

TLINX441X EVM User's Guide

This user guide describes the TLINX441X evaluation module (EVM). This EVM helps designers evaluate device performance, support fast development, and analyze automotive local interconnect network (LIN) systems using TLINX441X LIN physical layer transceiver devices.

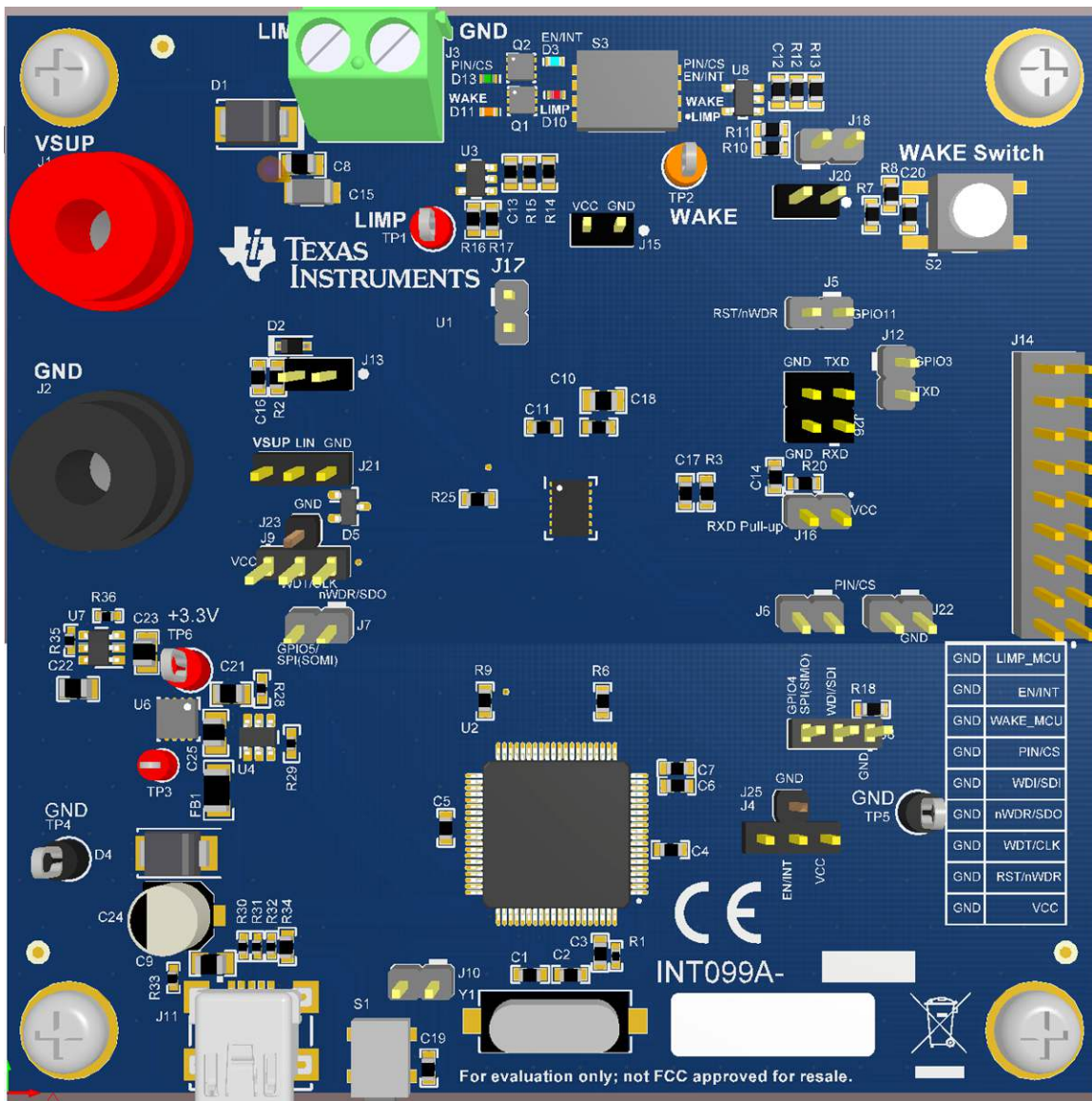


Figure 1. TLIN14415EVM Board Image

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1 Introduction

1.1 Features

The EVM supports the following features:

- *Master Mode* and *Slave Mode* configurations
- Terminal block and header pins are available on all power and LIN bus connections
- Access to the VCC output of the integrated LDO.
- Ability to test the local WAKE feature.
- Microprocessor on board with connections to device pins for control and monitoring through GUI using a controlling PC and commands through SPI.
- LED indicators for VCC, LIMP, EN, and PIN/nCS pins.

1.2 Description

The TLINX441X EVM provides users with the ability to evaluate TI's TLINx441x-Q1 family of single-channel, LIN transceivers with LDO, Watchdog, and SPI capability. The EVM allows both master and slave mode applications to be evaluated through the use of a single jumper that connects or disconnects the external 1-k Ω pullup resistor and series diode required in master mode from the LIN bus.

The EVM has access to the integrated, low-voltage VCC rail that provides the pull-up for RXD, and the logic level for the enable (EN) control input pins through the use of a jumper. The TLINX441X supports a VIH from 2 V to 5.5 V, allowing operation with a variety of microcontrollers with common IO voltage levels such as 2.5 V, 3.3 V, and 5 V. Non-populated capacitor pads are available on the TXD, RXD, and LIN pins to accommodate a variety of different tests requiring various capacitive load conditions.

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, plus an extended bus fault protection of ± 45 V.

If additional ESD protection is desired, a diode pad is available on the LIN bus to accommodate any SOD323 diode. A header is provided on the power and LIN bus connections to allow the EVM to be evaluated in a larger system.

An onboard microprocessor is available to monitor and control the device when it is in SPI mode. A GUI has been written and is available on the web to easily perform different tasks and guide the user through using the different features of the TLINx441x family. Please visit the product page on TI.com to gain access to this GUI software.

2 EVM Setup and Features Explained

Use the following equipment to evaluate the performance of the TLINX441X device:

- Power supply capable of supplying the desired supply voltage. Typical LIN applications use 12 V or 24 V, but the TLINX441X operate with any supply voltage from 5.5 V to 28 V. Connect this voltage across the VSUP and GND pins of either the J1 and J2 banana jacks.
- If the LIN bus interface is to be observed on an oscilloscope, use probes capable of tolerating voltages as large as VSUP.
- The logic interface pins (TXD, RXD, and EN) may interface to a microcontroller, pattern generator, or logic analyzer with logic levels matching the VCC voltage.
- 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 J15.

2.1 PIN and SPI modes

Two modes are available on this device: PIN and SPI mode. This mode is determined by the state of pin 9 on power up: if pin 9 is low or grounded, the device powers up in PIN mode with no SPI interface, if pin 9 is floating or high, the device powers up in SPI mode with the SPI interface enabled and access to internal registers for configuration of the device. Jumpers J6 and J22 give both of these options. If J22 is populated on power up, the device powers up into PIN mode; otherwise, the device powers up into SPI mode.

The TLIN14415 device has alternate pin designations and functions depending on the power up mode chosen. The designations are shown in [Table 1](#), and the functions of each pin can be found in the datasheet.

Table 1. Pinout in SPI Mode vs. PIN Mode

	PIN Mode Designation	SPI Mode Designation
Pin 3	EN	nINT
Pin 6	WDT	SCLK
Pin 7	nWDR	SDO
Pin 8	WDI	SDI
Pin 9	PIN	nCS
Pin 12	nRST	nWDR

2.2 Onboard Microprocessor and GUI

Included in the TLIN14415EVM is an onboard microprocessor that works with a GUI developed for the TLINx441x family of devices. The GUI is available on the TI.com product page for the TLINx441x family by request of access. Not only does the interface software help to configure and control the LIN SBC, it was developed to be a learn-as-you-go experience, and to be a user guide for the EVM and device family in and of itself. The processor comes flashed with the proper firmware so that the user just has to plug in the board in with a USB 2.0 Mini-B connector and a USB 2.0 Type A connector to the controlling PC. This GUI runs through the user's internet browser (optimized for Google Chrome, but also works in Internet Explorer/Microsoft Edge and Mozilla Firefox), and have real-time control of the TLIN14415 device on the EVM.

2.3 Master and Slave Configurations

To place the LIN bus into slave configuration, remove the shunt on J8 to disconnect the external 1-k Ω resistor and series diode from the LIN bus per the LIN specification. To place the LIN bus master mode, place a shunt on J8 to connect the external 1-k Ω resistor and series diode to the LIN bus per the LIN specification.

2.4 Local Wake-up

The TLINx441x family of LIN SBCs features a local wake-up function on the WAKE pin. On the EVM, this function can be tested and used by populating the J20 jumper and using the S2 pushbutton. Populating the J7 jumper connects the WAKE pin to the pushbutton, which biases the WAKE pin to a divided down VSUP level (~90% of VSUP). When the S2 pushbutton is pressed, it pulls this level to GND, and thus shows a high to low transition on the pin. This triggers a local wake-up request, and place the device in STANDBY mode. If the voltage level needs to be adjusted, R7 and R8 can be switched out to change the resistor divider. Though this is a high voltage pin, there is also a circuit that brings this to a logic level, and is brought out to the J14 header on the EVM. There is also the option to connect this logic-level version of the WAKE pin to the onboard microprocessor for monitoring with the GUI; this connection is made by populating the R6 resistor with 0 Ω .

2.5 LIMP Monitoring

The LIMP pin is accessible through the J3 terminal block for connection to an external board using cables/wires. The LIMP signal is high-voltage, but like the WAKE signal, is connected to a circuit that outputs a logic level to be read by the onboard microprocessor. This can be used to monitor the status of the LIMP pin real-time by populating the R9 resistor with 0 Ω .

2.6 TXD and RXD

Access to the TXD and RXD pins is available on the J3 2x2 header on the board. GND pins are also included on this header to allow for easy driving using a function generator or return path for an oscilloscope probe. Pads to add capacitance to the TXD and RXD traces are available by using the C7 and C8 pads, respectively. The TXD header pin is connected directly to the TXD pin on the TLINx441x device, and can be used to drive a signal into the LIN bus. This signal can be read back on the RXD header pin, which is directly connected to the RXD pin on the TLINx441x device. TXD can also be connected to the onboard microprocessor. Through this connection and using the GUI, a square wave of frequency up to 20kHz can be applied to the TXD pin.

2.7 VCC Load Testing

J15 gives access to the integrated LDO output, with a GND connection on the other header pin for convenience. Loads can be applied here to test the stability and performance of the integrated LDO.

2.8 LED Indication

LEDs D3, D10, D11 and D13 indicate the state of the EN pin (D3), the state of the LIMP pin (D10), the state of the WAKE pin (D11), and the state of the PIN/nCS pin (D13). These LEDs can only be connected to their respective signals if the sliders on S5 are in the "On" position, as indicated on the S1 component. Resistors R19, R21, R22, and R23 need to be populated for the LEDs to be powered once enabled on S5. It is recommended that 5kΩ resistors are populated for proper function and brightness.

2.9 SPI Interface

The SPI interface pins (SDO, SDI, SCLK, nCS) are all connected to header J14 (all other digital signals are connected to this header as well) for user access to any kind of microprocessor or controller board that they may use. There is also the option to connect the SPI pins to the onboard microprocessor using jumpers J6, J7, J8, and J9. The SPI pins are only available in SPI mode, otherwise the pins serve a separate function, shown in [Table 1](#).

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

[Table 2](#), [Table 3](#), and [Table 4](#) list all the jumpers, headers, connectors, test points, and switches and explain their functions.

Table 2. Jumpers, Headers, and Connectors

Designator	Function
J1	Banana jack connector for the positive voltage supply of the device, connected to the VSUP pin
J2	Banana jack connector for the negative, or the return path of the voltage supply of the device, connected to the GND pin
J3	Terminal block with connections for GND and the LIMP pin output
J4 & J25	Configuration options for the EN/nINT pin <ul style="list-style-type: none"> • Jumper populated 1-2: EN/nINT is connected to the microprocessor • Jumper populated 2-3: EN/nINT is connected to VCC • Jumper populated 2-J25: EN/nINT is connected to GND
J5	Jumper to connect RST/nWDR to the microprocessor
J6	Jumper to connect PIN/nCS to the microprocessor
J7	Jumper to connect nWDR/SDO to the microprocessor
J8	Configuration options for the WDI/SDI pin <ul style="list-style-type: none"> • Jumper populated 1-2: WDI/SDI is connected to the microprocessor • Jumper populated 2-3: WDI/SDI is connected to GND through a 10kΩ resistor
J9 & J23	Configuration options for the WDT/SCLK pin <ul style="list-style-type: none"> • Jumper populated 1-2: WDT/SCLK is connected to VCC • Jumper populated 2-3: WDT/SCLK is connected to the microprocessor • Jumper populated 2-J23: WDT/SCLK is connected to GND

Table 2. Jumpers, Headers, and Connectors (continued)

Designator	Function
J10	Populating this jumper will short through S1 switch, which allows the flashing of the microprocessor
J11	The USB Mini-B connector to connect to the controlling PC to the microprocessor
J12	Jumper to connect TXD to the microprocessor
J13	Jumper to configure the LIN bus for master or slave mode. Connecting a shunt places the LIN bus into master configuration, leaving it open places the LIN bus into slave configuration.
J14	18-pin header with all the digital signals of the device brought out. <ul style="list-style-type: none"> • Pin 1: VCC • Pin 3: RST/nWDR • Pin 5: WDT/SCLK • Pin 7: nWDR/SDO • Pin 9: WDI/SDI • Pin 11: PIN/nCS • Pin 13: WAKE logic signal • Pin 15: EN/nINT • Pin 17: LIMP logic signal • All even numbered pins are connected to GND
J15	Header with GND on pin 1 and VCC on pin 2, for applying loads to VCC and/or probing the voltage output.
J16	Jumper to apply a pull-up voltage to the RXD pin. Connecting a shunt connects VCC through a 10.2kΩ resistor, leaving it open has no pull-up on the signal.
J17	Jumper to connect the LIMP pin to the comparator circuit creating the logic-level version of the LIMP signal.
J18	Jumper to connect the WAKE pin to the comparator circuit creating the logic-level version of the WAKE signal.
J19	Connector for specific testing, only necessary for internal use.
J20	Jumper to connect WAKE to the pushbutton wake circuit for local wake up function by the user.
J21	3-pin header with GND on pin 1, LIN bus on pin 2, and VSUP on pin 3. This is for any LIN controller connectors the user may want to utilize with the EVM.
J22	Jumper to connect PIN/nCS. Shunting this on power up forces the device into PIN mode, otherwise the device powers up in SPI mode.
J24	Connector for specific testing, only necessary for internal use.
J26	Header for control and monitoring of TXD and RXD. Pins 1 and 3 are connect to RXD and TXD respectively, pins 2 and 4 are connected to GND.

Table 3. Test Points

Designator	Function
TP1	Test point to monitor LIMP
TP2	Test point to monitor WAKE
TP3	Test point to monitor 5V from USB connection in microprocessor circuit.
TP4 & TP5	GND Connections
TP6	Test point to monitor 3.3V LDO output in the microprocessor circuit.

Table 4. Switches

Designator	Function
S1	Hold this switch down when applying power to the microprocessor to allow flashing of the processor. Only necessary for internal use.
S2	Pushbutton switch for local wake up function.
S3	Button switch to enable notification LEDs for LIMP, WAKE, EN/nINT, and PIN/nCS.

4 Schematic and Bill of Materials

4.1 Schematic

Figure 2 illustrates the EVM schematic.

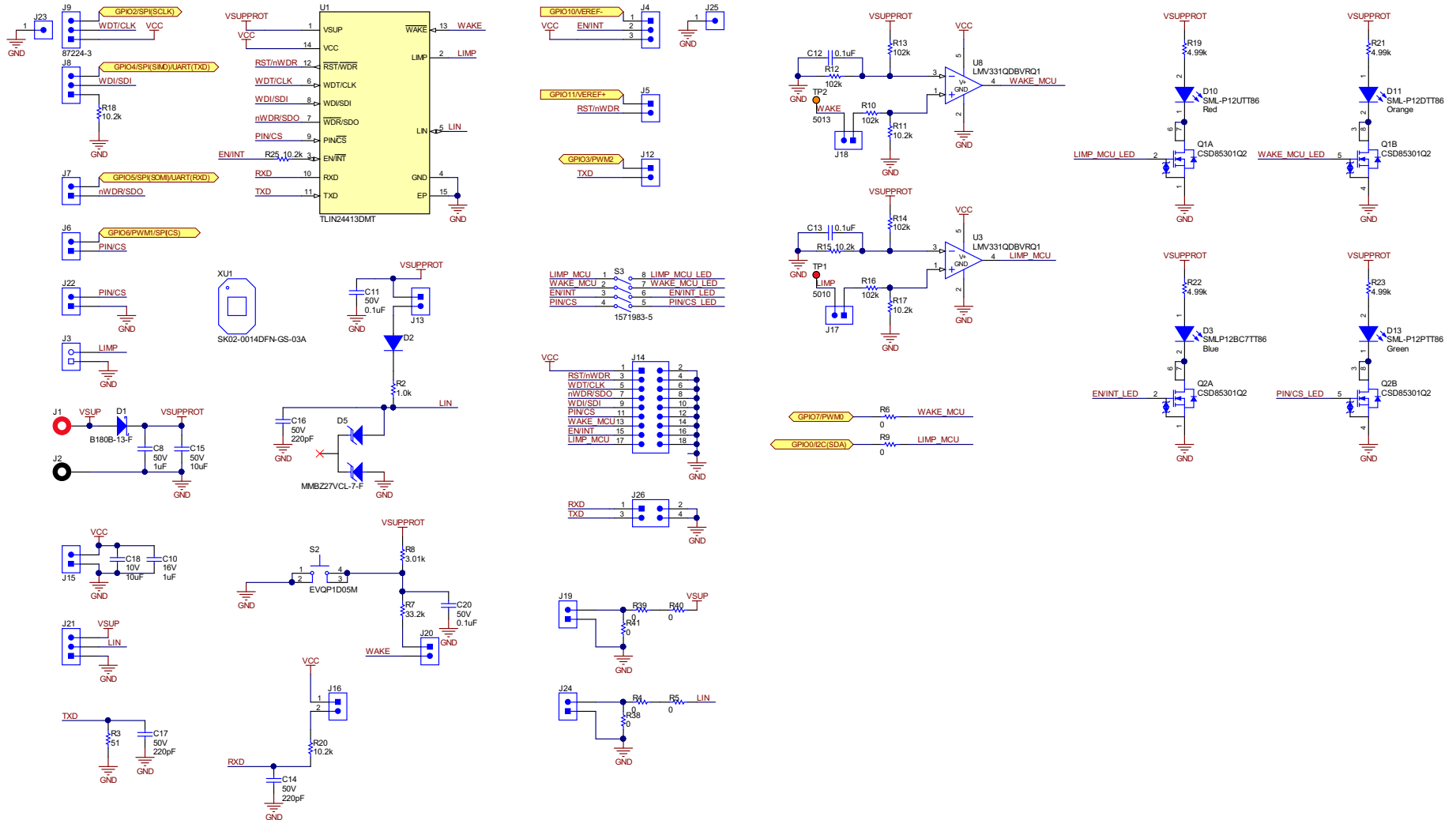


Figure 2. TLIN14415EVM Schematic LIN SBC

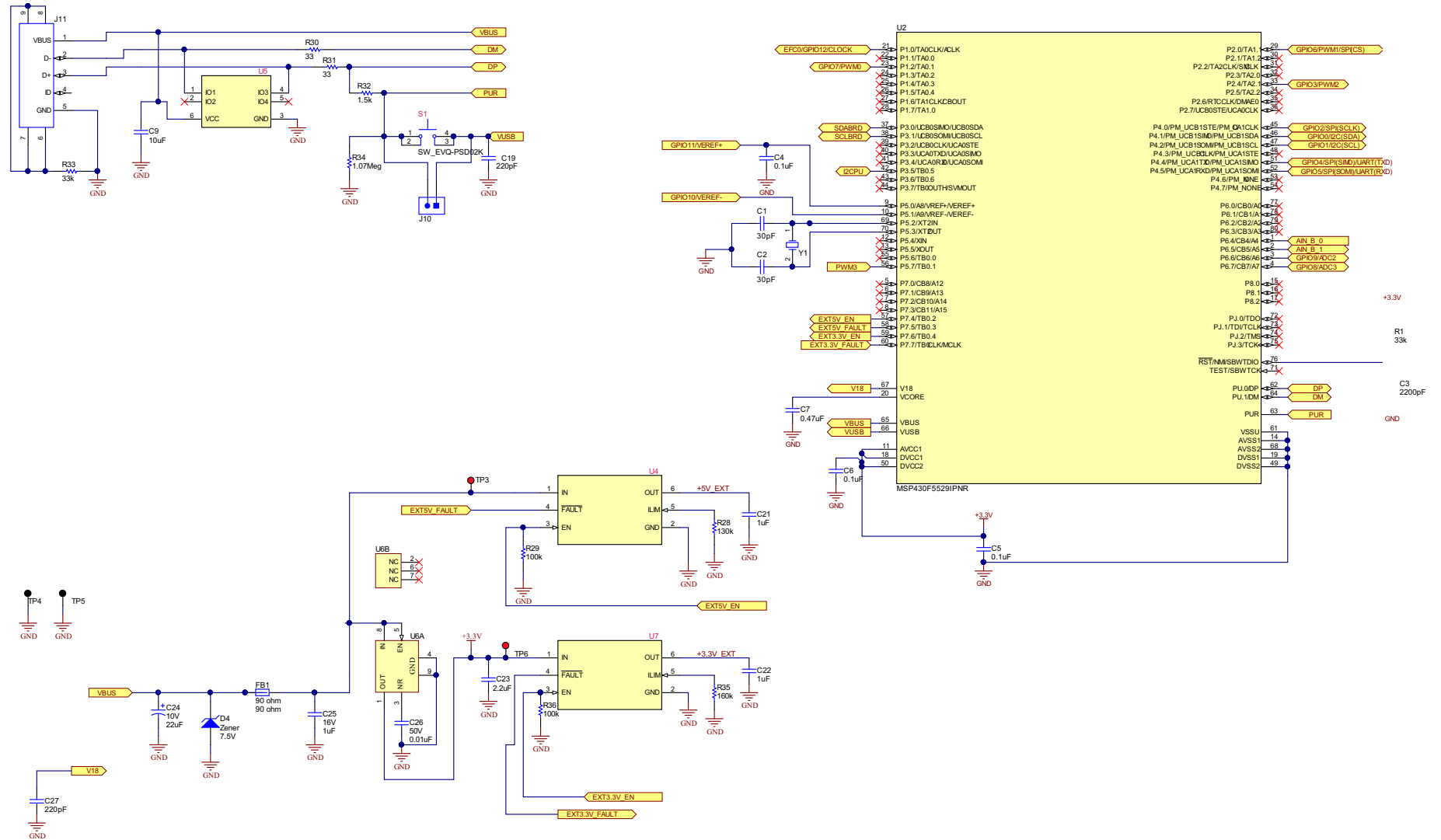


Figure 3. TLIN14415EVM Schematic USB2ANY

4.2 Bill of Materials

Table 5 lists the EVM BOM.

Table 5. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
C1, C2	2	30pF	CAP, CERM, 30 pF, 100 V, +/- 5%, C0G/NP0, 0603	0603	GRM1885C2A300JA01D	MuRata
C3	1	2200pF	CAP, CERM, 2200 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603X222K5RACTU	Kemet
C4, C5, C6	3	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 5%, X7R, 0603	0603	0603YC104JAT2A	AVX
C7	1	0.47uF	CAP, CERM, 0.47 uF, 10 V, +/- 10%, X7R, 0603	0603	C0603C474K8RACTU	Kemet
C8	1	1uF	CAP, CERM, 1 uF, 50 V, +/- 10%, X7R, 0805	0805	C0805C105K5RACTU	Kemet
C9	1	10uF	CAP, CERM, 10 uF, 16 V, +/- 20%, X5R, 0805	0805	0805YD106MAT2A	AVX
C10	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	GCM188R71C105KA64D	MuRata
C11, C12, C13	3	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	885012206095	Würth Elektronik
C15	1	10uF	CAP, CERM, 10 uF, 50 V, +/- 10%, X7T, 1206_190	1206_190	GCM31CD71H106K	MuRata
C18	1	10uF	CAP, CERM, 10 uF, 10 V, +/- 10%, X7R, 0805	0805	885012207026	Würth Elektronik
C19, C27	2	220pF	CAP, CERM, 220 pF, 50 V, +/- 1%, C0G/NP0, 0603	0603	06035A221FAT2A	AVX
C20	1	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H104K080AA	TDK
C21, C22	2	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X5R, 0805	0805	0805YD105KAT2A	AVX
C23	1	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X5R, 0805	0805	0805YD225KAT2A	AVX
C24	1	22uF	CAP ALUM 22UF 10V 20% SMD	E55	EEE-1AA220WR	Panasonic - ECG
C25	1	1uF	CAP, CERM, 1 uF, 16 V, +/- 10%, X7R, 0805	0805	C0805C105K4RACTU	Kemet
C26	1	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 10%, X7R, 0603	0603	C1608X7R1H103K080AA	TDK
D1	1	80V	Diode, Schottky, 80 V, 1 A, SMB	SMB	B180B-13-F	Diodes Inc.
D2	1	150V	Diode, P-N, 150 V, 0.2 A, SOD-323	SOD-323	BAV20WS-TP	Micro Commercial Components
D3	1	Blue	LED, Blue, SMD	Blue LED	SMLP12BC7TT86	Rohm
D4	1	7.5V	Diode, Zener, 7.5 V, 550 mW, SMB	SMB	1SMB5922BT3G	ON Semiconductor
D10	1	Red	LED, Red, SMD	LED, 1x.2x.6mm	SML-P12UTT86	Rohm
D11	1	Orange	LED, Orange, SMD	Orange LED	SML-P12DTT86	Rohm
D13	1	Green	LED, Green, SMD	LED, 1x.2x.6mm	SML-P12PTT86	Rohm
FB1	1	90 ohm	Ferrite Bead, 90 ohm @ 100 MHz, 1.5 A, 1206	1206	MI1206K900R-10	Laird-Signal Integrity Products
H1, H2, H3, H4	4		Machine Screw, Round, 4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B and F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L 4-40 Nylon	Standoff	1902C	Keystone
J1	1		BANANA JACK, SOLDER LUG, RED, TH	Red Insulated Banana Jack	SPC15363	Tenma
J2	1		BANANA JACK, SOLDER LUG, BLACK, TH	Black Insulated Banana Jack	SPC15354	Tenma
J3	1		Terminal Block, 5.08 mm, 2x1, TH	2POS Terminal Block	1715721	Phoenix Contact
J4	1		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec
J5, J6, J7, J10, J12, J17, J18, J22	8		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54 mm, 2x1, TH	GBC02SAAN	Sullins Connector Solutions
J8, J9	2		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	87224-3	TE Connectivity
J11	1		Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	USB Mini Type B	1734035-2	TE Connectivity
J13, J15, J20	3		Header, 100mil, 2x1, Gold, TH	Header, 2x1, 100mil	5-146261-1	TE Connectivity

Table 5. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
J16	1		Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator	PBC02SAAN	Sullins Connector Solutions
J21	1		Header, 100mil, 3x1, Gold, TH	PBC03SAAN	PBC03SAAN	Sullins Connector Solutions
J23, J25	2		Header, 2.54 mm, 1x1, Gold, TH	Header, 2.54 mm, 1x1, TH	61300111121	Würth Elektronik
J26	1		Header, 2.54mm, 2x2, Gold, TH	Header, 2.54mm, 2x2, TH	PBC02DAAN	Sullins Connector Solutions
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650 x 0.200 inch	THT-14-423-10	Brady
Q1, Q2	2	20V	MOSFET, 2-CH, N-CH, 20 V, 6.7 A, DQK0006B (WSON-6)	DQK0006B	CSD85301Q2	Texas Instruments
R1, R33	2	33k	RES, 33 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233K0JNED	Vishay-Dale
R2	1	1.0k	RES, 1.0 k, 5%, 0.1 W, 0603	0603	CRCW06031K00JNEA	Vishay-Dale
R6, R9	2	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R7	1	33.2k	RES, 33.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0733K2L	Yageo America
R8	1	3.01k	RES, 3.01 k, 1%, 0.1 W, 0603	0603	CRCW06033K01FKEA	Vishay-Dale
R10, R13, R14, R16	4	102k	RES, 102 k, 1%, 0.1 W, 0603	0603	RC0603FR-07102KL	Yageo America
R11, R12, R15, R17, R20, R25	6	10.2k	RES, 10.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710K2L	Yageo America
R18	1	10.2k	RES, 10.2 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060310K2FKEA	Vishay-Dale
R19, R21, R22, R23	4	4.99k	RES, 4.99 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K99FKEA	Vishay-Dale
R28	1	130k	RES, 130 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402130KJNED	Vishay-Dale
R29, R36	2	100k	RES, 100 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100KJNED	Vishay-Dale
R30, R31	2	33	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040233R0JNED	Vishay-Dale
R32	1	1.5k	RES, 1.5 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K50JNED	Vishay-Dale
R34	1	1.07Meg	RES, 1.07 M, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031M07FKEA	Vishay-Dale
R35	1	160k	RES, 160 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402160KJNED	Vishay-Dale
S1	1		Switch, Tactile, SPST-NO, SMT	Switch, 6.1x1.8x4.6 mm	EVQ-PSD02K	Panasonic
S2	1		Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	6x5x6 mm	EVQP1D05M	Panasonic
S5	1		Switch, SPST, 4 Pos, Top Actuated, SMD	SMD, 8-Leads, Pitch 1.27mm	1571983-5	TE Connectivity
TP1, TP6	2		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone
TP2	1		Test Point, Multipurpose, Orange, TH	Orange Multipurpose Testpoint	5013	Keystone
TP3	1		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP4, TP5	2		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		Automotive Local Interconnect Network Transceiver, DMT0014A (VSON-14)	DMT0014A	TLIN24413DMT	Texas Instruments
U2	1		25 MHz Mixed Signal Microcontroller with 128 KB Flash, 8192 B SRAM and 63 GPIOs, -40 to 85 degC, 80-pin QFP (PN), Green (RoHS & no Sb/Br)	PN0080A	MSP430F5529IPNR	Texas Instruments
U3, U8	2		GENERAL-PURPOSE LOW-VOLTAGE COMPARATOR, DBV0005A (SOT-23-5)	DBV0005A	LMV331QDBVRQ1	Texas Instruments
U4, U7	2		Adjustable, Active High, Latch-off, Current-Limited Power-Distribution Switch, 0.075 to 1.7 A Current Limit, -40 to 85 degC, 6-pin SOT-23 (DBV), Green (RoHS & no Sb/Br)	DBV0006A	TPS2553DBVT-1	Texas Instruments
U5	1		4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	DRY0006A	TPD4E004DRYR	Texas Instruments

Table 5. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
U6	1		Single Output High PSRR LDO, 500 mA, Fixed 3.3 V Output, 2.7 to 6.5 V Input, with Low IQ, 8-pin SON (DRB), -40 to 125 degC, Green (RoHS & no Sb/Br)	DRB0008A	TPS73533DRBT	Texas Instruments
XU1	1		Socket, DFN-14, 0.65 mm	Socket, IC	SK02-0014DFN-GS-03A	RS Tech Incorporated
Y1	1		Crystal, 24.000 MHz, 20pF, SMD	Crystal, 11.4x4.3x3.8mm	ECS-240-20-5PX-TR	ECS Inc.
C14, C16, C17	0	220pF	CAP, CERM, 220 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603C221K5RACTU	Kemet
D5	0	27V	Diode, TVS, Uni, 27 V, 38 Vc, SOT-23	SOT-23	MMBZ27VCL-7-F	Diodes Inc.
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
J14	0		Header, 100mil, 9x2, Gold, TH	9x2 Header	TSW-109-07-G-D	Samtec
J19, J27	0		Header, 2.54mm, 2x1, Gold, SMT	Header, 2.54mm, 2x1, SMT	61000218321	Würth Elektronik
R3	0	51	RES, 51, 5%, 0.1 W, 0603	0603	CRCW060351R0JNEA	Vishay-Dale
R4, R5, R38, R39, R40, R41	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06030000Z0EA	Vishay-Dale

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 semiconductor 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.
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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3.4 *European Union*

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

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

4 *EVM Use Restrictions and Warnings:*

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

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

4.3 *Safety-Related Warnings and Restrictions:*

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

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

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

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

6. *Disclaimers:*
- 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
- 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.
7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.
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- 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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