LP8870Q1EVM User's Guide

TEXAS INSTRUMENTS

Description

The Texas Instruments LP8870Q1EVM evaluation module helps designers to evaluate the operation and performance of the LP8870-Q1 device. This document includes a hardware setup instructions, software instructions, a complete schematic diagram, printed-circuit board (PCB) layout, and bill of materials (BOM) of the LP8870Q1EVM.

Get Started

1. Request the LP8870Q1 EVM from ti.com .
2. Request the LP8870-Q1 data sheet from ti.com.
3. Download the LP887xGUI from ti.com.

## Features

- Input voltage range 3V to 48V
- Up to 48V V_{OUT} boost controller
- Six high-precision current sinks
- Supports built-in phase-shift PWM dimming, hybrid dimming, current dimming and direct PWM dimming mode
- LED brightness controlled globally through I2C interface or PWM input
- Extensive fault diagnostics

Applications

Backlight for:

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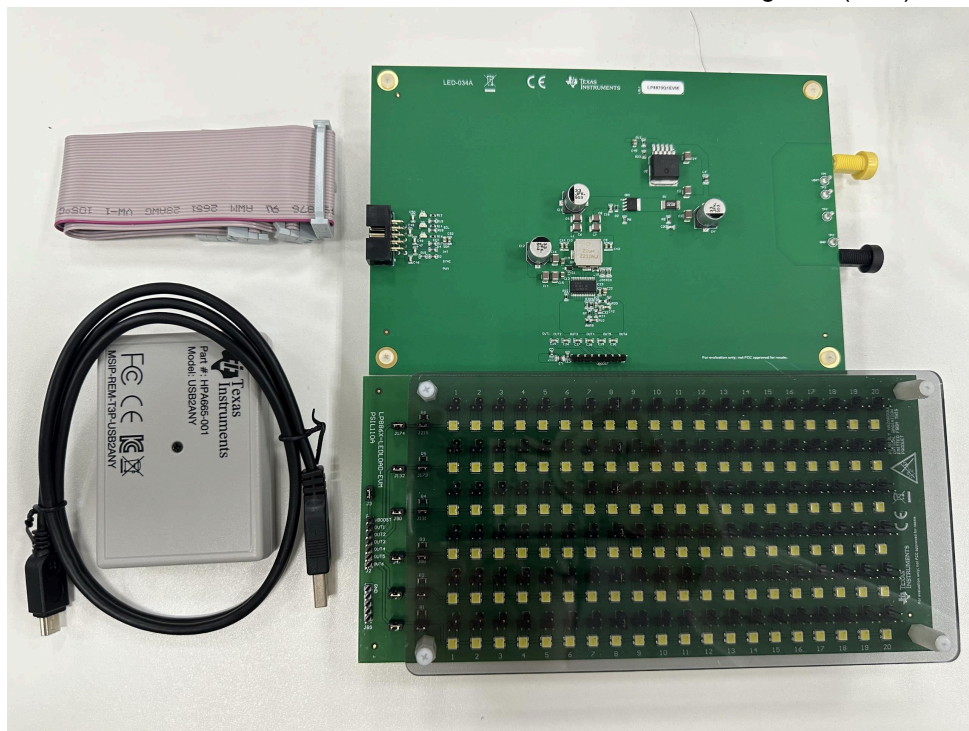
Hardware Image

1 Introduction

The LP8870Q1EVM helps designers to evaluate the characteristics, operation, and use of the LP8870-Q1 device, a high-performance LED driver for automotive lighting. The LP8870-Q1 device is a high-efficiency LED driver with boost controller. The six 150mA high-precision current sinks support phase shifting that is automatically adjusted based on the number of channels in use. LED brightness can be controlled globally through the I²C interface or PWM input.
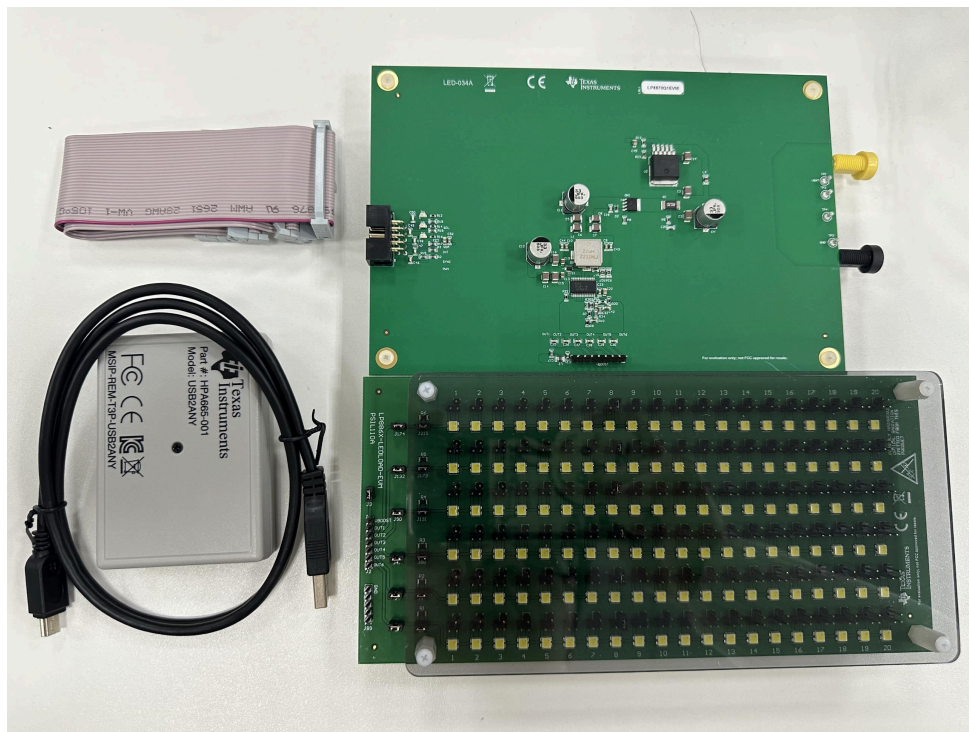
2 Test Setup

This section describes how to properly connect and setup the LP8870Q1EVM.

2.1 The LP8870Q1EVM Kit

The LP8870Q1EVM kit contains (see Figure 2-1):

- USB2ANY
  - Ribbon cable
  - USB cable
- LP8870Q1EVM
- LP886X-LEDLOAD-EVM
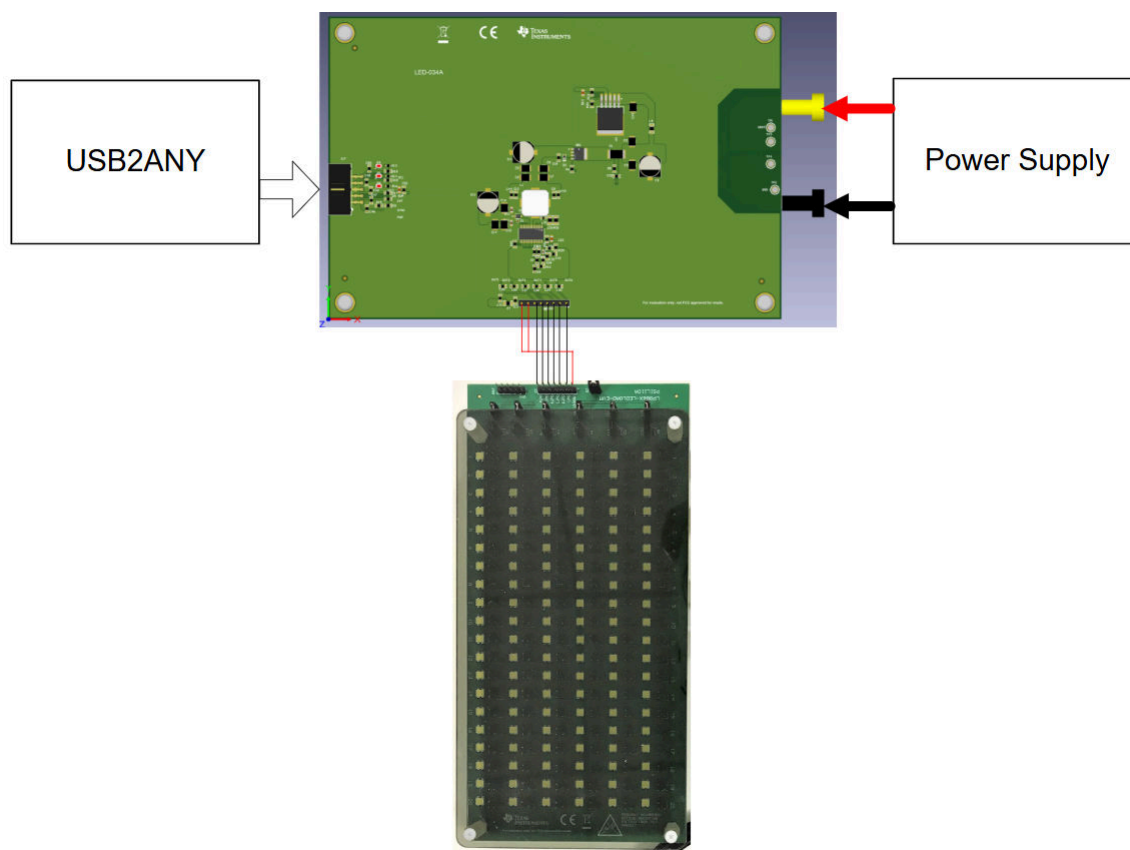

Figure 2-1. LP8870Q1EVM Kit

2.2 System/Equipment Requirements

- DC power supply: 12V or higher, 6A or higher
- LED cable: 7-position ribbon cable
- PC to run GUI software
- GUI software

2.3 Hardware Setup

Figure 2-2 shows the hardware setup of the LP8870Q1EVM.

- Connect a 12V external power supply between the power input terminals VBAT+ and GND on the LP8870Q1EVM.
- Connect the USB2ANY module to the PC with the USB cable.
- Connect the USB2ANY module to the LP8870Q1EVM with the provided ribbon cable.
- Connect the LP8870Q1EVM to the LP886X-LEDLOAD-EVM with a 7-position ribbon cable.


Figure 2-2. LP8870Q1EVM Hardware Setup

2.4 Software Installation

Download the GUI software from the LP8870Q1EVM tools folder. Follow the instructions to finish the GUI installation. Once installed, a shortcut to the GUI is found on the desktop and also in the start-up menu under the Texas Instruments folder.

2.5 Quick Start-Up Procedure

1. After the hardware is connected successfully, run the GUI software. Turn on the 12V external power supply. Select the Register Write and Read Page, as shown in Figure 2-3.
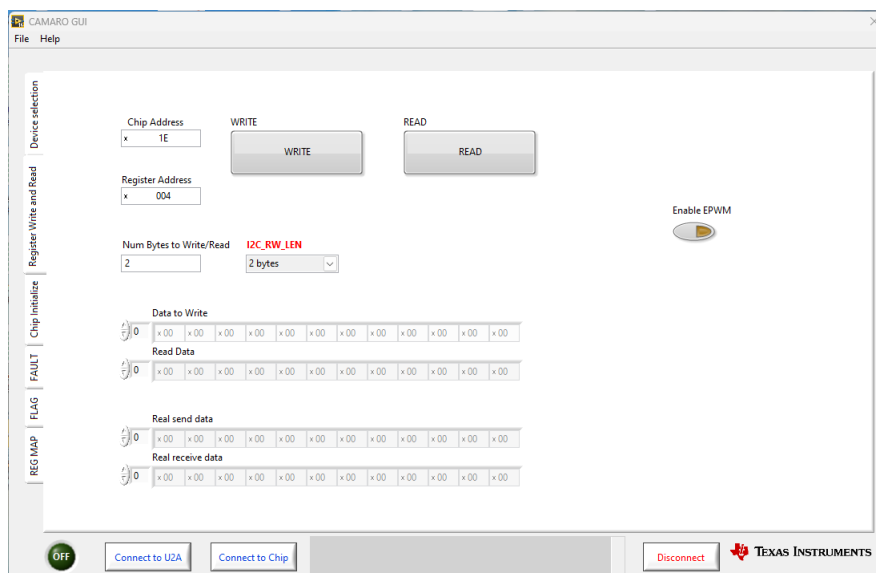

Figure 2-3. LP8870Q1EVM GUI Register Page

2. Input the suitable chip address, default is 0x1E. Click the "Connect to U2A" button on the bottom of the GUI. Then click the green button to enable the device. Finally, click the "Connect to Chip" button on the bottom of the GUI to connect the device. Once the connection is done, the page should be like the one shown in Figure 2-4. There should be a "Data Read Successfully" message on the status bar next to the button.
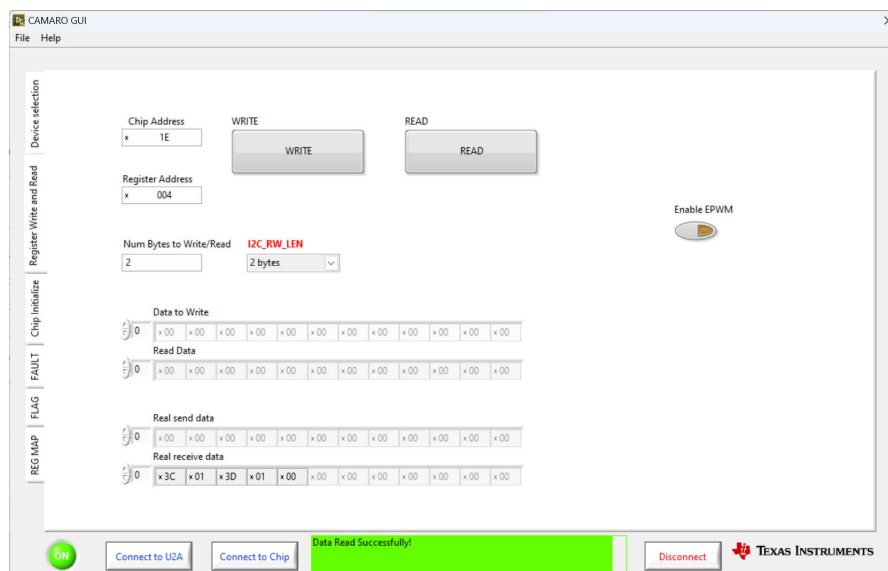
Figure 2-4. LP8870Q1EVM GUI Connection Page

3. Click "Chip Initialize" to go to the Initial page (see Figure 2-5). On the LED Initial page, the user can control all the register based control functions of the device, like brightness control, current control, sloper control, dimming mode, LED setup and spread spectrum configuration. After finishing the setup, choose "enable" in "START_UP_ENABLE" register to light on the device
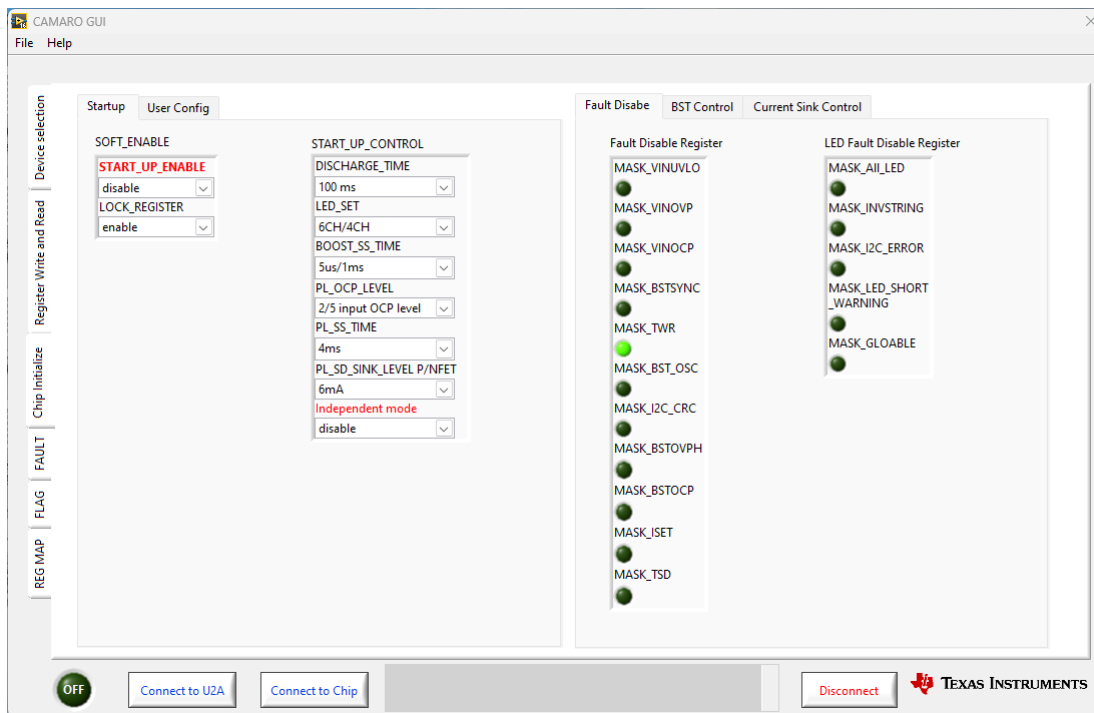

Figure 2-5. LP8870Q1EVM Initial Page

2.6 Additional GUI Functions

In the selection tab on the left-hand side, the user can switch between Fault, Flag and Reg Map tabs. This section introduces GUI functions provided in the Fault and Flag.

2.6.1 Fault Page

From the Faults page (see Figure 2-6), the user has access to LP8870-Q1 fault status bits. Boost fault and LED fault is divided into to two section, click "Read SUPPLY_BOOST_STATUS" can readback the boost fault Faults from the device. When a fault happened, the light below the fault will turn red. Click "Clear SUPPLY_BOOST_STATUS" will clear the fault in the device. Similar action can used in LED status section.
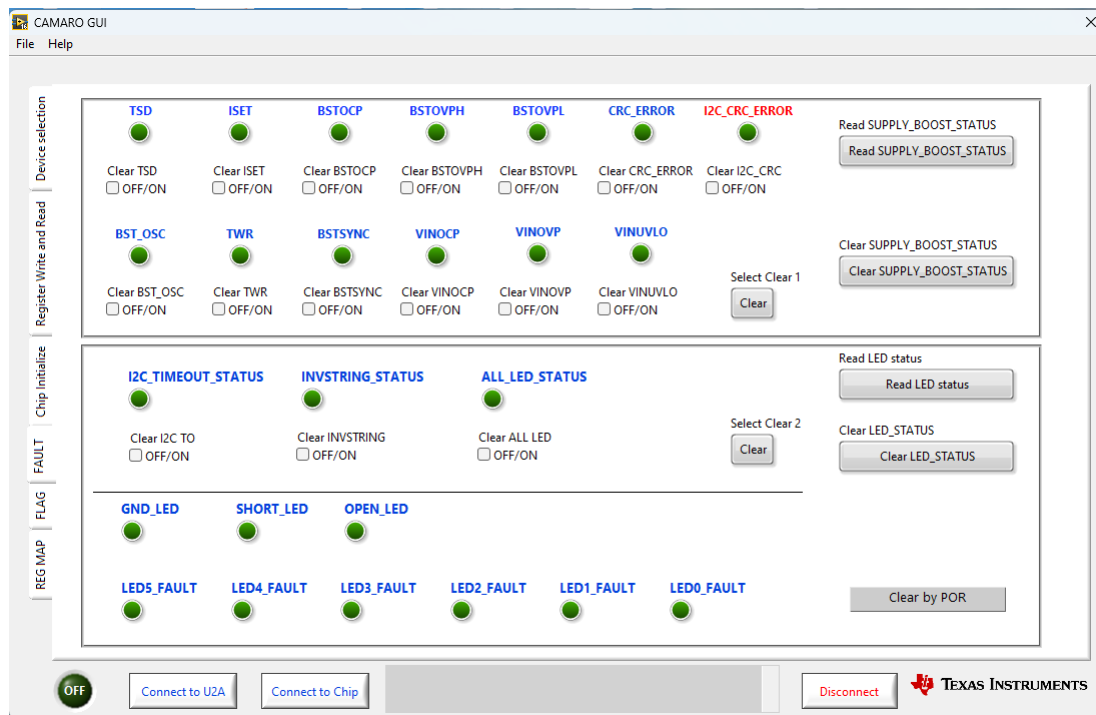
Figure 2-6. LP8870Q1EVM Monitor Faults Page

2.6.2 Flag Page

From the Flag Page (see Figure 2-7), the user can read back the flag register values and corresponding device status.

Click the Read button to get the target value from the chip.

Figure 2-7. LP8870Q1EVM Flag Page

3 LP8870Q1EVM Board Layout
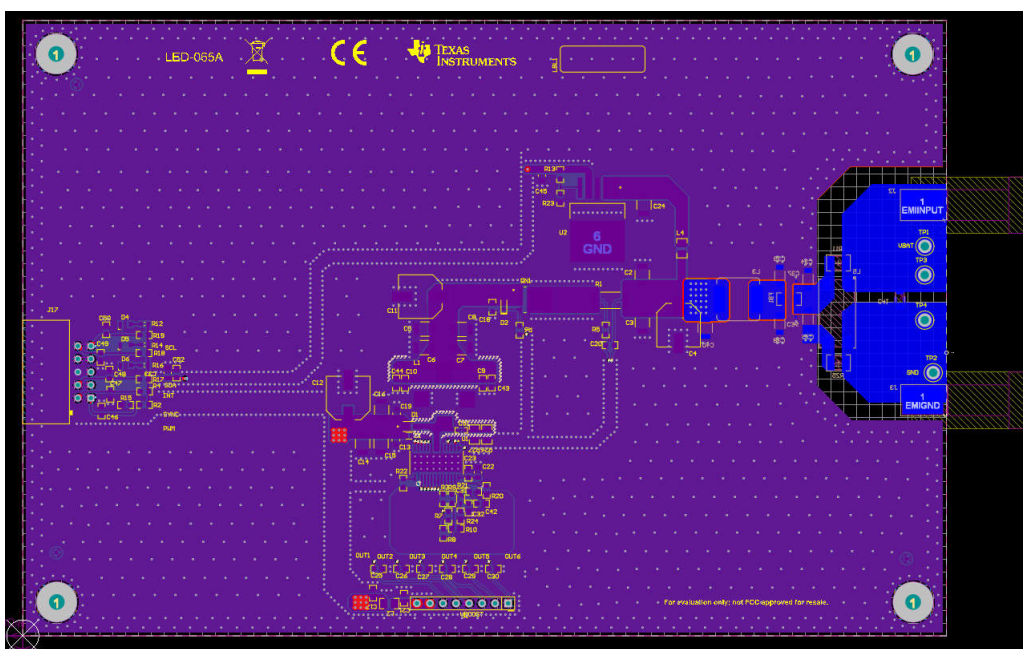
and illustrate the EVM board layout.
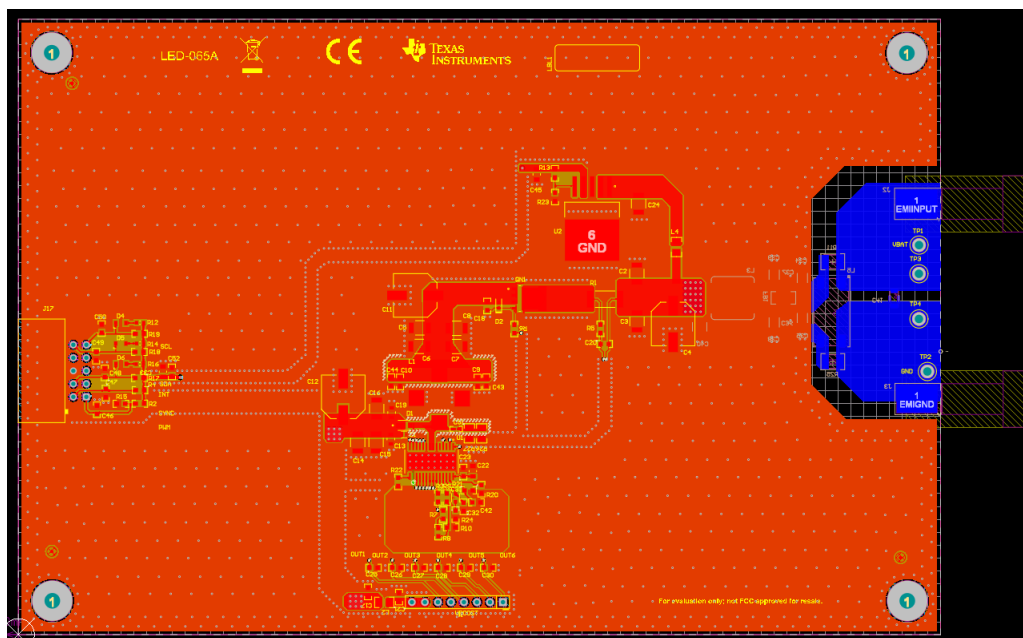
Figure 3-1. LP8870Q1EVM Layout - Top

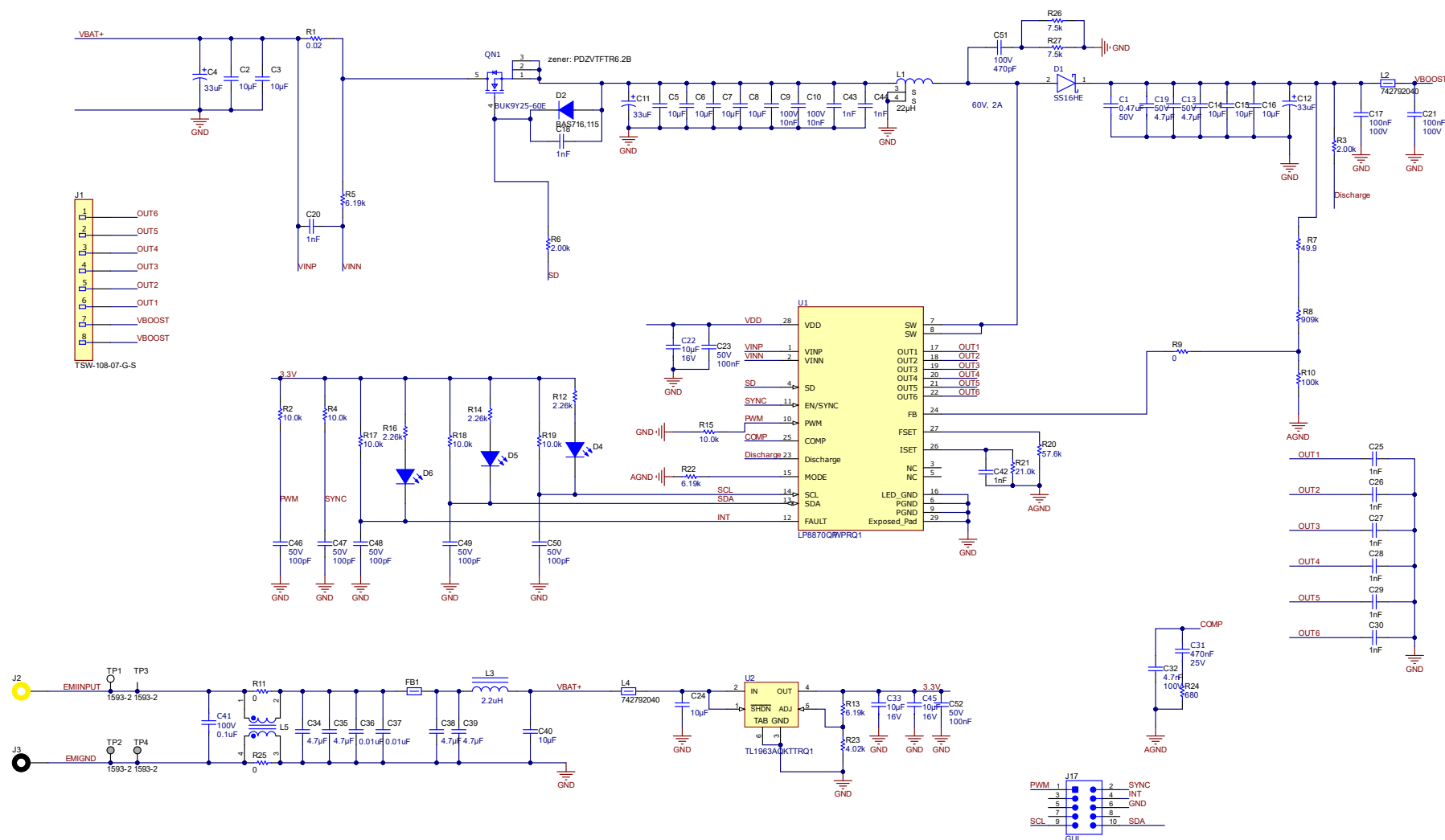**Figure 3-2. LP8870Q1EVM Layout - Bottom**

4 LP8870Q1EVM Schematic

Figure 4-1 shows the LP8870Q1EVM schematic.

Figure 4-1. LP8870Q1EVM Schematic

5 LP8870Q1EVM Bill of Materials

Table 5-1 lists the bill of materials for the LP8870Q1EVM.
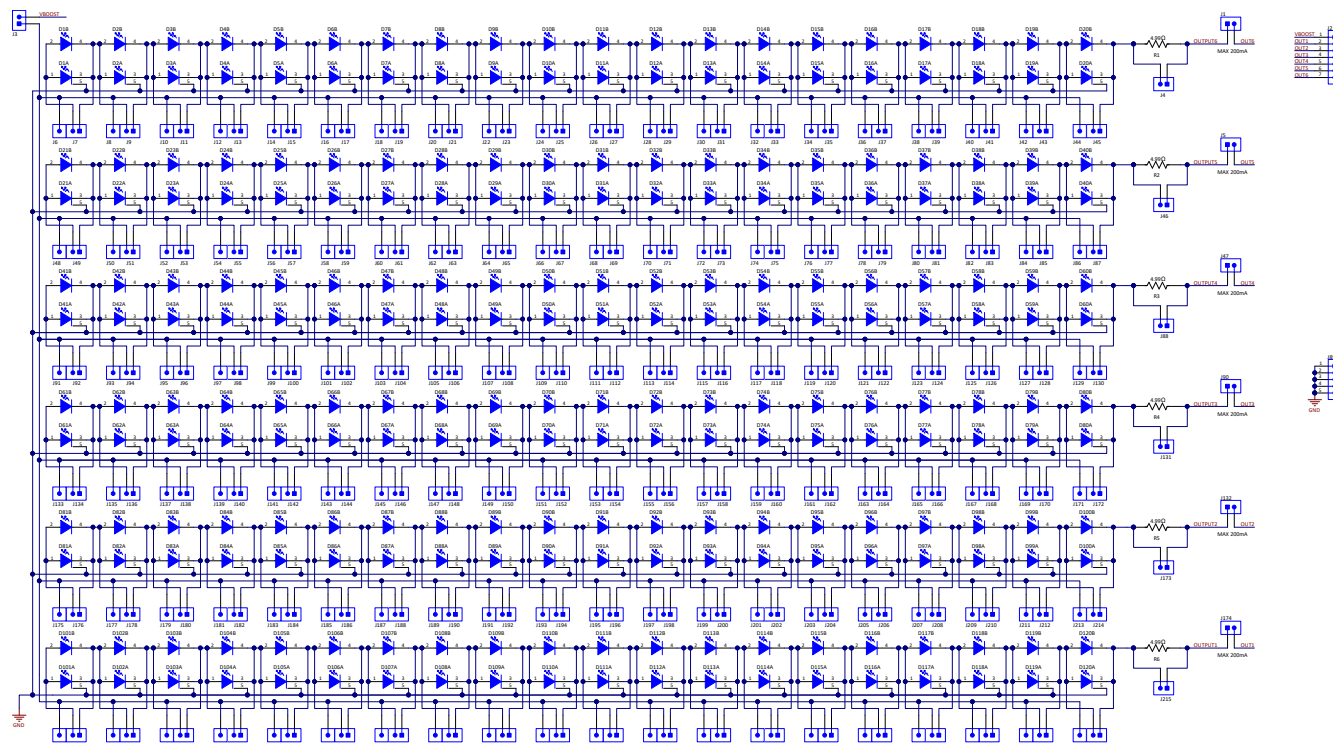
Table 5-1. LP8870Q1EVM Bill of Materials

Designator	QTY	Description	Part Number	Manufacturer
!PCB	1	Printed Circuit Board	LED-065	Any
D4, D5, D6	3	LED, Super Red, SMD, 2.2x1.3x1.4mm	VLMS20J2L1-GS08	Vishay-Semiconductor
J1	1	Header, 100mil, 8x1, Gold, TH	TSW-108-07-G-S	Samtec
L5	1	Coupled inductor, 9µH, A, 0.0036Ω, SMD, 12.9x6.6mm	PLT10HH501100PNL	MuRata
L3	1	Inductor, Shielded, Powdered Iron, 2.2µH, 10.5A, 0.0137Ω, SMD, 322x158x322mil	IHLP3232DZER2R2M01	Vishay-Dale
C36, C37	2	Capacitor, ceramic, 0.01µF, 50 V, +/- 10%, C0G/NP0, 0402	GCM155R71H103KA55D	MuRata
C51	1	Capacitor, ceramic, 470pF, 100 V, +/- 10%, X7R, 0402	GRM155R72A471KA01D	MuRata
C1	1	Capacitor, ceramic chip multilayer, for General Purpose, 0402, 0.47µF, X5R, 15%, 10%, 50V	GRM155R61H474KE11D	Murata
C31	1	Capacitor, ceramic, 0.47µF ±10% 25V, X7R 0603 (1608 Metric)	885012206075R	Wurth Electronics
C9, C10	2	Capacitor, ceramic, 0.01µF, 100V, ±10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R72A103KA37J	MuRata
C23, C52	2	Capacitor, ceramic, 0.1µF, 50V, ±10%, X7R, AEC-Q200 Grade 0, 0603	06035C104K4Z4A	AVX
C17, C21	2	Capacitor, ceramic, 0.1µF, 100V, ±10%, X7R, AEC-Q200 Grade 1, 0603	HMK107B7104KAHT	Taiyo Yuden
C46, C47, C48, C49, C50	5	Capacitor, ceramic, 100pF, 50V, ± 1%, C0G/NP0, 0603	C0603C101F5GACTU	Kemet
C18, C20	2	Capacitor ceramic, 1000pF, 50V, ±5%, X7R, AEC-Q200 Grade 1, 0603	C0603C102J5RACAUTO	Kemet
C25, C26, C27, C28, C29, C30, C42, C43, C44	9	Capacitor, ceramic, 1000pF, 100V, ±10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E2X7R2A102K080AA	TDK
C32	1	Capacitor, ceramic, 4700pF, 100V, ±10%, X7R, 0603	06031C472KAT2A	AVX
R9	1	Resistor, 0Ω, 1%, 0.1W, AEC-Q200 Grade 0, 0603	RMCF0603ZT0R00	Stackpole Electronics Inc
R3, R6	2	Resistor, 2.00kΩ, 1%, 0.125W, AEC-Q200 Grade 0, 0603	RNCP0603FTD2K00	Stackpole Electronics Inc
R12, R14, R16	3	Resistor, 2.26kΩ, 1%, 0.1 W, AEC-Q200 Grade 0, 063	CRCW06032K26FKEA	Vishay-Dale
R23	1	Resistor, 4.02kΩ, 0.1%, 0.1W, 0603	RT0603BRD074K02L	Yageo America
R5, R13, R22	3	Resistor, 6.19kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW06036K19FKEA	Vishay-Dale
R2, R4, R15, R17, R18, R19	6	Resistor, 10.0kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060310K0FKEA	Vishay-Dale
R21	1	Resistor, 21.0kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060321K0FKEA	Vishay-Dale
R7	1	Resistor, 49.9Ω, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060349R9FKEA	Vishay-Dale
R20	1	Resistor, 57.6kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060357K6FKEA	Vishay-Dale
R10	1	Resistor, 100kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW0603100KFKEA	Vishay-Dale
R24	1	Resistor, 680Ω, 0.1%, 0.1W, 0603	RG1608P-681-B-T5	Susumu Co Ltd

Table 5-1. LP8870Q1EVM Bill of Materials (continued)

Designator	QTY	Description	Part Number	Manufacturer
R8	1	Resistor, 909kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW0603909KFKEA	Vishay-Dale
C13, C19	2	4.7µF ±10% 50V Ceramic Capacitor X7R 0805 (2012 Metric)	C2012X7R1H475K125AC	TDK
C22, C33, C45	3	10µF ±10% 16V Ceramic Capacitor X7R 0805 (2012 Metric)	0805YC106KAT2A	Kyocera AVX
L2, L4	2	Ferrite Bead, 600Ω at 100MHz, 2A, 0805	742792040	Wurth Elektronik
R26, R27	2	Resistor, 7.5kΩ, 5%, 0.125W, AEC-Q200 Grade 0, 0805	CRCW08057K50JNEA	Vishay-Dale
J2	1	BANANA JACK, 15A, Insulated, Nylon,Yellow	108-0907-001	Cinch Connectivity
C41	1	Capacitor, ceramic 0.1µF ±10% 100V, X7R 1206 (3216 Metric)	GCM319R72A104KA37D	Murata
C34, C35, C38, C39	4	Capacitor, ceramic, 4.7µF, 50V, ±10%, X7R, AEC-Q200 Grade 1, 1206	CGA5L3X7R1H475K160AE	TDK
FB1	1	Ferrite Bead, 50Ω at 100MHz, 12A, 1206	BLM31SN500SZ1L	MuRata
C2, C3, C5, C6, C7, C8, C14, C15, C16, C24, C40	11	Capacitor, ceramic, 10µF, 75V, ±20%, X7R, AEC-Q200 Grade 1, 1210	CGA6P1X7R1N106M250AC	TDK
R11, R25	2	Resistor, 0, 1%, 0.75W, AEC-Q200 Grade 0, 1210	CRCW12100000Z0EAHP	Vishay-Dale
R1	1	Resistor, 0.02, 1%, 3W, 2512	CRA2512-FZ-R020ELF	Bourns
J3	1	Standard Banana Jack, Insulated, Black	6092	Keystone
J17	1	Header(shrouded), 2.54mm, 5x2, Gold, R/A, TH	SBH11-PBPC-D05-RA-BK	Sullins Connector Solutions
U1	1	LP8870QPWPRQ1	LP8870QPWPRQ1	Texas Instruments
TP1, TP2, TP3, TP4	4	Terminal, Turret, TH, Double	1593-2	Keystone
U2	1	Single Output Fast Transient Response LDO, 1.5A, Adjustable 1.21 to 20V Output, 2.1 to 20V Input, 5-pin DDPAK (KTT), -40 to 125°C, Green (RoHS and no Sb/Br)	TL1963AQKTTRQ1	Texas Instruments
QN1	1	N-Channel 60V 34A (Tc) 65W (Tc) Surface Mount LFPAK56, Power-SO8	BUK9Y25-60E	Nexperia
FID1, FID2, FID3	3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A
LBL1	1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
H1, H2, H3, H4	4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B&F Fastener Supply
L1	1	Inductor, Shielded, 22µH, 4.1A, 0.07544Ω, AEC-Q200 Grade 0, SMD	IHLE4040DDER220M5A	Vishay-Dale
C4, C11, C12	3	Capacitor, aluminum, 33µF, 63V, ±20%, 0.65Ω, AEC-Q200 Grade 2, SMD	EEE-FK1J330P	Panasonic
D1	1	Diode Schottky 60V 1A Surface Mount SOD-323HE	SS16HE	ON Semiconductor
D2	1	Diode, Switching, 75V, 0.2A, SOD-523	BAS716,115	Nexperia
H5, H6, H7, H8	4	Standoff, Hex, 0.5"L #4-40 Nylon	1902C	Keystone

6 LED Load Board

An LED load board LP886X-LEDLOAD-EVM is included in the EVM kit. The LED board is intended to be used as the load for LED driver 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). The initial setting on the board is 8 LEDs in series per string. Cree XLamp ML-C LEDs with maximum current of 350mA (for parallel use) and maximum forward voltage of 3.4V at 100mA (3.2V typical) are used on the board.

Figure 6-1. LP886X-LEDLOAD-EVM Schematic

Table 6-1. LP886X-LEDLOAD-EVM Bill of Materials

Designator	QTY	Description	Part Number	Manufacturer
!PCB1	1	Printed Circuit Board	PSIL110	
D1…D120	120	LED XLAMP COOL WHITE 6500K 4SMD	MLCAWT-A1-0000-000XE1	Cree Inc.
H1, H2, H3, H4	4		NY PMS 440 0038 PH	B&F Fastener Supply
H5, H6, H7, H8	4	Standoff	1902C	Keystone
H9, H10, H11, H12	4		4802	Keystone
H13	1	Gray smoked plexiglass, 0.125" THK. Must comply with REACH directive. Must meet or exceed UL94-V0, 7.53" X 4" X 0.125"	MCH050	
J7, J9...J43, J45; J49, J51...J85, J87; J92, J94...J128, J130; J134, J136...J170, J172; J176, J178...J212, J214; J217, J219...J253, J255; J1, J3, J4, J5, J46, J47, J88, J90, J131, J132, J173, J174, J215	133	Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	Samtec
J2	1	Header, 100mil, 7x1, Gold, TH	TSW-107-07-G-S	Samtec
J6, J8...J42, J44; J48, J50...J84, J86; J91, J93...J127, J129; J133, J135...J169, J171; J175, J177...J211, J213; J216, J218...J252, J254	120	Header, 100mil, 1pos, Gold, TH, Testpoint	TSW-101-07-G-S	Samtec
J89	1	Header, 100mil, 5x1, Gold, TH	TSW-105-07-G-S	Samtec
R1, R2, R3, R4, R5, R6	6	Res Thick Film 1206 4.99 Ohm 1% 0.75W(3/4W) ±100ppm/C Pad SMD Automotive T/R	CRCW12064R99FKEAHP	Vishay Dale
SH-J1...SH-J19	19	Shunt, 100mil, Flash Gold, Black	SPC02SYAN	Sullins Connector Solutions
FID1, FID2, FID3	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A

7 Additional Information

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けて

いないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの

措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・イ

ンスツルメンツ株式会社

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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.

5.   *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6.   *Disclaimers:*

6.1   EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

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7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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