATION

The output voltage and current delivered by the HV96001 Offline LED Driver Evaluation Board can be set by using the rotary encoder E1. After the board is supplied with 230V<sub>AC</sub> the initial PWM dimming value is 50% and current reference limit LCR is 200 mV. To increase the PWM duty cycle the encoder must be rotated to the right (clockwise) and to decrease the encoder must be rotated to the left (counter-clockwise). The actual value of the PWM percent reference will be displayed on the LCD from the secondary side of the flyback, in the first information row, as in the picture below. The value of 0.15% is given by the minimum voltage over the UVLO protection performed by the HV96001 for the input voltage. When the PWM is getting lower than 15%, the LCR is decreasing linearly to avoid big currents spikes.

For the current increase or decrease, the encoder must be pressed to activate the switch button and to be rotated to the left or to the right in a similar way as for PWM dimming variation described above.

The maximum value of the PWM dimming is 100% and of the current reference (LCR) is 400 mV. The maximum LCR value of 400 mV is corresponding to a 0.7-0.8A current through the LED Load.



**FIGURE 2-2:** Rotary Encoder and LCD Used to Display Parameters.

The LED Load current limit is calculated using the following formula:

### EQUATION 2-1:

$$I_{LED} = \frac{V_{LCR}}{R_{LCS}}$$

Where:

$$V_{LCR} = 400 \text{ mV}$$

$$R_{LCS} = 0.524\Omega (R32 \parallel R41 \parallel R45)$$

$$R32 = 1\Omega$$

$$R41 = 2.2\Omega$$

$$R45 = 2.2\Omega$$

$$\text{Resulting } I_{LED} = 0.76\text{A}$$

The board has a mikroBus™ connector to allow multi-protocol communication by using different click boards (produced by MikroElektronika Serbia, not provided with this kit). The firmware was developed for the RN4871 Bluetooth® module click board. The click board should be plugged in the mikroBus connector before the main board is supplied from the grid. After the board is supplied, the Bluetooth module is configured and can be used with the provided Android application.

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## **Appendix A. Schematic and Layouts**

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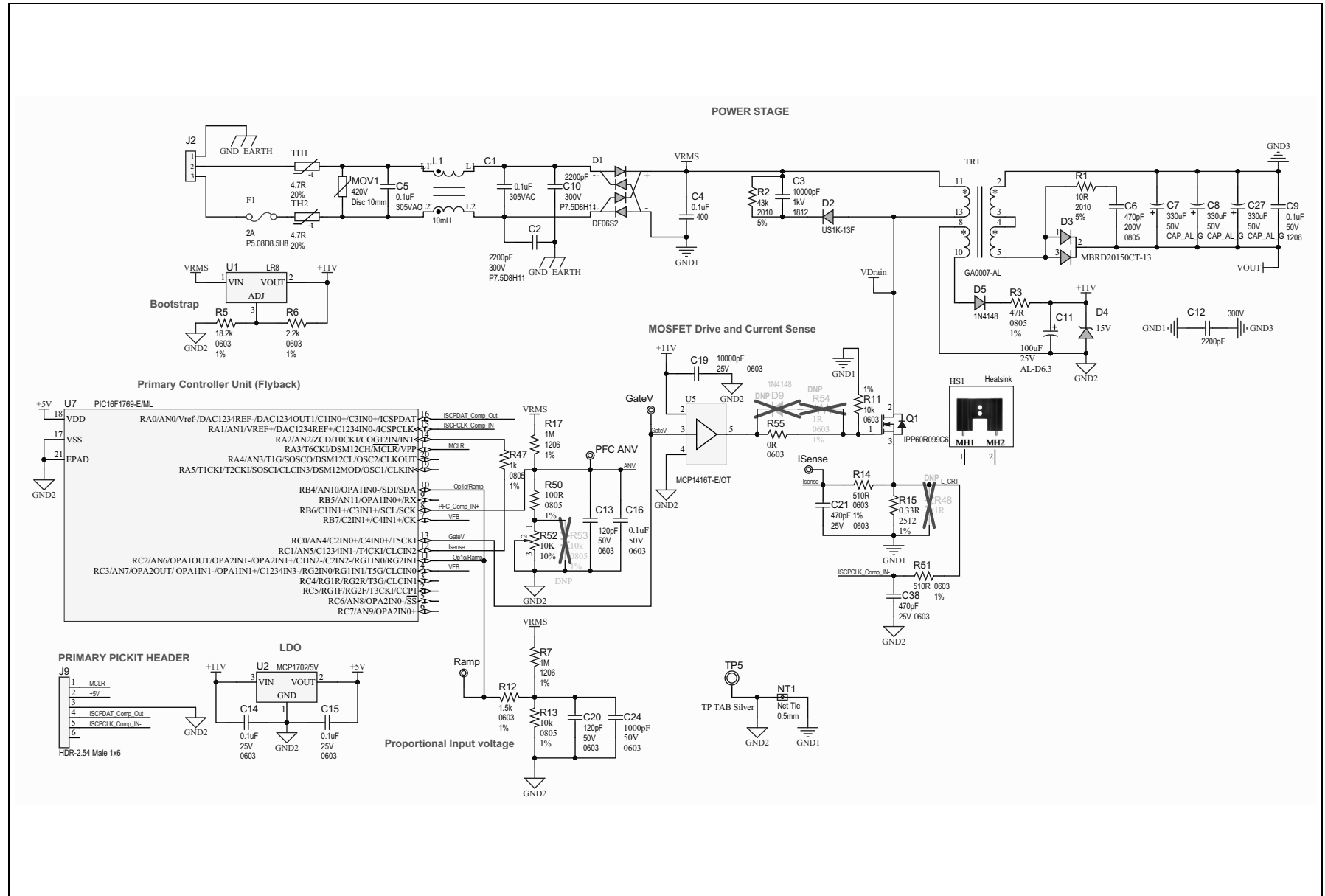
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### **A.1 INTRODUCTION**

This appendix contains the following schematics and layouts for the HV96001 Offline LED Driver Evaluation Board:

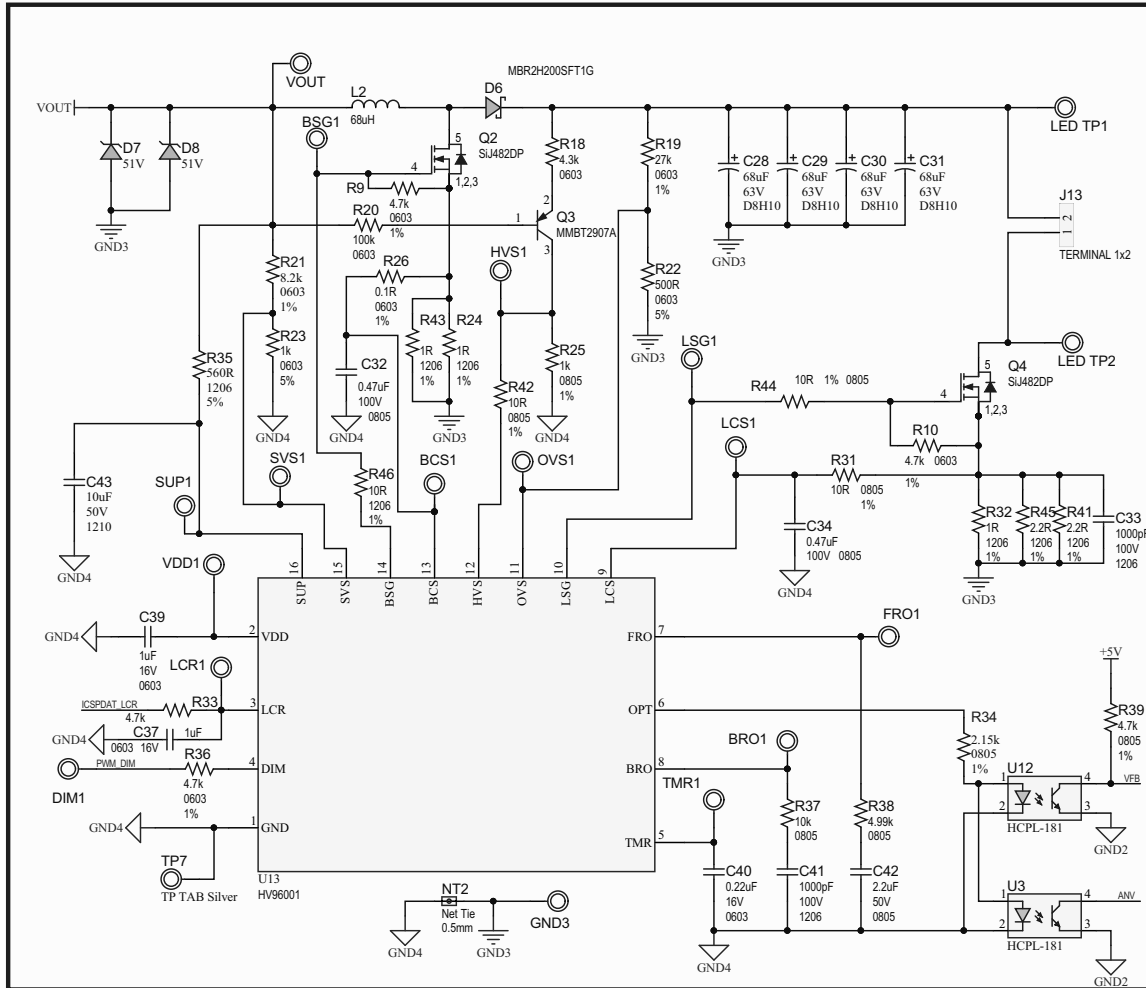
- [Board – Schematic 1](#)
- [Board – Schematic 2](#)
- [Board – Schematic 3](#)
- [Board – Top Silk](#)
- [Board – Top Copper and Silk](#)
- [Board – Top Copper](#)
- [Board – Bottom Copper](#)
- [Board – Bottom Copper and Silk](#)
- [Board – Bottom Silk](#)

# A.2 BOARD – SCHEMATIC 1

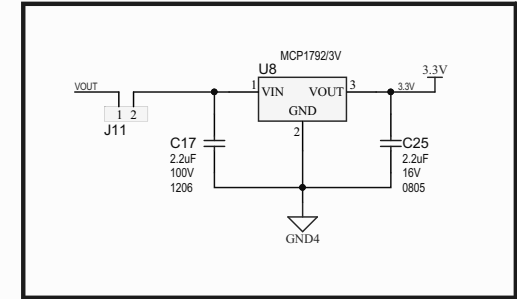


### A.3 BOARD – SCHEMATIC 2

HV96001 CIRCUIT

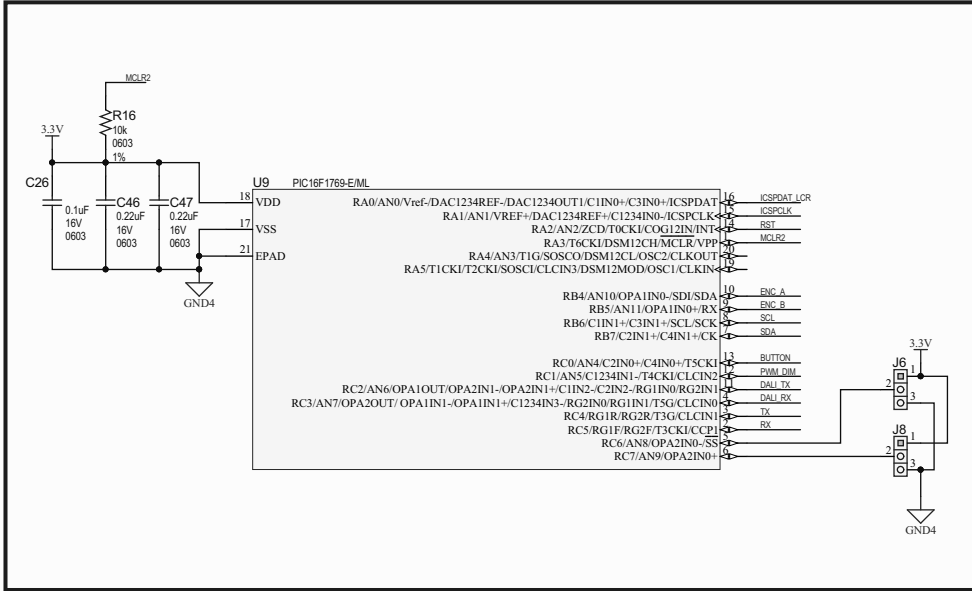


3.3V Supply

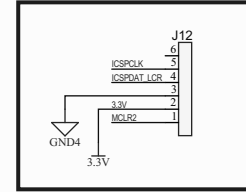


# A.4 BOARD – SCHEMATIC 3

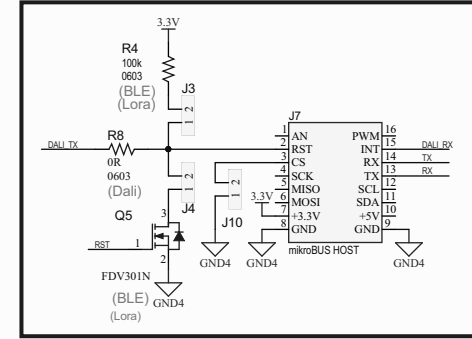
SECONDARY SIDE PIC (U9) for Dimming Control



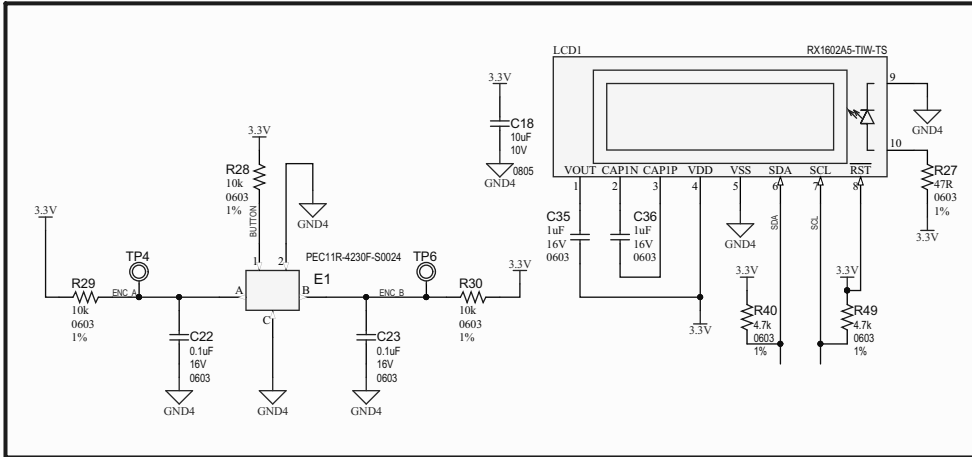
SECONDARY PICKIT HEADER



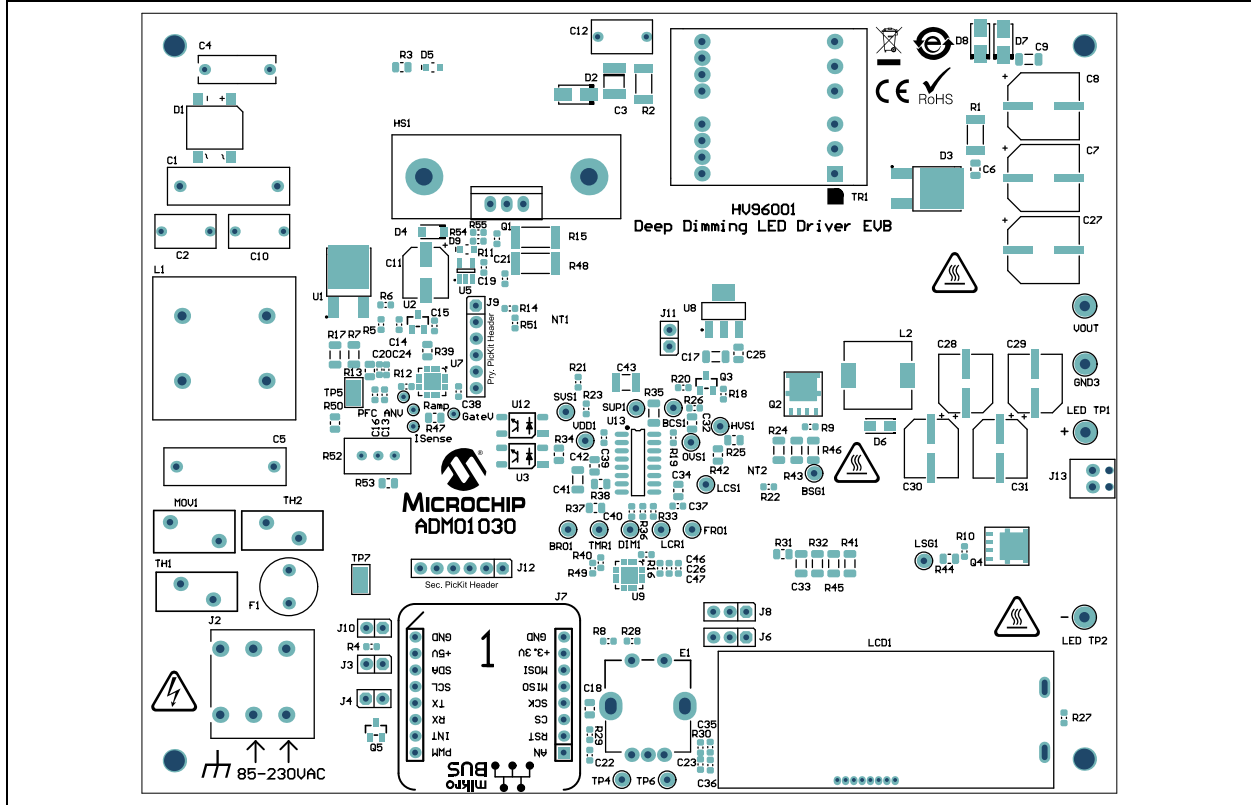
CLICKBOARD HEADER DALI2



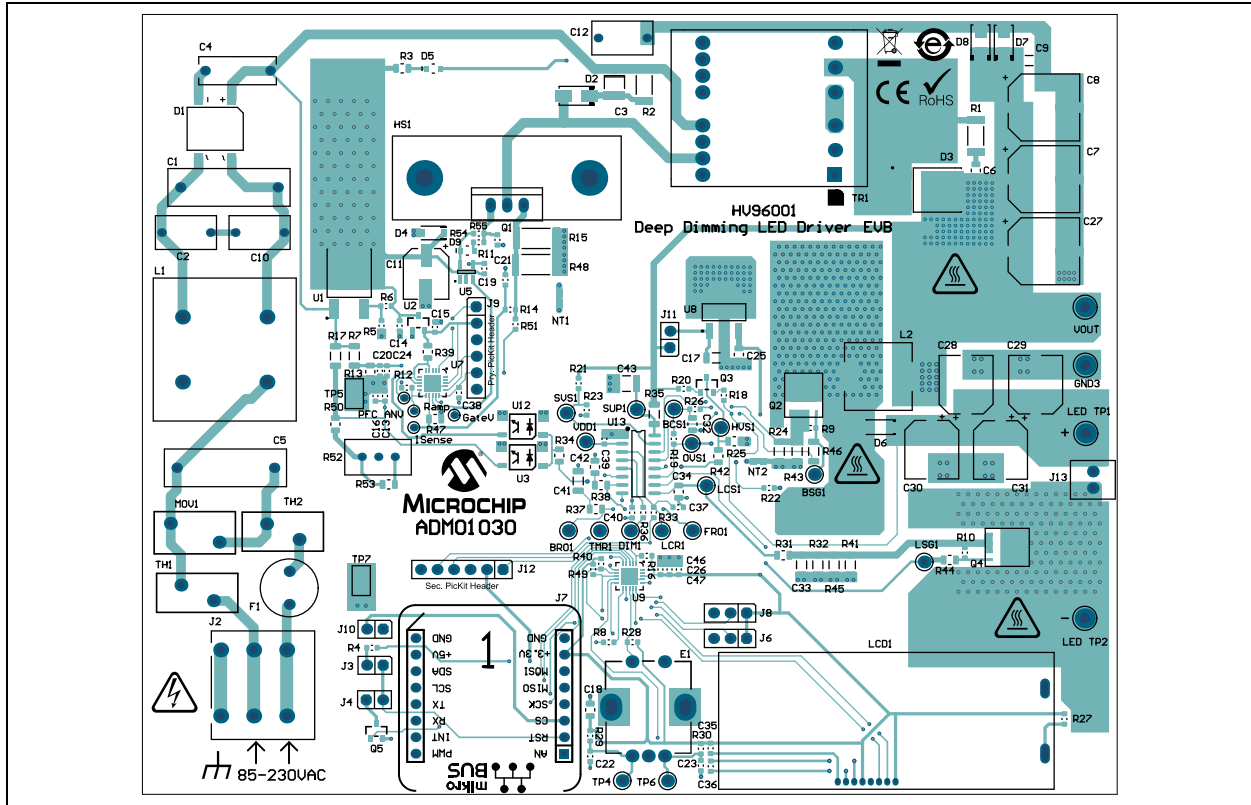
Secondary PIC CONTROL



## A.5 BOARD – TOP SILK

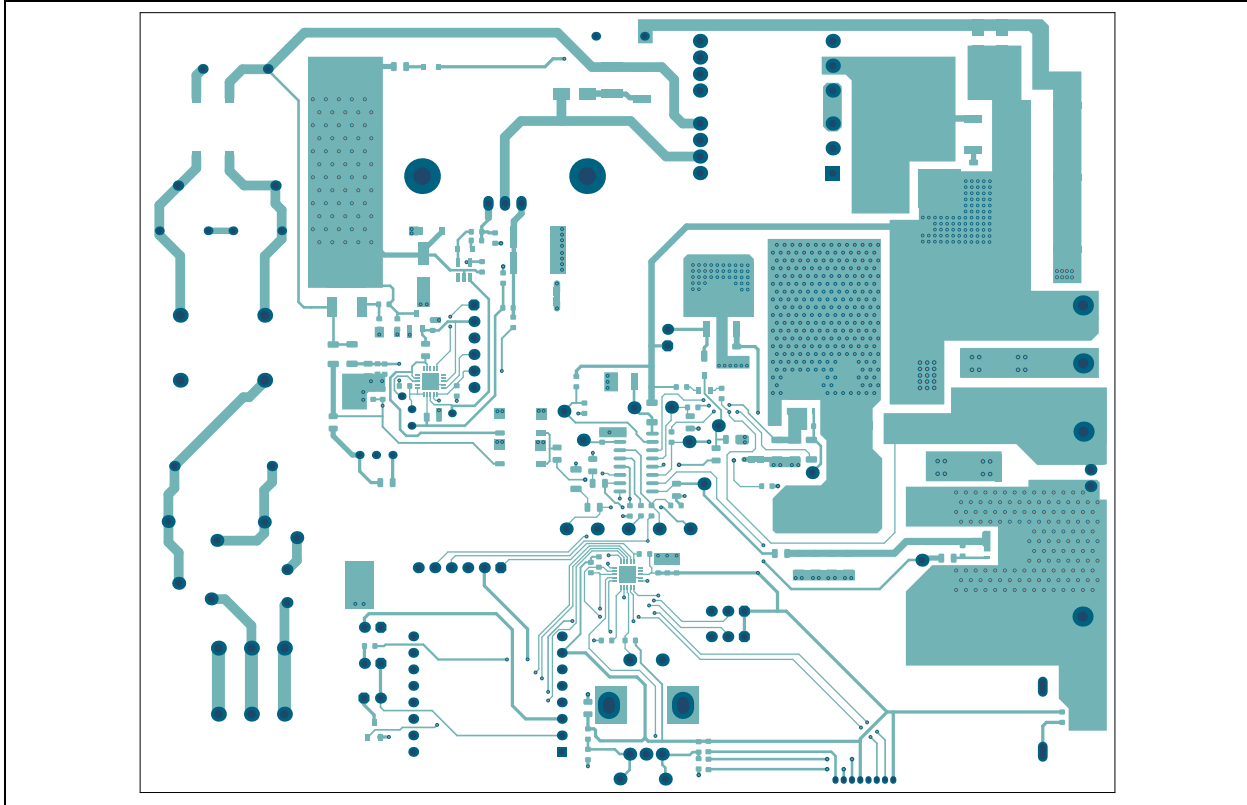


## A.6 BOARD – TOP COPPER AND SILK

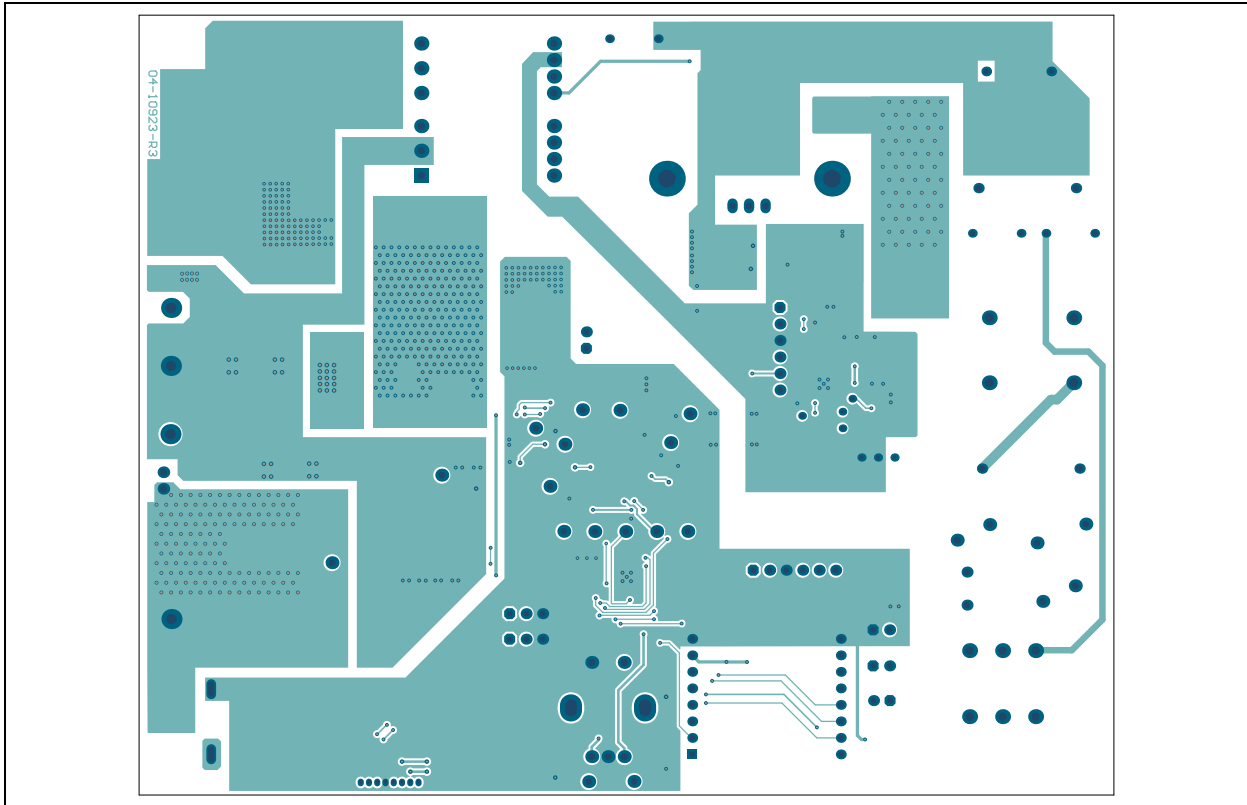


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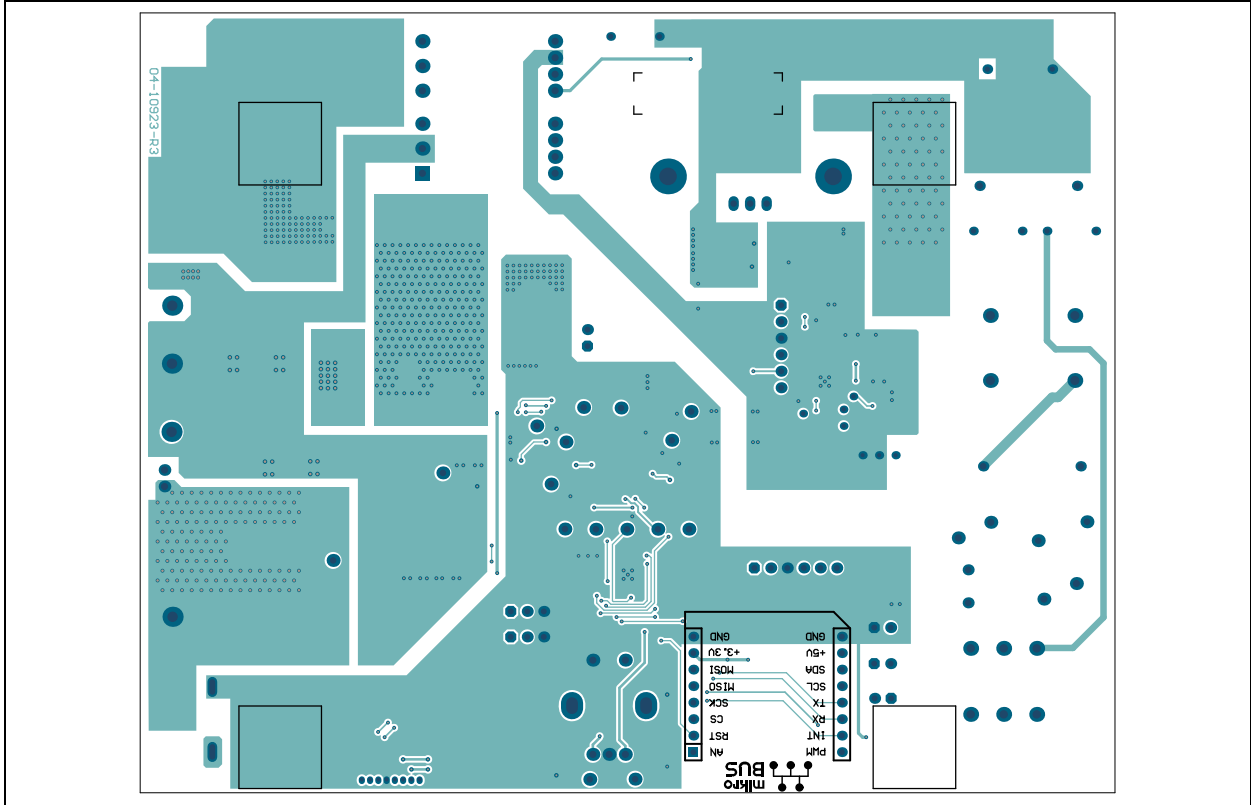
## A.7 BOARD – TOP COPPER



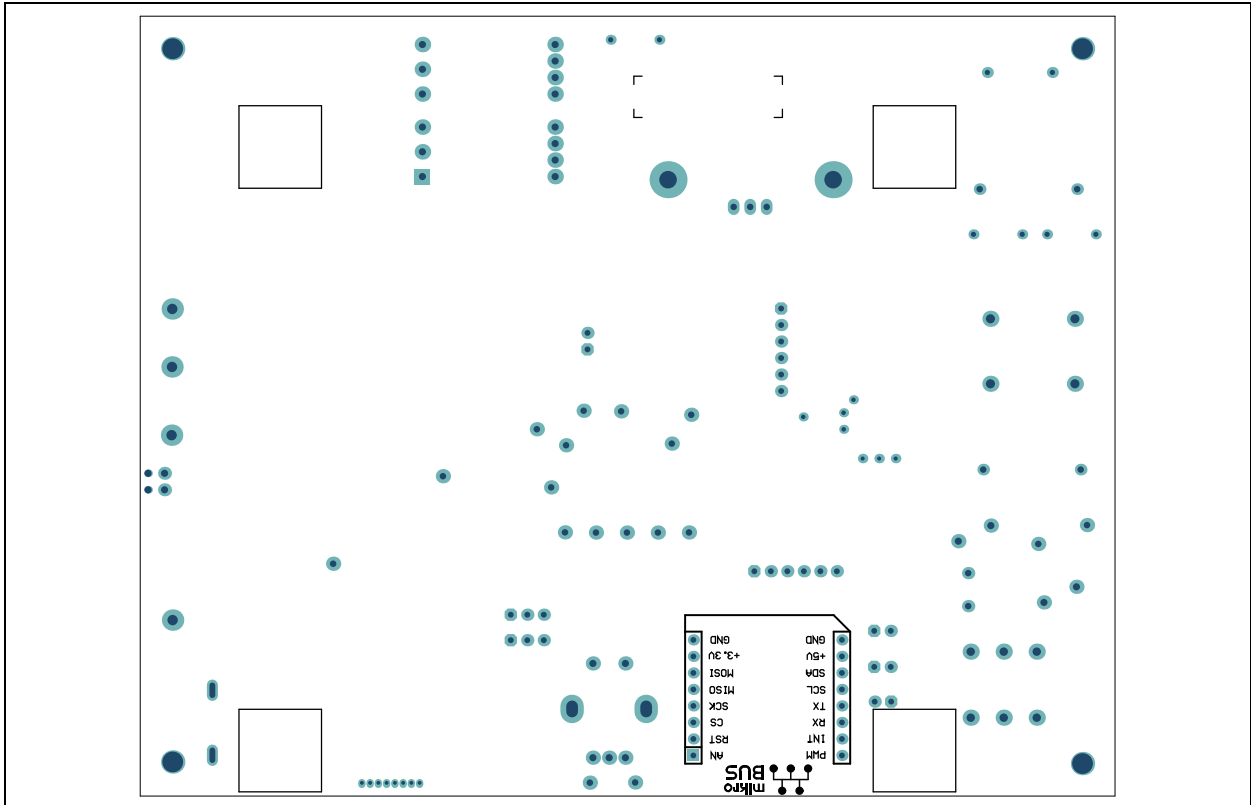
## A.8 BOARD – BOTTOM COPPER



## A.9 BOARD – BOTTOM COPPER AND SILK



## A.10 BOARD – BOTTOM SILK



# **HV96001 Offline LED Driver Evaluation Board User's Guide**

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NOTES:

**Appendix B. Bill of Materials (BOM)**

**TABLE B-1: BILL OF MATERIALS (BOM)**

Qty.	Designator	Description	Manufacturer	Part Number
16	BCS1, BRO1, BSG1, DIM1, FRO1, HVS1, LCR1, LCS1, LSG1, OVS1, SUP1, SVS1, TMR1, TP4, TP6, VDD1	Misc., Test Point multipurpose mini black	Keystone® Electronics Corp.	5001
2	C1, C5	Capacitor, film, 0.1 µF 305VAC 20% radial, P15L18W5H10.5	TDK Corporation (EPCOS)	B32922C3104M000
3	C2, C10, C12	Capacitor, ceramic, 2200 pF 300V 20% radial, P7.5D8H11	Murata Electronics®	DE2E3KY222MN3AU02F
1	C3	Capacitor, ceramic, 10000 pF 1kV 20% X7R, surface mount, 1812	Johanson Dielectrics	102S43W103MV4E
1	C4	Capacitor, film, 0.1 µF 400V 10% radial, P10L11.5W4H6.9	TDK Corporation (EPCOS)	B32561J6104K
1	C6	Capacitor, ceramic, 470 pF 200V 5% NP0, surface mount, 0805	AVX Corporation	08052A471JAT2A
3	C7, C8, C27	Capacitor, aluminum, 330 µF 50V 20% surface mount G	Panasonic® - ECG	EEEFT1H331AP
1	C9	Capacitor, ceramic 0.1 µF 50V 10% X7R surface mount, 1206	Murata Electronics	GRM42-6X7R104K050BL
1	C11	Capacitor, aluminum, 100 µF 25V 20% surface mount, W6.6L6.6H7.7	Würth Elektronik	865090445008
2	C13, C20	Capacitor, ceramic, 120 pF 50V 5% NP0, surface mount, 0603	Panasonic - ECG	ECJ-1VC1H121J
2	C14, C15	Capacitor, ceramic, 0.1 µF 25V 20% Y5V surface mount, 0603	Cal-Chip Electronics Inc.	GMC10Y5V104Z25NTLF
1	C16	Capacitor, ceramic, 0.1 µF 50V 20% X7R surface mount, 0603	TDK Corporation	C1608X7R1H104M080AA
1	C17	Capacitor, ceramic, 2.2 µF 100V 10% X7S surface mount, 1206	TDK Corporation	C3216X7S2A225K160AB
1	C18	Capacitor, ceramic, 10 µF 10V 10% X5R surface mount, 0805	Taiyo Yuden Co., Ltd.	LMK212BJ106KG-T

**Note:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

# HV96001 Offline LED Driver Evaluation Board User's Guide

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Designator	Description	Manufacturer	Part Number
1	C19	Capacitor, ceramic 10000 pF 25V 10% X7R surface mount, 0603	Panasonic - ECG	ECJ-1VB1E103K
2	C21, C38	Capacitor, ceramic 470 pF 25V 5% NP0 surface mount, 0603	AVX Corporation	06033A471JAT2A
2	C22, C23	Capacitor, ceramic 0.1 µF 16V 10% X7R surface mount, 0603	Taiyo Yuden Co., Ltd.	EMK107B7104KA-T
1	C24	Capacitor, ceramic 1000 pF 50V 20% X7R surface mount, 0603	KEMET	C0603C102M5RACTU
1	C25	Capacitor, ceramic 2.2 µF 16V 20% Y5V surface mount, 0805	AVX Corporation	0805YG225ZAT2A
1	C26	Capacitor, ceramic 0.1 µF 16V 10% X7R surface mount, 0603	AVX Corporation	0603YC104KAT2A
4	C28, C29, C30, C31	Capacitor, aluminum, 68 µF 63V 20%, surface mount, F AEC-Q200	Panasonic - ECG	EEE-FK1J680UP
2	C32, C34	Capacitor, ceramic 0.47 µF 100V 10% X7R, surface mount, 0805	AVX Corporation	08051C474KAT2A
1	C33	Capacitor, ceramic 1000 pF 100V 10% X7R, surface mount, 1206	KEMET	C1206Y102K1RACTU
1	C41	Capacitor, ceramic 4700 pF 100V 10% X7R, surface mount, 1206	KEMET	C1206C472K1RECAUTO
4	C35, C36, C37, C39	Capacitor, ceramic 1 µF 16V 10% X7R surface mount, 0603	Würth Elektronik	885012206052
3	C40, C46, C47	Capacitor, ceramic 0.22 µF 16V 20% Y5V surface mount, 0603	KEMET	C0603C224Z4VACTU
1	C42	Capacitor, ceramic 2.2 µF 50V 10% X5R surface mount, 0805	TDK Corporation	C2012X5R1H225K
1	C43	Capacitor, ceramic 10 µF 50V 20% X7R surface mount, 1210	TDK Corporation	C3225X7R1H106M250AC
1	D1	Diode, rectifier, BRG DF06S2 1.1V 2A 600V, surface mount, 4-SDIP	ON Semiconductor® (Fairchild Semiconductor)	DF06S2
1	D2	Diode, rectifier US1K 1.7V 1A 800V DO-214AC_SMA	Diodes Incorporated®	US1K-13-F
1	D3	Diode, Schottky, array, MBRD20150CT-13 0.9V 2x10A 150V surface mount, TO-252-3	Diodes Incorporated	MBRD20150CT-13
1	D4	Diode, Zener, NZH15B 15V 500 mW SOD-124	NXP Semiconductors	NZH15B,115
1	D5	Diode, rectifier, 1N4148 855 mV 300 mA 75V SOD-323	Diodes Incorporated	1N4148WS-7-F
1	D6	Diode, Schottky, MBR2H200SFT1G 2A 200V, surface mount, SOD-123FL	ON Semiconductor	MBR2H200SFT1G
2	D7, D8	Diode, Zener, 1SMA5942BT3G 51V 1.5W 5% DO-214AC_SMA	ON Semiconductor	1SMA5942BT3G
1	E1	Sensor, encoder, 24PPR, PEC11R-4230F-S0024, THT	Bourns®, Inc.	PEC11R-4230F-S0024
1	F1	Resistor, fuse, 2A 300VAC, slow radial, TH, P5.08D8.5H8	Littelfuse®	38312000000

**Note:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

# Bill of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Designator	Description	Manufacturer	Part Number
4	GND3, LED TP1, LED TP2	Connector, TP, loop, black, TH	Keystone Electronics Corp.	5011
1	HS1	Mechanical, hardware, heatsink, L34.9 mmx W12.7 mmx H25.4 mm, black anodize	Digi-Key® Electronics	HS351-ND
1	J2	Connector, terminal, 5.08 mm 1x3, female, 16-22AWG 10A, TH, R/A	Würth Elektronik	691415520003
4	J3, J4, J10, J11	Connector, header-2.54, male, 1x2, gold, 5.84MH, TH, vertical	FCI	77311-118-02LF
2	J6, J8	Connector, header-2.54, male, 1x3, gold, 5.84MH, TH, vertical	Samtec, Inc.	TSW-103-07-G-S
1	J7	Socket, mikroBUS, host, DIP 16, TH	Sullins Connector Solutions	PPTC081LFBN-RC
2	J9, J12	Connector, header-2.54, male, 1x6, tin, 5.84MH, TH, vertical	Sullins Connector Solutions	PEC06SAAN
1	J13	Connector, terminal, 2.54 mm, 1x2, female, 20-30AWG 6A, TH, R/A	Phoenix Contact GmbH & Co.	1725656
1	L1	Inductor, choke, 10 mH 800 mA, radial, L22xW22xH18.5 SS20H	KEMET	SS20H-08100
1	L2	Inductor, 68 µH 2.2A 20%, surface mount, L10W10H5	Würth Elektronik	7447714680
1	LABEL1	Label, assembly, W/rev level, (small modules) per MTS-0002	—	—
1	LCD1	Display, LCD, COG RX1602A5-TIW-TS 16x2, alpha, white 3V-5V, TH	Raystar Optronics, Inc.	RX1602A5-TIW-TS
1	MOV1	Resistor, varistor, MO 420V 45J, disc, 10 mm	TDK Corporation	S10K420
1	PCB	HV96001 Offline LED Driver Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	<b>04-10923</b>
1	Q1	Transistor, FET, N-Channel, IPP60R099C6 600V 37.9A 278W TO-220-3	Infineon Technologies AG	IPP60R099C6
2	Q2, Q4	Transistor, FET, N-Channel, SIJ482DP-T1-GE3 80V 60A PowerPAK SO-8L	Vishay Intertechnology, Inc.	SIJ482DP-T1-GE3
1	Q3	Transistor, BJT PNP, MMBT2907A 60V 800 mA, 350 mW, SOT-23-3	ON Semiconductor	MMBT2907A
1	Q5	Transistor, FET N-Channel, FDV301N 25V 220 mA 350 mW SOT-23-3	ON Semiconductor	FDV301N
1	R1	Resistor, TKF, 10R 5% 3/4W, surface mount, 2010	Panasonic - ECG	ERJ-12ZYJ100U
1	R2	Resistor, TKF, 43 kΩ 5% 3/4W, surface mount, 2010	Panasonic - ECG	ERJ-12ZYJ433U
1	R3	Resistor, TKF, 47R 1% 1/8W, surface mount, 0805	Yageo Corporation	RC0805FR-0747RL
2	R4, R20	Resistor, TF, 100 kΩ 1% 1/8W, surface mount, 0603	Vishay Beyschlag	MCT06030C1003FP500

**Note:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Designator	Description	Manufacturer	Part Number
1	R5	Resistor, TKF, 18.2 kΩ 1% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3EKF1822V
1	R6	Resistor, TKF 2.2 kΩ 1% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3EKF2201V
2	R7, R17	Resistor, TKF, 1M 1% 1/4W, surface mount, 1206	Stackpole Electronics, Inc.	RMCF1206FT1M00
1	R8	Resistor, TKF, 0R 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3GEY0R00V
6	R9, R10, R33, R36, R40, R49	Resistor, TKF, 4.7 kΩ 1% 1/10W, surface mount, 0603	Digi-Key Electronics	311-4.70KHRTR-ND
2	R11, R16	Resistor, TF, 10 kΩ 1% 1/16W, surface mount, 0603	TE Connectivity, Ltd.	5-1879337-9
1	R12	Resistor, TF, 1.5 kΩ 1% 1/8W, surface mount, 0603	Stackpole Electronics, Inc.	RNCP0603FTD1K50
1	R13	Resistor, TKF, 10 kΩ 1% 1/8W, surface mount, 0805	Panasonic - ECG	ERJ-6ENF1002V
2	R14, R51	Resistor, TKF, 510R 1% 1/10W, surface mount, 0603	ROHM Semiconductor	MCR03EZPFX5100
1	R15	Resistor, TKF, 0.33R 1% 1W, surface mount, 2512	Vishay/Dale	WSL2512R3300FEA
1	R18	Resistor, TKF, 4.3 kΩ 1% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3EKF4301V
1	R19	Resistor, TKF, 27 kΩ 1% 1/10W, surface mount, 0603	Yageo Corporation	RC0603FR-0727KL
1	R21	Resistor, TKF, 8.2 kΩ 1% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3EKF8201V
1	R22	Resistor, TKF, 500R 5% 1/10W, surface mount, 0603	Stackpole Electronics, Inc.	RMC 1/16 500 5% R
1	R23	Resistor, TKF, 1 kΩ 5% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3GEYJ102V
3	R24, R32, R43	Resistor, TF, 1R 1% 1/2W, surface mount, 1206	Stackpole Electronics, Inc.	RNCP1206FTD1R00
2	R25, R47	Resistor, TKF, 1 kΩ 1% 1/8W, surface mount, 0805	Vishay/Dale	CRCW08051K00FKEA
1	R26	Resistor, TKF, 0.1R 1% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3RSFR10V
1	R27	Resistor, TKF, 47R 1% 1/10W, surface mount, 0603	ROHM Semiconductor	MCR03EZPFX47R0
3	R28, R29, R30	Resistor, TKF, 10 kΩ 1% 1/10W, surface mount, 0603	Panasonic - ECG	ERJ-3EKF1002V
3	R31, R42, R44	Resistor, TKF, 10R 1% 1/8W, surface mount, 0805	Vishay/Dale	CRCW080510R0FKEAC
1	R34	Resistor, TKF, 2.15 kΩ 1% 1/8W, surface mount, 0805	Panasonic - ECG	ERJ-6ENF2151V
1	R35	Resistor, TKF, 560R 5% 1/4W, surface mount, 1206	Panasonic - ECG	ERJ-8GEYJ561V
1	R37	Resistor, TKF, 10 kΩ 5% 1/2W, surface mount, 0805	Panasonic - ECG	ERJ-P06J103V

**Note:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

# Bill of Materials (BOM)

**TABLE B-1: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty.	Designator	Description	Manufacturer	Part Number
1	R38	Resistor, TF, 4.99 kΩ 0.1% 1/10W, surface mount, 0805	TE Connectivity, Ltd.	RN4K99
1	R39	Resistor, TKF, 4.7 kΩ 1% 1/8W, surface mount, 0805	Yageo Corporation	RC0805FR-074K7L
2	R41, R45	Resistor, TF, 2.2R 1% 1/2W, surface mount, 1206	Susumu Co., LTD.	RL1632R-2R20-F
1	R46	Resistor, TKF, 10R 1% 1/4W, surface mount, 1206	Panasonic - ECG	ERJ-8ENF10R0V
1	R48	Resistor, TKF, 1R 1% 1W, surface mount, 2512	Vishay/Dale	CRCW25121R00FKEG
1	R50	Resistor, TKF, 510R 1% 1/8W, SMRES TKF, 100R 1% 1/8W, surface mount 0805 D 0805	Vishay/Dale	CRCW0805100RFKEAC
1	R52	Resistor, trimmer, cermet 10 kΩ 10% 500 mW, TH, 3296W	Murata Electronics	PV36W103C01B00
1	R55	Resistor, TKF, 0R 1% 1/10W SMD 0603	Yageo Corporation	RC0603FR-070RL
2	TH1, TH2	Resistor, Thermistor, NTC 4.7 Ohms 3A, Radial	TDK Corporation	B57153S479M
2	TP5, TP7	Connector, TP, tab, silver, mini 3.8x2.03. surface mount	Keystone Electronics Corp.	5019
1	TR1	Transistor, power Flyback 5:1 270 μH 10% 16V-32V GA0007-AL, surface mount	Coilcraft	GA0007-AL
1	U1	Microchip, Analog, voltage regulator, 1.2V - 440V, LR8K4-G, TO-252-3	Microchip Technology Inc.	<b>LR8K4-G</b>
1	U2	Microchip, Analog, LDO, 5V, MCP1702T-5002E/CB, SOT-23A-3	Microchip Technology Inc.	<b>MCP1702T-5002E/CB</b>
2	U3, U12	IC, photo, HCPL-181 4-SMD	Avago Technologies	HCPL-181-00CE
1	U5	Microchip, Analog, FET driver, Single-Noninverting, MCP1416T-E/OT, SOT-23-5	Microchip Technology Inc.	<b>MCP1416T-E/OT</b>
2	U7, U9	Microchip, MCU 8-Bit, 32 MHz, 8 kB, 1 kB, PIC16F1769-E/ML, QFN-20	Microchip Technology Inc.	<b>PIC16F1769-E/ML</b>
1	U8	Microchip, Analog, LDO, 3V, MCP1792, SOT-223-3	Microchip Technology Inc.	<b>MCP1792-3302H/DB</b>
1	U13	Microchip, Analog, LED driver, HV96001, SOIC-16	Microchip Technology Inc.	<b>HV96001-E/D7X</b>

**Note:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

**TABLE B-2: BILL OF MATERIALS (BOM) – MECHANICAL PARTS**

Qty.	Reference	Description	Manufacturer	Part Number
1	HS1	Mechanical, HW HEATSINK L34.9mmxW12.7mmxH25.4mm Black Anodize	Aavid Thermalloy	531002B02500G
1	HS2	Mechanical, hardware, heatsink, thermally conductive film for TO-220	Conrad	189066 - 62

**Note 1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

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**TABLE B-2: BILL OF MATERIALS (BOM) – MECHANICAL PARTS (CONTINUED)**

Qty.	Reference	Description	Manufacturer	Part Number
1	LABEL1	Label, assembly with rev. level (small modules) per MTS-0002	—	—
1	NUT1	Mechanical, hardware, nut, M3x3mm, hex, zinc	Bossard	M3/BN131
1	SCR1	Mechanical, hardware, screw, M3x12mm, Phillips Cheese Head, zinc	Bossard	1154273
1	WASHER1	Mechanical, hardware, washer, 3.2mm	Duratool™	6797/3.0
1	WASHER2	Mechanical, hardware, insulating shoulder washer, 3.2mm	Aavid Thermalloy	7721-7PPSG
1	JP1	Mechanical, hardware, jumper, 2.54mm, 1x2 handle, gold	TE Connectivity AMP	881545-2
4	PAD1, PAD2, PAD3, PAD4	Mechanical, hardware, rubber pad, square, L12.1 W12.1 H3.1, black	Hammond Manufacturing Ltd.	1421T8BK

**Note 1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

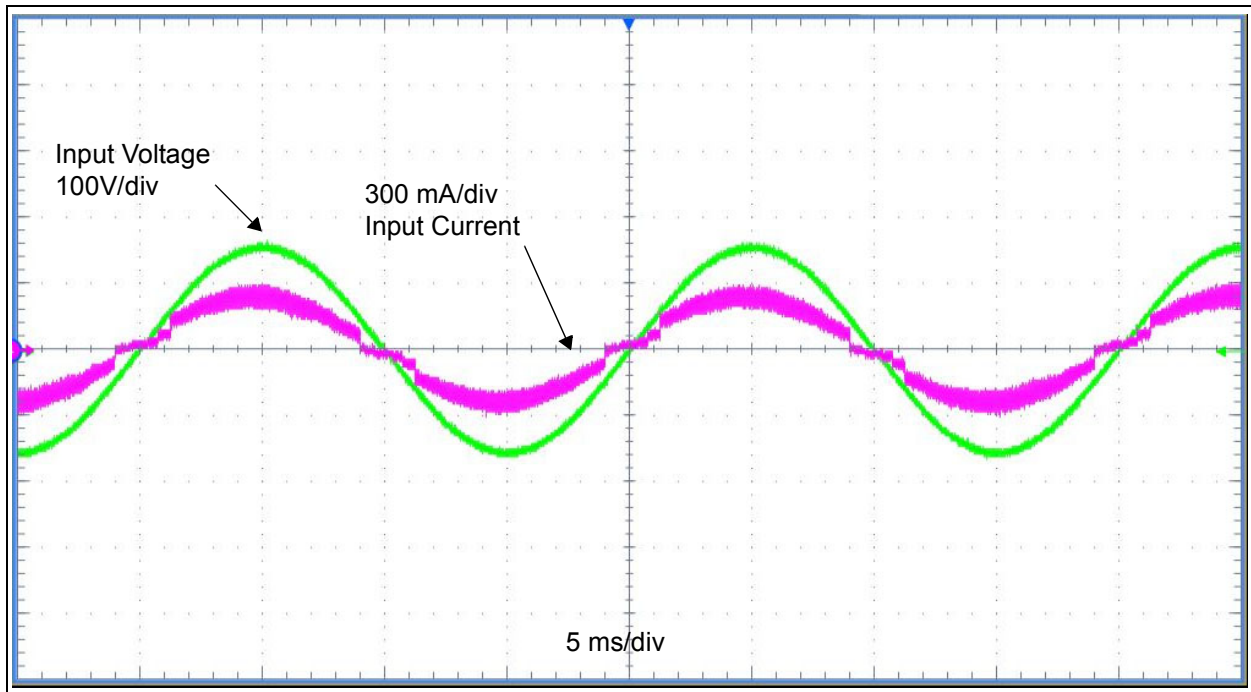
**TABLE B-3: BILL OF MATERIALS (BOM) – DO NOT POPULATE PARTS**

Qty.	Reference	Description	Manufacturer	Part Number
0	D9	Diode, rectifier, 1N4148, 855 mV 300 mA, 75V, SOD-323 <b>DO NOT POPULATE</b>	Diodes Incorporated	1N4148WS-7-F
0	R48	Resistor, TKF, 1R, 1% 1W, surface mount, 2512 <b>DO NOT POPULATE</b>	Vishay Dale	CRCW25121R00FKEG
0	R53	Resistor, TKF, 10k, 1%, 1/8W, surface mount, 0805 <b>DO NOT POPULATE</b>	Panasonic - ECG	ERJ-L06KF10CV
0	R54	Resistor, TKF, 1R, 1% 1/10W, surface mount, 0603 <b>DO NOT POPULATE</b>	Yageo	RC0603FR-071RL

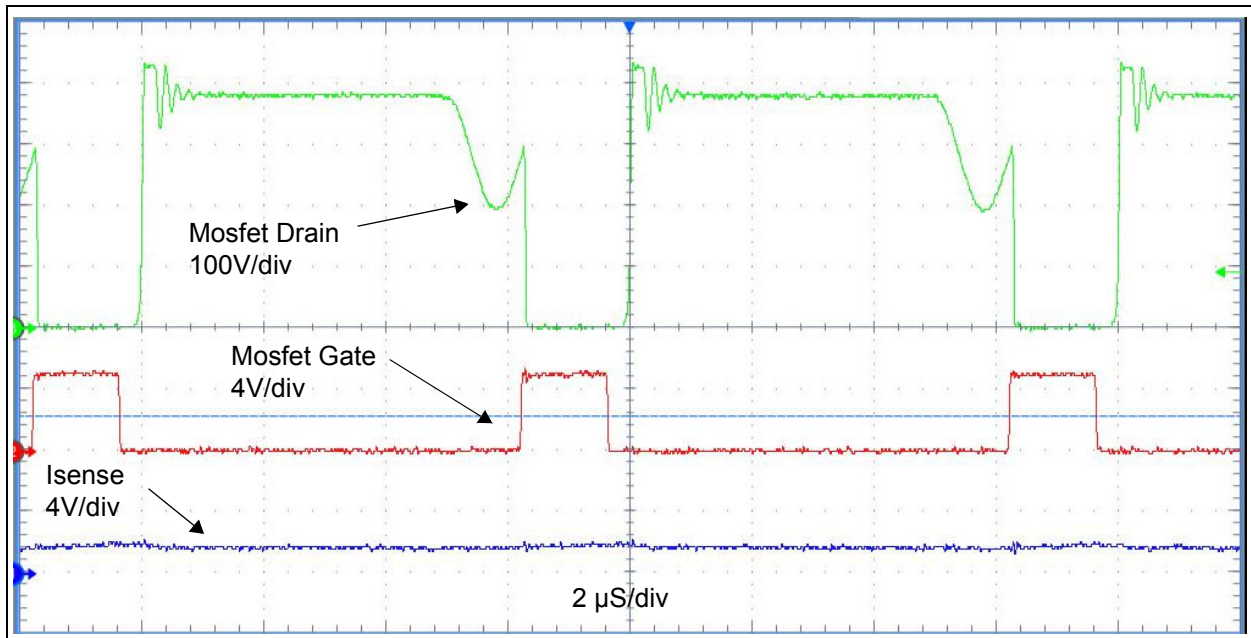
**Note 1:** The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

## Appendix C. Demo Board Waveforms

### C.1 MAIN WAVEFORMS

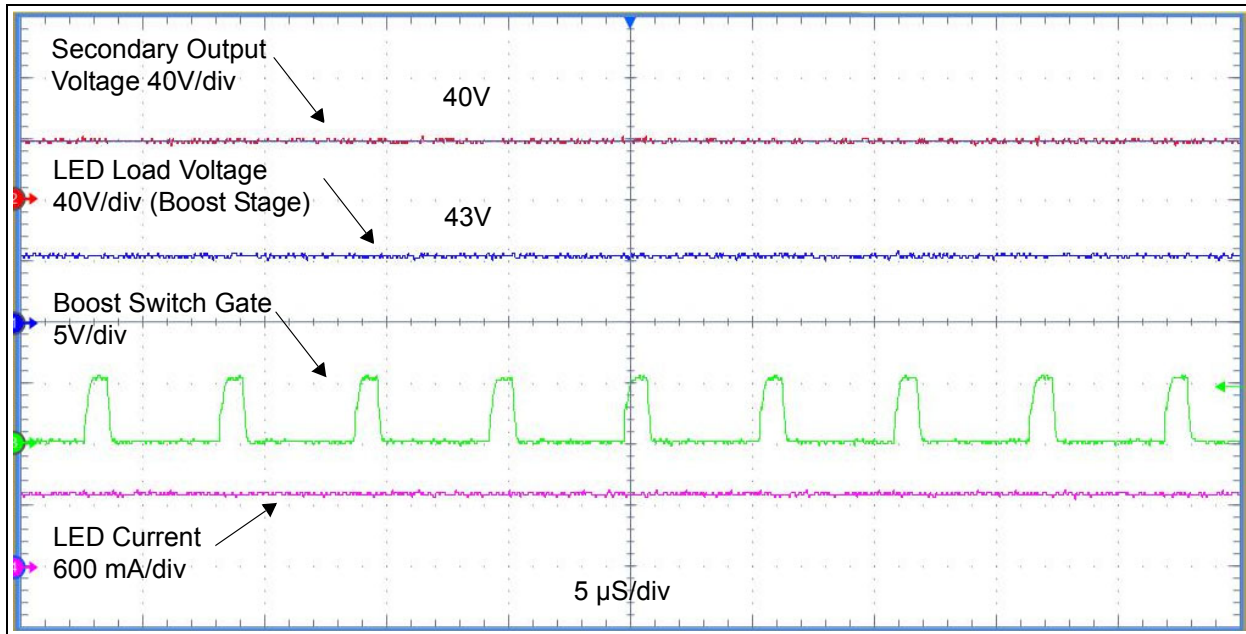


**FIGURE C-1:** 230VAC 50 Hz Input Current vs. Line Voltage.

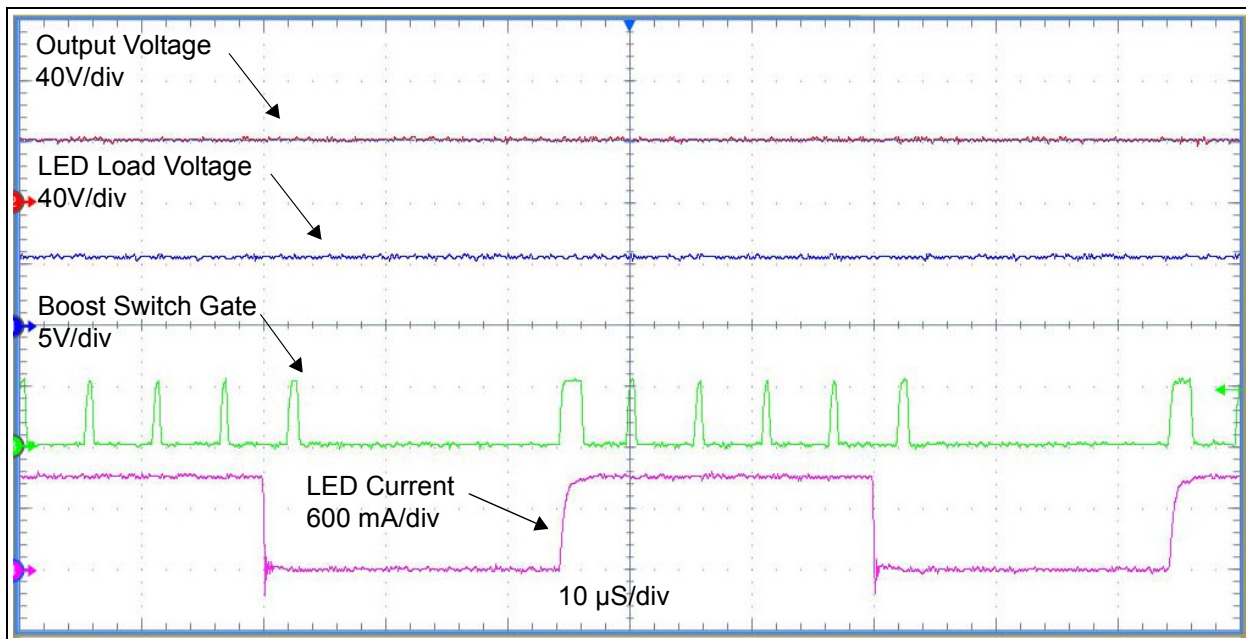


**FIGURE C-2:** Flyback, Primary Side Switch Waveforms at 230VAC 50 Hz input, 42W LED Load.

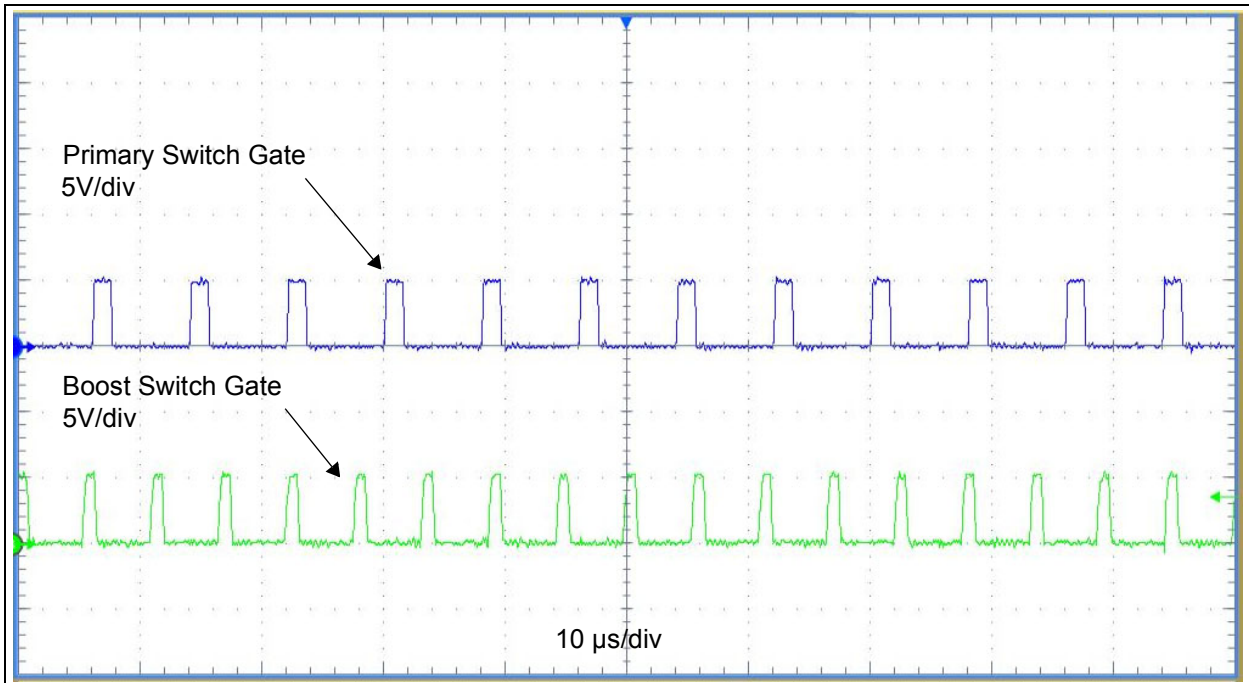
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**FIGURE C-3:** Secondary Output Voltages, Flyback and HV96001 Boost Stage, and LED Load Current without Dimming.

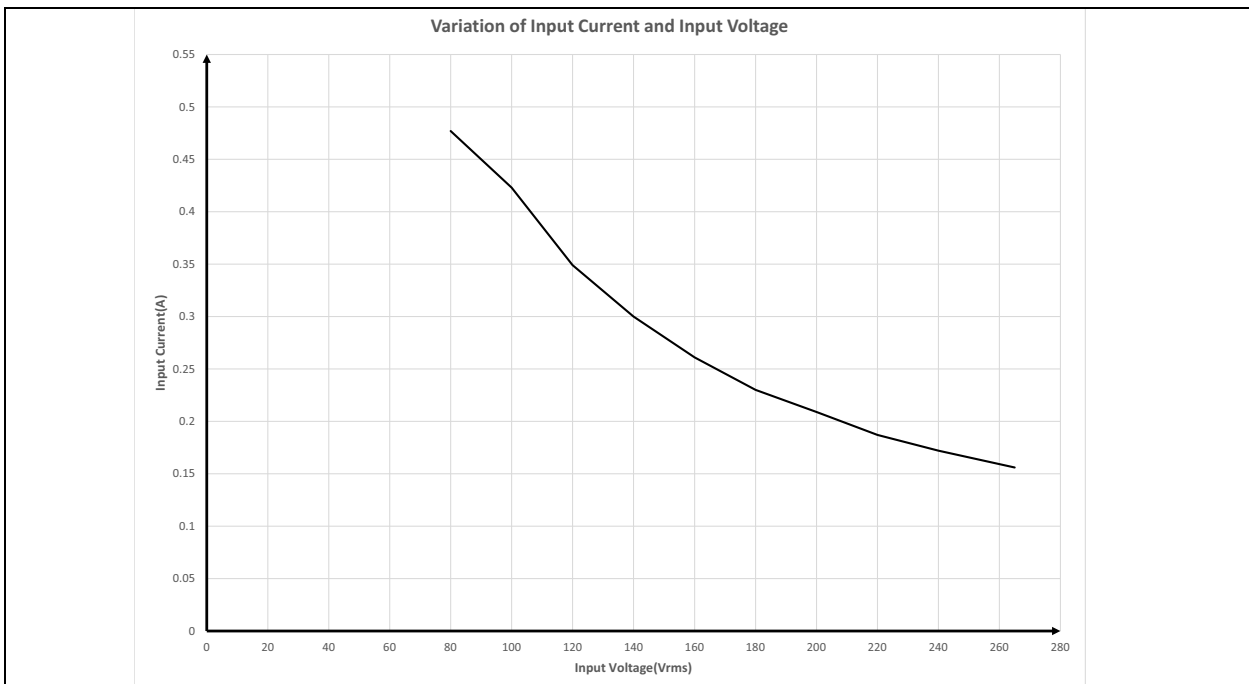


**FIGURE C-4:** Secondary Output Flyback Voltage, Boost Stage Voltage and Gate Switch Signal (Q2) and LED Load Current with 50% PWM Dimming Control.



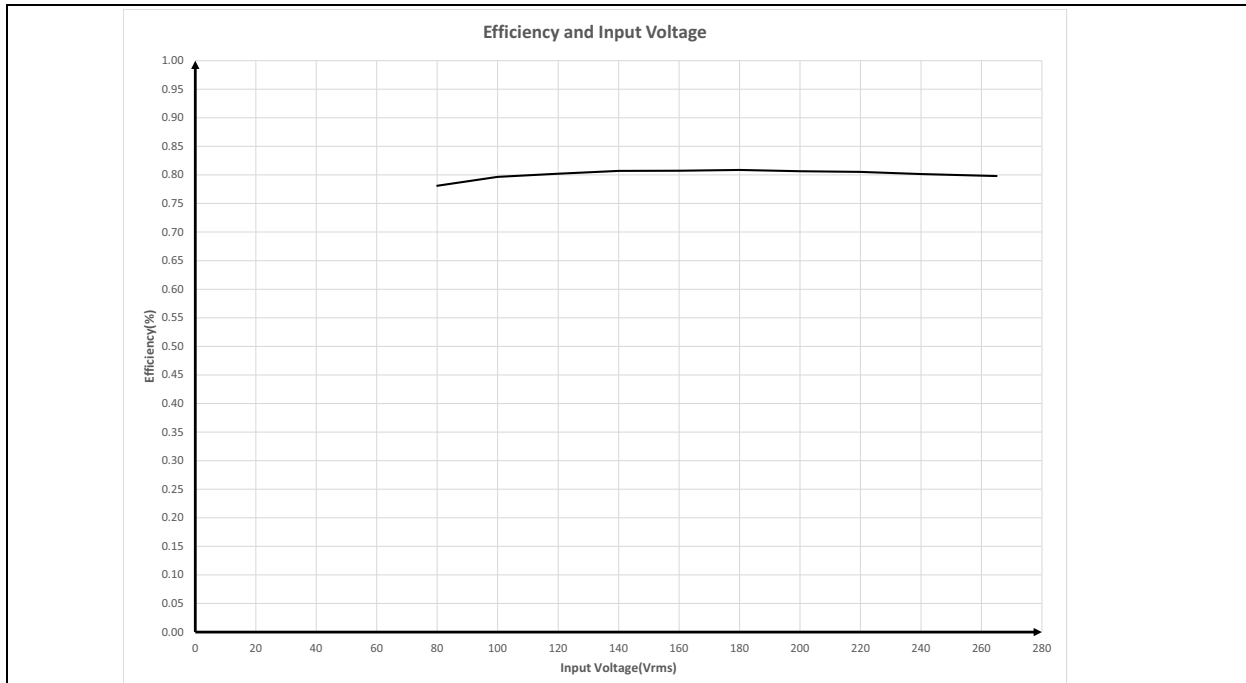
**FIGURE C-5:** Primary Side Controller (Q1) and Secondary Side Boost Stage (Q2) Gate Switch Signals.

## C.2 PERFORMANCE CURVES

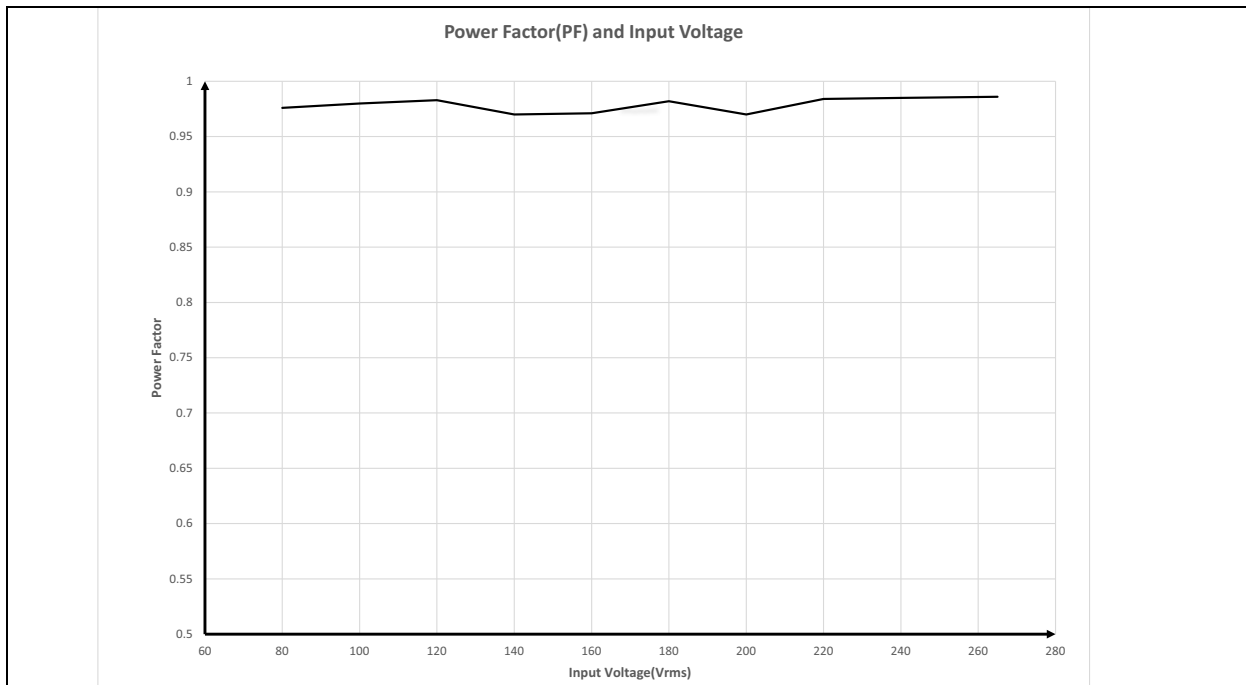


**FIGURE C-6:** Input Current vs. Input Voltage for a 45V/0.77A LED Load.

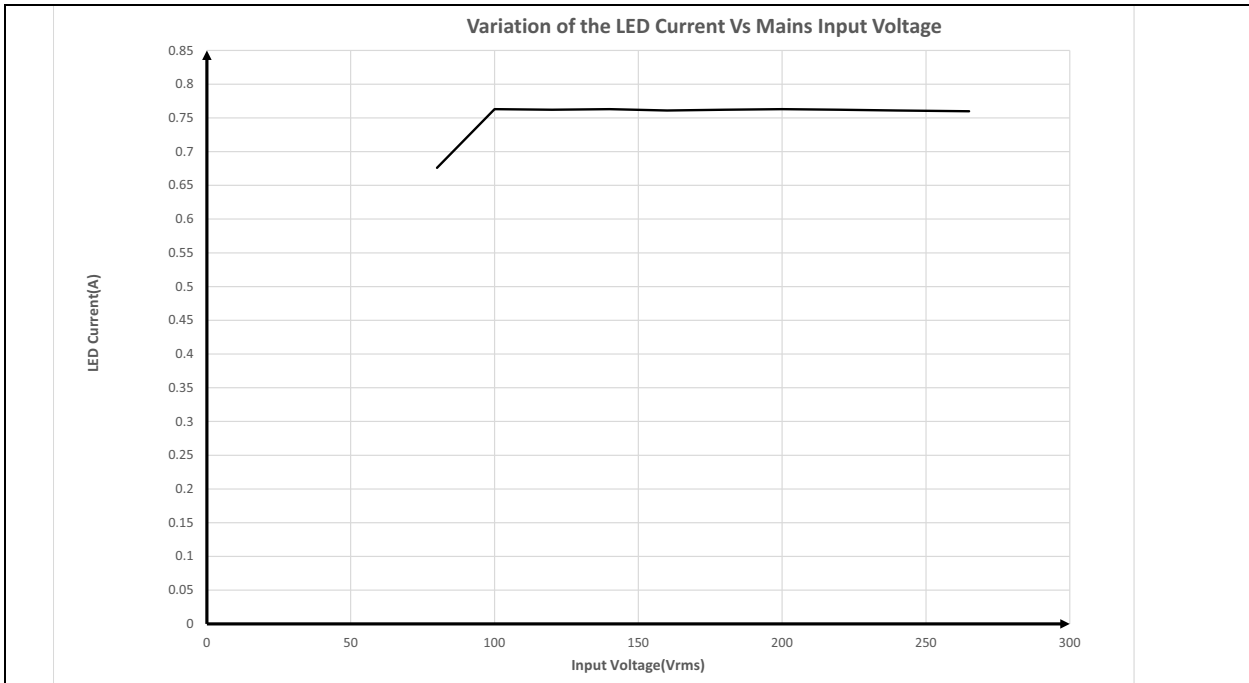
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**FIGURE C-7:** Efficiency vs. Input Voltage.



**FIGURE C-8:** Power Factor vs. Input Voltage.



**FIGURE C-9:** LED Load Current vs. Input Voltage.

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NOTES:



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