AN-2249 LM3532 Evaluation Kit

1 Introduction

The LM3532 Evaluation Board is designed to fully evaluate the LM3532 Triple Output, White LED Driver with I²C-Compatible Interface. For a detailed description of the LM3532 refer to the LM3532 datasheet. The board comes equipped with 3 series strings of 10 white LEDs. Additionally there are two ambient light sensors (Avago APDS-9005) which feed into the LM3532's ambient light sensor inputs (ALS1 and ALS2). Each Input and/or output from the LM3532 has its own separate header pin to serve as a test-point. Figure 1 shows the schematic of the Evaluation Board.

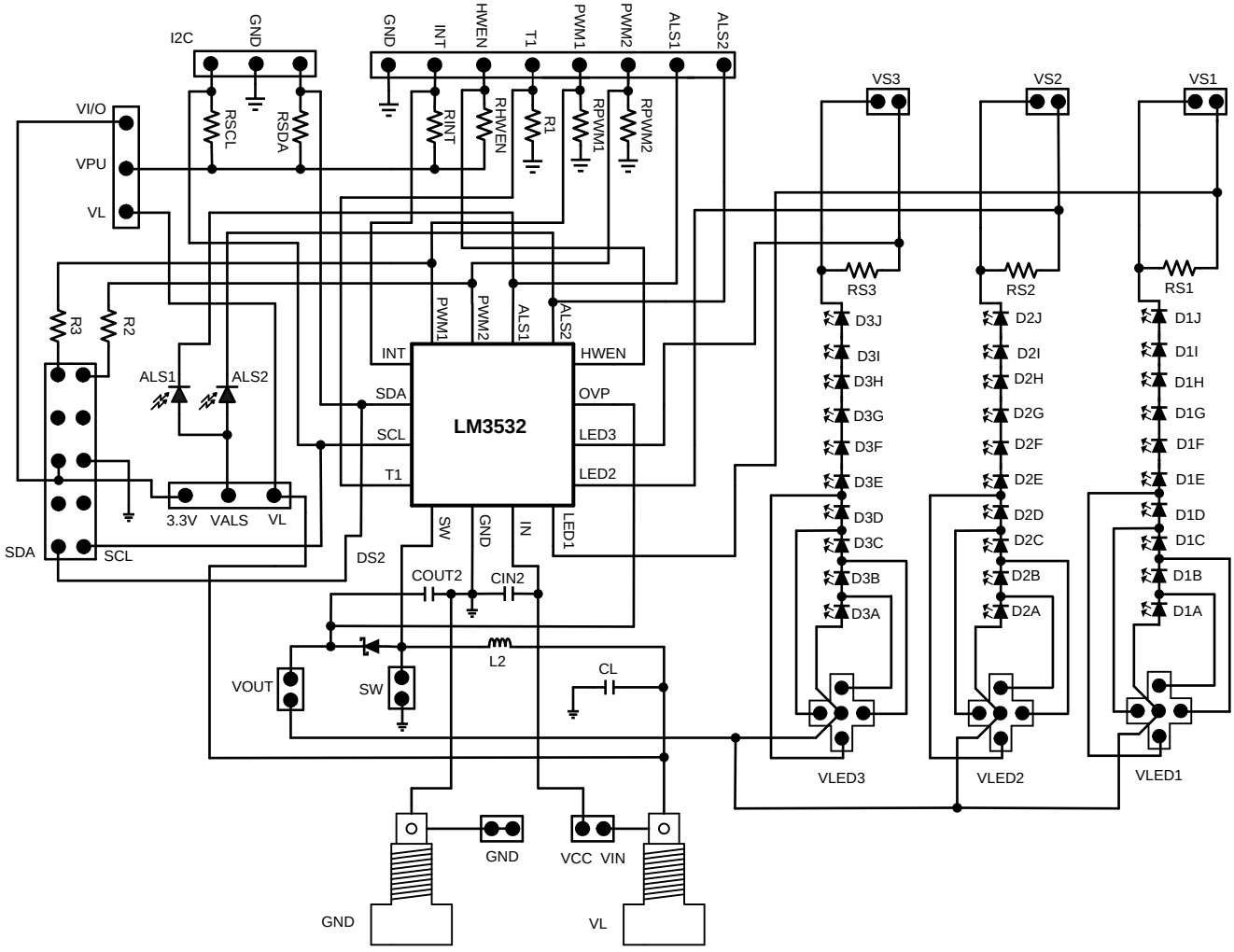

Figure 1. LM3532 Evaluation Board Schematic

The software supplied with the LM3532 Evaluation Kit (LM3532 GUI.exe) provides an easy method to evaluate all the features of the device via a PC. The LM3532 GUI.exe, when loaded on a PC, communicates to the LM3532 Eval Board through the Texas Instruments USB to I^2C controller (USB2ANY).

2 LM3532 Evaluation Board Bill of Materials

Component Symbol	Value	Manufacturer	Part #	Size (L x W x H)
U1	LED Driver	Texas Instruments	LM3532	(1.745mm x 1.845mm x 0.4mm)
L1	22µH, I_{SAT} = 700mA, R_L = 0.36Ω	TDK	LPS4018-223ML	(3.9mm x 3.9mmx 1.7mm)
CIN	2.2 µF, 25V	TDK	C1608X5R1E225K	0603 (1.6mm x 0.8mm x 0.8mm)
COUT	1 µF, 50V	TDK	C2012X7R1H105K	0805 (2mm x 1.25mm x 1.25mm)
D1-D10	White LED	ROHM	SML312WBCW1	0805
RHWEN	4.7 kΩ	Vishay-Dale	CRCW06034K70JNEA	0603
RSDA, RSDA	4.7 kΩ	Vishay-Dale	CRCW06034K70JNEA	0603
RINT	4.7 kΩ	Vishay-Dale	CRCW06034K70JNEA	0603
D1	Schottky, 40V, 250mA	On-Semi	NSR0240V2T1G	SOD-523 (1.2mm x 0.8mm x 0.6mm)
RS1, RS2, RS3	10Ω, 0.1%	Vishay	CRCW080510R0 FKEA	0805
ALS1	0 - 1100 LUX Ambient Light Sensor	Avago	APDS-9005	(1.6mm x 1.5mm x 0.55mm)
ALS2	0 - 1100 LUX Ambient Light Sensor	Avago	APDS-9005	(1.6mm x 1.5mm x 0.55mm)
R2, R3	0Ω	Vishay-Dale	CRCW06030000Z0EA	0603
CL	10µF	TDK	C1608X5R1A106M	0805
RPWM1, RPWM2	4.7kΩ	Vishay-Dale	CRCW06034K70JNEA	0603

3 LM3532 Evaluation Board Layout

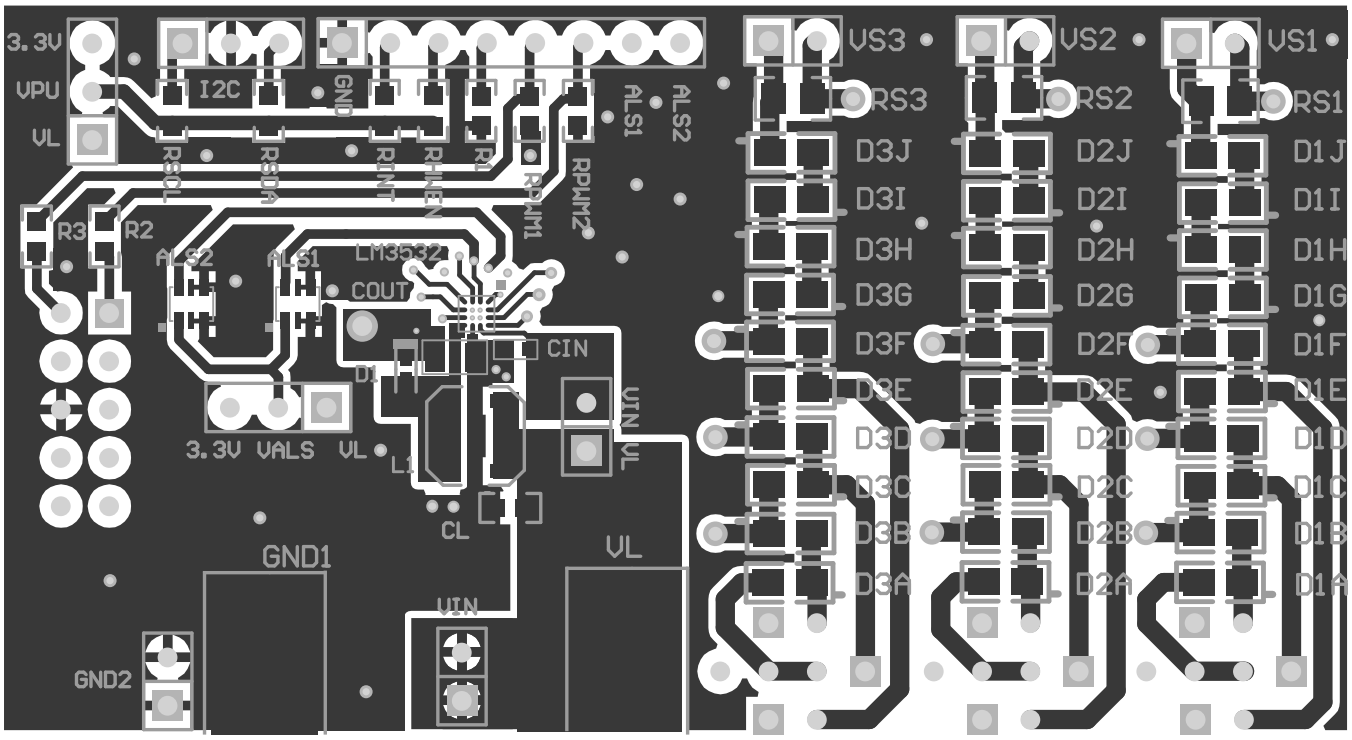

Figure 2. Top Layer

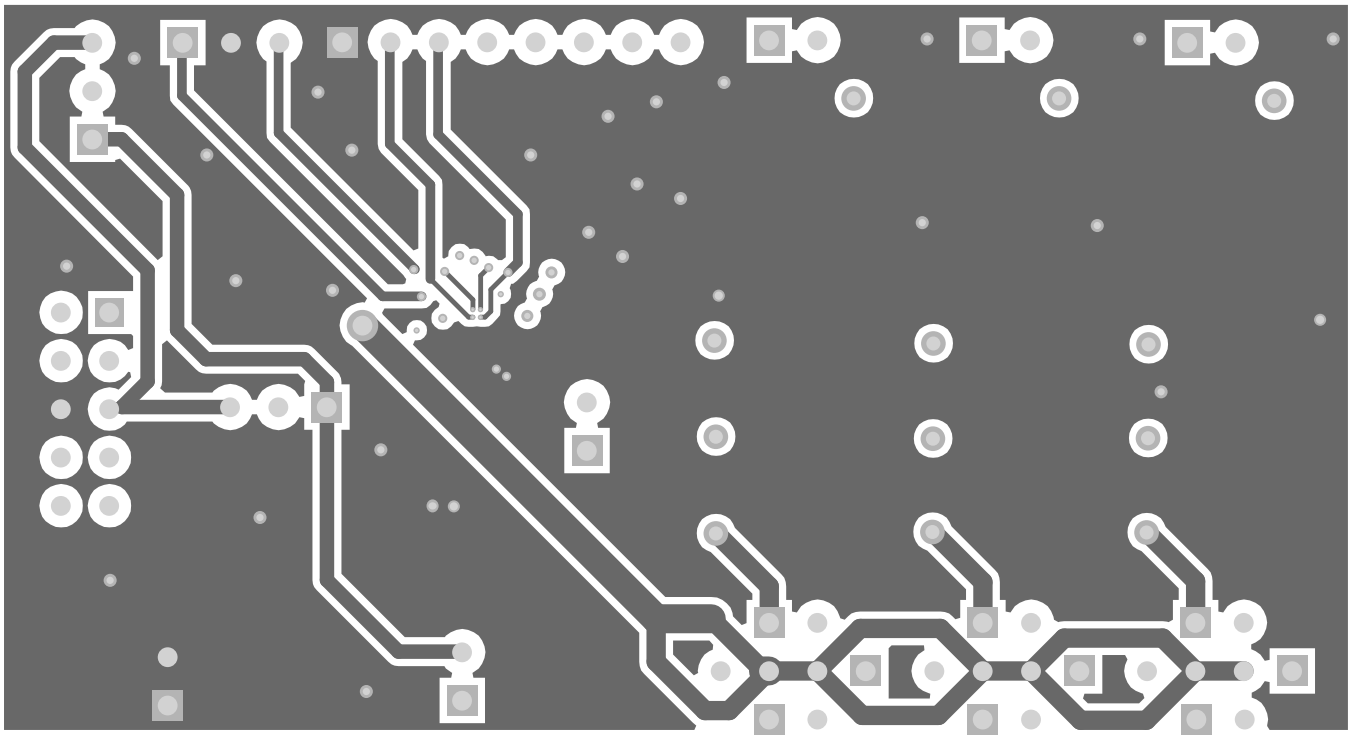

Figure 3. Mid Layer 1

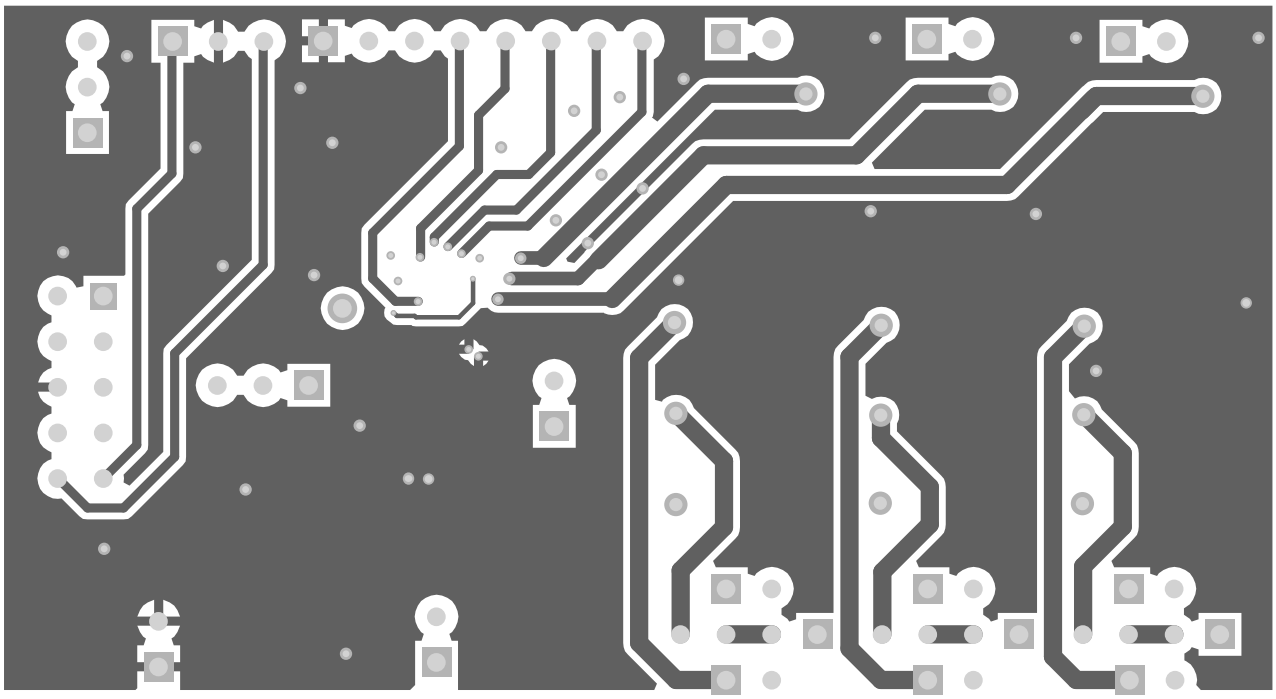

Figure 4. Mid Layer 2

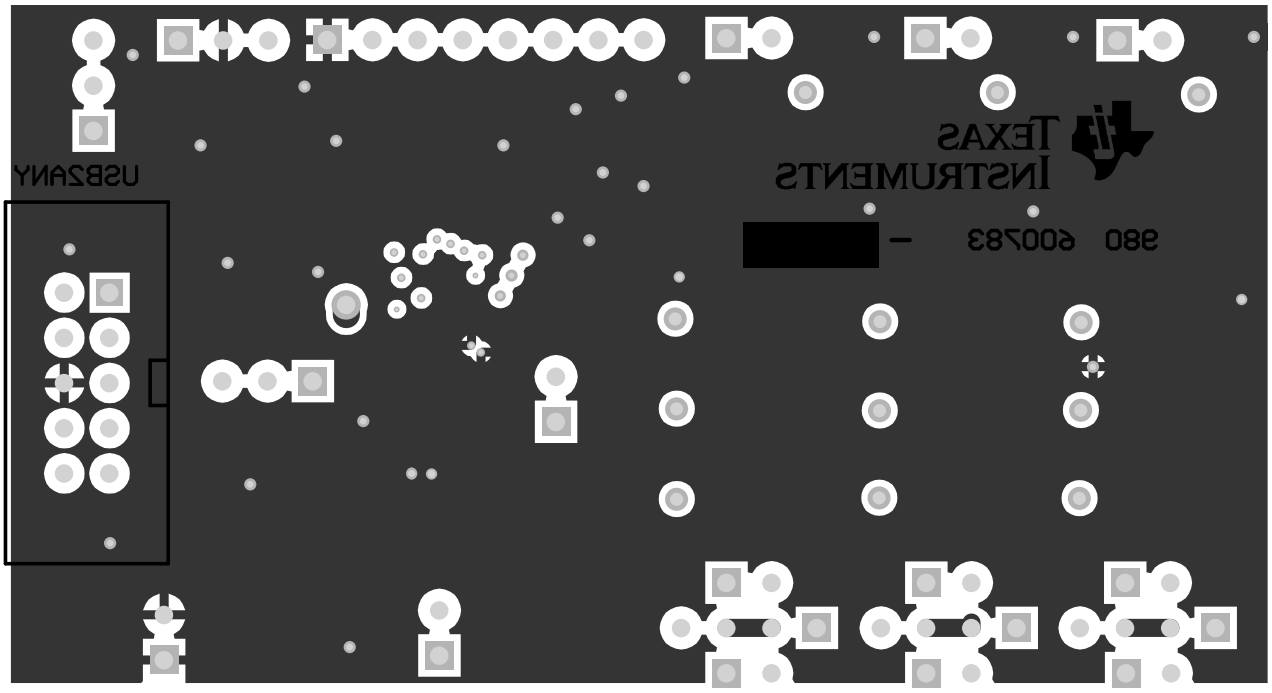

Figure 5. Bottom Layer

4 LM3532 Board Set-up

To operate the LM3532 Evaluation Board connect a jumper across the (VIN VL) header, a jumper at the (3.3V VPU VL) header, and a jumper at the VOUT header. The board should come with these jumpers already installed. The jumper at (VIN VL) connects the supply at VL to the IN pin of the device. The jumper at (3.3V VPU VL) connects the on-board pull-up resistors at SDA, SCL, HWEN, and INT to the center pin (VPU). VPU can be connected to either the supply at VL or the regulated 3.3V supply from the USB2ANY board. The jumper at VOUT will connect the output of the LM3532's boost converter to the LED string anodes. Once all the jumpers are in place, connect a 2.5V to 5.5V supply at the VL and GND banana plugs.

5 USB2ANY Interface board

The LM3532 Evaluation Board can be controlled directly by connecting an I^2C master to the SCL and SDA headers, or through the USB2ANY interface board. The USB2ANY board is designed to interface the LM3532 Eval Board to a PC which runs the LM3532 GUI.exe software. The LM3532 GUI.exe program needs to have the two .dll files (USB2ANY_API.dll and HID_API.dll) copied to the same folder which contains the LM3532 GUI.exe program. Once the LM3532 Evaluation Board has power applied, plug the USB2ANY into the bottom side connector with the included ribbon cable, then open the LM3532 GUI.exe program.

6 LM3532 GUI.exe (Graphical User Interface)

The LM3532 graphical user interface program (LM3532 GUI.exe) provides an easy method to demonstrate all the features within the LM3532. The program is divided into 6 separate tabbed sections: a Configuration Tab, a separate tab for each Control Bank (A, B, C), an Ambient Light Sensor (ALS) Tab, and a Demo Tab which provides controls to drive the PWM inputs via the USB2ANY's PWM output channels. Writing to the device happens automatically when any of the pull-down menu's are selected, or when a button is pushed.

7 LM3532 Configuration Tab

The Configuration Tab (Figure 6) contains the global registers for the LM3532 that control the current sink assignments, the enable registers, the feedback enable/disable, and the ramp rates. There is also a field for direct read and writes to the I^2C registers. Additionally there is a Default button which when pushed, places the LM3532 GUI.exe in the default state and writes all the LM3532 registers to their default (power-on reset) state. Table 1 through Table 5 describe these registers in detail.

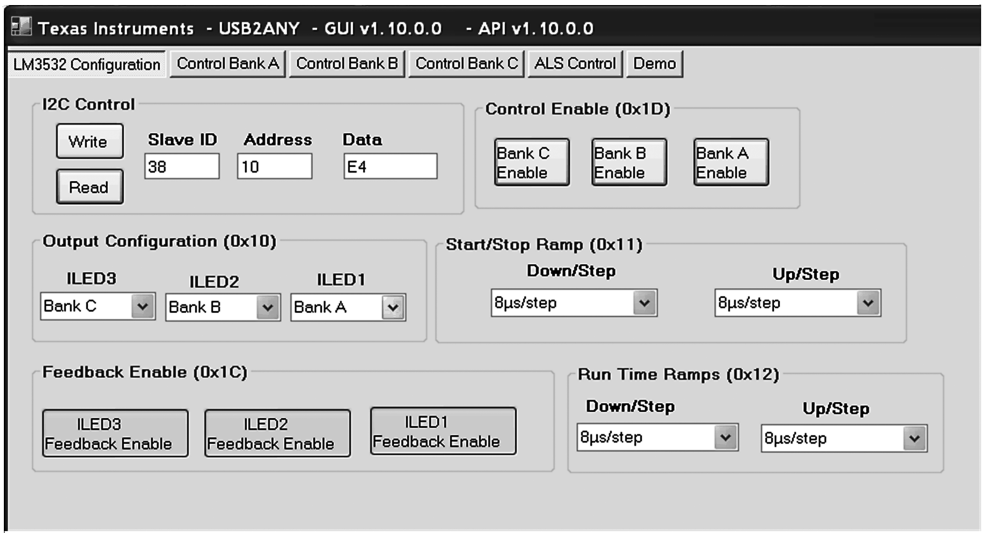

Figure 6. LM3532 Configuration Tab

Table 1. Output Configuration (0x10)

Bits [5:4] ILED3 Control	Bits [3:2] ILED2 Control	Bits [1:0] ILED1 Control
00 = ILED3 is controlled by Control A PWM and Control A Brightness Registers **(default)** 01 = ILED3 is controlled by Control B PWM and Control B Brightness Registers 1X = ILED3 is controlled by Control C PWM and Control C Brightness Registers	00 = ILED2 is controlled by Control A PWM and Control A Brightness Registers **(default)** 01 = ILED2 is controlled by Control B PWM and Control B Brightness Registers 1X = ILED2 is controlled by Control C PWM and Control C Brightness Registers	00 = ILED1 is controlled by Control A PWM and Control A Brightness Registers **(default)** 01 = ILED1 is controlled by Control B PWM and Control B Brightness Registers 1X = ILED1 is controlled by Control C PWM and Control C Brightness Registers

Table 2. Start/Stop Ramp (0x11)

Bits [5:3] Shutdown Ramp	Bits [2:0] Startup Ramp
000 = 8µs/step (2.048ms from Full-Scale to 0) **(default)** 001 = 1.024 ms/step (261 ms) 010 = 2.048 ms/step (522 ms) 011 = 4.096 ms/step (1.044s) 100 = 8.192 ms/step (2.088s) 101 = 16.384 ms/step (4.178s) 110 = 32.768 ms/step (8.356s) 111 = 65.536 ms/step (16.711s)	000 = 8µs/step (2.048ms from 0 to Full-Scale) **(default)** 001 = 1.024 ms/step (261 ms) 010 = 2.048 ms/step (522 ms) 011 = 4.096 ms/step (1.044s) 100 = 8.192 ms/step (2.088s) 101 = 16.384 ms/step (4.178s) 110 = 32.768 ms/step (8.356s) 111 = 65.536 ms/step (16.711s)

Table 3. Run Time Ramps (0x12)

Bits [5:3] Ramp Down	Bits [2:0] Ramp Up
000 = 8µs/step **(default)** 001 = 1.024 ms/step 010 = 2.048 ms/step 011 = 4.096 ms/step 100 = 8.192 ms/step 101 = 16.384 ms/step 110 = 32.768 ms/step 111 = 65.536 ms/step	000 = 8µs/step **(default)** 001 = 1.024 ms/step 010 = 2.048 ms/step 011 = 4.096 ms/step 100 = 8.192 ms/step 101 = 16.384 ms/step 110 = 32.768 ms/step 111 = 65.536 ms/step

Table 4. Feedback Enable (0x1C)

Bit 2 ILED3 Feedback Enable	Bit 1 ILED2 Feedback Enable	Bit 0 ILED1 Feedback Enable
0 = ILED3 is not part of the boost control loop 1 = ILED3 is part of the boost control loop **(default)**	0 = ILED2 is not part of the boost control loop 1 = ILED2 is part of the boost control loop **(default)**	0 = ILED1 is not part of the boost control loop 1 = ILED1 is part of the boost control loop **(default)**

Table 5. Control Enable (0x1D)

Bit 2 Bank C Enable	Bit 1 Bank B Enable	Bit 0 Bank A Enable
0 = Control C is disabled **(default)** 1 = Control C is enabled	0 = Control B is disabled **(default)** 1 = Control B is enabled	0 = Control A is disabled **(default)** 1 = Control A is enabled

8 Control Bank A, B, and C Tabs

There is a separate tab for each of the LM3532's Control Banks (Control Bank A, Control Bank B, and Control Bank C). Each tab has the registers that are specific to each control bank. Table 6 through Table 8 detail the bank specific registers.

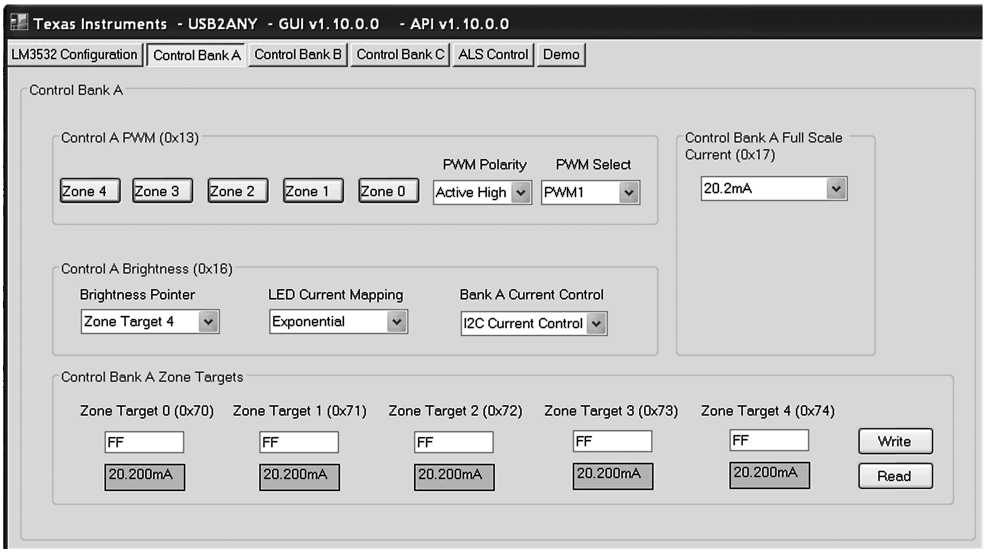

Figure 7. Control Bank Tab (Control Bank A Shown)

Table 6. Control (A/B/C) PWM (0x13/0x14/0x15)

Bit 6 Zone 4 PWM Enable	Bit 5 Zone 3 PWM Enable	Bit 2 Zone 2 PWM Enable	Bit 2 Zone 1 PWM Enable	Bit 2 Zone 0 PWM Enable	Bit 1 PWM Input Polarity	Bit 0 PWM Select
0 = Active PWM input is disabled in Zone 4 **(default)**	0 = Active PWM input is disabled in Zone 3 **(default)**	0 = Active PWM input is disabled in Zone 2 **(default)**	0 = Active PWM input is disabled in Zone 1 **(default)**	0 = Active PWM input is disabled in Zone 0 **(default)**	0 = active low polarity	0 = PWM1 input is mapped to Control Bank A **(default)**
1 = Active PWM input is enabled in Zone 4	1 = Active PWM input is enabled in Zone 3	1 = Active PWM input is enabled in Zone 2	1 = Active PWM input is enabled in Zone 1	1 = Active PWM input is enabled in Zone 0	1 = active high polarity **(default)**	1 = PWM2 is mapped to Control Bank A

Table 7. Control (A/B/C) Brightness (0x16/0x17/0x18)

Bits [4:2] Control A Brightness Pointer (I^2C Current Control Only)	Bit 1 LED Current Mapping Mode	Bit 0 Bank A Current Control
000 = Control X Zone Target 0 001 = Control X Zone Target 1 010 = Control X Zone Target 2 011 = Control X Zone Target 3 1XX = Control X Zone Target 4 **(default)**	0 = Exponential Mapping **(default)** 1 = Linear Mapping	0 = ALS Current Control 1 = I^2C Current Control **(default)**

Table 8. Control (A/B/C) Full-Scale Current (0x17/0x19/0x1B)

Bits [4:0] Control A/B/C Full-Scale Current Select Bits
00000 = 5 mA
00001 = 5.8 mA
00010 = 6.6 mA
00011 = 7.4 mA
00100 = 8.2 mA
00101 = 9 mA
00110 = 9.8 mA
00111 = 10.6 mA
01000 = 11.4 mA
01001 = 12.2 mA
01010 = 13 mA
01011 = 13.8 mA
01100 = 14.6 mA
01101 = 15.4 mA
01110 = 16.2 mA
01111 = 17 mA
10000 = 17.8 mA
10001 = 18.6mA
10010 = 19.4 mA
10011 = 20.2 mA **(default)**
10100 = 21 mA
10101 = 21.8 mA
10110 = 22.6 mA
10111 = 23.4 ma
11000 = 24.2 mA
11001 = 25 mA
11010 = 25.8 mA
11011 = 26.6 mA
11100 = 27.4 mA
11101 = 28.2 mA
11110 = 29 mA
11111 = 29.8 mA

In I^2C Current Control, any of the 5 Zone Target Registers for the particular Control Bank can be the LED brightness register. This is set according to Control A, B, or C Brightness Configuration Registers (Bits [4:2]). In the LM3532 GUI.exe, once a Zone Target value is written, the Write button must be pressed to write the contents of all zone targets to the LM3532.

9 Control Bank (A/B/C) Zone Targets

Control A Zone Target Register 0 maps directly to Zone 0 (Address 0x70)
Control A Zone Target Register 1 maps directly to Zone 1 (Address 0x71)
Control A Zone Target Register 2 maps directly to Zone 2 (Address 0x72)
Control A Zone Target Register 3 maps directly to Zone 3 (Address 0x73)
Control A Zone Target Register 4 maps directly to Zone 4 (Address 0x74)

Control B Zone Target Register 0 maps directly to Zone 0 (Address 0x75)
Control B Zone Target Register 1 maps directly to Zone 1 (Address 0x76)
Control B Zone Target Register 2 maps directly to Zone 2 (Address 0x77)
Control B Zone Target Register 3 maps directly to Zone 3 (Address 0x78)
Control B Zone Target Register 4 maps directly to Zone 4 (Address 0x79)

Control C Zone Target Register 0 maps directly to Zone 0 (Address 0x7A)
Control C Zone Target Register 1 maps directly to Zone 1 (Address 0x7B)
Control C Zone Target Register 2 maps directly to Zone 2 (Address 0x7C)
Control C Zone Target Register 3 maps directly to Zone 3 (Address 0x7D)
Control C Zone Target Register 4 maps directly to Zone 4 (Address 0x7E)

10 ALS Control Tab

The ALS Control Tab (Figure 8) contains all the registers that are programmable for the LM3532's Ambient Light Sensor Interface. Table 9 through Table 12 describe these registers. The evaluation board has two on board light sensors (ADPS-9005 from Avago). These connect directly to the LM3532's ALS1 and ALS2 inputs. The APDS-9005 requires a minimum of 1V saturation voltage for proper operation and has a typical response of 400nA/lux. For example, for detecting 0 to 2k Lux across the LM3532's 2V ALS input voltage range would require the APDS9005 be biased from a 3V minimum supply (supplied at the VALS header on the board), with an ALS load resistor of 2V/(2k Lux x 400nA/Lux) = 2.5kOhms. This corresponds to an ALS resistor Select Register code of 0x0F for register 0x20 (ALS1) or 0x0F for register 0x21 (ALS2).

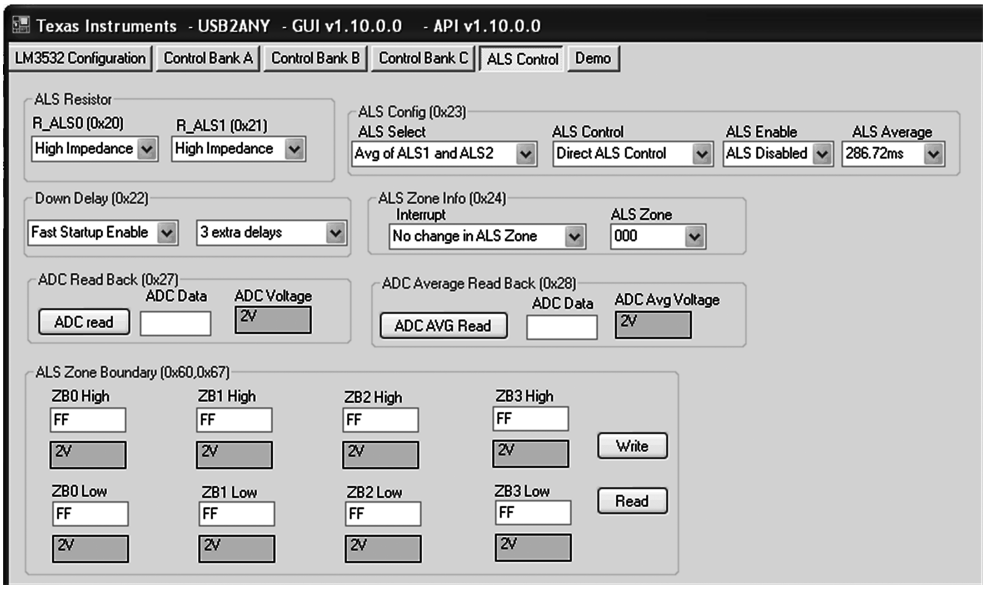

Figure 8. ALS Control Tab

Table 9. ALS Resistor (R_ALS0, 0x20/R_ALS1, 0x21)

Bit [4:0] ALS1/ALS2 Resistor Select Bits
00000 = High Impedance **(default)**
00001 = 37 kΩ
00010 = 18.5 kΩ
00011 = 12.33 kΩ
00100 = 9.25 kΩ
00101 = 7.4 kΩ
00110 = 6.17 kΩ
00111 = 5.29 kΩ
01000 = 4.63 kΩ
01001 = 4.11 kΩ
01010 = 3.7 kΩ
01011 = 3.36 kΩ
01100 = 3.08 kΩ
01101 = 2.85 kΩ
01110 = 2.64 kΩ
01111 = 2.44 kΩ
10000 = 2.31 kΩ
10001 = 2.18 kΩ
10010 = 2.06 kΩ
10011 = 1.95 kΩ
10100 = 1.85 kΩ
10101 = 1.76 kΩ
10110 = 1.68 kΩ
10111 = 1.61 kΩ
11000 = 1.54 kΩ
11001 = 1.48 kΩ
11010 = 1.42 kΩ
11011 = 1.37 kΩ
11100 = 1.32 kΩ
11101 = 1.28 kΩ
11110 = 1.23 kΩ
11111 = 1.19 kΩ

Table 10. Down Delay (0x22)

Bit [5] ALS Fast startup Enable	Bits [4:0] Down Delay
0 = ALS Fast startup is Disabled 1 = ALS Fast startup is Enabled **(default)**	00000 = 6 total Average Period delay for Down Delay Control **(default)** : : : 11111 = 34 total Average Periods of Delay for Down Delay Control

Table 11. ALS Configuration (0x23)

Bits [7:6] ALS Input Select	Bit [5:4] ALS Control	Bit 3 ALS Enable	Bits [2:0] ALS Average Time
00 = Average of ALS1 and ALS2 is used to determine backlight current 01 = Only the ALS1 input is used to determine backlight current **(default)** 10 = Only the ALS2 input is used to determine the backlight current 11 = The maximum of ALS1 and ALS2 is used to determine the backlight current	00 = Direct ALS Control. ALS inputs respond to up and down transitions **(default)** 01 = This setting is for a future mode. 1X = Down Delay Control. Extra delays of 3 x t_{AVE} to 34 x t_{AVE} are added for down transitions, before the new backlight target is programmed.	0 = ALS is disabled **(default)** 1 = ALS is enabled	000 = 17.92 ms 001 = 35.84 ms 010 = 71.68 ms 011 = 143.36 ms 100 = 286.72 ms **(default)** 101 = 573.44 ms 110 = 1146.88 ms 111 = 2293.76 ms

Table 12. ALS Zone Information (0x24)

Bit 3 Zone Change Bit	Bits [2:0] Brightness Zone
0 = No change in ALS Zone **(default)** 1 = There was a change in the ALS Zone since the last read of this register. This bit is cleared on read back.	000 = Zone 0 **(default)** 001 = Zone 1 010 = Zone 2 011 = Zone 3 1XX = Zone 4

11 ALS ZONE BOUNDARIES

There are 4 ALS Zone Boundary registers that form the boundaries for the 5 Ambient Light Zones. Each Zone Boundary register is 8 bits with a maximum voltage of 2V. This gives a step size for each Zone Boundary Register bit of:

$$\text{ZoneBoundaryLSB} = \frac{2V}{255} = 7.8\ \text{mV} \quad (1)$$

ALS Zone Boundary 0 High (Address 0x60), **default = 0x35 (415.7 mV)**
ALS Zone Boundary 0 Low (Address 0x61), **default = 0x33 (400 mV)**

ALS Zone Boundary 1 High (Address 0x62), **default = 0x6A (831.4 mV)**
ALS Zone Boundary 1 Low (Address 0x63), **default = 0x66 (800 mV)**

ALS Zone Boundary 2 High (Address 0x64), **default = 0xA1 (1262.7 mV)**
ALS Zone Boundary 2 Low (Address 0x65), **default = 0x99 (1200 mV)**

ALS Zone Boundary 3 High (Address 0x66), **default = 0xDC (1725.5 mV)**
ALS Zone Boundary 3 Low (Address 0x67), **default = 0xCC (1600 mV)**

12 ADC and ADC Average Readback (0x27, 0x28)

Both the ADC readback and ADC average readback are read-only registers that read the contents at the output of the LM3532's ADC. The ADC readback is the 8-bit data which is sampled at 7.142 ksps and updated every 154 µs. The ADC average readback is the 8-bit value from the ADC Readback Register which is averaged over the programmed ALS Average Time. Once either the ADC Read or ADC Average Read button is pushed, the appropriate field gets updated with the data.

13 Demo Tab

The Demo tab (Figure 9) provides the controls for activating the USB2ANY's PWM outputs which are then applied to the LM3532's PWM inputs. PWM1 and PWM2 correspond to the LM3532's PWM1 and PWM2 inputs. The field (PWM Duty Cycle (%)) is the duty cycle input from the user in steps of 0.1%. Once a new duty cycle is entered and the Update button is pressed, the duty cycle output from the USB2ANY board is changed.

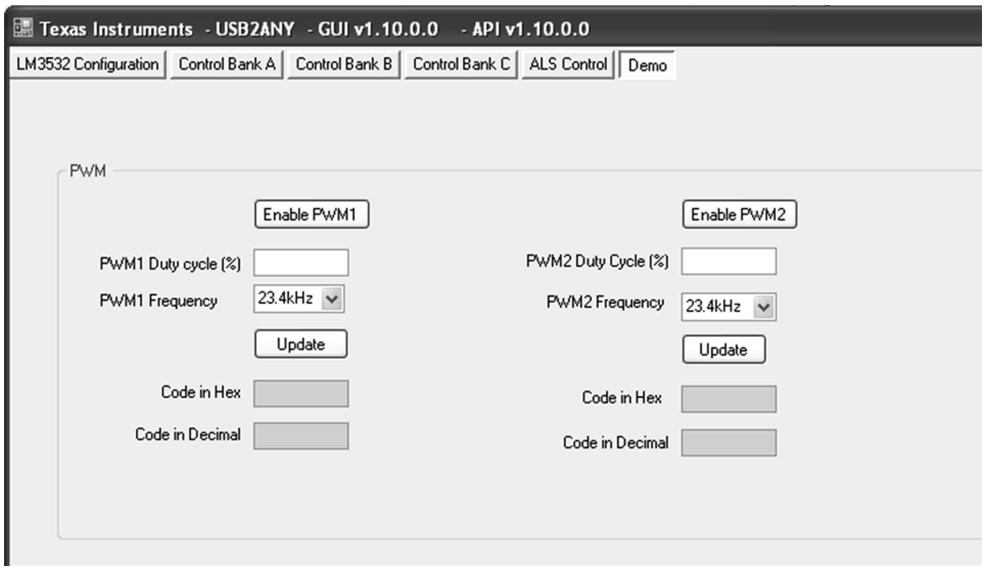

Figure 9. Demo Tab

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

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

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

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

CAUTION

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

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

FCC Interference Statement for Class A EVM devices

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

FCC Interference Statement for Class B EVM devices

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

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

3.2 *Canada*

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

Concerning EVMs Including Radio Transmitters:

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

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

Concernant les EVMs avec appareils radio:

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

Concerning EVMs Including Detachable Antennas:

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

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance 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。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

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

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

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

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 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。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

6. *Disclaimers:*

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

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

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

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

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

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

IMPORTANT NOTICE AND DISCLAIMER

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

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

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

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

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

Last updated 10/2025