The LP8863EVM Evaluation Module

This user's guide describes the module used to evaluate characteristics, operation, and use of the LP8863-Q1 automotive LED backlight driver. This document includes a schematic diagram, PCB layout, and bill of materials (BOM).

Contents

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1 Introduction

TI's LP8863-Q1 evaluation module (EVM) helps designers evaluate the operation and performance of the LP8863-Q1 automotive LED backlight driver. The device offers configurability and can be set up through external resistor options for boost switching frequency, LED current, and PWM out frequency. Internal register options enable various controls such as brightness inputs, slope control, dimming options, etc. The EVM contains one LP8863-Q1 LED driver with boost circuit and a Tiva Launchpad evaluation circuit to provide control signals for LED driver.

Table 1.

LED DRIVER	IC	PACKAGE
U8	LP8863-Q1	HTSSOP

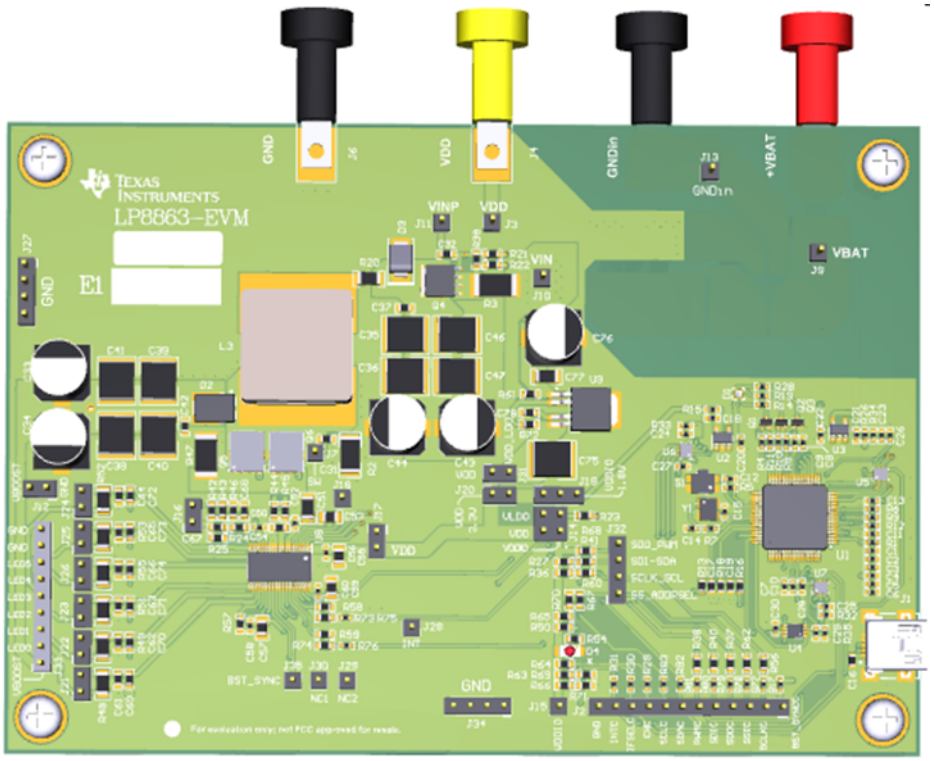


Figure 1. LP8863-Q1 Evaluation Board (Top View)

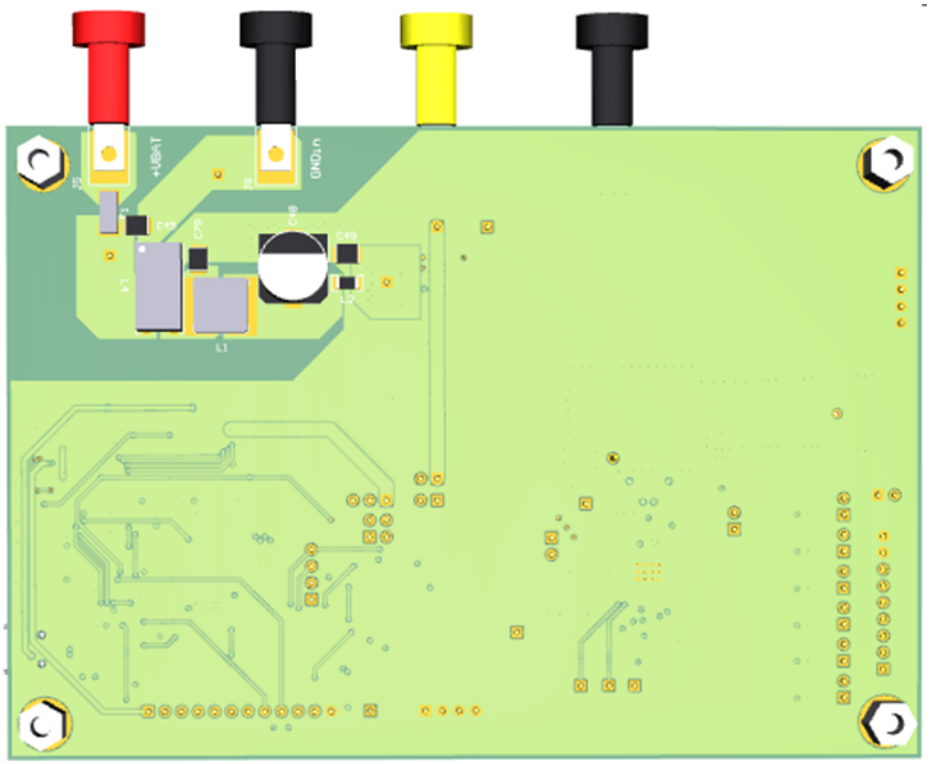


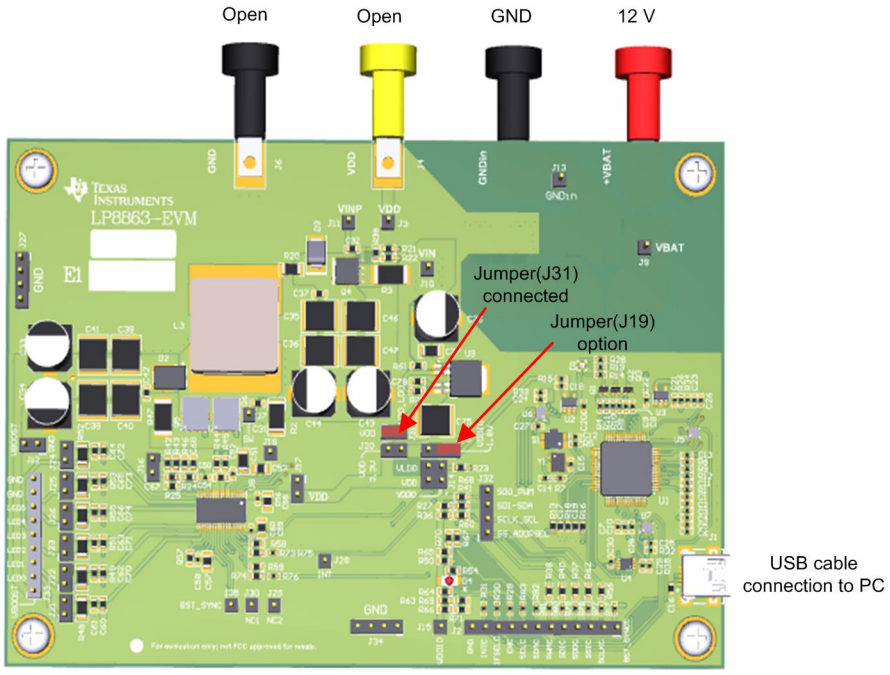
Figure 2. LP8863-Q1 Evaluation Board (Bottom View)

2 Setup

This section describes the jumpers and connectors on the EVM as well as how to properly connect and setup to use the LP8863EVM.

Default resistor values and jumper positions are set to:

- Boost SW frequency – 300 kHz (set by external resistor R59)
- Maximum LED current per string – 120 mA (set by external resistor R57)
- PWM input to control brightness (register control)
- PWM output frequency – 9.8 kHz (set by external resistor R58)
- I^2C interface to communicate with LP8863-Q1 – base address 0x2C
- Charge pump for SW gate drive enabled
- J14 : Open to disconnect VDDIO input from V_{LDO} out
- J17 : Open to use internal charge pump
- J19 : Close to connect onboard LDO outputs (1.8 V from Tiva controller circuit) to VDDIO
- J31 : Close to connect onboard LDO output (5 V) to VDD input to LP8863-Q1 measurement
- J12 : Open – probing point of boost output
- J16 : Open – a probing/noise injecting point for stability measurement



System/equipment required:

- Power supplies for V_{IN} : 24 V or higher, 6 A or higher
- Power supplies for VDD: 5.5 V or higher, 0.5 A or higher (only needed when external power supply is used for VDD input. Not needed for default setting)
- Power cables for V_{IN}, VDD connection – cables with banana plugs recommended
- LED load board (not included in package): 6 strings, 8 LEDs per string (LEDs per string can be adjusted by moving jumpers on load board)
- LED cable: 7-position ribbon cable
- USB cable (USB A to mini)
- PC to run GUI software
- Windows® 7 or previous version)
- GUI software

2.1 Input/Output Connector/Header Descriptions

J3 Input— This header is the power input (VDD) terminal and also probing header for LP8863-Q1 power. The terminal provides a power connection to allow the user to attach the EVM to a power supply and also monitor VDD connected to J4.

J4 - Input — This banana socket is the power input (VDD) terminal for LP8863-Q1 power. The terminal provides a power (VDD) connection to allow the user to attach the EVM to a power supply.

J5 - Input— This banana socket is the power input (VBAT) terminal for the boost converter. The terminal provides a power (VBAT) connection to allow the user to attach the EVM to a power supply.

J6 – GND— This banana socket is the power input (GND) terminal for the boost converter. The terminal provides a power ground (GND) connection to allow the user to attach the EVM to a power supply.

J7 – Header— This header is a probing point of SW node.

J8 – GND— This banana socket is the power input (GND) terminal for the boost converter. The terminal provides a power ground (GND) connection to allow the user to attach the EVM to a power supply.

J9 – Input— This header is the power input (VBAT) terminal and also probing header for the boost converter. The terminal provides a power connection to allow the user to attach the EVM to a power supply and also monitor VBAT connected to J5.

J10 – Header — This header is a probing point of VIN (boost input power after power filters).

J11 – Header— This header is a probing point of VINP (boost input power after power line FET).

J12 – Headers— These headers are probing points of boost output (VBOOST).

J13 – GND— This header is the power input (GND) terminal and also probing header for the boost converter. The terminal provides power ground connection to allow the user to attach the EVM to a power supply and also monitor VBAT connected to J8.

J14 – Jumper— This connector is for selection of the source of VDDIO between VDD and internal LDO out (V_{LDO}) of LP8863-Q1.

J15 – Input— This header is the power input (VDDIO) terminal and also probing header for VDDIO. The terminal provides a power connection to allow the user to attach the EVM to a power supply and also monitor VDDIO selected by J14.

J16 – Headers— These headers are probing/noise injecting points for stability measurement of boost.

J17 – Connector— This connector is to connect VDD to the internal charge pump output (when charge pump is not used).

J18 – Header— This header is a probing point of GD.

J19 – Jumper— This connector is for selection of the source of VDDIO between 1.8-V and 3.3-V output from on-board LDOs.

J20 – Connector— This connector is to connect 5-V output from on-board LDO to VDD input.

J21 to J26 – Headers— These headers are to measure LED string current of LED0 to LED5.

J27 – GND— These headers are probing points of GND.

J28 – Header— This header is a probing point of INT.

J31 – Connector— This connector is to connect 5-V output from on-board LDO to VDD input.

J32 – Headers— These headers are probing points of SDO_PWM, SDI_SDA, SCLK_SCL, and SS_ADDRSEL.

J33 – Connector— This connector is to connect LED load board to EVM.

J34 – GND— These headers are probing points of GND.

2.2 LP8863EVM Setup

External power must be provided to the board. Connect a standard type-A plug from the PC to a Mini-B plug, which goes to the EVM connector. The I²C-compatible interface program provides all of the controls that the LP8863-Q1 device requires.

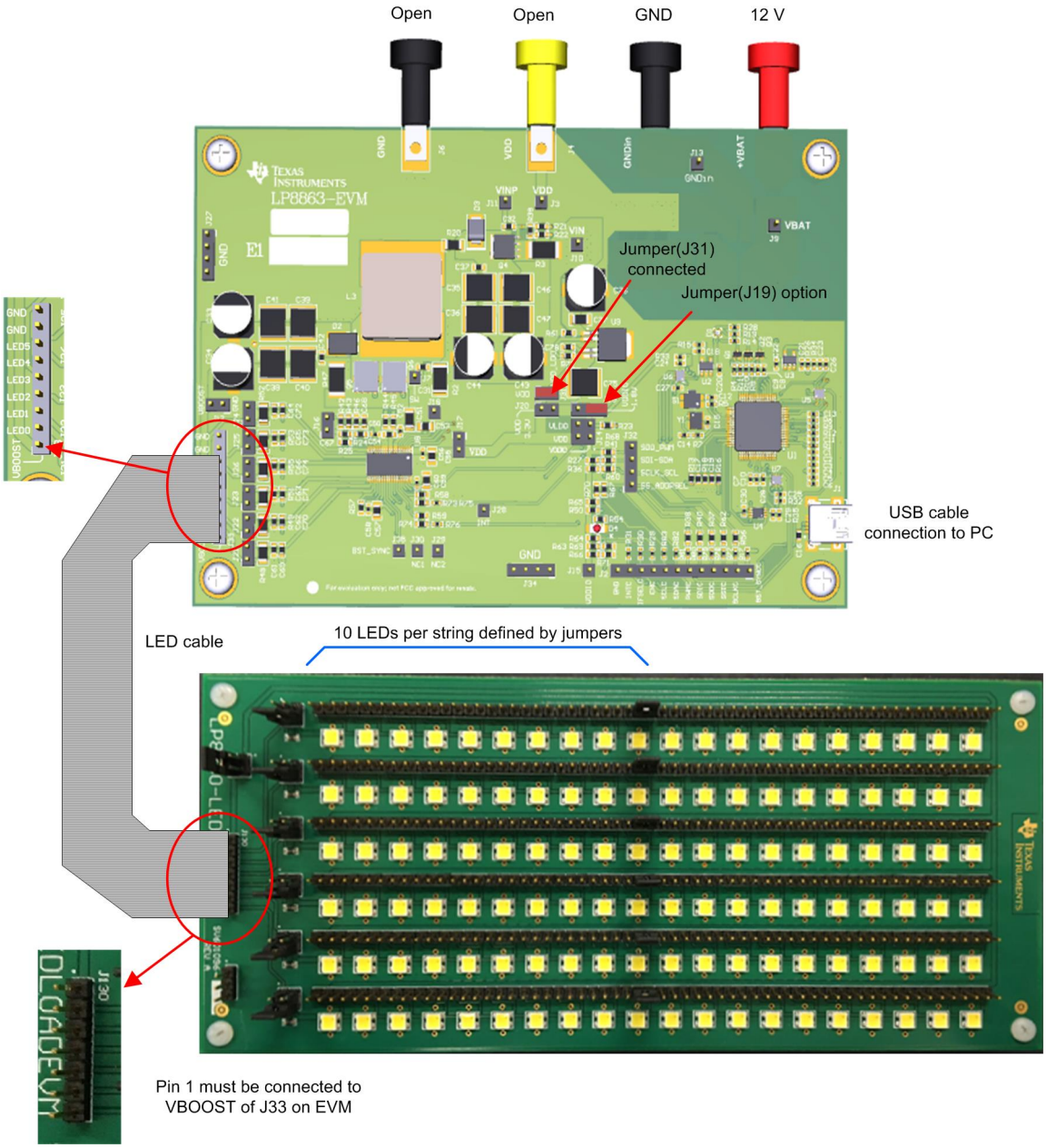


Figure 3. LP8863EVM With LED Load Board Connected

2.3 Installation Guide for GUI program (Windows 7-compatible)

- Run “setup_LP8863_EVM_1.0.0.exe”.
- Click “Next” button on this setup screen.

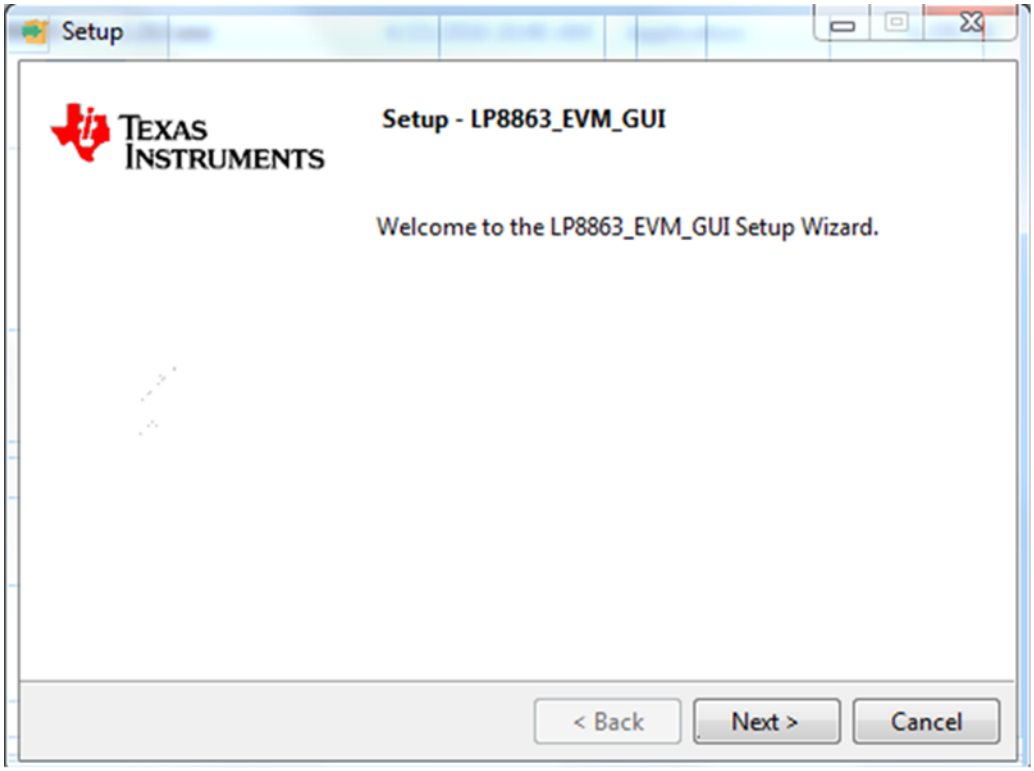


Figure 4. LP8863_EVM_GUI Setup

- Check ”I accept the agreement” and press ”Next” button again.

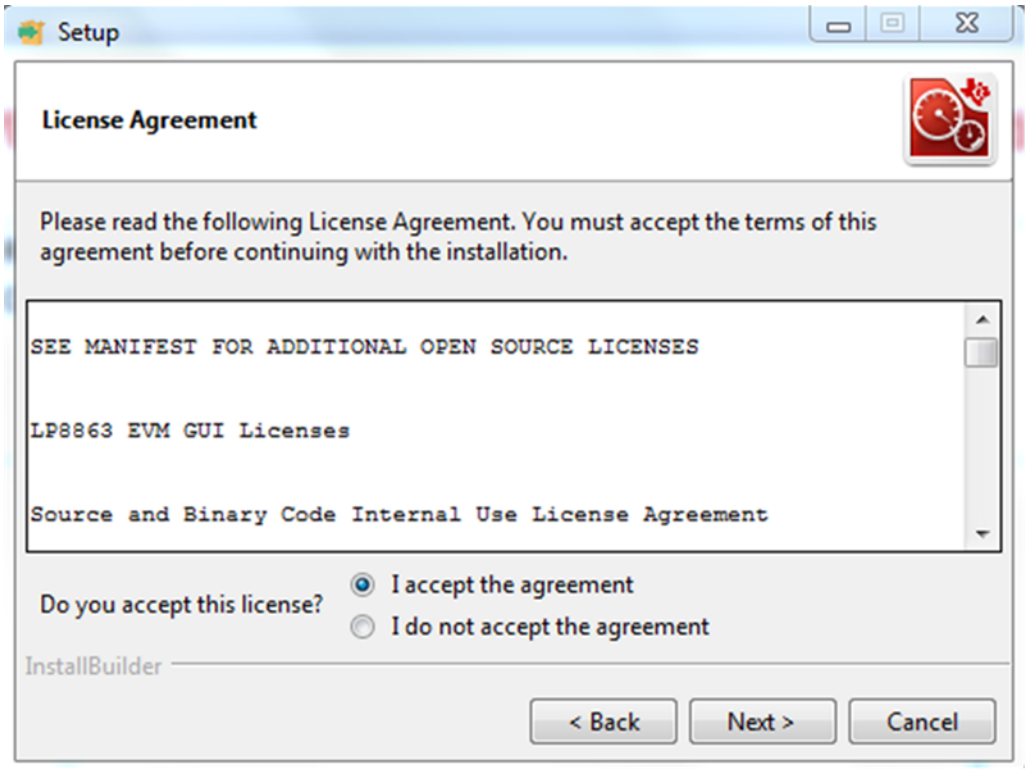


Figure 5. License Agreement

- Choose the folder name of GUI to be installed, then press ”Next” button or simply press ”Next” button.

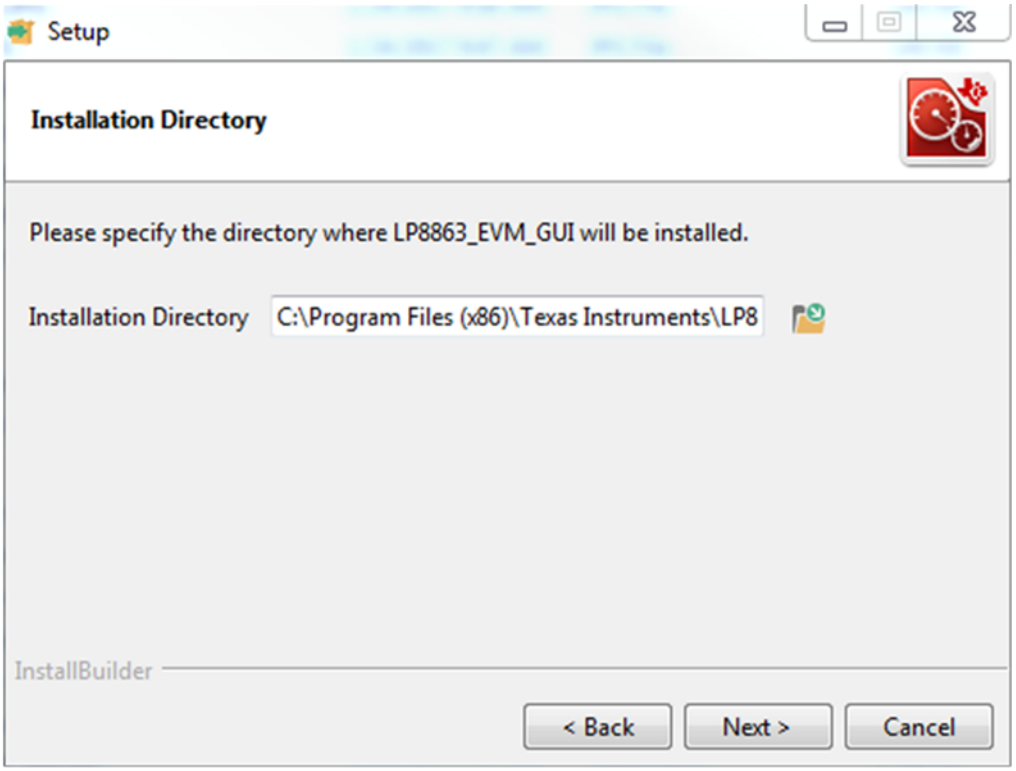


Figure 6. Installation Directory

- Begin SW installation by pressing ”Install” button in next window.
- Once installation is completed, press ”Finish” to launch SW GUI of LP8863-Q1.

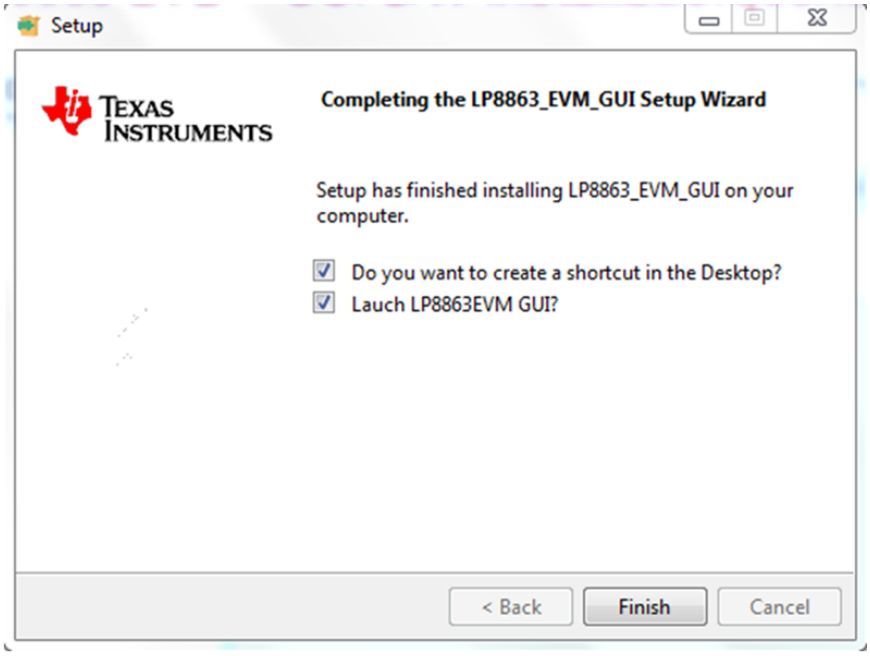


Figure 7. Completing the LP8863_EVM_GUI Setup Wizard

- Initial window of GUI. Prepare hardware connection after this window, as described in the following sections.

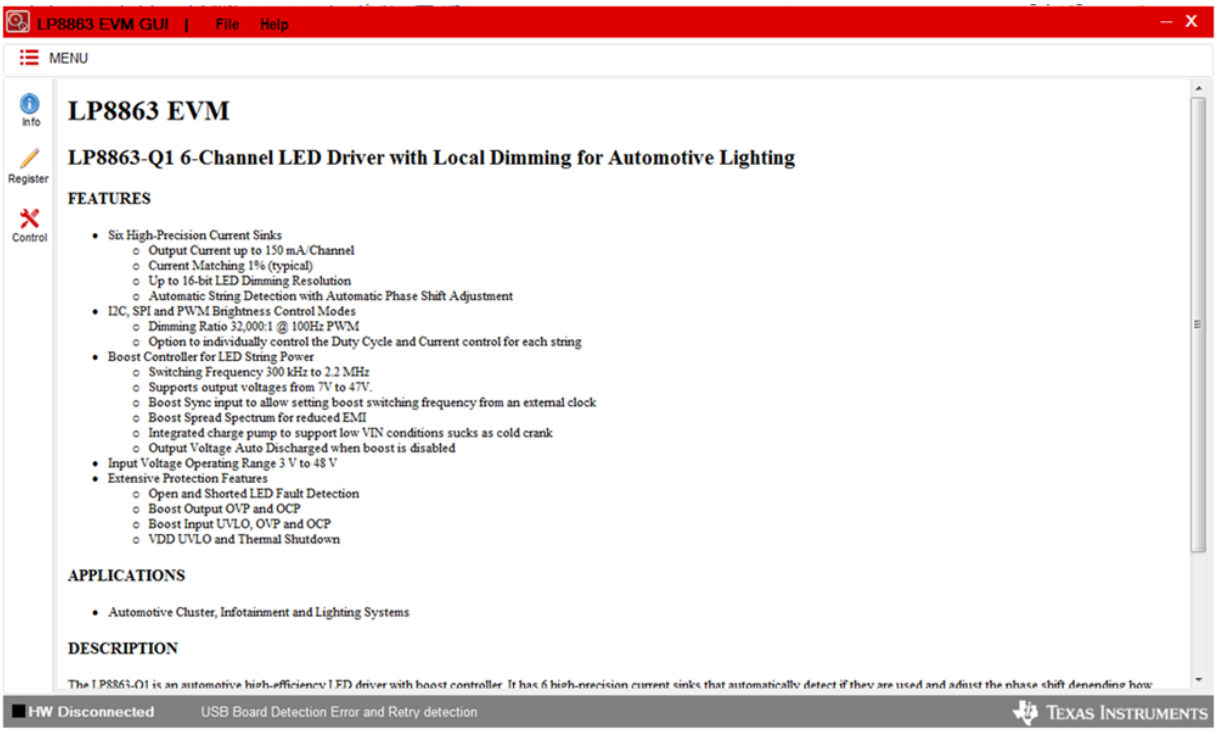


Figure 8. LP8863_EVM_GUI Home Page

3 Quick Start-Up Procedure

- Connect USB cable between EVB and PC.
- Connect external power supply to V_{IN}: 12 V (typical), 5-A setting, output not enabled yet.
- Run the LP8863 GUI software and click ”Control” icon 

on left of GUI, then control window appears as in Figure 9.

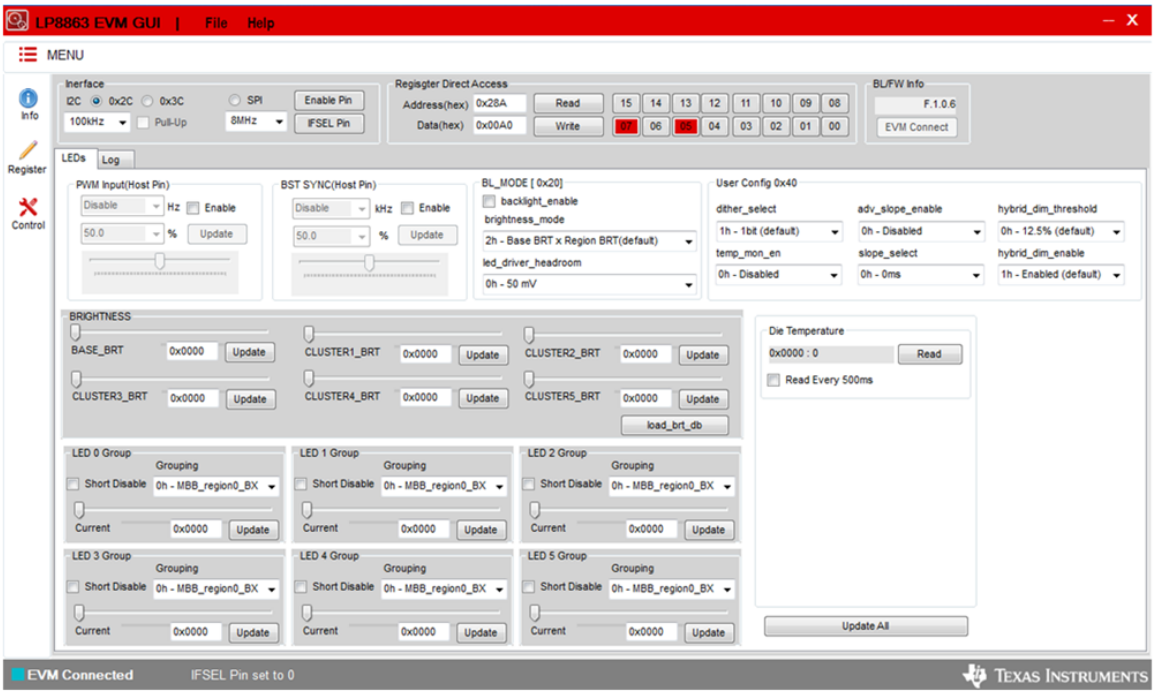
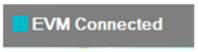
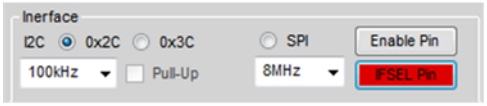


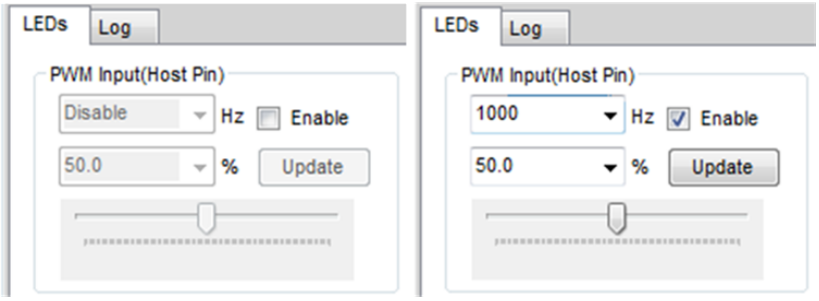
Figure 9. GUI Control Window

- Check ”EVM connected” mark on bottom of GUI software. 

- Press ”IFSEL Pin” button to select I^2C interface: This is not required if register control is not used.

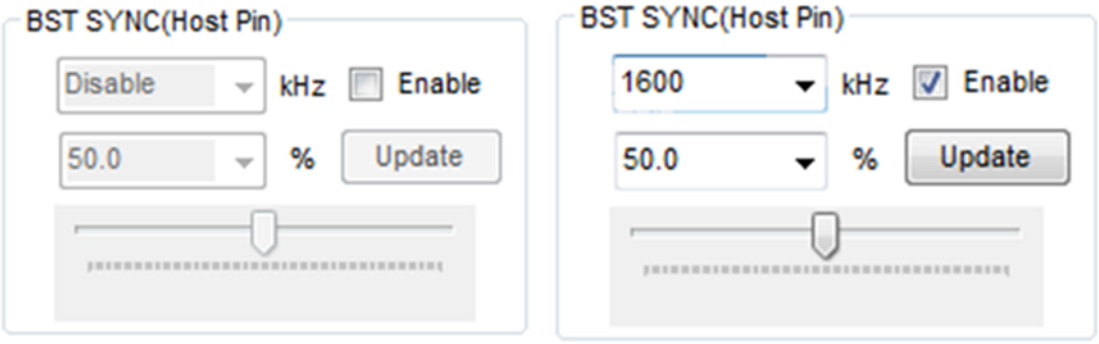


- Enable V_{IN} power supply output: IIN is approximately a couple of mA at normal cases. If higher current on either power rail is monitored, disable power supply output and begin debugging.
- Click ”Enable Pin” button on GUI software: boost converter starts working, and LEDs stay off without PWM input.
- On PWM input control, check ”Enable” box of PWM input, select frequency and duty from drop-down boxes, and press ”Update” button: LED turns on at adjusted brightness level by PWM input.

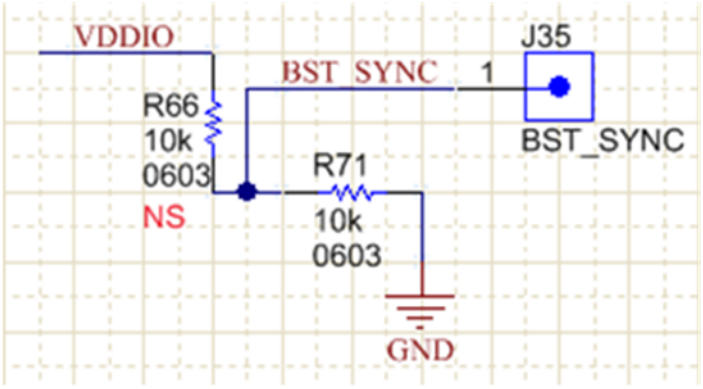


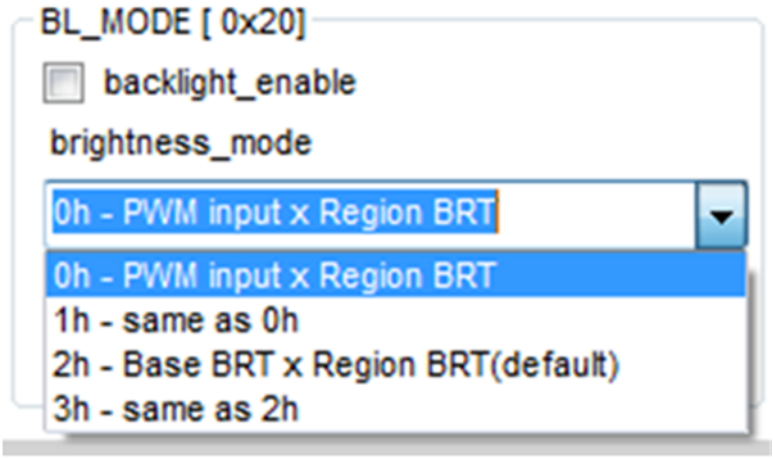
4 Additional Control Options

- If external boost frequency sync is needed, check “Enable” box of BST SYNC, select frequency and duty from drop-down boxes, and press ”Update” button:



- Remove pullup and/or pulldown resistors on EVM to avoid voltage division by these resistors when external boost sync signal is used.

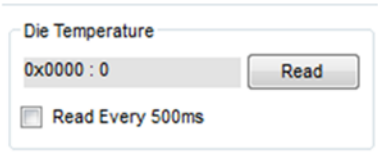




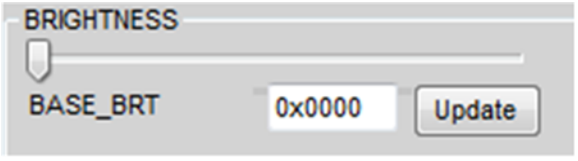
- LED driver headroom voltage can be controlled by led_driver_headroom. Use drop-down box to select desired headroom voltage.

- Other control options such as dither, slope control, dimming mode,and temperature sensor are available by User Config.

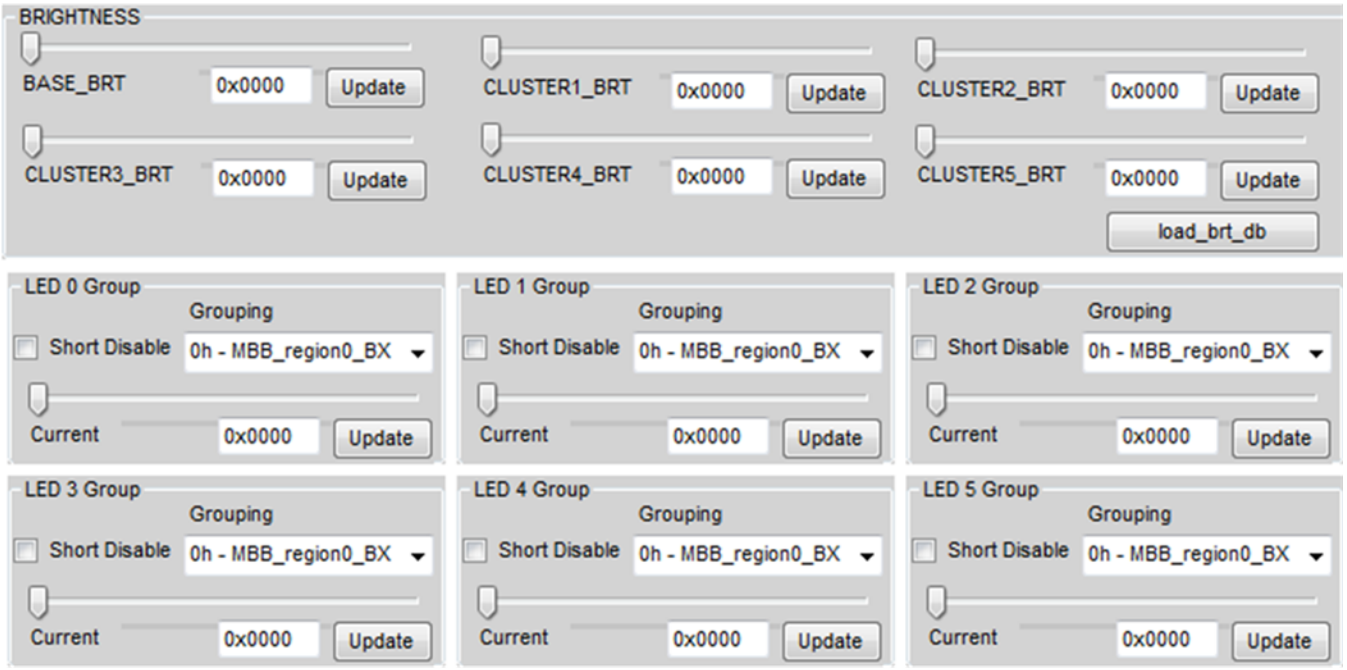
- If temp_mon_en is set, die temperature can be read by window below:



- If brightness mode is selected to use brightness register as a brightness input, not PWM input signal, base brightness can be controlled by window below.



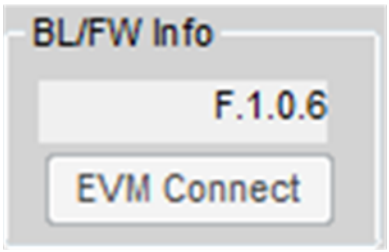
- Control windows below can be used for independent dimming where each LED string is controlled independently. See the LP8863-Q1 data sheet for independent dimming control.



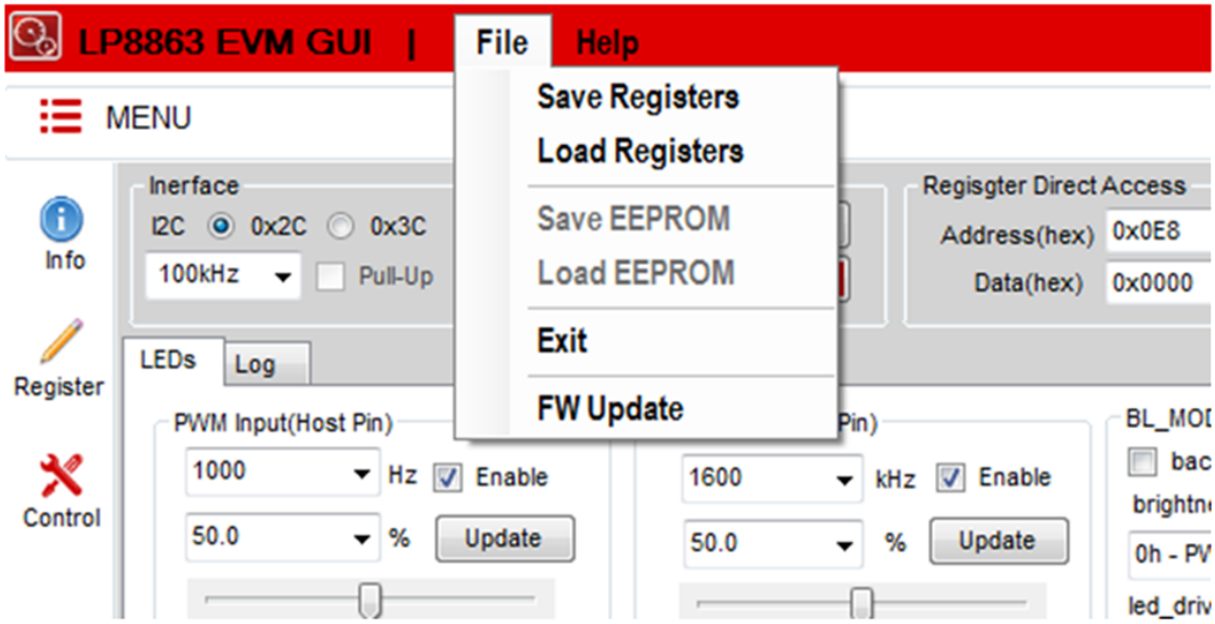
- All register values on control window can be manually updated to reflect latest values by pressing “Update All” button.

- If additional register controls or direct register controls are needed, each register can be accessed directly by input window below.

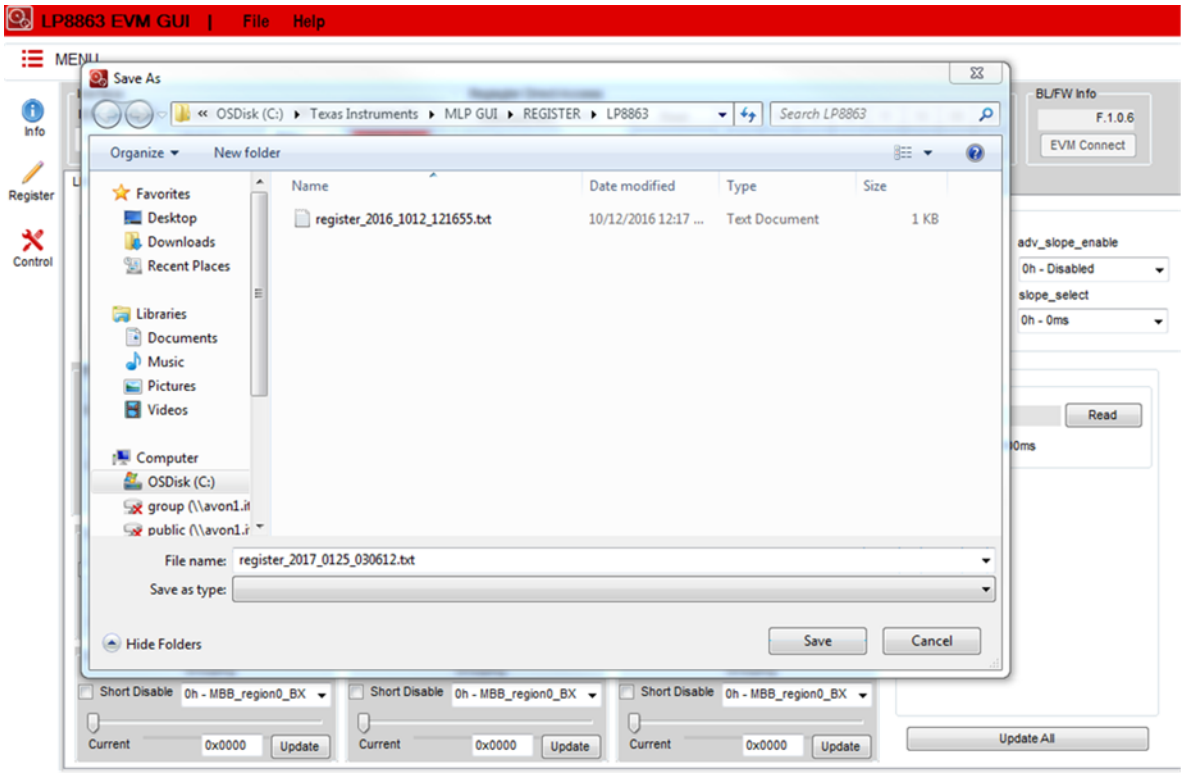
- Firmware version of the Tiva Launchpad is shown here and the latest version is 1.0.6.



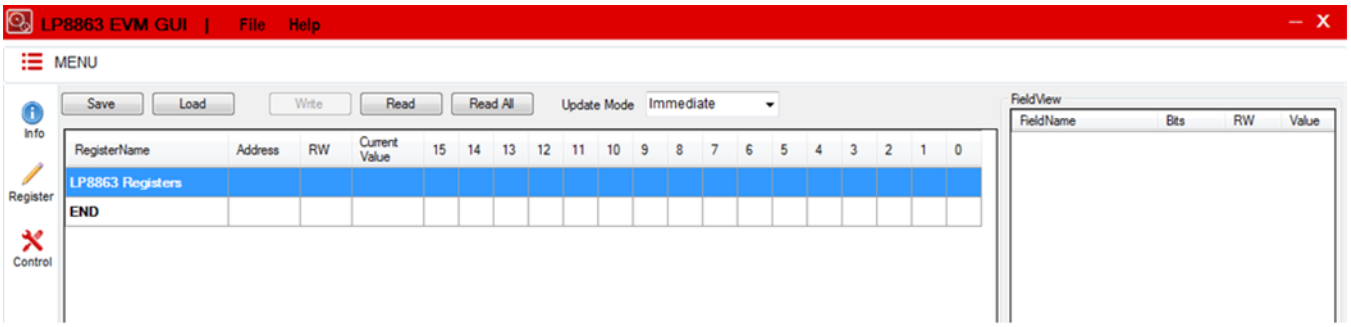
- Individually programmed register values can be saved or loaded by file menu on top of the GUI.



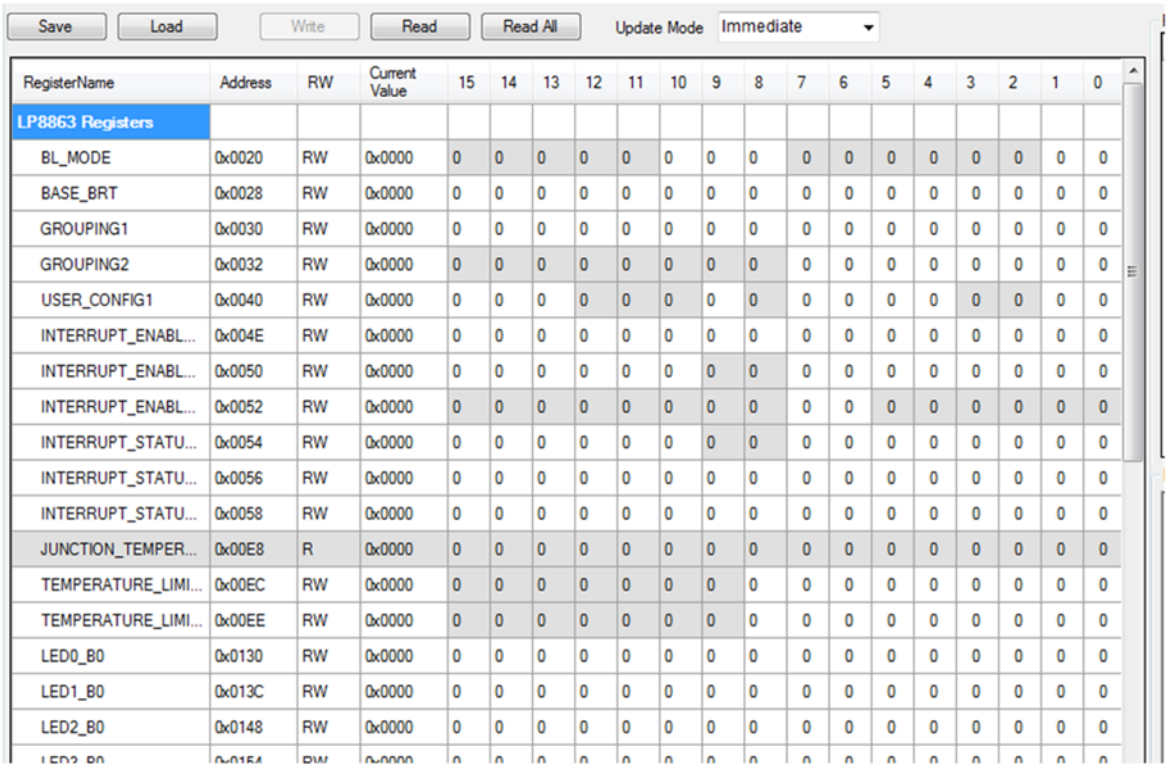
- Register file is *.txt format and can be renamed in the GUI or with a file managing program such as Windows Explorer.



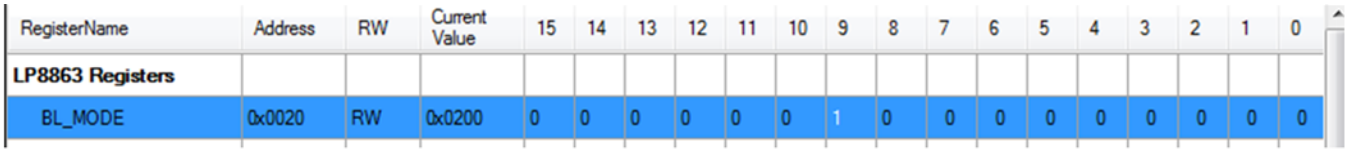
- Settings saved can be opened and programmed automatically by selecting “Load Registers” from file menu.
- Register tab can be selected by pressing icon on left side of GUI.
- Initially, all register values are hidden as below.



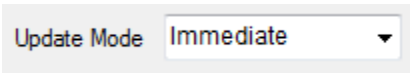
- All register values appear if cell for “LP8863 Registers” is pressed.



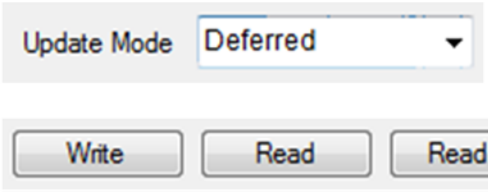
- Press “Read All” to update all register values with current values.
- “Read” button is used to read only selected register on “Register name” column to reduce read time.
- Each register bit can be changed by double click each bit cell.



- Changed bit values by double click can be written immediately by selecting “Immediate” mode.

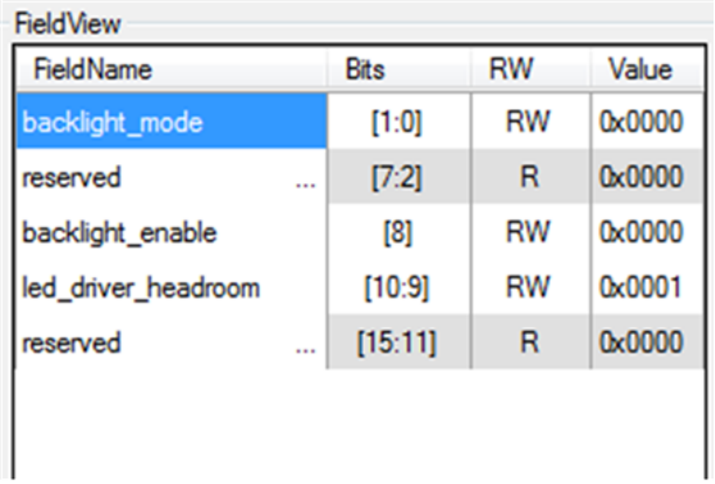


- If Update Mode is “Deferred”, bit value change by double click can be written only when “Write” button is clicked.



- “Save” and “Load” functions are also supported on “Register” window.

- Field View shows register bit name, type, and values:



5 Instructions for Standalone Evaluation

The LP8863EVM can be used for standalone evaluation (without evaluation software and PC connection).

These are minimum requirements to use LP8863EVM as a standalone mode:

- Power supplies for V_{IN} – 24 V or higher, 6 A or higher
- Power supplies for VDD – 5.5 V or higher, 0.5 A or higher (if external power supply is used)
- Power cables for V_{IN} (and/or VDD) connection – TI recommends cables with banana plugs
- LED load board (not included in package, order number EVMSVA-E99-B-250) – 6 strings, 8 LEDs per string (LEDs per string can be adjusted by moving jumpers on load board
- LED cable – 7-position ribbon cable

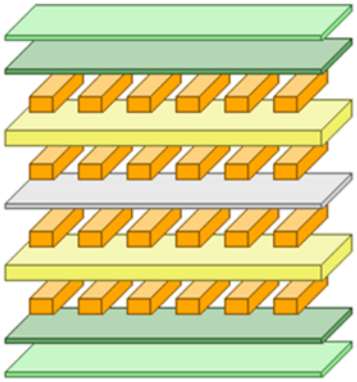
The LP8863EVM must be modified to support standalone mode from its default settings described as follows:

1. Remove jumper on J19.
2. Connect pin 3 and 4 of J14 to connect V_{LDO} output from LP8863-Q1 to VDDIO input.
3. Mount R68 to pull up PWM input for 100% brightness. If brightness needs to be changed from 100%, connect external PWM source here (SDO_PWM).
4. Mount R63 to select I^2C interface, so PWM input pin is not assigned to SDO of SPI interface.
5. Mount R64 to pull up EN input.
6. Change pullup and pulldown resistors to select spread spectrum enable (R66) or disable (R71) option.

The minimum procedures for turning on the LEDs after modifications above are as follows:

- Connect external power (VBAT, 3 V to 48 V; typical 12 V, 6 A) and ground to the board (recommended boost conversion ratio less than 10).
- Connect LED load board (6 strings, 8 LEDs per string) to J33 (use caution about the boost output pin location).
- Enable external power supply.

6 LP8863EVM Board Stackup



	Layer Name	Type	Material	Thickness (mil)	Dielectric Material	Dielectric Constant
☑	Top Overlay	Overlay				
☑	Top Solder	Solder Mask/Co...	Surface Material	0.4	Solder Resist	3.5
☑	Top Layer	Signal	Copper	1.4		
☑	Dielectric1	Dielectric	Core	40	FR-4	4.8
☑	Signal Layer 1	Signal	Copper	1.4		
☑	Dielectric 2	Dielectric	Prepreg	5		4.2
☑	Signal Layer 2	Signal	Copper	1.4		
☑	Dielectric 3	Dielectric	Core	10		4.2
☑	Bottom Layer	Signal	Copper	1.4		
☑	Bottom Solder	Solder Mask/Co...	Surface Material	0.4	Solder Resist	3.5
☑	Bottom Overlay	Overlay				

Figure 10. LP8863EVM Board Stackup

7 LP8863EVM Component Placement

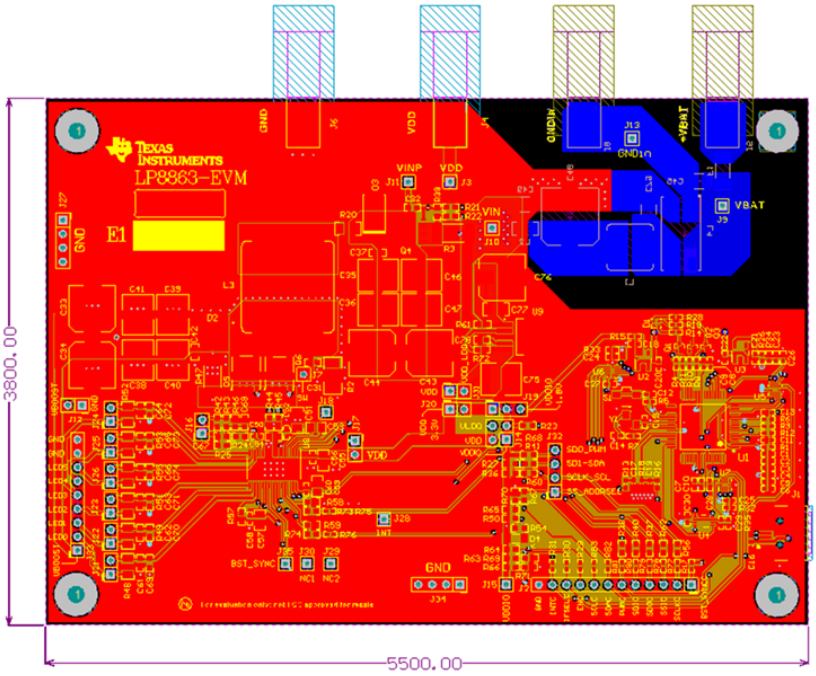


Figure 11. LP8863EVM Component Placement (Top Layer)

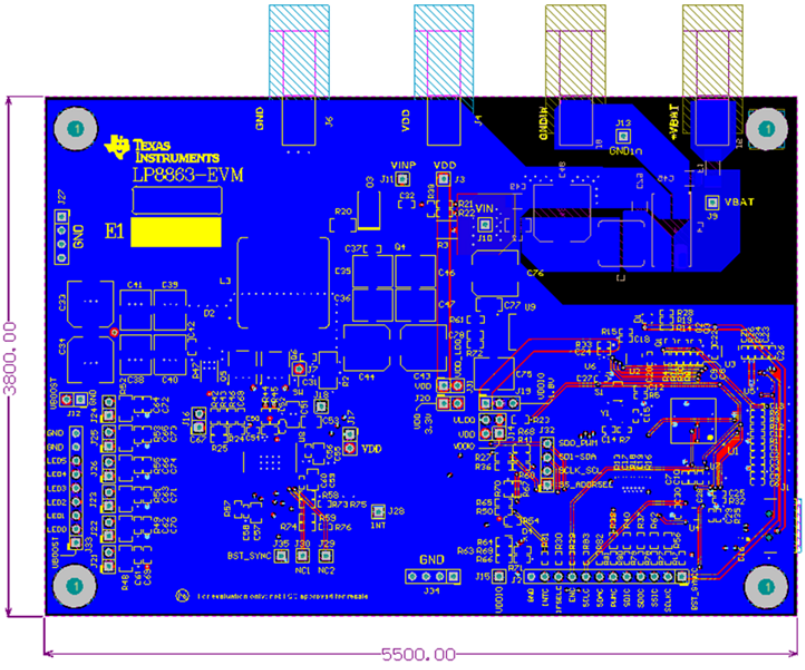


Figure 12. LP8863EVM Component Placement (Bottom Layer)

8 LP8863EVM Component List

DESIGNATOR	QTY	VALUE	DESCRIPTION	FOOTPRINT	PART NUMBER
PCB1	1		Printed Circuit Board		LP8863EVM
C1, C8, C18, C20, C21, C22	6	1uF	CAP, CERM, 1 µF, 16 V, +/- 10%, X6S, 0402	402	C1005X6S1C105K050BC
C2, C4, C6	3	0.01uF	CAP, CERM, 0.01uF, 25V, +/-10%, X7R, 0402	402	C1005X7R1E103K
C3, C5, C7, C9, C10, C11, C12, C13	8	0.1uF	CAP, CERM, 0.1 µF, 50 V, +/- 10%, X7R, 0402	402	C1005X7R1H104K050BB
C14, C15	2	10pF	CAP, CERM, 10pF, 50V, +/-5%, C0G/NP0, 0402	402	500R07S100JV4T
C16	1	10uF	CAP, CERM, 10 µF, 16 V, +/- 20%, X5R, 0603	0603L	EMK107BBJ106MA-T
C17, C19	2	10pF	CAP, CERM, 10 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603L	06035A100JAT2A
C23, C24, C25, C26, C27, C28, C29, C30, C52, C56, C58, C60	12	0.1uF	CAP, CERM, 0.1uF, 16V, +/-10%, X7R, 0402	402	GRM155R71C104KA88D
C31	1	220pF	CAP, CERM, 220 pF, 100 V, +/- 10%, X7R, 0603	603	06031C221KAT2A
C32, C37, C42, C67, C68	5	1000pF	CAP, CERM, 1000pF, 100V, +/-5%, C0G/NP0, 0603	603	GRM1885C2A102JA01D
C33, C34, C43, C44, C76	5	33uF	CAP, AL, 33uF, 63V, +/-20%, 40 ohm, SMD	SM_RADIAL_8MM	EEHZC1J330P
C35, C36, C38, C39, C40, C41, C46, C47	8	10uF	CAP, CERM, 10uF, 100V, +/-20%, X7S, 2220	2220	C5750X7S2A106M
C45, C49, C79	3	10uF	CAP, CERM, 10 µF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	1210_280	UMK325AB7106KMHT
C48	1	56uF	CAP, AL, 56uF, 63V, +/-20%, 30 ohm, SMD	SM_RADIAL_10BMM	EEHZC1J560P
C50	1	100pF	CAP, CERM, 100pF, 25V, +/-10%, X7R, 0603	603	06033C101KAT2A
C51	1	10uF	CAP, CERM, 10uF, 16V, +/-20%, X7R, 1206	1206	C3216X7R1C106M
C53	1	2.2uF	CAP, CERM, 2.2uF, 25V, +/-10%, X7R, 0805	0805_HV	GRM21BR71E225KA73L
C54	1	100pF	CAP, CERM, 100 pF, 50 V, +/- 10%, X7R, 0402	402	CC0402KRX7R9BB101
C55, C57	2	4.7uF	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X7R, 0805	0805_HV	LMK212B7475KG-T
C59	1	10uF	CAP, CERM, 10uF, 10V, +/-10%, X7R, 0805	0805_HV	GRM21BR71A106KE51L
C61, C62, C63, C64, C65, C66, C69, C70, C71, C72, C73, C74	12	2200pF	CAP, CERM, 2200 pF, 100 V, +/- 10%, X7R, 0603	603	06031C222KAT2A
C75	1	47uF	CAP, CERM, 47 µF, 16 V, +/- 20%, X7R,	2220_250	C5750X7R1C476M230KB
C77	1	0.33uF	CAP, CERM, 0.33 µF, 50 V, +/- 20%, X7R, 1206	1206	12065C334MAT2A
C78	1	0.047uF	CAP, CERM, 0.047 µF, 25 V, +/- 5%, X7R, 0603	603	06033C473JAT2A
D1	1	Rgb	LED, Rgb, SMD	SML_RGB_0404	SML-LX0404SIUPGUSB
D2	1	100V	Diode, Schottky, 100 V, 10 A, AEC-Q101, TO-277A	TO-277A	FSV10100V
D3	1	60V	Diode, Schottky, 60 V, 1 A, AEC-Q101, SMB	SMB	CMSH1-60 TR13
D4	1	Red	LED, Red, SMD	1105W_Red	HBR1105W-TR
F1	1		Fuse, 15 A, SMD	Fuse_SSQ	SSQ 15
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	NY PMS 440 0025 PH
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Keystone_1902C	1902C
J1	1		Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	CONN_USB-Mini-B-1734035-2	1734035-2
J2	1		Header, 100mil, 12x1, Gold, TH	TSW-112-07-G-S	TSW-112-07-G-S
J3	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J4	1		BANANA JACK, 15A, Insulated, Nylon,Yellow	CONN_108-0907-001	108-0907-001
J5	1		Standard Banana Jack, Insulated, Red	6091	6091
J6, J8	2		Standard Banana Jack, Insulated, Black	6092	6092
J7	1		Header, 100mil, 1x1, Gold, TH	Samtec_HTSW-101-09-x-S	HTSW-101-09-G-S

J9	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J10	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J11	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J12, J16, J20, J21, J22, J23, J24, J25, J26, J31	10		Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	TSW-102-07-G-S	TSW-102-07-G-S
J13	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J14	1		Header, TH, 100mil, 2x2, Gold plated, 230 mil above insulator	TSW-102-07-G-D	TSW-102-07-G-D
J15	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J17	1		Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	TSW-102-07-G-S	TSW-102-07-G-S
J18	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J19	1		Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	TSW-103-07-G-S	TSW-103-07-G-S
J27, J32, J34	3		Header, 100mil, 4x1, Gold, TH	TSW-104-07-G-S	TSW-104-07-G-S
J28	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J29	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J30	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
J33	1		Header, 100mil, 9x1, Vertical, TH	Samtec_TSW-109-07-G-S	TSW-109-07-G-S
J35	1		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	TSW-101-07-G-S	TSW-101-07-G-S
L1	1	2.2uH	Inductor, Shielded, Powdered Iron, 2.2 µH, 10.5 A, 0.0137 ohm, SMD	IHLP-3232DZ	IHLP3232DZER2R2M01
L2	1	50 ohm	Ferrite Bead, 50 ohm @ 100 MHz, 12 A, 1206	1206	BLM31SN500SZ1L
L3	1	22uH	Inductor, Shielded, Powdered Iron, 22 µH, 12 A, 0.0265 ohm, AEC-Q200 Grade 0, SMD	SRP1770TA	SRP1770TA-220M
L4	1	9uH	Coupled inductor, 9 µH, A, 0.0036 ohm, SMD	MuRata_PLT10H	PLT10HH501100PNL
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Label_650x200	THT-14-423-10
Q1, Q2, Q3	3	50 V	Transistor, NPN, 50 V, 0.1 A, AEC-Q101, SOT-416	SOT-416	DTC114EET1G, ON Semiconductor
Q4	1	-60V	MOSFET, P-CH, -60V, 30A, PowerPAK_SO-8L	PowerPAK_SO-8L	SQJ461EP
Q5	1	60V	MOSFET, N-CH, 60 V, 25 A, AEC-Q101, SO-8FL	SO-8FL	NVMFS5C682NLT1G
Q6	1	60V	MOSFET, N-CH, 60 V, 25 A, AEC-Q101, SO-8FL	SO-8FL	NVMFS5C682NLT1G
R1, R5, R6	3	10k	RES, 10k ohm, 5%, 0.063W, 0402	402	CRCW040210K0JNED
R2	1	5.1	RES, 5.1, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20105R10JNEF
R3	1	0.02	RES, 0.02 ohm, 1%, 3W, 2512	2512M	CRA2512-FZ-R020ELF
R4, R7, R8, R9, R10, R11, R12, R15, R17, R26, R29, R30, R31, R75, R76, R77, R78, R79, R80, R81, R82, R83	22	0	RES, 0 ohm, 5%, 0.063W, 0402	402	CRCW04020000Z0ED
R13, R16	2	27	RES, 27, 5%, 0.1 W, 0603	0603L	CRCW060327R0JNEA
R14, R19, R28	3	10.0k	RES, 10.0k ohm, 1%, 0.063W, 0402	402	CRCW040210K0FKED
R18	1	1.0Meg	RES, 1.0 M, 5%, 0.1 W, 0603	0603L	CRCW06031M00JNEA
R20	1	0	RES, 0, 5%, 0.25 W, 1206	1206	RC1206JR-070RL
R21, R22, R23, R37, R38, R40, R41, R44, R45, R56, R60, R61, R62, R67, R73, R74	16	0	RES, 0 ohm, 5%, 0.1W, 0603	603	MCR03EZPJ000

R24, R25	2	0	RES, 0, 5%, 0.1 W, 0603	603	CRCW06030000Z0EA
R27, R36	2	2.2k	RES, 2.2k ohm, 5%, 0.1W, 0603	603	CRCW06032K20JNEA
R32, R33, R34, R35	4	100k	RES, 100 k, 5%, 0.063 W, 0402	402	CRCW0402100KJNED
R39	1	20.0k	RES, 20.0k ohm, 1%, 0.1W, 0603	603	CRCW060320K0FKEA
R42	1	20	RES, 20.0 ohm, 1%, 0.1W, 0603	603	RC0603FR-0720RL
R43	1	910k	RES, 910k ohm, 1%, 0.1W, 0603	603	RC0603FR-07910KL
R46	1	100k	RES, 100k ohm, 1%, 0.1W, 0603	603	RC0603FR-07100KL
R47	1	0.015	RES, 0.015, 1%, 3 W, 2512	2512	CRA2512-FZ-R015ELF
R48, R49, R51, R52, R53, R55	6	4.99	RES, 4.99 ohm, 1%, 0.25W, 1206	1206	CRCW12064R99FKEA
R50, R63, R64, R65, R66, R68, R69, R70, R71	9	10k	RES, 10k ohm, 5%, 0.1W, 0603	603	CRCW060310K0JNEA
R54	1	150	RES, 150, 5%, 0.1 W, 0603	603	CRCW0603150RJNEA
R58	1	42.2k	RES, 42.2 k, 0.1%, 0.1 W, 0603	603	RT0603BRD0742K2L
R59	1	3.92k	RES, 3.92 k, 1%, 0.1 W, 0603	603	RC0603FR-073K92L
R72	1	4.99k	RES, 4.99 k, 0.5%, 0.1 W, 0603	603	RT0603DRE074K99L
R?	1	25.5k	RES, 25.5 k, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERA-3AEB2552V
S1	1		Switch, Tactile, SPST-NO, 0.05A, 12V , SMD	SW_EVQP7A	EVQ-P7A01P
U1	1		Tiva C Series Microcontroller, PM0064A	PM0064A_M	TM4C123GH6PMI7R
U2	1		ULTRA LOW-NOISE, 250-mA LINEAR REGULATOR FOR RF AND ANALOG CIRCUITS REQUIRES NO BYPASS CAPACITOR, DBV0005A	DBV0005A_N	LP5907MFX-1.8/NOPB
U3	1		ULTRA LOW-NOISE, 250-mA LINEAR REGULATOR FOR RF AND ANALOG CIRCUITS REQUIRES NO BYPASS CAPACITOR, DBV0005A	DBV0005A_N	LP5907MFX-3.3/NOPB
U4	1		TCA9406 Dual Bidirectional 1-MHz I2C-BUS and SMBus Voltage Level-Translator, 1.65 to 3.6 V, -40 to 85 degC, 8-pin US8 (DCU), Green (RoHS & no Sb/Br)	DCU0008A_N	TCA9406DCUR
U5, U6, U7	3		4-Bit Bidirectional Level-Shifter/Voltage Translator With Automatic Direction Sensing, RUT0012A	RUT0012A	TXB0304RUTR
U8	1		6-Channel LED Driver with Local Dimming for Automotive Lighting, DCP0038A	DCP0038A_N	LP8863ADCPRQ1
U9	1		Single Output Automotive LDO, 700 mA, Fixed 5 V Output, 5.5 to 42 V Input, 5-pin PFM (KVU), -40 to 125 degC, Green (RoHS & no Sb/Br)	KVU0005A_N	TLE4275QKVURQ1
Y1	1		Crystal, 16MHz, SMD	TXC_7V	7V-16.000MAAE-T

9 LP8863EVM Schematics

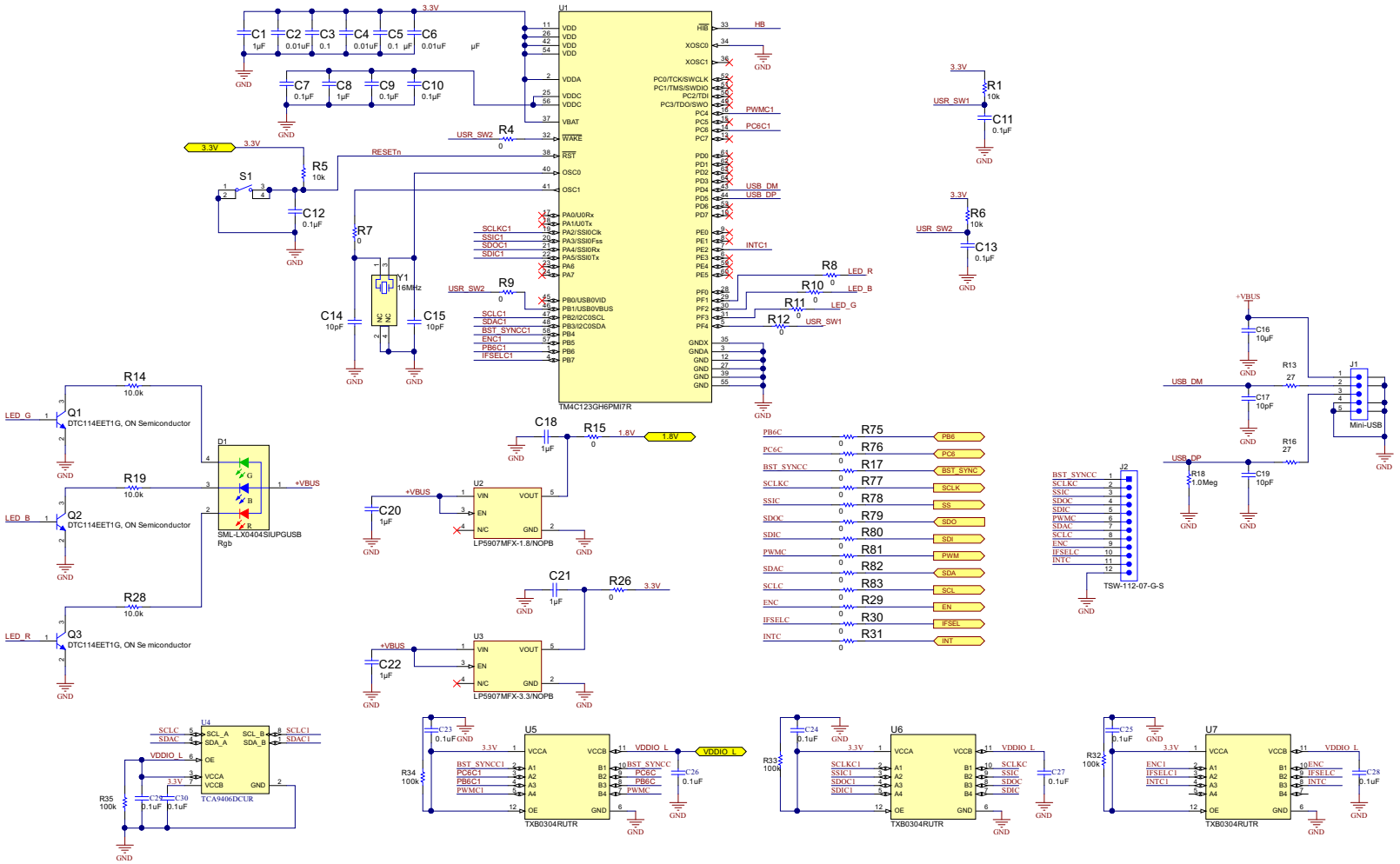


Figure 13. LP8863EVM Schematic(LED driver circuit)

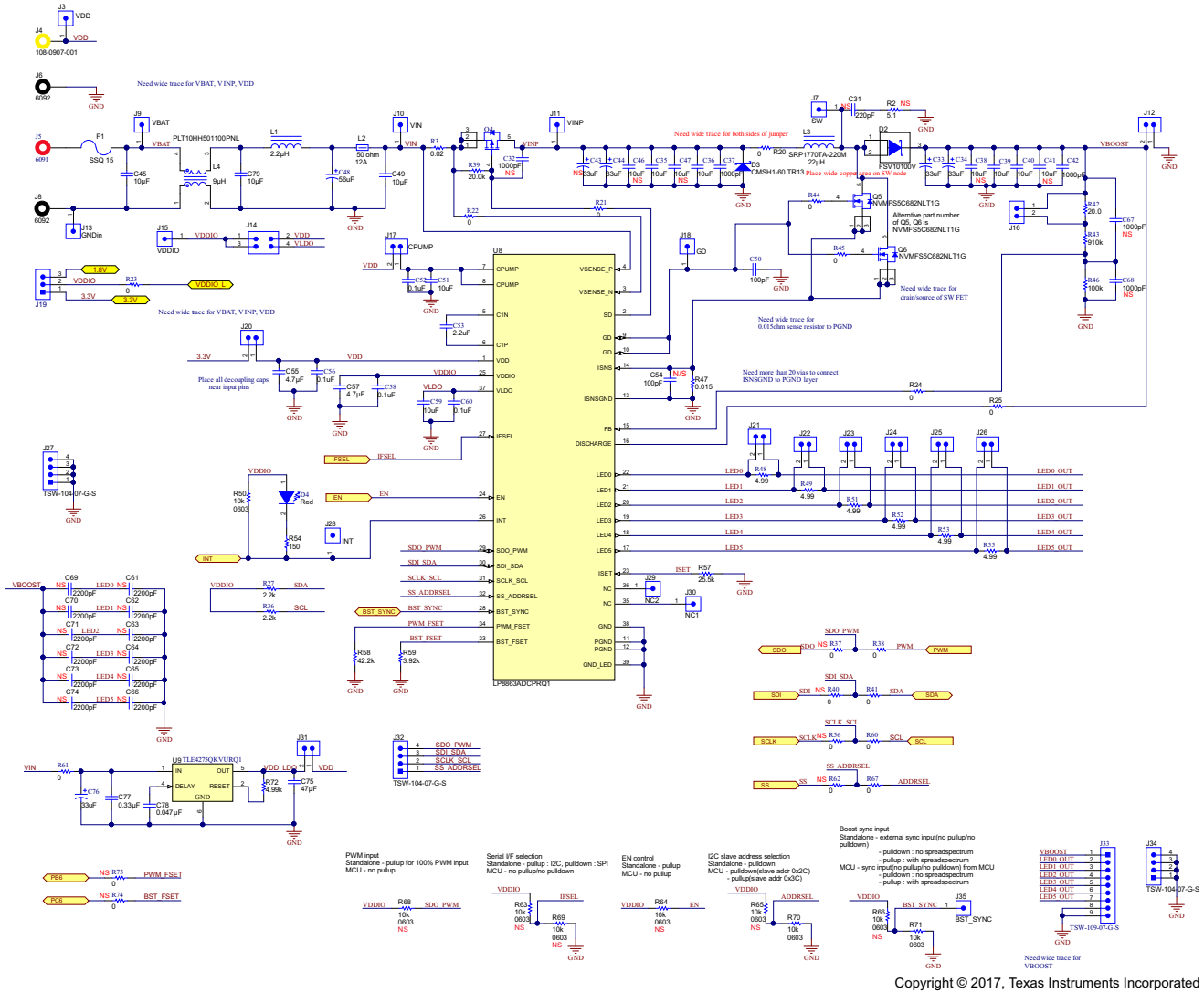


Figure 14. LP8863EVM Schematic (Tiva Launchpad circuit)

10 Using the LP8863EVM

The LP8863-Q1 automotive LED driver can be set or programmed to support optimal application configuration for boost and LED driver control. A few basic settings such as boost switch frequency, PWM output frequency, and LED string current can be controlled by external resistor options, and other settings for preferences such as dimming option, brightness input selection, slope control, etc can be programmed using LP8863-Q1 GUI software. This section shows how to set hardware conditions such as power sequences, external resistor options, etc.

10.1 Power up/down sequence

Power up: Input V_{IN} (generating VDD from on-board LDO) a few hundred µs earlier than EN. Input VBAT and VDDIO earlier than EN.

Power down: V_{IN} must be high for at least 400 ms after EN is low for correct discharge operation. VDDIO and VBAT must be low after EN is low.

10.2 Enable

The EN pin controls boost enable/disable. If brightness input is 0% while EN is high, boost output voltage stays at the initial voltage (approximately 46 V).

10.3 Setting Boost Switch Frequency

R59 between BST_FSET and GND sets boost switch frequency. The value can be selected from Table 2. The default switch frequency setting is 300 kHz.

Table 2.

R_FSET (kΩ)	BOOST SW FREQUENCY (kHz)
3.92	303
4.75	400
5.76	606
7.87	800
11	1000
17.8	1250
42.2	1667
140	2222

10.4 Setting PWM Output Frequency

R58 between PWM_FSET and GND sets PWM output frequency. The value can be selected from Table 3. The default PWM output frequency setting is 9.8 kHz.

Table 3.

R_FSET (kΩ)	BOOST SW FREQUENCY (kHz)
3.92	152
4.75	304
5.76	610
7.87	1221
11	2441
17.8	4883
42.2	9766
140	19531

10.5 Setting the LED String Current

R57 between ISET and GND sets LED string current. The value can be calculated from Equation 1. The default LED string current setting is 120 mA (25.8 kΩ).

$$I_{LED}(n) = \frac{2560 \times V_{BG}}{R_{ISET}} \times \frac{LED(n)\_current[11:0]}{4095} \quad (1)$$

where

- V_{BG} = 1.2 V

10.6 LED String Configuration

LED string configuration of LP8863-Q1 is automatically detected at VDD POR. Any LED out pins (LED0 to LED5) connected to GND are disabled and removed from adaptive loop control. Pin 2 of J21 to J26 can be used to connect LED out pins to GND.

11 LED Load Board

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

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

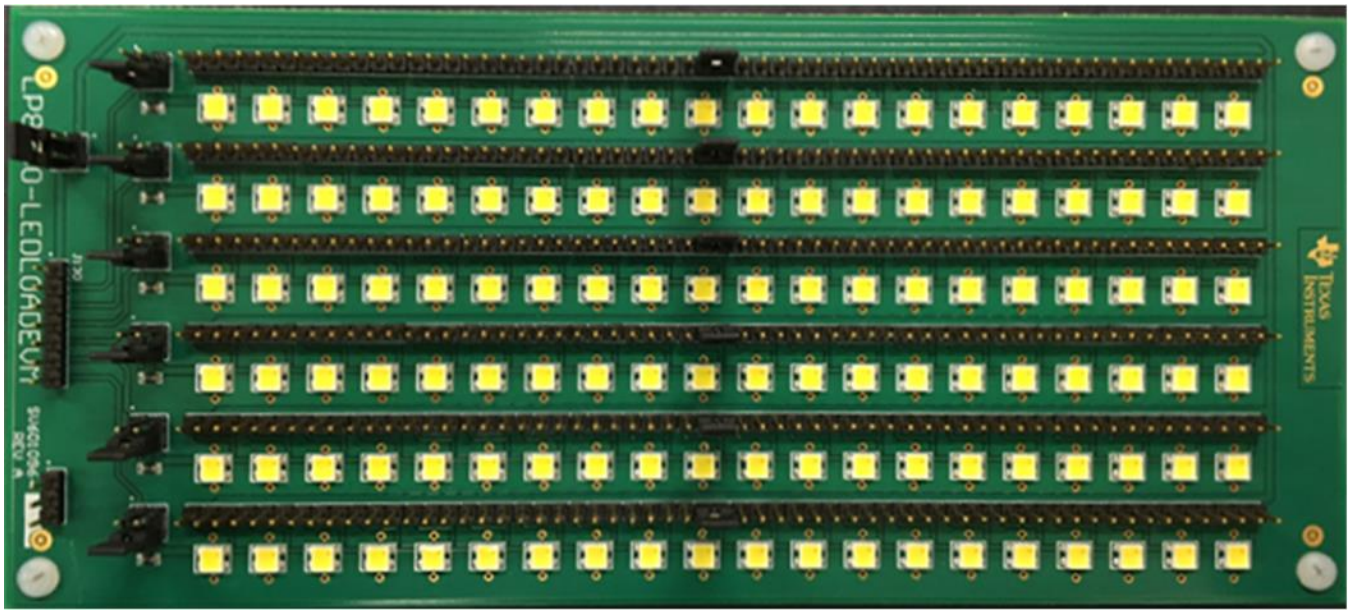


Figure 15. LED Load Board (Top View)

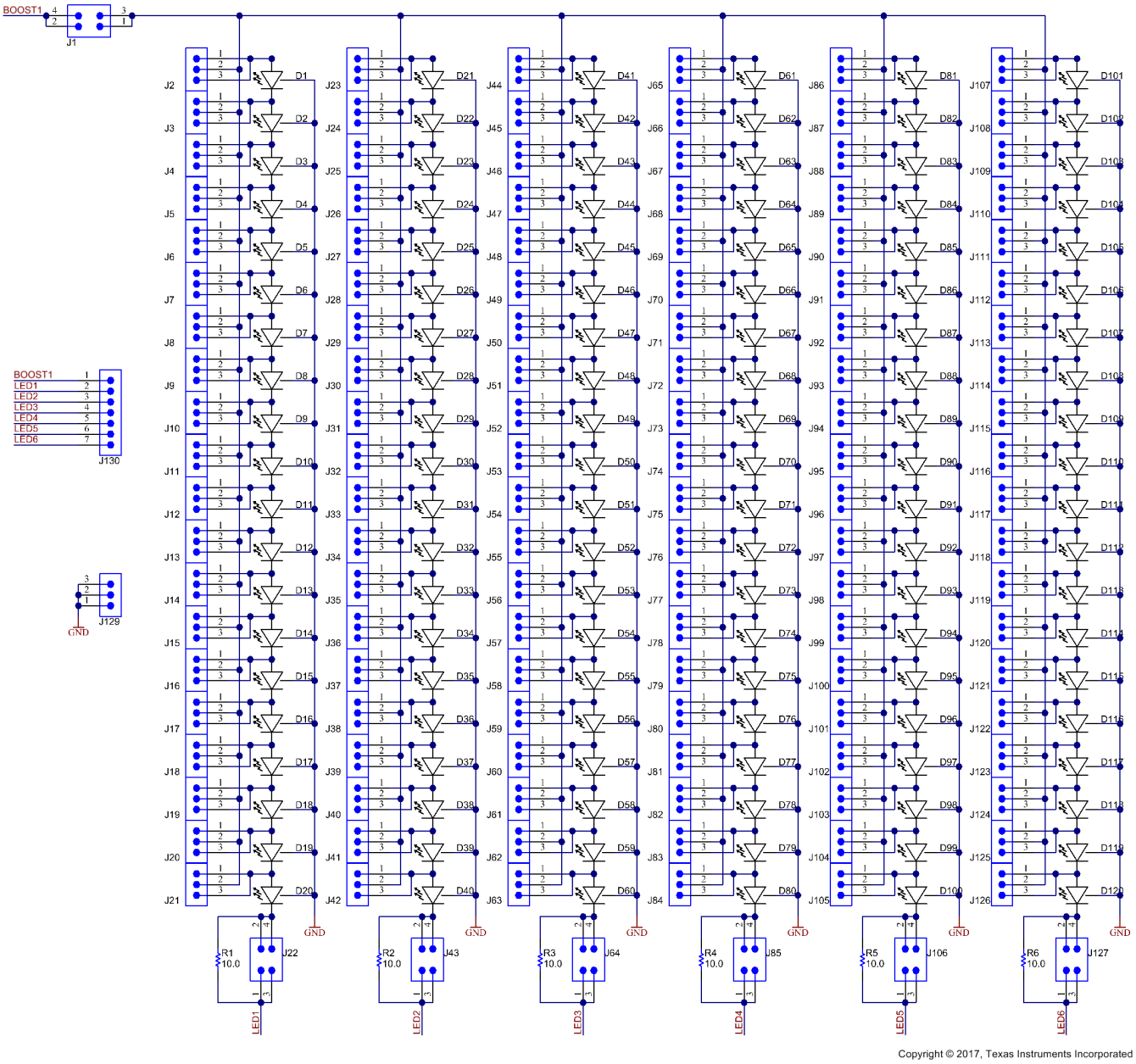


Figure 16. LED Load Board (Schematic Diagram)

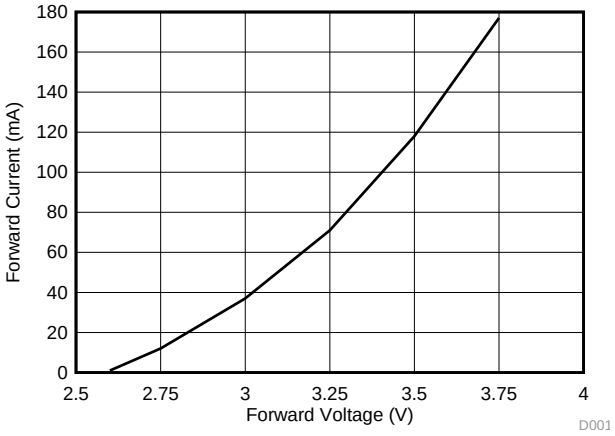


Figure 17. Forward Voltage for Cree Xlamp ML-B LEDs

Table 4. Bill of Material for LED Load Board

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

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   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

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   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.

3 *Regulatory Notices:*

   3.1 *United States*

      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

      FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

      3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

      CAUTION

      This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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

      FCC Interference Statement for Class A EVM devices

      NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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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。

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東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。http://www.tij.co.jp/lsds/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.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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

6. *Disclaimers:*

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

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8. *Limitations on Damages and Liability:*

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

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

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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