

LP8556TM-EVM User's Guide

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1. Introduction

The Texas Instruments LP8556TM-EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LP8556 High-Efficiency LED Backlight Driver. The device offers configurability and can be setup to switch at 312.5 kHz, 625 kHz and 1.25 MHz.

The EVM contains one LED Driver (See Table 1).

Table 1: Device and Package Configurations

LED DRIVER	IC	PACKAGE
U1	LP8556TME-E05	TMD20EQA

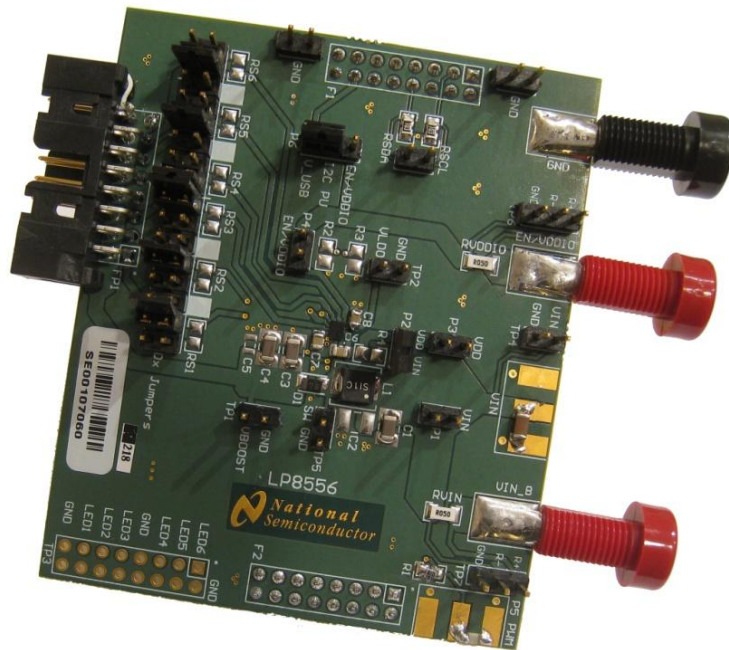


Figure 1: LP8556TM-EVM Picture

2. Setup

This section describes the jumpers and connectors on the EVM as well and how to properly connect, set up and use the LP8556TM-EVM. For a quicker way to enabling the LEDs refer to the LP8556TM-EVM Quick Start document.

2.1. Input / Output Connector Description

VIN_B – Input is the power input terminal for the boost converter. The terminal provides a power (Vbat) connection to allow the user to attach the EVM to a power supply via a cable assembly with banana plugs.

VIN – Input is the alternative power input terminal for the boost converter. The terminal provides a power (Vbat) connection to allow the user to attach the EVM to a power supply via a cable assembly with SMA connectors.

EN/VDDIO – Input is the power input terminal for the LED driver I/O circuitry. The terminal provides a power (VDDIO) connection to allow the user to attach the EVM to a power supply via a cable assembly with banana plugs.

GND – Input is the power input terminal for the boost converter. The terminal provides a common ground (GND) connection to allow the user to attach the EVM to a power supply via a cable assembly with banana plugs.

P1 – VIN Input is another alternative power input terminal or a test point for the boost converter input.

P2 – Jumper is a place for connecting the VDD pin directly to the boost input (VIN).

P3 – VDD Input is a power input terminal for the internal LDO of the LED driver.

P4 – EN/VDDIO Input is another alternative power input terminal or a test point for the LED driver I/O circuitry.

P5 – PWM Input is a signal input terminal for the external PWM signal.

P6 – I2C Pullup Selection Jumper is a place for selecting a pull-up reference for the I2C bus. V-USB is a 3.3V reference provided by the USB-I2C Interface Board

F1, F2 – Connectors for interfacing to the USB-I2C Interface Board.

FP1 – Connector for interfacing to the LED Board.

Dx Jumpers – Jumpers for bypassing LED current sense resistors.

TP1 – VBOOST Output test point.

TP2 – VLDO Output test point.

TP3 – Current sinks' headroom voltages test points.

TP4 – VIN Input test point.

TP5 – Switch node test point.

TP6 – EN / VDDIO test point.

TP7 – VIN input test point.

2.2. Test Setup

Figure 2 shows the picture of the LP8556TM-EVM board in the setup with the USB-I2C Interface Board and LED Board.

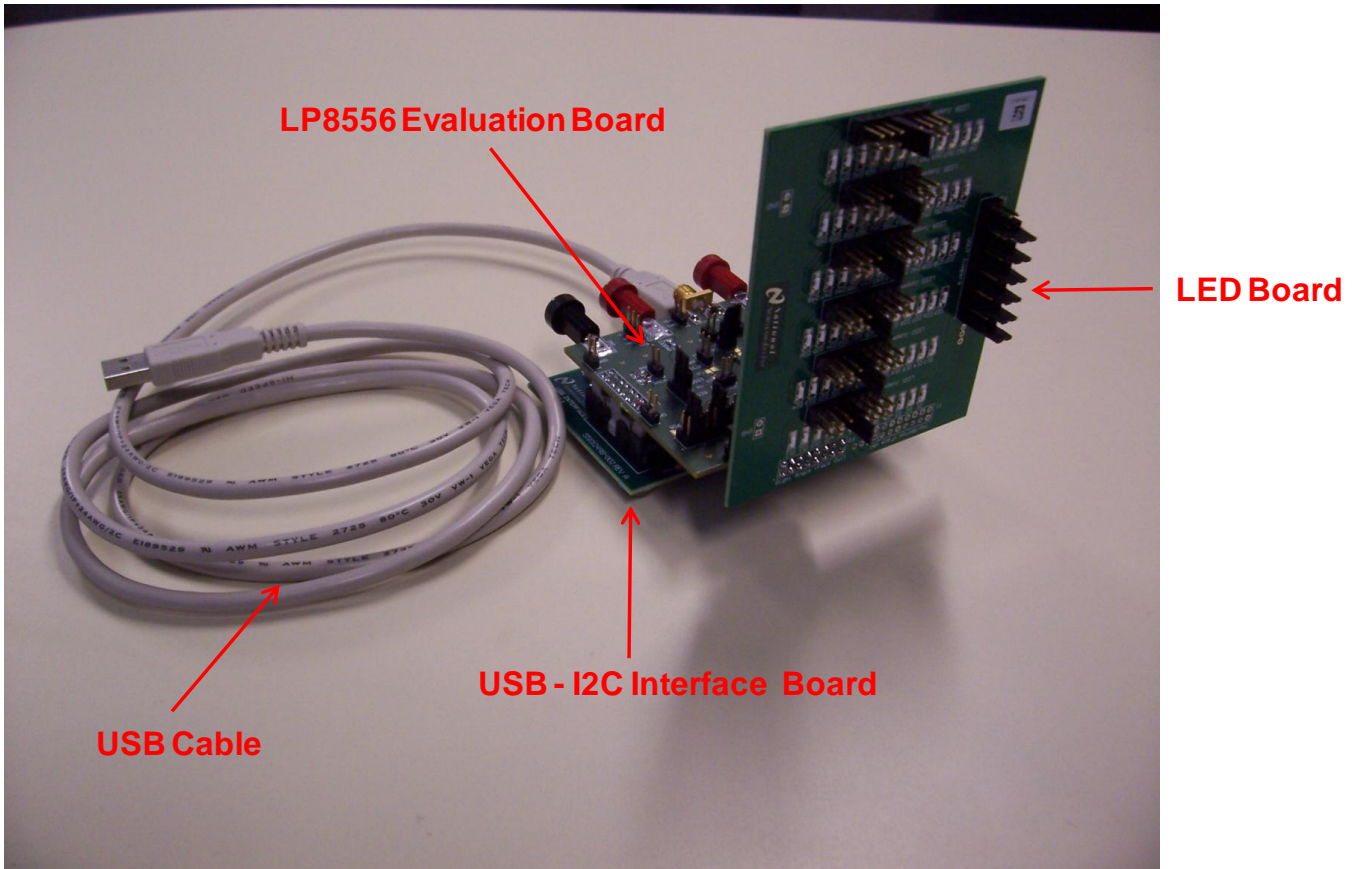


Figure 2: LP8556TM-EVM Test Setup

2.3. LP8556TM-EVM Setup

Figures 3 and 4 illustrate how to properly configure the LP8556TM-EVM.

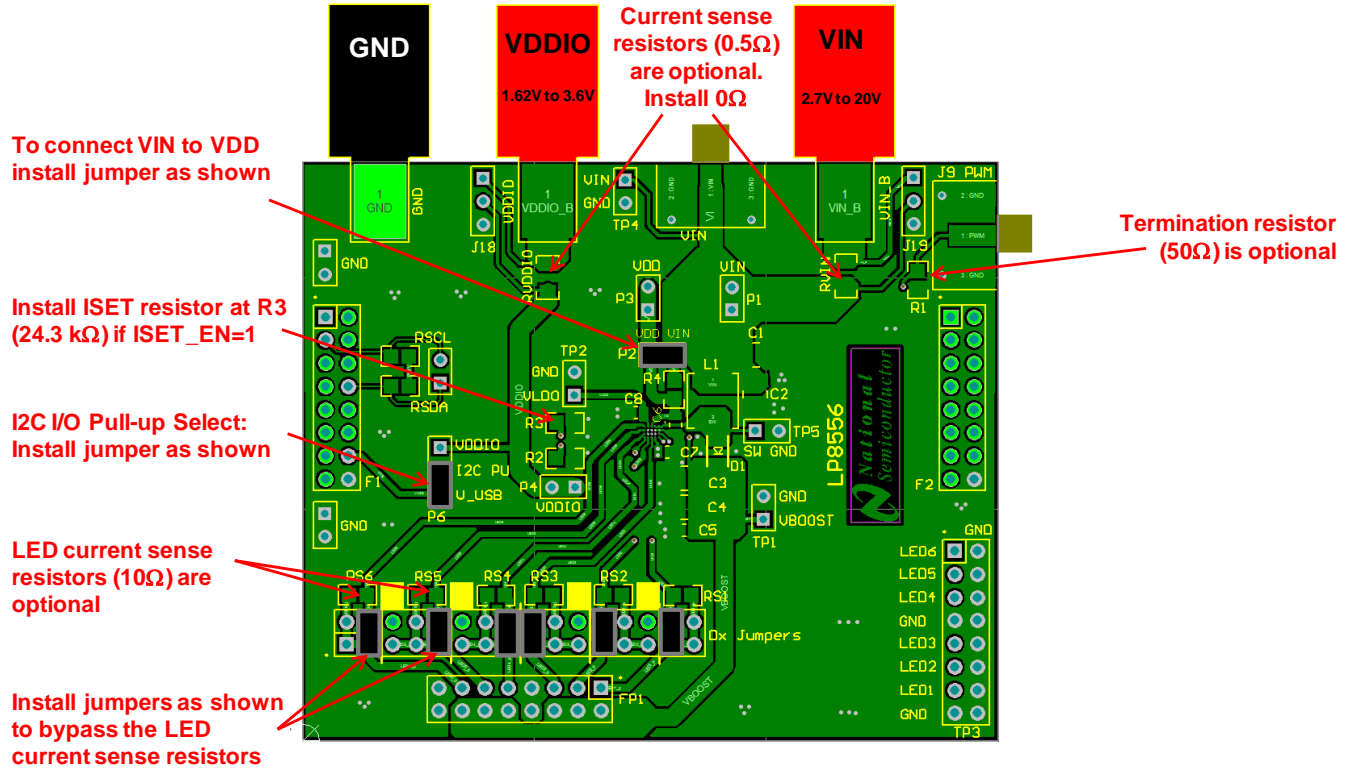


Figure 3: LP8556TM-EVM Configuration

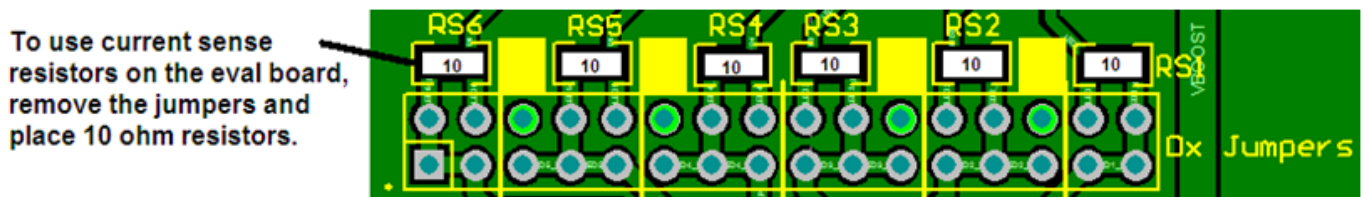


Figure 4: Sense Resistors on the LED Current Sinks Detail

2.4. LED Board Setup

Figure 5 illustrates how to properly configure the LED Board.

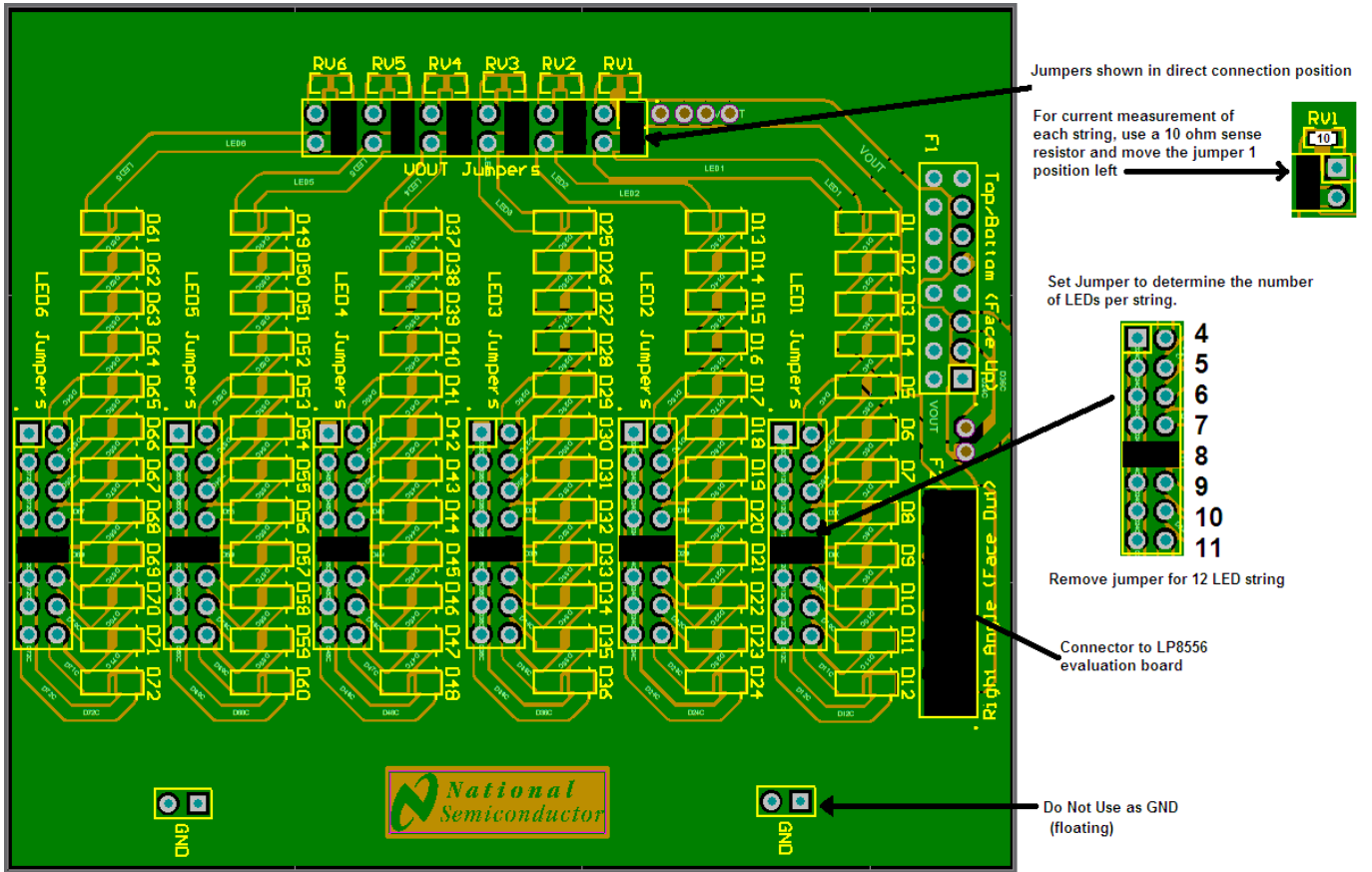


Figure 5: LED Board Configuration

2.5. Instructions

The LP8556 evaluation kit includes an I2C compatible program and USB docking board that can help exercise the part in a simple way. Contained in this document is a description of how to use the USB docking board with the evaluation board and interface software.

The LP8556 evaluation board has the means to “plug into” the USB docking board. The USB docking board provides all of the control signals for the simple interface. Power to the part must be provided externally. A standard USB cable must be connected to the board from a PC.

The I2C compatible interface program provides all of the control that the LP8556 part requires. For proper operation, first power the evaluation board, then the USB docking board should be plugged into the PC before the interface program is opened. Once connected, and the program is executed, a basic interface window will open.

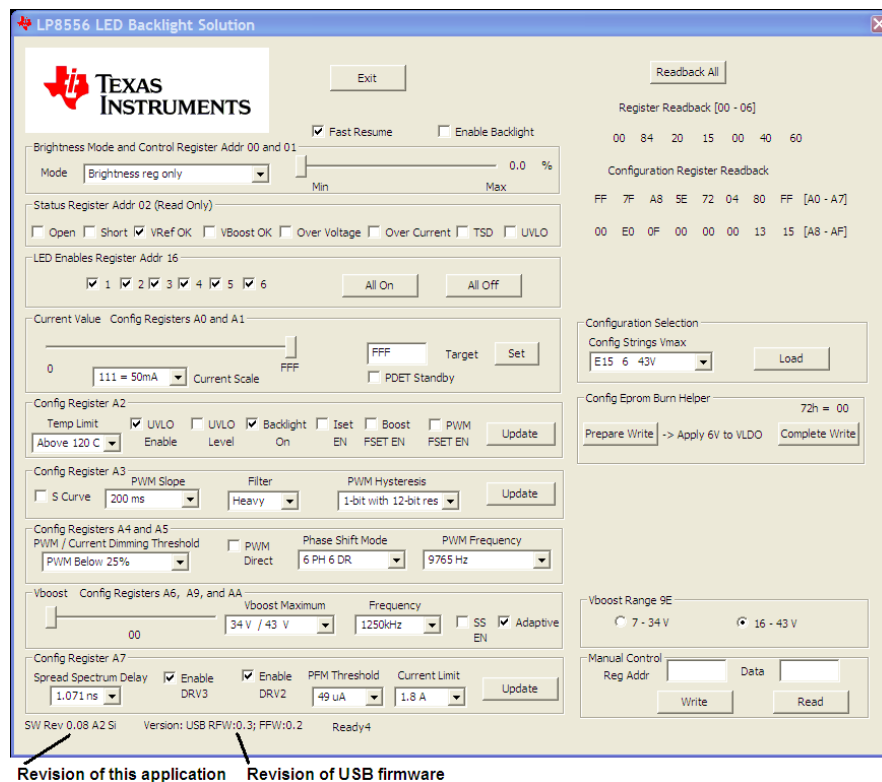


Figure 6: LP8556TM-EVM Evaluation Software Window

The USB board is recognized as an HID-compliant device in Windows Device Manager. Successful communication with the board by the application is confirmed by the Version: field at the bottom of the application showing the correct USB firmware revision.

The I2C device address is fixed at 0x0C in this program. The sections on the left side are used to update the registers of the device. The columns of registers on the right are updated by clicking the Readback All button. An update to the registers on the left does not automatically reflect in the Readback All registers. Just click the Readback All button to check the results of the actions.

The register addresses are shown with the register names in the boxes surrounding the controls. The minimum procedure for turning on the LEDs is as follows:

1. Connect the LED board to the LP8556 evaluation board. Set jumpers for number of LEDs per string.
2. Connect external power and ground to the board.
 - a. Suggest 3.6V to VIN jack.
 - b. Suggest 3.3V to VDDIO jack.
 - c. Connect Ground to GND jack.
3. Jumper on P2 VDD to VIN
4. Jumper on P6 I2C PU to VUSB
5. Turn on the external supplies.
6. Connect interface board to computer USB port.
7. Run LP8556A.exe
8. Change the Mode in the dropdown box under Brightness Mode and Control Registers 00 and 01 to Brightness register only.
9. Check the Enable Backlight box.
10. Move the slider under Brightness Mode and Control Registers 00 and 01 to increase the current provided to the LEDs

The 02 Status Register will update every time the Readback All button is pressed. The status register should show VRef OK and VBoost OK checked indicating normal operation after the steps listed above are performed and the Readback All button is pressed.

Access to any register is available through the Manual Control on the lower right.

See the LP8556 datasheet for detailed descriptions of the registers and their usage.

NOTE: Do not change the configuration of the device while the backlight is enabled. First disable the backlight by making sure Enable Backlight is unchecked. Then adjust the configuration and turn on the backlight. Changing the configuration while the backlight is on may produce unexpected results.

NOTE: If the part is enabled to any level of brightness or state and the program is closed, the LP8556 device will remain in the last controlled state.

3. LP8556TM-EVM Component Placement

Figure 7 shows the top assembly layer of the LP8556TM-EVM.

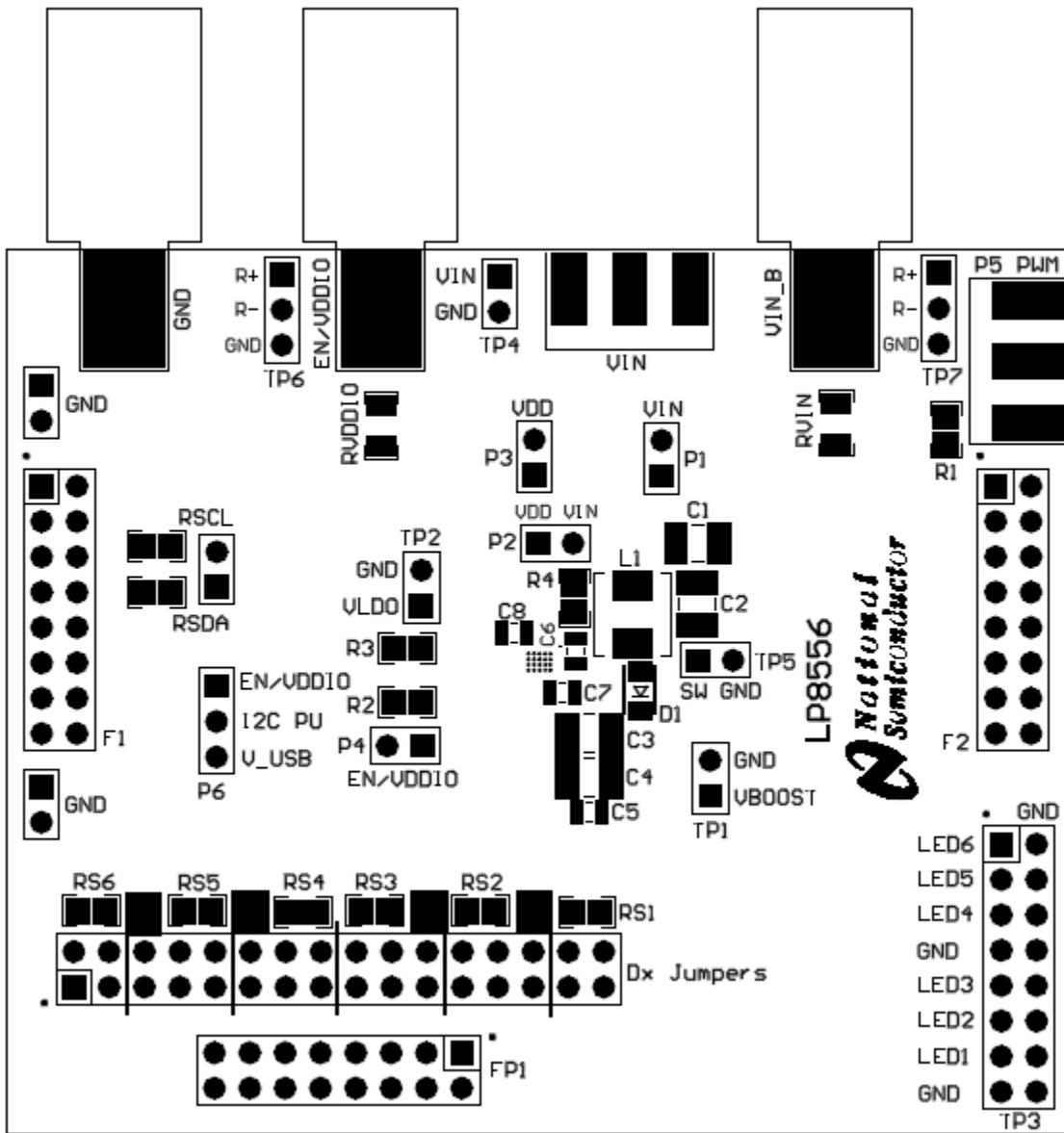


Figure 7: Top Assembly Layer

4. LP8556TM-EVM Component List

Table 2 shows the component list of the LP8556TM-EVM.

Table 2: Component List

Quantity	Designator	Description	Footprint	Part Number	Manufacturer	Value
1	C1	MLCC, 50V, X5R, 10%	SM1206	UMK316BJ225KD-T	Taiyo Yuden	2.2 uF
0	C2	NS	SM1210			
2	C3, C4	MLCC, 50V, X5R, 10%	SM1206	UMK316BJ225KD-T	Taiyo Yuden	2.2 uF
0	C5	NS	SM0603			
2	C6, C7	MLCC, 25V, X5R, 20%	SM0603		Standard	1 uF
1	C8	MLCC, 25V, X5R, 20%	SM0603		Standard	4.7 uF
1	D1	60V, 1A Schottky Rectifier	SOD-123F	RB160M-60	Rohm	
0	Dx Jumpers	0.100" Header, 16x2		TSW-116-07-G-D	Tyco	
2	F1, F2	0.100" Header, 8x2		MSPV16-ND	Tyco	
1	GJ1	Black banana plug recepticle				
9	GND, P1, P2, P3, P4, TP1, TP2, TP4, TP5	0.100" Header, 1x2			Standard	
1	L1	Isolated power inductor	4.5mm x 4.5mm	MPI4040R3	Coiltronics	4.7 uH
2	P5, VIN	SMA	SMA			
3	P6, TP6, TP7	0.100" Header, 1x3			Standard	
1	PJ1	Red banana plug recepticle				
1	PJ2	Red banana plug recepticle				
1	R1	Resistor, 0.1W, 5%	SM0805		Standard	49.9
1	R3	Resistor, 0.1W, 5%	SM0805		Standard	24.3k
0	R2, R4	NS	SM0805			
2	RVDDIO, RVIN	Resistor, 0.1W, 1%	SM0805		Standard	0.05
0	RS1, RS2, RS3, RS4, RS5, RS6	NS	SM0805			
2	RSCL, RSDA	Resistor, 0.1W, 5%	SM0805		Standard	10k
0	TP3	NS				
1	U1	LED Driver	TMD20EQA	LP8556TME-E05	TI	

6. LED Board Schematic

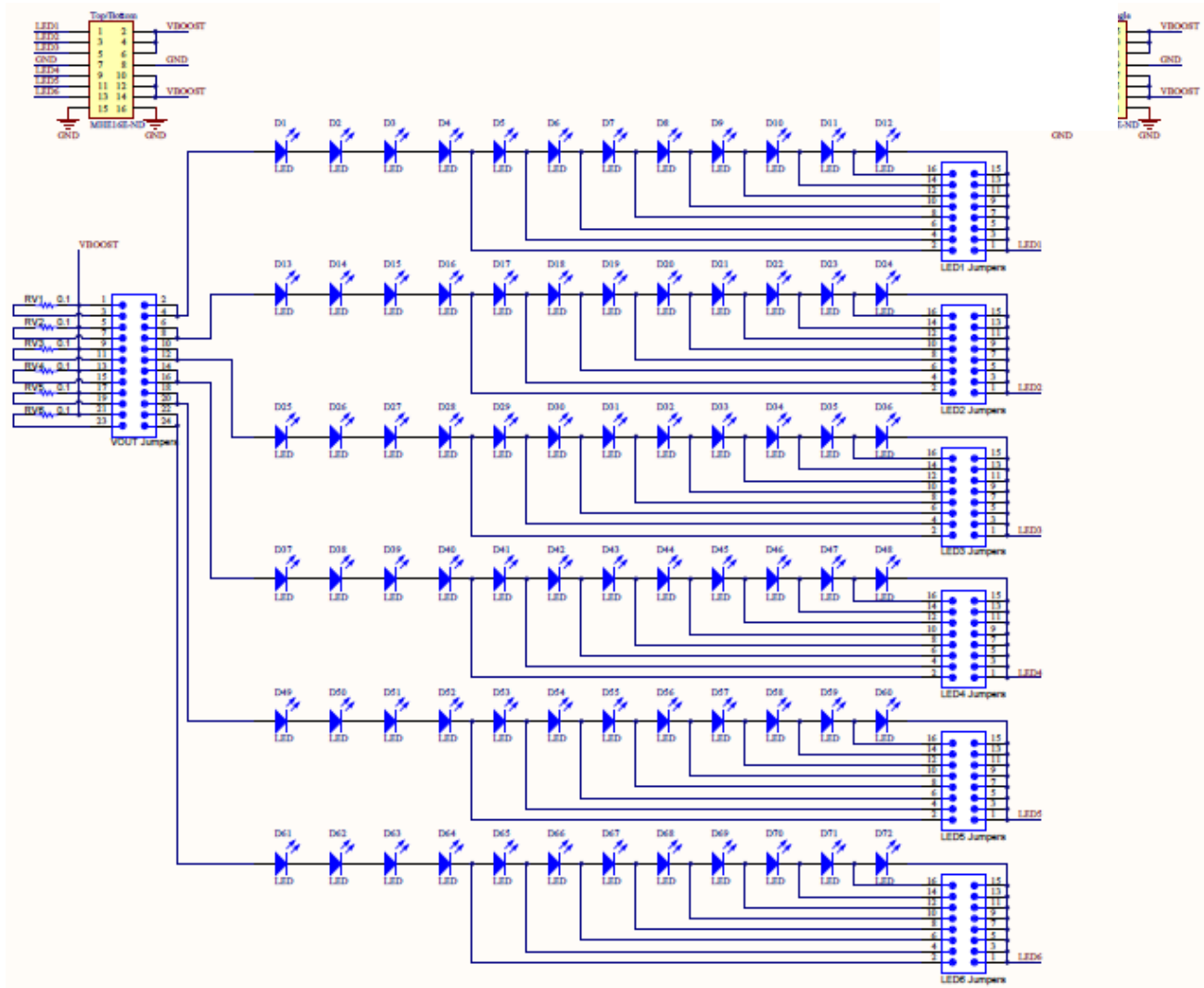


Figure 9: LED Board Schematic

7. LP8556 Usage and Programming

The LP8556 white LED driver requires configuration of the boost converter and dimming operation. The boost converter can operate at three switching frequencies. Options can be set for spread spectrum and slew rate control. The dimming can be done with a full PWM output, linear current control, or an adaptive combination of the two for the greatest power savings. Phase-shift modes are available for the PWM output. Additional safety features also need to be configured.

7.1. In Circuit Operation

The LP8556 white LED driver can be controlled during operation either with I2C register accesses or by external resistor selection. For either case, a configuration must be saved in EPROM which is specific for the chosen control scheme. If I2C register access is used to control the LP8556, then saved configuration values in the EPROM can be overwritten to change settings during setup for operation. The following sections highlight the configuration steps needed for both. A complete configuration should be written to the device and the EPROM burn sequence described below must be completed for operation without I2C register access. In circuit control using external resistors will be referred to as “**Resistor Config**” in the following text. A configuration is saved in EPROM and the external resistors complete the configuration. The only change made to the LP8556 device in circuit is done by the PWM input to set the dimming value. Control using I2C register access will be referred to as “**I2C Control**”. The term control is used because the configuration of the device is still stored in EPROM but the LP8556 may also be updated via I2C during operation. Another possible usage model is to have a preset configuration saved in EPROM, not use external resistors, and not update the registers during operation. The register configuration for this model is the same as for “**I2C Control**” except the BL_ON bit must be set in CFG2 to allow the backlight to turn on.

7.2. Enable and Standby

The EN/VDDIO pin controls enabling and shutdown of the LP8556. A zero value on this pin holds the device in shutdown with minimum current consumption. Register access is not available during shutdown. Once enabled, a standby mode is available using the PWM input detector. If the PDET_STBY bit is set in CFG1, the LP8556 will enter a low power standby mode when a zero level is detected on the PWM pin for more than 50 ms. In standby mode the boost and led driver are shut down. The oscillator remains on allowing detection of activity on the PWM signal to resume operation.

7.3. Boost Converter Configuration

The LP8556 boost converter configuration is determined by the size of the LED array to be driven. Additionally, component constraints will affect operating frequency selection. A calculation tool is available for selecting the boost operating point and external components along with the desired frequency of operation.

7.3.1. Setting Boost Switching Frequency

Using Resistor Config: The desired frequency of operation is programmed by an external resistor placed on the FSET pin. The BOOST_FSET_EN bit must be set in the CFG2 register. Note the PWM_FSET_EN bit must also be set as the PWM output frequency is also set by the resistor on the FSET pin. Note the BL_ON bit must be set to insure the backlight comes on during operation. See the datasheet table titled *Setting Switching and PWM Dimming Frequency with an External Resistor*.

Using I2C Control: The desired frequency of operation is programmed in the BOOST_FREQ bits of the CFG6 register. The bits BOOST_FSET_EN and PWM_FSET_EN must be reset to zero in CFG2.

7.3.2. Setting Boost Voltage

The boost voltage can be adaptively set by the LP8556 to control the LED headroom in real time which provides the most efficient operation. This mode of operation is suggested. The ADAPTIVE bit must be set in CFG10. When using adaptive mode, the value set in VBOOST of CFG6 is the initial boost output voltage. VBOOST_MAX must also be set in CFG9 to select the maximum boost voltage allowed during adaptive mode.

The boost voltage can be forced by resetting the ADAPTIVE bit to zero. The value in VBOOST of CFG6 is the boost output voltage. The value in VBOOST_MAX of CFG9 will limit the maximum value that can be set. This usage is not recommended.

7.3.3. Setting Inductor Current Limit

The boost inductor current limit is determined by the inductor used and the amount of power output required. The limit is set in the IBOOST_LIM bits of the CFG7 register.

7.3.4. EMI Reduction Settings

The boost driver strength is controlled by the EN_DRV2 and EN_DRV3 bits in the CFG7 register. Enabling all three drivers provides the best efficiency and fastest transition times. It is recommended to have these bits set to one. Each one could be cleared to reduce the boost output slew rate.

A spread spectrum edge control feature is also available. This feature changes the switching edge placement to reduce harmonics of the boost switching frequency. Spread spectrum is enabled by the SSCLK_EN bit in the CFGA register.

7.4. LED Driver Configuration

The LED driver can control the power to the LEDs using PWM dimming, pure current control, or an adaptive combination of the two. See the Adaptive Dimming Control and Brightness control sections of the datasheet for descriptions. The appropriate registers must be set once brightness and dimming control method is selected. The PWM_DIRECT bit in CFG5 may be set for direct control of the PWM output or the BRT_MODE must be selected in the Device Control register at 01h. Note if using I2C Control, the backlight is turned on and off using the BL_CTL bit in the Device Control Register at 01h.

7.4.1. Setting the Maximum LED Current

Using Resistor Config: The desired maximum LED current can be set using an external resistor on the RSET pin. The ISET_EN bit must be set in the CFG2 register. The maximum current will then depend on the value set in the CURRENT_MAX bits in CFG1.

Using I2C Control: The desired maximum LED current is set in the CURRENT_MAX bits of CFG1. The CURRENT value in CFG0 can be used for finer adjustments of the maximum current. The ISET_EN bit in CFG2 is reset to zero.

7.4.2. PWM Output Frequency

Using Resistor Config: The PWM output is set by the resistor on the FSET pin. The PWM_FSET_EN bit must be set in the CFG2 register. Note the BOOST_FSET_EN bit must also be set as the boost output frequency is also set by the resistor on the FSET pin. Note the BL_ON bit must be set to insure the backlight comes on during operation. See the datasheet table titled *Setting Switching and PWM Dimming Frequency with an External Resistor*.

Using I2C Control: The desired PWM output frequency is programmed in the PWM_FREQ bits of the CFG6 register. The bits BOOST_FSET_EN and PWM_FSET_EN must be reset to zero in CFG2.

7.4.3. Adaptive Dimming Settings

The PWM_TO_I_THRESHOLD bits of the CFG4 register set the point for the transition between current dimming and PWM output dimming. Setting these bits to values above 0Ah will force PWM output dimming to always occur as shown in the top diagram of the Adaptive Dimming Control section of the datasheet. Setting these bits to 00h will select current dimming across the entire range as shown in the bottom diagram. An intermediate value will select the transition point to occur between 10% and 50%.

7.4.4. Brightness Control Mode

Using Resistor Config: The brightness control mode is defaulted to PWM only (00) in the Device Control register. This allows the blocks in the PWM Brightness Control Signal Path as shown in Figure 1 of the data sheet to be used in controlling the output. To bypass these blocks and connect the PWM input of the LP8556 to the LED driver output set the PWM_DIRECT bit of CFG5 to one. Note if PWM_DIRECT is set to one, the phase-shift and output curve shaping features are not available. The desired output brightness is control by the configuration acting upon the PWM signal at the input pin.

Using I2C Control: The brightness control mode is set in the Device Control register bits BRT_MODE. The PWM_DIRECT bit of CFG5 may be set in EPROM to use direct mode to bypass the PWM Brightness Control Signal Path as shown in Figure 1 of the data sheet. Note if PWM_DIRECT is set to one, the phase-shift and output curve shaping features are not available. If BRT_MODE is other than 00b, then the desired brightness value is written to the Brightness Control register at address 00h. If BRT_MODE is 10b or 11b then the output brightness is a combination of the Brightness Control Register setting and the PWM signal at the input pin.

7.4.5. Phase Shift LED Outputs

The Phase Shift PWM scheme delays the time when each LED driver becomes active as shown in the PS_MODE diagram of the datasheet. Set the PS_MODE bits in the CFG5 to the desired setting. A 111b value selects no phase shift for six drivers.

7.4.6. Curve Shaping and Brightness Change Control

Large changes in brightness can be smoothed and controlled using the features of the LP8556. The CFG3 register is used to enable S curve transitions in brightness which are more pleasing to the eye. Additionally the PWM_SLOPE needs to be set to determine the S curve shape. The PWM_SLOPE allows the transition between brightness levels to be slowed. The FILTER bits can be used to alter the transition even more. The FILTER bits add RC delay to slow the curve shape.

The PWM_INPUT_HYSTERESIS setting is used to alter how the output PWM reacts to the input. A larger hysteresis value (lower bit resolution) will make the output less sensitive to very small changes in the PWM input. This can be used if the PWM input signal is not stable, noisy, or less sensitivity is desired.

The recommended setting for the CFG3 register is 00h until the target application is prototyped and brightness settings are applied.

7.4.7. PWM Output Dithering

The Dithering scheme can be used during brightness changes and during steady state conditions. The STEADY_DITHER bit in CFG4 can be set to one to dither all of the time or reset to zero to only dither during brightness changes. The DITHER bits in CFG4 control how much to dither or reset to 00b to disable dithering.

7.5. Safety Feature settings

7.5.1. Thermal Shutdown

The LP8556 will shut down the LED outputs and the boost if the temperature exceeds 150 degrees C. The TSD bit will be set in the Status register and will clear upon a read. The device will exit thermal shutdown when the temperature drops below 130 C.

7.5.2. Under Voltage Lock Out

The bits UVLO_EN and UVLO_TH in the CFG2 register control whether UVLO is enabled and what the threshold is set at. A fault occurring when enabled will set the flag in the Status Register at 02h. The fault is cleared by setting UVLO_EN to zero or by reading the fault register.

7.5.3. LED Fault Detection

An open or short circuit can be detected on the LED driver outputs when in automatic PWM and current dimming mode. The comparators for adjusting headroom are used to detect an open or a short. The LED_FAULT_TH bits in CFGE sets the high comparator threshold for detecting a short.

7.6. ID Register

The CFGF register is used to store panel information and can identify the stored EPROM configuration. This register can be set to the fields shown in the datasheet or any 8 bits as desired.

7.7. EPROM Settings Examples

Table 3: Example EPROM Configuration Using External Resistors

NAME	B7	B6	B5	B4	B3	B2	B1	B0	Hex
CFG0	CURRENT[7:0]								
	11111111 (Set maximum current and dim with PWM)								FF
CFG1	PDET_SB	CURR_MAX[2:0]			CURRENT[11:8]				
	1	011 (20mA)			1111				BF
CFG2	RESERVED		UVLO_EN	UVLO_TH	BL_ON	ISET_EN	BST_FSET	PWM_FSET	
	00		1	0	1	1	1	1	2F
CFG3	RESERVED	PWM_SLOPE[2:0]			FILTER[1:0]		PWM_HYST[1:0]		
	0	000			00		00		00
CFG4	PWM_TO_I_THRESHOLD[3:0]				NLC_EN	STEADY	DITHER[1:0]		
	0111 (25% transition point)				0	0	00		70
CFG5	PDIRECT	PS_MODE[2:0]			PWM_FREQ[3:0]				
	0	000 (6 phase)			0100 (9.6kHz)				04
CFG6	BOOST_FREQ[1:0]		VBOOST[5:0]						
	10 (1.25 MHz)		000000 (Initial Boost Voltage 16V)						80
CFG7	Reserved		EN_DRV3	EN_DRV2	PFM_THR[1:0]		IBOOST_LIM[1:0]		
	00		1	1	11		11 (1.8A)		3F
CFG8	Reserved		Reserved		Reserved		Reserved		
	00		00		00		00		00
CFG9	VBOOST_MAX[2:0]			JUMP_EN	JUMP_THR[1:0]		JUMP_VOLT[1:0]		
	100 (33V)			0	00		00		80
CFG10	SSCLK_EN	Reserved	Reserved		ADAPTIVE	HEADROOM[2:0]			
	0	0	00		1	111			0F
CFG11	Reserved								00
CFG12	Reserved				Reserved				00
CFG13	Reserved								00
CFG14	STEP_UP[1:0]		STEP_DN[1:0]		FAULT_THR[1:0]		COMP_HYST[1:0]		
	00		00		11		11		0F
CFG15	ID[7:0]								
	00000001								01

Table 4: Example EPROM Configuration Using I2C Control

NAME	B7	B6	B5	B4	B3	B2	B1	B0	Hex
CFG0	CURRENT[7:0]								
	11111111 (Set maximum current, adjust with Brightness Control)								FF
CFG1	PDET_SB	CURR_MAX[2:0]			CURRENT[11:8]				
	0	011 (20mA)			1111				3F
CFG2	Reserved		UVLO_EN	UVLO_TH	BL_ON	ISET_EN	BST_FSET	PWM_FSET	
	00		1	0	0	0	0	0	20
CFG3	Reserved	PWM_SLOPE[2:0]			FILTER[1:0]		PWM_HYST[1:0]		
	0	000			00		00		00
CFG4	PWM_TO_I_THRESHOLD[3:0]				Reserved	STEADY	DITHER[1:0]		
	0111 (25% transition point)				0	0	00		70
CFG5	PDIRECT	PS_MODE[2:0]			PWM_FREQ[3:0]				
	0	000 (6 phase)			0100 (9.6kHz)				04
CFG6	BOOST_FREQ[1:0]		VBOOST[5:0]						
	10 (1.25 MHz)		000000 (Initial Boost Voltage 16V)						80
CFG7	Reserved		EN_DRV3	EN_DRV2	PFM_THR[1:0]		IBOOST_LIM[1:0]		
	00		1	1	11		11 (1.8A)		3F
CFG8	Reserved		Reserved		Reserved		Reserved		
	00		00		00		00		00
CFG9	VBOOSTMAX[2:0]			JUMP_EN	JUMP_THR[1:0]		JUMP_VOLT[1:0]		
	100 (30V)			0	00		00		80
CFG10	SSCLK_EN	Reserved	Reserved		ADAPTIVE	HEADROOM[2:0]			
	0	0	00		1	111			0F
CFG11	Reserved								00
CFG12	Reserved				Reserved				00
CFG13	Reserved								00
CFG14	STEP_UP[1:0]		STEP_DN[1:0]		FAULT_THR[1:0]		COMP_HYST[1:0]		
	00		00		11		11		0F
CFG15	ID[7:0]								
	00000001								01

7.8. Instructions for Burning the EPROM

Once in production the configuration settings will be burned into the EPROM at the factory. Sample units will not have the configuration information saved in EPROM. This can be verified by reading register 72h. The low four bits will read back as 0000b if the configuration portion of the EPROM has not been burned. A successfully burned configuration EPROM will read back as 0Fh.

Once a configuration is set it can be burned to the EPROM. First program all of the CFG registers to their desired value. A write of value 80h is written to register 72h. This sets the write bit. The voltage applied to the VLDO pin is increased to 6V. Another write of 00h to 72h is needed to complete the write process. The VLDO pin can be returned to nominal voltage. Then a read of register 72h should be 0Fh to indicate a successful burn.

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions: The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

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REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

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

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

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.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

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.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

[Important Notice for Users of this Product in Japan]

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product 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 this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
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西新宿三井ビル

<http://www.tij.co.jp>

EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure 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.
3. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to 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 use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components which meet ISO/TS16949 requirements, mainly for automotive use. Components which have not been so designated are neither designed nor intended for automotive use; and TI will not be responsible for any failure of such components to meet such requirements.

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