EVM User's Guide: THVD4421EVM

THVD4421 Evaluation Module

Description

The THVD4421EVM allows for quick prototyping of TI's RS-485 and RS-232 multiprotocol transceiver (THVD4421). The EVM allows for half and full duplex RS-485 operational modes, 2T2R RS-232 communication, and allows for on-chip diagnostic loopback testing for the RS-232. The THVD4421EVM 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

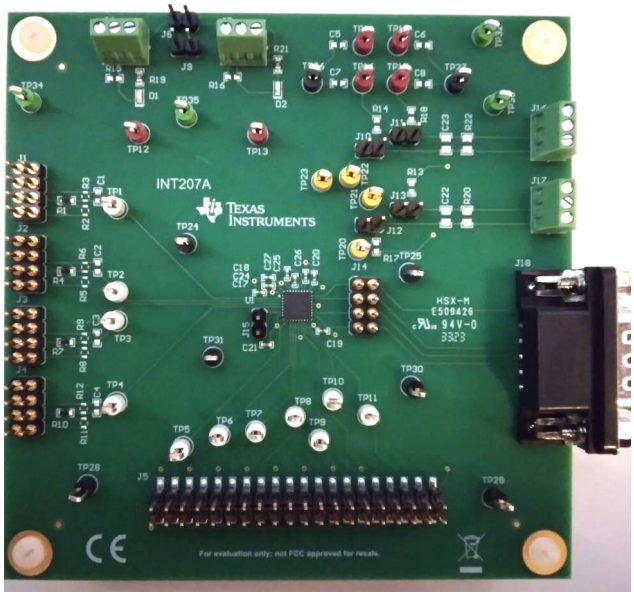
1. Order the EVM from ti.com (THVD4421EVM)
2. See the latest product information and data sheet for the THVD4421 (SLLSFS0)

Features

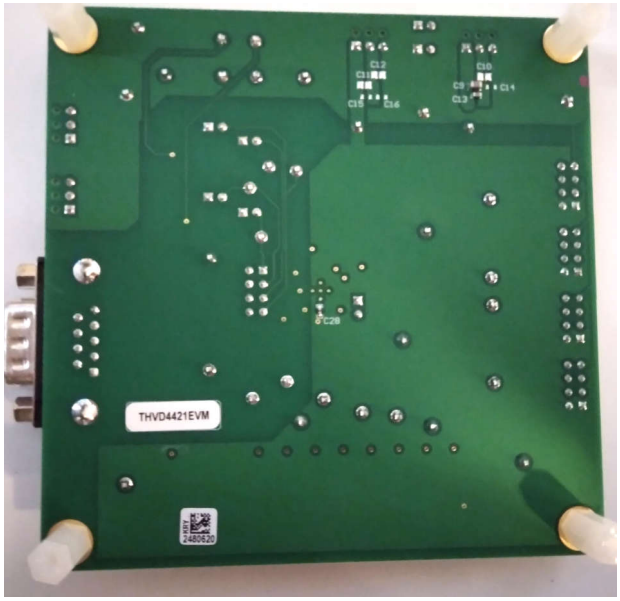
- THVD4421RHB pre-installed onto evaluation module.
- 8 bulk power-supply decoupling capacitor pads for VCC and VIO connections (bottom layer connection).
- 0603 resistor pads available to create resistive link between GND and EARTH connections for both VIO and VCC terminals.
- Terminal and header pin 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 transportation



THVD4421EVM (Top Side)



THVD4421EVM (Bottom Side)

1 Evaluation Module Overview

1.1 Introduction

This document is the EVM user's guide for the THVD4421EVM, which provides a quick way to evaluate TI's THVD4421EVM. The THVD4421 is among TI's first RS-485 and RS-232 multiprotocol transceivers. This configuration allows for 2T2R RS-232 communication, half duplex RS-485 communication, full duplex RS-485 communication, and a loopback mode for RS-232 to allow for on chip diagnostic testing.

1.2 Kit Contents

(1) THVD4421EVM with the THVD4421RHB pre-installed and ready to operate directly out of box.

1.3 Specification

Refer to THVD4421 data sheet 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 J6) is expected to be between 3V and 5.5V for compatible devices.
- VIO input (at J7) is expected to be between 1.65V and 5.5V for compatible devices.
- Signal inputs at J1-J4 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

THVD4421 is a highly integrated and robust multiprotocol transceiver supporting RS-232, RS-422 and RS-485 physical layers. The device has two transmitters and two receivers to enable 2T2R RS-232 port. The device also integrates one transmitter and one receiver to enable half duplex and full duplex RS-485 port. The 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. Diagnostic loopback mode for RS-232 is provided to check for logic to bus and bus to logic path functional integrity and check for cable and connector shorts. 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 an excellent choice for power-sensitive applications. The device needs 3V to 5.5V supply that powers the charge pump for RS-232 and the 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

THVD4421 IC Variant Considerations

The most modern variant of the THVD4421RHB has pin 7 of the IC as no connect (NC). However, this EVM can include the original pinout of the THVD4421RHb, which is slightly different. The original pinout has pin 7 connected to VCC. To remedy multiple possible pinouts for the THVD4421, jumper J15 must be configured before operation. With J6 oriented at the top left of the board, J15 is to the bottom left of U1.

Table 2-1. Variant Considerations

Component ID	Comment
J15 – Original pinout THVD4421	Shunt J15 to connect VCC to pin 7
J15 – Current pinout THVD4421	Leave J15 open

Single Supply Operation (Logic Supply Equals Main Voltage Supply)

The THVD4421 Transceiver in the RHB (VQFN) 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 THVD4421RHB, the VIO pin must be shorted to VCC by shorting the header pins of J8, so that the digital circuits are properly powered.

Table 2-2. Single Supply Operation

Component ID	Comment
J6	VCC power terminal – Attach voltage source of 3V to 5.5V to terminal block.
J7	VIO power terminal – leave open for single supply operation.
J8	Shunted for single supply operation.
J9	Shunted for applications with no separation between EARTH and GND.

To apply power onto the board, VCC is applied through the J6 terminal, with the board oriented so that J1 is on the top left side of the board. 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 the user wants testing methods on reducing ground loop current, then install a resistor on pad R16. For applications without a separate EARTH connection, EARTH and GND can be shorted together by jumper J9. Bulk supply decoupling capacitors can be found on the underside of the board.

Dual Supply Operation (Separate Digital Logic and Driver Supplies)

The THVD4421 transceiver in the RHB (VQFN) 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 – L4) 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. J8 must be left open for dual supply operation.

Table 2-3. Dual Supply Operation

Component ID	Comment
J6	VCC power terminal – Attach voltage source of 3V to 5.5V to terminal block.
J7	VIO power terminal – Attach voltage source of 1.65V to 5.5V to terminal block.
J8	Left open for dual supply operation.
J9	Shunted for applications with no separation between EARTH and GND.

Powering the board up is similar to the single supply operation. J6 is powered as described in Table 2-2. Using the same orientation as before (J6 at top left of the board), the inputs for the VIO power terminal (J7) are similar VCC (J6); from right to left is EARTH, GND, VIO. Bulk supply decoupling capacitors can be found on the underside of the board. For applications without a separate EARTH connection, GND and EARTH can be shorted by shunting J9.

2.2 Board Setup and Operation

After the power supply of the THVD4421EVM 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. In Figure 2-1, the map to the J5 header pins is shown; assume that the board is oriented with J6 in the top left of the EVM. The numbered boxes correspond to the pin number for J9 as indicated in the schematic.

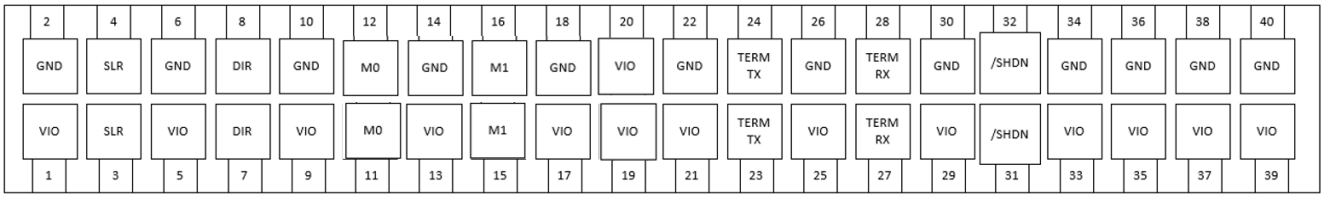


Figure 2-1. THVD4421EVM Control Signal Header Map

To select a configuration option, find the signal of interest on J5 according to Figure 2-1. 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 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 is determined by the operational mode. This is controlled by the M0, and M1 connected to U1 by J5-11/12 and J5-15/16, respectively.

M1 (J5-15;J5-16)	M0 (J5-11;J5-12)	Mode	Comment
0	0	RS-232 loopback	L3 reflects on L2/R2/R3; L4 reflects on L1/R4/R1.
0	1	RS-232	2T2R mode; L3, L4 are logic inputs for RS232 driver; L1, L2 are logic outputs.
1	0	Half duplex RS-485	L2 is RX Logic output; L3 is Driver Logic input; R1/R2 are Bus inverting and non-inverting terminals, respectively.
1	1	RS-485 full duplex	R1/R2 are inverting and non-inverting driver terminals; R3/R4 are non-inverting and inverting receiver terminals.

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+ Pin ID	Associated GND Pin	Logic '0' Operation	Associated VIO Pin	Logic '1' Operation
SLR	J5-3; J5-4	J5-2	RS485: 20Mbps RS232: 1Mbps	J5-1	RS485: 500kbps RS232: 250kbps
DIR	J5-7; J5-8	J5-6	RS485: RX mode	J5-5	RS485: TX mode
TERM_TX	J5-23; J5-24	J5-22	RS485 TX: unterminated	J5-21	RS485 TX: terminated with 120Ω
TERM_RX	J5-27; J5-28	J5-26	RS485 RX: unterminated	J5-25	RS485 RX: terminated with 120Ω
/SHDN	J5-31; J5-32	J5-30	Device in shutdown mode	J5-29	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.

Logic and Bus Pins of the THVD4421

All the various modes of the THVD4421 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 THVD4421 with a controller. The logic pins are supplied and bounded by the VIO voltage, which means that these pins can accept GND to VIO input voltages and can output GND to VIO voltages. All logic pins L1 – L4 are accessible through 4x2 headers J1-J4 that populate the left side of the board when oriented with J6 in the top left corner. Figure 2-2 shows the headers pinouts.

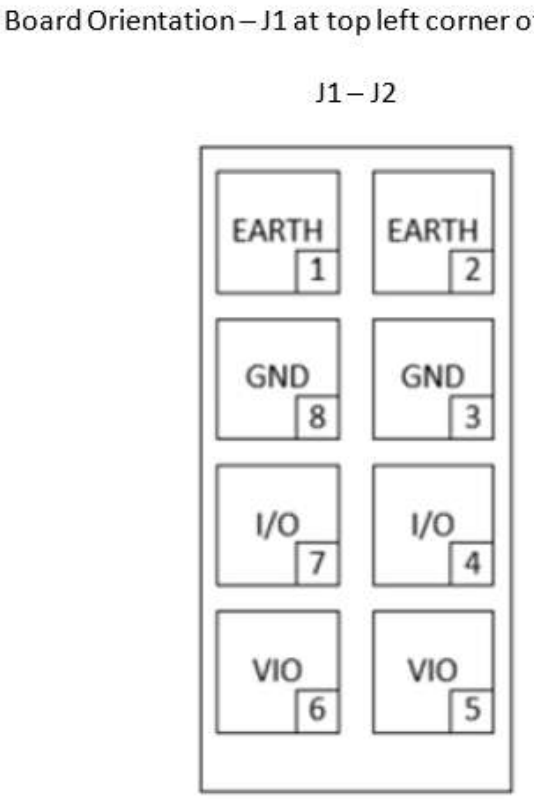


Figure 2-2. Logic Side Data I/O Header Map

The function of each individual (L) pin depends on the mode in which the THVD4421 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 the table below.

U1 Pin	Output Option 1	Output Option 2	Output Option 3	Output Option 4
R1	J14; Row 1; Column 1	J12; Column 1	J17 (if J12 is shunted)	J18 (if J14 row 1 is shunted)
R2	J14; Row 2; Column 1	J13; Column 1	J17 (if J13 is shunted)	J18 (if J14 row 2 is shunted)
R3	J14; Row 3; Column 1	J10; Column 1	J16 (if J10 is shunted)	J18 (if J14 row 3 is shunted)
R4	J14; Row 4; Column 1	J11; Column 1	J16 (if J11 is shunted)	J18 (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 001 for M1 and M0, respectively, the device enters RS-232.

Mode	L1	L2	L3	L4	R1	R2	R3	R4
01	Not used	Console side RX	Console side input	Console side input	RS-232 bus input	RS-232 bus input	RS-232 bus output	RS-232 bus output

This is commonly referred to as a 2T2R setup, as there are two transmitters and two receivers. 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, RX, RTS, and CTS. While this configuration of signals is not strictly required, most 2T2R RS-232 applications use these signals and require this configuration. If J18 (the DSUB connector) is used, then the pinout of the connector mimics the standard placement of the aforementioned RS-232 cables.

U1 Pin	Standard RS-232 Circuit Mnemonic	J18 Pin
R1	RX	2
R2	CTS	8
R3	TX	3
R4	RTS	7

Many RS-232 test plans typically require a loop back test. The THVD4421 integrates a RS-232 loopback mode to make testing quick and simple. When putting the device into mode 00 for M1 and M0, respectively, the THVD4421 enters RS-232 loopback mode. This creates shorts on R2 to R3 and R1 to R4. This configuration allows a signal on L1 to be received on L4, while also showing up on pins R1 and R4. The same can be applied when looking at R2 and R3.

Mode	L1	L2	L3	L4	R1	R2	R3	R4
00	Loopback RX for L4	Loopback RX for L3	L3 -> R3 -> R2 -> L2	L4 -> R4 -> R1 -> L1	Shorted to R4	Shorted to R3	Shorted to R2	Shorted to R1

RS-485 Operation

With RS-232 operational modes covered, this is a brief overview of 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 THVD4421) 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	L3	L4	R1	R2	R3	R4
10	Unused	Console side RX	Console side TX	Unused	Non-inverting bus facing pin	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. The driver input is connected to L3 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	L3	L4	R1	R2	R3	R4
10	Unused	Console side RX	Console side TX	Unused	Non-inverting bus facing driver	Inverting bus facing driver	Non-inverting bus facing receiver	Inverting bus facing receiver

2.3 Header and Jumper Information

The THVD4421EVM comes pre-installed with THVD4421RHB installed at U1. All the signal and signal jumpers and IO connections (J1 – J18) come pre-installed on board. See Table 2-4 for descriptions on every pad on the board and if the pads are pre-installed by default.

Table 2-4. Headers and Jumpers

Jumper ID	Function	Package	Comment	Installed?
J1	L1 I/O	4x2 header	L1 Pin on U1	Yes
J2	L2 I/O	4x2 header	L2 Pin on U1	Yes
J3	L3 I/O	4x2 header	L3 Pin on U1	Yes
J4	L4 I/O	4x2 header	L4 Pin on U1	Yes
J5	Control signals inputs	2x20 header	THVD4421 control signal access	Yes
J6	VCC input	3 pin terminal block	Power, GND, and EARTH connections	Yes
J7	VIO input	3 pin terminal block	Power, GND, and EARTH connections	Yes
J8	VCC to VIO jumper	1x2 header	Used in single supply applications (shunt jumper)	Yes
J9	GND to EARTH jumper	1x2 header	Used when no Earth is present (shunt jumper)	Yes
J10	R3 RS-485 bus jumper	1x2 header	Shunt to connect R3 to J16 (RS-485)	Yes
J11	R4 RS-485 bus jumper	1x2 header	Shunt to connect R4 to J16 (RS-485)	Yes
J12	R1 RS-485 bus jumper	1x2 header	Shunt to connect R1 to J17 (RS-485)	Yes
J13	R2 RS-485 bus jumper	1x2 header	Shunt to connect R2 to J17 (RS-485)	Yes
J14	RS-232 bus signal jumper	4x2 header	Shunt each row to connect to D-SUB	Yes
J15	IC variant jumper	1x2 header	See ***Powering the Board*** for J15 usage instructions	Yes
J16	RS-485 terminal block for R3 and R4	3 pin terminal block	R3 and R4 Output (RS-485)	Yes
J17	RS-485 terminal block for R1 and R2	3 pin terminal block	R1 and R2 output (RS-485)	Yes
J18	RS-232 DSUB connector	9 pin d-sub connector	RS-232 output	Yes

2.4 Resistor Information

Table 2-5. Resistors

Resistor ID	Function	Package	Comment	Installed?
R1	0 Ohm resistor	0603	J1 to U1:L1	Yes
R2	Pull up resistor	0603	U1:L1	No
R3	Pull down resistor	0603	U1:L1	No
R4	0 Ohm resistor	0603	J2 to U1:L2	Yes
R5	Pull up resistor	0603	U1:L2	No
R6	Pull down resistor	0603	U1:L2	No
R7	0 Ohm resistor	0603	J3 to U1:L3	Yes
R8	Pull up resistor	0603	U1:L3	No
R9	Pull down resistor	0603	U1:L3	No
R10	0 Ohm resistor	0603	J4 to U1:L4	Yes
R11	Pull up resistor	0603	U1:L4	No
R12	Pull down resistor	0603	U1:L4	No
R13	Common mode load R2	0603	U1:R2 – 1 Unit Load = 12K	No
R14	Common mode load R3	0603	U1:R3 – 1 Unit Load = 12K	No
R15	Earth to GND resistor	0603	N/A	No
R16	Earth to GND resistor	0603	N/A	No
R17	Common mode load R1	0603	U1:R1 – 1 Unit Load = 12K	No
R18	Common mode load R4	0603	U1:R4 – 1 Unit Load = 12K	No
R19	LED current limiting resistor	0603	Limits current to D1	Yes
R20	R3 to R4 RS-485 termination	0805	120 Ohm termination resistor pad	No
R21	LED current limiting resistor	0603	Limits current to D2	Yes
R22	R1 to R2 RS-485 termination	0805	120 Ohm termination resistor pad	No

2.5 Capacitor Information

Table 2-6. Capacitors

Capacitor ID	Function	Package	Comment	Installed?
C1	Load capacitance for U1:L1	0603	N/A	No
C2	Load capacitance for U1:L2	0603	N/A	No
C3	Load capacitance for U1:L3	0603	N/A	No
C4	Load capacitance for U1:L4	0603	N/A	No
C5	100nF | 25V decoupling capacitor	0603	U1:R1 common mode voltage decoupling capacitor	No
C6	100nF | 25V decoupling capacitor	0603	U1:R2 common mode voltage decoupling capacitor	No
C7	100nF | 25V decoupling capacitor	0603	U1:R3 common mode voltage decoupling capacitor	No
C8	100nF | 25V decoupling capacitor	0603	U1:R4 common mode voltage decoupling capacitor	No
C9	4.7uF | 25V decoupling capacitor	0805	VCC to GND capacitor	Yes
C10	4.7uF | 25V decoupling capacitor	0805	GND to EARTH capacitor	No
C11	4.7uF | 25V decoupling capacitor	0805	VIO to GND capacitor	MP
C12	4.7uF | 25V decoupling capacitor	0805	GND to EARTH capacitor	No
C13	1uF | 25V decoupling capacitor	0603	VCC to GND capacitor	Yes

Table 2-6. Capacitors (continued)

Capacitor ID	Function	Package	Comment	Installed?
C14	1uF | 25V decoupling capacitor	0603	GND to EARTH capacitor	No
C15	1uF | 25V decoupling capacitor	0603	VIO to GND capacitor	No
C16	1uF | 25V decoupling capacitor	0603	GND to EARTH capacitor	No
C17	100nF | 25V decoupling capacitor	0603	U1: Pin 1 VCC decoupling capacitor	Yes
C18	100nF | 25V decoupling capacitor	0603	U1: Pin 31 VCC decoupling capacitor	Yes
C19	100nF | 25V decoupling capacitor	0603	U1: Pin 17 VCC decoupling capacitor	Yes
C20	100nF | 25V decoupling capacitor	0603	U1: Pin 25 VCC decoupling capacitor	Yes
C21	100nF | 25V decoupling capacitor	0603	J15 / U1: Pin 7 decoupling capacitor	Yes
C22	100nF | 25V termination capacitor for RS-485 Bus	0805	*Actual value added to circuit varies with application	No
C23	100nF | 25V termination capacitor for RS-485 Bus	0805	*Actual value added to circuit varies with application	No
C24	100nF | 25V charge pump capacitor	0603	Charge pump capacitor	Yes
C25	100nF | 25V charge pump capacitor	0603	Charge pump capacitor	Yes
C26	100nF | 25V charge pump capacitor	0603	Charge pump capacitor	Yes
C27	100nF | 25V Charge pump capacitor	0603	Charge pump capacitor	Yes
C28	100nF | 25V decoupling capacitor	0603	U1: Pin 13 VIO decoupling capacitor	Yes

2.6 LED Information

Table 2-7. LED Information

LED ID	Function	Package	Comment	Installed?
D1	VCC status LED (green)	Non-standard	VCC	Yes
D2	VCC status LED (red)	Non-standard	Possibly not light up for VIO < 3.3V	Yes

2.7 IC Information

Table 2-8. IC Information

IC ID	Function	Package	Comment	Installed?
U1	THVD4421 – RS-485 and RS-232 multiprotocol transceiver	RHB	Comes pre-installed with THVD4421RHB	Yes

2.8 Test Points

Table 2-9. Test Points

Test Point ID	Color	Signal
TP1	White	U1:L1
TP2	White	U1:L2
TP3	White	U1:L3
TP4	White	U1:L4
TP5	White	SLR
TP6	White	DIR
TP7	White	M0
TP8	White	M1
TP9	White	TERM_TX
TP10	White	TERM_RX
TP11	White	nSHDN
TP12	Red	VCC
TP13	Red	VIO
TP14	Red	VCM U1:R1
TP15	Red	VCM U1:R2
TP16	Red	VCM U1:R3
TP17	Red	VCM U1:R4
TP20	Yellow	U1:R1
TP21	Yellow	U1:R2
TP22	Yellow	U1:R3
TP23	Yellow	U1:R4
TP24	Black	GND
TP25	Black	GND
TP26	Black	GND
TP27	Black	GND
TP28	Black	GND
TP29	Black	GND
TP30	Black	GND
TP31	Black	GND
TP32	Green	EARTH
TP33	Green	EARTH
TP34	Green	EARTH
TP35	Green	EARTH

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 THVD4421 data sheet (SLLSFS0) for proper part operation.

3 Hardware Design Files

3.1 Schematics

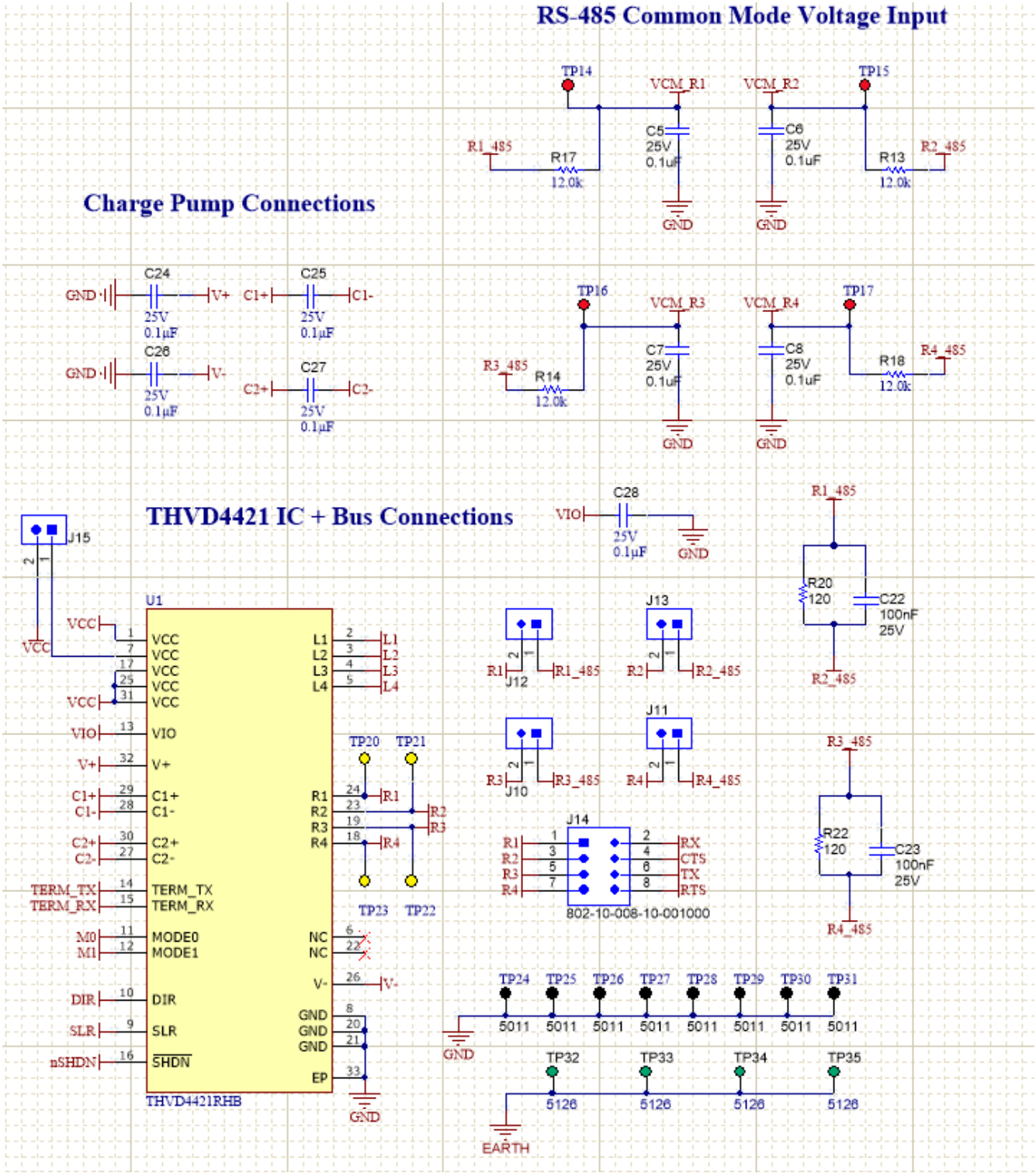


Figure 3-1. THVD4421EVM - Main IC Schematic (Generic)

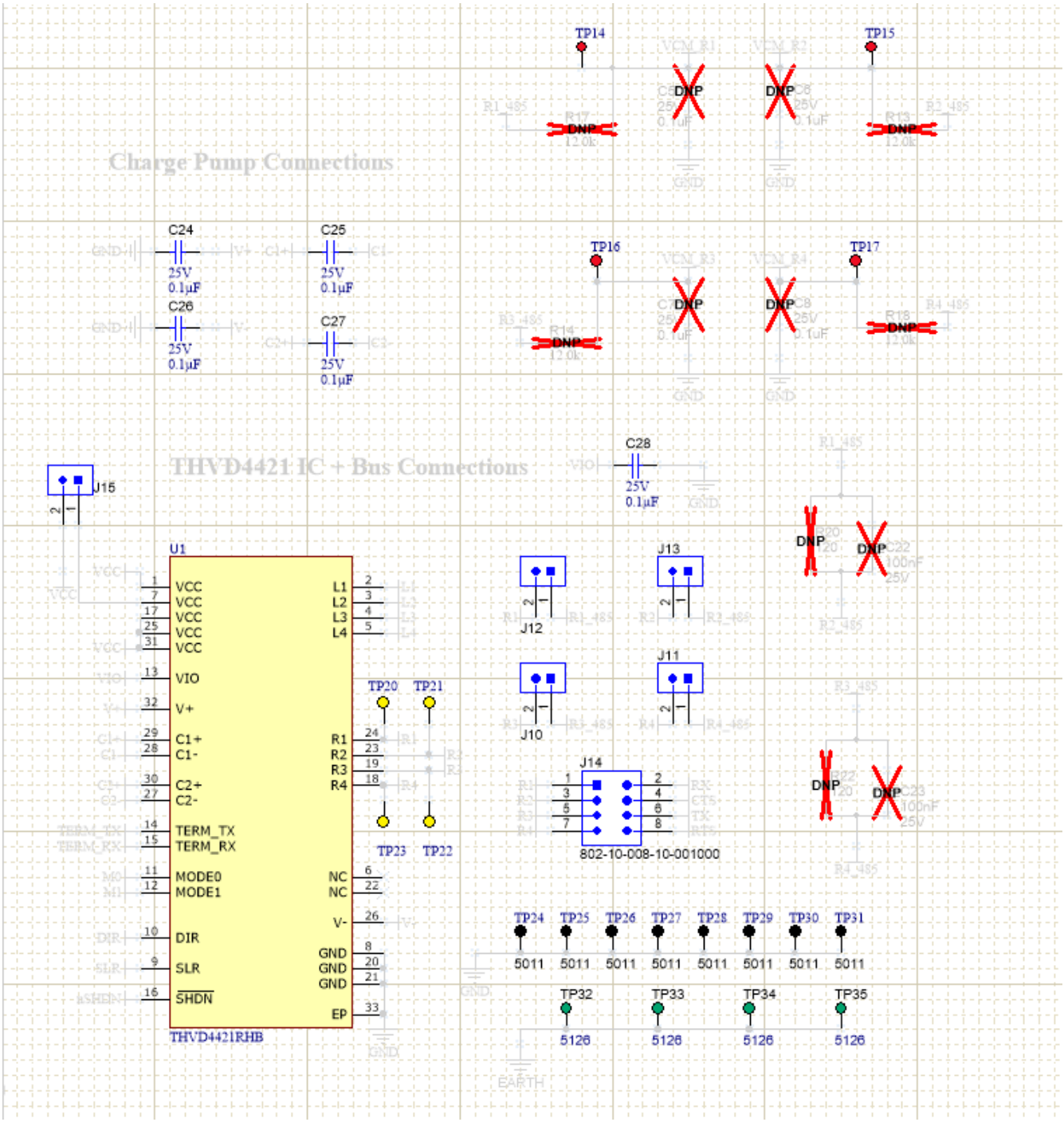


Figure 3-2. THVD4421EVM - Main IC Schematic (Out of Box)

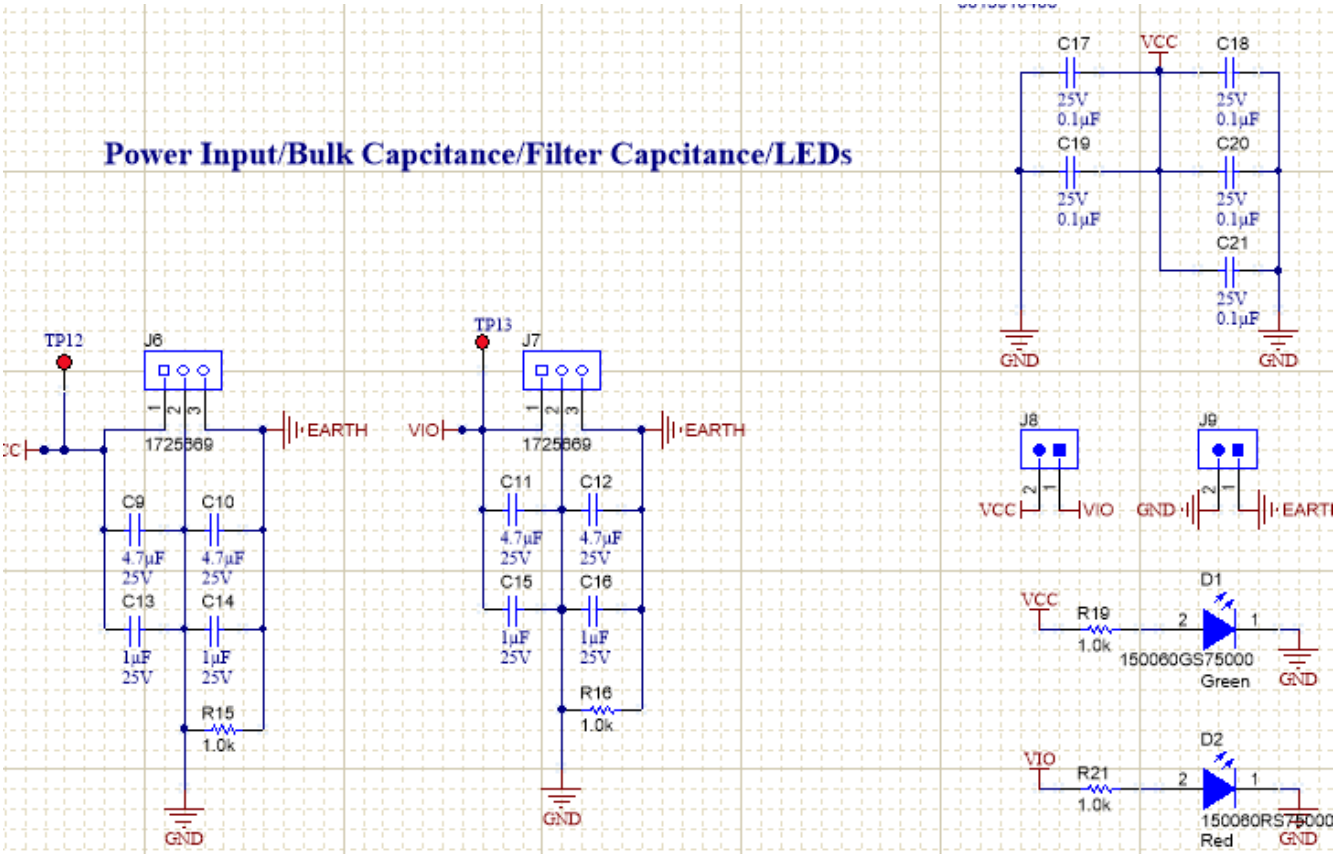


Figure 3-3. THVD4421EVM - Power Input Scheamtic (Generic)

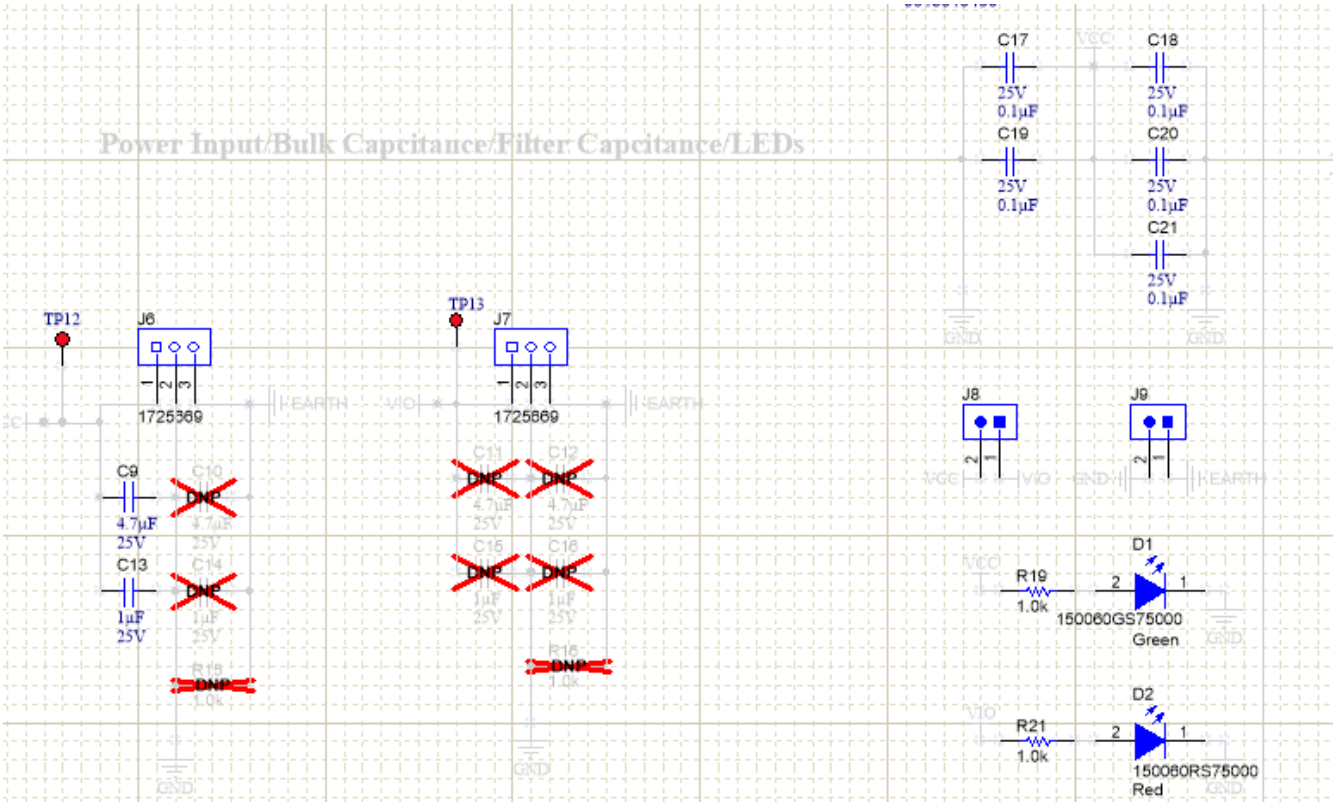


Figure 3-4. THVD4421EVM - Power Input Scheamtic (Out of Box)

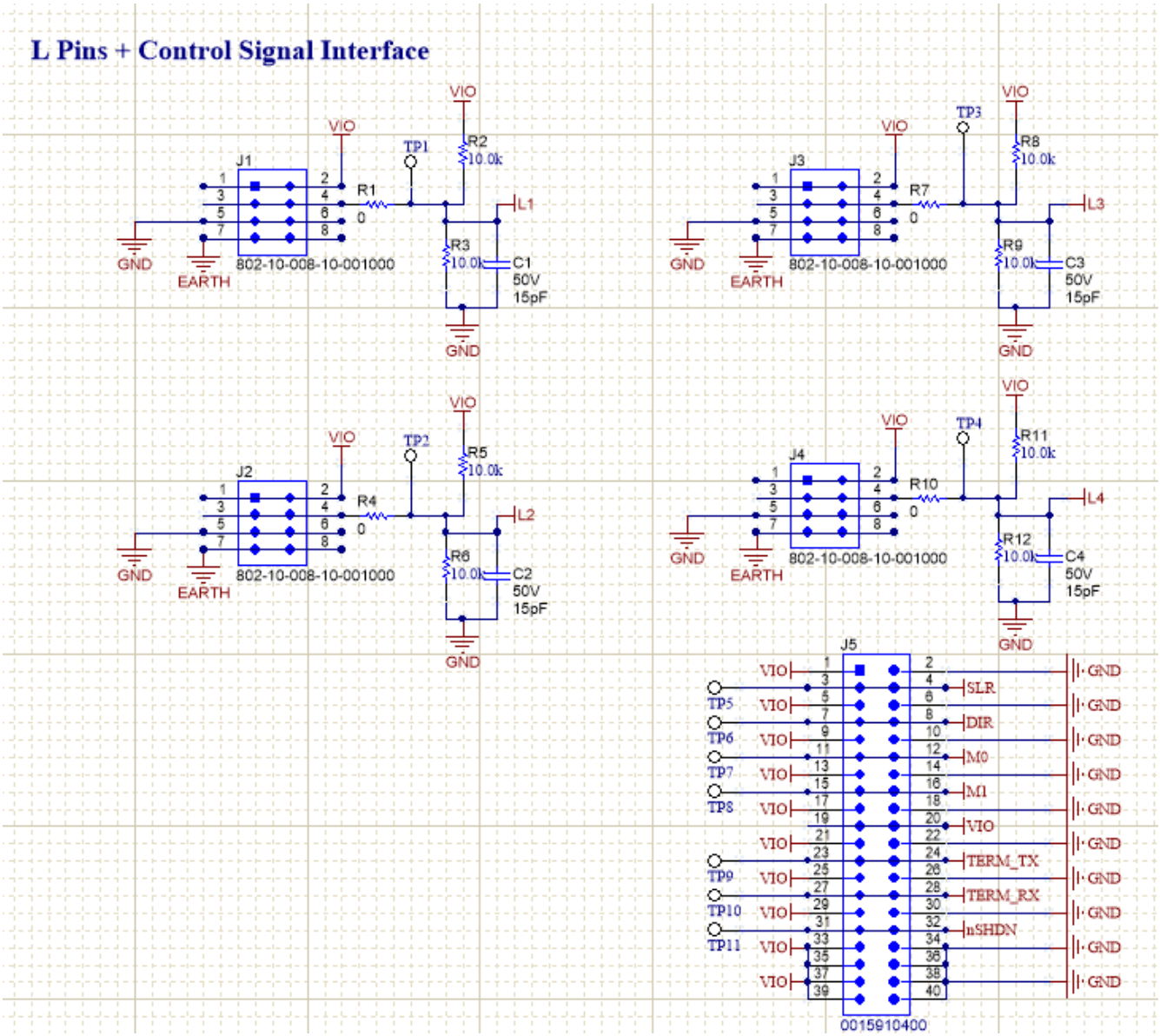


Figure 3-5. THVD4421EVM - Logic Signal I/O (Generic)

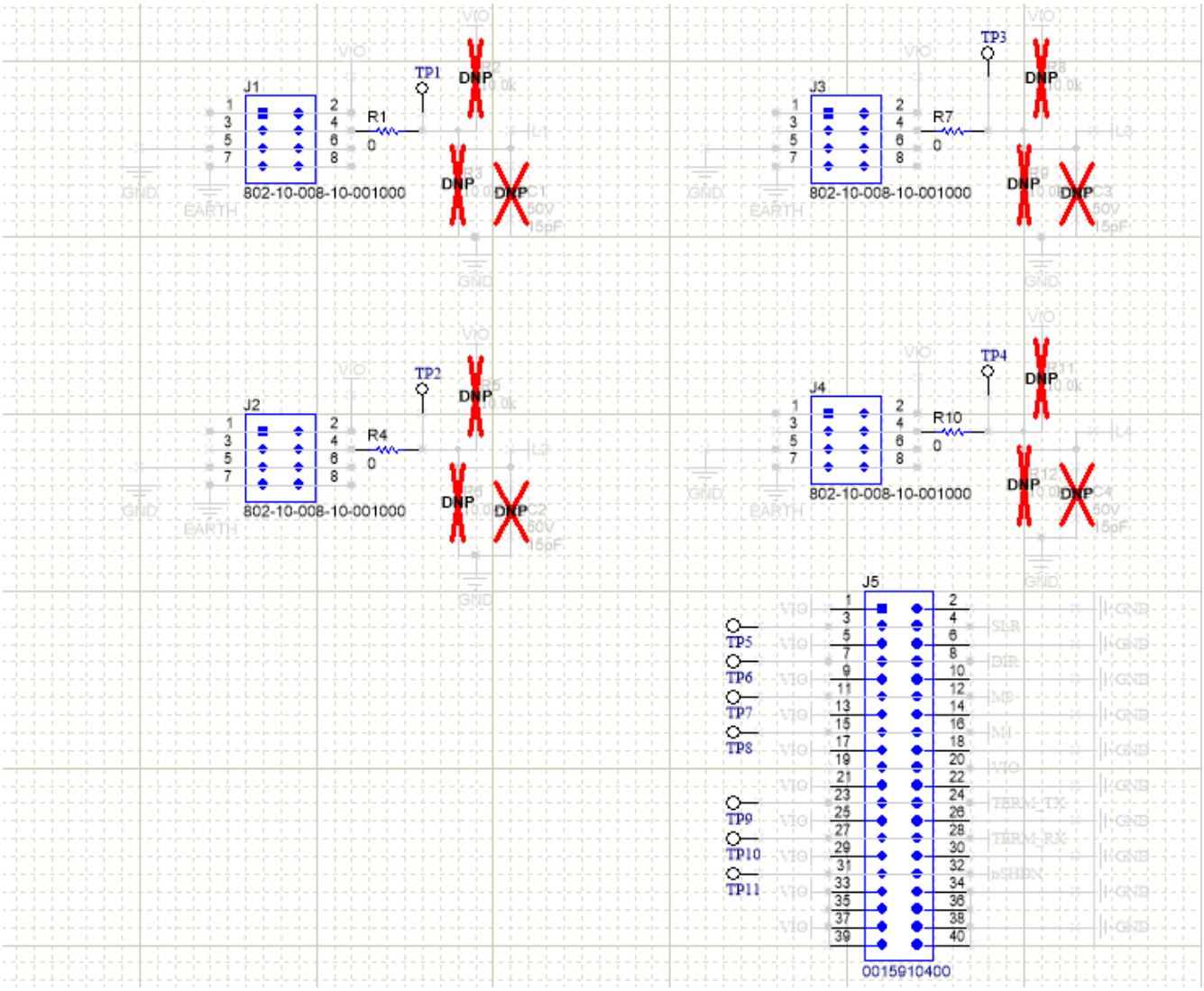


Figure 3-6. THVD4421EVM - Logic Signal I/O (Out of Box)

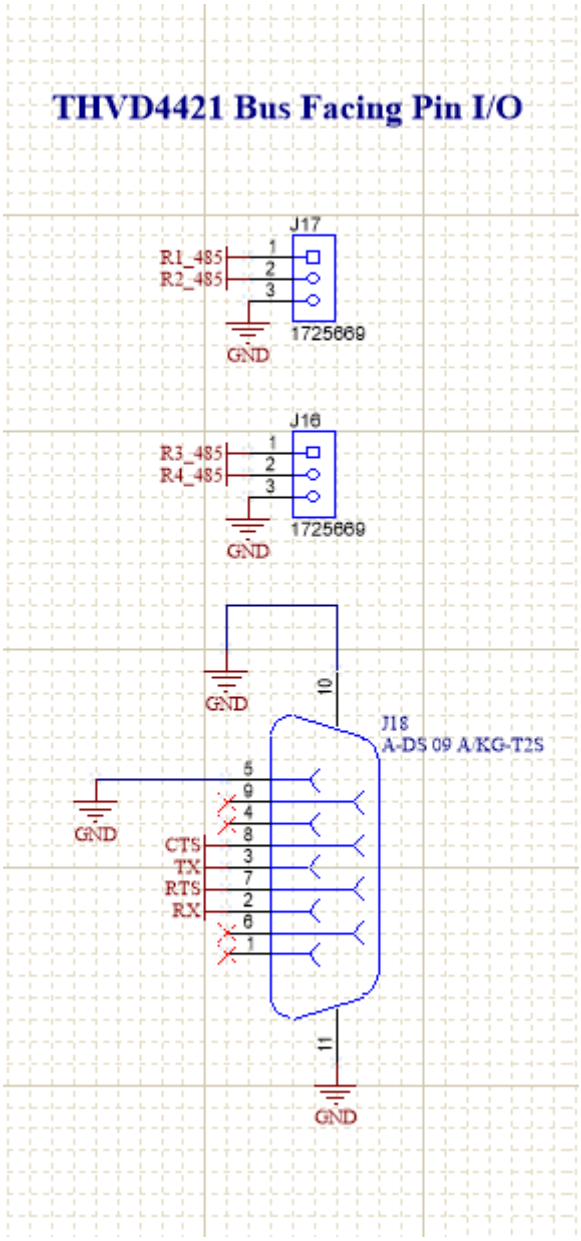


Figure 3-7. THVD4421EVM - Face Interface (Generic and Out of Box)

3.2 PCB Layouts

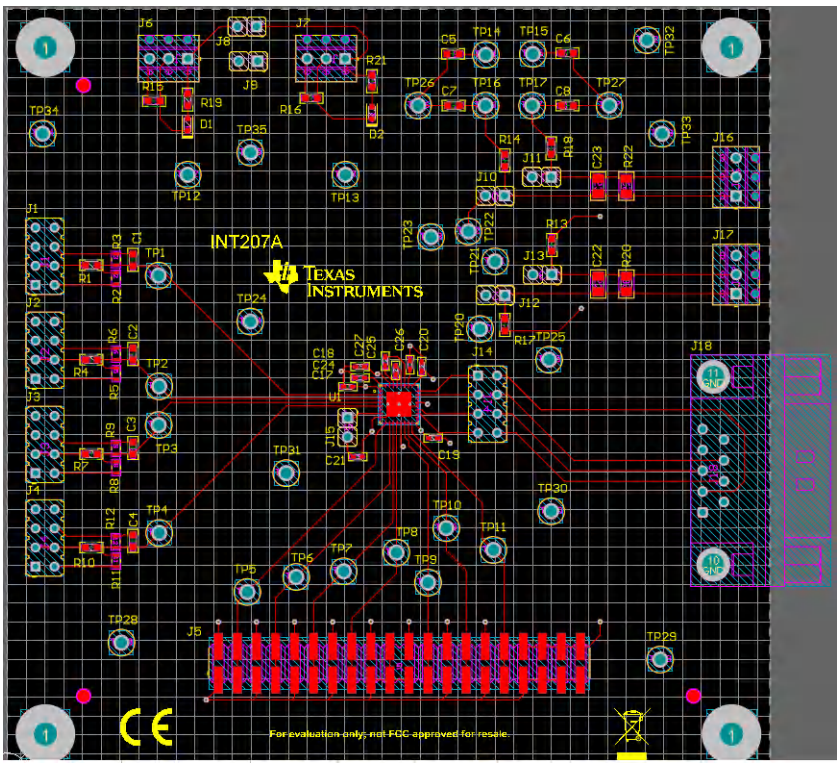


Figure 3-8. THVD4421EVM - Top Layer 2D PCB Layout

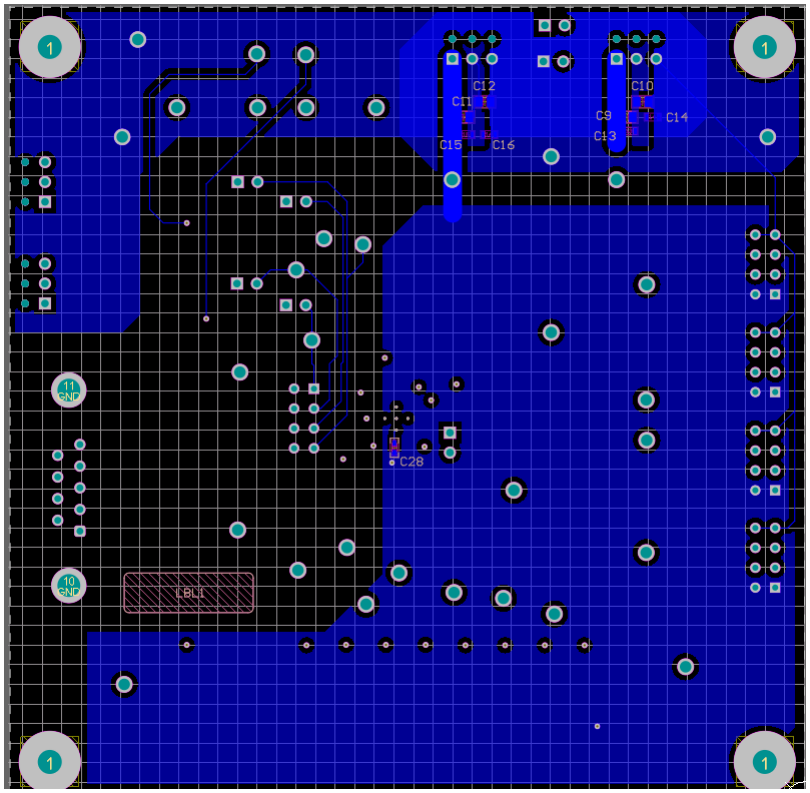


Figure 3-9. THVD4421EVM - Bottom Layer 2D PCB Layout

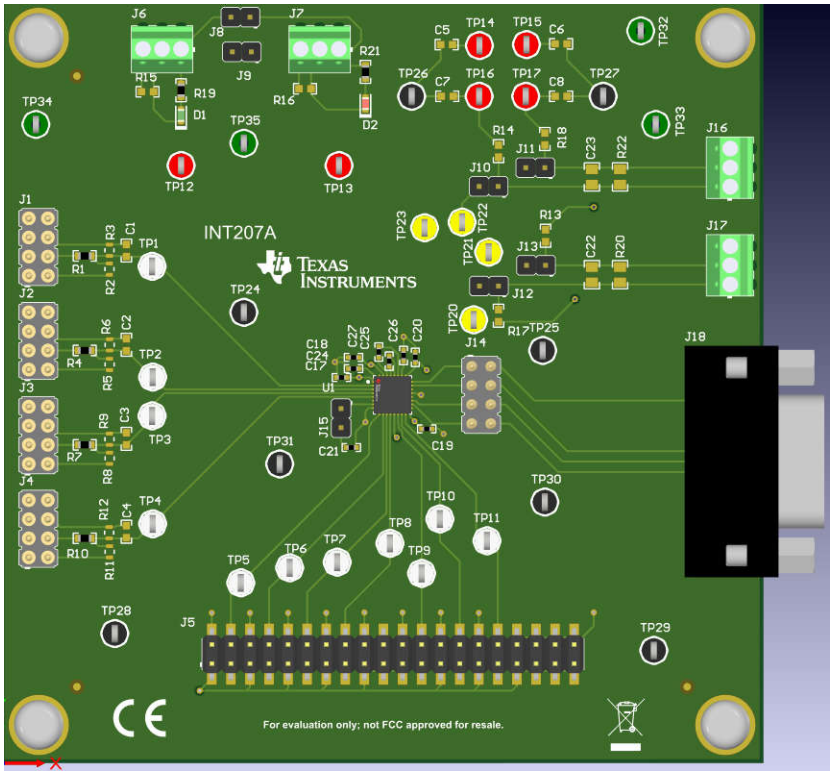


Figure 3-10. THVD4421EVM - Top Layer 3D PCB Layout

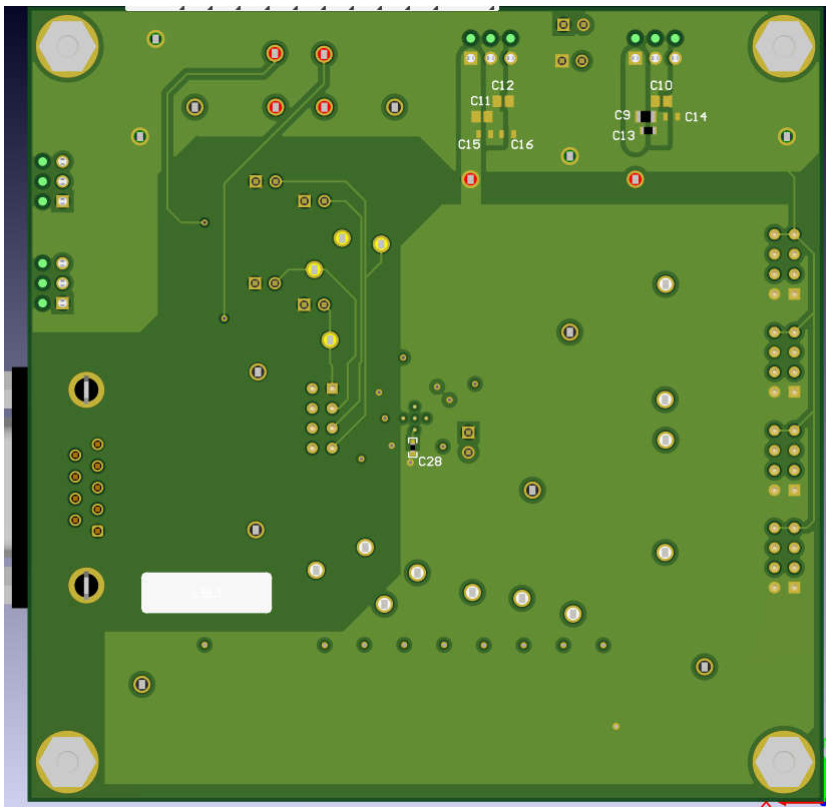


Figure 3-11. THVD4421EVM - Bottom Layer 3D PCB Layout

3.3 Bill of Materials (BOM)

Table 3-1. Bill of Materials

Designator	Quantity	Part Number	Manufacturer
C9	1	CGA4J1X7R1E475K125AC	TDK
C13	1	CGA3E1X7R1E105K080AC	TDK
C17, C18, C19, C20, C21, C24, C25, C26, C27, C28	10	CGA2B3X7R1E104K050BB	TDK
D1	1	150060GS75000	Wurth Elektronik
D2	1	150060RS75000	Wurth Elektronik
H1, H2, H3, H4	4	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4	1902C	Keystone
J1, J2, J3, J4, J14	5	802-10-008-10-001000	Mill-Max
J5	1	0015910400	Molex
J6, J7, J16, J17	4	1725669	Phoenix Contact
J8, J9, J10, J11, J12, J13, J15	7	961102-6404-AR	3M
J18	1	A-DS 09 A/KG-T2S	Assman WSW
LBL1	1	THT-14-423-10	Brady
R1, R4, R7, R10	4	RCS06030000Z0EA	Vishay-Dale
R19, R21	2	CRCW06031K00JNEA	Vishay-Dale
TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11	11	5012	Keystone Electronics
TP12, TP13, TP14, TP15, TP16, TP17	6	5010	Keystone Electronics
TP20, TP21, TP22, TP23	4	5014	Keystone Electronics
TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31	8	5011	Keystone Electronics
TP32, TP33, TP34, TP35	4	5126	Keystone Electronics
U1	1	THVD4421RHB	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 References

THVD4421 data sheet (SLLSFS0)

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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.

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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.

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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.

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