EVM User's Guide: LP8868YQ1EVM

LP8868Y-Q1 Evaluation Module

Description

The LP8868YQ1EVM helps designers evaluate the operation and performance of the LP8868Y-Q1, a nonsynchronous buck-boost switching regulator designed for high-current LED driver applications. The LP8868Y-Q1 provides 4A nonsynchronous buck-boost LED driver functionality. The device features a wide input voltage range from 4.5V to 65V. The component offers four dimming options: analog dimming, PWM dimming, hybrid dimming, and flexible dimming. Each dimming mode can be configured through the PWM or EN and ADIM or HD input pins by simple high and low signals. The EVM also provides full protections, including LED open protection and short protection, sense resistor open protection and short protection, configurable thermal foldback, and thermal shutdown.

Get Started

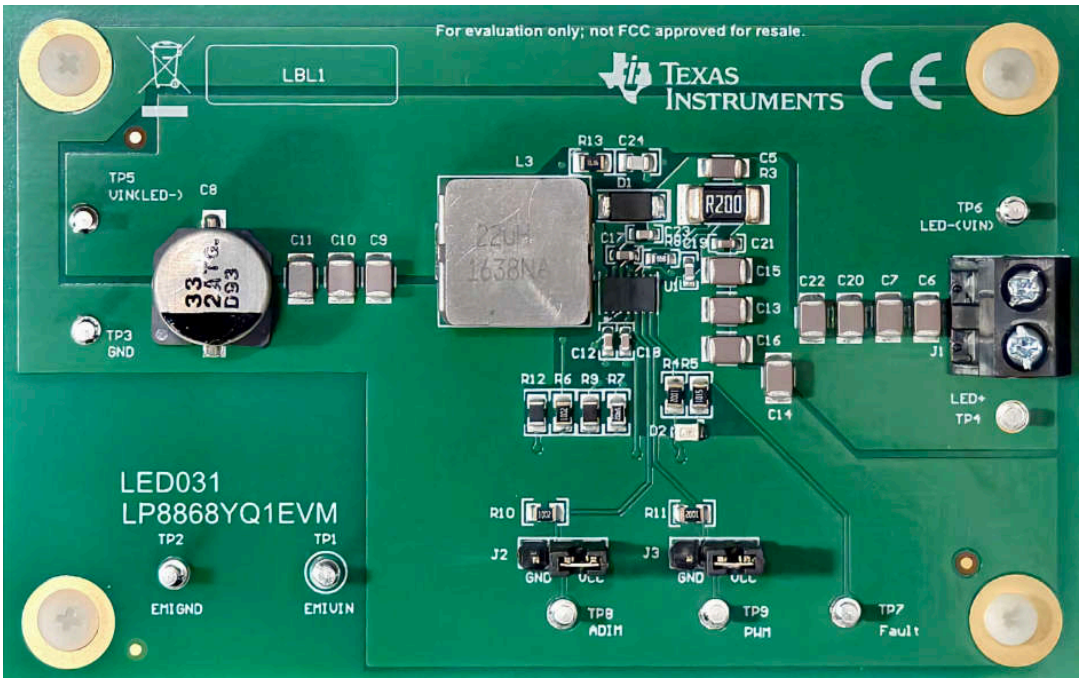
1. Order the LP8868YQ1EVM.
2. Download and examine the *LP8868-Q1 Automotive Multi-Topology LED Driver with Inductive Fast Dimming* data sheet.

Features

- Wide input voltage: 4.5V to 65V
- Integrated 5.2A and 150mΩ metal-oxide semiconductor field-effect transistor (MOSFET)
- High precision power field-effect transistor (FET) dimming
- Switching frequency 100kHz to 2.2MHz
- Full protection features

Applications

- Automotive infotainment
- Automotive instrument cluster
- Heads-up displays (HUD)
- Automotive lighting



LP8868YQ1EVM

1 Evaluation Module Overview

1.1 Introduction

The LP8868YQ1EVM provides an LED driver based on the LP8868YQ1 buck-boost switching regulator. The EVM is designed to operate with an input voltage in the range of 4.5V to 65V. The EVM is set up for a default output current of 1A and can work in four configurable dimming options. See also the *LP8868-Q1 Automotive Multi-Topology LED Driver with Inductive Fast Dimming* data sheet. By applying 0–100% duty cycle PWM signal on ADIM, HD pin, or PWM, EN pin, the device is able to operate in analog dimming or PWM dimming, respectively.

This user's guide describes the LP8868YQ1EVM evaluation module. This user's guide is used as a reference for engineering evaluation. Included in this user's guide are test setup instructions, a schematic diagram, a printed board (PCB) layout, and a bill of materials (BOM).

Observe the following precautions when using the LP8868YQ1EVM.

WARNING

When choosing an LED component (not included with this EVM), users must refer to the LED data sheet supplied by the LED manufacturer to identify the EN62471 Risk Group Rating and review any potential eye hazards associated with the LED chosen. Always consider and implement the use of effective light filtering and darkening protective eyewear and be fully aware of surrounding laboratory-type setups when viewing intense light sources that can be required to minimize or eliminate such risks to avoid accidents related to temporary blindness.

WARNING

All external connections to the hardware must stay within the recommended operating conditions and intended usage for all hardware and components connected in the system

1.2 Kit Contents

The LP8868YQ1EVM kit contains:

- (1) LP8868YQ1EVM

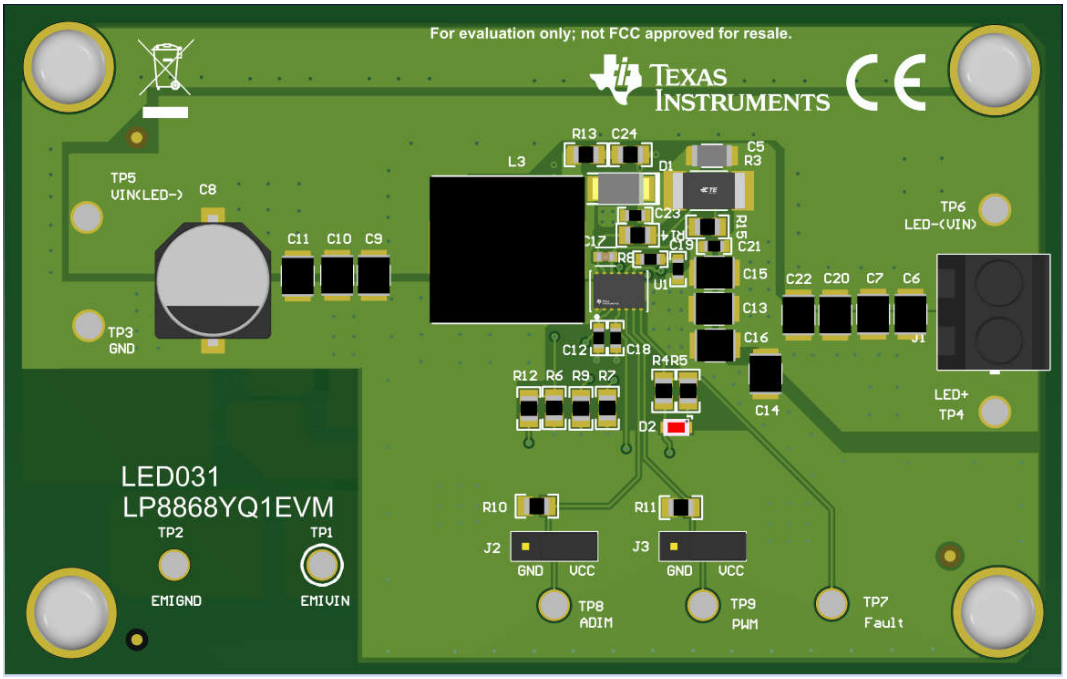


Figure 1-1. LP8868YQ1EVM Kit

1.3 Specification

The LP8868YQ1EVM is intended to provide basic functional evaluation of the device. Changing the jumpers J2 and J3 helps achieve the four different dimming modes. The board is designed as 1A output current with 37V LED+ overvoltage protection threshold. Limited by the input and output capacitor voltage rating, input voltage and LED+ voltage needs to be lower than 50V.

1.4 Device Information

The LP8868Y-Q1 is a non-synchronous constant current buck-boost converter with 4.5V to 65V wide input range. By integrating the low-side NMOS switch, the device is capable of driving LEDs with high power density and high efficiency. The device family also supports single-layer PCB design. The switching frequency is configurable from 100kHz to 2.2MHz with an optional spread-spectrum feature for better EMI performance.

2 Hardware

2.1 Test Setup

This section describes how to properly connect and setup the LP8868YQ1EVM.

2.1.1 System and Equipment Requirements

Collect the following equipment to use the LP8868YQ1EVM:

- DC power supply: 12V or higher, 6A or higher
- LED load board

2.1.2 Connector Description

Table 2-1 shows the EVM connectors and test points.

Table 2-1. EVM Connectors and Test Points

Reference Designator	Function
J1	Connector for LED+ and LED-
J2	ADIM/HD optional connection to V_{LDO} or GND
J3	EN/PWM optional connection to V_{LDO} or GND
TP1	Power connection with EMI filter
TP2	GND connection with EMI filter
TP3	GND connection without EMI filter
TP4	Test point of the LED+
TP5	Power connection without EMI filter
TP6	Test point of the LED-
TP7	FAULT test point
TP8	ADIM/HD signal input
TP9	EN/PWM signal input

2.1.3 Input and Output Connection

A power supply capable of supplying 6A must be connected to TP5 (VIN) and TP3 (GND) through a pair of 20-AWG wires. The LED load must be connected to TP4 and TP6 or J1 through a pair of 20-AWG wires. Connect the positive terminal of the LED load to the TP4 or J1 terminal beside TP4, and connect the negative terminal of the LED load to TP6 or J1 terminal beside TP6. Twist the wires and keep the wire length as short as possible to minimize voltage drop, inductance, and EMI transmission.

TP8 and TP9 are the input terminals for control signals of different dimming modes. The configuration to one of the four dimming modes are shown in Table 2-2. For high signal, the DC voltage level needs to be higher than 1.2V (typically 3.3V). The PWM signal on EN/PWM pin or ADIM/HD pin needs to be a square wave with a low level of GND and a high-level voltage higher than 1.2V (typically 3.3V). The dimming frequency needs to be in the range of 0.1kHz and 50kHz for PWM signal at PWM/EN pin. For the PWM signal on the ADIM/HD pin, the dimming frequency needs to be within 0.1kHz and 100kHz.

Table 2-2. Dimming Mode Configuration

Dimming Mode	EN/PWM Pin	ADIM/HD Pin
PWM Dimming	PWM signal	High
Analog Dimming	High	PWM signal
Hybrid Dimming	PWM signal	Low
Flexible Dimming	PWM signal	PWM signal

3 Hardware Design Files

3.1 Schematic

Figure 3-1 shows the LP8868YQ1EVM schematic.

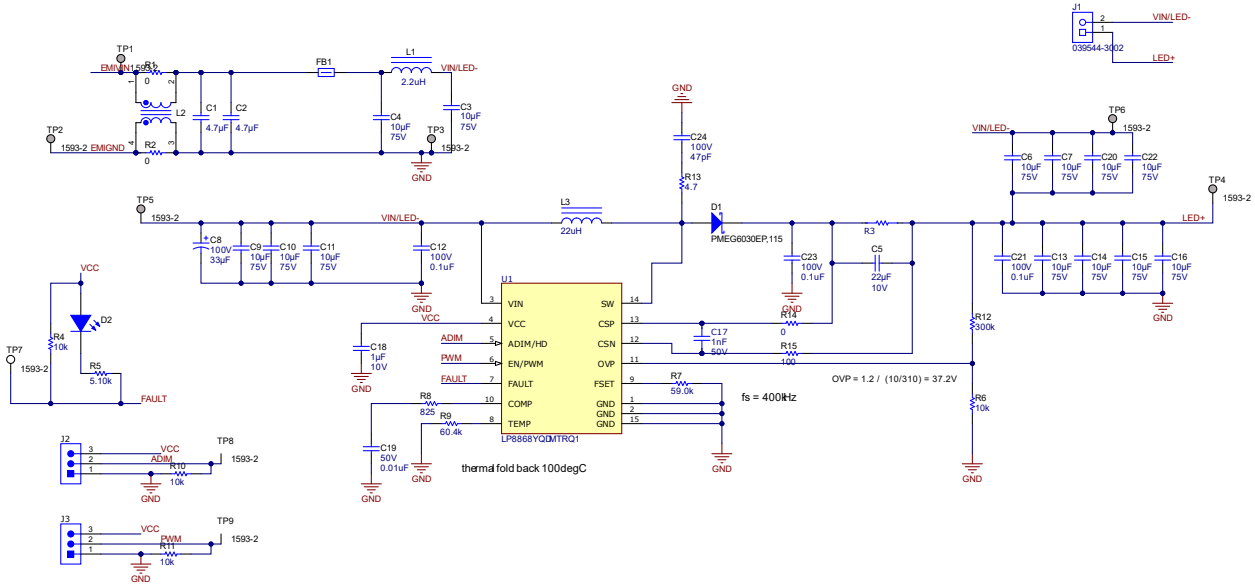


Figure 3-1. LP8868YQ1EVM Schematic

3.2 Layout

Figure 3-2, Figure 3-3, Figure 3-4, and Figure 3-5 show the layout of the LP8868YQ1EVM printed circuit board (PCB).

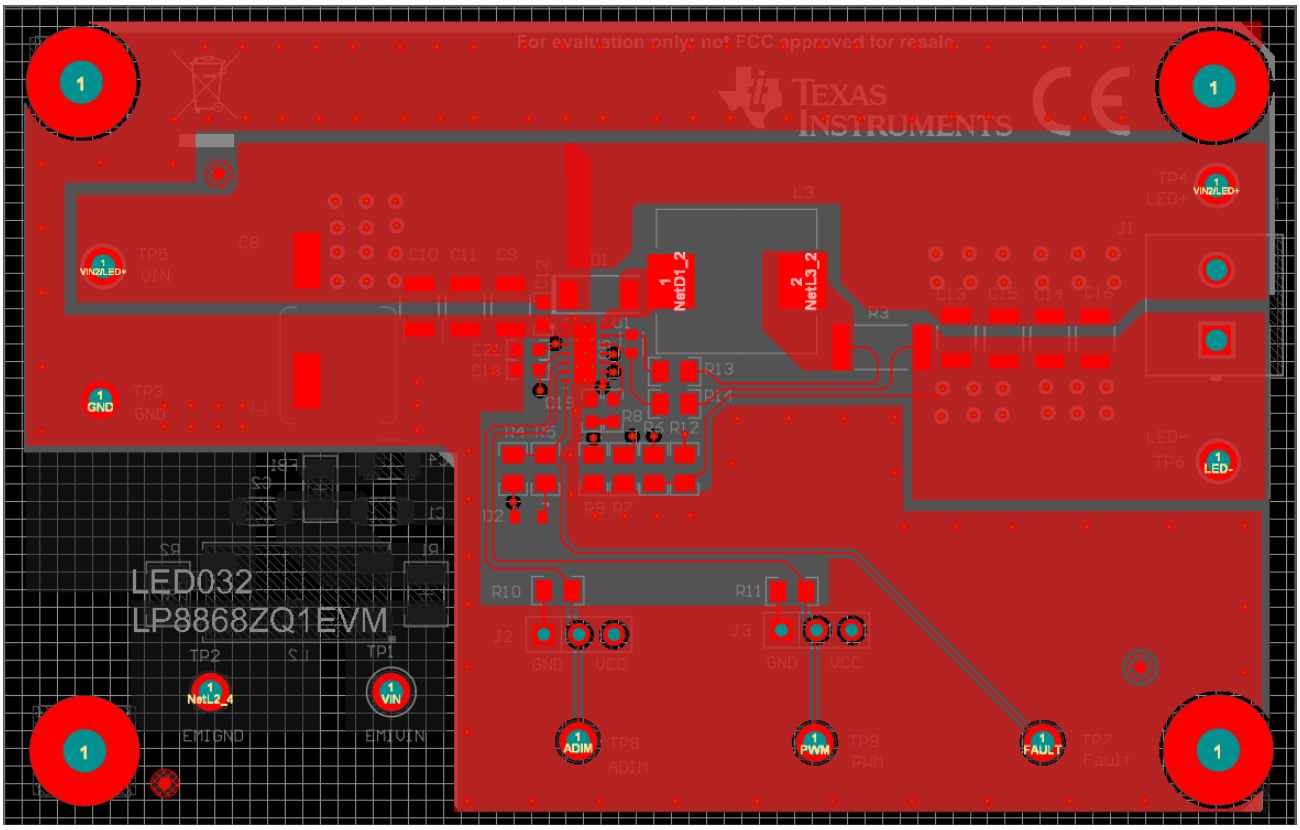


Figure 3-2. LP8868YQ1EVM Top Layer

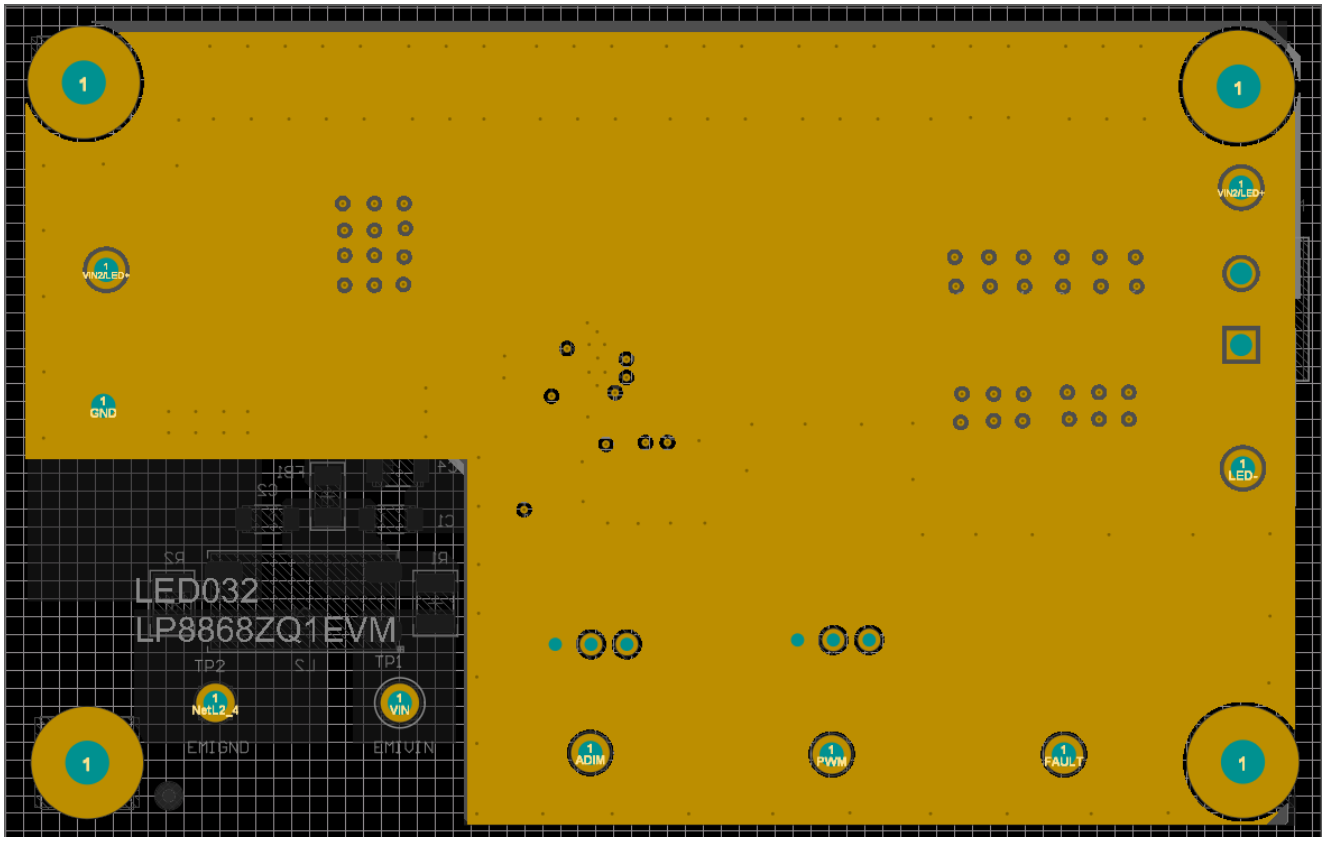


Figure 3-3. LP8868YQ1EVM Inner Layer 1

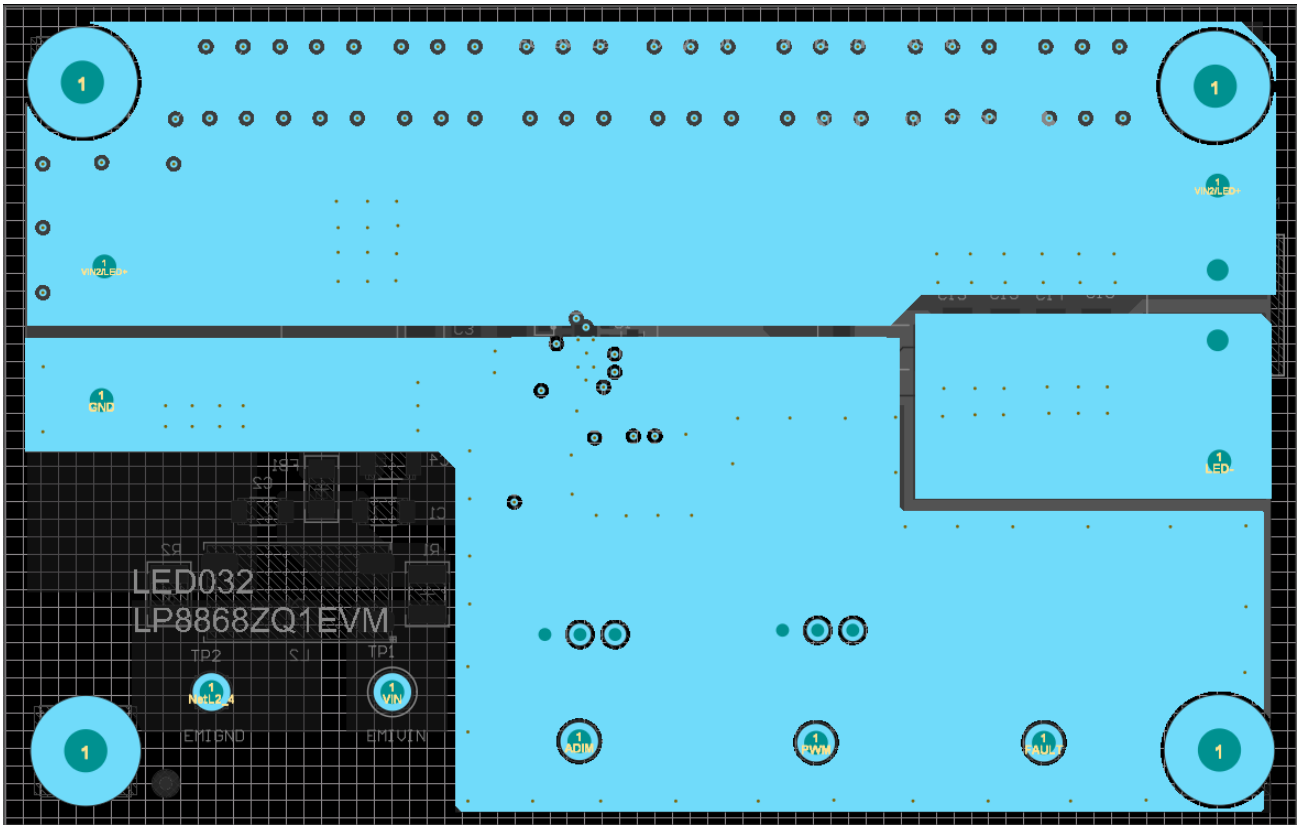


Figure 3-4. LP8868YQ1EVM Inner Layer 2

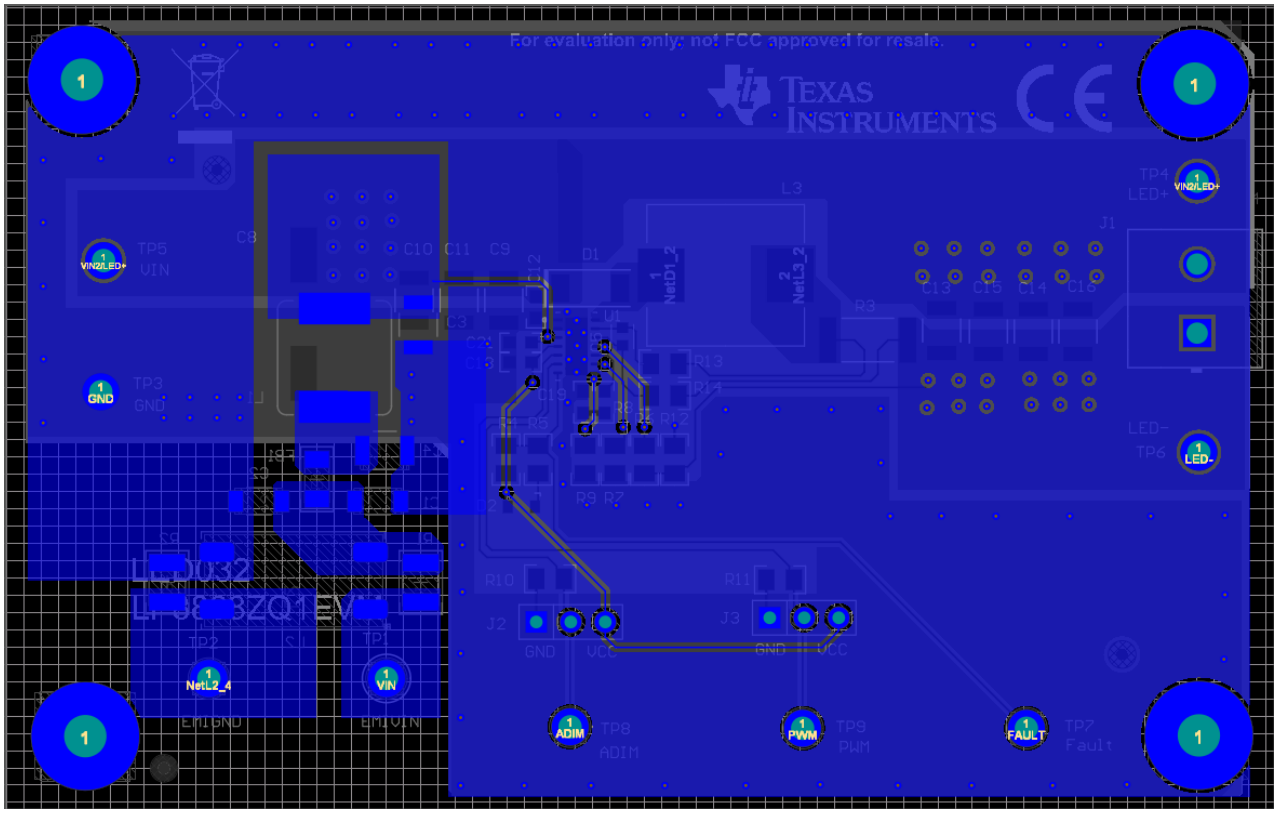


Figure 3-5. LP8868YQ1EVM Bottom Layer

3.3 Bill of Materials

Table 3-1 shows the LP8868YQ1EVM bill of materials.

Table 3-1. LP8868YQ1EVM Bill of Materials

Designator	Qty.	Value	Description	Package	Part Number	Manufacturer
C1, C2	2	4.7uF	CAP, CERM, 4.7 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1, 1206	1206	CGA5L3X7R1H475K160AE	TDK
C3, C4, C6, C7, C9, C10, C11, C13, C14, C15, C16, C20, C22	13	10uF	CAP, CERM, 10 µF, 75 V, ±20%, X7R, AEC-Q200 Grade 1, 1210	1210	CGA6P1X7R1N106M250AC	TDK
C5	1		CAP CER 22UF 10V X7S 1206	1206	CGA5L1X7S1A226M160AC	TDK
C8	1	33uF	CAP, AL, 33 µF, 100 V, ±20%, 1 ohm, AEC-Q200 Grade 1, SMD	Dia 10 mm	EEE-TG2A330P	Panasonic
C12, C21, C23	3	0.1uF	CAP, CERM, 0.1 uF, 100 V, ±10%, X7S, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7S2A104K080AB	TDK
C17	1	1nF	1000 pF ±10% 50V Ceramic Capacitor X7R 0603 (1608 Metric)	0603	C0603X102K5RAC7867	KEMET
C18	1	1uF	CAP, CERM, 1 uF, 10 V, ±10%, X7R, AEC-Q200 Grade 1, 0603	0603	LMK107B7105KAHT	Taiyo Yuden
C19	1	0.01uF	CAP, CERM, 0.01 uF, 50 V, ±5%, C0G/NP0, AEC-Q200 Grade 1, 0603	0603	CGA3E2C0G1H103J080AA	TDK
C24	1	47pF	CAP, CERM, 47 pF, 100 V, ±5%, C0G/NP0, 0805	0805	08051A470JAT2A	AVX
D1	1	60V	Diode, Schottky, 60 V, 3 A, SOD-128	SOD-128	PMEG6030EP,115	Nexperia
D2	1	Super Red	LED, Super Red, SMD	2.2x1.3x1.4mm	VLMS20J2L1-GS08	Vishay-Semiconductor
FB1	1	50 ohm	Ferrite Bead, 50 ohm @ 100 MHz, 12 A, 1206	1206	BLM31SN500SZ1L	MuRata
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1	1		Terminal Block, 5.08mm, 2x1, TH	Terminal Block, 5.08mm, 2x1, TH	039544-3002	Molex
J2, J3	2		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
L1	1	2.2uH	Inductor, Shielded, Powdered Iron, 2.2 uH, 10.5 A, 0.0137 ohm, SMD	322x158x322mil	IHLP3232DZER2R2M01	Vishay-Dale
L2	1	9uH	Coupled inductor, 9 uH, 10A, 0.0036 ohm, SMD	12.9x6.6mm	PLT10HH501100PNL	MuRata
L3	1	22uH	Inductor, Shielded, Powdered Iron, 22 uH, 5.5 A, 0.0313 ohm, SMD	IHLP-5050FD	IHLP5050FDER220M5A	Vishay-Dale
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady

Table 3-1. LP8868YQ1EVM Bill of Materials (continued)

Designator	Qty.	Value	Description	Package	Part Number	Manufacturer
R1, R2	2	0	RES, 0, 1%, 0.75 W, AEC-Q200 Grade 0, 1210	1210	CRCW12100000Z0EAHP	Vishay-Dale
R3	1	0.2	200 mOhms ±1% 2W Chip Resistor 2512 (6432 Metric) Anti-Sulfur, Automotive AEC-Q200, Current Sense Metal Element	2512	TLRP3A20WR200FTE	TE Connectivity
R4, R6, R10, R11	4	10k	RES, 10 k, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080510K0JNEA	Vishay-Dale
R5	1	5.10k	RES, 5.10 k, 0.1%, 0.125 W, 0805	0805	RG2012P-512-B-T5	Susumu Co Ltd
R7	1	59.0k	RES, 59.0 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	ERJ-6ENF5902V	Panasonic
R8	1	825	RES, 825, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603825RFKEA	Vishay-Dale
R9	1	60.4k	RES, 60.4 k, 1%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW080560K4FKEA	Vishay-Dale
R12	1	300k	RES, 300 k, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW0805300KJNEA	Vishay-Dale
R13	1	4.7	RES, 4.7, 5%, 0.25 W, 0805	0805	CRM0805-JW-4R7ELF	Bourns
R14	1	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
R15	1	100	RES, 100, 0.01%, 0.125 W, 0805	0805	RNCF0805TKY100R	Stackpole Electronics Inc
SH-J1, SH-J2	2	1x2	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt	SPC02SYAN	Sullins Connector Solutions
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9	9		Terminal, Turret, TH, Double	Keystone1593-2	1593-2	Keystone
U1	1		Automotive 65-V 4-A Buck-Boost LED Driver with Inductive Fast Dimming	VSON14	LP8868YQDMTRQ1	Texas Instruments

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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