

LP8867-Q1 Evaluation Module User's Guide

The Texas Instruments LP8867Q1EVM evaluation module helps designers to evaluate the operation and performance of the LP8867-Q1 and LP8869-Q1 device. This document includes a complete schematic diagram, printed-circuit board (PCB) layout, and bill of materials (BOM) of the LP8867Q1EVM.

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Trademarks

1 Introduction

The LP8867Q1EVM helps designers to evaluate the characteristics, operation, and use of the LP8867/9-Q1 device, a high-performance LED driver for automotive lighting. The LP8867/9-Q1 device is an easy-to-use LED driver with integrated DC-DC converter. The device also has four/three 120-mA high-precision current sinks that can be controlled by a PWM input signal and integrates extensive fault detection features.

1.1 Features

The EVM has the following features:

- Integrated boost or SEPIC for LED string power
- Four/Three high-precision current sinks
- Power-Line FET control for inrush current protection and standby energy saving
- Extensive fault detection features and fault output
- Automatic LED current reduction with external temperature sensor

1.2 Typical Applications

- Backlight for:
 - Automotive infotainment
 - Automotive instrument clusters
 - Smart mirrors
 - Heads-Up Displays (HUD)
 - Central Information Displays (CID)
 - Audio-Video Navigation (AVN)

2 LP8867Q1EVM Hardware Setup

This section describes the jumpers and connectors on the EVM as well as how to properly connect and setup the LP8867Q1EVM.

Figure 1 shows connectors and main components on the LP8867Q1EVM when used to evaluate the LP8867-Q1 device. When evaluating the LP8869-Q1 device, the only difference is to close the jumper J22.

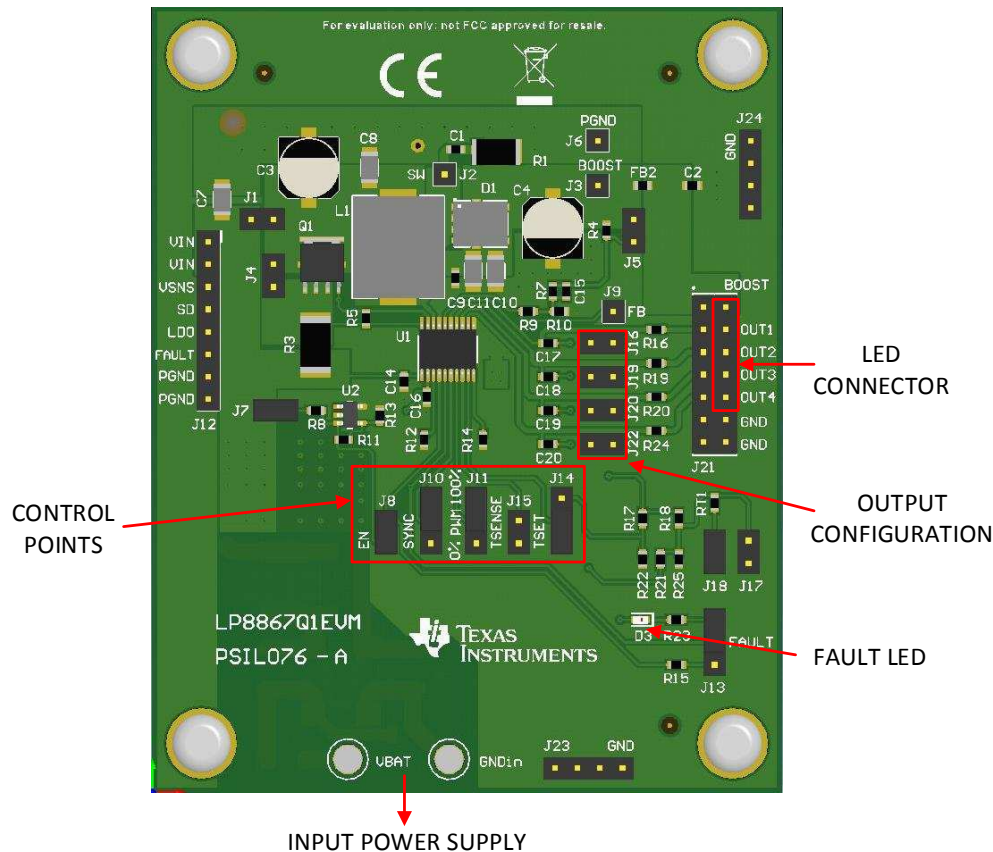


Figure 1. LP8867Q1EVM Board

Default resistor values and jumper positions are set to:

- Boost switching frequency - 400 kHz (set by external resistor R12)
- Maximum LED current per string - 120 mA (set by external resistor R14)
- J1, J4: Open to enable the power line FET and VIN_OCP protection
- J5: Open - a probing /noise injecting point for stability measurement
- J7, J8: Closed to enable the device
- J10: Close pins 2-3 to enable the spread spectrum feature
- J11: Close pins 2-3 to connect PWM to VDDIO/EN to set 100% brightness
- J13: Close pins 1-2 to enable the LED D3 for fault indication
- J14: Close pins 1-2 to disable the LED current dimming with external temperature sensor
- J15: Open to disable the LED current dimming with external temperature sensor
- J17: Open - used to connect external temperature sensor
- J18: Closed to use the NTC thermistor RT1 if LED current dimming with external temperature sensor is enabled
- J16, J19, J20, J22: Open to enable the four current sinks when configured to evaluate the LP8867-Q1 device

When configuring the LP8867Q1EVM to evaluate the LP8869-Q1 device, the only difference is that jumper J22 should be closed.

3 LP8867Q1EVM Test Setup

Figure 2 shows the test setup for the LP8867Q1EVM. Follow these steps for the EVM test:

- Set the voltage of the dc power supply to 12 V and set the current limit to 4 A.
- Connect four LED strings on the LED board to OUT1 - OUT4 of connector J21. Connect Boost pin of the LED board to the Boost pin of connector J21. (Note: LED current default is 120 mA and maximum boost voltage default is 37 V. LED outputs that are not used must be grounded via corresponding jumpers J16, J19, J20 and J22.)
- Connect the positive and negative outputs of the power supply to connectors VBAT and GNDin on the EVM board.
- Turn on the power supply. The LEDs will be turned on immediately since the jumpers on the EVM are set for PWM input of 100% duty cycle.

For other connector and jumper positions, please refer to [Figure 1](#) and [Figure 6](#).

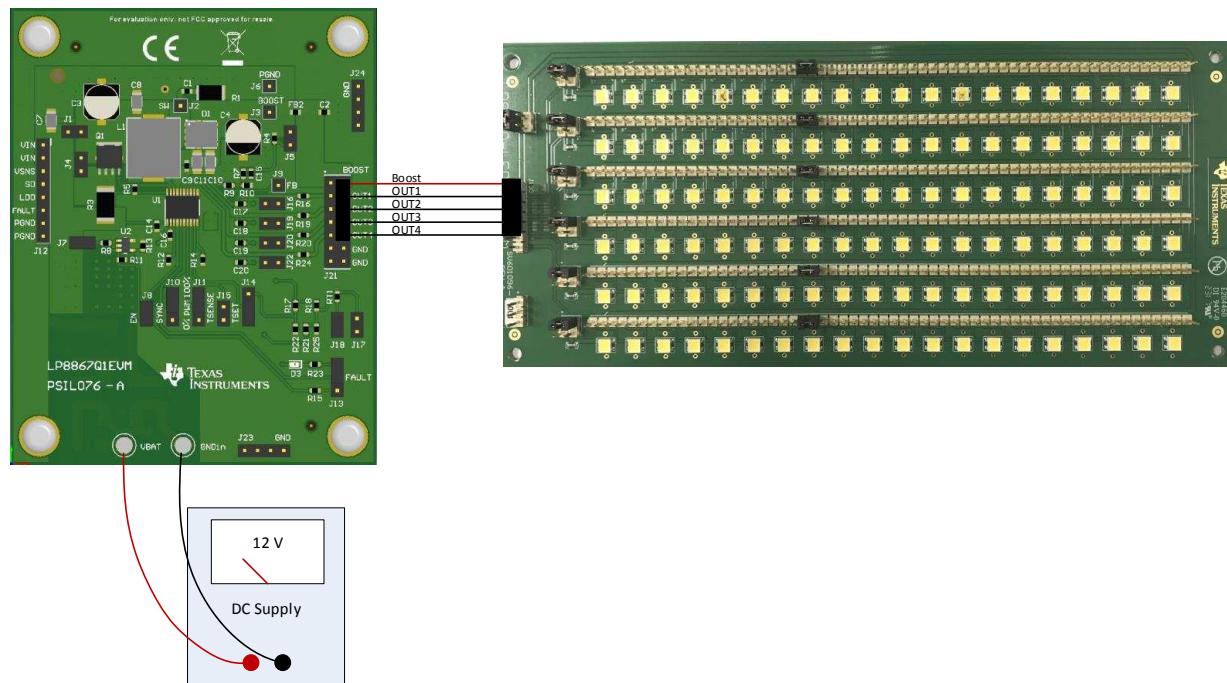


Figure 2. LP8867Q1EVM Test Setup

4 LP8867Q1EVM Board Layout

Figure 3 and Figure 4 illustrate the EVM board layout.

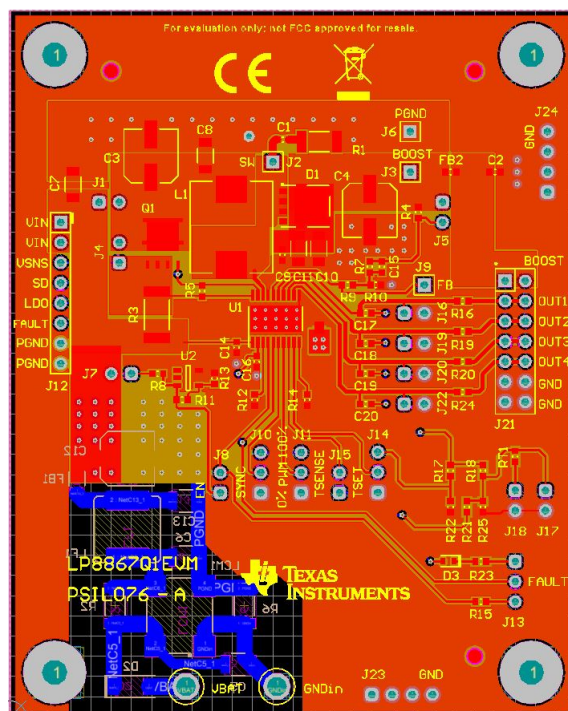


Figure 3. LP8867Q1EVM Layout -Top Layer

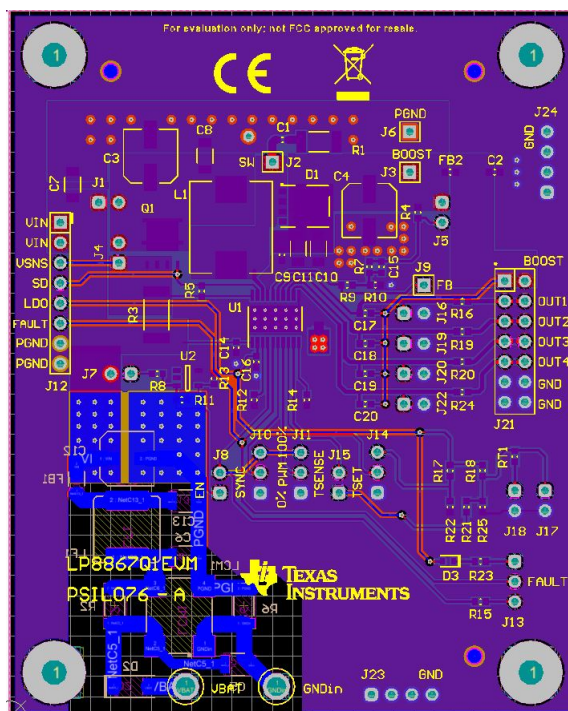


Figure 4. LP8867Q1EVM Layout - Bottom Layer

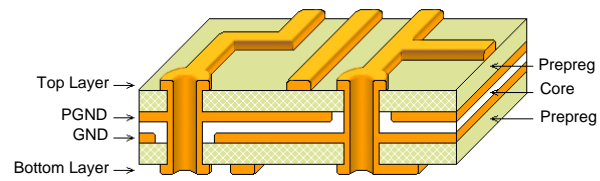


Figure 5. LP8867Q1EVM Board Stackup

5 LP8867Q1EVM Schematic

Figure 6 shows the EVM schematic.

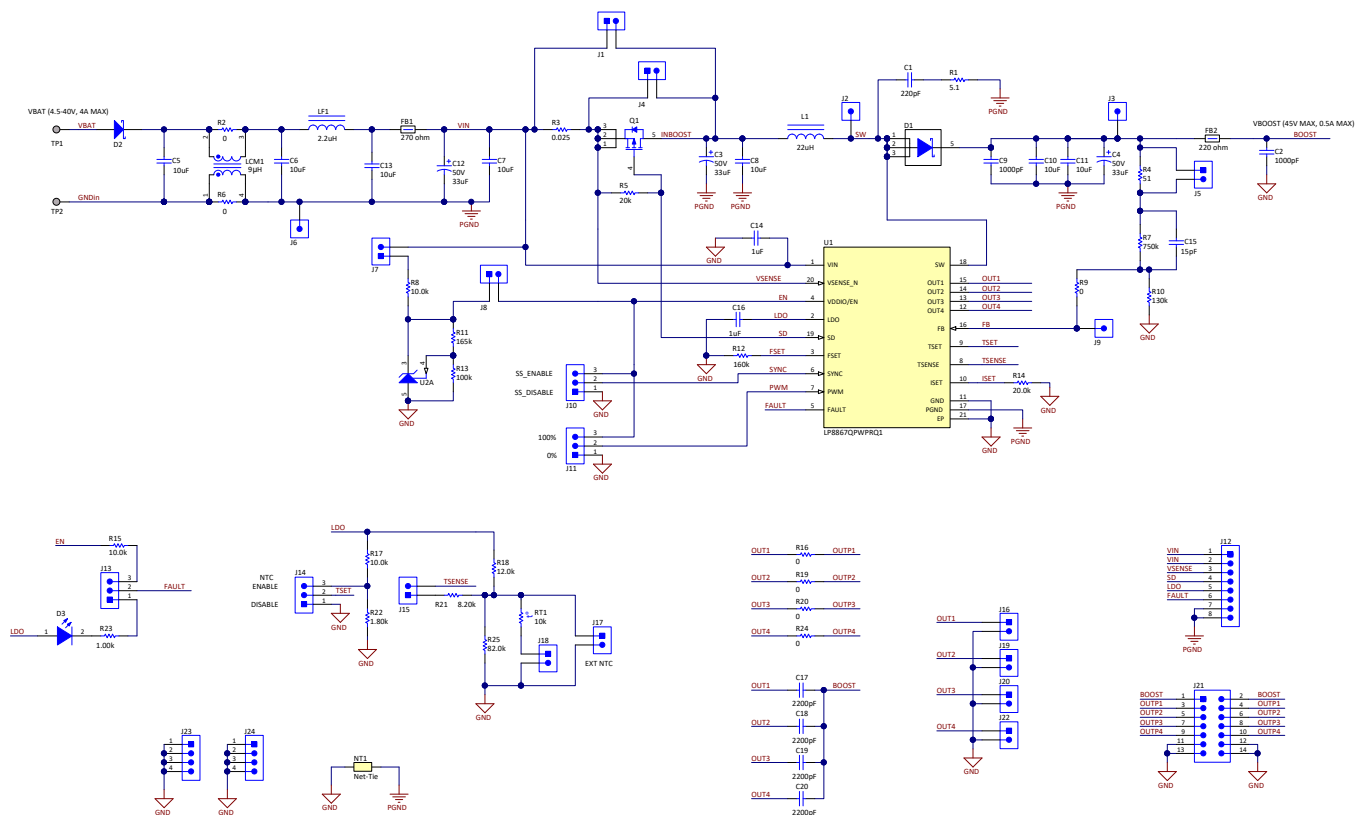


Figure 6. LP8867Q1EVM Schematic

6 LP8867Q1EVM Bill of Materials

Table 1 lists the bill of materials for the LP8867Q1EVM.

Table 1. LP8867Q1EVM Bill of Materials

NO.	Designator	QTY	Value	Part Number	Manufacturer	Description	Package Reference
1	!PCB1	1		PSIL076		Printed Circuit Board	
2	C2, C9	2	1000pF	GRM1885C2A102JA01D	MuRata	CAP, CERM, 1000 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603
3	C3, C4, C12	3	33uF	EEH-ZC1H330XP	Panasonic	CAP, Polymer Hybrid, 33 uF, 50 V, +/- 20%, 40 ohm, 6.3x7.7 SMD	6.3x7.7
4	C5, C6, C13	3	10uF	UMK325AB7106KMHT	Taiyo Yuden	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	1210
5	C7, C8, C10, C11	4	10uF	CGA5L3X5R1H106K160AB	TDK	CAP, CERM, 10 uF, 50 V, +/- 10%, X5R, 1206_190	1206_190
6	C14	1	1uF	UMK107AB7105KA-T	Taiyo Yuden	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0603	0603
7	C15	1	15pF	06035A150JAT2A	AVX	CAP, CERM, 15 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603
8	C16	1	1uF	C0603C105K8PACTU	Kemet	CAP, CERM, 1 uF, 10 V, +/- 10%, X5R, 0603	0603
9	C17, C18, C19, C20	4	2200pF	C0603C222K5RACTU	Kemet	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0603	0603
10	D1	1	60V	NRVB460MFST3G	ON Semiconductor	Diode, Schottky, 60 V, 4 A, SO-8FL	SO-8FL
11	D2	1	40V	PMEG4050EP,115	Nexperia	Diode, Schottky, 40 V, 5 A, AEC-Q101, SOD-128	SOD-128
12	D3	1	Red	TLMS1000-GS08	Vishay-Semiconductor	LED, Red, SMD	1.6x0.8mm
13	FB1	1		BLM31KN271SZ1L	MuRata	Inductor, Ferrite Bead, Ferrite, 4.5 A, 270 ohm @ 100 MHz, AEC-Q200 Grade 1, SMD	1206
14	FB2	1	220 ohm	MPZ1608S221ATD25	TDK	Ferrite Bead, 220 ohm @ 100 MHz, 2.2 A, 0603	0603
15	H1, H2, H3, H4	4		NY PMS 440 0025 PH	B&F Fastener Supply	Machine Screw, Round, #4-40 x 1/4, Nylon, Phillips panhead	Screw
16	H5, H6, H7, H8	4		1902C	Keystone		Standoff
17	J1, J4, J5, J7, J8, J15, J16, J17, J18, J19, J20, J22	12		TSW-102-07-G-S	Samtec	Header, 100mil, 2x1, Gold, TH	2x1 Header
18	J2, J3, J6, J9	4		TSW-101-07-G-S	Samtec	Header, 100mil, 1pos, Gold, TH	Testpoint
19	J10, J11, J13, J14	4		TSW-103-07-G-S	Samtec	Header, 100mil, 3x1, Gold, TH	3x1 Header
20	J12	1		TSW-108-07-G-S	Samtec	Header, 100mil, 8x1, Gold, TH	8x1 Header
21	J21	1		TSW-107-07-G-D	Samtec	Header, 100mil, 7x2, Gold, TH	7x2 Header
22	J23, J24	2		TSW-104-07-G-S	Samtec	Header, 100mil, 4x1, Gold, TH	4x1 Header
23	L1	1	22uH	IHLP4040DZER220M8A	Vishay-Dale	Inductor, Shielded Drum Core, Powdered Iron, 22 uH, 4.1 A, 0.0705 ohm, AEC-Q200 Grade 0, SMD	IHLP-4040DZ
24	LCM1	1	9uH	744273801	Würth Elektronik	Coupled inductor, 9 uH, 0.011 ohm, SMD	SMD, 4-Leads, Body 9.5x8.3mm
25	LF1	1	2.2uH	IHLP3232DZER2R2M01	Vishay-Dale	Inductor, Shielded, Powdered Iron, 2.2 uH, 10.5 A, 0.0137 ohm, SMD	322x158x322mil
26	Q1	1	-60V	SQJ457EP-T1_GE3	Vishay-Siliconix	MOSFET, P-CH, -60 V, -36 A, AEC-Q101, PowerPAK_SO-8L	PowerPAK_SO-8L
27	R2, R6	2	0	CRCW20100000Z0EF	Vishay-Dale	RES, 0, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010
28	R3	1	0.025	CSRN2512FK25L0	Stackpole Electronics Inc	RES, 0.025, 1%, 2 W, 2512	2512
29	R4	1	51	CRCW060351R0JNEA	Vishay-Dale	RES, 51, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
30	R5	1	20k	CRCW060320K0JNEA	Vishay-Dale	RES, 20 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
31	R7	1	750k	CRCW0603750KFKEA	Vishay-Dale	RES, 750 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
32	R8, R15, R17	3	10.0k	CRCW060310K0FKEA	Vishay-Dale	RES, 10.0 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
33	R9, R16, R19, R20, R24	5	0	CRCW06030000Z0EA	Vishay-Dale	RES, 0, 5%, 0.1 W, 0603	0603
34	R10	1	130k	CRCW0603130KFKEA	Vishay-Dale	RES, 130 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
35	R11	1	165k	RC0603FR-07165KL	Yageo	RES, 165 k, 1%, 0.1 W, 0603	0603
36	R12	1	160k	RC0603FR-07160KL	Yageo	RES, 160 k, 1%, 0.1 W, 0603	0603

Table 1. LP8867Q1EVM Bill of Materials (continued)

NO.	Designator	QTY	Value	Part Number	Manufacturer	Description	Package Reference
37	R13	1	100k	CRCW0603100KFKEA	Vishay-Dale	RES, 100 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603
38	R14	1	20.0k	RG1608P-203-B-T5	Susumu Co Ltd	RES, 20.0 k, 0.1%, 0.1 W, 0603	0603
39	R18	1	12.0k	RC0603FR-0712KL	Yageo	RES, 12.0 k, 1%, 0.1 W, 0603	0603
40	R21	1	8.20k	RC0603FR-078K2L	Yageo	RES, 8.20 k, 1%, 0.1 W, 0603	0603
41	R22	1	1.80k	RC0603FR-071K8L	Yageo	RES, 1.80 k, 1%, 0.1 W, 0603	0603
42	R23	1	1.00k	RC0603FR-071KL	Yageo	RES, 1.00 k, 1%, 0.1 W, 0603	0603
43	R25	1	82.0k	RC0603FR-0782KL	Yageo	RES, 82.0 k, 1%, 0.1 W, 0603	0603
44	RT1	1	10k	NCP18XH103F03RB	MuRata	Thermistor NTC, 10.0k ohm, 1%, 0603	0603
45	SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7	7	1x2	SPC02SYAN	Sullins Connector Solutions	Shunt, 100mil, Flash Gold, Black	Closed Top 100mil Shunt
46	TP1, TP2	2		1502-2	Keystone	Terminal, Turret, TH, Double	Keystone1502-2
47	U1	1		LP8867QPWPQRQ1	Texas Instruments	Low-EMI Automotive LED Driver With Four 120-mA Channels, PWP0020D (HTSSOP-20)	PWP0020D
48	U2	1		TLVH431AQDBVRQ1	Texas Instruments	Automotive Catalog Low-Voltage Adjustable Precision Shunt Regulator, 80 mA, -40 to 125 degC, 5-pin SOT-23 (DBV), Green (RoHS & no Sb/Br)	DBV0005A
49	C1	0	220pF	06031C221KAT2A	AVX	CAP, CERM, 220 pF, 100 V, +/- 10%, X7R, 0603	0603
50	FID1, FID2, FID3, FID4, FID5, FID6	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
51	R1	0	5.1	CRCW20105R10JNEF	Vishay-Dale	RES, 5.1, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010

7 LED Load Board

The LED board is intended to be used as the load for LED drivers and can be configured for up to 6 strings and up to 20 LEDs in the string (number of LEDs in use is defined by jumpers). Cree Xlamp ML-B LEDs with maximum current 175 mA and maximum forward voltage 3.5 V at 80 mA (3.3-V typical) are used on the board. For the LP8867-Q1, 4 strings must be connected to the EVM. For the LP8869-Q1, 3 strings are connected.

NOTE: The LED board is not included with the EVM -- contact your local TI sales representative if board is needed.

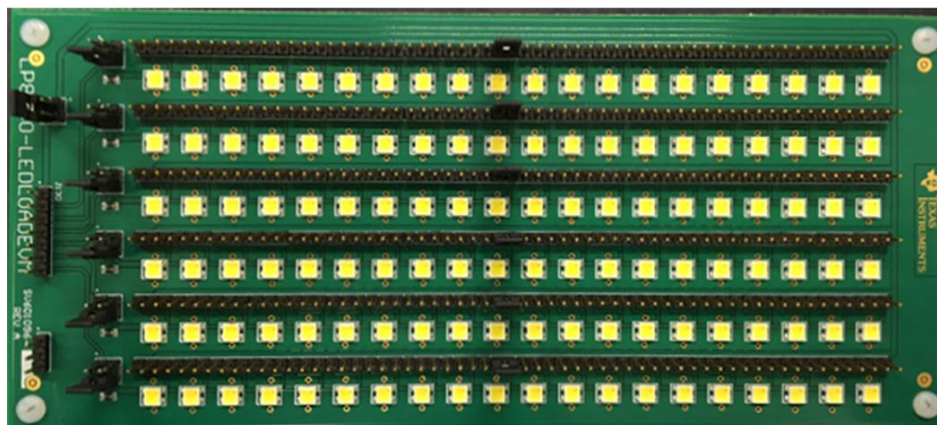


Figure 7. LED Load Board - Top View

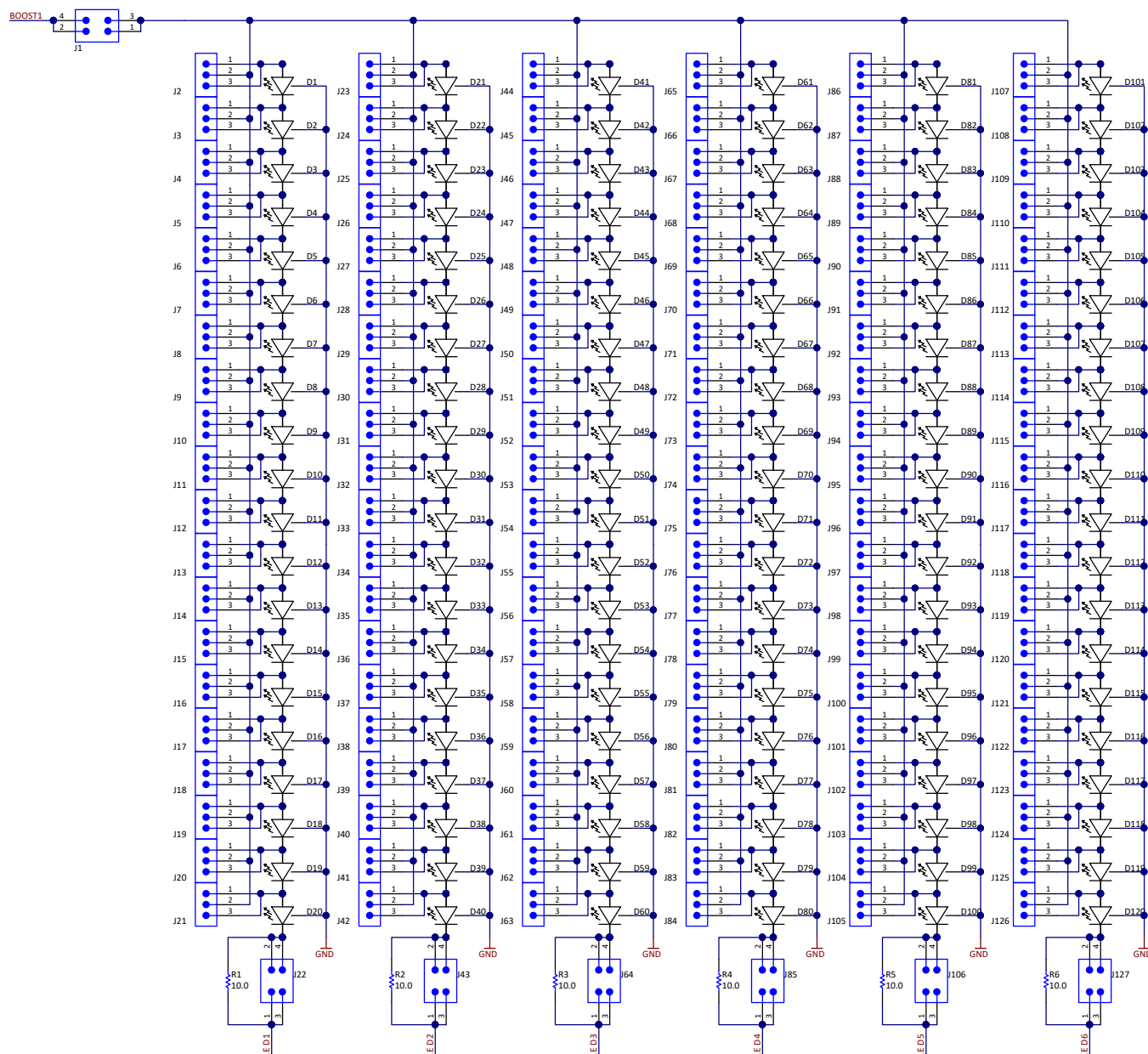


Figure 8. LED Load Board - Schematic Diagram

Table 2. Bill of Material for LED Load Board

QTY	DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER
6	R1, R2, R3, R4, R5, R6	RES, 10.0 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW060310R0FKEA
7	J1, J22, J43, J64, J85, J106, J127	Header, TH, 100mil, 2x2, Gold plated, 230 mil above insulator	Samtec	TSW-102-07-G-D
121	J2...J21, J23...J42, J44...J63, J65...J84, J86...J105, J107...J126, J129	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	Samtec	TSW-103-07-G-S
1	J130	Header, TH, 100mil, 7x1, Gold plated, 230 mil above insulator	Samtec	TSW-107-07-G-S
120	D1...D120	Cool White SMD LED Xlamp mL-B	Cree	MLBAWT-A1-0000-000W51

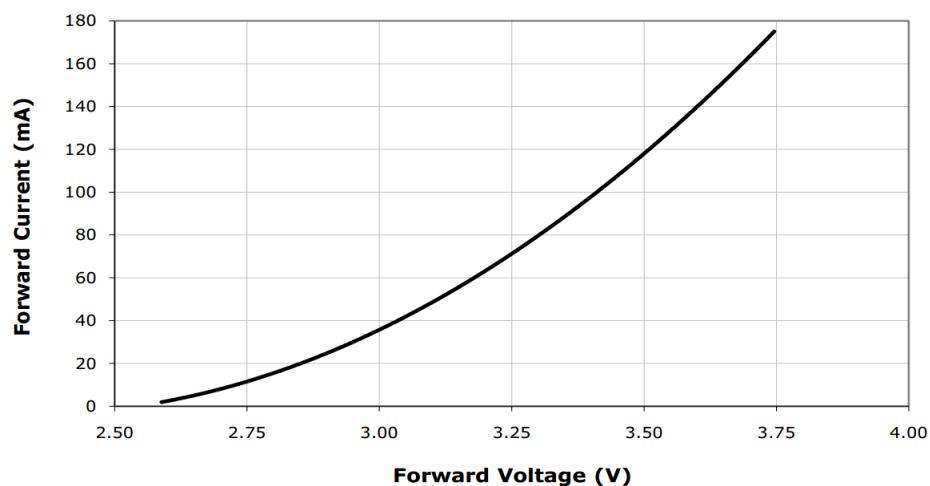


Figure 9. Forward Voltage for Cree Xlamp ML-B LEDs

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 DEGRADATION 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/lscs/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。
http://www.tij.co.jp/lscs/ti_ja/general/eStore/notice_01.page

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/lscs/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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