Using the LP8860-Q1EVM Evaluation Module

User's Guide

Literature Number: SNVU382A
April 2014–Revised June 2014

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About this Manual

This user's guide describes the module used to evaluate characteristics, operation, and use of the LP8860-Q1 low EMI, high-performance 4-channel LED driver for automotive lighting. This document includes a schematic diagram, PCB layout, and bill of materials (BOM). Evaluation software (SW) usage is also described.

How to Use This Manual

This document contains the following chapters:

- Chapter 1: Introduction
- Chapter 2: Description of the LP8860-Q1
- Chapter 3: Hardware Setup
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Related Documentation from Texas Instruments

LP8860-Q1 data sheet

FCC Warning

This equipment is intended for use in a laboratory test environment only. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to subpart J of part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user, at their own expense, will be required to take whatever measures may be required to correct this interference.

If You Need Assistance

Contact your local TI sales representative.

Introduction

The Texas Instruments LP8860-Q1EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LP8860-Q1 device. The LP8860-Q1EVM uses the LP8860-Q1 to drive up to 4 LED strings for LCD backlighting with high efficiency. Information about output voltage and current ratings of the LP8860-Q1 can also be found in the device datasheet.

In order to facilitate ease of testing and evaluation of this circuit, the EVM contains a TI MSP430 microprocessor to provide easy communication via USB. Power supply connection for the VIN, VDD, and test points for each signal can be found on the evaluation board. Windows® SW is used to control I^2C/SPI™ registers of the device. A separate LED board can be used as a load; it is also possible to connect LCD panel to the output connectors.

For evaluation purposes, the EVM has been tested over a 3-V to 48-V input range. This voltage range is within the recommended operating range for input voltage of the LP8860-Q1. Users are cautioned to evaluate their specific operating conditions and choose components with the appropriate voltage ratings before designing this support circuitry into a final product.

1.1 Trademarks

Windows is a registered trademark of Microsoft Corporation.
SPI is a trademark of Motorola.
All other trademarks are the property of their respective owners.

Description of the LP8860-Q1

The LP8860-Q1 is an automotive high-efficiency LED driver with integrated boost controller. It has 4 high-precision current sinks that can be controlled by a PWM input signal, an SPI/I²C master, or both.

The boost converter has adaptive output voltage control based on the LED current sink headroom voltages. This feature minimizes the power consumption by adjusting the voltage to the lowest sufficient level in all conditions. A boost controller supports spread spectrum for switching frequency and an external synchronization with a dedicated pin. The high switching frequency allows the LP8860-Q1 to avoid disturbance for AM radio band.

The LP8860-Q1 supports built-in Hybrid PWM and Current Dimming which reduces EMI, extends the LED lifetime, and increases the total optical efficiency. Phase-shift PWM allows reduced audible noise and smaller boost output capacitors.

The LP8860-Q1 can drive an external p-FET to disconnect the input supply from the system in the event of a fault and reduce inrush current and standby power consumption.

The input voltage range for LP8860-Q1 is 3 V to 48 V to support car stop/start conditions. The device integrates extensive safety and protection features.

2.1 Features

- Four High-Precision Current Sinks
  - Current Matching 0.5% typ
  - Output Current up to 150 mA/Channel
  - Individual LED String Current Adjustment
  - Dimming Ratio >13000:1 with External PWM Brightness Control
  - 16-bit dimming control with SPI or I²C Control
  - Two Modes: Display Mode and Cluster Mode with Individual Control
- Hybrid PWM and Current Dimming for Higher LED Drive Optical Efficiency
- Synchronization for LED PWM
- Boost Controller With Programmable Switching Frequency 100 kHz to 2.2 MHz and Spread Spectrum Option
- Boost Synchronization Input
- Input Voltage Operating Range 3 V to 48 V
- Power Line FET Control for Inrush Current Protection and Standby Energy Saving
- Automatic LED Current Reduction with External Temperature Sensor
- Extensive Safety and Fault Tolerance Features
- SPI or I²C Interface

2.2 Applications

- Automotive Infotainment, Instrument Cluster and Backlighting Systems

2.3 Typical Applications

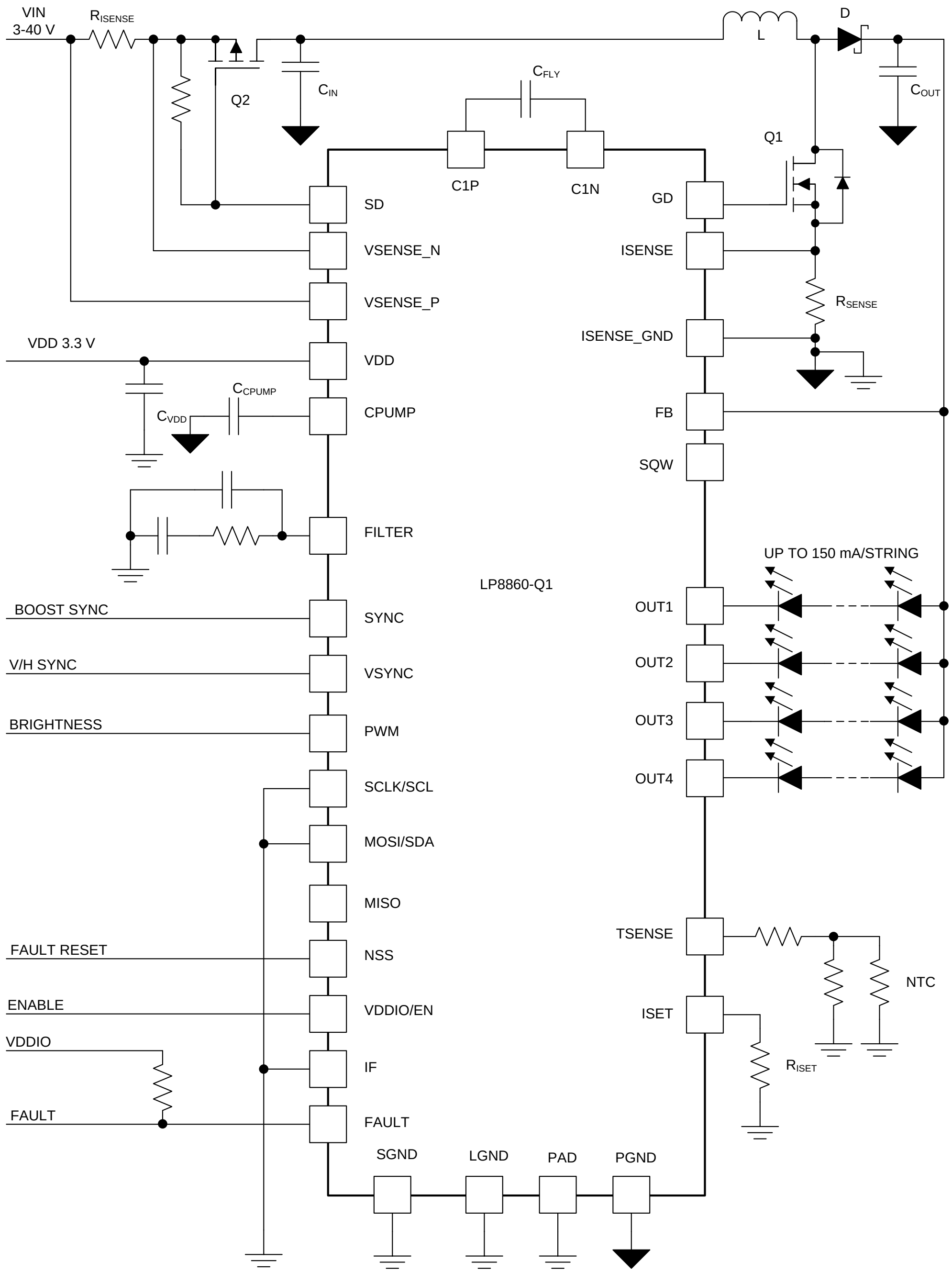


Figure 2-1. Typical Application, Simple PWM Control, VDD = 3.3 V, Charge Pump On, 4 Strings

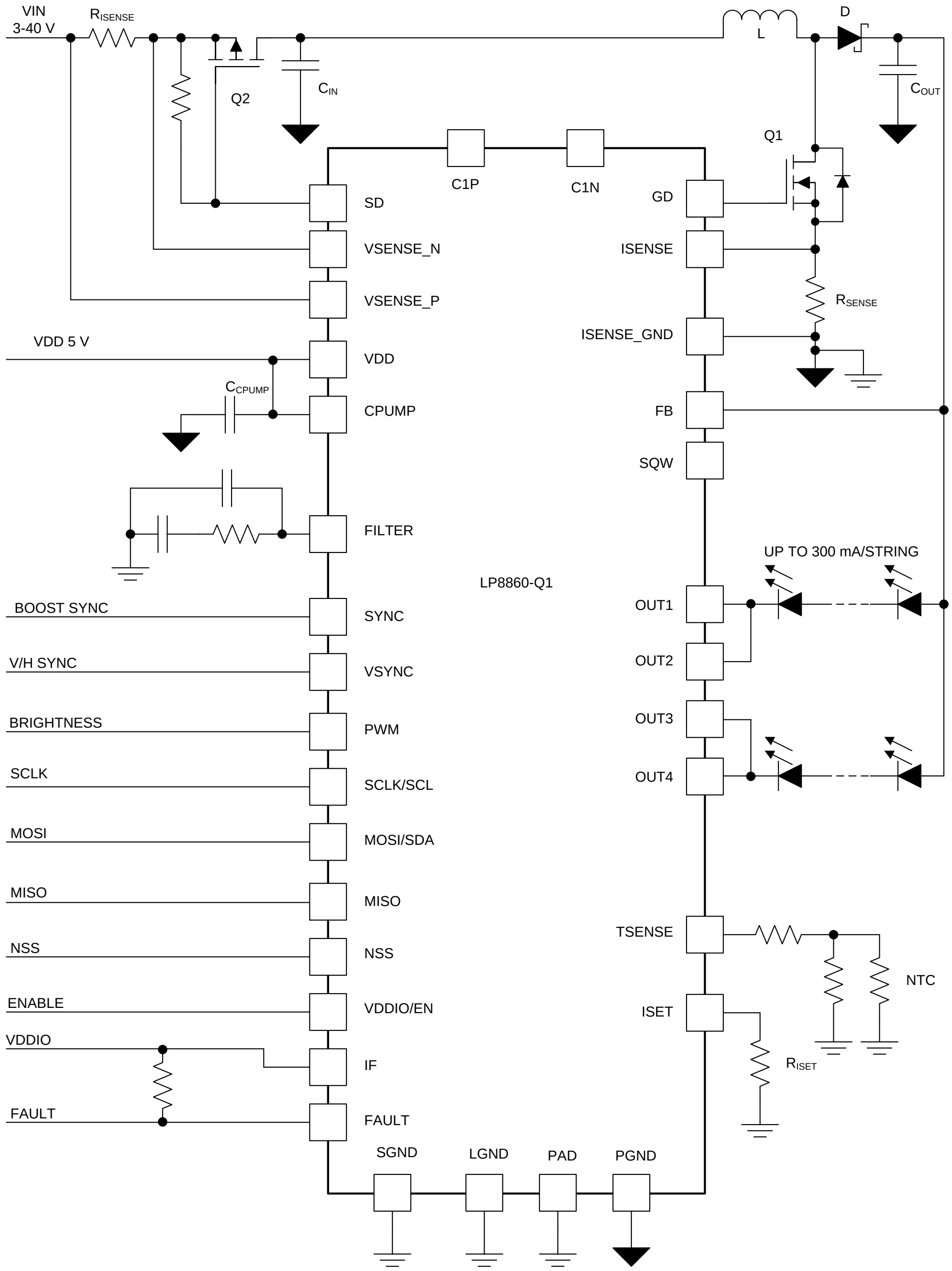


Figure 2-2. Typical Application, SPI Control, VDD = 5 V, Charge Pump Off, 2 Strings

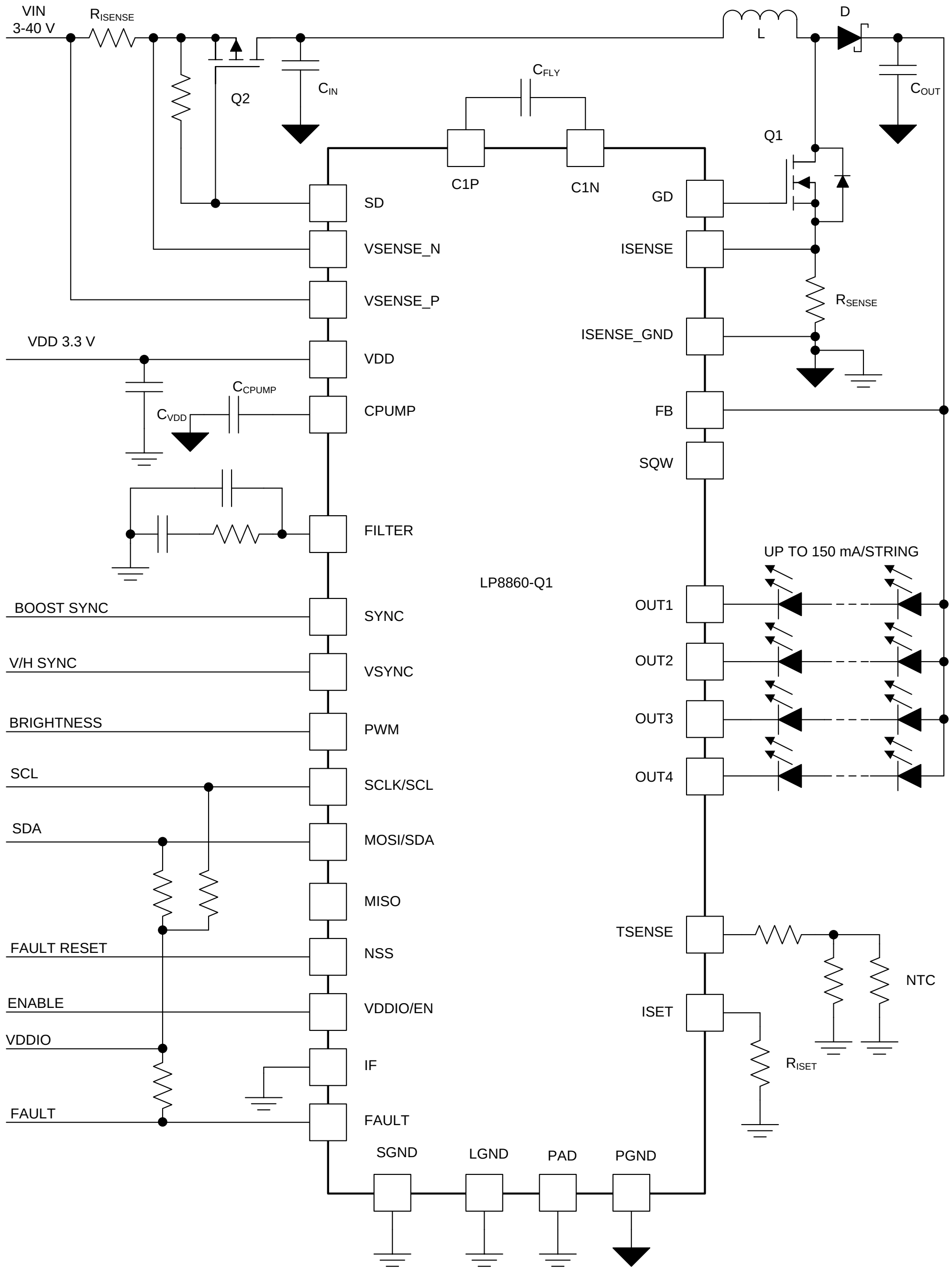


Figure 2-3. Typical Application, I²C Control, VDD = 3.3 V, Charge Pump On, 4 Strings

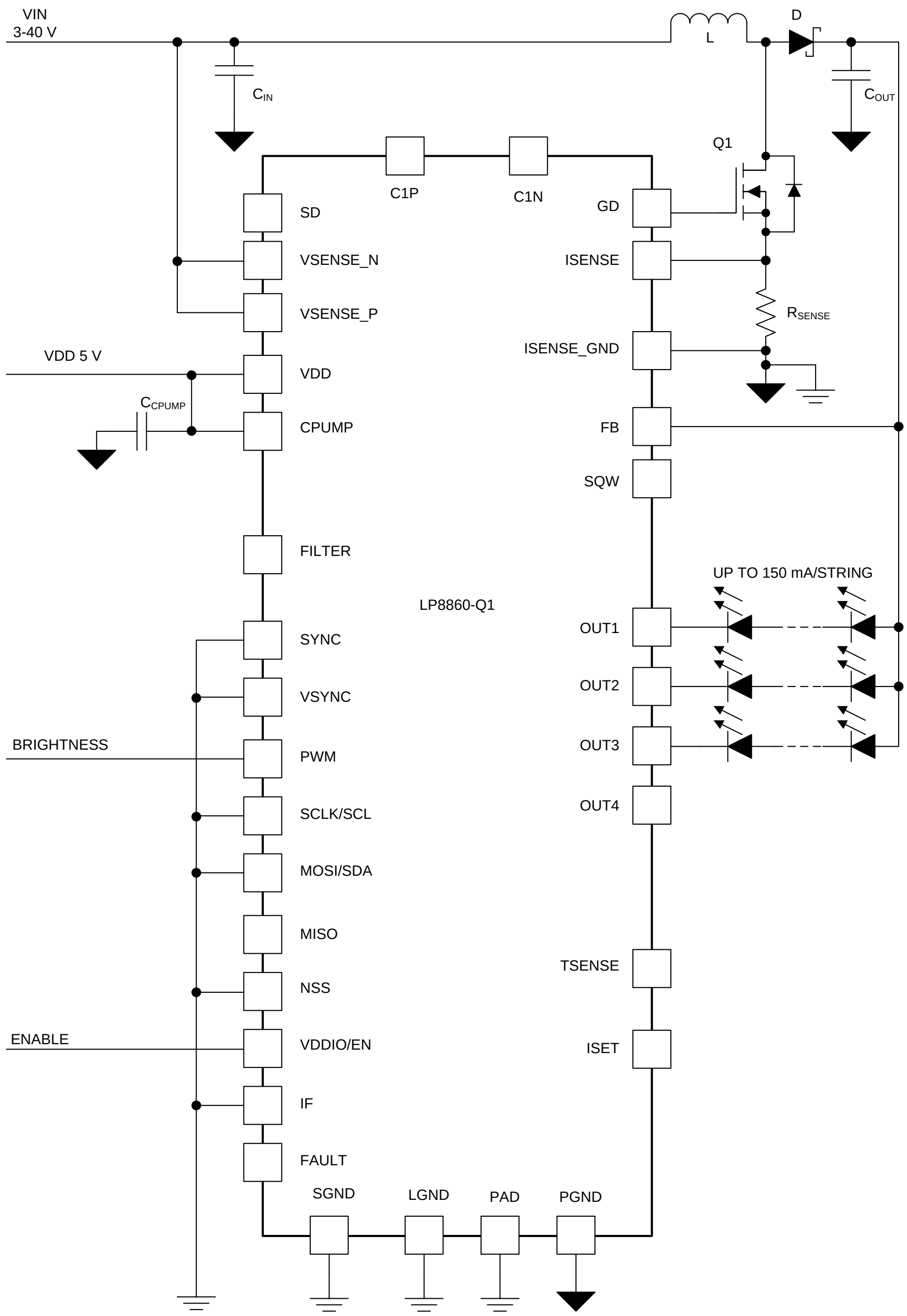


Figure 2-4. Typical Application, without Serial Interface, VDD = 5 V, Charge Pump Off, 3 Strings

Hardware Setup

Figure 3-1 shows connectors and main components on the board.

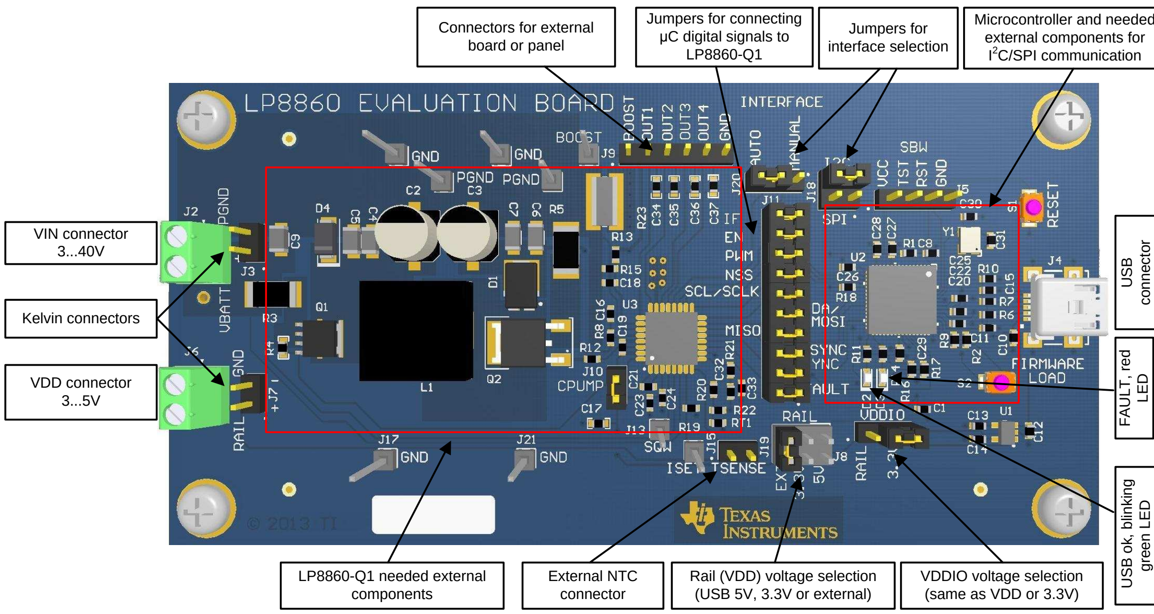


Figure 3-1. Evaluation Board Connectors and Setup

Note. If charge pump is not in use, J10 “CPUMP” should be shorted.

Board Layout

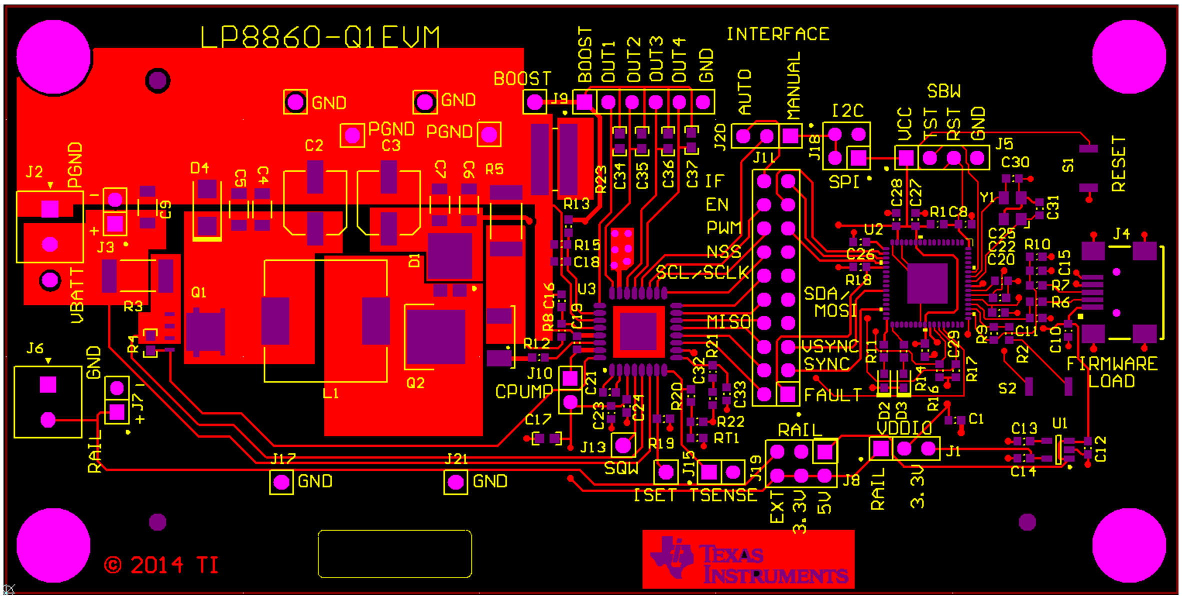


Figure 4-1. Top Layer

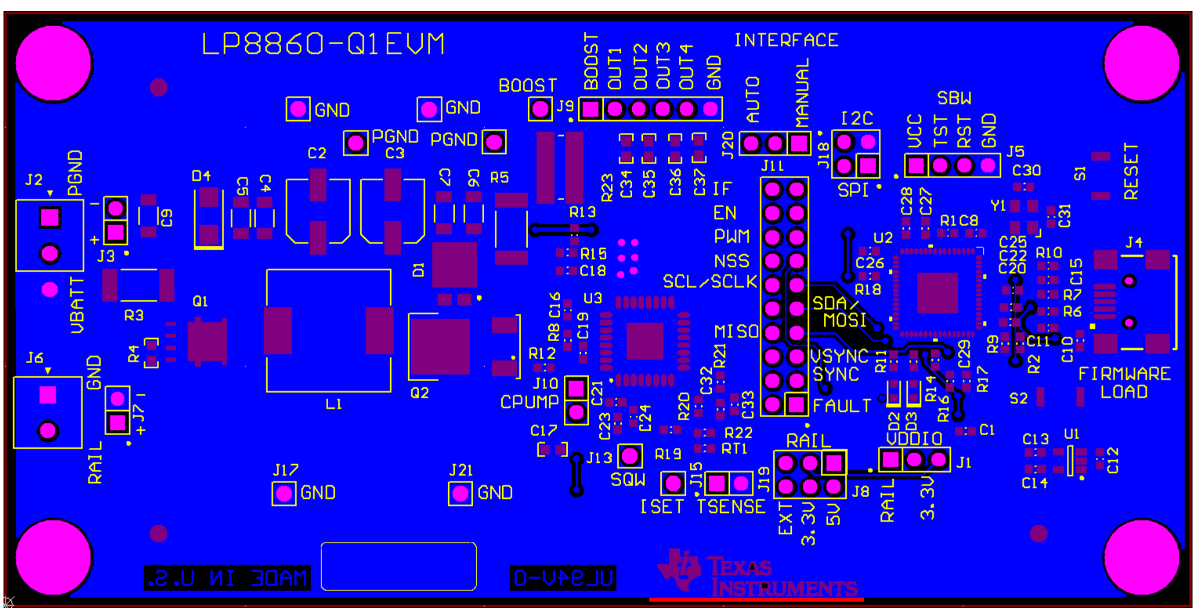


Figure 4-2. Bottom Layer (GND)

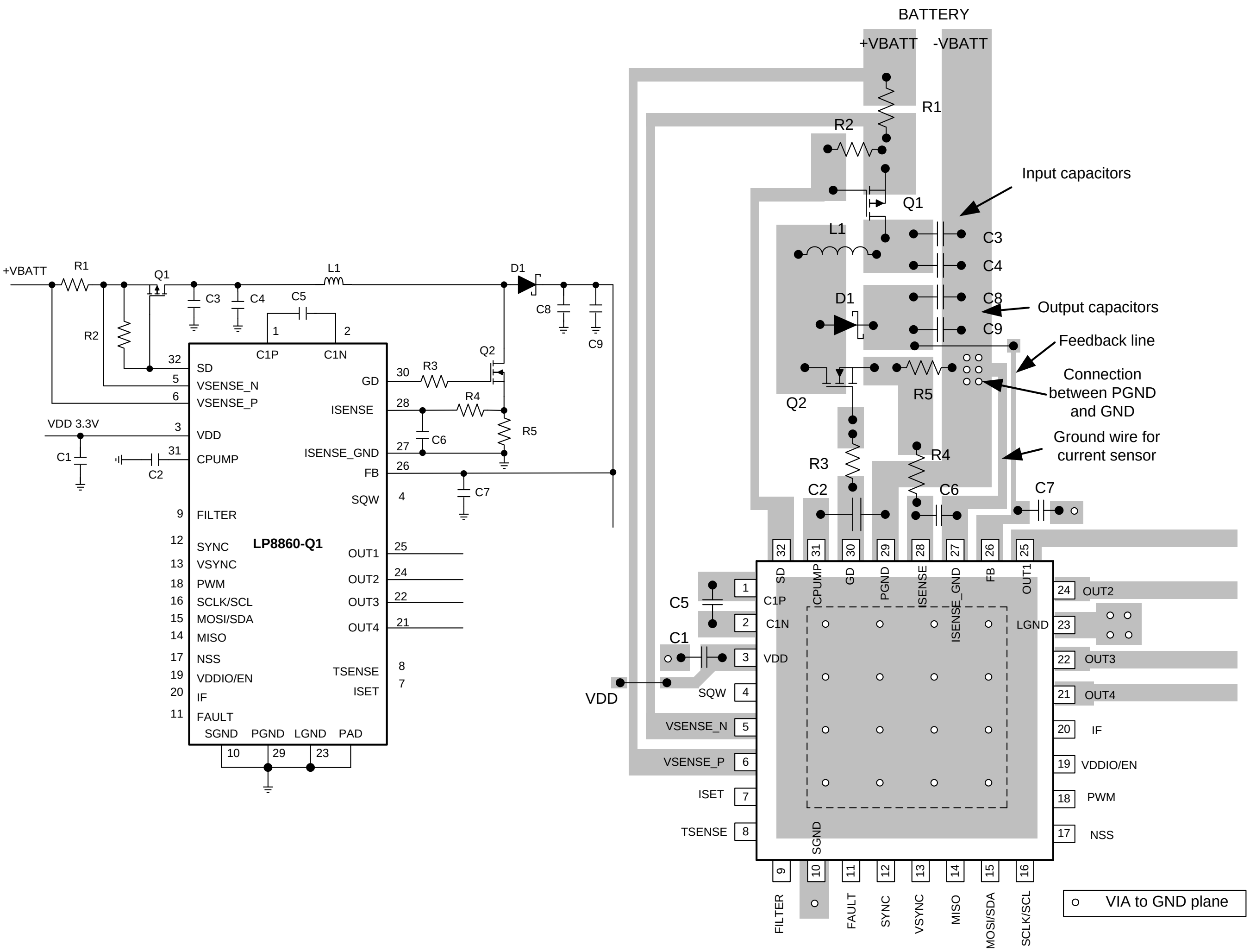


Figure 4-3. PCB Layout Example

See the LP8860-Q1 datasheet for PCB layout guidelines.

Board Stackup

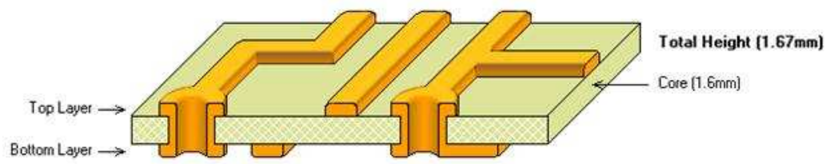


Figure 5-1. Evaluation Board Stackup

Details:

- 2-layer board FR4
- Top layer - copper 35 µm
- Core 1.6 mm
- Bottom Layer - copper 35 µm
- Surface finish immersion gold

Power Sequences

The LP8860-Q1 has a dual function VDDIO/EN pin. It acts as enable for the chip as well as supply/reference voltage for IO logic. Device starts when VDD voltage is present and above the VDD_UVLO voltage level and the VDDIO/EN voltage is set above threshold voltage (1.2 V).

6.1 Start-up Sequence

The backlight is started either by setting PWM input high or by writing not zero brightness value to registers, depending on the brightness control mode and phase shift configuration. See the LP8860-Q1 datasheet for details.

6.2 Shutdown Sequence

The backlight is shut down either with setting PWM input low or by writing zero brightness value to registers, depending on the brightness control mode and phase shift configuration. See the LP8860-Q1 datasheet for details.

Evaluation Board Schematic

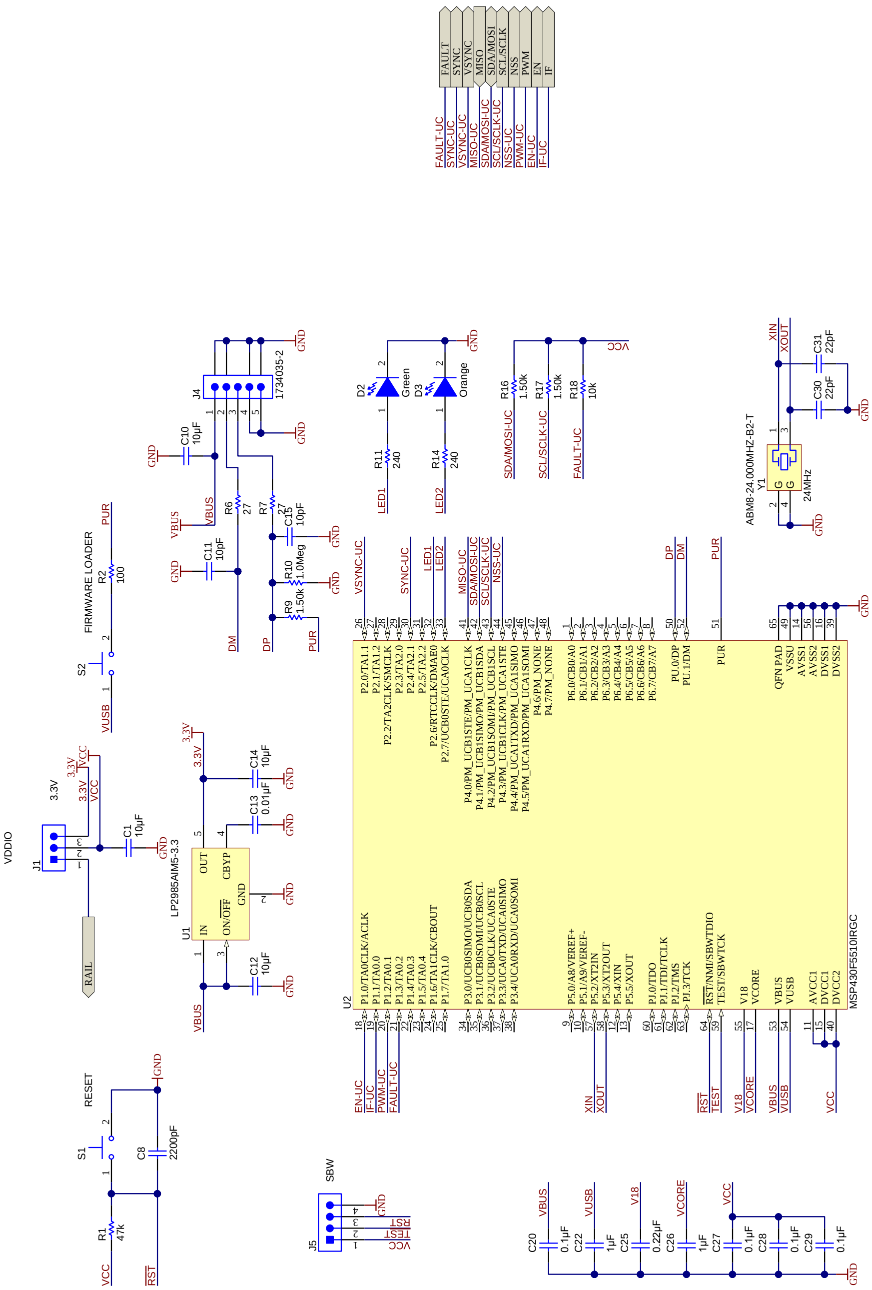


Figure 7-1. Evaluation Board Schematic, Microcontroller and Related Components

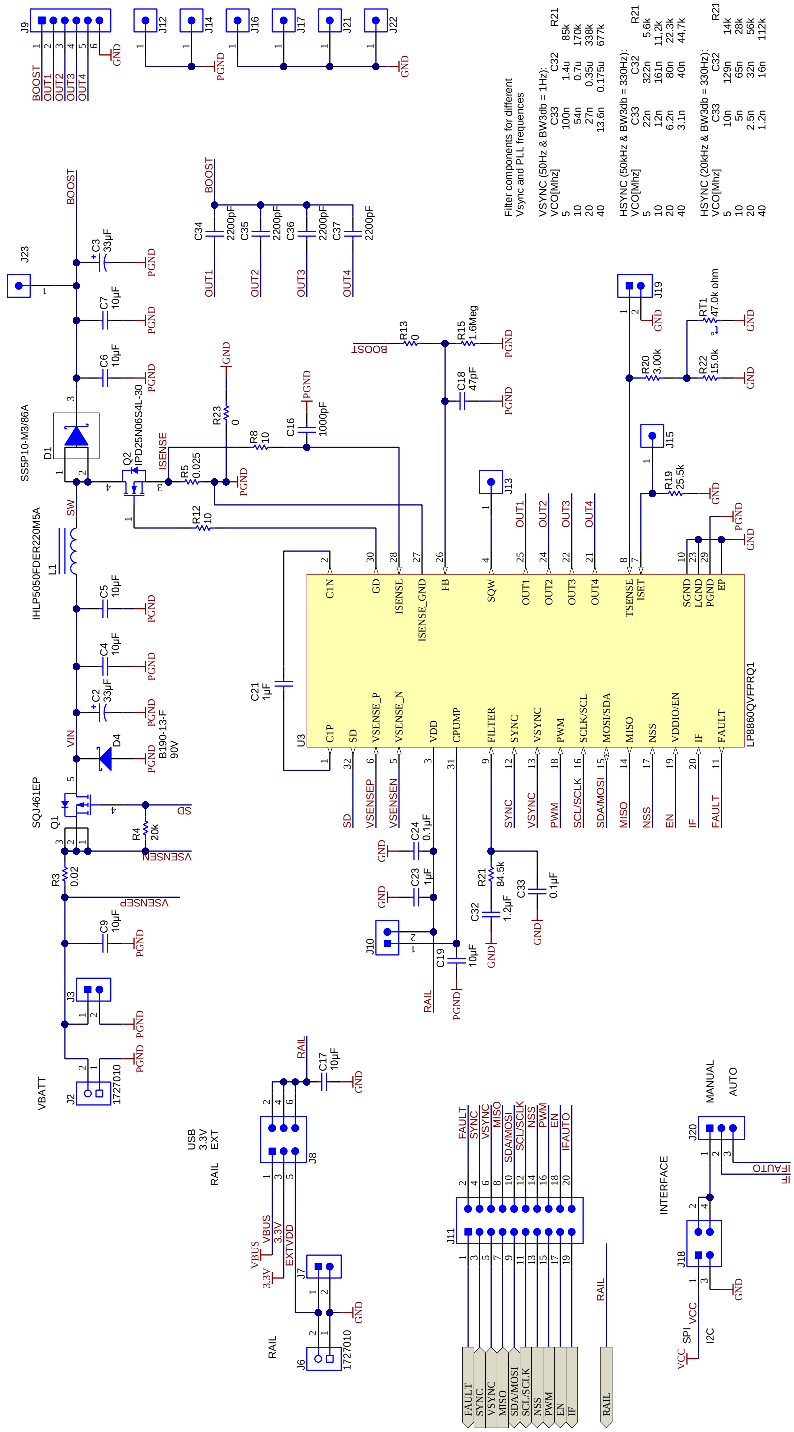


Figure 7-2. Evaluation Board Schematic, LP8860-Q1 and Main Components

Bill of Materials

The following is the bill of materials for the LP8860-Q1EVM:

Designator	Description	Manufacturer	Part Number	Qty
C1, C10, C12, C14, C19	CAP, CERM, 10uF, 16V, +/-20%, X5R, 0603	Taiyo Yuden	EMK107BBJ106MA-T	5
C2, C3	CAP, AL, 33uF, 50V, +/-20%, 40 mohm, SMD	Panasonic	EEHZC1H330XP	2
C4, C5, C6, C7, C9	CAP, CERM, 10uF, 50V, +/-10%, X5R, 1206_190	TDK	CGA5L3X5R1H106K160AB	5
C8	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	Kemet	C0603C222K5RACTU	1
C11, C15	CAP, CERM, 10pF, 50V, +/-5%, C0G/NP0, 0603	AVX	06035A100JAT2A	2
C13	CAP, CERM, 0.01uF, 50V, +/-5%, X7R, 0603	Kemet	C0603C103J5RACTU	1
C16	CAP, CERM, 1000pF, 100V, +/-10%, X7R, 0603	AVX	06031C102KAT2A	1
C17	CAP, CERM, 10uF, 16V, +/-20%, X5R, 0603	Taiyo Yuden	EMK107BBJ106MA-T	1
C18	CAP, CERM, 47pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C470J5GACTU	1
C20, C24, C27, C28, C29	CAP, CERM, 0.1uF, 16V, +/-20%, X7R, 0603	Kemet	C0603C104M4RACTU	5
C21, C22, C23, C26	CAP, CERM, 1uF, 10V, +/-10%, X5R, 0603	Kemet	C0603C105K8PACTU	4
C25	CAP, CERM, 0.22uF, 16V, +/-10%, X7R, 0603	Kemet	C0603C224K4RACTU	1
C30, C31	CAP, CERM, 22pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C220J5GACTU	2
C32	CAP, CERM, 1.2uF, 6.3V, +/-10%, X5R, 0603	Kemet	C0603C125K9PACTU	1
C33	CAP, CERM, 0.1uF, 25V, +/-5%, X7R, 0603	AVX	06033C104JAT2A	1
C34, C35, C36, C37	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	Kemet	C0603C222K5RACTU	4
D1	Diode, Schottky, 100V, 5A, TO-277A	Vishay-Semiconductor	SS5P10-M3/86A	1
D2	LED, Green, SMD	Lite-On	LTST-C190GKT	1
D3	LED, Orange, SMD	Lite-On	LTST-C190KFKT	1
D4	Diode, Schottky, 90V, 1A, SMA	Diodes Inc.	B190-13-F	1
J1, J20	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	Samtec	TSW-103-07-G-S	2
J2, J6	Conn Term Block, 2POS, 3.81mm, TH	Phoenix Contact	1727010	2

Designator	Description	Manufacturer	Part Number	Qty
J3, J7, J10, J19	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Samtec	TSW-102-07-G-S	4
J4	Conn Rcpt Mini USB2.0 Type B 5POS SMD	TE Connectivity	1734035-2	1
J5	Header, TH, 100mil, 4x1, Gold plated, 230 mil above insulator	Samtec	TSW-104-07-G-S	1
J8	Header, 100mil, 3x2, Tin, TH	Sullins Connector Solutions	PEC03DAAN	1
J9	Header, TH, 100mil, 6x1, Gold plated, 230 mil above insulator	Samtec	TSW-106-07-G-S	1
J11	Header, TH, 100mil, 10x2, Gold plated, 230 mil above insulator	Samtec	TSW-110-07-G-D	1
J12, J13, J14, J15, J16, J17, J21, J22, J23	CONN HEADER 1POS .100" SNGL TIN, TH	Samtec	TSW-101-17-T-S	1
J18	Header, TH, 100mil, 2x2, Gold plated, 230 mil above insulator	Samtec	TSW-102-07-G-D	9
L1	Inductor, Shielded, Powdered Iron, 22uH, 5.5A, 0.0313 ohm, SMD	Vishay-Dale	IHLP5050FDER220M5A	1
Q1	MOSFET, P-CH, -60V, 30A, PowerPAK_SO-8L	Vishay-Siliconix	SQJ461EP	1
Q2	MOSFET, N-CH, 60V, 25A, DPAK	Infineon Technologies	IPD25N06S4L-30	1
R1	RES, 47k ohm, 5%, 0.1W, 0603	Yageo America	RC0603JR-0747KL	1
R2	RES, 100 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603100RJNEA	1
R3	RES, 0.02 ohm, 1%, 3W, 2512	Bourns	CRA2512-FZ-R020ELF	1
R4	RES, 20k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060320K0JNEA	1
R5	RES, 0.025 ohm, 1%, 3W, 2512	Bourns	CRA2512-FZ-R025ELF	1
R6, R7	RES, 27 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060327R0JNEA	2
R8, R12	RES, 10 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060310R0JNEA	2
R9, R16, R17	RES, 1.50k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-071K5L	3
R10	RES, 1.0Meg ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031M00JNEA	1
R11, R14	RES, 240 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603240RJNEA	2
R13	RES, 0 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06030000Z0EA	1
R15	RES, 1.6Meg ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031M60JNEA	1
R18	RES, 10k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060310K0JNEA	1
R19	RES, 25.5k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-0725K5L	1
R20	RES, 3.00k ohm, 1%, 0.1W, 0603	Yageo America	RC0603FR-073KL	1
R21	RES, 84.5k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW060384K5FKEA	1
R22	RES, 15.0k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW060315K0FKEA	1
R23	RES, 0 ohm, 5%, 2W, 2512 WIDE	Vishay Draloric	RCL12250000Z0EG	1
RT1	Thermistor NTC, 47.0k ohm, 1%, 0603	MuRata	NCP18WB473F10RB	1
S1, S2	Switch, Push Button, SMD	Alps	SKRKAEE010	2
U1	Micropower 150 mA Low-Noise Ultra Low-Dropout Regulator, 5-pin SOT-23	Texas Instruments	LP2985AIM5-3.3	1
U2	Mixed Signal MicroController, RGC0064B	Texas Instruments	MSP430F5510IRGC	1
U3	LOW EMI, High Performance 4-Channel LED Driver for Automotive Lighting, VFP0032B	Texas Instruments	LP8860QVFPRQ1	1
Y1	Crystal, 24.000MHz, 18pF, SMD	Abracon Corportation	ABM8-24.000MHZ-B2-T	1

Evaluation Software

9.1 Setup

Evaluation software is available for download from the TI web site.

The LP8860-Q1EVM is connected via USB to the computer and controlled with special evaluation software (Windows). An MSP430 microcontroller is used with the EVM to provide easy I^2C/SPI communication, external PWM, boost SYNC and VSYNC control, VDDIO/EN, IF, and FAULT pins control with the LP8860-Q1 via USB. The EVM board and LP8860-Q1 VDDIO is powered by default via USB. VDD and VIN for the LP8860-Q1 must be supplied with an external power supply with high enough current limit.

When the board is connected to a computer, Windows should recognize it automatically and start to install the driver. A “Found New Hardware” dialog box prompts the user to locate the missing driver. Select “No, not this time” and continue with “Next”. Select “Install from a list or specific location (Advanced)” to install the driver. Select the directory where the supplied TI_CDC_Virtual_Port driver is. Windows should now install the driver, and the PC can communicate with the evaluation module using a virtual COM port. If Windows cannot find the driver, the user needs to manually install the TI_CDC_Virtual_Port driver from the Device Manager. There should be a "USB OK" message on the status bar at the bottom of evaluation program, when the board is recognized. The green LED should blink on the evaluation board, when the board is powered from USB. If the board is not recognized, check the USB address from Windows Control Panel. The USB address should always be less than or equal to 9 (from COM1 to COM9) (see Appendix A). Also switching to another USB port might solve the issue.

I^2C/SPI, PWM, SYNC, VSYNC, VDDIO/EN, IF, and FAULT communication can be controlled from an external source using pin headers if needed. Test point for all of the signals is provided, but jumpers to the on-board microcontroller must be removed if an external source is used for control.

9.2 Usage

The LP8860-Q1 evaluation software helps the user to control the evaluation hardware connected to the computer. The evaluation software consists of three sections: tab selection, register selection, and register control section. In the tab selection the user can switch between **Pin Control**, **Brightness Controls**, **Fault and status**, **Boost**, **Fault and adaptive voltage control**, **LED Drivers**, **Temperature**, **EEPROM map** and **History** tabs. In the left-hand side of the evaluation program the register view (see Figure 9-1) is always visible. From this view the user can see the register addresses, register names, and register values. The user can select the register that needs to be changed. Selected register is marked with red X beside the register value. When the user selects the register, the selected register can be viewed in detail at the bottom of the evaluation software. This view tells the register address, register name, register default value, register bits and current register value. The user can also read and write the register bits by pushing the **RD**-button (read) and **WR**-button (write).

In the **File** menu the user can save register or EEPROM settings to a file, or load ready-made register or EEPROM setups from a file to the LP8860-Q1 registers.

In the **Operation** menu the user can read register settings or EEPROM context with **Read Registers** from the LP8860-Q1 memory so that the GUI reflects the current state of the LP8860-Q1. **Operation** menu has controls for EEPROM, such as **Unlock**, **Lock**, **Read** and **Burn EEPROM**. With **Direct control** the user can manually control registers by selecting address and data in hexadecimal format. **Execute macro** executes macro from text file, where first hexadecimal number in string is register address and second is data which should be written.

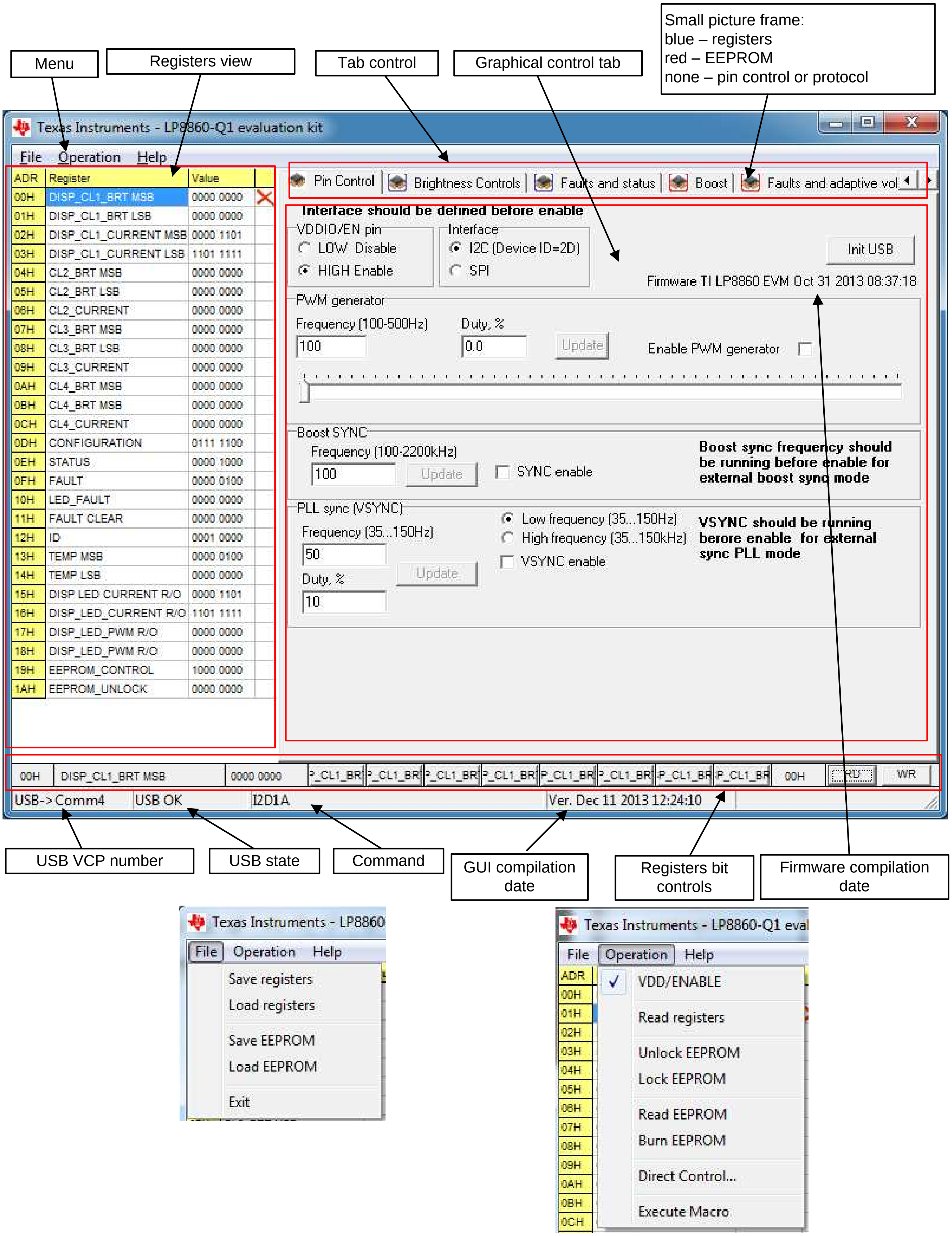


Figure 9-1. Main Window Structure

9.2.1 Pin Control Tab

From the **Pin Control** tab (see Figure 9-2) the user can control all the basic functions of the device:

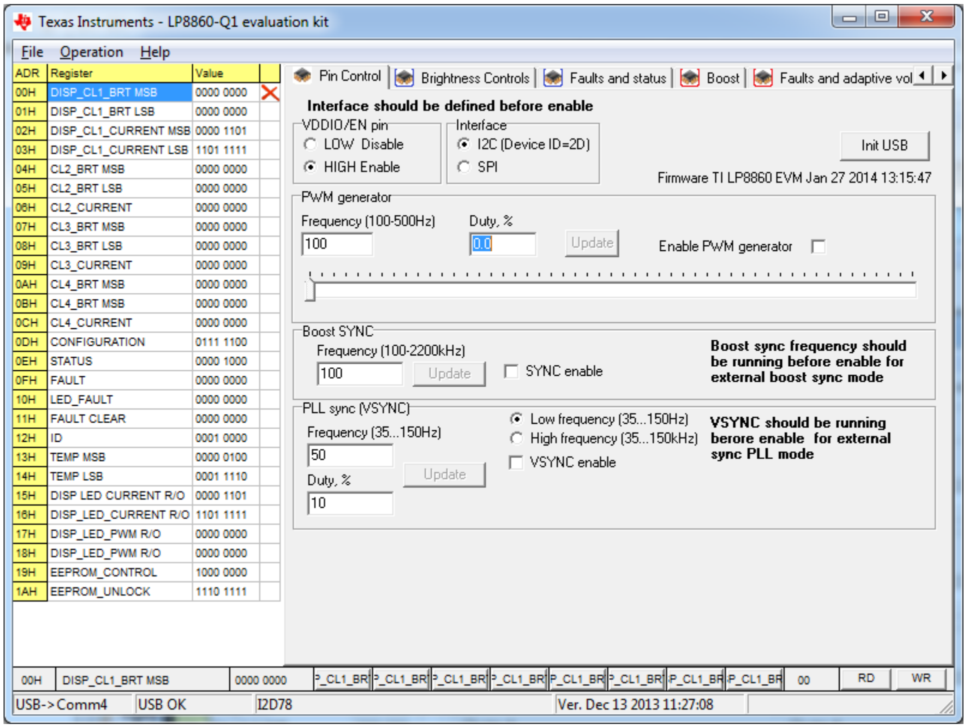


Figure 9-2. Main Window and Pin Control Tab

In this tab Interface mode (I^2C/SPI) can be set, **VDDIO/EN** control enables/disables the device. Frequency generators – **PWM** for brightness control, **SYNC** for boost and **VSYNC** for LED output PWM synchronization are in this tab.

9.2.2 Brightness Control Tab

From the **Brightness Control** tab (see Figure 9-3) the user controls all brightness control functions of the device. Here are provided additional register based controls, like slope control, current control, current scale and EEPROM control. If all outputs are configured as display mode outputs, only Display/Cluster_1 brightness and current controls can be used. Additional controls are functional when one or more outputs are in cluster mode. Please refer to the LP8860-Q1 datasheet for details.

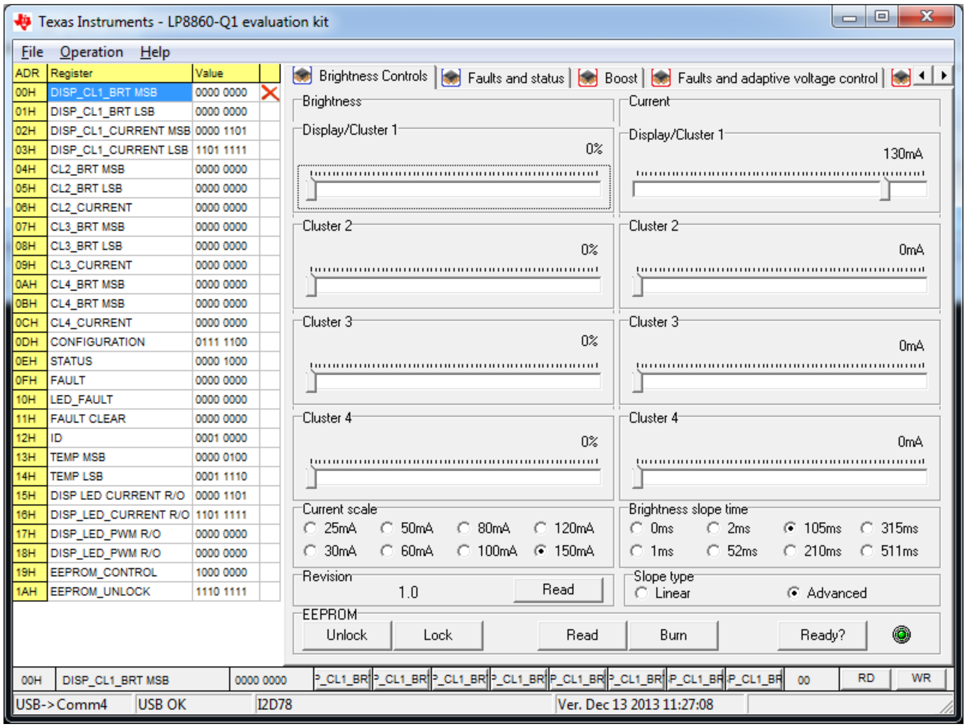


Figure 9-3. Brightness Control Tab

9.2.3 Faults and Status Tab

From the **Fault and Status** tab (see Figure 9-4) the user has access to LP8860-Q1 faults and status bits. Faults can be reset by software fault reset (register write) or hardware NSS pin in I²C interface mode. Temperature and output current/PWM reading are available from this tab as well. Output PWM and current reading can help to understand better Hybrid PWM and Current dimming functionality.

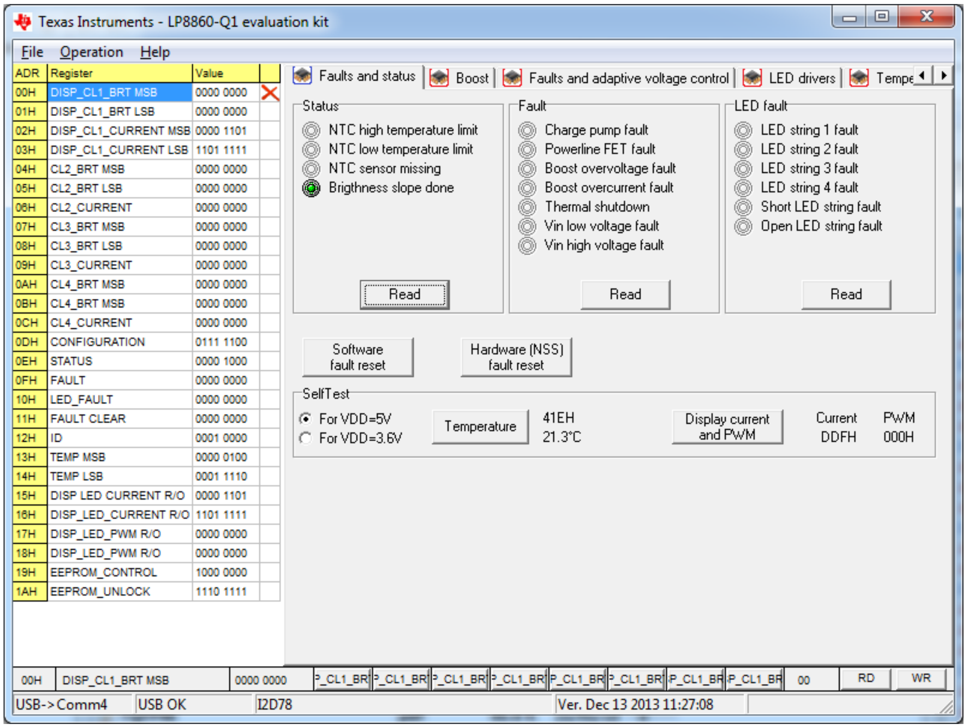


Figure 9-4. Fault and Status Tab

9.2.4 Boost Tab

From the **Boost Control** tab (see Figure 9-5) the user controls all boost functions of the device:

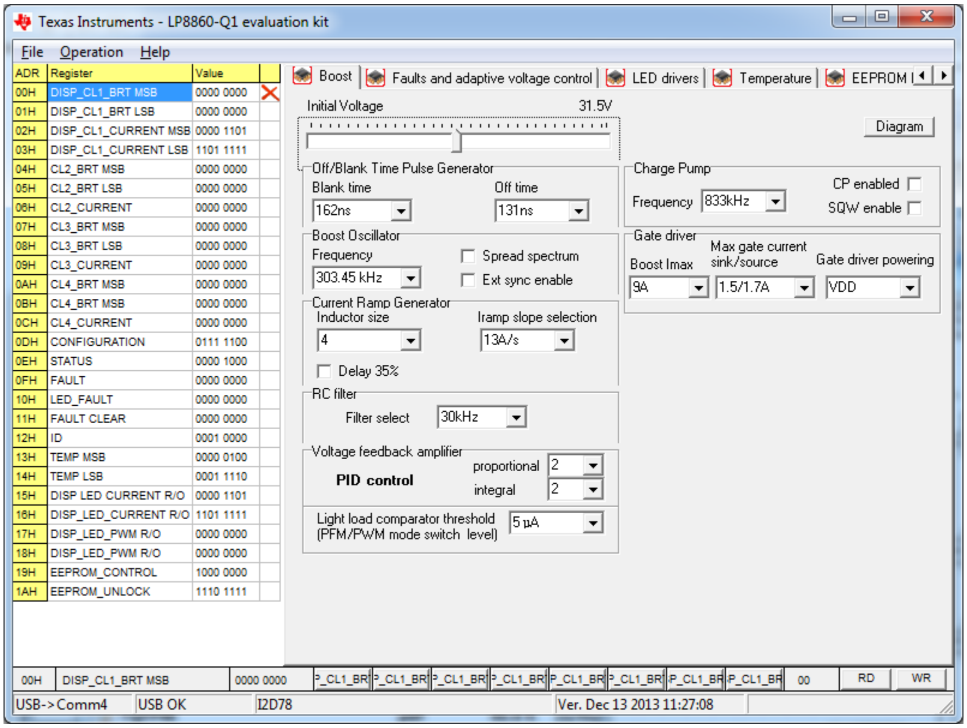


Figure 9-5. Boost Controls Tab

This tab controls all boost functionality bits, charge pump, and gate driver controls. By clicking **Diagram** button the user can open interactive boost diagram window, which shows all parameters in block diagram.

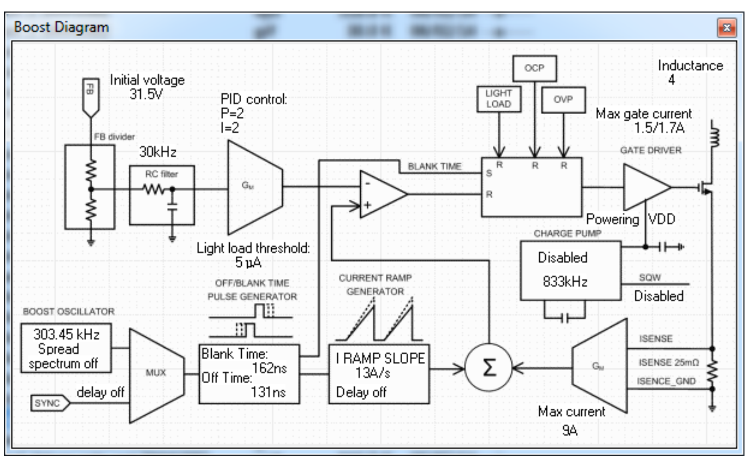


Figure 9-6. Interactive Boost Diagram Window

9.2.5 Fault and Adaptive Voltage Control Tab

From the **Fault and adaptive voltage control** tab (see Figure 9-7) the user controls fault and adaptive boost settings:

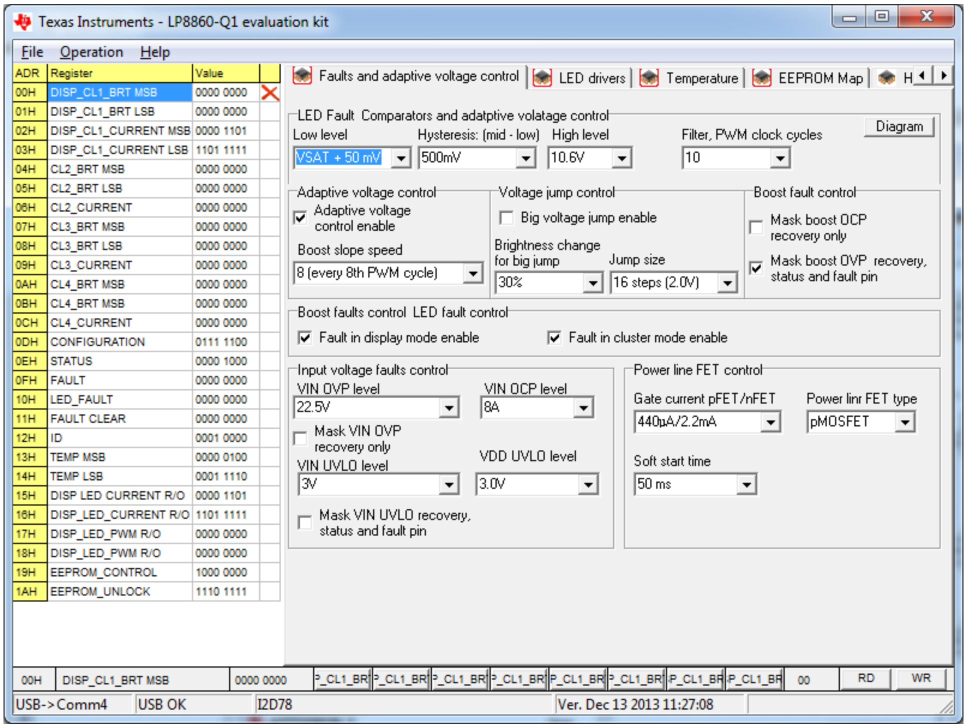


Figure 9-7. Fault and Adaptive Voltage Control Tab

Fault comparators are used for LED fault detection and adaptive boost control. Clicking **Diagram** button opens LED fault and adaptive voltage control diagram, see Figure 9-8. This window explains LED fault and adaptive boost control functionality:

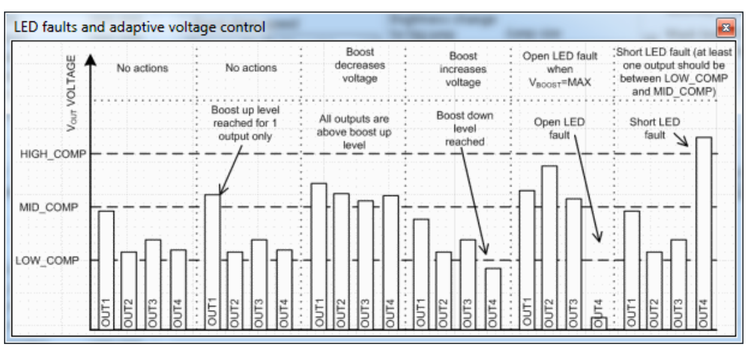


Figure 9-8. LED Fault And Adaptive Voltage Control Functionality Diagram

9.2.6 LED Drivers Tab

From the **LED Drivers** tab (see Figure 9-9) the user controls all EEPROM settings related to LED driver of the device:

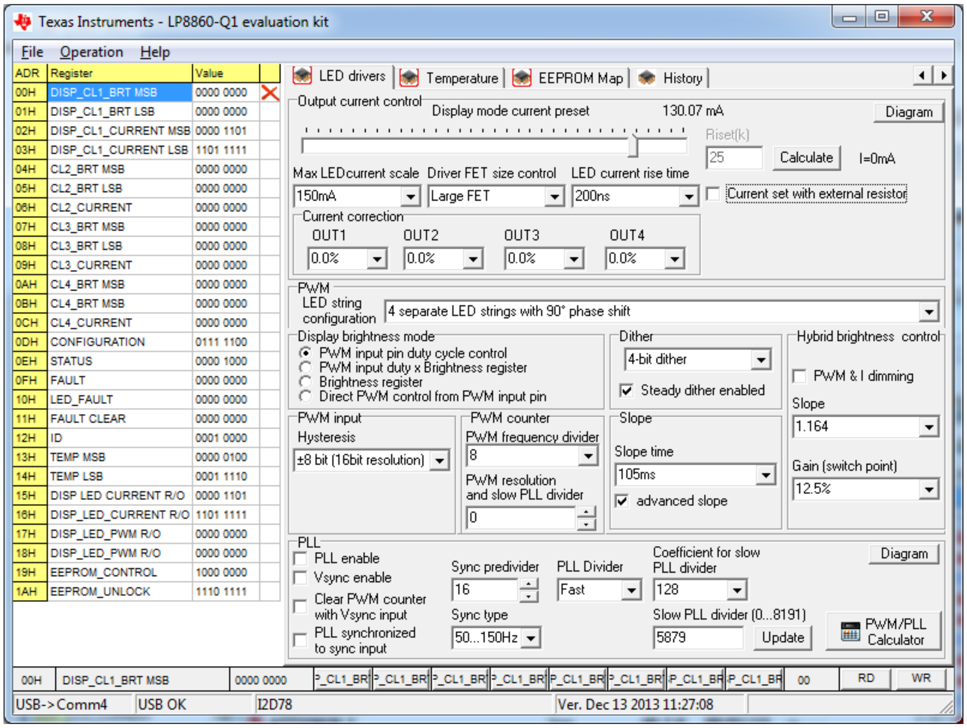


Figure 9-9. LED Driver Controls

In this tab the user controls LED driver settings: maximum current scale for all modes, initial current for display mode and current correction for every outputs. LED output PWM controls, input brightness PWM controls, and PLL controls are available from this tab as well. By clicking the **Diagram** button opens window with LED driver diagram (Figure 9-10) and PLL Diagram (Figure 9-11). PLL calculator for defining settings for external V/HSYNC (Figure 9-12) or internal oscillator (Figure 9-13) is available by clicking the **PWM/PLL Calculator** button.

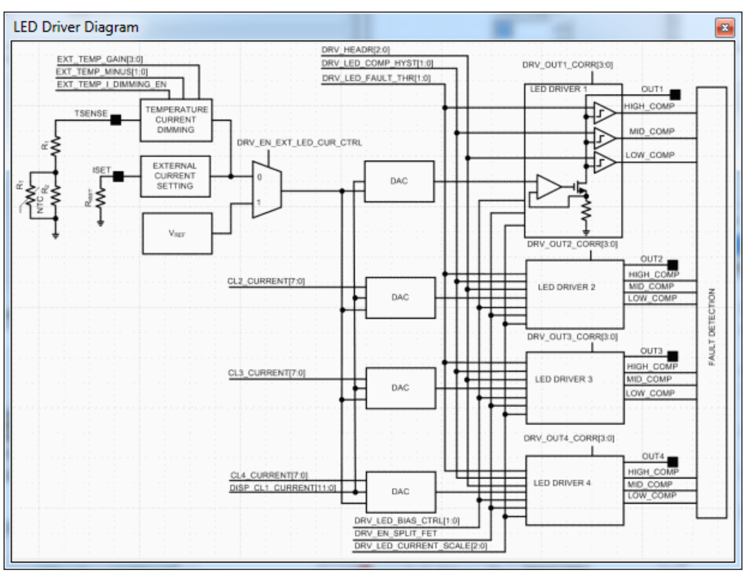


Figure 9-10. LED Driver Diagram Window

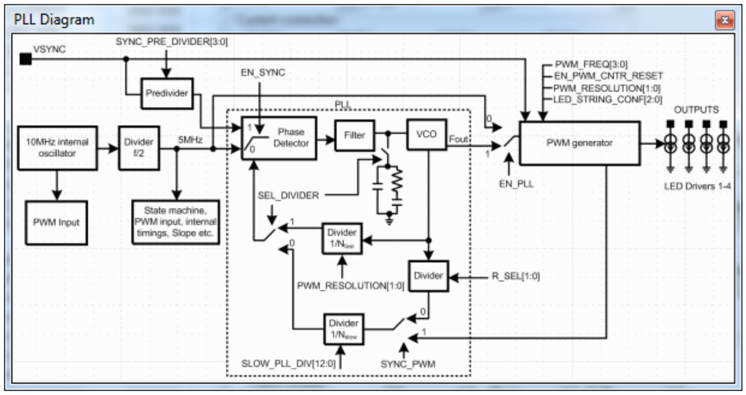


Figure 9-11. PLL Diagram Window

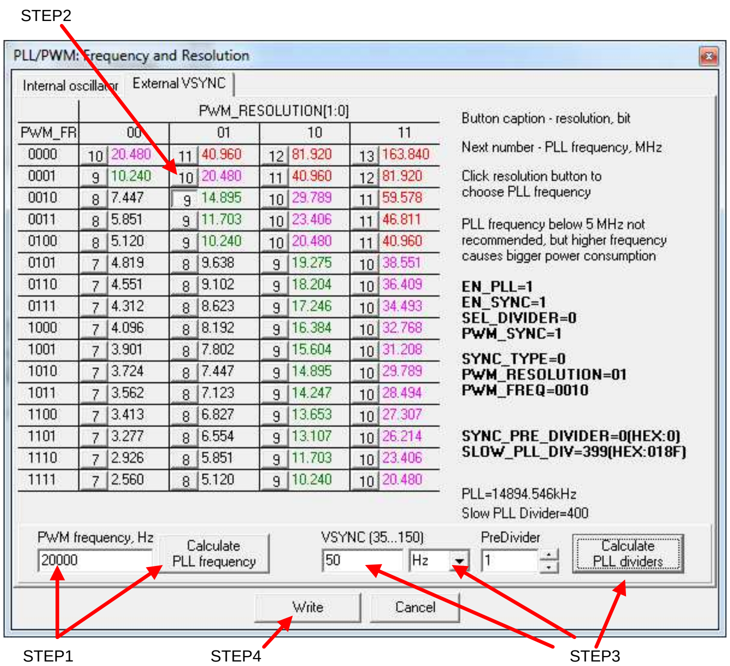
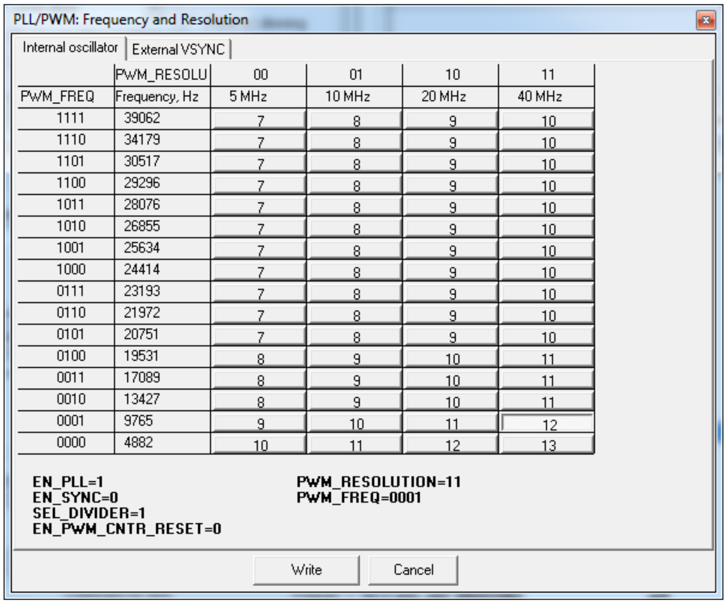


Figure 9-12. PLL Calculator for External VSYNC (Steps Show Order for Applying Commands)



	PWM_RESOLU	00	01	10	11
PWM_FREQ	Frequency, Hz	5 MHz	10 MHz	20 MHz	40 MHz
1111	39062	7	8	9	10
1110	34179	7	8	9	10
1101	30517	7	8	9	10
1100	29296	7	8	9	10
1011	28076	7	8	9	10
1010	26855	7	8	9	10
1001	25634	7	8	9	10
1000	24414	7	8	9	10
0111	23193	7	8	9	10
0110	21972	7	8	9	10
0101	20751	7	8	9	10
0100	19531	8	9	10	11
0011	17089	8	9	10	11
0010	13427	8	9	10	11
0001	9765	9	10	11	12
0000	4882	10	11	12	13

Figure 9-13. PLL Calculator for Internal Oscillator

9.2.7 Temperature Tab

From the **Temperature** tab (see Figure 9-14) the user controls internal and external sensors functionality: current de-rating with internal temperature sensor, LED temperature control mode, and current dimming with external temperature sensor.

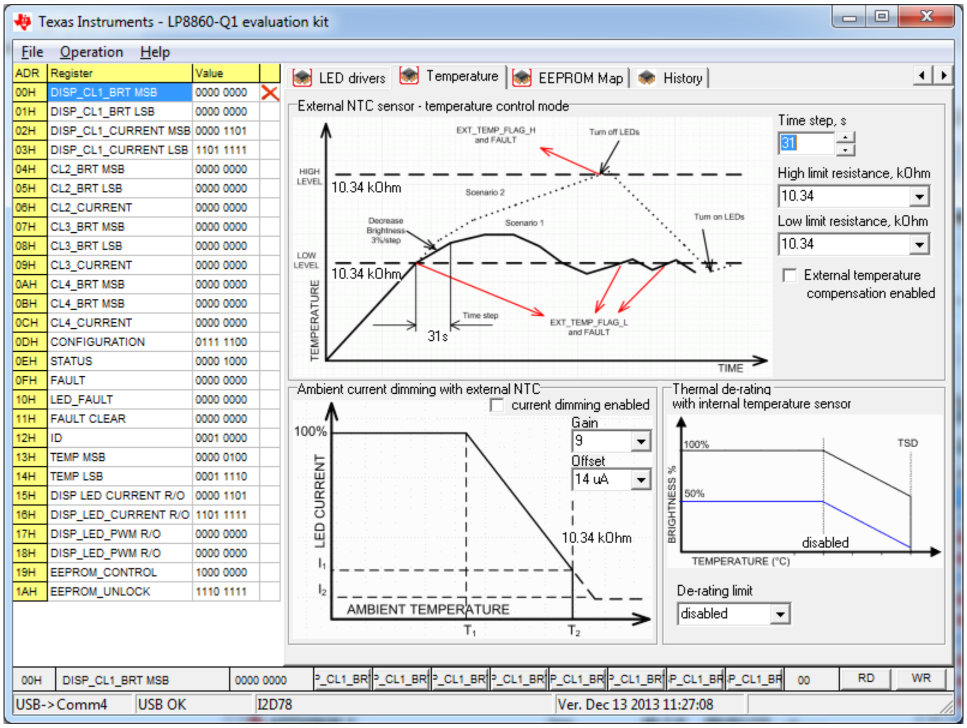


Figure 9-14. Temperature Sensors Control

9.2.8 EEPROM Map Tab

From the **EEPROM Map** tab (see Figure 9-15) the user can see actual value of EEPROM registers bit and control bits directly by writing or reading bytes (buttons **W** and **R** on the right side).

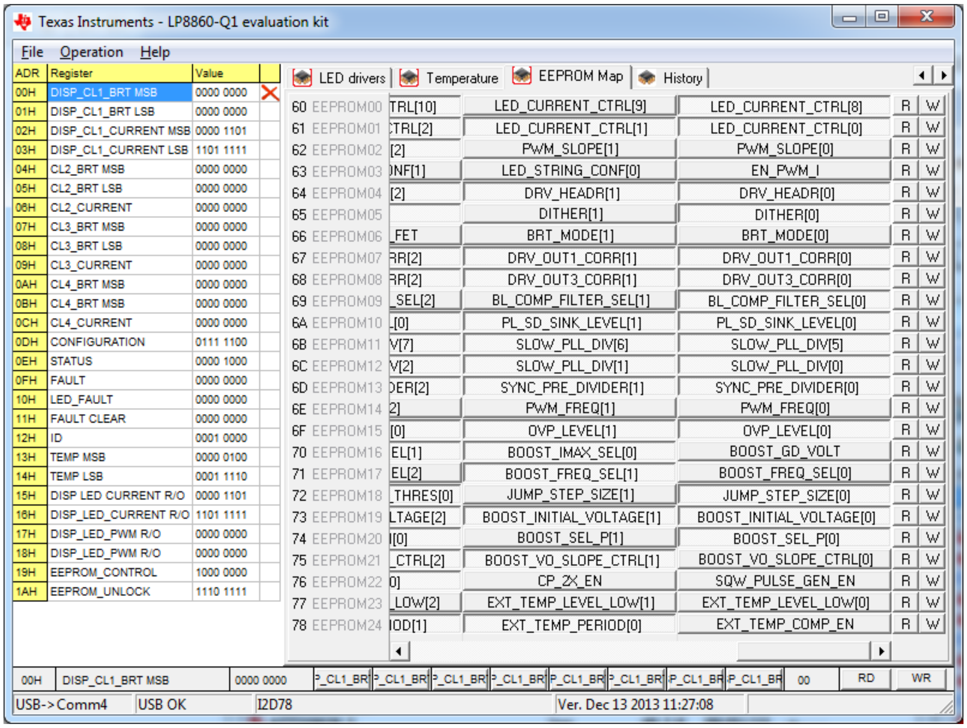


Figure 9-15. EEPROM Map

9.2.9 History Tab

The **History** tab (see Figure 9-16) provides information on the I²C/SPI writes used to configure/control the LP8860-Q1 device. This can be used as a reference for developing software for real application.

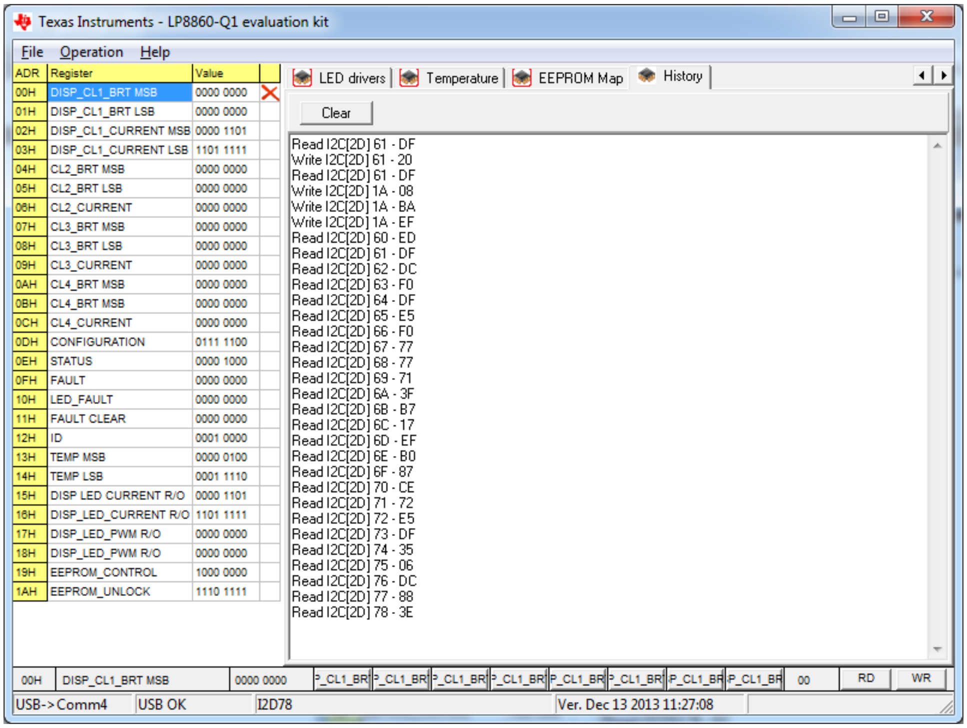


Figure 9-16. History Tab

Virtual COM Port Configuration

When the USB COM port number is bigger than 9, the evaluation program is not able to recognize the board. COM port number can be manually changed from Windows Device Manager. The below figures describe this sequence in Windows7. The Device Manager can be found from the Control Panel. Note that one may need to have Administrator rights to make the changes.

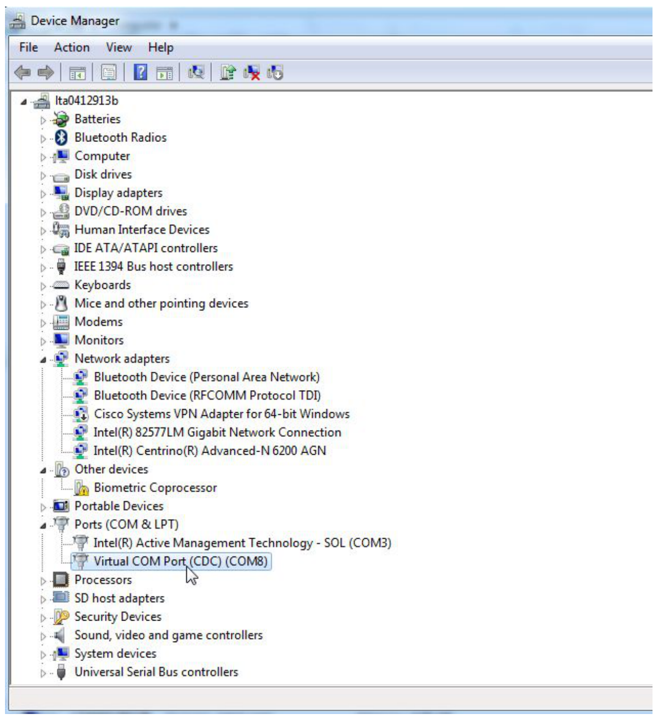


Figure A-1. Device Manager View. Select the Virtual COM Port

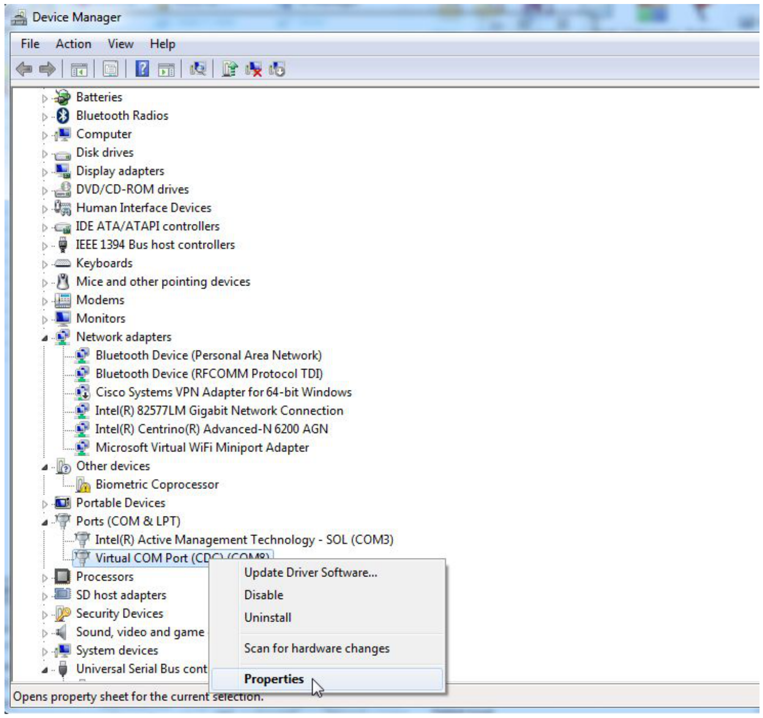


Figure A-2. Open Properties by Clicking Right Mouse Button on Virtual COM Port

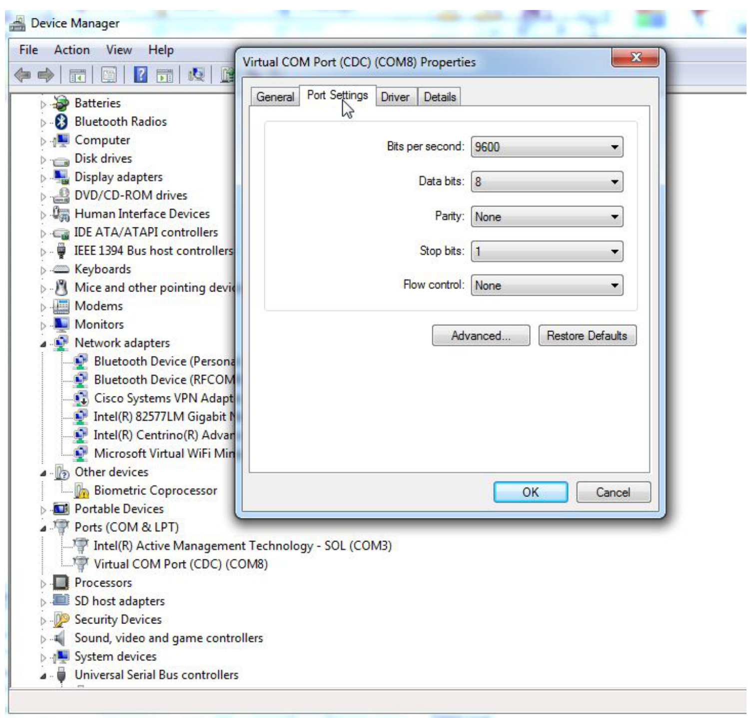


Figure A-3. Select Port Settings from the Virtual COM Port Properties

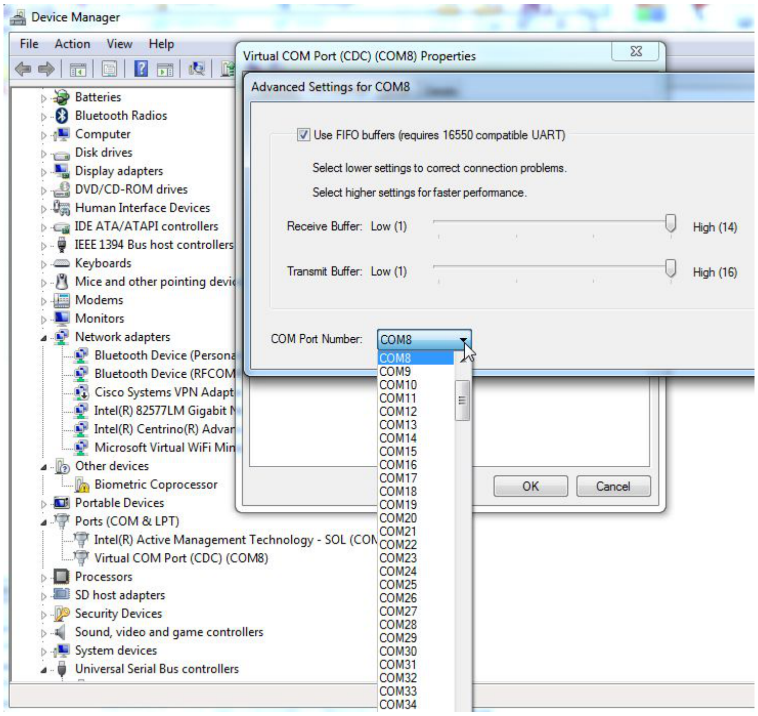


Figure A-4. Select Advanced from Virtual COM Port Properties and Select COM Port Number (9 or smaller)

Virtual COM Port Communication

The user can use their own software to communicate with evaluation board trough virtual serial port commands. List of commands is below.

Table B-1. Command Set

Command	Description	Example (command/*response*)
?	Check firmware version	**?** ***TI LP8860 EVK Jul 1 2013 09:58:54<0x0A>***
C123456	Configure ports, **12** - port number, **34** – direction byte (output, if bit high. Input otherwise), **56** – function selection (special function if corresponding bit is high, input/output otherwise), see MSP430F5528 DS for the reference.	**C010300** ***OK<0x0A>*** Port 01, bits 0 and 1 are configured as outputs.
I1234	Serial interface read,**12** - interface and address for I2C, 0x80 - SPI otherwise I2C, **34** – register. Returns error code and data.	**I8010** ***00_28_OK<0x0A>*** SPI Read, register 0x10. Return error 00 (no errors) and date 0x28 (LED_FAULTS for LP8860-Q1)
O123456	Serial interface write,**12** - interface and address for I^2C, 0x80 - SPI otherwise I^2C, **34** – register, **56** – data. Returns error code.	**O2D1101** ***00_OK<0x0A>*** I2C Write, device ID 0x2D, register 0x11, data 0x01 (clear faults command for LP8860-Q1), return error code, 00 – no errors
P0123456789	**0** - timer number (0-PWM for brightness ,1-VSYNC, 2-SYNC for boost) **1** - divider (3bit TAxEX0) **2345** – period (TAxCCR0) **6789** - duty (TAxCCR1) f_{OSC}=24MHz Divider 0->1, 1->2, …, 7->8 See MSP430F5528 DS for the reference.	**P03EA5F2EE0** ***OK<0x0A>*** PWM 100Hz duty=20% **P20000A0005** ***OK<0x0A>*** Boost SYNC 2.2MHz duty=50%
R1234	Reset masked bits, **12** - port number, **34** - mask	**R0101** ***OK<0x0A>*** Reset bit 0 port 01
S1234	Set masked bits, **12** - port number, **34** - mask	**S0101** ***OK<0x0A>*** Set bit 0 port 01

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 mA @ 80 mA (3.3 V typ.) are used on the board. For LP8860-Q1 4 strings are assembled.

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

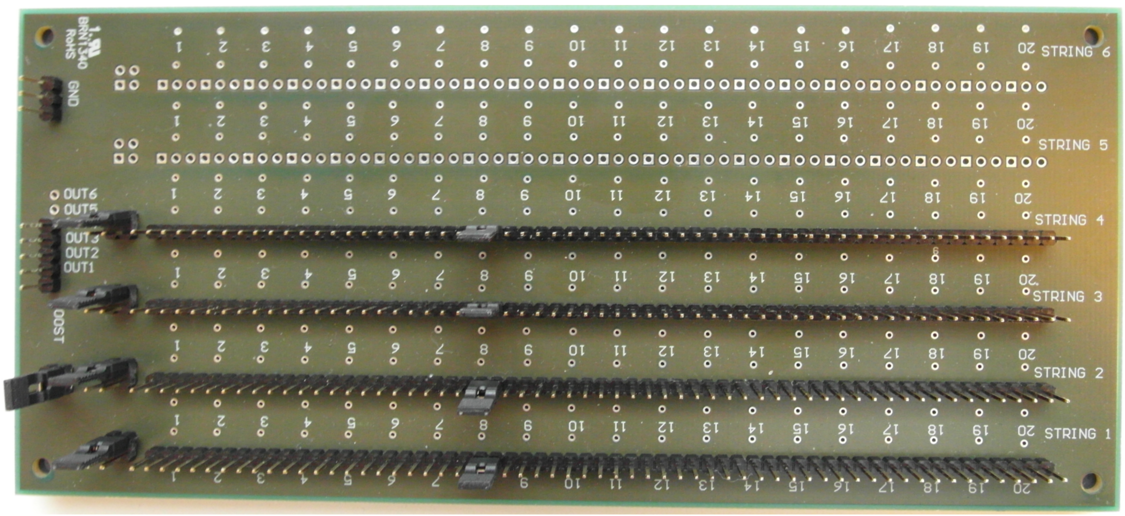


Figure C-1. LED Load Board - Top Side

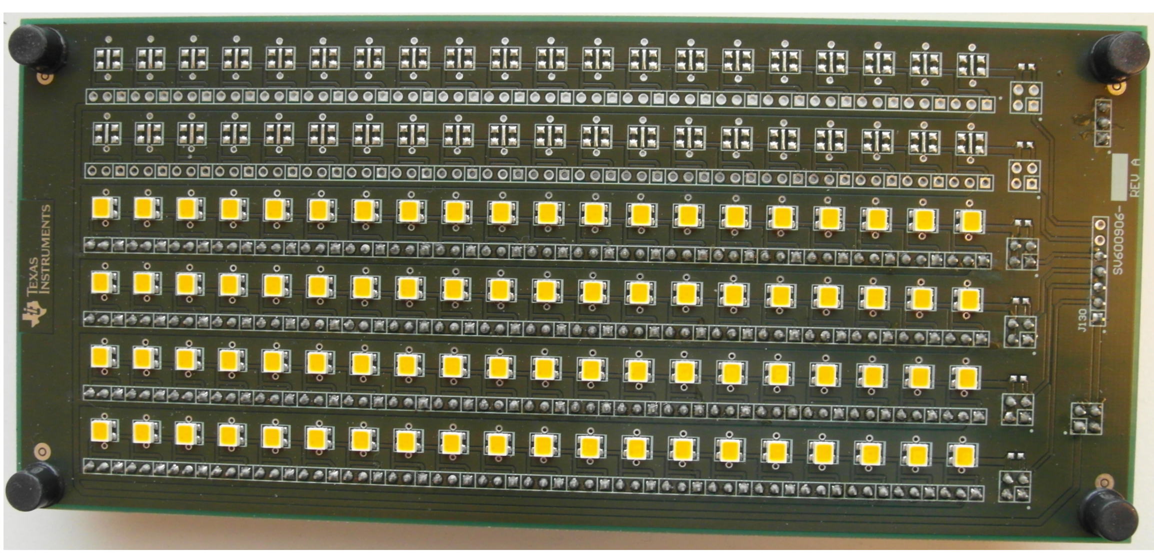


Figure C-2. LED Load Board - Bottom View

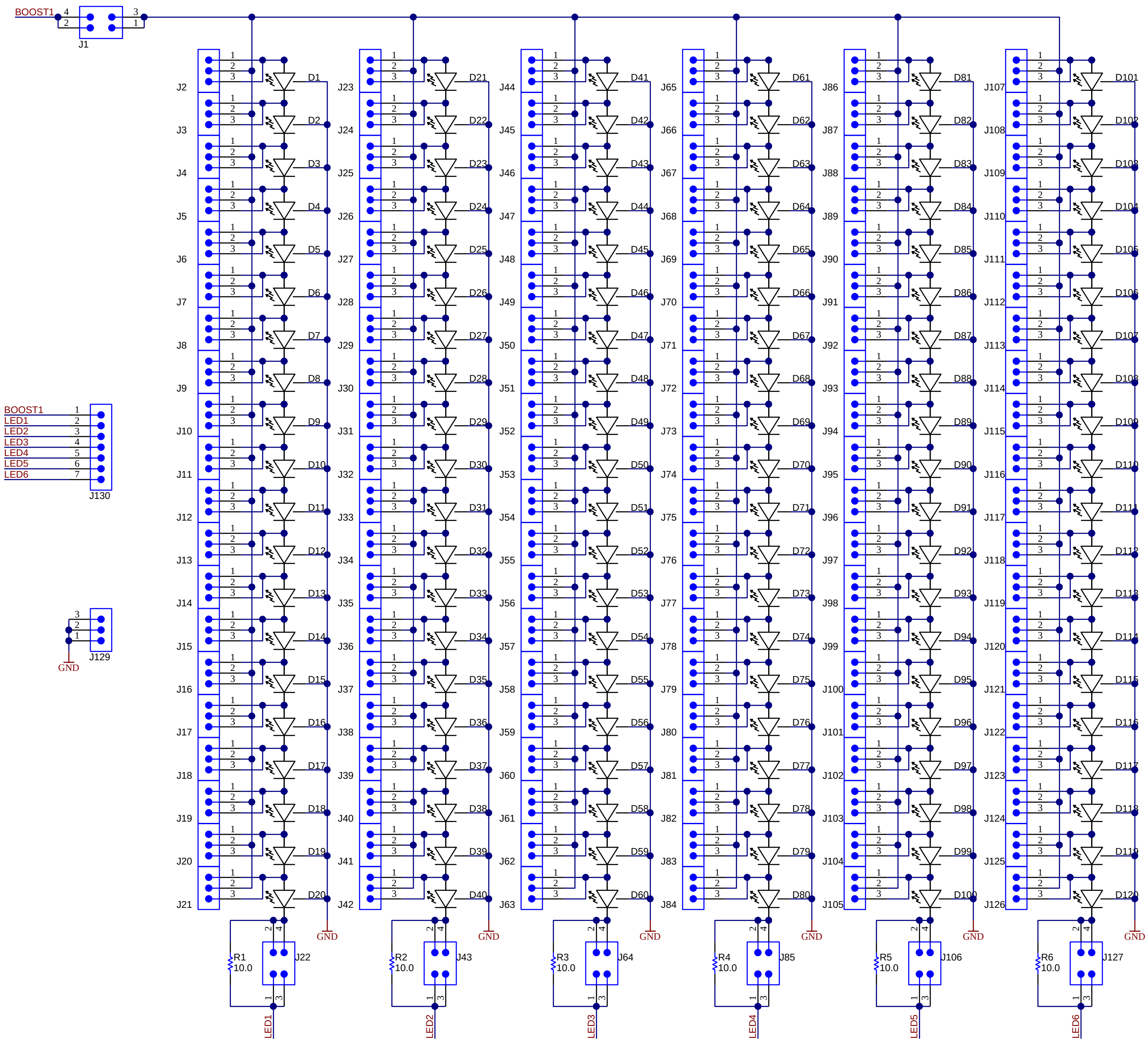


Figure C-3. LED Load Board - Schematic Diagram

Bill of Materials for LED Load Board

Designator	Description	Manufacturer	Part Number	Qty
R1, R2, R3, R4, R5, R6	Resistor 10.0 ohm, 1%, 0.1W, 0603 (not assembled)	Vishay-Dale	CRCW060310R0FKEA	6
J1, J22, J43, J64, J85,J106, J127	Header, 100mi, 2x2	Samtec	TSW-102-07-G-D	7
J2...J21, J23...J42, J44...J63, J65...J84 , J86...J105, J107...J126, J129	Header, 100mi, 3x1	Samtec	TSW-103-07-G-S	121
J130	Header, 100mi, 7x1	Samtec	TSW-107-07-G-S	1
D1...D120	Cool White SMD LED XLamp mL-B	Cree	MLBAWT-A1-0000-000W51	120

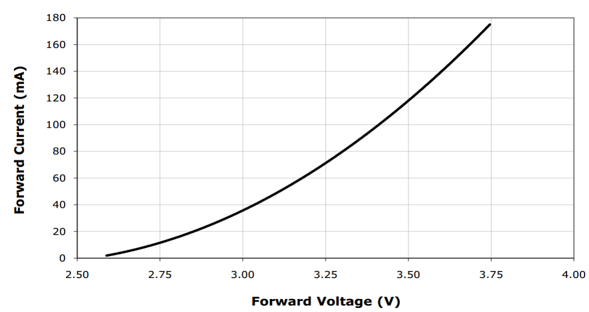


Figure C-4. Forward Voltage for Cree Xlamp ML-B LEDs

Quick Start Guide

Appendix D contains step-by-step explanations about how to start using the LP8860-Q1 EVM. The assumption is that an optional LED load board with EVM is used.

Some examples refer to eep-files (example: default EEPROM 300kHz.eep). These files are provided as part of the LP8860-Q1EVM software which can be downloaded from the LP8860-Q1 tools folder on the Texas Instruments website.

D.1 EVM Board Default Jumper and Cable Positions

Figure D-1 and Figure D-2 show the jumper and cable positions when the EVM is delivered.

NOTE: Keep jumper J1 at a 3.3-V setting to ensure safe operation regardless of RAIL value (MSP430 doesn't tolerate a 5-V input or output voltage).

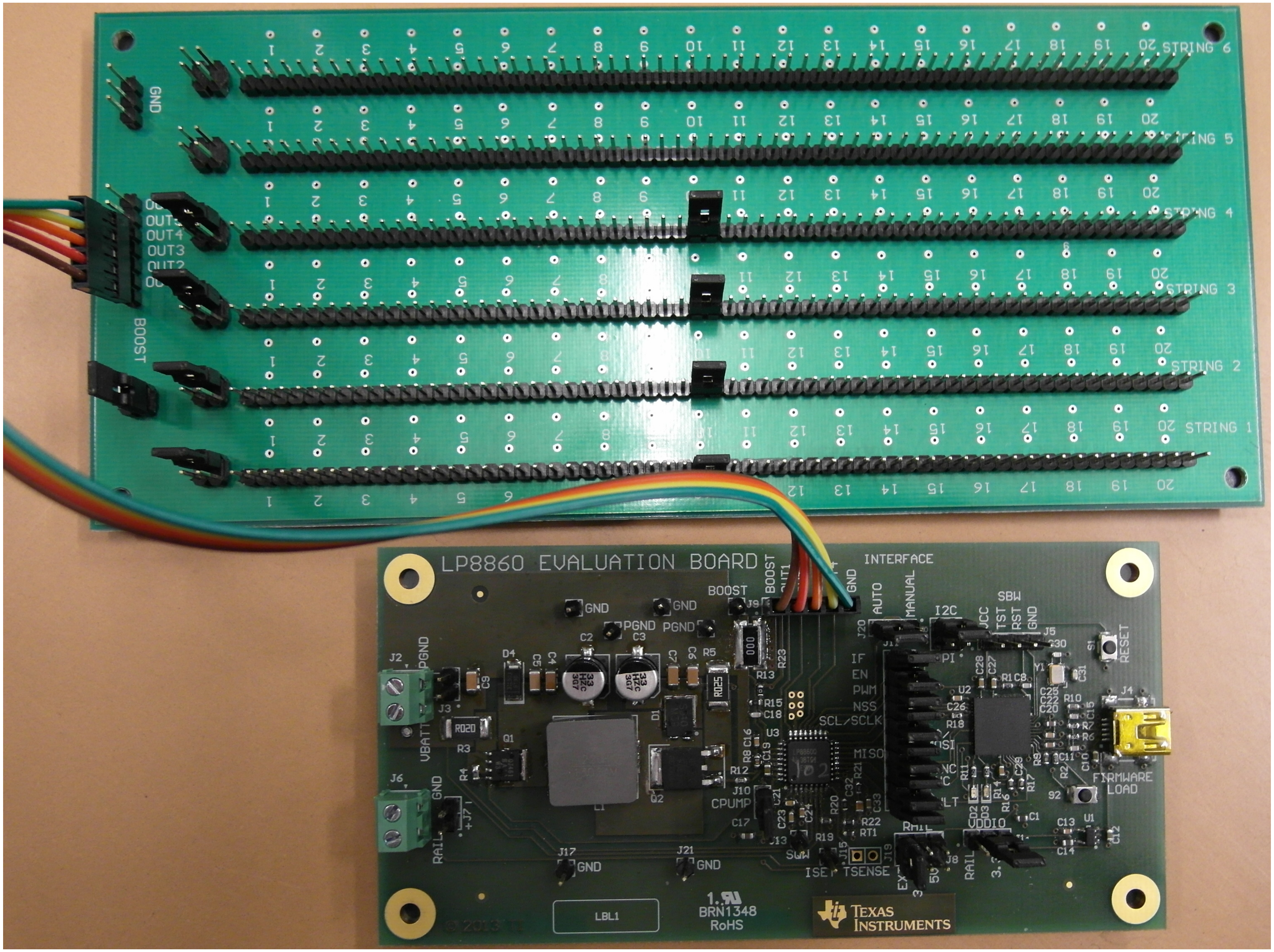


Figure D-1. Jumper Positions

If charge pump is disabled, jumper J10 CPUMP should be shorted

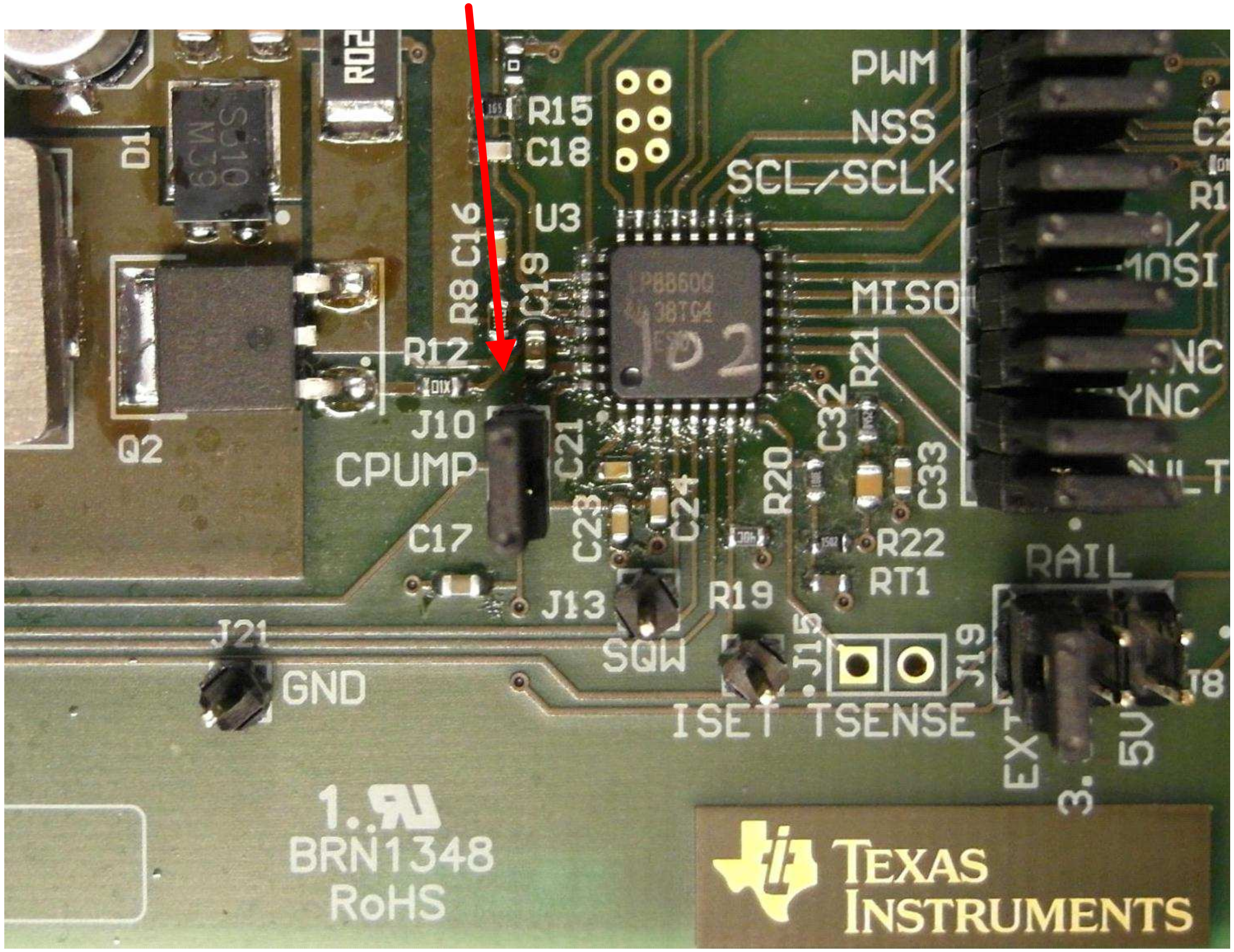


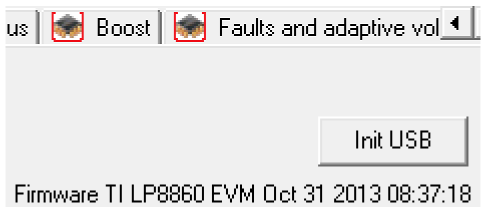
Figure D-2. CPUMP Jumper

D.2 First Step: Light up LEDs

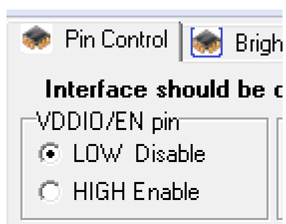
NOTE: Before powering up the EVM, software and driver should be installed.

When powering up the EVM for the first time follow these steps:

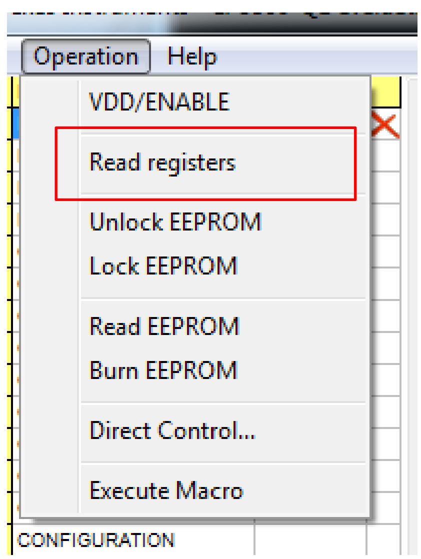
1. Connect USB cable to connector J4.
2. Connect 5V supply to J6. Check jumper J8, it should be at “EXT” (EXT RAIL) position. For basic functionality testing/demo purposes you can also use USB cable connected to J4 to provide 5V. In this case J8 should be at “5V” position.
3. Connect V_{BATT} (12V) supply to J2.
4. Run software:
   a. Press **Init USB** – the user should see line stating firmware version. This step is not mandatory if software is opened after USB was connected.



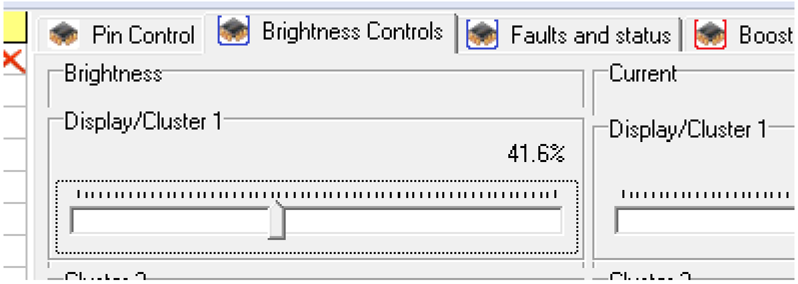
   b. Enable the LP8860-Q1.



   c. Not mandatory – check register content, **Read registers**. This will read the register contents of the LP8860-Q1 and make sure GUI reflects the register state.



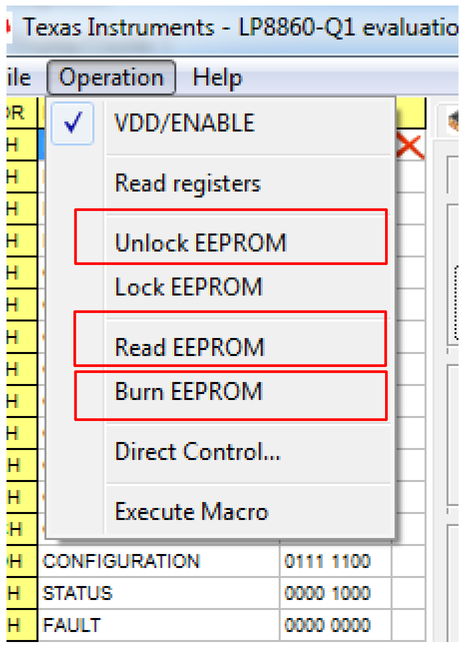
d. Set LED brightness (%) using the **Display/Cluster 1** control. Default mode (default EEPROM) is set to Display mode.



D.3 Changing EEPROM Parameters

The procedure is similar for any EEPROM parameter change. Section D.3 describes general procedure. In following chapters some specific examples are given.

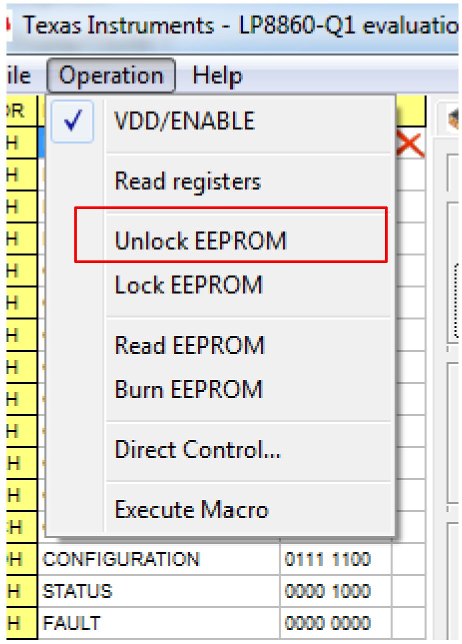
1. Make sure LED brightness is 0%. Also check that PLL is disabled in **LED drivers** tab.
2. Read EEPROM.
3. Unlock EEPROM.
4. Change parameter.
5. If user wants to save new setting in EEPROM – Burn EEPROM. After EEPROM burning toggle VDDIO/EN.



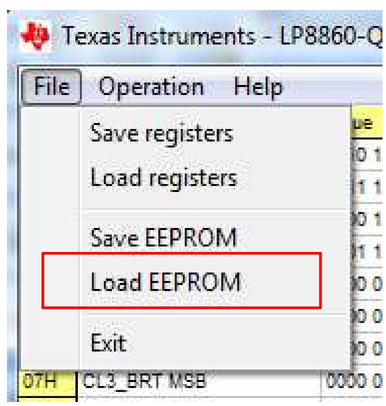
D.4 Recovering Original EEPROM Parameters

To recover original EEPROM settings:

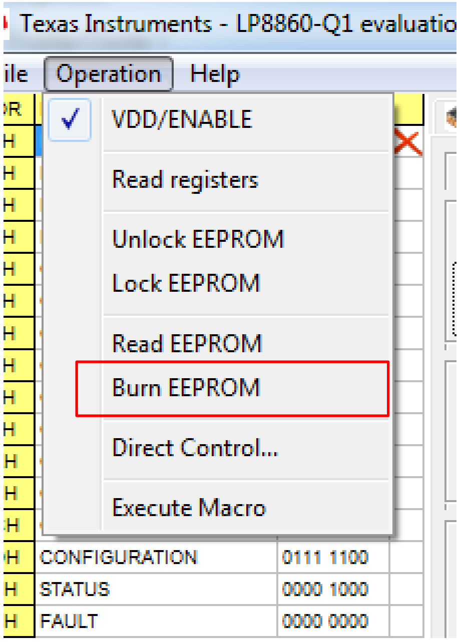
1. Make sure LED brightness is 0%. Also check that PLL is disabled in **LED drivers** tab.
2. Unlock EEPROM, if it is not done already.



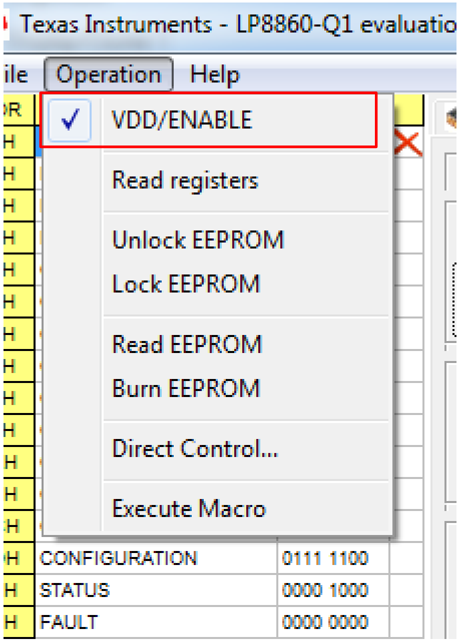
3. Load EEPROM setup file, ***“default EEPROM 300kHz.eep”***.



4. Burn EEPROM.



5. Toggle VDDIO/EN to restart the LP8860-Q1.

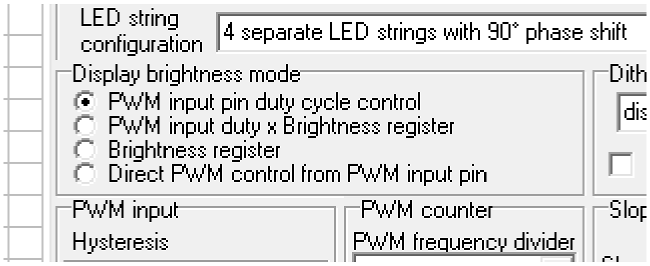


D.5 Changing Brightness Control from I²C/SPI Register Control to PWM Input Pin Control

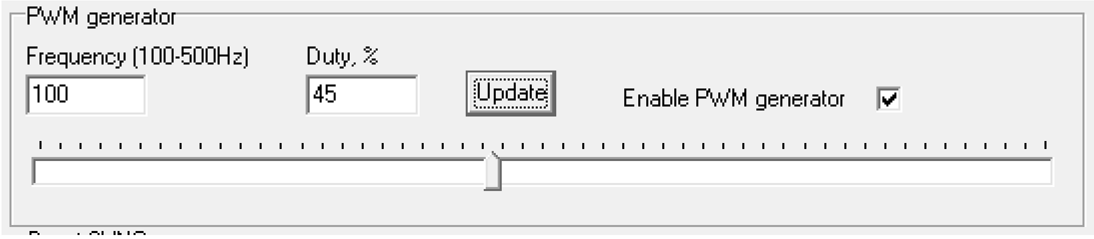
By default (default EEPROM setting of the LP8860-Q1 on the EVM) LED brightness is controlled through the I²C/SPI registers.

It is also possible to use an external PWM input signal to control LED brightness. On the EVM PWM signal is generated by MSP430 so that the user does not need to bring external signal for the first testing. To use PWM input pin for brightness control EEPROM setting needs to be modified using the following procedure:

1. Make sure LED brightness is 0%. Also check that PLL is disabled in **LED drivers** tab.
2. In **LED drivers** tab for **Display brightness mode** select **PWM input pin duty cycle control**.

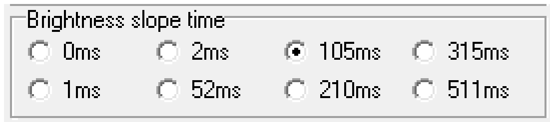


3. If the user wants to save new setting in EEPROM, **Burn EEPROM** is selected. After EEPROM burning toggle VDDIO/EN, the device resets.
4. In **Pin control** tab:
   a. Enable PWM generator (on MSP430, generating PWM input for the LP8860-Q1).
   b. Set PWM input duty cycle **Duty, %** , press **Update** to activate PWM. Another option is to use sliding control. LEDs will turn light on.

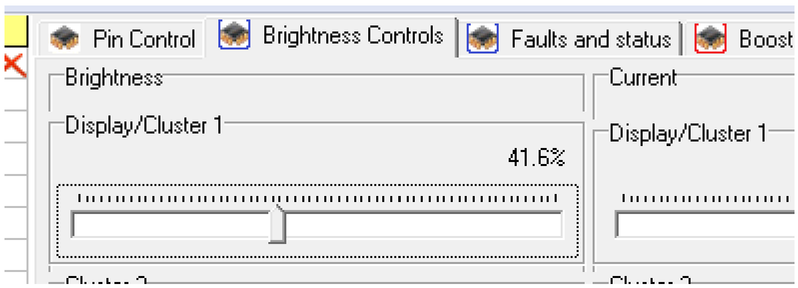


D.6 Smooth Brightness Change with Slope Control

Smooth brightness change is achieved by using slope feature. Slope mode can be linear or advanced, and slope time can be adjusted. In GUI slope is controlled on **Brightness Controls** tab:

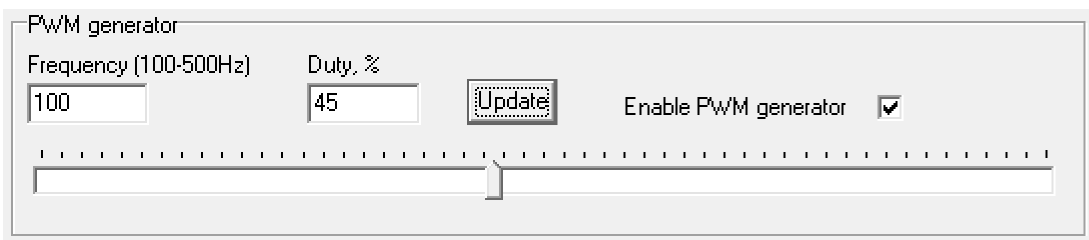


Slope control is effective through brightness control registers; brightness change can be controlled by sliding control:



However, manually using the sliding control in the GUI may introduce some unintended delay.

Another option is to use external PWM pin for brightness control. See Section D.5 for instructions how to set up this mode. In PWM brightness control mode brightness value is updated to new value defined by **Duty, %** simply by pressing **Update** button:

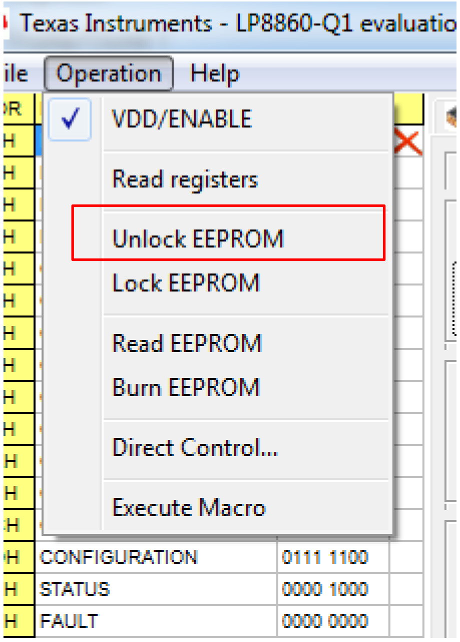


D.7 Changing Boost Switching Frequency to 2.2 MHz

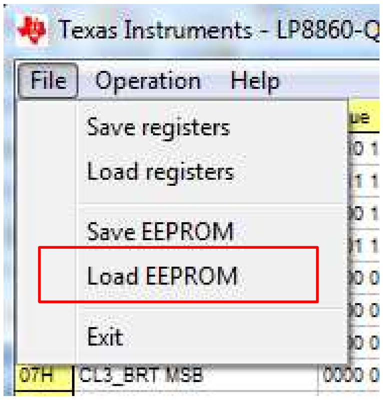
By default the boost switching frequency is 300 kHz; see **Boost tab** in GUI:

The procedure for testing boost operation at 2.2 MHz :

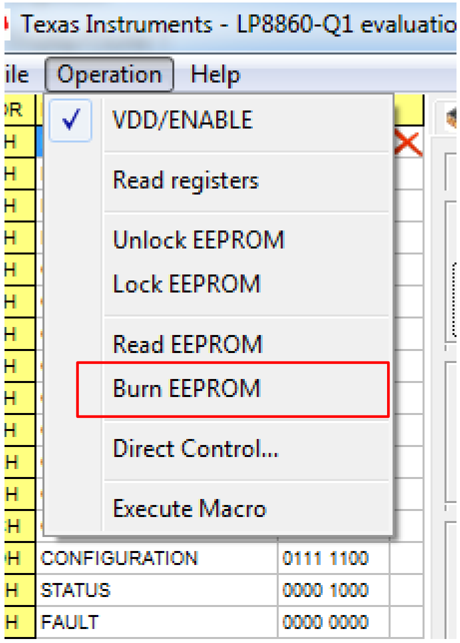
1. Make sure LED brightness is 0%. Also check that PLL is disabled in **LED drivers** tab.
2. Unlock EEPROM , if it is not done already.



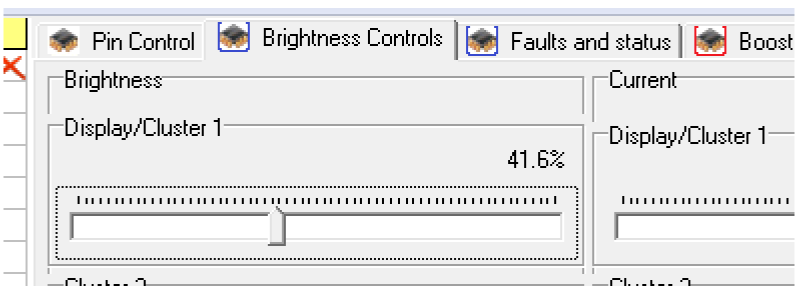
3. Load EEPROM setup file for 2.2 MHz, **"default EEPROM 2200kHz.eep"**. This file contains optimized parameter set for 2.2 MHz operation.



4. Burn EEPROM if necessary.



5. LEDs can be turned on from **Brightness controls** tab:



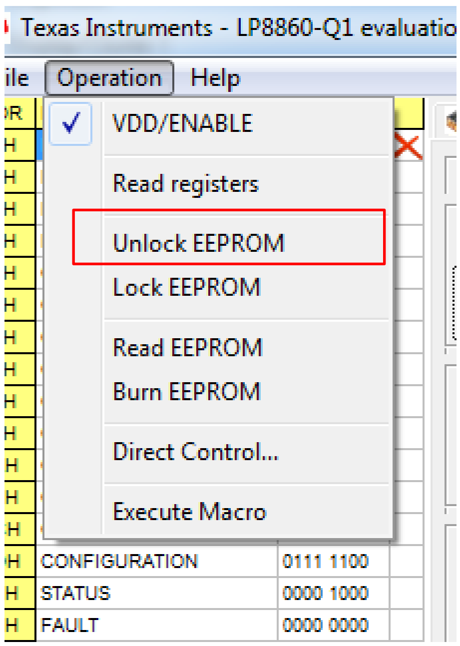
D.8 Cluster Mode, 4 LED Strings with Independent Brightness Control

Following the demo setup for cluster mode allows evaluation of the EVM and LED boards with boost providing supply to all four LED strings by disabling boost adaptive mode. Because of this, the LED current is also limited to avoid overheating.

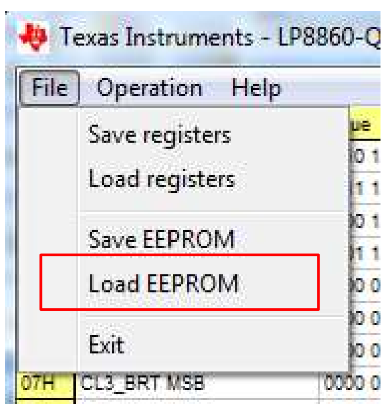
In normal operation an LED string in cluster mode must be connected to a separate supply instead of the LP8860-Q1 boost, if string(s) in display mode use(s) boost for powering.

The procedure for testing cluster mode:

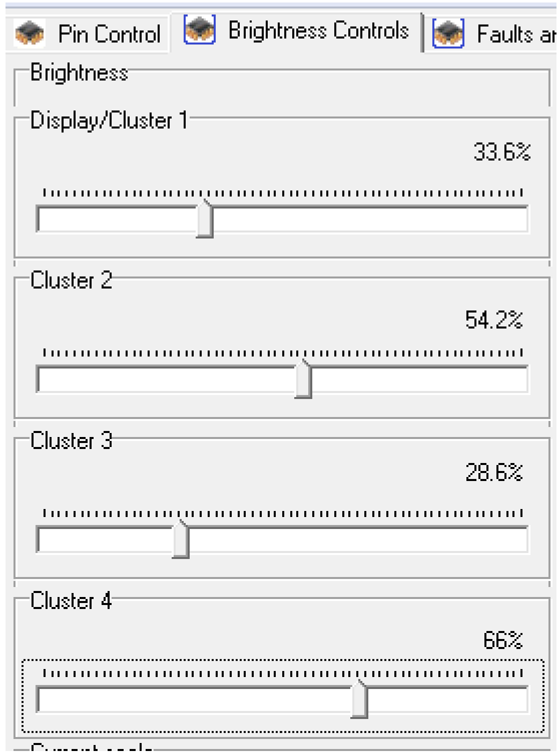
1. Make sure LED brightness is 0%. Also check that PLL is disabled in **LED drivers** tab, if you have changed PLL settings from original settings.
2. Unlock EEPROM, if it is not done already.



3. Load EEPROM set-up file for cluster mode, “Cluster mode EEPROM.eep”. This file contains a ready setup for demo cluster mode operation:



4. Brightness of each LED string can be controlled individually through **Cluster 1-4** :



D.9 Using EVM without MCU (MSP430), Standalone Mode

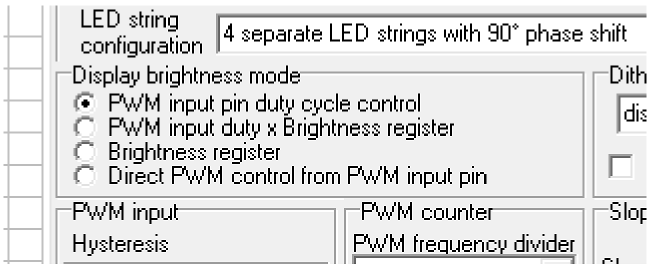
NOTE: The assumption is that LP8860-Q1 EEPROM has the default content. If modifications have been done, follow the steps described in Section D.4 to restore original EEPROM settings before proceeding.

By default (original EEPROM setting of the LP8860-Q1 on the EVM), LED brightness is controlled through I^2C/SPI registers.

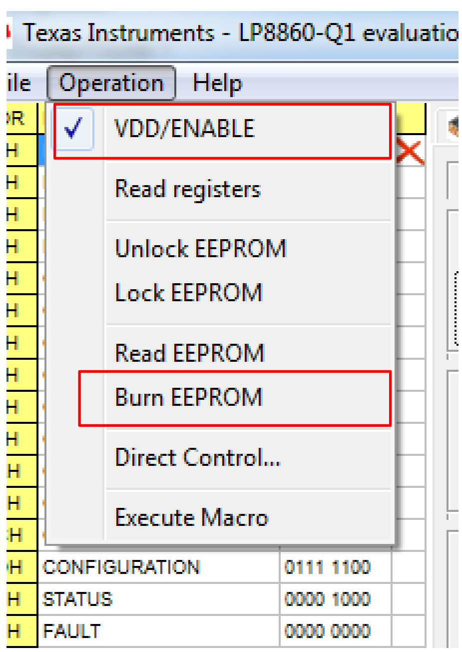
For operation without MCU, the most straightforward way to control brightness is to use an external PWM input signal.

To use PWM input pin for brightness control, the EEPROM setting needs to be modified using the following procedure:

1. Make sure LED brightness is 0%. Also check that PLL is disabled in **LED drivers** tab.
2. Unlock EEPROM.
3. In **LED drivers** tab for **Display brightness mode** select **PWM input pin duty cycle control**.



4. To save new setting in EEPROM – Burn EEPROM.



Check that EVM is powered as follows:

- Connect 5-V power supply to J6. Check jumper J8, it should be at “EXT” (EXT RAIL) position.
- Connect V_{BATT} (12 V) to J2.

To disconnect MCU from the LP8860-Q1 remove all jumpers from J11. External control can then be connected to the left side of the connector J11 (see Figure D-3):

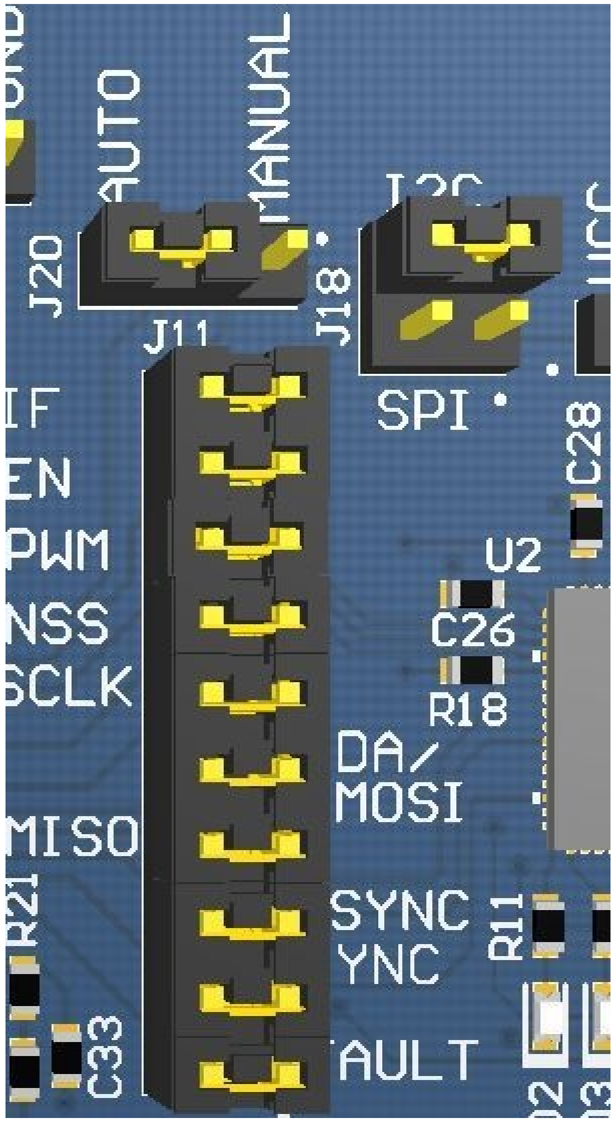


Figure D-3. Interface Jumpers

- **FAULT:** The LP8860-Q1 output indicates if fault has been detected. Note: when I^{2}C/SPI interface is not used, reason for fault condition cannot be checked from the LP8860-Q1 register.
- **SYNC, VSYNC:** connect to ground (not used in this example).
- **MISO:** leave floating (SPI interface output, not used in this example).
- **SDA, SCL:** connect to ground (I^{2}C is not used).
- **NSS:** input for clearing faults.
- **PWM:** connect external PWM signal (100 - 500 Hz) for brightness control.
- **EN:** enable for the LP8860-Q1.
- **IF:** connect to ground by connecting J20 to “Manual” and J18 to “I2C” position.

Signal level for FAULT, NSS, and PWM should be the same as EN (which defines the IO level of the LP8860-Q1). The EN level can be from 1.8 V up to the VDD of the LP8860-Q1.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.