

EVM User's Guide: THVD4411EVM

THVD4411 Evaluation Module



Description

The THVD4411EVM allows for quick prototyping of TI's RS-485 and RS-232 multiprotocol transceiver (THVD4411). The EVM allows for half and full duplex RS-485 operational modes as well as 1T1R RS-232 communication. The THVD4411EVM can be powered by a single supply from 3V to 5.5V or can have a separate logic supply that allows control of the transceiver by controllers operating as low as 1.8V. Multiple speeds are allowed through the use of the slew rate control pin and the ability to use integrated terminations in RS-485 mode.

Get Started

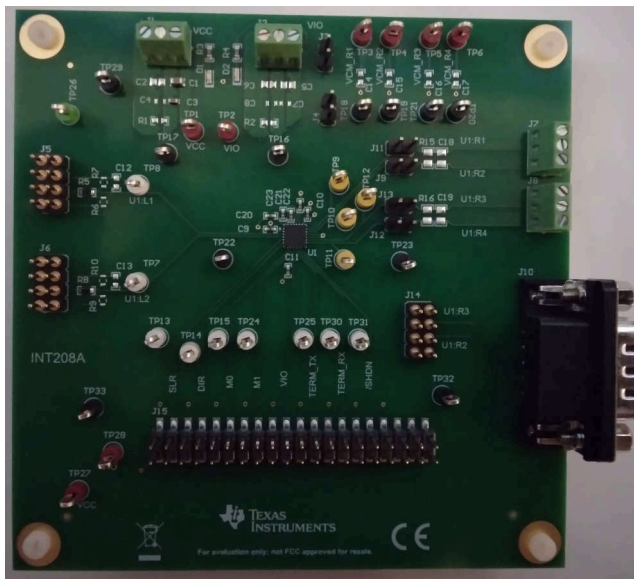
1. Order the EVM from ti.com ([THVD4411EVM](#))
2. See the latest product information and data sheet for [THVD4411](#)

Features

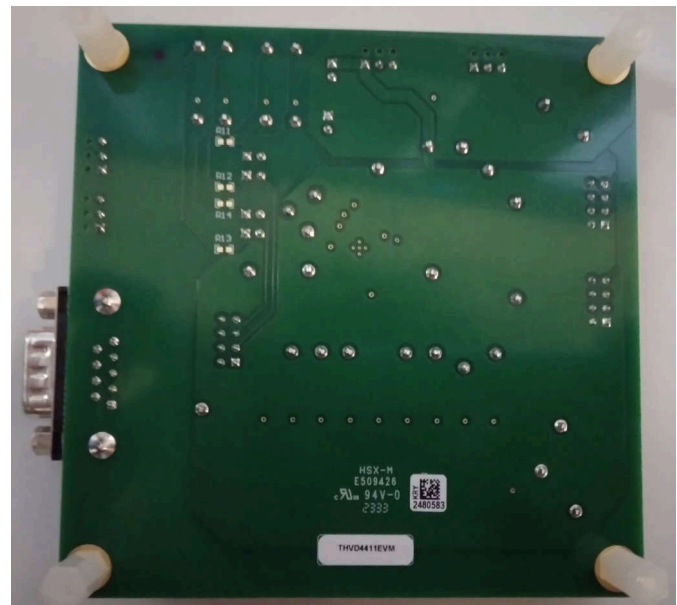
- THVD4411RGE pre-installed onto evaluation module
- Eight bulk power-supply decoupling capacitor pads for VCC and VIO connections
- 0603 resistor pads available to create resistive link between GND and EARTH connections for both VIO and VCC terminals
- Terminal and header pin access to RS-232 and RS-485 bus signals
- D-sub or header connections for RS-232 signals

Applications

- [Industrial PC](#)
- [Factory automation and control](#)
- [HVAC systems](#)
- [Building automation](#)
- [Point-of-sale terminals](#)
- [Grid infrastructure](#)
- [Industrial transport](#)



THVD4411EVM (Top Side)



THVD4411EVM (Bottom Side)

1 Evaluation Module Overview

1.1 Introduction

This document is the evaluation module user's guide for the THVD4411EVM, which provides a quick way to evaluate TI's THVD4411. The THVD4411 is among TI's first RS-485 and RS-232 multiprotocol transceivers. This configuration allows for 1T1R RS-232 communication, half duplex RS-485 communication, and full duplex RS-485 communication.

1.2 Kit Contents

(1) THVD4411EVM with the THVD4411RGE pre-installed ready to operate directly out of box.

1.3 Specification

Refer to THVD4411 data sheet ([SLLSFR9](#)) for most to up to date specification for device.

A selection of common usage ranges for devices considered in the construction of the board are shown below.

- VCC input (at J1) is expected to be between 3V and 5.5V for compatible devices.
- VIO input (at J2) is expected to be between 1.65V and 5.5V for compatible devices.
- Signal inputs at J5 and J6 are expected to be between 0V and VIO.
- The device on-board does not generate voltages above VCC alone.
- Each board is equipped with a 120 Ohm termination resistor Pad on each differential bus for RS-485 usage.
- Voltage inputs for common mode signals R1-R4 must remain in the range -7V to 12V.

1.4 Device Information

The THVD4411 is a highly integrated and robust multiprotocol transceiver supporting RS-232, RS-422 and RS-485 physical layers. The device has one transmitter and one receiver to enable 1T1R RS-232 port. The device also integrates one transmitter and one receiver to enable half and full duplex RS-485 port. MODE selection pins enable shared bus and logic pins for the protocols to share a common single connector. Integrated termination for RS-485 bus pins and for RS-232 receiver inputs verify no external components are needed to realize a fully-functional communication port. These devices have slew rate select feature that enables them to be used at two maximum speeds based on the SLR pin setting. These devices feature integrated Level 4 IEC ESD protection, eliminating the need for external system-level protection components. In addition, the RS-485 receiver fail-safe feature drives logic high on received logic output when the bus inputs are open or shorted together or when the bus is idle. Shutdown mode consumes ultra-low current (10µA typical), which is good for power-sensitive applications. The device needs 3V to 5.5V supply that powers the charge pump for RS-232, drivers, and receivers for both RS-232 and RS-485. A separate logic supply VIO (1.65V to 5.5V) enables interface with low-level microcontrollers.

2 Hardware

2.1 Power Requirements

Single Supply Operation (Logic Supply Equals Main Voltage Supply)

The THVD4411 Transceiver in the RGE package from TI has an additional logic supply pin, *VIO*. This is used to power the internal digital logic circuits inside of the device. In single supply operation mode for the THVD4421RGE, the *VIO* pin must be shorted to *VCC* by shorting the header pins of J3, so that the digital circuits are properly powered.

Table 2-1. Single Supply Operation

Component ID	Comment
J1	VCC Power Terminal – attach voltage source of 3V to 5.5V to terminal block.
J2	VIO Power Terminal – leave open for single supply operation.
J3	Shunted for single supply operation.
J4	Shunted for applications with no separation between EARTH and GND.

To apply power onto the board, *VCC* is applied through the J1 terminal. With the board oriented with J1 on the top left side of the board, as shown in figure 1.1, the signals are, from right to left, *VCC*, *GND*, *EARTH*. The *EARTH* and *GND* distinction are used to help the end user determine operational qualities with respect to ground potential differences. If testing methods on reducing ground loop current install a resistor on pad R1. For applications without a separate *EARTH* connection *EARTH* and *GND* can be shorted together via jumper J4. Bulk supply decoupling capacitors can be found on near J1 and J2 – high frequency decoupling capacitors exist closer to IC and are pre-installed.

Dual Supply Operation (Separate Digital Logic and Driver Supplies)

The THVD4411 Transceiver in the RGE package from TI has an additional logic supply pin, *VIO*. This is used to power the internal digital logic circuits inside of the device. In dual supply operation, the digital circuit supply, *VIO*, supplies the logic signal pins (L1 – L2) and the control signal pins (SLR, DIR, M0, M1, TERM_TX, TERM_RX, and /SHDN). This supply can operate from 1.65V to 5.5V to allow controllers to communicate with the transceiver at 2.5V and 1.8V logic levels. J3 must be left open for dual supply operation.

Table 2-2. Dual Supply Operation

Component ID	Comment
J1	VCC Power Terminal – attach voltage source of 3V to 5.5V to terminal block.
J2	VIO Power Terminal – attach voltage source of 1.65V to 5.5V to terminal block.
J3	Left open for dual supply operation.
J4	Shunted for applications with no separation between EARTH and GND.

Powering the board up is similar to single supply operation. J1 is powered as described in [Table 2-1](#). Using the same orientation as before (J1 at top left of the board), the inputs for the *VIO* power terminal (J7) are similar *VCC* (J6); from right to left is *VIO*, *GND*, *EARTH*. Bulk supply decoupling capacitors can be found near J1 and J2. For applications without a separate *EARTH* connection, *GND* and *EARTH* can be shorted by shunting J4.

2.2 Board Setup and Operation

After the power supply of the THVD4411EVM has been configured, set up the board for operation. Before any operation of the board can occur, the operational mode and control pins must be configured. The map to the J15 header pins is shown below.

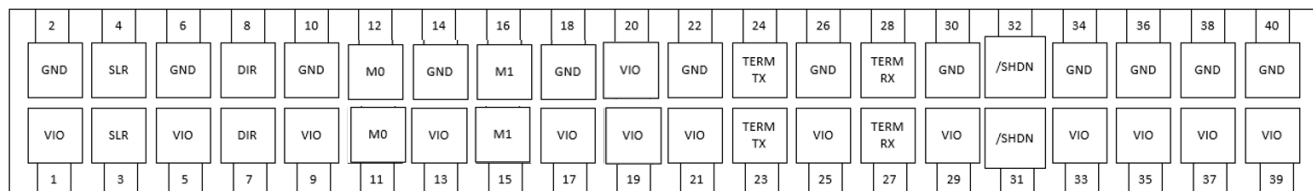


Figure 2-1. J15 Pinout

Assume that the board is oriented with J1 in the top left of the EVM. The numbered boxes correspond to the pin number for J15 as indicated in the schematic.

To select a configuration option, find the signal of interest on J15, according to [Figure 3-1](#). If a low value is wanted, then shunt the top row header pin connected to the signal of interest to the pin on the left. If a high value is wanted, then shunt the bottom row header pin connected to the signal of interest to the pin on the left. Next, the mode of operation must be determined. The operational mode is controlled by the M0 and M1 connected to U1 via J15-11/12 and J15-15/16, respectively.

M1 (J15-15; J15-16)	M0 (J15-11; J15-12)	Mode	Comment
0	0	Reserved	Unused
0	1	RS-232	1T1R mode; L2 is logic input for RS232 driver; L1 is logic output.
1	0	Half Duplex RS-485	L1 is logic input, L2 is logic output; RS-485 on R1 and R2.
1	1	RS-485 Full Duplex	L1 is logic input, L2 is logic output; RS-485 TX is R1 and R2 while RX is R3 and R4.

After the mode has been selected, the other features and control signals can be configured or connected to a signal source for the DIR and /SHDN signals.

Signal	Signal Jumper and Pin ID	Associated GND Pin	Logic '0' Operation	Associated VIO Pin	Logic '1' Operation
SLR	J15-3; J15-4	J15-2	RS485: 20Mbps RS232: 1Mbps	J15-1	RS485: 500kbps RS232: 250kbps
DIR	J15-7; J15-8	J15-6	RS485: RX mode	J15-5	RS485: TX mode
TERM_TX	J15-23; J15-24	J15-22	RS485 TX: unterminated	J15-21	RS485 TX: terminated with 120Ω
TERM_RX	J15-27; J15-28	J15-26	RS485 RX: unterminated	J15-25	RS485 RX: terminated with 120Ω
/SHDN	J15-31; J15-32	J15-30	Device in shutdown mode	J15-29	Device operational

The mode pins along with the TERM_TX and TERM_RX pins must be configured before communication starts as opposed to changing during communication for proper operation.

All the various modes of the THVD4411 share the use of the logic pins (denoted with the prefix “L”) and the bus pins (denoted with the prefix “R”).

Logic pins are for use when interfacing the THVD4411 with a controller. The logic pins are supplied and bounded by the VIO voltage, meaning that these pins can accept GND to VIO input voltages and can output GND to VIO voltages. All logic pins L1 – L2 are accessible through 4x2 headers J5-J6 that populate the left side of the board when the board is oriented with J1 in the top left corner. [Figure 3-2](#) shows the headers pinouts.

Board Orientation – J1 at top left corner of board

J1 – J2

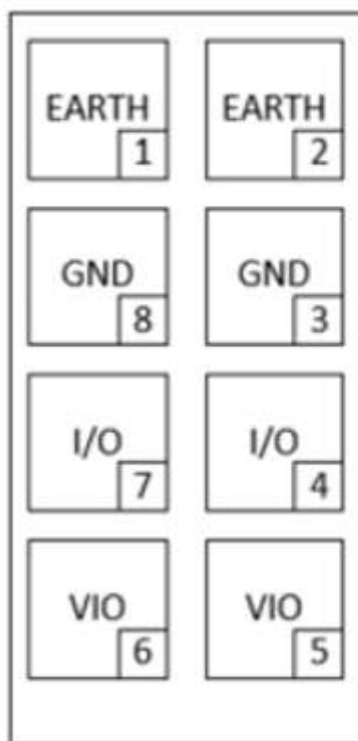


Figure 2-2. U1:LX Header Pinout

The function of each individual *L* pin depends on the mode in which the THVD4411 is being operated in.

Bus pins are the higher voltage tolerant pins for use with RS-485 or RS-232 depending on chosen operation mode. The bus pins are accessible in a few different ways depending on mode of use. Both RS-232 and RS-485 modes have all “R” pin signals routed to an 4x2 header J14. If every row of header J14 is shunted, then all signals R1-R4 are available on the D-SUB connector J18. If headers J12 and J13 are shunted, then R1 and R2 signals are available on terminal block J17. If headers J10 and J11 are shunted, then R3 and R4 signals are available on terminal block J16. A brief summary is given in [Table 3-1](#).

U1 Pin	Output Option 1	Output Option 2	Output Option 3	Output Option 4
R1	J11, column 1	J7 if J11 is shunted	N/A	N/A
R2	J9, column 1	J7 if J9 is shunted	J14; Row 2, Column 1	J10 if J14 Row 2 is Shunted
R3	J13, column 1	J8 if J13 is shunted	J14; Row 3, Column 1	J10 if J14 Row 3 is Shunted
R4	J12, column 1	J8 if J12 is shunted	J14 (if J11 is Shunted)	J10 (if J14 row 4 is shunted)

How these pins are connected depends on the chosen operation mode and personal preference of the end user.

RS-232 Operation

With an understanding of the general architecture of the device and EVM, a more thorough look at the RS-232 modes of operation is important. When entering the mode 01 for M1 and M0, respectively, the device enters RS-232 mode.

Mode	L1	L2	R1	R2	R3	R4
01	Console side input	Console side output	Unused	RS-232 bus output	RS-232 bus input	Unused

This is commonly referred to as a 1T1R setup as there is one transmitter and one receiver. At an individual transceiver level, the type of RS-232 signal being transmitter or received is not important to the transceiver as the PHY layer characteristics are the same, regardless of RS-232 signal type. However, the specific configuration is generally used with the following RS-232 signals: TX and RX. While this configuration of signals is not strictly required, most 1T1R RS-232 applications use these signals and require this configuration and if J10 (the DSUB connector) is used the pinout of the connector mimics the standard placement of the aforementioned RS-232 cables

U1 Pin	Standard RS-232 Circuit Mnemonic	J10 Pin
R2	TX	3
R3	RX	2

RS-485 Operation

With RS-232 operational modes covered, this section describes the RS-485 operation modes. There are two different operational modes of the RS-485 portion of the transceiver: half duplex and full duplex.

Half duplex operation is a very common implementation of RS-485 and entered when the mode is 10 for M1 and M0 respectively. In half duplex mode, the receive and transmit bus facing pins (denoted R# on the THVD4411) are shared by the transceiver, allowing for asynchronous bi-directional communication on two wires with the trade-off being that the bus can only have 1 driver at a time and a device cannot receive and transmit data simultaneously.

Mode	L1	L2	R1	R2	R3	R4
10	Console side input	Console side output	Inverting bus facing pin	Non-inverting bus facing pin	Unused	Unused

The termination resistor shown is disabled by default. In half-duplex mode, TERM_RX is a don't care value and the integrated termination is only controlled by TERM_TX. Driver input is connected to L1 and the RS-485 console side output is L2.

The next mode of operation is full duplex operation, which is mode 11 for M1 and M0 respectively. This mode of operation separates the driver and receiver of the RS-485 transceiver, which leads to a 4-signal wire interface.

Mode	L1	L2	R1	R2	R3	R4
11	Console side input	Console side output	Inverting bus facing driver	Non-inverting bus facing driver	Non-inverting bus facing receiver	Inverting bus facing receiver

The termination resistor shown is disabled by default. In full-duplex mode, TERM_TX and TERM_RX control both the RX and TX path integrated termination resistors.

2.3 Header and Jumper Information

The THVD4411EVM comes pre-installed with THVD4431RGE installed at U1. All the signal and signal jumpers and IO connections (J1 – J15) come pre-installed on board. Please see [Table 2-3](#) for descriptions on every pad on the board and if the pads are pre-installed by default.

Table 2-3. Headers and Jumpers

Jumper ID	Function	Package	Comment	Installed?
J1	VCC input	3 Pin Terminal Block	Power, GND, and EARTH connections	Yes
J2	VIO input	3 Pin Terminal Block	Power, GND, and EARTH Connections	Yes
J3	VCC to VIO jumper	2x1 Header	Shunt to make VIO = VCC	Yes
J4	GND to EARTH jumper	2x1 Header	Shunt if no EARTH connection in test.	Yes
J5	L1 I/O access	4x2 Header	THVD4411 L1 access	Yes
J6	L2 I/O access	4x2 Header	THVD4411 L2 access	Yes
J7	R1 and R2 I/O access	3 Pin Terminal Block	R1 and R2 access for RS-485 usage on THVD4411	Yes
J8	R3 and R4 I/O access	3 Pin Terminal Block	R3 and R4 access for RS-485 usage on THVD4411	Yes
J9	R2 to J7 jumper	1x2 Header	Shunt for R2 signal to be routed to J7	Yes
J10	D-SUB connector for RS-232 signals	D-SUB9 Connector	RS-232 signal output	Yes
J11	R1 to J7 jumper	1x2 Header	Shunt for R1 Signal to be routed to J7	Yes
J12	R4 to J8 jumper	1x2 Header	Shunt for R4 Signal to be routed to J8	Yes
J13	R3 to J8 jumper	1x2 Header	Shunt for R3 Signal to be routed to J8	Yes
J14	RS-232 bus signal jumper	4x2 Header	Shunt rows 2 and 3 to connect R2 and R3 pins to J10 for RS-232	Yes
J15	THVD4411 control signal access	2x20 Header	Access control pins for THVD4411 and VIO and GND connections available	Yes

2.4 Resistor Information

Table 2-4. Resistors

Resistor ID	Function	Package	Comment	Installed?
R1	Earth to GND resistor	0603	N/A	No
R2	Earth to GND resistor	0603	N/A	No
R3	LED current limiting resistor	0603	Green status LED for VCC	Yes
R4	LED current limiting resistor	0603	Red status LED for VIO	Yes
R5	0 Ohm resistor	0603	U1:L1	Yes
R6	Pull up resistor	0603	J5 to U1:L1	No
R7	Pull down resistor	0603	J5 to U1:L1	No
R8	0 Ohm resistor	0603	U1:L2	Yes
R9	Pull up resistor	0603	J6 to U1:L2	No
R10	Pull down resistor	0603	J6 to U1:L2	No
R11	Common mode load R1	0603	U1:R1 – approx. 1 Unit Load – 12K	No
R12	Common mode load R2	0603	U1:R2 – approx. 1 Unit Load – 12K	No
R13	Common mode load R4	0603	U1:R4 – approx. 1 Unit Load – 12K	No
R14	Common mode load R3	0603	U1:R3 – approx. 1 Unit Load – 12K	No

Table 2-4. Resistors (continued)

Resistor ID	Function	Package	Comment	Installed?
R15	RS-485 termination R1 to R2	0805	N/A	No
R16	RS-485 termination R3 to R4	0805	N/A	No

2.5 Capacitor Information

Table 2-5. Capacitors

Capacitor ID	Function	Package	Comment	Installed?
C1	4.7uF 25V Decoupling Capacitor	0805	VCC to GND	Yes
C2	4.7uF 25V Decoupling Capacitor	0805	GND to EARTH	No
C3	1uF 25V Decoupling Capacitor	0603	VCC to GND	Yes
C4	1uF 25V Decoupling Capacitor	0603	GND to EARTH	No
C5	4.7uF 25V Decoupling Capacitor	0805	VIO to GND	No
C6	4.7uF 25V Decoupling Capacitor	0805	GND to EARTH	No
C7	1uF 25V Decoupling Capacitor	0603	VIO to GND	No
C8	1uF 25V Decoupling Capacitor	0603	GND to EARTH	No
C9	100nF 25V Decoupling Capacitor	0603	VCC to GND Capacitor	Yes
C10	100nF 25V Decoupling Capacitor	0603	VCC to GND Capacitor	Yes
C11	100nF 25V Decoupling Capacitor	0603	VIO to GND Capacitor	Yes
C12	U1:L1 Load Capacitor	0603	U1:L1 to GND	No
C13	U1:L2 Load Capacitor	0603	U1:L2 to GND	No
C14	100nF 25V Decoupling Capacitor	0603	VCM_R1 to GND	No
C15	100nF 25V Decoupling Capacitor	0603	VCM_R2 to GND	No
C16	100nF 25V Decoupling Capacitor	0603	VCM_R3 to GND	No
C17	100nF 25V Decoupling Capacitor	0603	VCM_R4 to GND	No
C18	RS-485 Termination Capacitance R1 to R2	0805	N/A	No
C19	RS-485 Termination Capacitance R3 to R4	0805	N/A	No
C20	100nF Storage Capacitor for Charge Pump	0603	V+ Pin to GND	Yes
C21	100nF Flying Capacitor for Charge Pump	0603	C1+ and C1- Pins	Yes
C22	100nF Storage Capacitor for Charge Pump	0603	V- Pin to GND	Yes
C23	100nF Flying Capacitor for Charge Pump	0603	C2+ to C2- Pins	Yes

2.6 LED Information

Table 2-6. LEDs

LED ID	Function	Package	Comment	Installed?
D1	VCC Status LED (Green)	Non-Standard	VCC	Yes
D2	VIO Status LED (Red)	Non-Standard	Possibly not light up for VIO < 3.3V	Yes

2.7 IC Information

Table 2-7. Debug

IC ID	Function	Package	Comment	Installed?
U1	THVD4411 – RS-485 and RS-232 multiprotocol transceiver	RGE	Comes pre-installed with THVD4411RGE	Yes

2.8 Test Points

Table 2-8. Test Points

Test Point ID	Color	Signal
TP1	Red	VCC
TP2	Red	VIO
TP3	Red	VCM_R1
TP4	Red	VCM_R2
TP5	Red	VCM_R3
TP6	Red	VCM_R4
TP7	White	U1:L2
TP8	White	U1:L1
TP9	Yellow	U1:R1
TP10	Yellow	U1:R2
TP11	Yellow	U1:R3
TP12	Yellow	U1:R4
TP13	White	SLR
TP14	White	DIR
TP15	White	M0
TP16	Black	GND
TP17	Black	GND
TP18	Black	GND
TP19	Black	GND
TP20	Black	GND
TP21	Black	GND
TP22	Black	GND
TP23	Black	GND
TP24	White	M1
TP25	White	TERM_TX
TP26	Green	EARTH
TP27	Red	VCC
TP28	Red	VIO
TP29	Black	GND
TP30	White	TERM_RX
TP31	White	/SHDN
TP32	Black	GND
TP33	Black	GND

2.9 Assembly Instructions

No Additional Assembly Required. Component pads are available for modification if desired by end user.

2.10 Best Practices

For best results, refer to THVD4411 data sheet ([SLLSFR9](#)) for proper part operation.

3 Hardware Design Files

3.1 Schematics

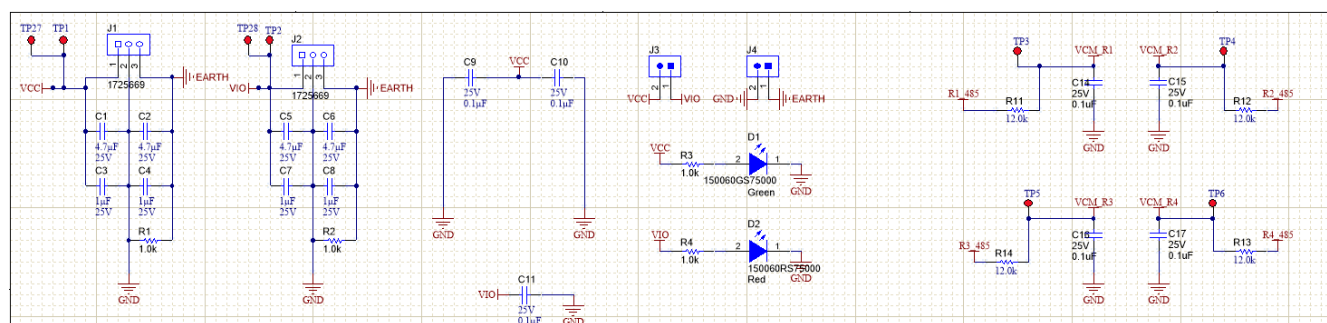


Figure 3-1. Power Supply Schematic THVD4411EVM - All Components Shown

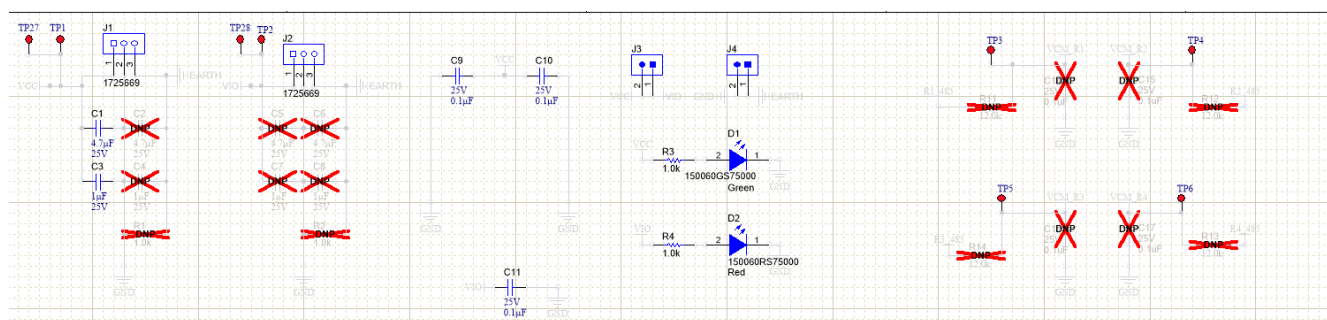


Figure 3-2. Power Supply Schematic THVD4411EVM - Default Configuration Shown

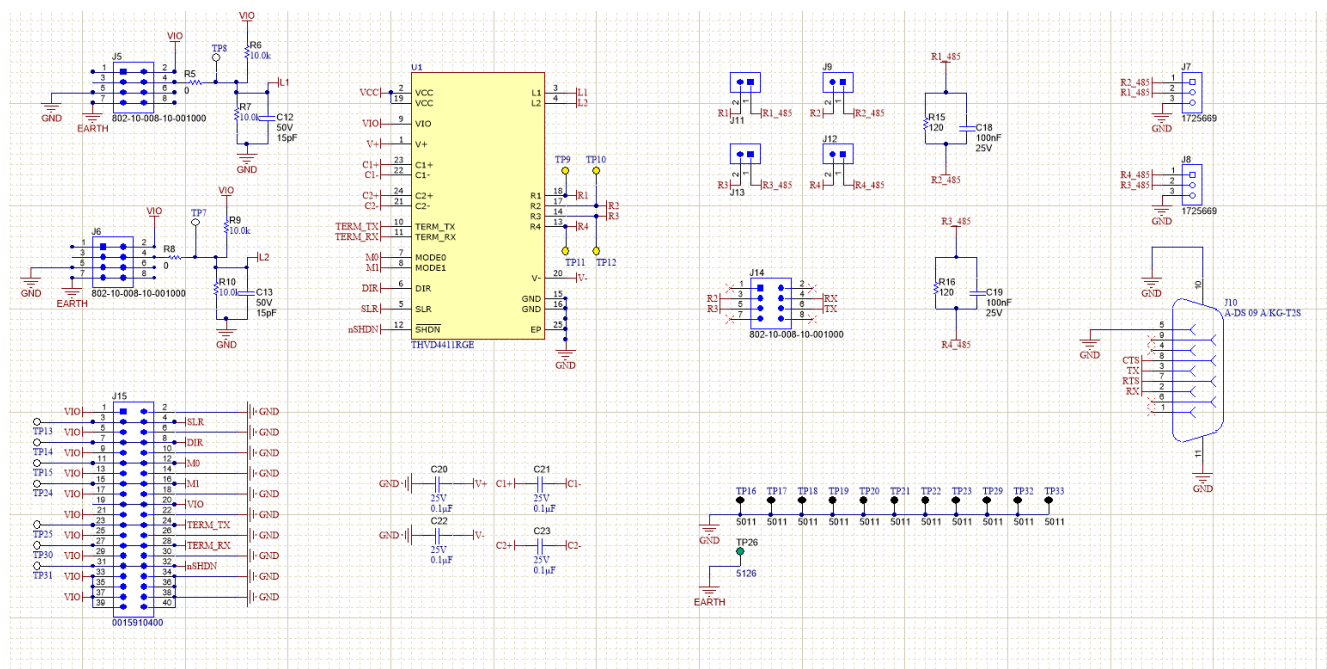


Figure 3-3. Main IC Schematic THVD4411EVM - All Components Shown

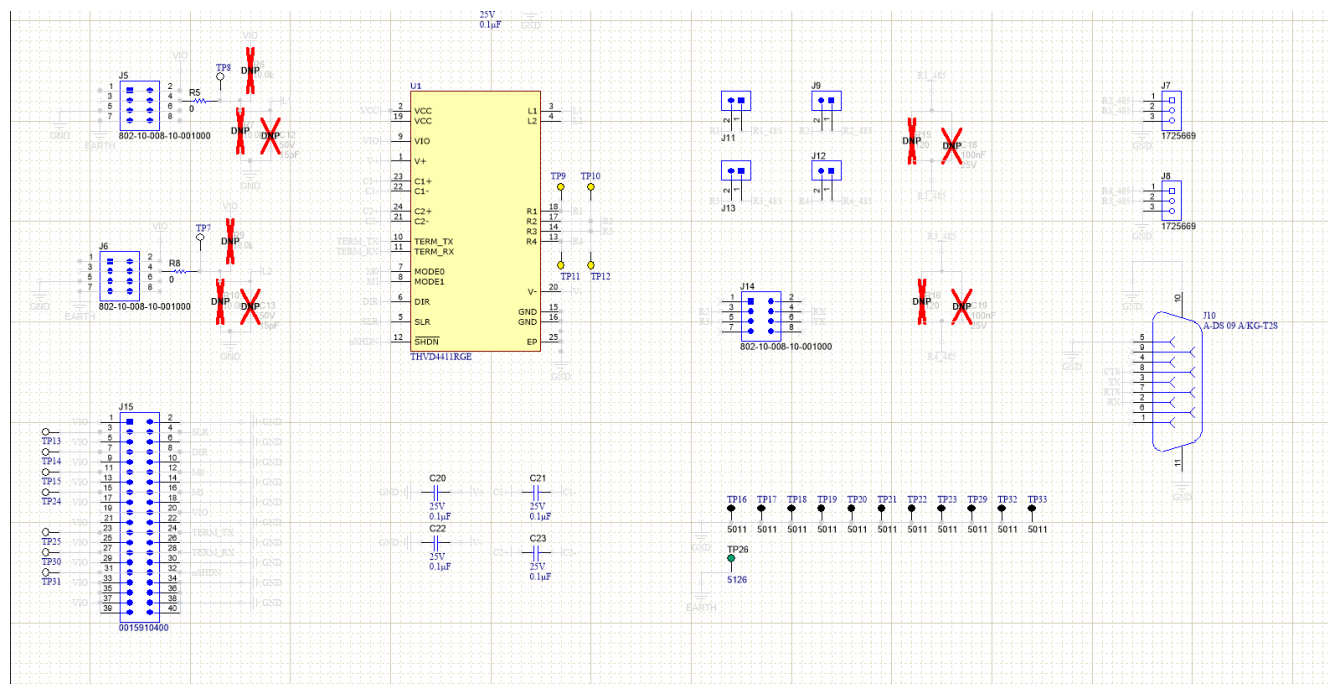


Figure 3-4. Main IC Schematic THVD4411EVM - Default Configuration Shown

3.2 PCB Layouts

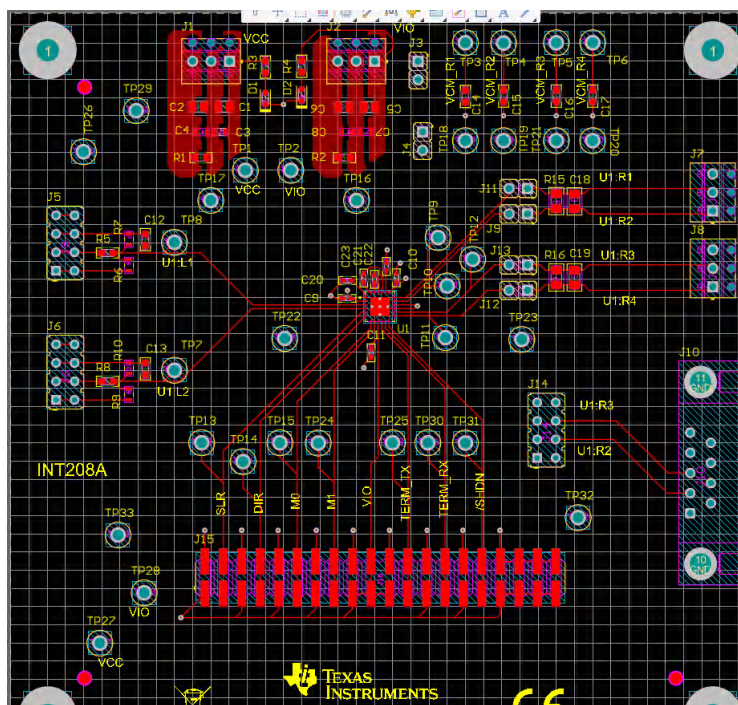


Figure 3-5. Top Layer of PCB Layout - THVD4411EVM

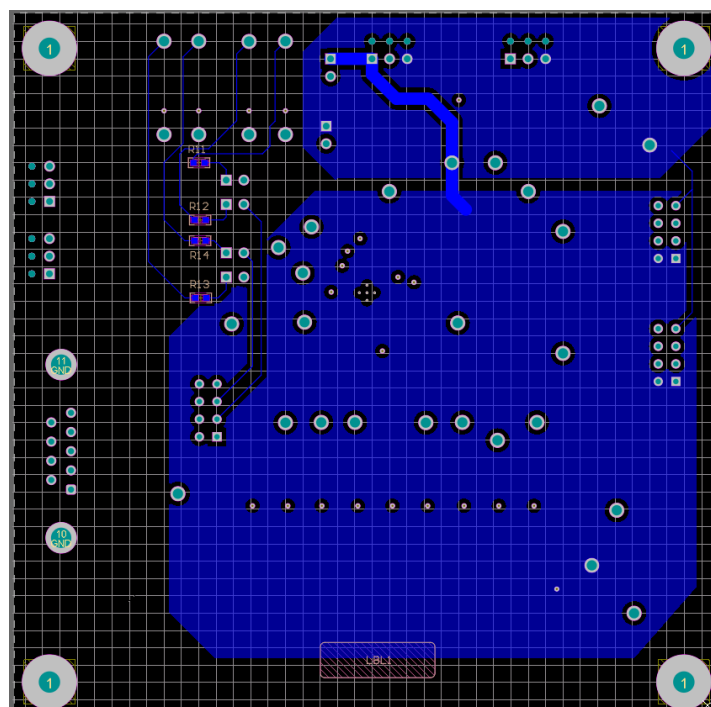


Figure 3-6. Bottom Layer of PCB Layout - THVD4411EVM

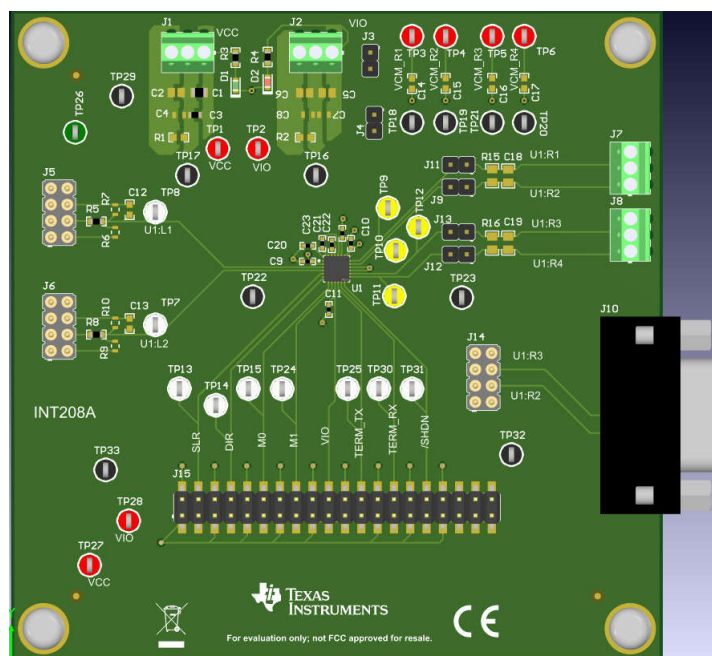


Figure 3-7. 3D Rendering of Top Layer - THVD4411EVM

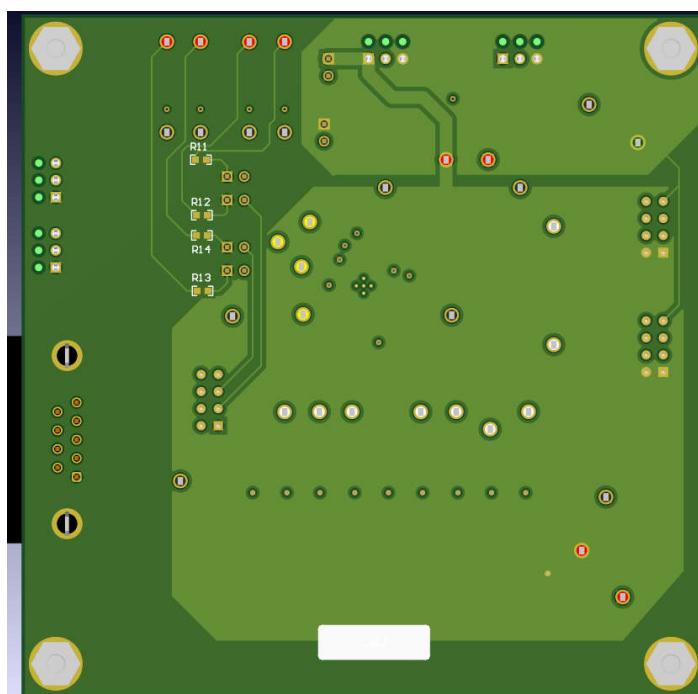


Figure 3-8. 3D Rendering of Bottom Layer - THVD4411EVM

Layer	Name	Material	Thickness	Constant	Board Layer Stack
1	Top Overlay				
2	Top Solder	Solder Resist	0.40mil	3.5	
3	Top Layer	Copper	1.40mil		
4	Dielectric 2		37.00mil	4.2	
5	GND	Copper	1.42mil		
6	Dielectric1	FR-4	5.00mil	4.2	
7	VCC	Copper	1.42mil		
8	Dielectric 3	FR-4	37.00mil	4.2	
9	Bottom Layer	Copper	1.40mil		
10	Bottom Solder	Solder Resist	0.40mil	3.5	
11	Bottom Overlay				

Figure 3-9. PCB Layer Stackup Information

3.3 Bill of Materials (BOM)

Table 3-1. Bill of Materials

Designator	Quantity	Part Number	Manufacturer
C1	1	CGA4J1X7R1E475K125AC	TDK
C3	1	CGA3E1X7R1E105K080AC	TDK
C9, C10, C11, C20, C21, C22, C23	7	CGA2B3X7R1E104K050BB	TDK
D1	1	150060GS75000	Würth Elektronik
D2	1	150060RS75000	Würth Elektronik
H1, H2, H3, H4	4	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4	1902C	Keystone
J1, J2, J7, J8	4	1725669	Phoenix Contact
J3, J4, J9, J11, J12, J13	6	961102-6404-AR	3M
J5, J6, J14	3	802-10-008-10-001000	Mill-Max
J10	1	A-DS 09 A/KG-T2S	Assman WSW
J15	1	0015910400	Molex
LBL1	1	THT-14-423-10	Brady
R3, R4	2	CRCW06031K00JNEA	Vishay-Dale
R5, R8	2	RCS06030000Z0EA	Vishay-Dale
TP1, TP2, TP3, TP4, TP5, TP6, TP27, TP28	8	5010	Keystone Electronics
TP7, TP8, TP13, TP14, TP15, TP24, TP25, TP30, TP31	9	5012	Keystone Electronics
TP9, TP10, TP11, TP12	4	5014	Keystone Electronics
TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP29, TP32, TP33	11	5011	Keystone Electronics
TP26	1	5126	Keystone Electronics
U1	1	THVD4411RGE	Texas Instruments

4 Additional Information

4.1 Known Hardware or Software Issues

No issues known.

4.2 Trademarks

All trademarks are the property of their respective owners.

5 Related Documentation

- Texas Instruments, [THVD4411 Multiprotocol \(RS-232, RS-422, RS485\) Transceiver with Integrated 120Ω Switchable Termination Resistor and IEC-ESD Protection](#), data sheet

6 Revision History

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

Changes from Revision * (March 2024) to Revision A (July 2025)	Page
• Updated <i>Board Setup and Operation</i> section to fix typos mentioned on E2E.....	4

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 instructions, 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/sds/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.

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

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

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

4 EVM Use Restrictions and Warnings:

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

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

4.3 Safety-Related Warnings and Restrictions:

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

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

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

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

6. Disclaimers:

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

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8.2 *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.
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