

User's Guide

TLIN1431EVM User's Guide



ABSTRACT

This user guide describes the TLIN1431-Q1 evaluation module (EVM). This EVM helps designers evaluate the device performance, support fast development, and analyze automotive local interconnect network (LIN) systems using the TLIN1431-Q1 family of LIN system basis chips (SBCs), which include wake functionality, integrated high-side switch, and watchdog.

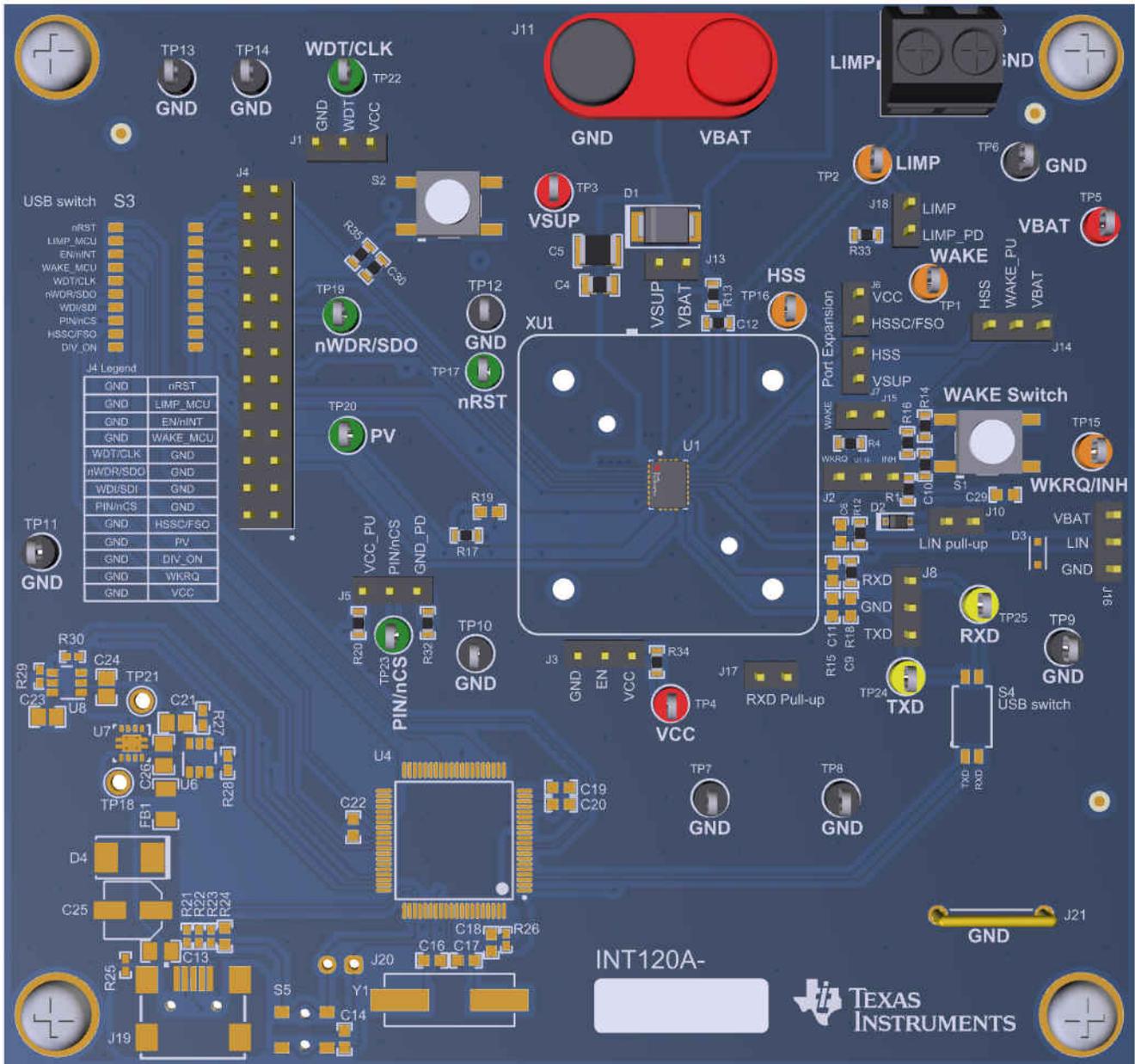


Figure 1-1. TLIN1431EVM Board Image

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Trademarks

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1 Introduction

1.1 Features

The EVM supports the following features:

- Commander and responder configuration options
- Terminal block and header pins on all power and LIN bus connections
- Access to the LDO output VCC
- Accessible wake functionality with push-button
- Selectable pull-up and pull-down resistors for device pins
- Logic-level signals for high-voltage WAKE and LIMP signals
- Test point connections for each board signal

1.2 Description

The TLIN1431EVM provides users with the ability to evaluate the TI TLIN1431-Q1 family of single-channel LIN SBCs, which include LDO, wake, high-side switch, watchdog, integrated battery voltage divider, LIMP, and channel expansion functionality. The EVM allows both commander and responder mode applications to be evaluated through the use of a single jumper that connects or disconnects the external 1 k Ω pull-up resistor and series diode required in commander mode applications on the LIN bus.

The EVM has access to the integrated VCC rail from the device LDO. This LDO output can be used as logic-level input voltages for the logic pins of the TLIN1431-Q1. The TLIN14315-Q1 includes a 5-V LDO, and the high-level logic inputs to the device can range from 2 V to 5.25 V, though the biasing of the PIN/nCS pin determines whether 3.3 V SPI or 5 V SPI is used (known as “VIOless” capability). This allows the TLIN14315-Q1 to interface with both 3.3 V and 5 V logic levels. The TLIN14313-Q1 includes a 3.3-V LDO, and the high-level logic inputs to the device range from 2 V to 3.6 V, allowing interfacing with 3.3 V systems.

Non-populated pads are included on TXD, RXD, and LIN to accommodate a variety of different tests requiring various capacitive load conditions. Additionally, the LIN signal contains a non-populated SOD-323 footprint on LIN allowing for the implementation of an ESD1LIN24-Q1 protection device as desired.

The TLIN SBC family supports both 12 V and 24 V automotive applications and is operated with a supply voltage from 5.5 V to 28 V, and is capable of handling supply/battery voltages up to 42 V. The LIN bus provides extended bus fault protection of ± 58 V.

External headers with power and LIN bus connections allow for the EVM to be evaluated in a larger system. Additional, channel expansion outputs provide the capability of interfacing with another device, such as a TCAN1042-Q1 or a TLIN1021-Q1 (or other TCAN and TLIN devices) as applicable.

The wake input functionality of the TLIN1431-Q1 is accessible in many ways, including via external interface or push-button wake.

2 EVM Setup and Features

Use the following equipment to evaluate the performance of the TLIN1431-Q1:

- Power supply capable of supplying the desired supply voltage. Typical LIN applications use 12 V or 24 V, but the TLIN1431-Q1 can operate with any supply voltage from 5.5 V to 28 V. Connect this voltage across the VBAT and GND pins of the J11 paired banana jack connector.
- If the LIN bus interface is to be observed using an oscilloscope, use probes capable of tolerating voltages as large as VBAT.
- The logic interface pins may interface to a microcontroller, pattern generator, or logic analyzer with logic levels matching the LDO VCC voltage, or a high-level voltage consistent with the V_{IH} requirements of the device.
- The LDO output can be used for testing load and thermal capabilities with a source meter or physical resistance connected between the jumper pins on J4 (pins 1 and 2) or any other VCC output pin or test point.
- An external device to be controlled via the channel expansion functionality (accessed from J6 and J7) can be connected using jumper cables or wires as appropriate.

2.1 Startup Mode Configurations

2.1.1 Pin and SPI Modes

Two modes of operation are available on the TLIN1431-Q1: pin mode and SPI mode. The mode of the device is determined by the state of pin 7 (PIN/nCS) upon power-up. If pin 7 is pulled low or connected to GND at startup, the device operates in pin mode, with no SPI interface. If pin 7 is left floating or pulled high at startup, then the device operates in SPI mode, where the SPI interface is enabled and the user can access the internal registers of the device.

Additionally, the TLIN14315-Q1 is capable of VIO less operation as determined by the biasing of this PIN/nCS pin. If it is left floating, the device operates using 3.3 V SPI communication. If it is pulled high to 5 V, then it operates using 5 V SPI communication.

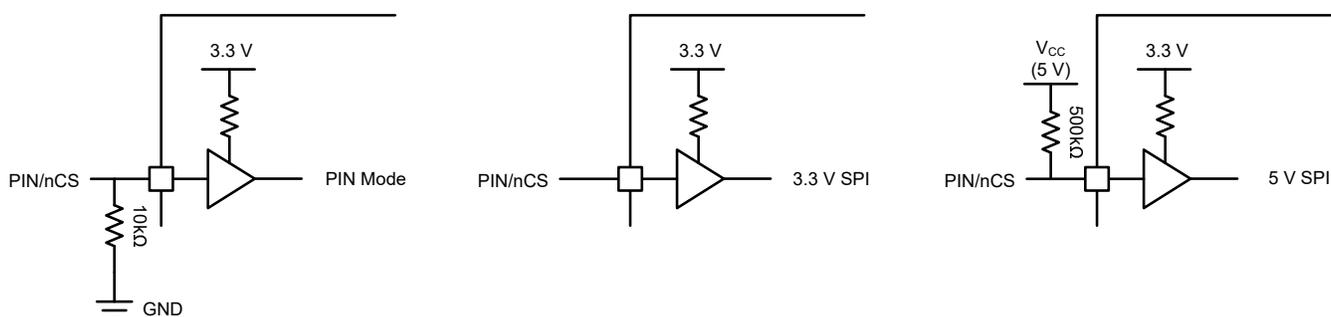


Figure 2-1. PIN/nCS Configuration

Note the TLIN14313-Q1, which includes a 3.3 V LDO, does not include VIOless operation and is only capable of 3.3 V SPI communication.

J5 allows for easy biasing of the PIN/nCS pin to either a pull-down resistor for pin mode or floating/pull-up for VIOless SPI mode operation.

The TLIN1431-Q1 device has alternate pin designations and functions depending on the power-up mode chosen. The designations are shown in [Table 2-1](#), and the functions of each pin are described in the TLIN1431-Q1 data sheet.

Table 2-1. Pinout in Pin Mode vs. Pinout in SPI Mode

Pin	Pin mode	SPI mode
4	WDT – Programmable watchdog window set input	CLK – SPI clock input
5	nWDR – Watchdog failure output trigger	SDO – SPI serial data output
6	WDI – Watchdog timer edge-triggered input	SDI – SPI serial data input
7	PIN – Input that sets the device to pin mode	nCS – SPI chip select
8	EN – Device mode change input	nINT – Device interrupt output
9	HSSC – High-side switch control input	FSO – Function output

The user can start up the TLIN1431-Q1 into pin mode by connecting a shunt between pins “PIN/nCS” and “GND_PD” of J5, which applies a pull-down to GND to pin 7. Leaving all pins of J5 floating results in the TLIN1431-Q1 operating in SPI mode, and the TLIN14315-Q1 operates with 3.3 V SPI. Connect a shunt between pins “PIN/nCS” and “VCC_PU” of J5 to apply a pull-up to VCC, resulting in 5 V SPI operation for the TLIN14315-Q1.

2.1.2 Wake Request (WKRQ) vs. Inhibit Output (INH)

The WKRQ/INH pin has the capability of operating as either a logic-level wake request (WKRQ) digital output, or a high-voltage inhibit (INH) output based upon its biasing at startup. Applying a 100 kΩ or stronger pull-down to GND on this pin results in the pin behaving as logic-level WKRQ. Alternatively, leaving this pin floating or applying a 1 MΩ pull-down to GND results in the pin behaving as high-voltage INH.

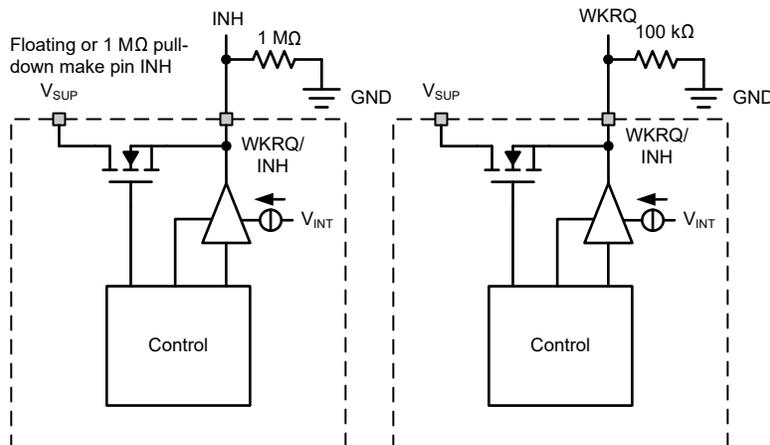


Figure 2-2. WKRQ or INH Pin Select

The user can configure this pin as WKRQ by connecting a shunt between pins “U1.16” and “WKRQ” of J2 to apply a 100 kΩ pull-down. Alternatively, the user can configure the WKRQ/INH pin as high-voltage INH by connecting a shunt between pins “U1.16” and “INH” of J2 at power-up to apply a 1 MΩ pull-down, or by leaving all of these pins floating. In addition, capacitor pad C29 allows for the user to test a capacitor in parallel with the 1 MΩ resistor in order to evaluate the behavior of this pin at startup.

2.2 Commander and Responder Configurations

The TLIN1431-Q1 has an internal pull-up resistor and serial diode on LIN that allows it to operate as a responder. To operate as a commander, an external 1 kΩ pull-up and serial diode is required on the bus. The user can apply a shunt between the pins of J10 to apply this 1 kΩ pull-up and allow for use as a commander node.

2.3 Local Wake-Up

The WAKE pin of the TLIN1431-Q1 is used for the local wake-up (LWU) function of the device, which is explained in detail in the data sheet. This can be directly interfaced close to the device using J15, pin “WAKE” without a shunt. Applying a shunt to J15 applies a pull-up and allows the use of the WAKE switch on the board.

J14 allows the user to select the pull-up source for this circuitry. Connect a shunt between pins “WAKE_PU” and “VBAT” to apply a pull-up to the battery voltage rail. In this configuration, the user can implement push-button wake using the WAKE switch S1.

Connecting a shunt between pins “WAKE_PU” and “HSS” of J14 provides a pull-up to the high-side switch of the device. This configuration is required if the user intends to implement cyclic-sense wake functionality. This functionality is described in detail in the device’s data sheet.

2.4 Channel Expansion

The VCC, FSO, HSS, and VSUP pins allow for channel expansion, such that the TLIN1431-Q1 can control an external transceiver or similar device. This effectively allows for an additional communication channel to be controlled via the TLIN1431-Q1.

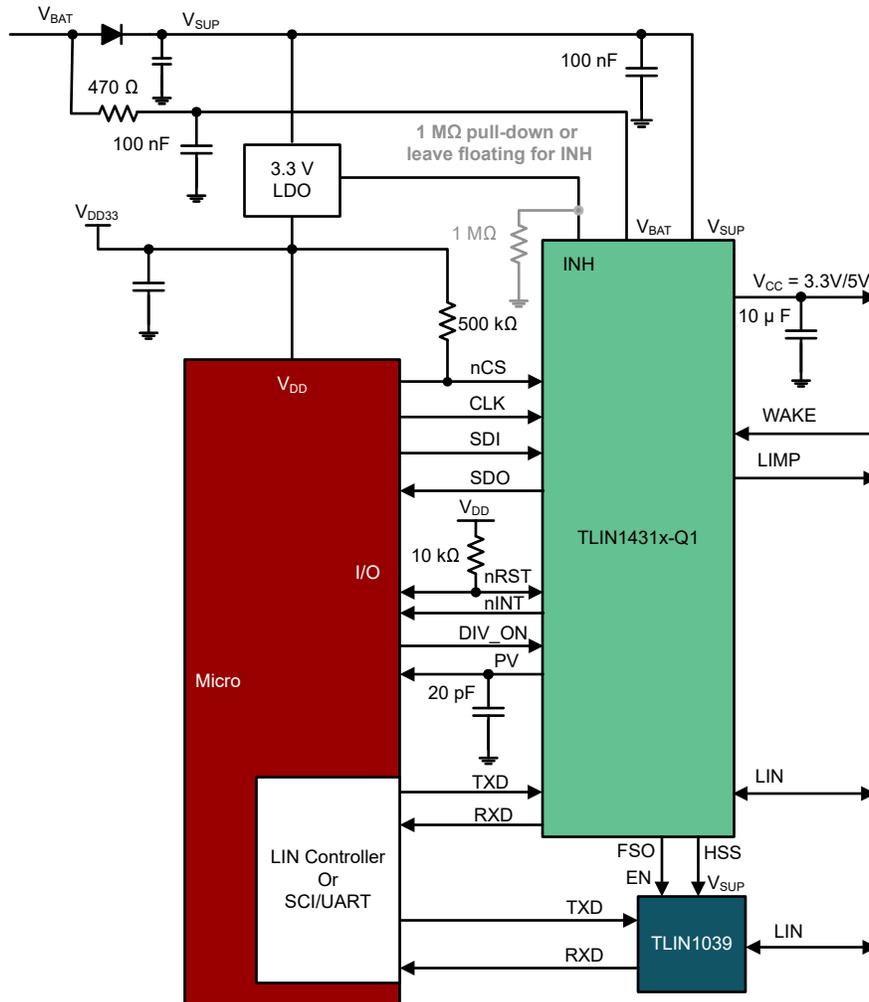


Figure 2-3. Channel Expansion with LIN Transceiver

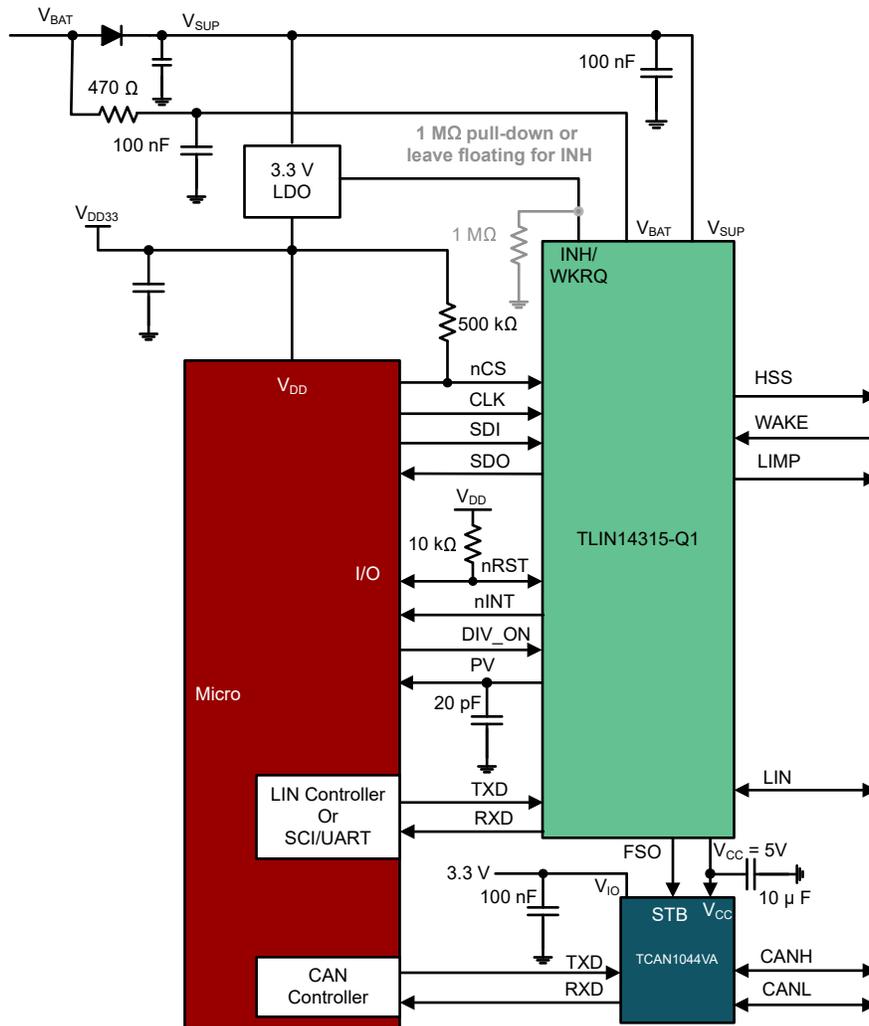


Figure 2-4. Channel Expansion with CAN Transceiver

Note that the VCC and FSO pins are logic-level voltages, while the HSS and VSUP signals are high-voltage outputs. Use care when implementing these outputs to ensure the proper voltage design requirements are met.

2.5 V_{BAT} Voltage Divider

To activate the internal V_{BAT} voltage divider on the TLIN1431-Q1, apply a high signal on DIV_ON using the appropriate pin on J4. By default, an internal pull-down deactivates the internal voltage divider when the pin is left floating.

The output of the voltage divider can be measured on PV.

2.6 Reset Input

Push-button nRST interfacing is possible using S2 on the EVM. Pressing S2 delivers a strong pull-down to the active-low nRST pin.

2.7 Logic-Level LIMP and WAKE Signals

This EVM implements on-board comparators to provide logic-level outputs representing the states of LIMP and WAKE respectively, which are high-voltage signals for the device. These are provided as “LIMP_MCU” and “WAKE_MCU” on J4, thus configuring all J4 signals as logic-level, and potentially capable of being connected to general-purpose inputs on an external micro controller.

Note that LIMP_MCU and WAKE_MCU are outputs, and are not connected to LIMP and WAKE. Thus, for example, a signal cannot be applied to WAKE_MCU that would impact the high-voltage WAKE signal on the TLIN1431-Q1.

It is also possible to reconfigure the WAKE_MCU output to reflect the state of HSS rather than WAKE. This can be accomplished by depopulating R17 and populating a 0 Ω resistor on R19. Take care to ensure that only one of these resistors is populated at a time.

2.8 High-Voltage Signal Monitoring

INH, HSS, and WAKE, which are high-voltage signals for the TLIN1431-Q1, can be monitored using the three orange test points on the board: TP1 (WAKE), TP15 (WKRQ/INH), and TP16 (HSS). These are colored differently from the logic-level signals accessible via the other test points on the board.

2.9 TXD and RXD

TXD and RXD are accessible either via TP24/TP25, or via the J8 connector. These can be used to interface with the input/output signals of the LIN bus.

Pads R15 and C9 allow for additional pull-down resistance or capacitance on the TXD line if it is needed for applications such as oscilloscope impedance matching. Pad C11 allows for the addition of capacitance to the RXD line.

Placing a shunt on J17 provides a pull-up to RXD. The TLIN1431-Q1 does not require a pull-up on RXD to operate, though this can be used to evaluate the performance of RXD under these conditions.

2.10 VCC Load Testing

The LDO output (VCC) is accessible using TP4 or via pin 1 of J4. The user can apply a load to these pins to test the stability and performance of the LDO on the TLIN1431-Q1.

2.11 SPI Interface

When operating in SPI mode, pins 4-7 of the TLIN1431-Q1 become the SPI interface for the device. Specifically, "WDT/CLK" is the SPI clock input, "nWDR/SDO" is the SPI serial data output, "WDI/SDI" is the SPI serial data input, and "PIN/nCS" is the SPI active-low chip select.

The four SPI interface pins are accessible via J4, pins 12, 14, 16, and 18. These four signals are vertically separated from the rest of the logic signals on J4. Per the silkscreen legend on the board, these four signals are on the leftmost column of J4, while the remaining signals on this header are located on the rightmost column.

These four SPI signals can be connected to a micro controller or similar processor to control the TLIN1431-Q1 via SPI. Note that the device must start up with PIN/nCS (pin 7) floating or pulled high to interface via SPI mode.

3 Jumpers, Headers, Connectors, Test Points, and Switches

Table 3-1, Table 3-2, and Table 3-3 list all the jumpers, headers, connectors, test points, and switches on the TLIN1431EVM and explain the functions of each of these components.

Table 3-1. Jumpers, Headers, and Connectors

Designator	Function
J1	Connector for WDT/CLK, with adjacent VCC and GND pins for WDT triggering, or GND referencing for CLK function.
J2	Connector for WKRQ/INH as described in Section 2.1.2 .
J3	Connector for EN/nINT, with adjacent pull-up to VCC and GND pins for interfacing the enable/interrupt pin.
J4	Generic output connector with multiple board signals connected. Pins 4-7, which are SPI communication pins in SPI mode, are separated column-wise from the other signals on J4. The non-signal pins are connected to GND.
J5	Connector for PIN/nCS, which is used to configure the startup mode of the TLIN1431-Q1 as described in Section 2.1.1 and operates as chip-select in SPI mode.
J6 & J7	Channel expansion output as described in Section 2.4 .
J8	TXD and RXD connection as described in Section 2.9 .
J9	Terminal block connector for LIMP.
J10	Commander node selector, as described in Section 2.2 .
J11	Banana jack connector for the VBAT and GND supplies for the device.
J13	Connector for VBAT and VSUP.
J14 & J15	Configuration connectors for pull-up on WAKE pin, as described in Section 2.3 .
J16	LIN output with adjacent VBAT and GND pins.
J17	RXD pull-up selector, as described in Section 2.9 .
J18	Pull-down connector for LIMP. Connect a shunt to apply a 100 kΩ pull-down on the LIMP pin.
J21	GND connection rail.

Table 3-2. Test Points

Designator	Function
TP1	Test point for WAKE (HV)
TP2	Test point for LIMP (HV)
TP3	Test point for VSUP (HV)
TP4	Test point for VCC
TP5	Test point for VBAT (HV)
TP6-TP14	GND connections
TP15	Test point for WKRQ/INH (HV possible)
TP16	Test point for HSS (HV)
TP17	Test point for nRST
TP19	Test point for nWDR/SDO
TP20	Test point for PV
TP22	Test point for WDT/CLK
TP23	Test point for PIN/nCS
TP24	Test point for TXD
TP25	Test point for RXD

Table 3-3. Switches

Designator	Function
S1	Push-button switch for WAKE interfacing, only active if J14 and J15 are appropriately connected as described in Section 2.3 .
S2	Push-button switch for applying a strong pull-down to nRST as described in Section 2.6 .

4 Bill of Materials

Table 4-1. TLIN1431EVM Bill of Materials

Designator	Quantity	Value	Description	Part Number	Manufacturer
C1, C2, C3	3	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	885012206095	Würth Elektronik
C4	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	C0805C105K5RACTU	Kemet
C5	1	10uF	CAP, CERM, 10 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 1210	UMJ325KB7106KMHT	Taiyo Yuden
C7	1	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	885012207026	Würth Elektronik
C8	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71C105KA64D	MuRata
C10, C12	2	0.01uF	CAP, CERM, 0.01 μ F, 50 V, +/- 10%, X7R, 0603	885012206089	Würth Elektronik
C30	1	220pF	CAP, CERM, 220 pF, 50 V, +/- 10%, X7R, 0603	C0603C221K5RACTU	Kemet
D1	1	80V	Diode, Schottky, 80 V, 1 A, SMB	B180B-13-F	Diodes Inc.
D2	1	250V	Diode, Standard Recovery Rectifier, 250 V, 0.2 A, SOD-323	BAV21WS-TP	Micro Commercial Components
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	1902C	Keystone
J1, J2, J3, J5, J8, J14, J16	7		Header, 100mil, 3x1, Gold, TH	TSW-103-07-G-S	Samtec
J4	1		Header, 100mil, 13x2, Gold, TH	TSW-113-07-G-D	Samtec
J6, J7, J10, J13, J15, J17, J18	7		Header, 100mil, 2x1, Gold, TH	TSW-102-07-G-S	Samtec
J9	1		Terminal Block, 5.08mm, 2x1, TH	039544-3002	Molex
J11	1		Mini DBL Banana Jack , Red, TH	2143-2	Pomona Electronics
J21	1		1mm Uninsulated Shorting Plug, 10.16mm spacing, TH	D3082-05	Harwin
J22	1		Default shunt positioning: between pins 1 and 2 of J2	2-881545-2	TE
J23	1		Default shunt positioning: between pins 1 and 2 of J5	2-881545-2	TE

Table 4-1. TLIN1431EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer
J24	1		Default shunt positioning: between pins of J10	2-881545-2	TE
J25	1		Default shunt positioning: between pins 1 and 2 of J14	2-881545-2	TE
J26	1		Default shunt positioning: between pins of J15	2-881545-2	TE
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	THT-14-423-10	Brady
R1	1	1.00Meg	RES, 1.00 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031M00FKEA	Vishay-Dale
R2, R8	2	200k	RES, 200 k, 1%, 0.1 W, 0603	RC0603FR-07200KL	Yageo
R3, R5, R9, R10, R32	5	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	RC0603FR-0710KL	Yageo
R4	1	100k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603100KJNEA	Vishay-Dale
R6, R11, R33	3	100k	RES, 100 k, 1%, 0.1 W, 0603	RC0603FR-07100KL	Yageo
R7, R18	2	10.2k	RES, 10.2 k, 1%, 0.1 W, 0603	RC0603FR-0710K2L	Yageo
R12	1	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031K00JNEA	Vishay-Dale
R13, R34	2	470	RES, 470, 5%, 0.25 W, AEC-Q200 Grade 0, 0603	ESR03EZPJ471	Rohm
R14, R16	2	3.01k	RES, 3.01 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06033K01FKEA	Vishay-Dale
R17	1	0	RES, 0, 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
R20	1	510k	RES, 510 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603510KJNEA	Vishay-Dale
R35	1	22.0	RES, 22.0, 1%, 0.1 W, 0603	RC0603FR-0722RL	Yageo
S1, S2	2		Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	EVQP1D05M	Panasonic
TP1, TP2, TP15, TP16	4		Test Point, Multipurpose, Orange, TH	5013	Keystone
TP3, TP4, TP5	3		Test Point, Multipurpose, Red, TH	5010	Keystone
TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14	9		Test Point, Multipurpose, Black, TH	5011	Keystone

Table 4-1. TLIN1431EVM Bill of Materials (continued)

Designator	Quantity	Value	Description	Part Number	Manufacturer
TP17, TP19, TP20, TP22, TP23	5		Test Point, Multipurpose, Green, TH	5126	Keystone
TP24, TP25	2		Test Point, Multipurpose, Yellow, TH	5014	Keystone
U1	1		Automotive LIN SBC with Integrated High-Side Switch and Watchdog	TLIN14315RGYRQ1	Texas Instruments
U2, U3	2		GENERAL-PURPOSE LOW-VOLTAGE COMPARATOR, DBV0005A (SOT-23-5)	LMV331QDBVRQ1	Texas Instruments

5 Schematic

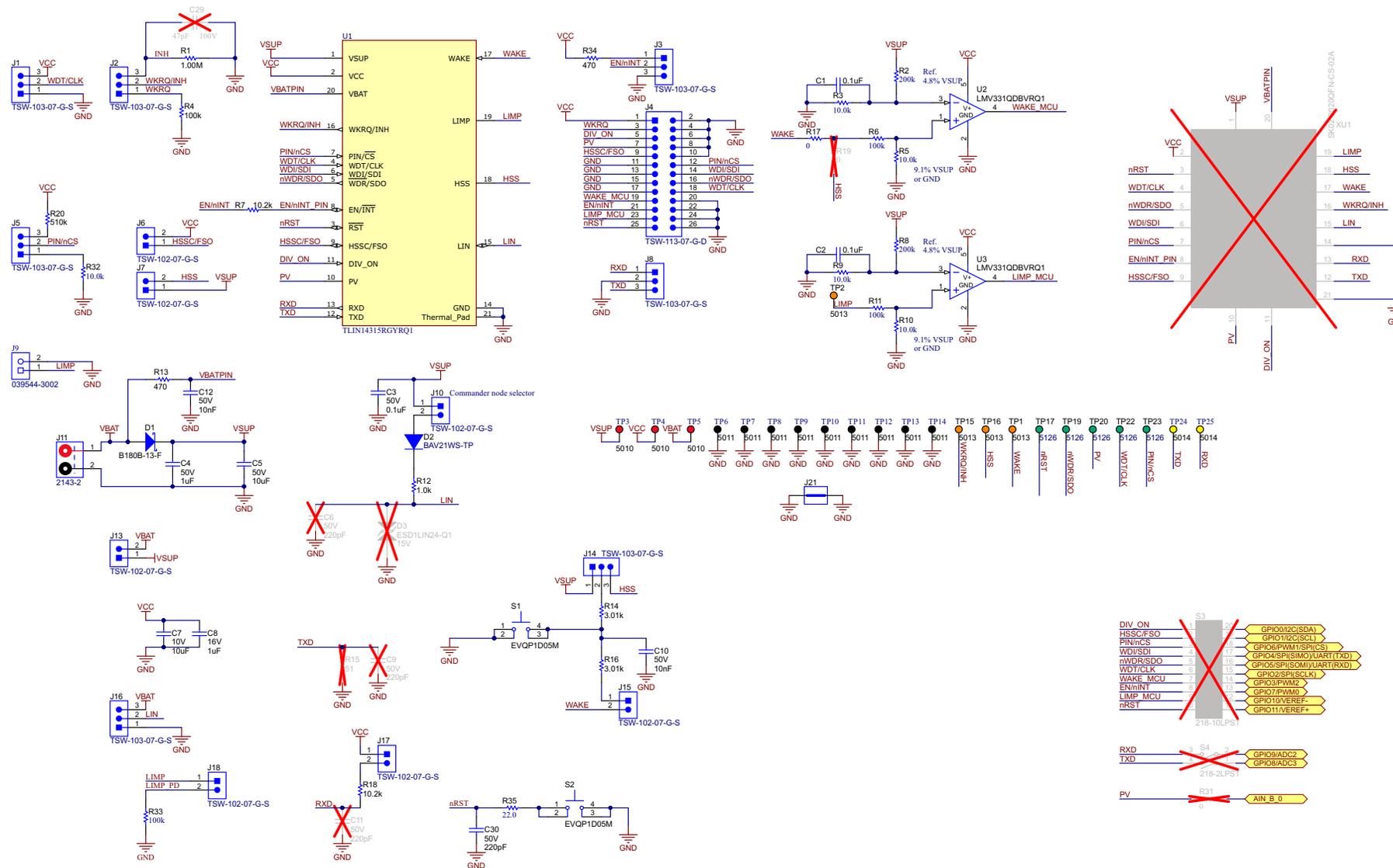


Figure 5-1. TLIN1431EVM Schematic

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 DEGRADATION 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/lstds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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

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

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

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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。

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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/lstds/ti_ja/general/eStore/notice_02.page 電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。
http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_02.page

3.4 European Union

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

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

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- 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.
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8. *Limitations on Damages and Liability:*

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

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY 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.

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