

Using the LM3633EVM Evaluation Module

User's Guide



Literature Number: SNVU232
June 2014

1 Introduction

The Texas Instruments LM3633EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LM3633 Complete Lighting Power Solution for Smartphone Handsets. The LM3633EVM can be easily configured to support 1, 2, or 3 parallel LED strings of 4, 5, 6, 7, 8, 9, or 10 series LEDs with 1, 2, 3, 4, 5, or 6 low-voltage Indicator LEDs. An on-board USB-to-I²C interface with PWM generator is provided for a quick out of the box setup and evaluation of the LM3633.

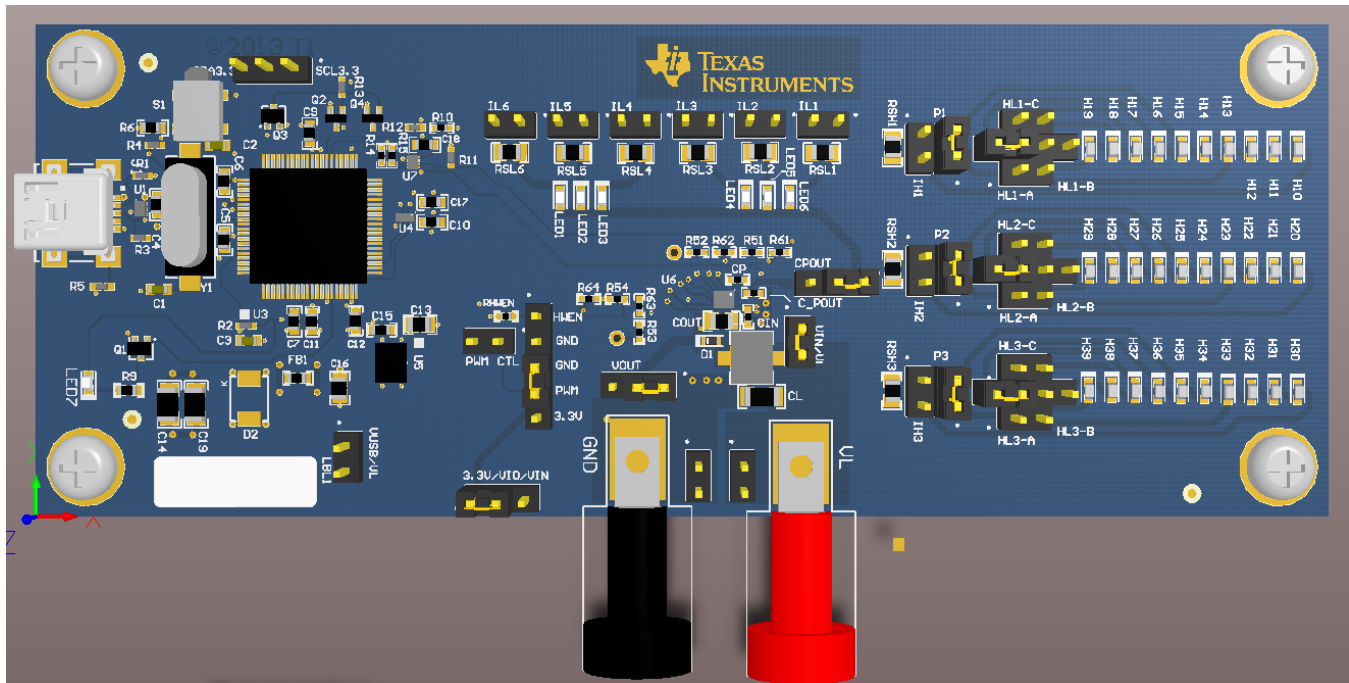


Figure 1. LM3633EVM Layout

2 Set-Up

This section describes the jumpers and connectors on the LM3633EVM as well as how to properly connect, set up, and use the LM3633.

2.1 INPUT/OUTPUT CONNECTOR DESCRIPTION

VL - INPUT is the power input terminal for the boost converter and the LM3633 VIN supply. This terminal provides a power (VBAT) connection to allow the user to attach the EVM to a power supply via a cable assembly with banana plugs.

GND - INPUT is the power input terminal for the boost converter and the LM3633 GND. This terminal provides a common ground (GND) connection to allow the user to attach the EVM to a power supply via a cable assembly with banana plugs.

J1 - INPUT/OUTPUT is the USB I/O connection to the MSP430 (USB2ANY). This terminal provides a USB to I²C connection to allow the user to evaluate the LM3633 features without the need of an external I²C tool.

VIN/VL - Connector is the connection between the power input terminal VL and the LM3633 VIN supply. This connector allows the user to insert a current meter between pins 1 and 2 to measure the LM3633 VIN current. A jumper must be installed when a current meter is not connected between pins 1 and 2.

VOU- Connector is the connection between the LM3633 boost convertor output and all three parallel LED strings. A jumper must be installed between pins 1 and 2 for normal operation.

VUSB/VL - Connector is provided to power the LM3633EVM using only USB power. Normally this jumper should remain open. If it is desired to use this feature the user must ensure that the USB power is not exceeded by the LED string configuration before inserting a jumper between pins 1 and 2. When using this option the VL input must be disconnected from an external power source.

SCL3.3, GND and SDA3.3 - Test Point Connector provide access to the 3.3V I²C interface signals. An I²C level shifter is provided to allow the user to connect an external I²C tool that does not support 5.5-V operation.

HWEN, GND, GND, PWM, +3.3 V - Test Point Connector provides access to the LM3633 HWEN and PWM inputs. An extra jumper is provided between pins 2 (GND) and 3 (GND). A jumper can be installed between pins 3 and 4 or pins 4 and 5 to connect the PWM input to GND or +3.3 V respectively. The PWM jumper must be removed if a jumper is inserted between pins 3 and 4 or pins 4 and 5.

PWM - Connector is provided to allow the user to disconnect the on-board PWM generator from the LM3633 PWM input. This jumper must be removed if the user connects an external PWM signal generator or if a jumper is installed between pins 3 and 4 or 4 and 5 of the PWM Test Point connector.

3.3V/VIO/VL - Connector is provided to select either 3.3 V or VL as the pull-up voltage for the LM3633 I²C SCL and SDA pull-up resistors.

P1 - Connector is provided to disconnect HVLED1 string from the LM3633 boost convertor output. A jumper must be installed for normal operation.

P2 - Connector is provided to disconnect HVLED2 string from the LM3633 boost convertor output. A jumper must be installed for normal operation.

P3 - Connector is provided to disconnect HVLED3 string from the LM3633 boost convertor output. A jumper must be installed for normal operation.

HL1A, HL1B, and HL1C - Connector provides a star connection to the HVLED1 string allowing the user to configure the HVLED1 string for 4, 5, 6, 7, 8, 9, or 10 series LEDs.

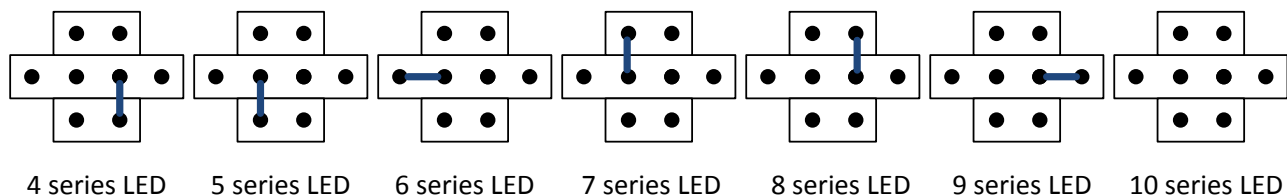
HL2A, HL2B, and HL2C - Connector provides a star connection to the HVLED2 string allowing the user to configure the HVLED2 string for 4, 5, 6, 7, 8, 9 or 10 series LEDs.

HL3A, HL3B, and HL3C - Connector provides a star connection to the HVLED3 string allowing the user to configure the HVLED3 string for 4, 5, 6, 7, 8, 9 or 10 series LEDs.

IH1 - Connector provides a convenient way to monitor the HVLED1 current by measuring the voltage drop across a 10-Ω series resistor RSH1. Connect the DMM positive terminal to pin2 and the DMM negative terminal to pin1.

IH2 - Connector provides a convenient way to monitor the HVLED2 current by measuring the voltage drop across a 10-Ω series resistor RSH2. Connect the DMM positive terminal to pin2 and the DMM negative terminal to pin1.

IH3 - Connector provides a convenient way to monitor the HVLED3 current by measuring the voltage drop across a 10-Ω series resistor RSH3. Connect the DMM positive terminal to pin2 and the DMM negative terminal to pin1.



**Figure 2. HL1A-C, HL2A-C and HL3A-C Star Jumper Configuration Settings
(blue line indicates jumper position)**

CPOUT- Connector is the connection between the LM3633 charge pump output and all six low voltage LEDs. A jumper must be installed between pins 1 and 2 for normal operation.

IL1 - Connector provides a convenient way to monitor the LVLED1 current by measuring the voltage drop across a 10-Ω series resistor RSL1. Connect the DMM positive terminal to pin1 and the DMM negative terminal to pin2.

IL2 - Connector provides a convenient way to monitor the LVLED2 current by measuring the voltage drop across a 10-Ω series resistor RSL2. Connect the DMM positive terminal to pin1 and the DMM negative terminal to pin2.

IL3 - Connector provides a convenient way to monitor the LVLED3 current by measuring the voltage drop across a 10-Ω series resistor RSL3. Connect the DMM positive terminal to pin1 and the DMM negative terminal to pin2.

IL4 - Connector provides a convenient way to monitor the LVLED4 current by measuring the voltage drop across a 10-Ω series resistor RSL4. Connect the DMM positive terminal to pin1 and the DMM negative terminal to pin2.

IL5 - Connector provides a convenient way to monitor the LVLED5 current by measuring the voltage drop across a 10-Ω series resistor RSL5. Connect the DMM positive terminal to pin1 and the DMM negative terminal to pin2.

IL6 - Connector provides a convenient way to monitor the LVLED6 current by measuring the voltage drop across a 10-Ω series resistor RSL6. Connect the DMM positive terminal to pin1 and the DMM negative terminal to pin2.

2.2 LM3633EVM CONFIGURATION

Figure 3 illustrates how to properly configure the LM3633EVM for three parallel six series (3p6s) LED string configuration, six low-voltage LED string configuration with the PWM input connected to GND.

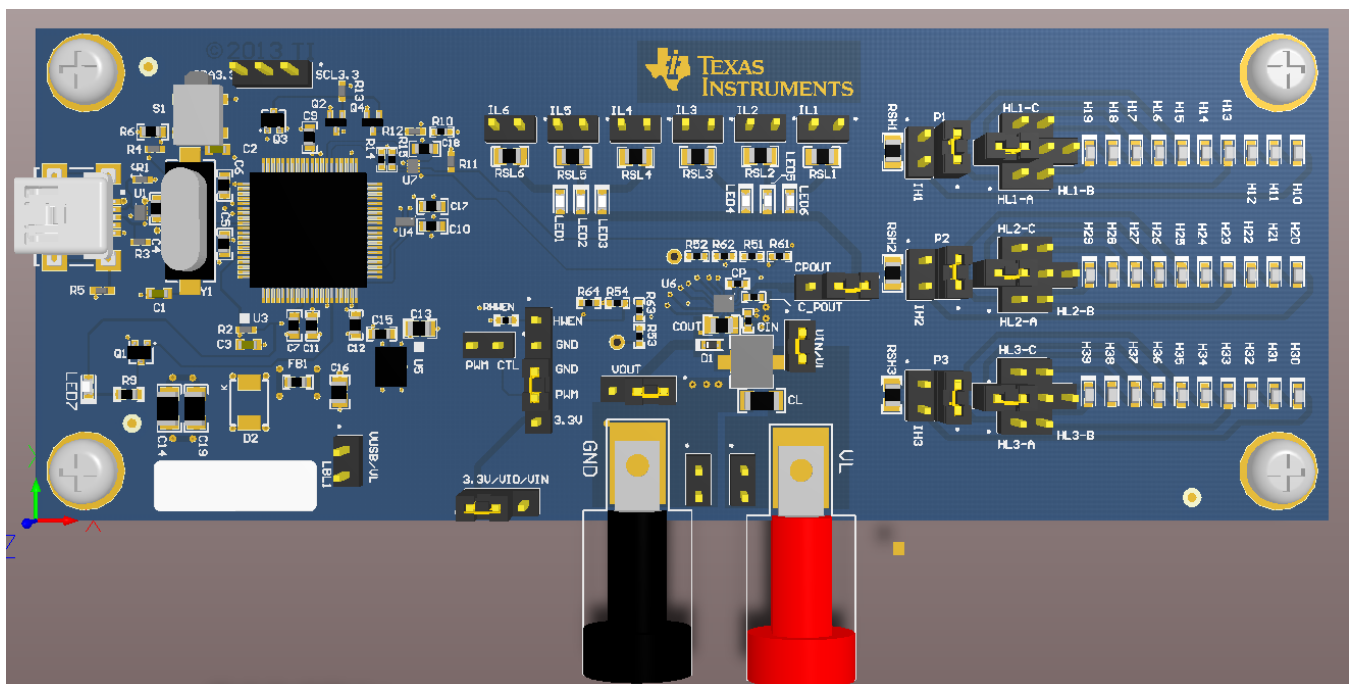


Figure 3. LM3633EVM Configuration

2.3 INSTRUCTIONS FOR EVALUATION WITH SOFTWARE

The LM3633EVM kit includes a windows program that can help exercise the part in a simple way. Figure 4 shows the LM3633EVM board setup for evaluation using the LM3633EVM GUI software.

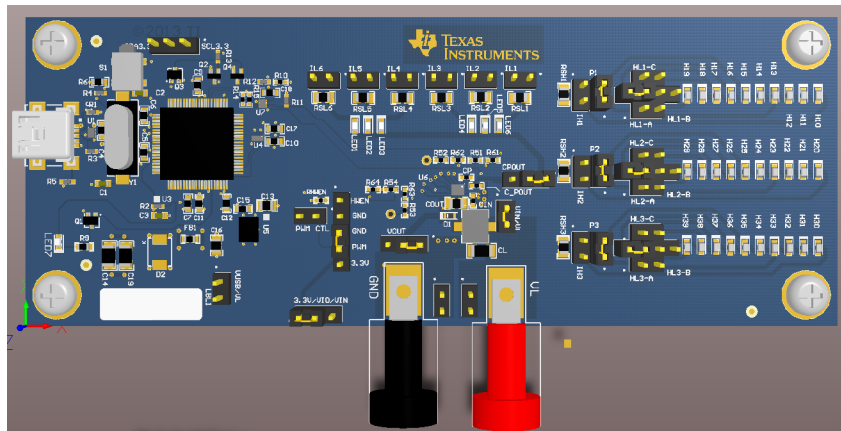


Figure 4. LM3633EVM Test Setup for Evaluation with LM3633EVM GUI Software

The LM3633EVM must be connected to the PC using the provided USB type mini-B cable. A power supply capable of 2.7-V to 5.5-V voltage range and up to 1.5-A current must be connected and turned on prior to configuring the LM3633.

The LM3633EVM GUI is organized into three sections as follows:

- Control Access
- U2A PWM Control
- LM3633

The Control Access section is used to establish the USB connection between the PC and the LM3633EVM, disconnect the USB connection between the PC, and the LM3633, select the I²C repeated start option and toggle the HWEN input to the LM3633.

The U2A PWM Control section is used to enable the on-board PWM generator, set the PWM frequency (20Khz to 100Khz), duty cycle (0 to 100%) and polarity (high/low).

The LM3633 I²C address (0x36 default) is set by the Slave Address control and is used for all six tabs of the LM3633 section. This section is organized into four separate tab pages as follows:

- High Voltage LED
- Low Voltage LED
- Pattern Generator
- LED Fault
- Single I²C Access
- EVM Quick Test

The High Voltage LED page provides access to all the High Voltage LED user-configurable registers in the LM3633. In some cases the information shown on the High Voltage LED page does not match the actual state of the LM3633 registers. To clear up this issue the user can click the Software Reset button followed by clicking the Default Values button.

The Low Voltage LED page provides access to the Low Voltage LED user configurable registers in the LM3633. In some cases the information shown on the High Voltage LED page does not match the actual state of the LM3633 registers. To clear up this issue the user can click the Software Reset button followed by clicking the Default Values button.

The Pattern Generator page provides access to all the Low Voltage LED Pattern Generator user configurable registers in the LM3633. In some cases the information shown on the High Voltage LED page does not match the actual state of the LM3633 registers. To clear up this issue the user can click the Software Reset button followed by clicking the Default Values button.

The LED Fault page provides the user access to verify the LM3633 LED Open/Short detect feature (refer to the [LM3633 datasheet](#) for the proper test sequence).

The Single I²C Access page provides the user access to individual LM3633 registers.

The EVM Quick Test page provides the user a simple way to quickly verify the EVM operation using thirteen different test cases. The user cycles through the test cases by clicking on the Advance Test button. When the test is complete clicking the Advance Test button will restart the test sequence beginning with the first test case. The EVM Test Verification Instructions field will be updated to reflect the test case performed.

When the LM3633EVM GUI software is executed, a basic interface window will open as shown in [Figure 5](#). The user needs to click the Open button under the Control Access section of the GUI interface to establish the USB connection between the PC and the LM3633EVM. When the connection is properly established the Serial: field will be updated and the Firmware Version: field will be updated with 1.18,0.0. If the communication is not properly established both of these fields will contain the word Error. When the Close button is clicked the HWEN signal will be asserted and the GUI window will be closed.

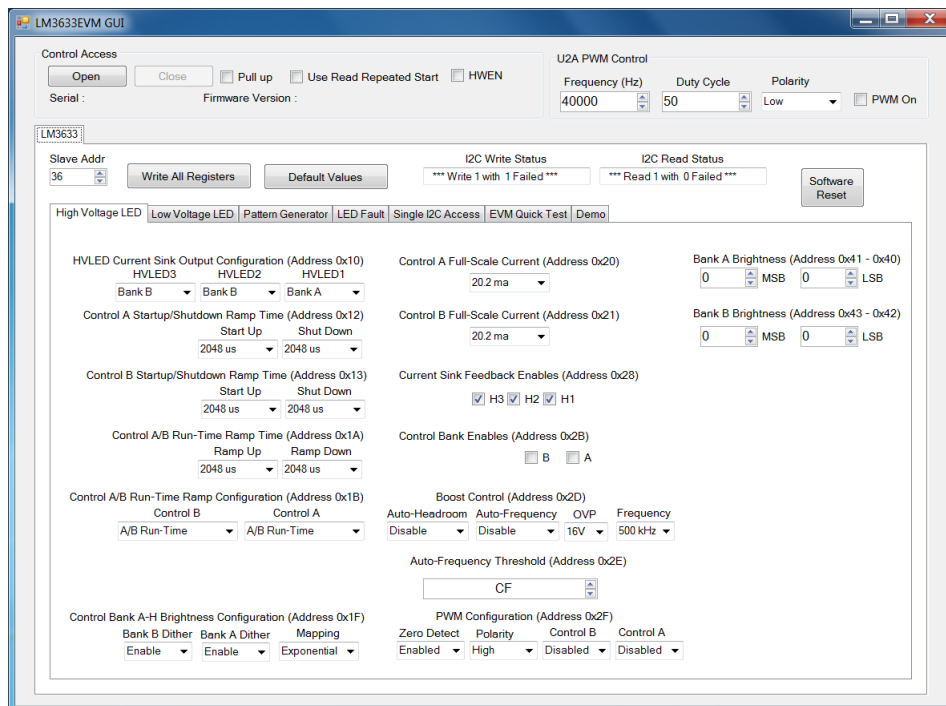


Figure 5. LM3697EVM GUI Initial Window

[Figure 6](#) shows the updated Serial: and Firmware Version: fields after the USB connection has been successfully opened.

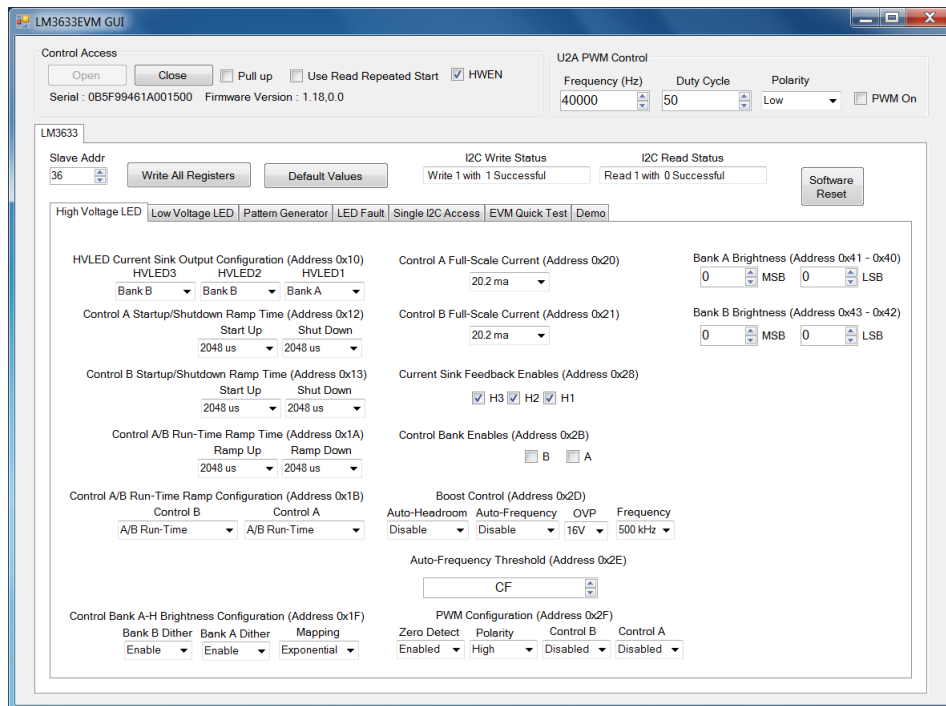


Figure 6. LM3633EVM GUI Open Success

Figure 7 shows the register settings to enable the 3p6s configuration using control bank A with PWM enabled. The PWM on check box in the U2A PWM Control section of the GUI needs to be checked to enable the internal PWM generator. The registers that need to be configured are as follows:

- Address 0x10 with Data 0x00
- Address 0x2D with Data 0x02
- Address 0x2F with Data 0x0D
- Address 0x41 with Data 0xFF
- Address 0x2B with Data 0x01

When the LM3633 register contains more than one field the I²C write packet will be sent when any one of the fields have been changed on the LM3633EVM GUI. The status of the write operation will be updated in the I2C Write Status and I2C Read Status fields. The LM3633EVM GUI will always perform an I²C read of the address written.

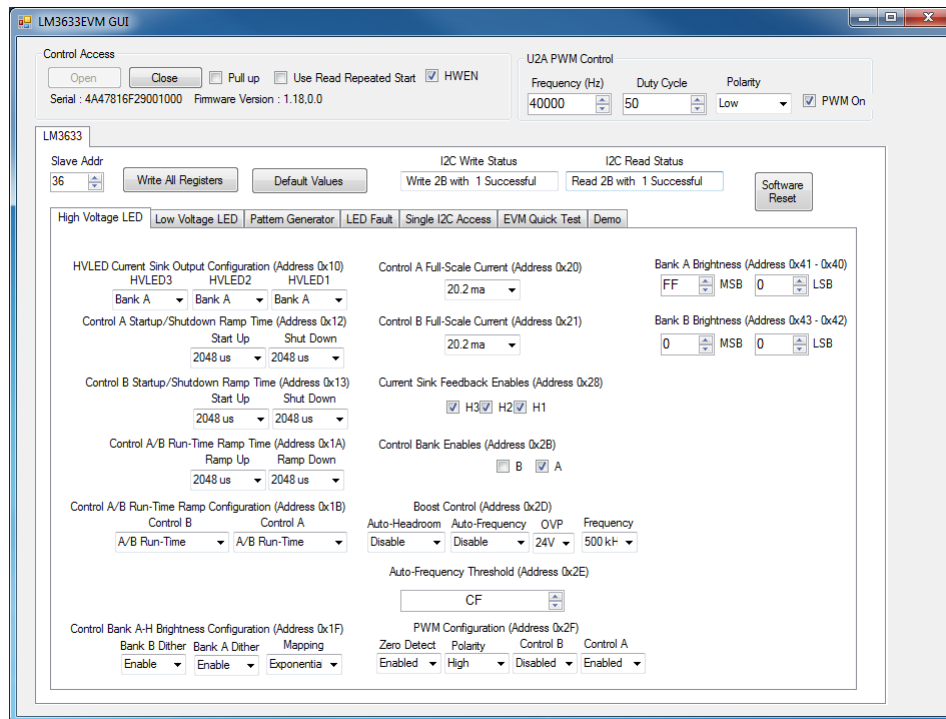


Figure 7. LM3633EVM GUI Control Bank A 3p6s Example with PWM

Click the Low Voltage LED tab to access the Low Voltage LED specific registers. Figure 8 illustrates all six Low Voltage LEDs enabled on separate control banks. In the event that the user needs to enable all six LVLEDs simultaneously the Single I2C Access tab can be used to enable the all Control Banks by writing 0xFC to Address 0x2B .

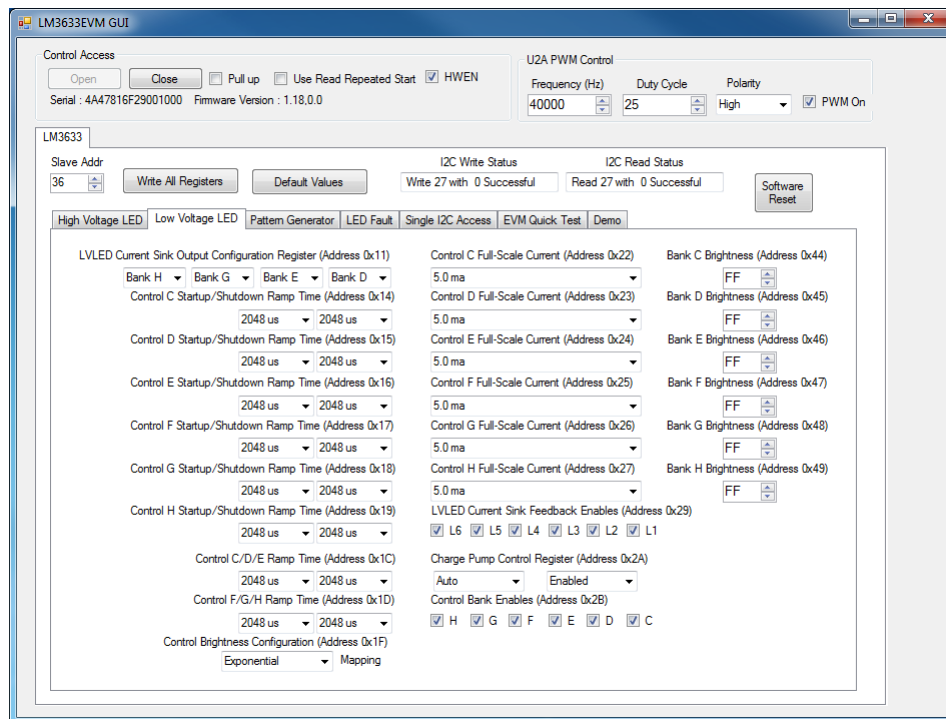


Figure 8. LVLED Control Tab

Click the Pattern Generator tab to access the Low Voltage LED specific registers. The Pattern Generator tab contains six tabs for Pattern Generator C thru H specific registers. Figure 9 illustrates the default settings for all Pattern Generators using Pattern Generator C as an example.

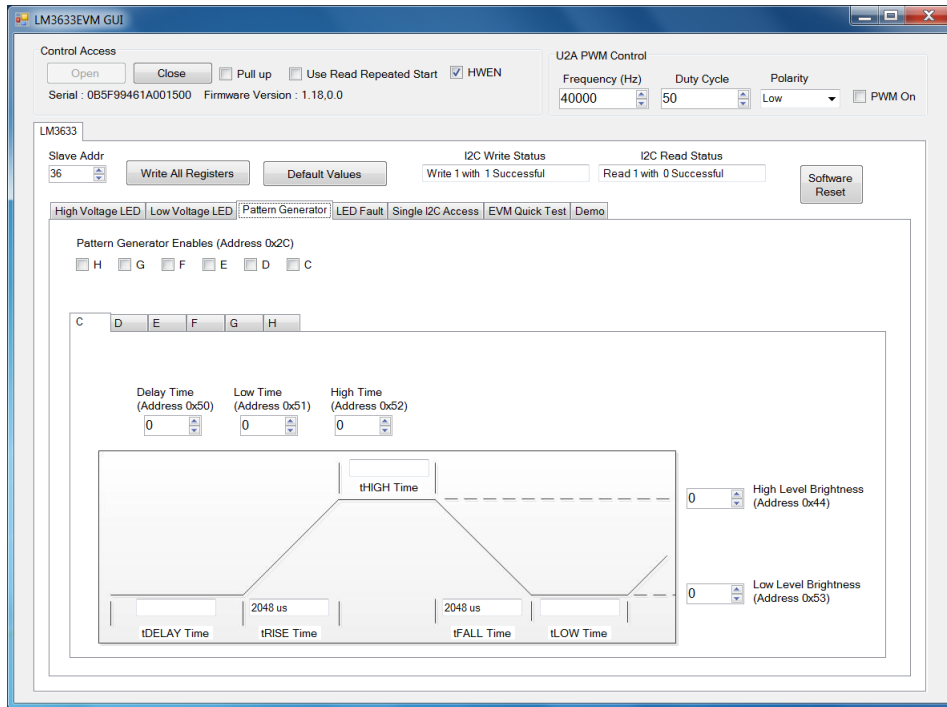


Figure 9. LVLED Pattern Generator Default Settings

Figure 10 illustrates an example of Pattern Generator timing using Pattern Generator F. The Delay Time, Rise Time, High Time, Fall Time and Low Time values are populated based on the register setting.

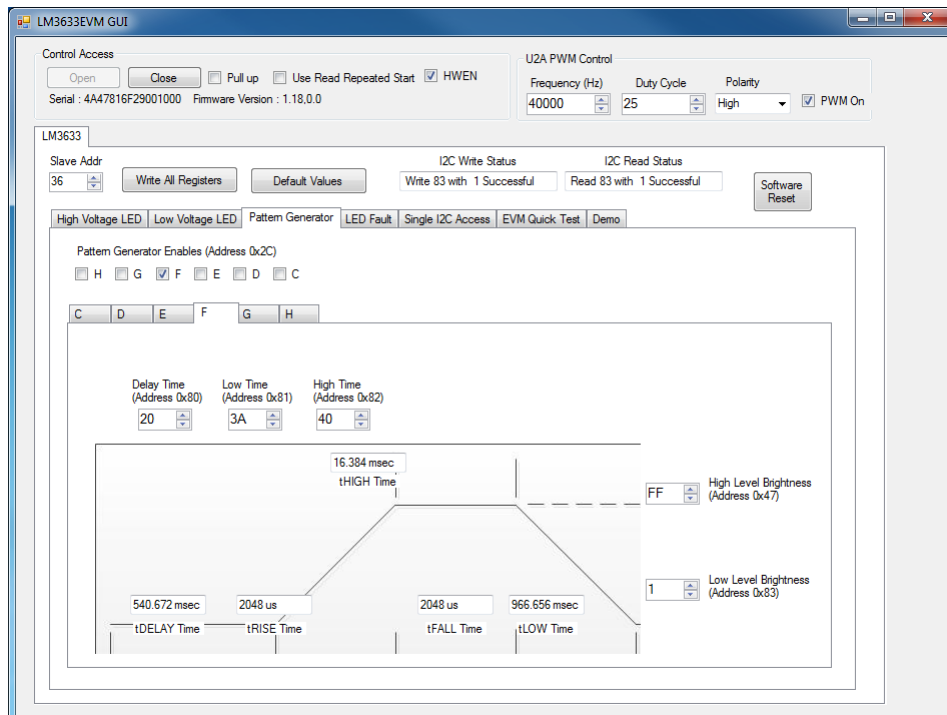


Figure 10. LVLED Pattern Generator F Example

Click the LED Fault tab to access the LED Fault registers. Refer to the [LM3633 datasheet](#) for the proper sequence to use for LED fault detection.

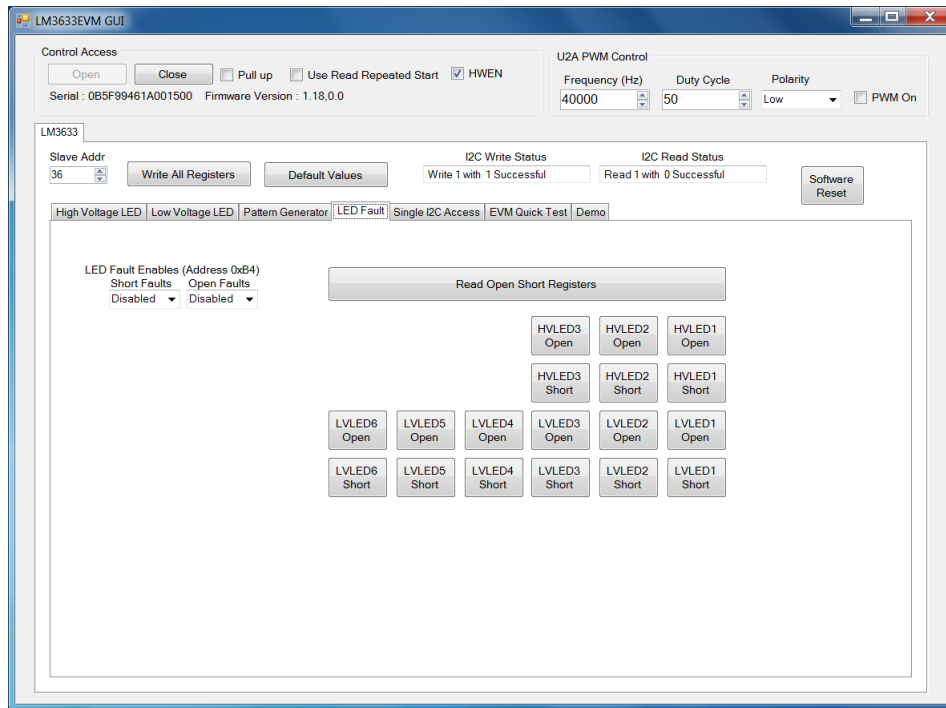


Figure 11. LED Open Short Tab

Click the Single I2C Access Tab to perform an I²C write to any I²C register.

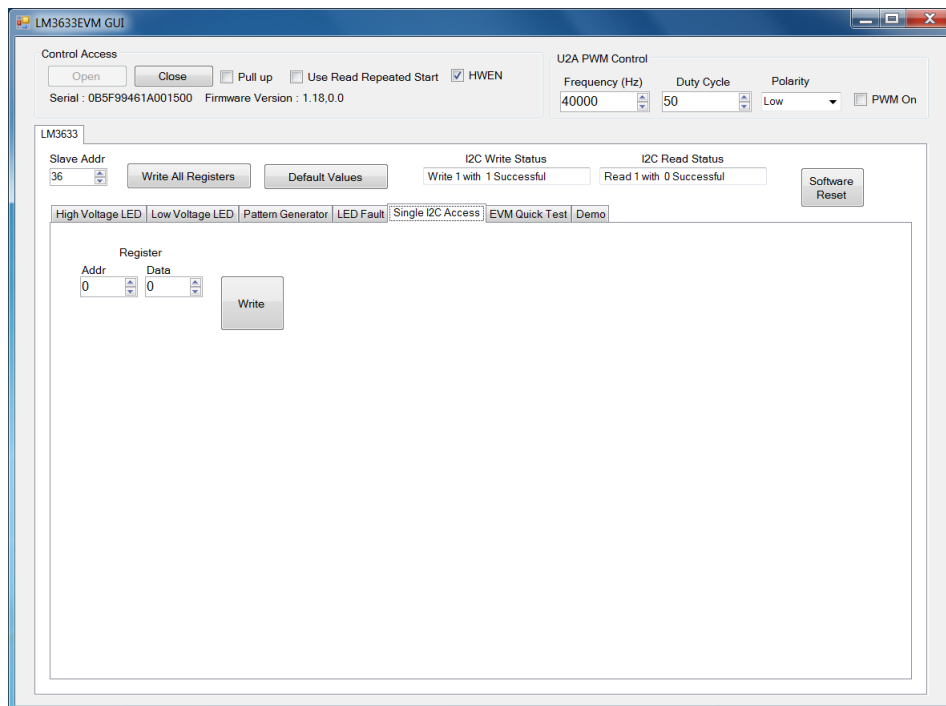


Figure 12. Single I²C Access Tab

Clicking the EVM Quick Test tab provides access to running thirteen tests to verify basic operation of the LM3633EVM. Clicking the Advance Test button will cycle through all thirteen tests. The EVM Test Verification Instructions dialog will guide the user to verify the EVM operation. [Figure 13](#) shows the EVM Quick Test after clicking the Advance Test button three times. In this mode only control bank A is enabled using the on-board PWM generator set to 25% duty cycle.

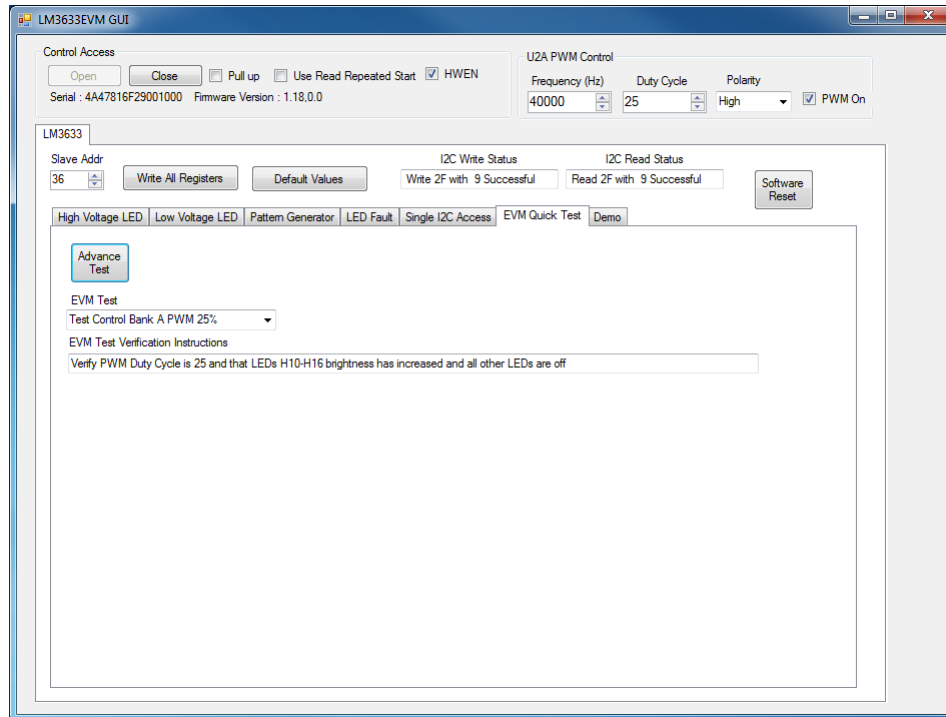


Figure 13. LM3697EVM GUI EVM Quick Test Example

The Demo tab provides access to three demonstration routines. The Ramp Demo and Cycle Test exercise only the High Voltage LED drivers and the LVLED Pattern Generator Demo configures only the Low Voltage LED drivers.

The Ramp Demo is provided to illustrate the difference in dimming resolution. The options are:

- Wait Time: this is the delay between I²C writes to the brightness register.
- Resolution: range from 11-bits to 4-bits
- High Code: maximum brightness used during ramping
- Low Code: minimum brightness used during ramping
- Repeat: this checkbox allows the pattern to repeat until the Stop button is clicked.
- Mapping: either Exponential or Linear mapping mode can be selected.

Note: the default wait time, high code and low code would result in a ramp time of 34 minutes. After the options are selected the user can click on Ramp Up, Ramp Down or Code Step to start the Ramp Demo. The Stop button is used to terminate the demo execution at any time. [Figure 14](#) shows the Ramp Demo configured to repeat a 11-bit ramp up between brightness codes 280 and 300 using 10 msec step.

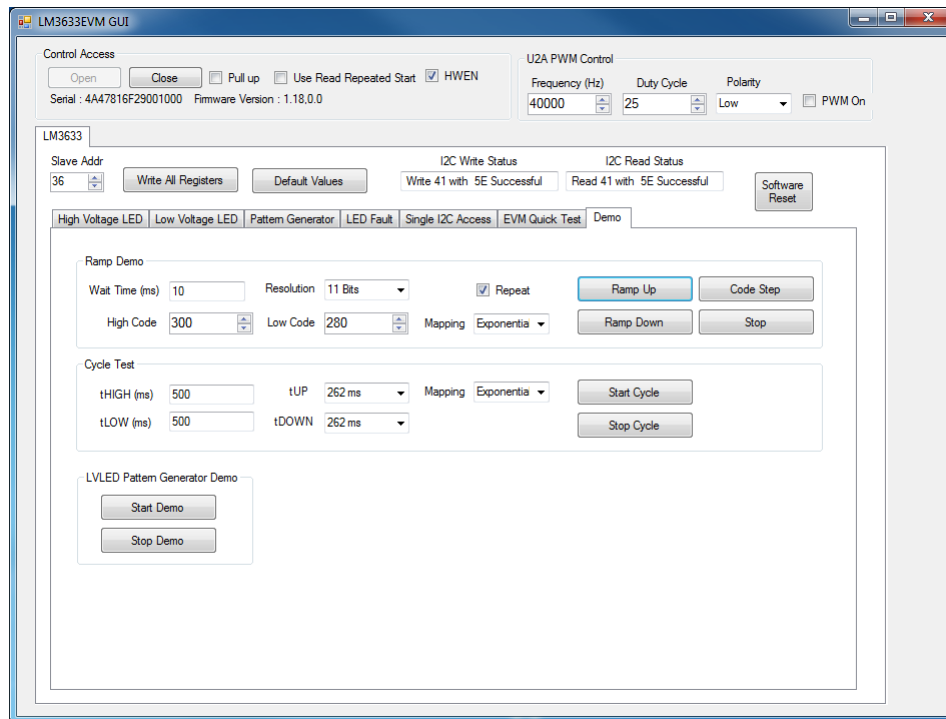


Figure 14. Ramp Demo Example

The Cycle Test is provided to demonstrate the smooth ramping at low brightness levels. The options are:

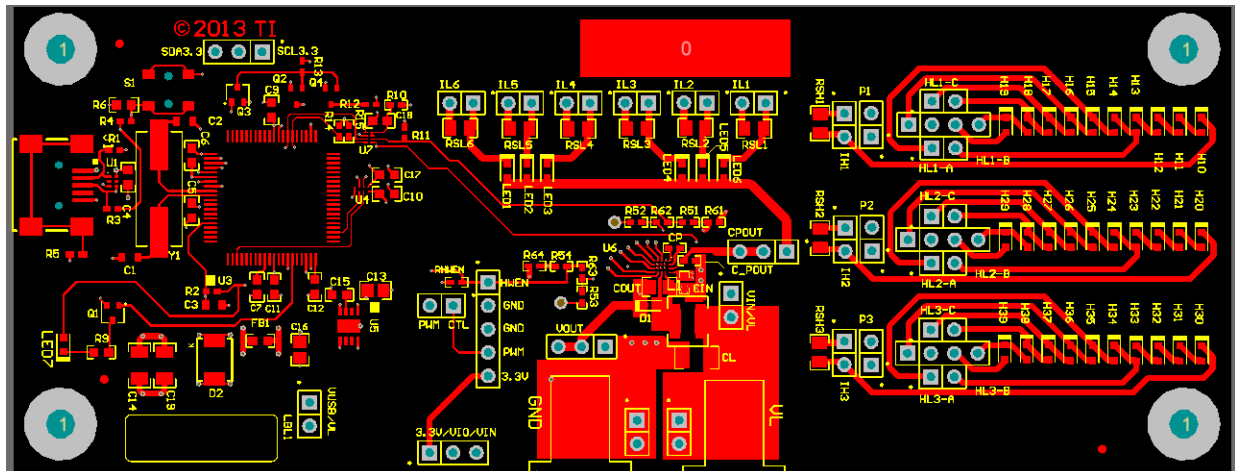
- tHIGH: this is the time duration of the high brightness level.
- tLOW: this is the time duration of the low brightness level.
- tUP: this is the time duration of the ramp from low to high brightness levels.
- tDOWN: this is the time duration of the ramp from high to low brightness levels.
- Mapping: either Exponential or Linear mapping mode can be selected.

After the options are selected the user must click the Start Cycle button to begin the test. This test will continue to repeat until the Stop Cycle button is clicked.

The LVLED Pattern Generator Demo is provided to demonstrate the low voltage LED pattern generation capability of the LM3633. There are no options to this demo, the user must click the Start Demo button to configure the device and begin the demonstration. This test will continue to repeat until the Stop Demo button is clicked. This demo implements a chasing pattern on LVLED1 thru LVLED6 with fadeout on all six LVLEDs.

3 LM3633EVM Component Placement

Figure 15 shows the top and bottom PCB layers of the LM3633EVM.


Figure 15. LM3633EVM Top Layers
Table 1. LM3633EVM Component List

Item	Designator	Description	Manufacturer	PartNumber	Qty
1	!PCB	Printed Circuit Board	Any	SV600885	1
2	C1, C2	CAP, CERM, 30pF, 100V, +/-5%, C0G/NP0, 0603	MuRata	GRM1885C2A300JA01D	2
3	C3	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	Kemet	C0603X222K5RACTU	1
4	C4, C7, C9, C10, C11, C17, C18	CAP, CERM, 0.1uF, 25V, +/-10%, X5R, 0603	AVX	06033D104KAT2A	7
5	C5, C6	CAP, CERM, 220pF, 50V, +/-1%, C0G/NP0, 0603	AVX	06035A221FAT2A	2
6	C12	CAP, CERM, 0.47uF, 10V, +/-10%, X7R, 0603	MuRata	GRM188R71A474KA61D	1
7	C13	CAP, CERM, 2.2uF, 16V, +/-10%, X5R, 0805	AVX	0805YD225KAT2A	1
8	C14, C19, CL	CAP, CERM, 10uF, 25V, +/-10%, X5R, 1206	MuRata	GRM31CR61E106KA12L	3
9	C15	CAP, CERM, 0.01uF, 50V, +/-10%, X7R, 0603	TDK	C1608X7R1H103K080AA	1
10	C16	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0805	TDK	C2012X7R1C105K	1
11	CIN	CAP, CERM, 2.2uF, 10V, +/-10%, X5R, 0402	TDK	C1005X5R1A225K050BC	1
12	COUT	CAP, CERM, 1uF, 50V, +/-10%, X7R, 1206	TDK	C3216X7R1H105K	1
13	CTL	Header, TH, 100mil, 5x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-105-07-G-S	1
14	D1	Diode, Schottky, 40V, 0.25A, SOD-523	ON Semiconductor	NSR0240V2T1G	1
15	D2	Diode, Zener, 7.5V, 550mW, SMB	ON Semiconductor	1SMB5922BT3G	1
16	FB1	Bead, Ferrite, SMT, 60Ohms, 800mA	Taiyo Yuden	BK1608HS600-T	1
17	GND	Standard Banana Jack, Insulated, Black	Keystone	6092	1

Table 1. LM3633EVM Component List (continued)

18	GND_S, HL1-A, HL1-C, HL2-A, HL2-C, HL3-A, HL3-C, IH1, IH2, IH3, IL1, IL2, IL3, IL4, IL5, IL6, P1, P2, P3, PWM, VIN/VL, VL_S, VUSB/VL	Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-102-07-G-S	23
19	H1, H2, H3, H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B and F Fastener Supply	NY PMS 440 0025 PH	4
20	H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C	4
21	H10, H11, H12, H13, H14, H15, H16, H17, H18, H19, H20, H21, H22, H23, H24, H25, H26, H27, H28, H29, H30, H31, H32, H33, H34, H35, H36, H37, H38, H39	LED, White, SMD	Rohm	SML312WBCW1	30
22	HL1-B, HL2-B, HL3-B	Header, TH, 100mil, 4x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-104-07-G-S	3
23	J1	Conn Rcpt Mini USB2.0 Type B 5POS SMD	TE Connectivity	1734035-2	1
24	JTM, SDA, VOUT, 3.3V/VIO/VL	Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	Samtec, Inc.	TSW-103-07-G-S	4
25	L1	INDUCTOR POWER 10UH 1.0A SMD	TDK	VLF4014ST-100M1R0	1
26	LBL1	Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	Brady	THT-14-423-10	1
27	LED1, LED4	LED, 468NM, BLUE, 0603 SMD	Lite-On	LTST-C191TBKT	2
28	LED2, LED5, LED7	LED, GREEN, 0603 SMD	Lite-On	LTST-C191KGKT	3
29	LED3, LED6	LED, SUPER RED, 0603 SMD	Lite-On	LTST-C191KRKT	2
30	Q1	MOSFET, N-CH, 50V, 200MA, SC70-3	Diodes Inc	BSS138W-7-F	1
31	Q2, Q4	MOSFET, P-CH, 50V, 130MA, SOT323	Diodes Inc	BSS84W-7-F	2
32	Q3	MOSFET NCH 60V 310MA SOT323	Fairchild Semiconductor	2N7002KWCT-ND	1
33	R1, R3	RES, 33 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040233R0JNED	2
34	R2, R5	RES, 33k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040233K0JNED	2
35	R4	RES, 1.5k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW04021K50JNED	1
36	R6	RES, 1.2Meg ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031M20JNEA	1
37	R7	RES, 200 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603200RFKEA	1
38	R10	RES, 200k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW0402200KJNED	1
39	R11, R12, R14, R15, RHWEN	RES, 10k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040210K0JNED	5
40	R16	RES, 0 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06030000Z0EA	1
41	RSH1, RSH2, RSH3, RSL1, RSL2, RSL3, RSL4, RSL5, RSL6	RES 10 OHM 1/8W .1% 0805 SMD	Bourns	CRT0805-BY-10R0ELF	9
42	S1	Switch, SMD Light-Touch, Side Operation	Panasonic	EVQ-PSD02K	1

Table 1. LM3633EVM Component List (continued)

43	SH-JMP1, SH-JMP2, SH-JMP3, SH-JMP4, SH-JMP5, SH-JMP6, SH-JMP7, SH-JMP8, SH-JMP9, SH- JMP10, SH-JMP11	Shunt, 100mil, Gold plated, Black	3M	969102-0000-DA	11
44	U1	ESD-Protection Array for High-Speed Data Interfaces, 4 Channels, -40 to +85 degC, 6-pin SON (DRY), Green (RoHS & no Sb/Br)	Texas Instruments	TPD4E004DRYR	1
45	U3	IC, Mixed Signal Microcontroller	Texas Instruments	MSP430F5529IPN	1
46	U4	IC BUS TRANSCVR 2B N-INV 8DSBGA	TI	SN74LVC2T45YZPR	1
47	U5	IC, 500mA, Low Quiescent Current, Ultra-Low Noise, High PSRR LDO, 3.3-V	Texas Instruments	TPS73533DRBT	1
48	U6	LM3633 High-Efficiency Three-String White LED Driver, YFQ0020FAA	Texas Instruments	LM3633	1
49	U7	IC VOLT LEVEL TRANSLATOR 8-VSSOP	TI	PCA9306DQER	1
50	VL	Standard Banana Jack, Insulated, Red	Keystone	6091	1
51	Y1	Crystal, SMT Quart Crystal	ECS	ECS-240-20-5PX-TR	1

4 LM3633EVM Schematic

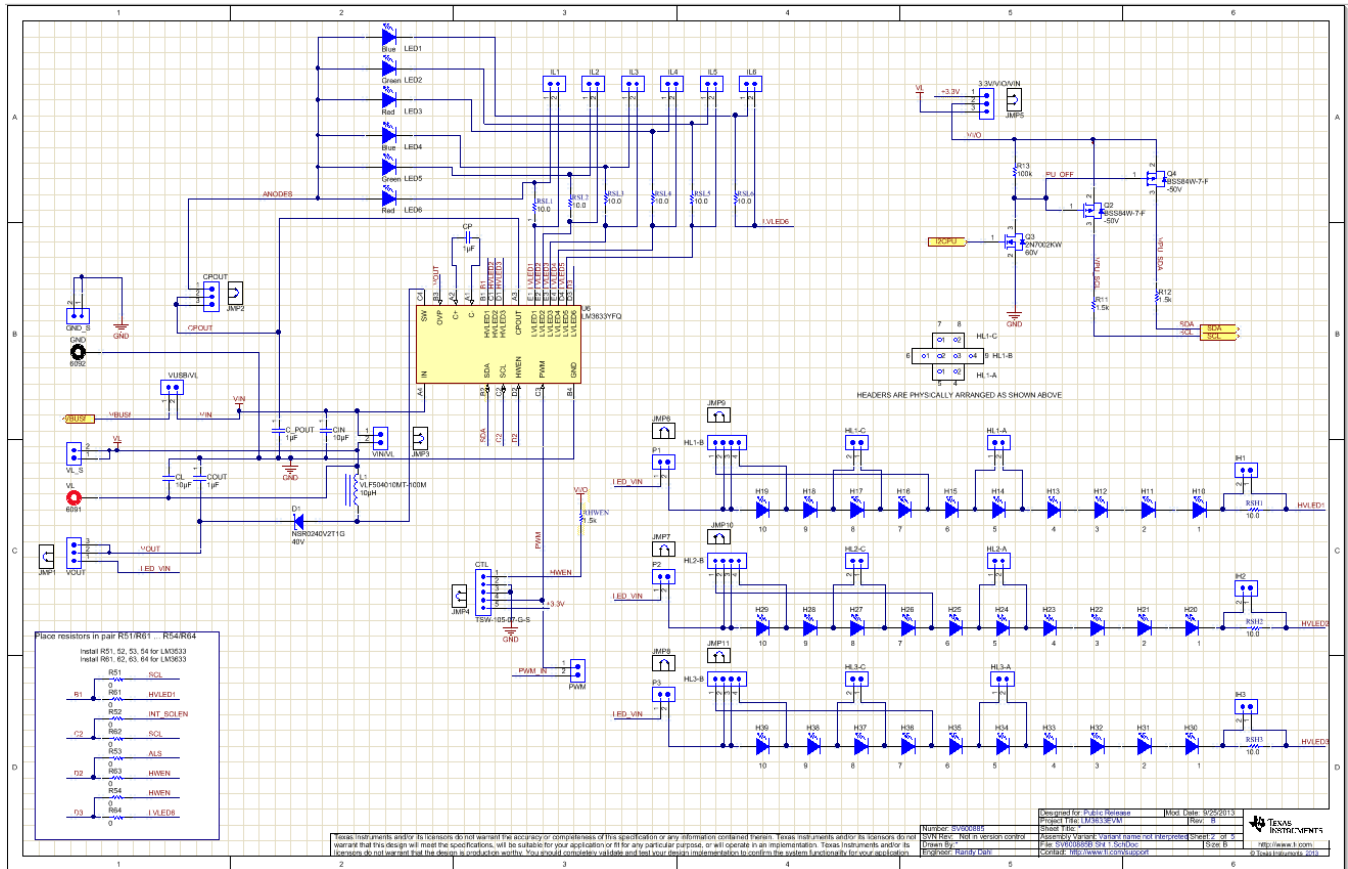


Figure 16. LM3633EVM Schematic Sheet1

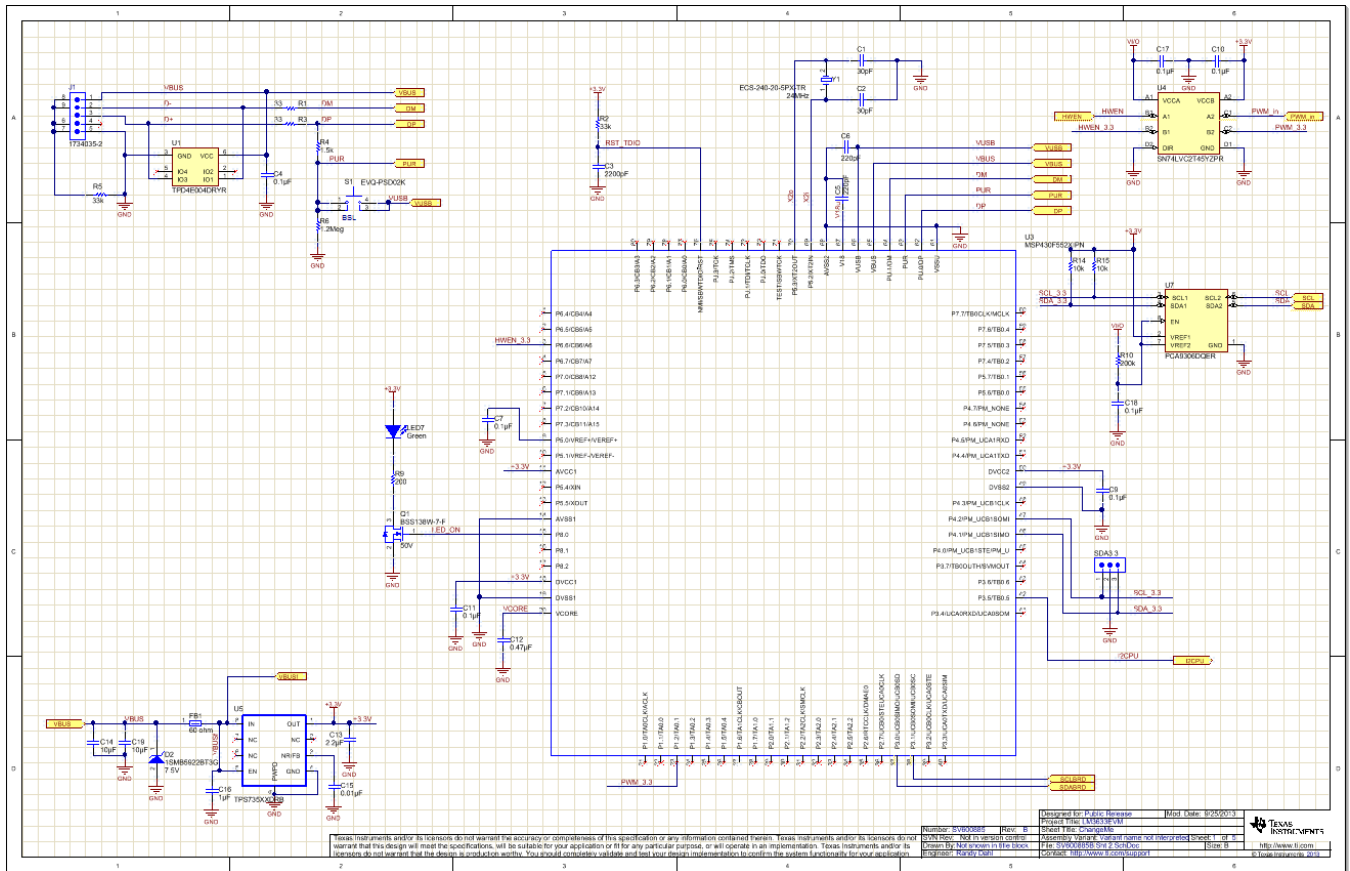


Figure 17. LM3633EVM Schematic Sheet 2

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2. Unless otherwise indicated, EVMs are not finished products and not intended for consumer use. EVMs are intended solely for use by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.
3. User agrees that EVMs shall not be used as, or incorporated into, all or any part of a finished product.
4. User agrees and acknowledges that certain EVMs may not be designed or manufactured by TI.
5. User must read the user's guide and all other documentation accompanying EVMs, including without limitation any warning or restriction notices, prior to handling and/or using EVMs. Such notices contain important safety information related to, for example, temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.
6. User assumes all responsibility, obligation, and any corresponding liability for proper and safe handling and use of EVMs.
7. Should any EVM not meet the specifications indicated in the user's guide or other documentation accompanying such EVM, the EVM may be returned to TI within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY TI TO USER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. TI SHALL NOT BE LIABLE TO USER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES RELATED TO THE HANDLING OR USE OF ANY EVM.
8. No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which EVMs might be or are used. TI currently deals with a variety of customers, and therefore TI's arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services with respect to the handling or use of EVMs.
9. User assumes sole responsibility to determine whether EVMs may be subject to any applicable federal, state, or local laws and regulatory requirements (including but not limited to U.S. Food and Drug Administration regulations, if applicable) related to its handling and use of EVMs and, if applicable, compliance in all respects with such laws and regulations.
10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

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

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of, or in connection with, any handling and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

RADIO FREQUENCY REGULATORY COMPLIANCE INFORMATION FOR EVALUATION MODULES

Texas Instruments Incorporated (TI) evaluation boards, kits, and/or modules (EVMs) and/or accompanying hardware that is marketed, sold, or loaned to users may or may not be subject to radio frequency regulations in specific countries.

General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

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

U.S. Federal Communications Commission Compliance

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 could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

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

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

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs Including Detachable Antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Canada Industry Canada Compliance (French)

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

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

Concernant les EVMs avec appareils radio

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

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

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Important Notice for Users of EVMs Considered “Radio Frequency Products” in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

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

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

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

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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