

AN-1631 LP55281 Evaluation Kit

1 General Description

The LP55281 is a quad RGB LED driver for handheld devices. It can drive 4 RGB LED sets and a single fun light LED. The boost DC-DC converter drives high current loads with high efficiency. The RGB driver can drive individual color LEDs or RGB LEDs powered from boost output or external supply. Built-in audio synchronization feature allows easy control of LP55281. Small DSBGA package or DSBGAXt package together with minimum number of external components is a best fit for handheld devices. LP55281 has also a LED test feature, which can be used for example in production for checking the LED connections.

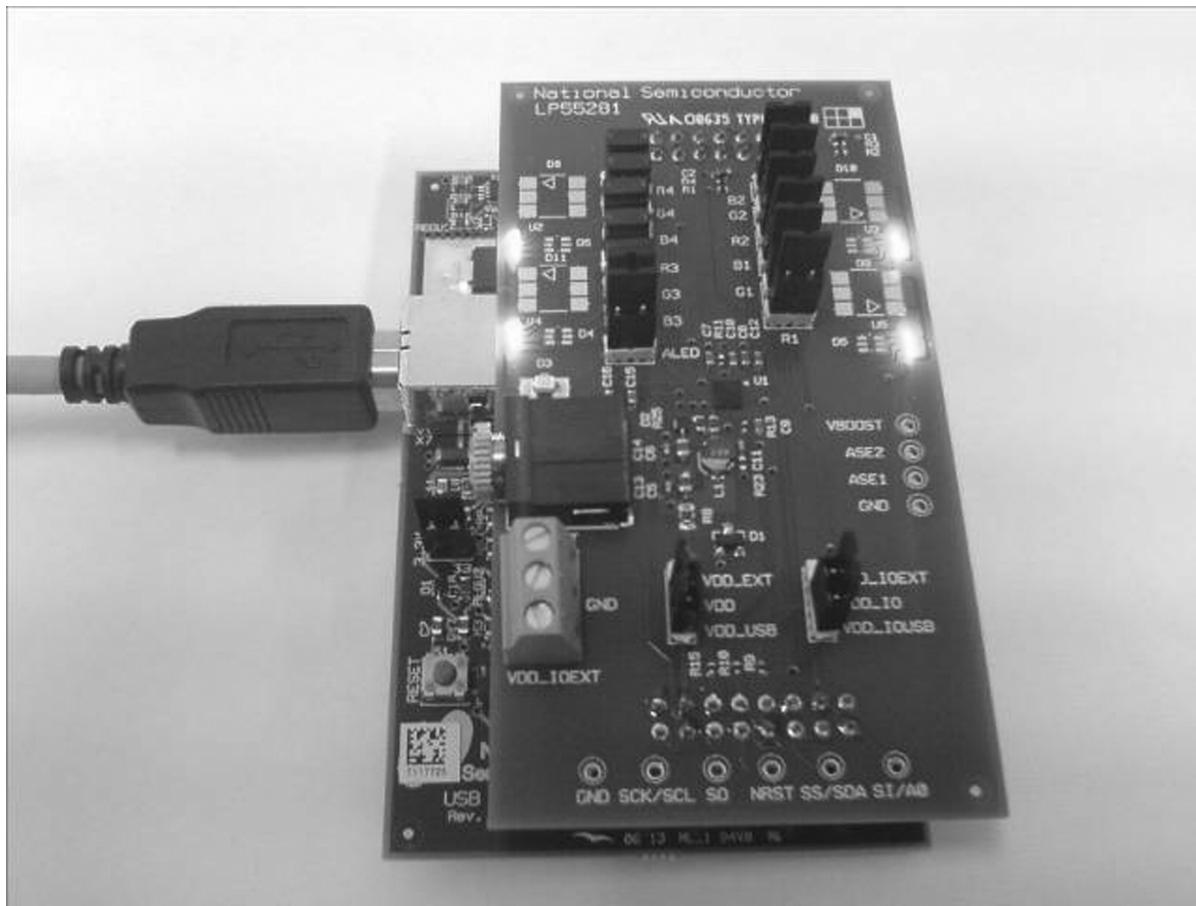


Figure 1. LP55281 Evaluation Board with USB Interface Board

All trademarks are the property of their respective owners.

2 Evaluation Kit Overview

LP55281 Evaluation Kit is based on a modular system, where the actual evaluation board is plugged on top of the PC interface board. The interface operates through the USB port. The kit supports complete functional evaluation of the circuit. The evaluation kit consists of:

- LP55281 evaluation board
- USB interface board
- USB interface cable
- Audio cable and 3.5mm branch plug
- CD including:
 - Evaluation software for PC
 - LP55281 datasheet
 - DSBGA package - YZR0036 Wafer Level Chip Scale Package [SNVA009](#)
 - DSBGAXt package - YPG0036 Wafer Level Chip Scale Package [SNVA131](#)
 - PCB design application note AN1149 ([SNVA021](#))
 - Evaluation kit document (this doc.)

3 Evaluation Software

LP55281 evaluation software and some support files are supplied on the delivery CD together with all available documentation regarding the circuit. You can copy the software and the files to your PC's hard disk. The program and the support files must be in the same folder. The software is started by double-clicking its icon. The software does not require any installation.

This document describes the use of the LP55281.exe program.

The evaluation software is organized in tabs according to the main functions of the chip. On the left side of the tabs, see [Figure 2](#), is shown the entire register map of LP55281. Below the tabs are shown the registers, which are affected by the selected tab. Both register displays reflect immediately the changes you make by clicking the selection boxes or sliders in the tabs. The contents of the tabs should be mostly self-explanatory. One example register settings are included in the delivery CD and they can be loaded from the File/Open menu. You can similarly save your own settings.

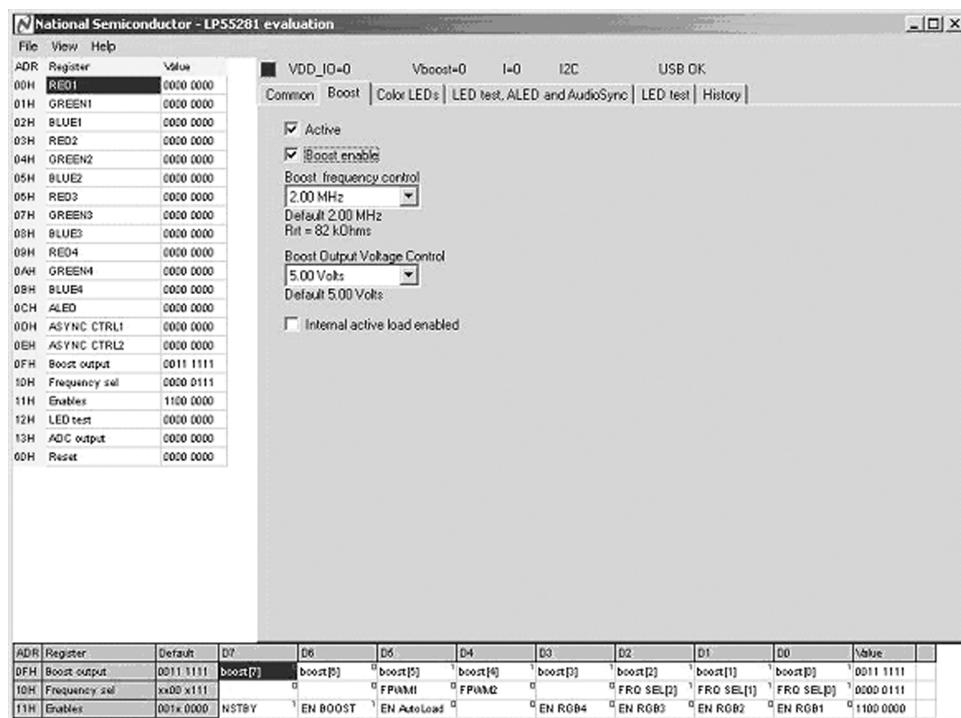


Figure 2. LP55281 Evaluation Software User Interface

3.1 Common Tab

The Common Tab, [Figure 3](#), contains evaluation board control functions. Automatic writing (Update registers immediately) is enabled by default. It means that a write operation is done after every mouse click. If you want to change several settings in one or more tabs and write the register(s) after making all the changes, you can disable automatic writing. Then after the changes you have to initiate the register write by clicking the right mouse key with the cursor in the Register Map area. From the pop-up menu, you can choose to write all registers or just a selected register. The same pop-up lets you write default values to one or all registers and read one or all registers.

Interface can be selected between I²C and SPI. For I²C there are two addresses available, 0x4C and 0x4D. Interface port is always USB.

The regulated voltage supplied from the USB board can be set to 3.0 or 3.9V. The raw voltage from the USB port is 5V and maximum current is 500mA. By changing jumper J1 on the USB board to 5V position the raw voltage is connected to the evaluation board and power from USB board can be maximally used for LEDs.

USB board can measure voltages from the evaluation board. On the LP55281 board the circuit V_{DDIO} and the converter output voltage V_{BOOST} are measured. The current supplied by the USB board to the evaluation board is measured. Measurement is enabled, when the Polling interval in the Common tab is set. Measurement results are shown on top of the window.

Device can be reset by hard reset or by soft reset. Soft reset writes to register 0x60.

By checking the debug mode you can write or read data directly to or from addresses given in Direct Access field.

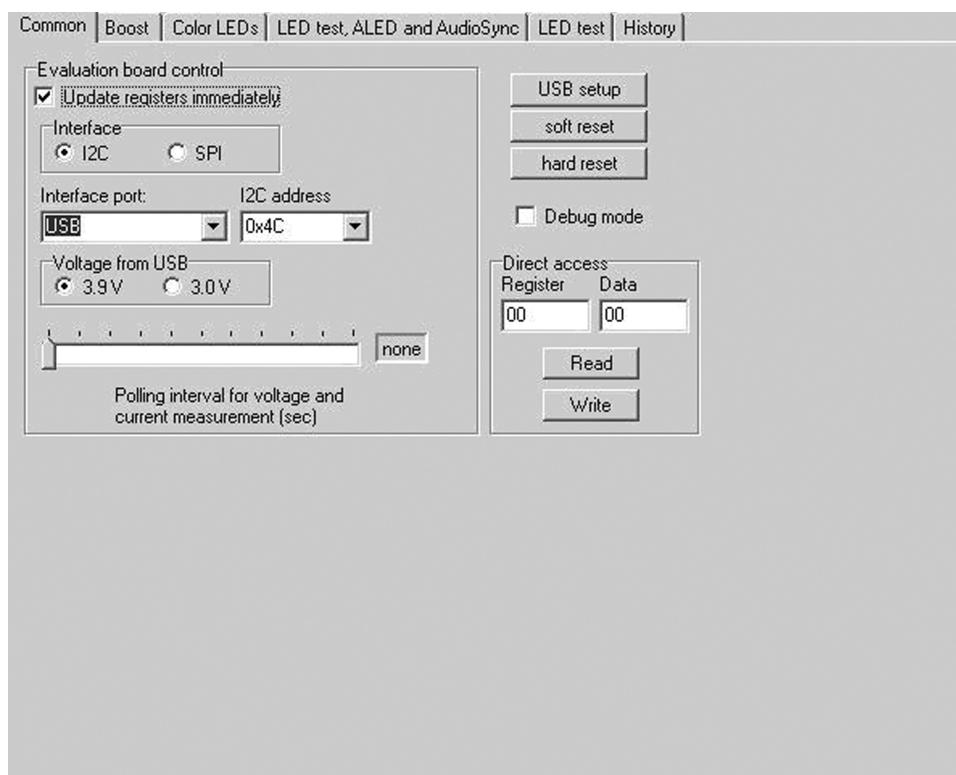


Figure 3. Common Tab

3.2 Boost Tab

Boost is enabled in the Boost tab, [Figure 4](#), by checking the boost enable. The internal active load can be enabled to eliminate pulse skipping of the boost converter. Active load will consume some power when the boost output current is small. It will decrease efficiency at very light load conditions. Also the boost PWM frequency and output voltage is set here. One can also enable the Boost internal active load.

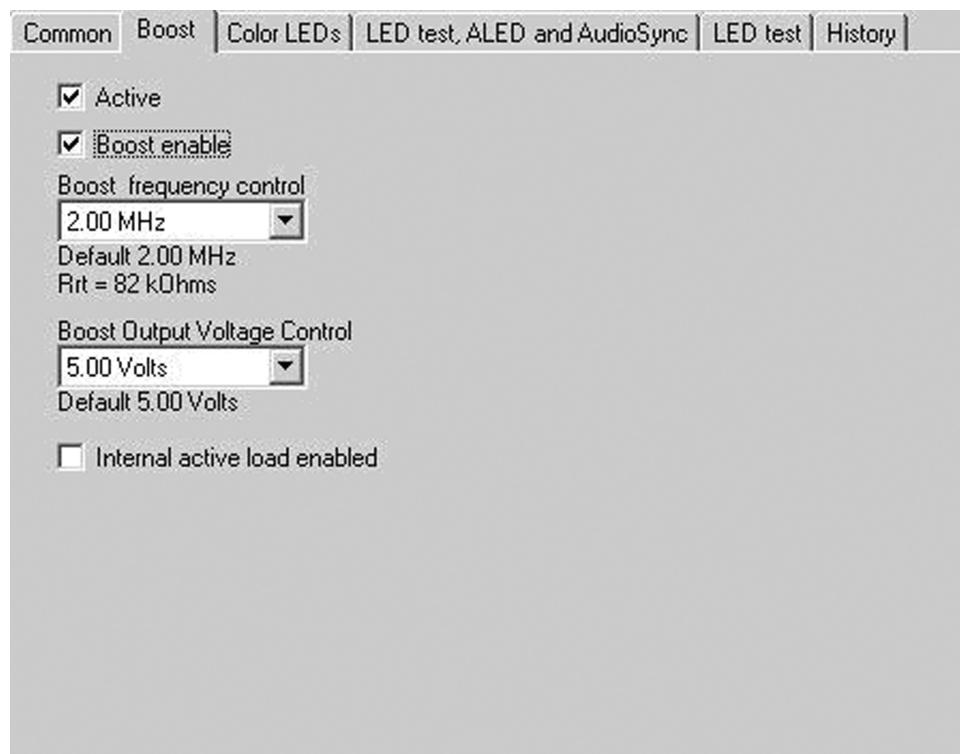


Figure 4. Boost Tab

3.3 Color LEDs Tab

For each RGB LED, there is its own subtab in the Color LEDs tab, [Figure 5](#). In each subtab (RGB1-4) you can enable the RGB, set its PWM with the slider and select its current from the drop-down menu.

The Max current selection can be used to show the required current set resistor value for a given LED current. It doesn't control the current in any way.

The PWM frequency can be controlled in this tab also.

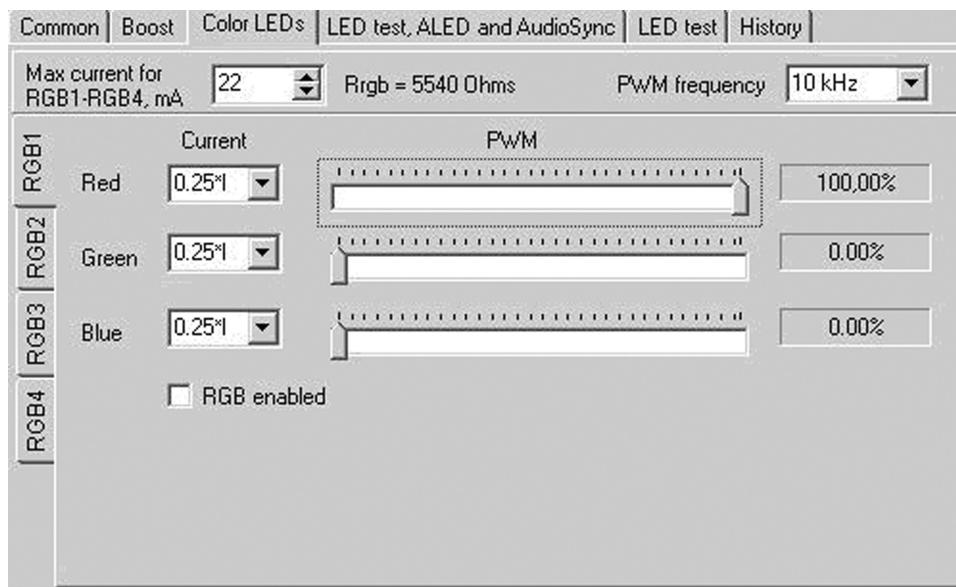


Figure 5. Color LEDs Tab

3.4 LED Test, ALED and Audio Synchronization Tab

In this tab, [Figure 6](#), LED test, ALED and Audio Sync are controlled.

LED test can be done automatically with LED Auto Test by pushing Start button. Test will go thru all the leds and indicate if they are connected or not. LED test can be done by using ADC also. Test is enabled by checking the Test enable box. Desired LED is chosen from pull-down menu and value can be read by pushing the Read ADC button. Note that LED test will not work correctly unless the PWM of the LED under test is 100%. Also the LED current should be at minimum.

ALED current is controlled with Current slider. Below the slider is the Audio synchronization enable box, which sets the ALED into Audio Sync. mode.

With audio synchronization controls, you can enable the Automatic Gain Control, set gain control level manually, select Speed from pull-down menu, select DC filter between 80 Hz or 510 Hz and set the Threshold.

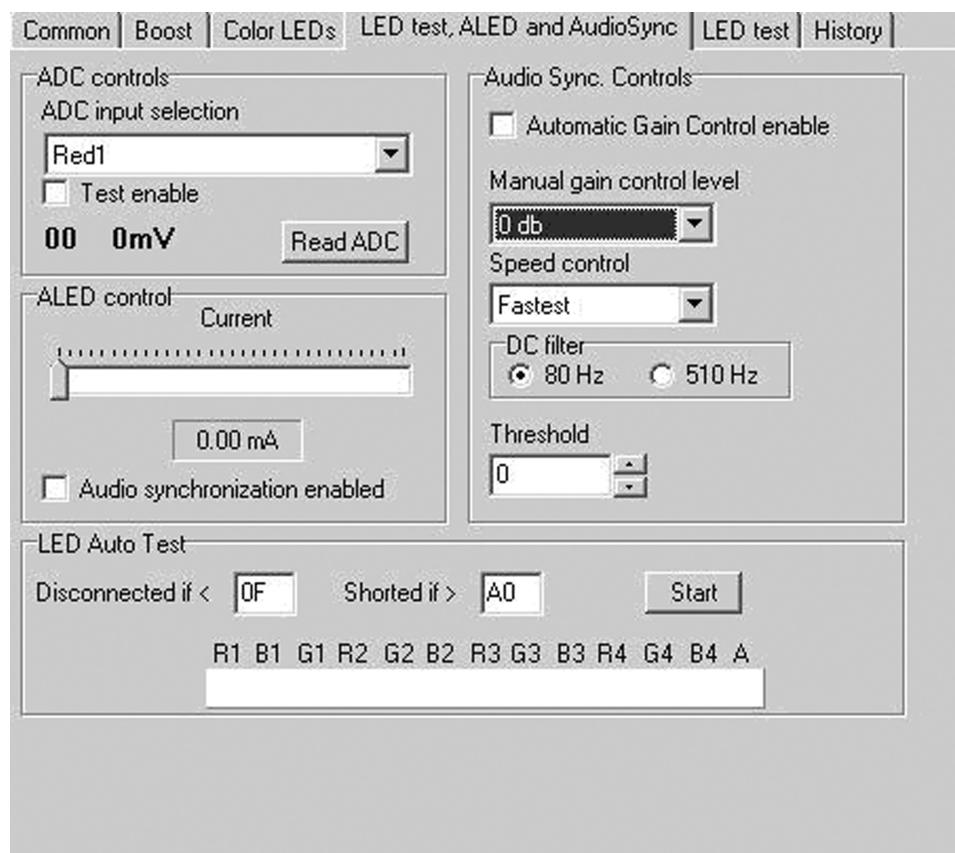
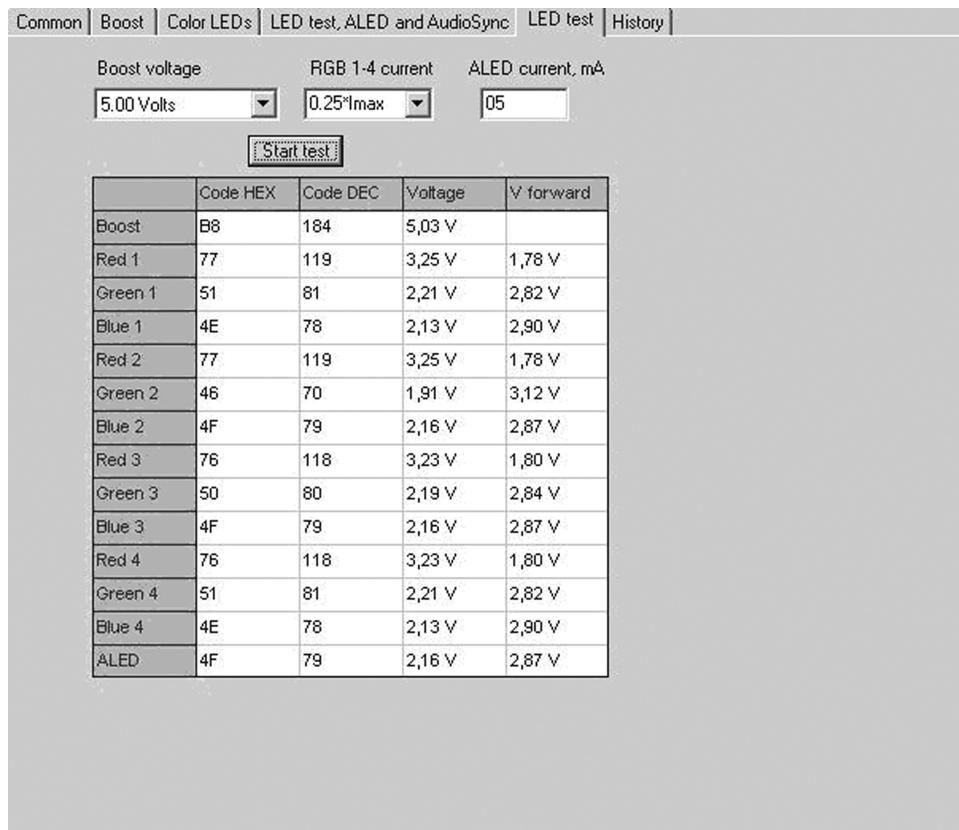


Figure 6. LED Test, ALED and Audio Sync Tab

3.5 LED Test Tab

In LED test tab, [Figure 7](#), all the LEDs are tested with one press of a button. You can set Boost voltage, RGB 1-4 currents and ALED current. After pressing Start, test program automatically tests all the LEDs and Boost voltage. Results are displayed on a table with ADC code, both in HEX and in DEC, voltages and forward voltages for the LEDs.

After performing the LED test, the device is reset and have to be put to active mode again. Also the boost is disabled. The RGB LEDs PWM value is set to 100%, RGB current values, ALED current and Boost voltage are set as you have chosen.



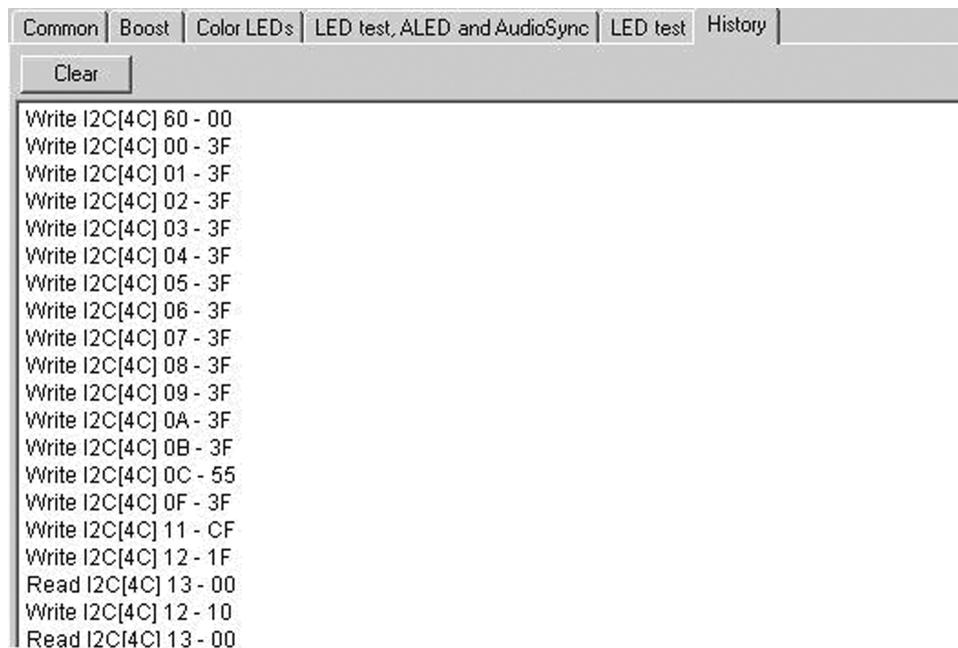
The screenshot shows the 'LED test' tab of the evaluation software. At the top, there are three dropdown menus: 'Boost voltage' set to '5.00 Volts', 'RGB 1-4 current' set to '0.25*I_{max}', and 'ALED current, mA' set to '05'. Below these is a 'Start test' button. The main area is a table with the following data:

	Code HEX	Code DEC	Voltage	V forward
Boost	B8	184	5,03 V	
Red 1	77	119	3,25 V	1,78 V
Green 1	51	81	2,21 V	2,82 V
Blue 1	4E	78	2,13 V	2,90 V
Red 2	77	119	3,25 V	1,78 V
Green 2	46	70	1,91 V	3,12 V
Blue 2	4F	79	2,16 V	2,87 V
Red 3	76	118	3,23 V	1,80 V
Green 3	50	80	2,19 V	2,84 V
Blue 3	4F	79	2,16 V	2,87 V
Red 4	76	118	3,23 V	1,80 V
Green 4	51	81	2,21 V	2,82 V
Blue 4	4E	78	2,13 V	2,90 V
ALED	4F	79	2,16 V	2,87 V

Figure 7. LED Test Tab

3.6 History Tab

The History Tab, [Figure 8](#), records the command sequence of your session. You can copy-paste this information to another application if you wish.



Common	Boost	Color LEDs	LED test, ALED and AudioSync	LED test	History
Clear					
Write I2C[4C] 60 - 00					
Write I2C[4C] 00 - 3F					
Write I2C[4C] 01 - 3F					
Write I2C[4C] 02 - 3F					
Write I2C[4C] 03 - 3F					
Write I2C[4C] 04 - 3F					
Write I2C[4C] 05 - 3F					
Write I2C[4C] 06 - 3F					
Write I2C[4C] 07 - 3F					
Write I2C[4C] 08 - 3F					
Write I2C[4C] 09 - 3F					
Write I2C[4C] 0A - 3F					
Write I2C[4C] 0B - 3F					
Write I2C[4C] 0C - 55					
Write I2C[4C] 0F - 3F					
Write I2C[4C] 11 - CF					
Write I2C[4C] 12 - 1F					
Read I2C[4C] 13 - 00					
Write I2C[4C] 12 - 10					
Read I2C[4C] 13 - 00					

Figure 8. History Tab

4 Evaluation Hardware

The evaluation board, [Figure 9](#), has the LP55281 circuit with the necessary external components placed around it. Test points for the circuit pins are on the board edges. LEDs are on the right and left side of the board (there are places for different types of LEDs). The power and audio connector is on the left side of the board. Two PCB connectors make the connection to the USB interface board or some other controller if needed.

The supply voltage V_{DD} , ground GND and I/O-voltage V_{DDIO} can be connected to the green power connector. When the USB interface is used, the V_{DD} and V_{DDIO} can be either supplied from external power or from the USB board.

The evaluation board makes possible to use the circuit in normal mode and in 7V tolerant mode. 2.8V LDO on the board provides the V_{DD} for the circuit in 7V tolerant mode. If 7V is used, the 6.2V protection zener diode on the solder side of the board should be removed.

There are jumpers on the board for connecting V_{BOOST} to each set of LEDs.

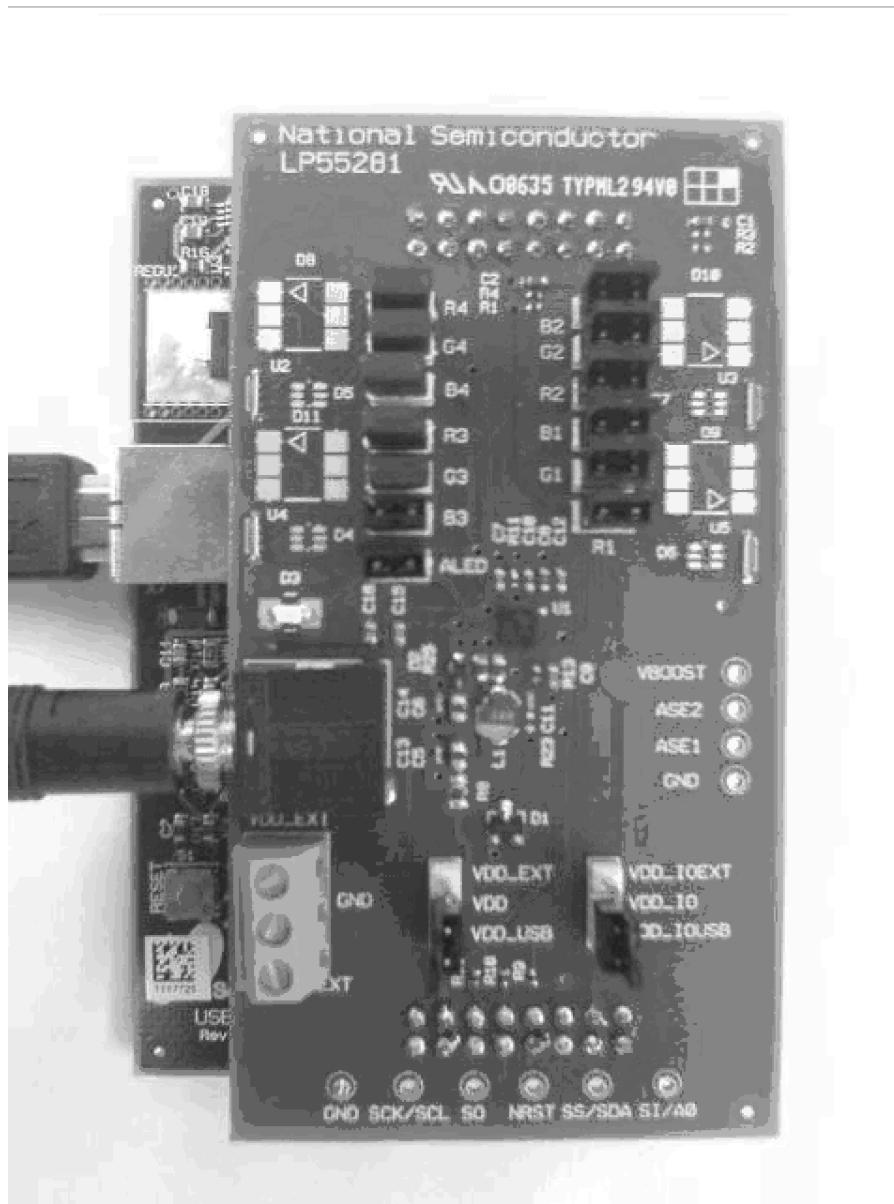


Figure 9. LP55281 Evaluation Board

5 USB Interface

The USB interface, [Figure 10](#), forms the connection between the PC and the evaluation system. It converts the commands from PC to I²C or SPI format. It also provides adjustable supply voltage for the evaluation board and makes possible to measure selected voltages and the input current in the evaluation board.

The USB interface checks for the firmware version of the USB board when the evaluation software is started. If the firmware needs updating, the software prompts you to allow automatic update.

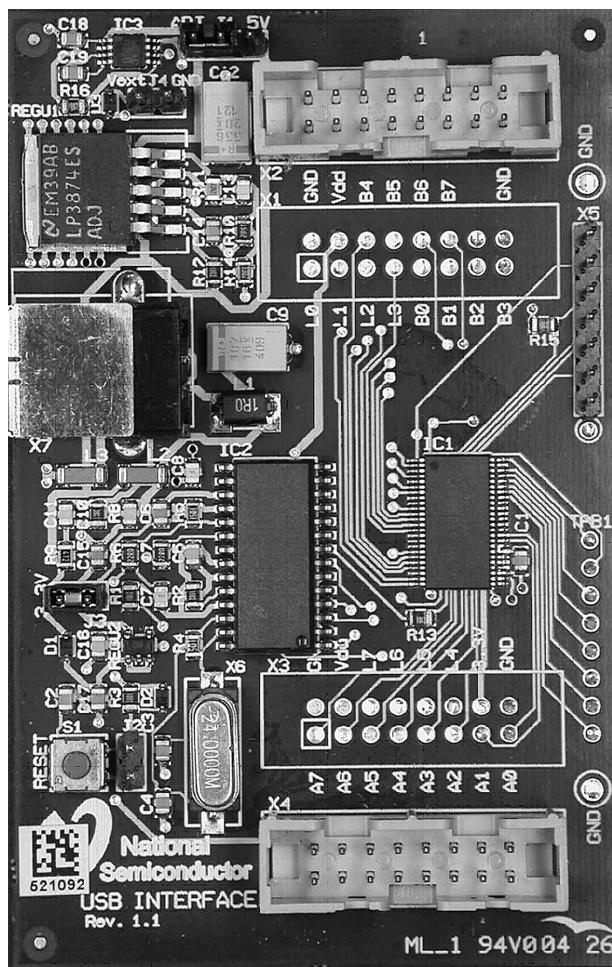


Figure 10. USB Interface Board

6 Getting Started

The following instructions show how to use the LP55281 evaluation kit in default conditions with the USB interface board. Please use the ESD protection (ground cable) to prevent any unwanted damaging ESD events.

1. Check the jumpers and switches on the board.
2. Plug in the evaluation board to the USB board. Connect the USB cable to the evaluation board and to the USB port of your PC. When you plug in the USB board for the first time, your operating system prompts you about "New hardware found" and installs the USB driver. With Win95 and Win98 operating systems you have to accept the installation and click "Next" several times as the installation proceeds.
3. Copy the evaluation software and the support files to your PC's hard disk. Start the software by double-clicking its icon.
4. Press Hardware Reset and USB Setup buttons to reset the chip and the USB interface board.
5. Turn on the chip and the boost converter by enabling stand-by and boost.
6. The Evaluation Kit is now ready to use and the chip can be controlled through the PC-software.

You should disconnect the USB cable from the computer always, when plugging in or removing the evaluation board from the interface board and also when changing the supply jumper settings. Otherwise the USB board may stop responding.

If the USB board is not responding or the software hangs up, press the reset button on the USB board, or disconnect the USB cable for 5 seconds.

If the evaluation software notices that the firmware on the USB board needs to be updated, the software can propose automatic firmware updating. The new firmware will be included in the evaluation kit software.

7 List of Main Components

Part Number	Qty	Value, Size, Tolerance	Description	Vendor/Type
L1	1	4.7 μ H	Power Inductor	TDK VLF4012A-SMD
D8-D11	4		RGB 3-Color LEDs	Sharp GM5WA06270A-SMD
D1	1		Zener Diode	BZX84C5V6-ZENER-SOT23
D2	1		Schottky Barrier Diode	Philips BAT760-SOD323
C5, C6	2	10 μ F, 0805, 10%	10V Capacitor	

8 Schematic of the Evaluation Board

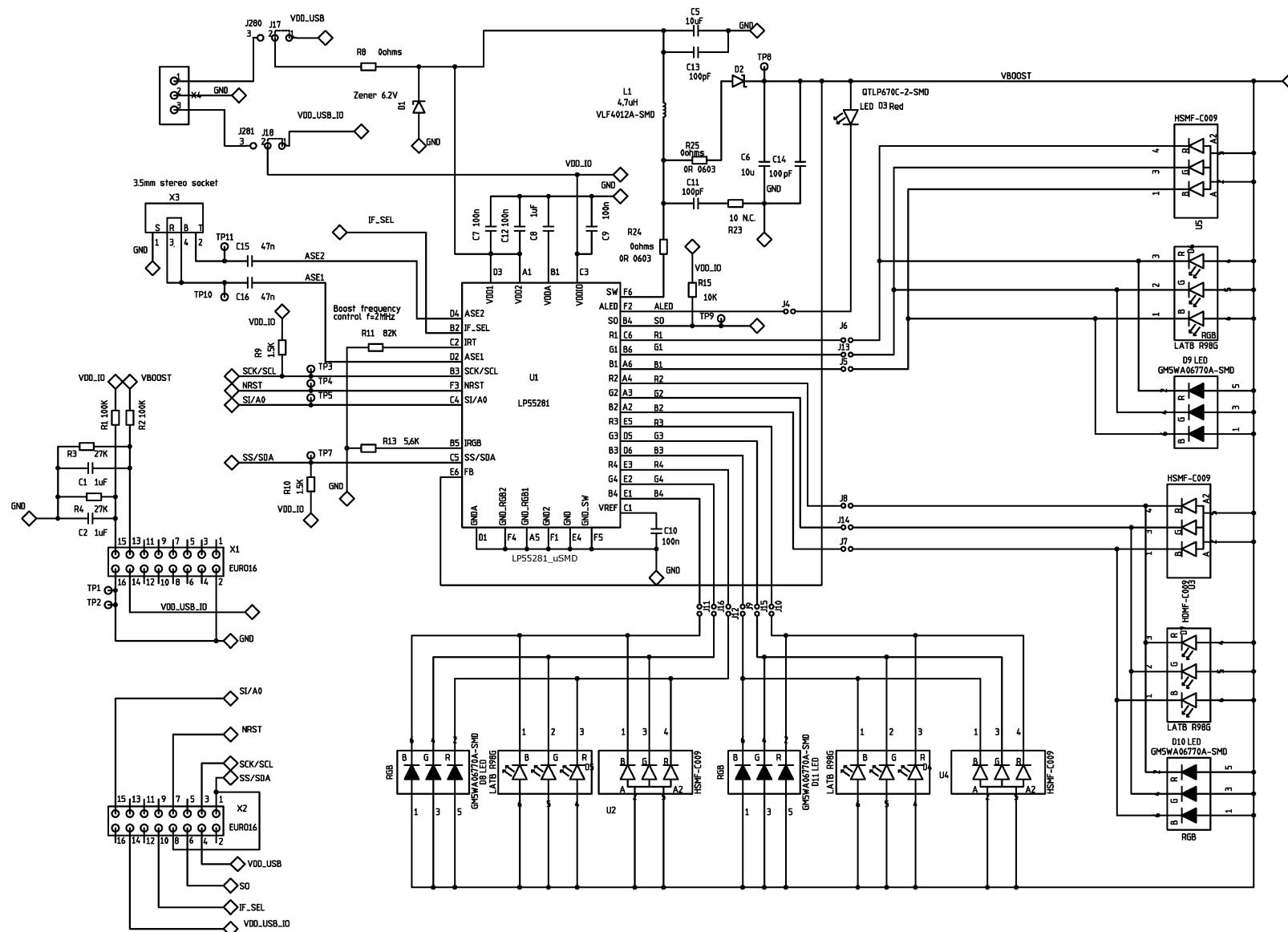


Figure 11. LP55281 Evaluation Board Schematic

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 isotope 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/lsts/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/lsts/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.
- 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.

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2023, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025