

User's Guide

LP5860 Evaluation Module



ABSTRACT

This user's guide describes the characteristics, setup, and usage of the LP5860 evaluation module (EVM). The LP5860EVM helps the user evaluate the features of the Texas Instruments LP5860 LED matrix driver, which integrates 11 scan switches and 18 constant current sinks. This user's guide includes hardware setup instructions, graphical user interface (GUI) instructions, printed-circuit board (PCB) layout drawings, a schematic diagram, and a bill of materials.

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Trademarks

All trademarks are the property of their respective owners.

1 Introduction

The LP5860EVM is used to evaluate the characteristics, operation, and usage for LED matrix driver LP5860. The LP5860 device is a high performance and small size solution, which integrates 18 constant current sinks with 11 switching MOSFETs, to drive up to 198 LED dots or 66 RGB LED pixels. Every LED dot is supported by 8-bit analog dimming and 8-bits or 16-bits configurable PWM dimming methods, which enable smooth and audible-noise-free dimming control.

This document covers following topics:

- [How to set up the LP5860EVM hardware](#)
- [How to use the LP5860 GUI to illuminate LEDs](#)
- [Design resources for the LP5860EVM](#)

The LP5860EVM kit includes the following materials and is illustrated in [Figure 1-1](#).

- LP5860 evaluation module
- USB2ANY interface adapter with ribbon cables and USB cable

Full functions for the LP5860, the performance with RGB LED matrix, and some simple animation effects can be easily verified through this kit.

The LP5860EVM can be converted for testing the LP5868 and LP5866, which are from the same device family, by removing the factory-installed device (U1) and replacing it with the LP5868 or LP5866 counterpart. When testing the LP5868 or LP5866 device, select the corresponding tag from the menu on the GUI start page to start evaluation.

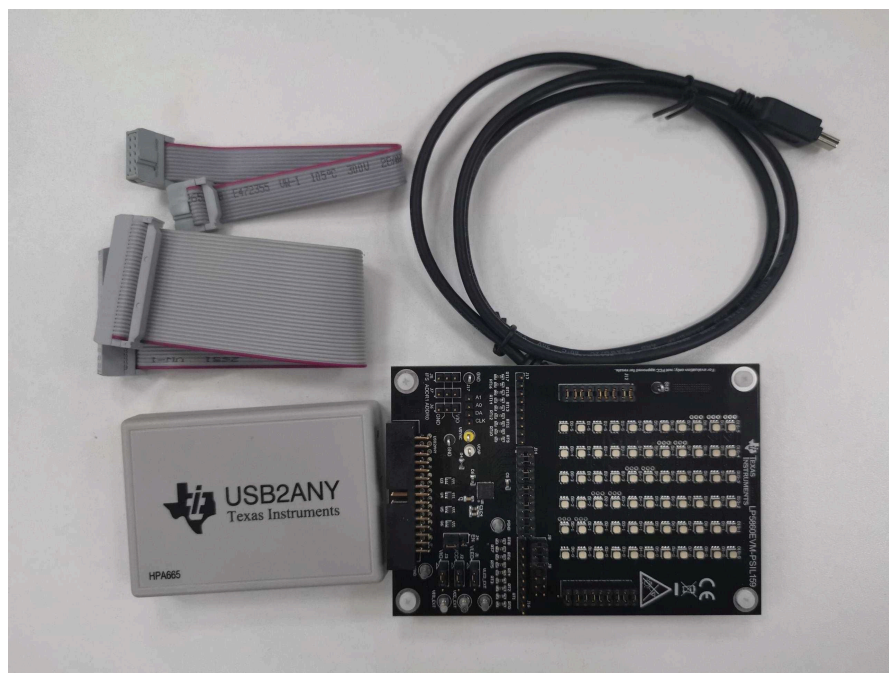


Figure 1-1. LP5860EVM Kit

2 Hardware and Software Preparation

This following chapters describe how to set up the LP5860EVM and GUI properly. Items from the following list are required to begin evaluating the LP5860:

- Computer
- LP5860EVM kit hardware
- LP586x GUI software

2.1 Hardware Setup

In the default jumper setting, the board can be evaluated by USB power directly and does not need an external power supply. Setup connection is demonstrated in [Figure 2-1](#). The setup procedure follows:

1. Connect the USB2ANY with the LP5860EVM using the 30-pin ribbon cable
2. Plug the USB cable into the USB port on the computer

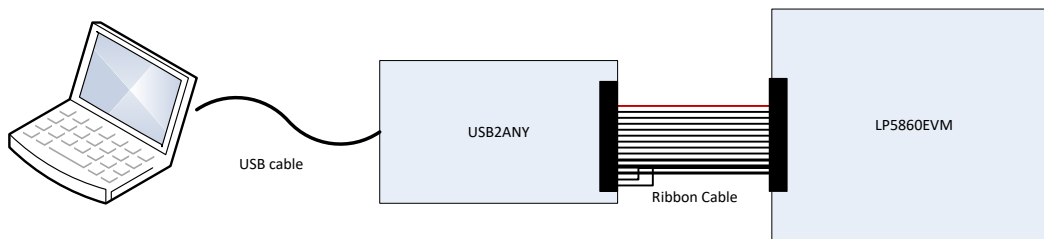


Figure 2-1. Hardware Connection

[Figure 2-2](#) shows the default jumper settings.

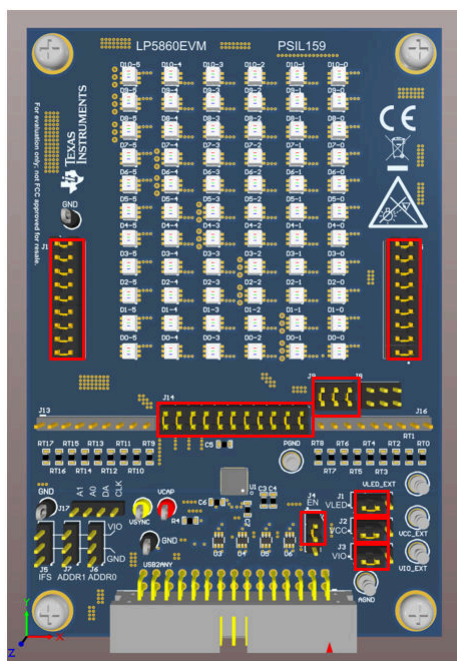


Figure 2-2. Default Jumper Setting

If maximum current is set above 20 mA, an external VLED supply is recommended during evaluation, since the USB can only provide around 400-mA current. The setup procedure follows:

1. Connect the USB2ANY to the LP5860EVM using the 30-pin ribbon cable
2. Connect a 5-V external power supply to the VLED_EXT terminal (see [Figure 2-3](#)) and connect the switching jumper (J1) to another side
3. Plug the USB cable into the USB port on the computer

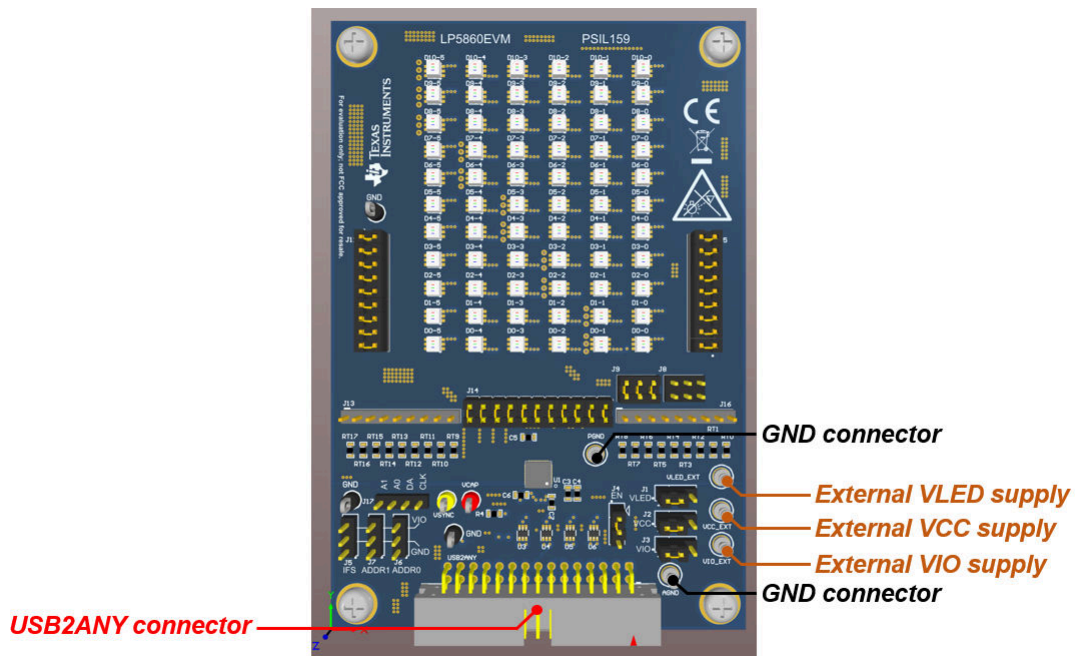


Figure 2-3. Key External Connectors

2.2 Software Setup

Download the LP586x GUI installation package from the [LP5860 product folder](#). Follow the setup wizard to install the LP586x GUI successfully, see [Figure 2-4](#).

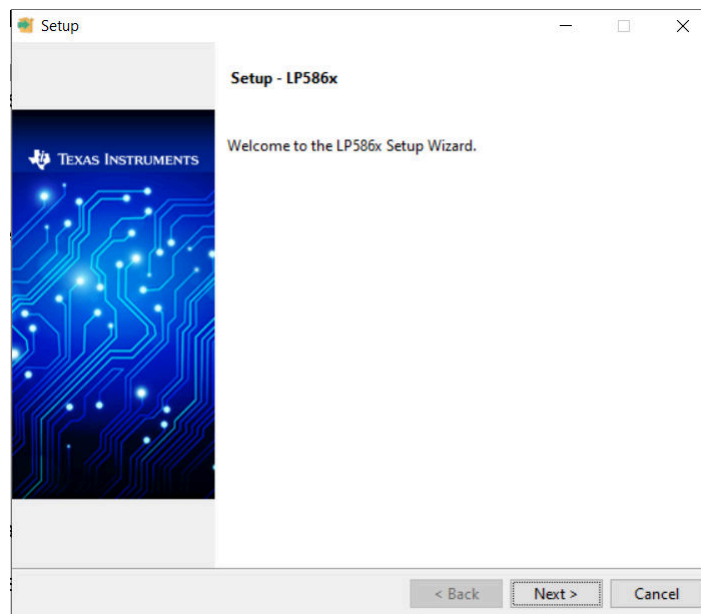


Figure 2-4. GUI Installation

3 Graphical User Interface (GUI) Guidance

The LP586x GUI is a convenient tool to control and evaluate all functions of LP586x family. Open the LP586x.exe file and plug the USB cable into the USB port of the computer. The GUI automatically connects with the LP5860EVM. **Figure 3-1** illustrate the status bar showing the connection status at the bottom of GUI. *Hardware Connected* shows in the status and the indicator in the USB2ANY stops blinking when successfully connected. Click the connection button to connect or disconnect the LP5860EVM with the GUI.



Figure 3-1. Status Bar

If the USB2ANY has not been previously used to evaluate the LP5860EVM, a correlating firmware (FW) version must be updated into USB2ANY. Following the instructions in the GUI when plugging in the USB cable can update the FW successfully, see **Figure 3-2**.

Update Firmware

The device is using firmware version 2.8.2.0. Recommended firmware version is 3.0.4.0.

- Step 1: **UPDATE** Firmware
- Step 2: After firmware update succeeds, please click Finish

SKIP UPDATE

Update Firmware

The device is using firmware version 2.8.2.0. Recommended firmware version is 3.0.4.0.

- Step 1: **UPDATE** Firmware
- Step 2: After firmware update succeeds, please click Finish

i Update succeeded

FINISH

Figure 3-2. Firmware Update

3.1 Start Page

Different device variants in the LP586x family are selected from the *Start Page*. To begin evaluation, select the LP5860 tab then click the *EXPLORE* button to begin evaluation, see **Figure 3-3**.

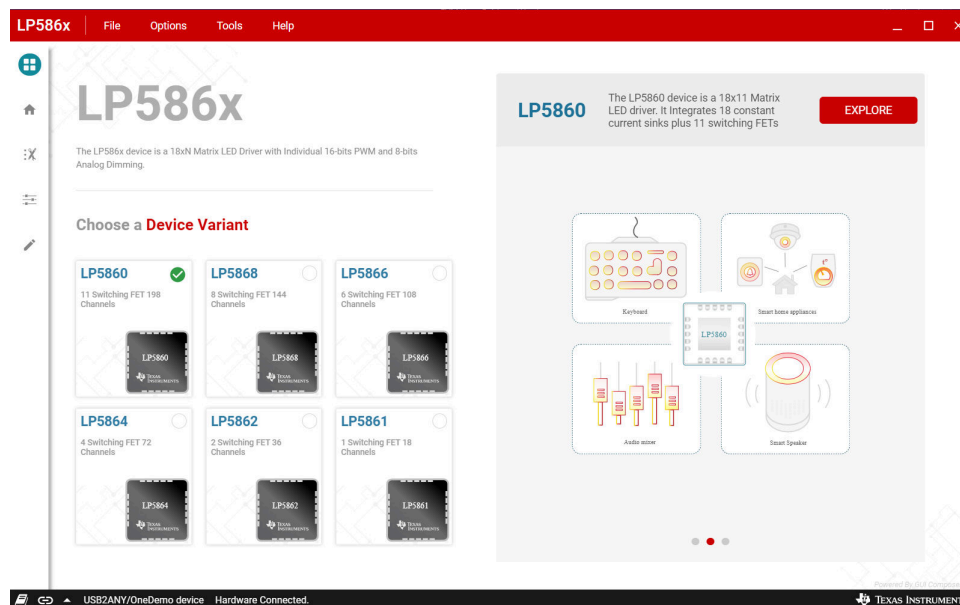


Figure 3-3. Start Page

3.2 Home Page

Figure 3-4 shows the interface protocol selected in the *Home* page. Click the *Configure & Connect* button to connect the USB2ANY with the LP5860EVM. The I2C protocol with 0x10 chip address is the default. Other addresses with 0x11, 0x12, and 0x13 and SPI are also available.

Click the *START* button below the *LED CONTROL* block to set current and PWM for every individual LED. Other configurable functions can also be set through graphical buttons in this page. Predefined animations are performed with the *PATTERN* page while every individual register is configured in the *REGISTER MAP* page.

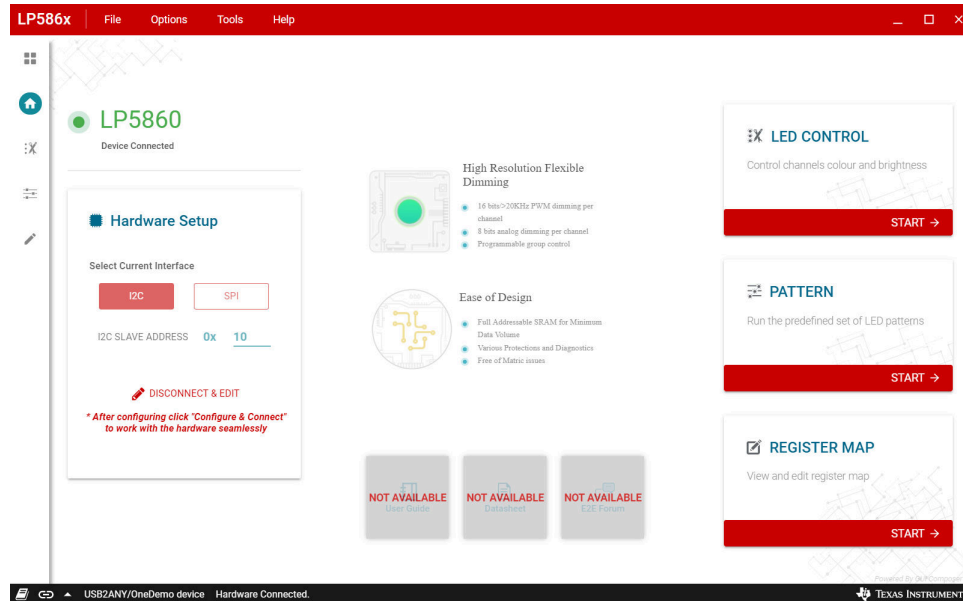


Figure 3-4. Home Page

3.3 LED Control Page

Set the color and brightness for every RGB LED pixel in the LED control page. To illuminate one LED with default configuration, use the following procedure and see Figure 3-5.

1. Click the *Enable* button to enable the LP5860 in the software
2. Select the LED you want to control
3. Set a color for this LED
4. Click the *VSync* button to active this LED (The default is Mode 3 so the SYNC signal is necessary).

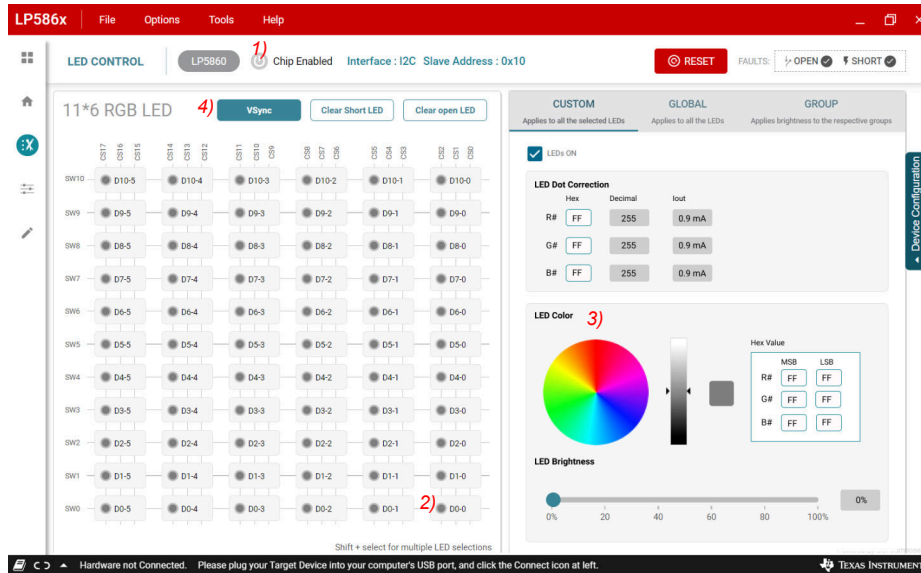


Figure 3-5. LED Control Page and Test Procedure

Device Configuration

To improve performance under different applications, first configure some key settings. Select the *DEVICE CONFIGURATION* button to show the detail setting slide, which is illustrated in Figure 3-6. Maximum current (MC) is set here. If a high maximum current is set, an external VLED supply is recommended. The *Data Refresh Mode* settings determine whether a SYNC signal is required to synchronize the PWM change for every LED dot. The *Max Scan Lines* controls select how many scan lines are active. For more information on the functions for other settings, see the [LP5860 11 × 18 LED Matrix Driver with 8-bit Analog and 8-, 16-bit PWM Dimming Data Sheet](#).

When evaluating matrix-issue free performance, de-ghosting and low brightness compensation are configured here.

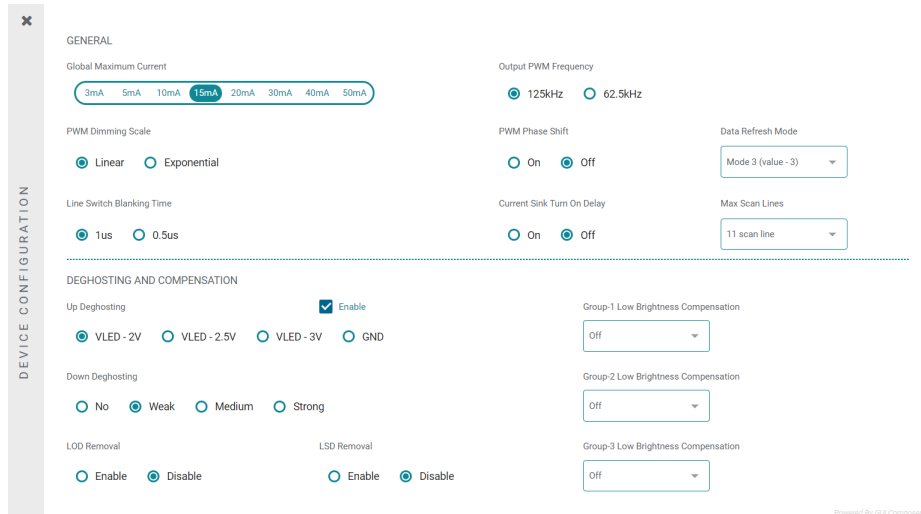


Figure 3-6. Device Configuration

Custom LED Setting

Before setting color and brightness for RGB LED, one or multiple LEDs (Shift + select for multiple LED selections) must first be selected. In the *CUSTOM* tag, set the color in color selector on the right side, see Figure 3-7. Brightness is used to adjust the PWM for all 3 dots in one RGB LED. For some high requirement applications, dot current can adjust white balance for every RGB LED.

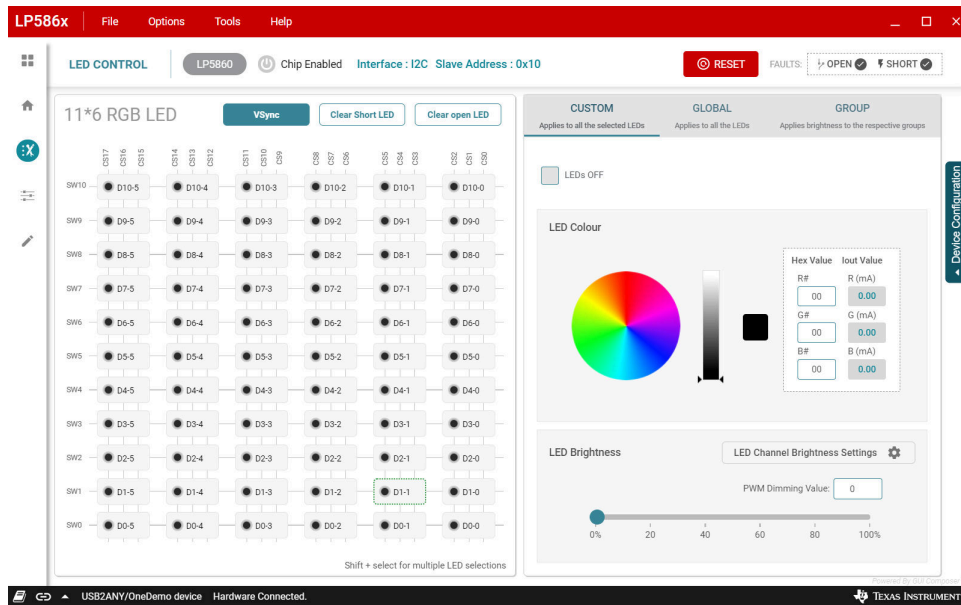


Figure 3-7. Custom Setting

Global and Group Setting

Figure 3-8 illustrates the *GLOBAL* tab where color current for RGB groups and global PWM for all LED dots are set. Figure 3-9 illustrates the *GROUP* tab where every LED dot can be configured to 3 groups arbitrarily, while the PWM for the same group can be changed synchronously.

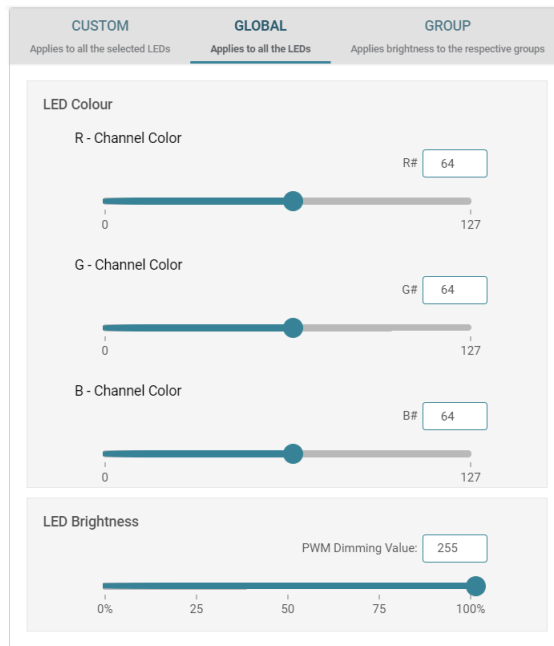


Figure 3-8. Global Setting

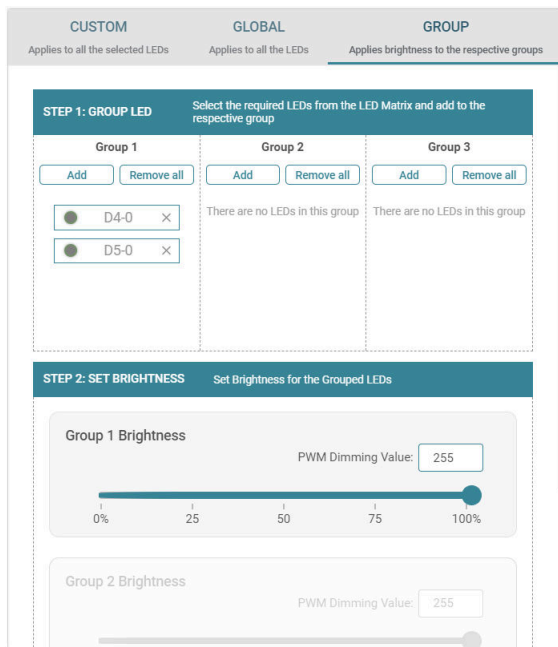


Figure 3-9. Group Setting

Fault Detection

The LP5860 continually detects the status for every LED dot. Once an open or short failure is detected, the fault status is also be monitored on the GUI. Clicking the warning bar near an abnormal LED shows the fault details, as illustrated in [Figure 3-10](#). Clicking the fault summary at the right-top of the GUI shows the summary for all fault status (see [Figure 3-11](#)). The *Clear Short LED* and *Clear open LED* buttons are used to clear related fault flags when the failures are removed.

To have precise detection results, the current for every LED dot must be set above 0.5 mA and the PWM must be set above 25%, due to the parasitic capacitor induced from the LED matrix. A current that is too small leads to abnormal LSD results.

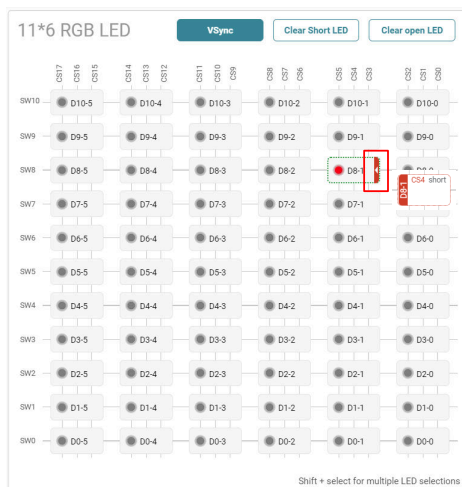


Figure 3-10. Single Fault Alarm

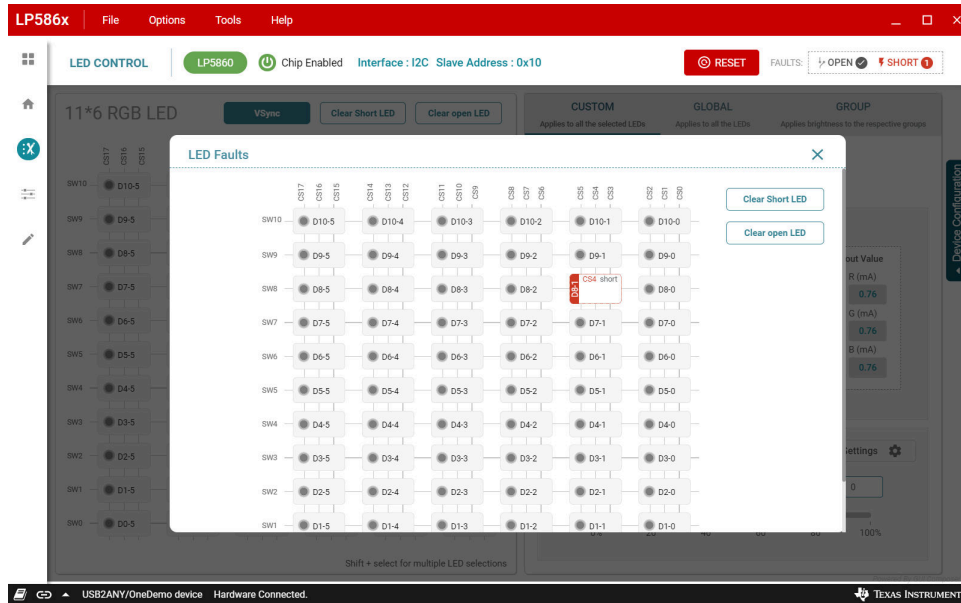


Figure 3-11. Total Fault Summary

3.4 Pattern Page

Six predefined patterns can be performed in pattern page, see in [Figure 3-12](#). Select one pattern and click the *Play* button to display the animation. Speed and color are set at the right side. Before evaluating the patterns, first reset the LP5860EVM board if some values are already set in LED control page.

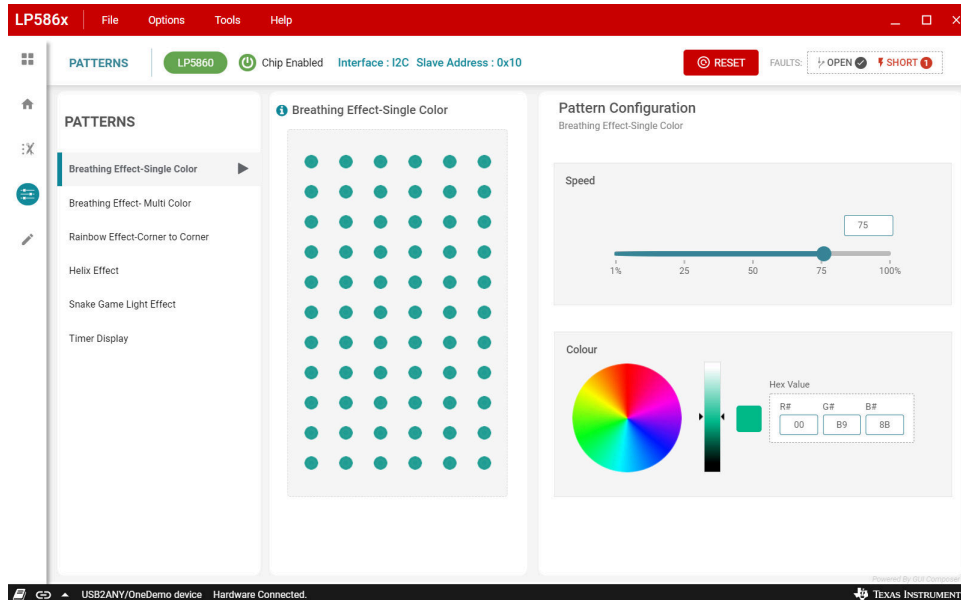


Figure 3-12. Pattern Page

3.5 Register Map Page

Figure 3-13 illustrates how all registers are displayed in the register map page, where register address, value, and description are provided. Modify every register value by writing a HEX value directly into the *Value* column, or by double-clicking the corresponding single bit in the *Bits* column to flip the value. The modified value is effective immediately if *Immediate Write* is selected from the drop-down menu at the top right. When *Deferred Write* is selected, the modified value does not take effect until the user clicks the *WRITE REGISTER* button.

When *Auto Read* is enabled, the value of all registers is read automatically and the interval for every read cycle can also be set. When *Auto Read* is off, click *Read Register* to read the value from the selected register, and click *Read all Registers* to read all registers manually.

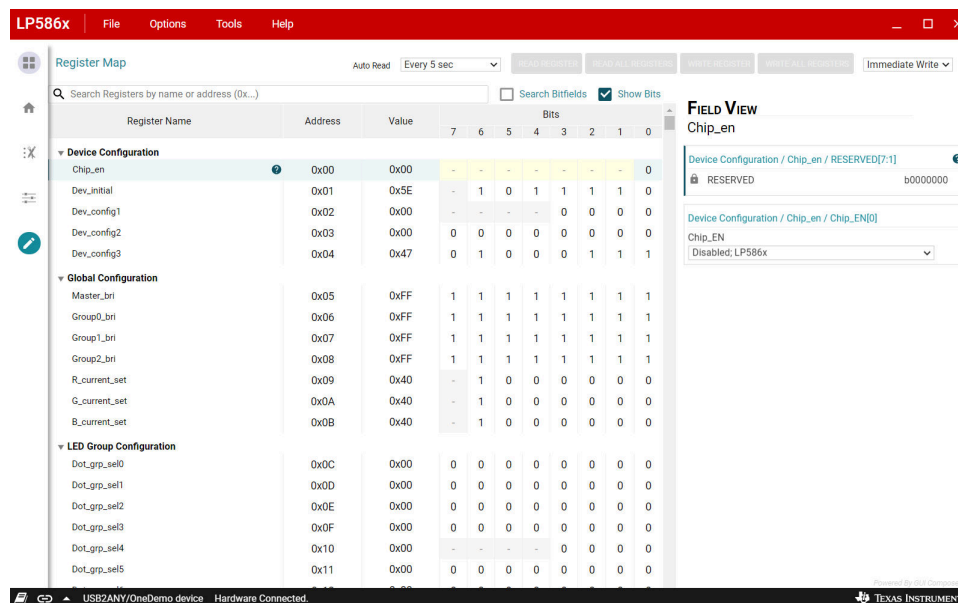


Figure 3-13. Register Map Page

4 LP5860EVM Design Resources

The [layout](#), [schematic](#), and [bill of materials \(BOM\)](#) of the LP5860 EVM board design are included in this section.

4.1 LP5860EVM Layout

Figure 4-1, Figure 4-2, Figure 4-3, and Figure 4-4 demonstrate the LP5860EVM layout images.

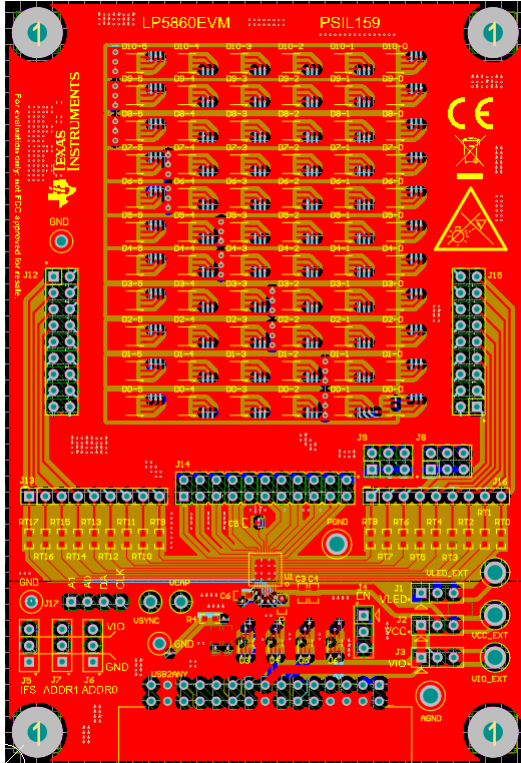


Figure 4-1. LP5860EVM Top Layer

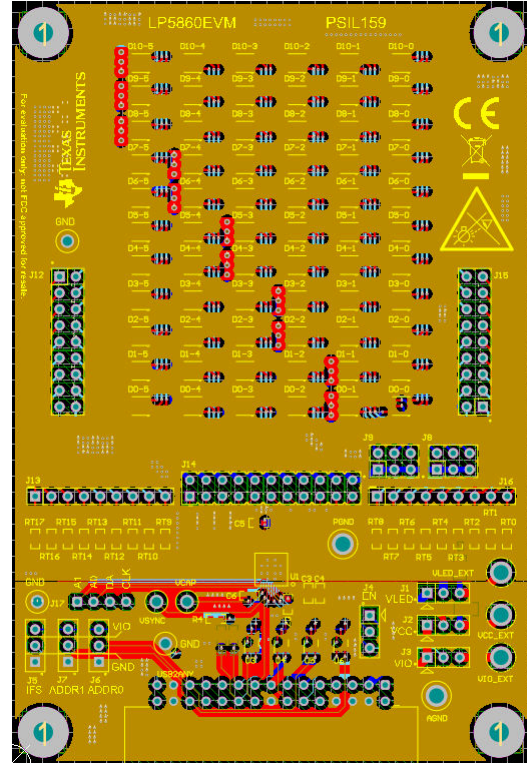


Figure 4-2. LP5860EVM Signal Layer 1

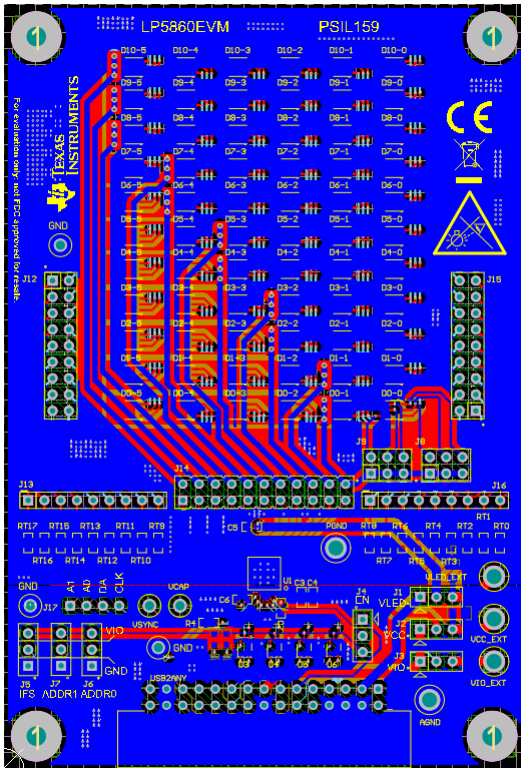


Figure 4-3. LP5860EVM Bottom Layer

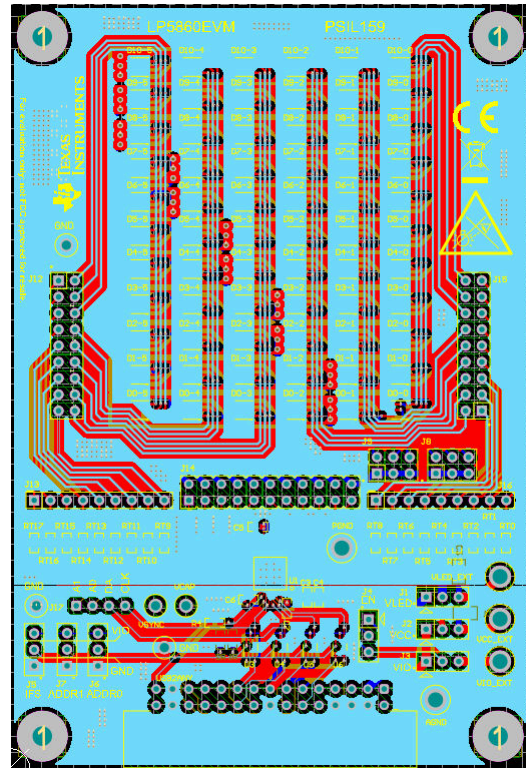


Figure 4-4. LP5860EVM Signal Layer 2

4.2 LP5860EVM Schematic

Figure 4-5 shows the LP5860EVM schematic.

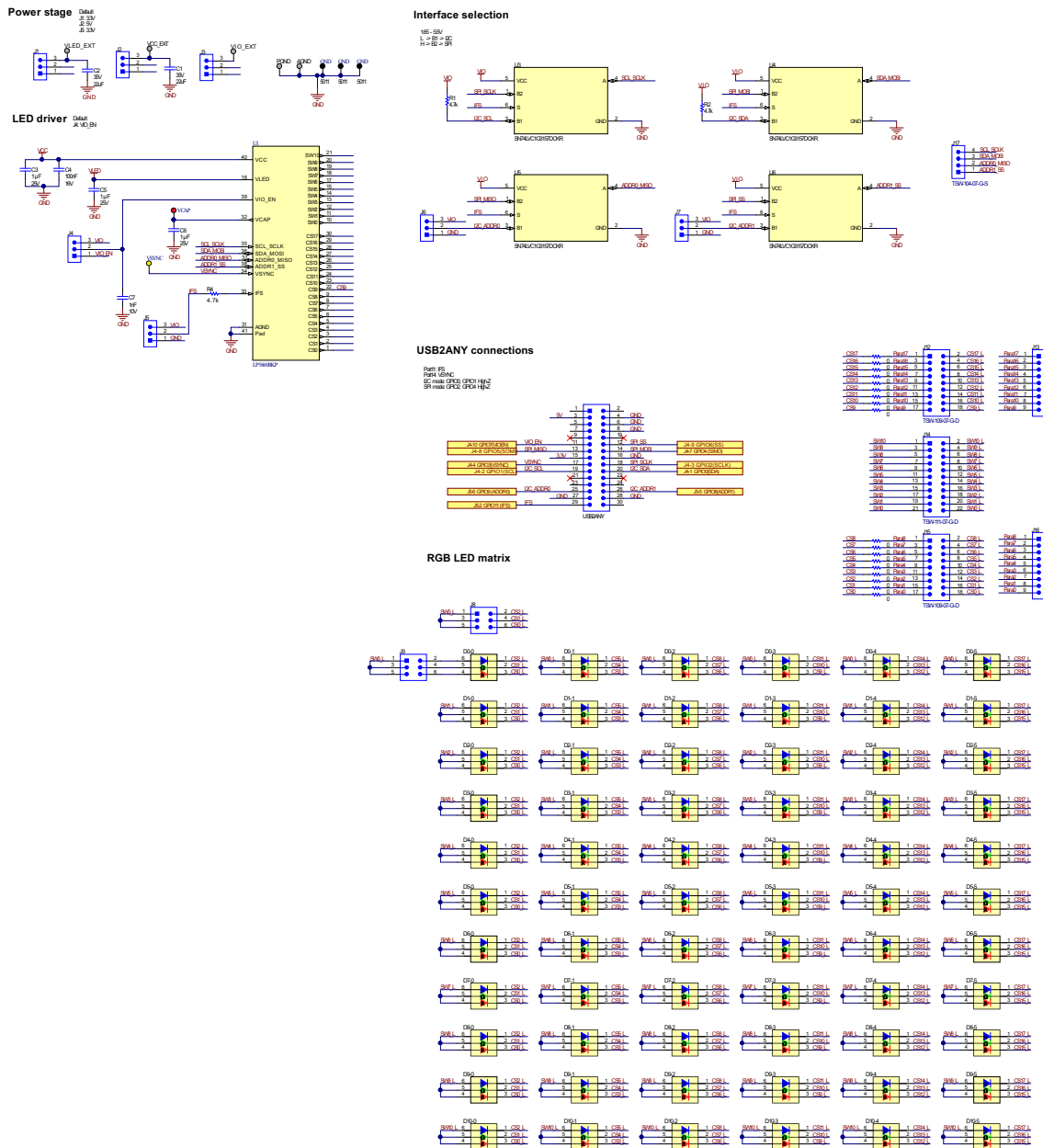


Figure 4-5. LP5860EVM Schematic

4.3 LP5860EVM BOM

Table 4-1 displays the bill of materials (BOM). To download the BOM, see the design files at the LP5860EVM tools page.

Table 4-1. Bill of Materials (BOM)

DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QUANTITY
C1, C2	CAP, CERM, 22 uF, 35 V, ±20%, X5R, 0805	TDK	C2012X5R1V226M125AC	2
C3, C5, C6	CAP, CERM, 1 uF, 25 V, ±10%, X7R, 0603	AVX	06033C105KAT2A	3
C4	CAP, CERM, 0.1 uF, 16 V, ±5%, X7R, 0603	AVX	0603YC104JAT2A	1
D0-0 to D10-5	LED, RGB, SMD	Cree	CLY6D-FKC-CK1N1D1BB7D3D3	66
GND	Test Point, Multipurpose, Black, TH	Keystone	5011	3
H0, H1, H2, H3	'Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH	4
H4, H5, H6, H7	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	4
J1, J2, J3, J4, J5, J6, J7	Header, 100mil, 3x1, Gold, TH	Samtec	TSW-103-07-G-S	7
J8, J9	Header, 100mil, 3x2, Gold, TH	Samtec	TSW-103-07-G-D	2
J12, J15	Header, 100mil, 9x2, Gold, TH	Samtec	TSW-109-07-G-D	2
J13, J16	Header, 100mil, 9x1, Gold, TH	Samtec	TSW-109-07-G-S	2
J14	Header, 2.54 mm, 11x2, Gold, TH	Samtec	TSW-111-07-G-D	1
J17	'Header, 100mil, 4x1, Gold, TH	Samtec	TSW-104-07-G-S	1
R1, R2, R4	'RES, 4.7 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	Vishay-Dale	CRCW06034K70JNEA	3
RT0 to RT17	RES, 0, 5%, 0.1 W, 0603	Yageo	RC0603JR-070RL	18
SH-J1 to SH-J36	Shunt, 100mil, Gold plated, Black	Samtec	SNT-100-BK-G	36
U1	LED matrix driver	Texas Instruments	LP5860RKPR	1
U3, U4, U5, U6	1-Channel, 2:1 Analog Switch, DCK0006A (SOT-SC70-6)	Texas Instruments	SN74LVC1G3157DCKR	4
USB2ANY	Header(shrouded), 2.54mm, 15x2, Gold with Tin tail, R/A, TH	Samtec	'TST-115-04-L-D-RA	1
VCAP	Test Point, Multipurpose, Red, TH	Keystone	5010	1
VSYNC	Test Point, Multipurpose, Yellow, TH	Keystone	5014	1

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 semiconductor 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.
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 - 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/lstds/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/lstds/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.

【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 2 4 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/lstds/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。http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

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.

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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.
 - 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
 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.
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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.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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