LMH1219EVM Evaluation Board

User's Guide

Literature Number: SNLU185A
March 2016–Revised June 2018

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LMH1219EVM Evaluation Board

1 Overview

The LMH1219EVM Evaluation Board provides a complete high bandwidth platform to evaluate the SDI and 10 GbE signal conditioning features of the Texas Instruments LMH1219 UHD Cable Equalizer. The LMH1219EVM can be used for standard compliance testing, performance evaluation, and initial system prototyping. The SMA and BNC edge connectors used for the LMH1219EVM will interface to multiple system connector types via commercially available breakout cables, adaptors, and boards (not included). This flexible connectivity enables integrated system level testing between TI's 12G SDI Adaptive Cable Equalizer with Reclocker and 3rd party ASIC/FPGA host boards.

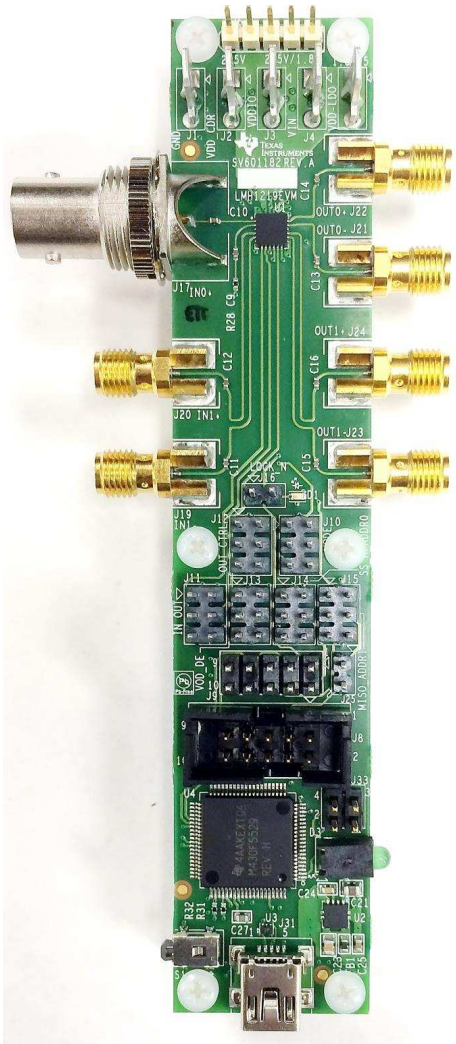

Figure 1. LMH1219EVM

2 Features

- Locks to standard SDI (2.97 Gbps, 1.485 Gbps, 270 Mbps, or divide-by-1.001 sub-rates), DVB-ASI (270 Mbps), ST-2081 (5.94 Gbps proposed and divide-by-1.001 subrates), ST-2082 (11.88 Gbps proposed and divide-by-1.001 subrates), and 10 GbE data rates
- Integrated 2:1 mux on input (one 75 Ω and one 100 Ω) and 1:2 fan-out 100 Ω output drivers with de-emphasis
- 75 Ω single-ended adaptive cable equalizer (IN0+) and 100 Ω differential adaptive or programmable FR4 trace equalizer (IN1±)
- Programmable by Pin, SPI, or SMBus Interface
- Can be operated using single (2.5 V) or dual (2.5 V and 1.8 V) supplies
- High speed signal flow–thru pinout package: 24-pin QFN (4 mm × 4 mm, 0.5 mm pitch)

3 Applications

- UHDTV/4K/8K/HDTV/SDTV Video
- Digital Video Routers and Switches
- Digital Video Processing and Editing
- DVB-ASI
- Distribution Amplifiers

4 Ordering Information

Table 1. LMH1219 Ordering Information

EVM ID	DEVICE ID	DEVICE PACKAGE
LMH1219EVM	LMH1219RTW	RTW0024A

5 Setup

This section describes the jumpers and connectors on the EVM as well as how to connect, set up, and use the LMH1219EVM. When operating the LMH1219EVM, signal inputs and outputs can be connected as shown in Figure 2.

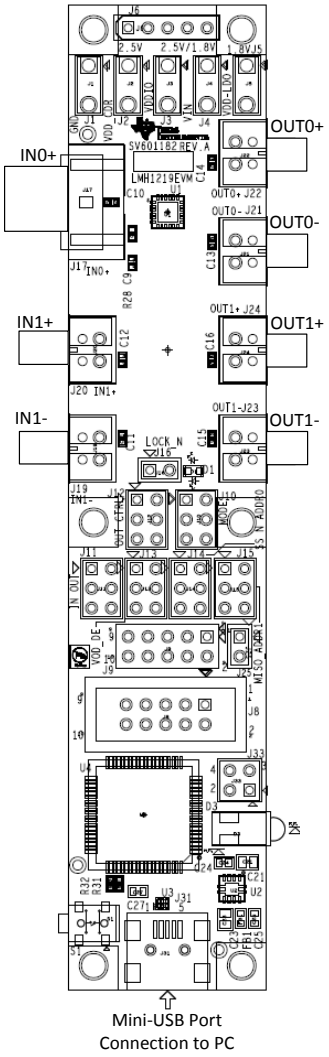

Figure 2. LMH1219EVM Input and Output Pins

5.1 Modes of Operation

The LMH1219EVM can be used in one of three modes:

1. **Pin Mode (Default)** – Provides general access to the LMH1219 signal integrity and control settings via IC pin-level logic.
2. **SPI Mode** – Provides full access to the LMH1219 signal integrity and control settings via MISO, MOSI, SCK, and SSN pins.
3. **SMBus Mode** – Provides full access to the LMH1219 signal integrity and control settings via SDA, SCL, and GND pins. ADDR0 and ADDR1 pins are used for SMBus address strap.

Using either SPI or SMBus mode, users have full access to all register controls in the LMH1219. For convenience, the LMH1219EVM features an on-chip MSP430 that is configured as a USB2ANY interface between LMH1219 and PC via the mini-USB port header on J31.

NOTE: Currently, the interface from PC to the LMH1219EVM on-board MSP430 can only support SMBus communication.

The external control pins on the LMH1219EVM are used to configure the default device settings. A 4-level input scheme across the control pin interface increases the amount of control levels available to the device with fewer physical pins. The channel settings and controls are configurable in pin mode for the LMH1219 4-logic levels (L, R, F, H). The four logic levels correspond to the following voltages in Table 2.

Table 2. Description of 4-Level Voltage Inputs

Level	Setting	Internal Pin Voltage (2.5 V Mode)
L	Tie 1 kΩ to GND	0.08 V
R	Tie 20 kΩ to GND	1/3 x VDD
F	Float (Leave Pin Open)	2/3 x VDD
H	Tie 1 kΩ to VIN or VDD	VDD – 0.04 V

Typical 4-Level Input Thresholds:

- Internal Threshold between 0 and R = 0.2 × VDD
- Internal Threshold between R and F = 0.5 × VDD
- Internal Threshold between F and 1 = 0.8 × VDD

In order to set these 4-level voltage inputs, each input is controlled by a group of 6 jumper pins set in accordance with Figure 3.

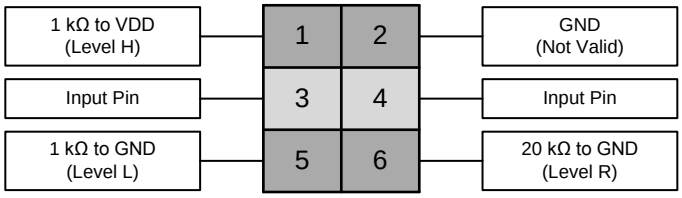

Figure 3. Jumper Orientation for User Configuration

Therefore, the following jumper positions allow access to each of the four logic levels:

Level	Jumper Ties
H	Pin 1-3
F	Pin 3-4 (or no connect)
R	Pin 4-6
L	Pin 3-5

The following jumpers have 4-level input control: J10, J11, J12, J13, J14, J15.

In Pin Mode, IN_OUT_SEL, OUT_CTRL, and VOD_DE pins control different LMH1219 settings. Using SPI or SMBus, these initial pin control values can be overridden by setting the appropriate override bits via register control. Both SPI and SMBus interfaces allow full control over a wide range of device settings. See Table 3 and Table 4 for jumper descriptions and differences.

Table 3. Description of Connections in SPI Mode (MODE_SEL = Level F)

Component	Name	Description/Function
J1	GND	GND power supply
J2	VDD_CDR	2.5 V VDD_CDR power supply
J3	VDDIO	2.5 V VDDIO power supply. Refer to the LMH1219 datasheet for different power options.
J4	VIN	2.5 V or 1.8 V power supply. When VIN is powered from 2.5 V, VDD_LDO is the output of the on-chip LDO regulator. When VIN is powered from 1.8 V, both VIN and VDD_LDO should be connected to 1.8 V supply.
J5	VDD_LDO	1.8 V LDO regulator output when VIN is connected to 2.5 V supply. VDD_LDO must be connected to 1.8 V supply if VIN is 1.8 V.
J6		VDDIO selection. Shunt Pin 1 and 2 to tie VDDIO and VDD_CDR. Shunt Pin 3 and 4 to tie VDDIO to VIN.
J8	SPI Access	SPI access pins. See EVM schematic for detailed pin-out information.
J9	SPI Access	For SPI mode, install Pin 1-2, 3-4, and 5-6 for SPI 3.3 V to 2.5 V level shift. Leave Pin 7-10 open. See datasheet for additional information on SPI operation.
J10	MODE_SEL	Level F: SPI Mode
J11	IN_OUT_SEL	IN_OUT_SEL selects the signal flow at input ports to output ports. See datasheet and EVM schematic for additional operation information.
J12	OUT_CTRL	OUT_CTRL selects the signal flow from the selected IN port to OUT1± and OUT0±. It selects reclocked data, reclocked data and clock, bypass reclocker (equalized data route to output driver), or both equalizer and reclocker bypassed. See datasheet and EVM schematic for additional operation information.
J13	VOD_DE	VOD_DE selects the driver output amplitude and de-emphasis level for both OUT0± and OUT1±. See datasheet and EVM schematic for additional operation information.
J14	SS_N	Slave Select. When SS_N is at logic low, it enables SPI access to the LMH1219 slave device.
J15		These pins should only be used for SMBus mode. Leave pins floating for proper SPI operation.
J16	LOCK_N	Reclocker lock indicator for the selected input. Shunt Pin 1 and 2 for proper operation. LOCK_N pin can be reconfigured to indicate CD_N or INT_N for IN0 or IN1 through register programming.
J25	MISO	Shunt Pin 1 and 2 to connect MISO signal to J8 for proper SPI mode operation.

Table 4. Description of Connections in SMBus Mode (MODE_SEL = Level L)

Component	Name	Description/Function
J8	SMBus Access	SMBus access pins. See EVM schematic for detailed pin-out information.
J9	SMBus Access	External 2 kΩ pull-up resistor to 3.3 V supply. Install shunt jumpers on Pin 7-8 and 9-10 for proper operation. Leave Pins 1-6 open. See datasheet for additional information on SPI operation.
J14	ADDR0	4-Level strap pins to determine up to 16 unique SMBus address with J15 to create AD[1:0]. See datasheet for different SMBus address combinations.
J15	ADDR1	4-Level strap pins to determine up to 16 unique SMBus address with J14 to create AD[1:0]. See datasheet for different SMBus address combinations.
J10	MODE_SEL	Level L: SMBus Mode
J25		Leave Pin 1 and 2 open for proper SMBus mode operation.

NOTE: Jumpers not listed in Table 4 are identical to the functions mentioned in Table 3.

Table 5. Input and Output Channel Connections

Signal Inputs and Outputs	
Junction Numbers	**Function**
J17	IN0+ (BNC Single-Ended)
J20, J19	IN1+, IN1- (SMA)
J22, J21	OUT0+, OUT0- (SMA)
J24, J23	OUT1+, OUT1- (SMA)

5.2 Single and Dual Supply Operation

The LMH1219 can be configured to operate with either a single supply (2.5 V only) or dual supply (2.5 V and 1.8 V). Using the LMH1219 in dual supply mode lowers the overall device power consumption. For proper operation, VDD_CDR and VDDIO pins must be connected to a 2.5 V supply. In single supply mode, VIN should be connected to a 2.5 V supply and VDD_LDO should be left unconnected. In dual supply mode, both VIN and VDD_LDO should be connected to a 1.8 V supply. To configure the LMH1219EVM for single supply or dual supply operation, reference the following connection requirements.

Table 6. LMH1219EVM Power Supply Pin Configurations

Mode of Operation	Description of Required Settings
Single Supply Mode: VDD_CDR, VDDIO, VIN = 2.5 V	• Shunt J6 Pin 1 (VDD_CDR) to J6 Pin 2 (VDDIO). • Shunt J6 Pin 3 (VDDIO) to J6 Pin 4 (VIN). • Apply 2.5 V supply to J4 (VIN). • Apply GND to J1 (GND).
Dual Supply Mode: VDD_CDR, VDDIO = 2.5 V VIN, VDD_LDO = 1.8 V	• Shunt J6 Pin 1 (VDD_CDR) to J6 Pin 2 (VDDIO). • Shunt J6 Pin 4 (VIN) to J6 Pin 5 (VDD_LDO). • Apply 2.5 V supply to J1 (VDD_CDR). • Apply 1.8 V supply to J4 (VIN). • Apply GND to J1 (GND).

5.3 Software/Hardware Description and Setup

By factory default, the LMH1219EVM is configured to accept a valid SDI signal on IN0 and output the retimed data on OUT0 and OUT1 without programming the LMH1219 beforehand.

The general procedure for setting up and testing with the LMH1219EVM is as follows. For hardware setup and connections in the steps below, reference the illustration in Figure 4.

1. Connect 2.5 V power (0.5 A maximum) to the EVM and verify the appropriate default installed shunt jumper placements to operate in Single Supply, SMBus Mode:
    1. Connect J4: VIN = 2.5 V and J1: GND.
        1. Install shunt jumper on J6 Pins 1-2 and 3-4.
    2. Set the control switches for appropriate operation.
        1. Install shunt jumpers on J9 Pins 7-8 and Pins 9-10.
        2. Install shunt jumper on J10 Pins 3-5.
        3. Install shunt jumper on J11 Pins 1-3.
        4. Install shunt jumper on J13 Pins 1-3.
        5. Install shunt jumper on J14 Pins 3-5.
        6. Install shunt jumper on J15 Pins 3-5.
        7. Install shunt jumpers on J16 Pins 1-2.
2. Connect PC to LMH1219EVM with a USB-to-miniUSB cable via miniUSB port located on J31 of the LMH1219EVM. The LMH1219's control and signal integrity settings are programmable with SigCon Architect, a GUI which supports full register access through SMBus communication. For more information about Sigcon Architect, reference the "SigCon Architect: Installation and Starter's Guide"

(SNLU178).

3. Connect the LMH1219EVM to the system under test.
   1. The input signal on J17 can be connected to a video signal generator over 75 Ω coax cable. Alternatively, the LMH1218EVM can be used as a 100 Ω differential-to-75 Ω single-ended converter. Then, the LMH1218's 75 Ω OUT0+ can be used as an input to the LMH1219's IN0+.
   2. The output signals on J22 and J21 can be connected with matched 100 Ω differential cables to a high-speed scope to view the output eye diagram.
   3. The output signals on J24 and J23 can be connected with matched 100 Ω differential cables to a BERT to view the output bit error rate.

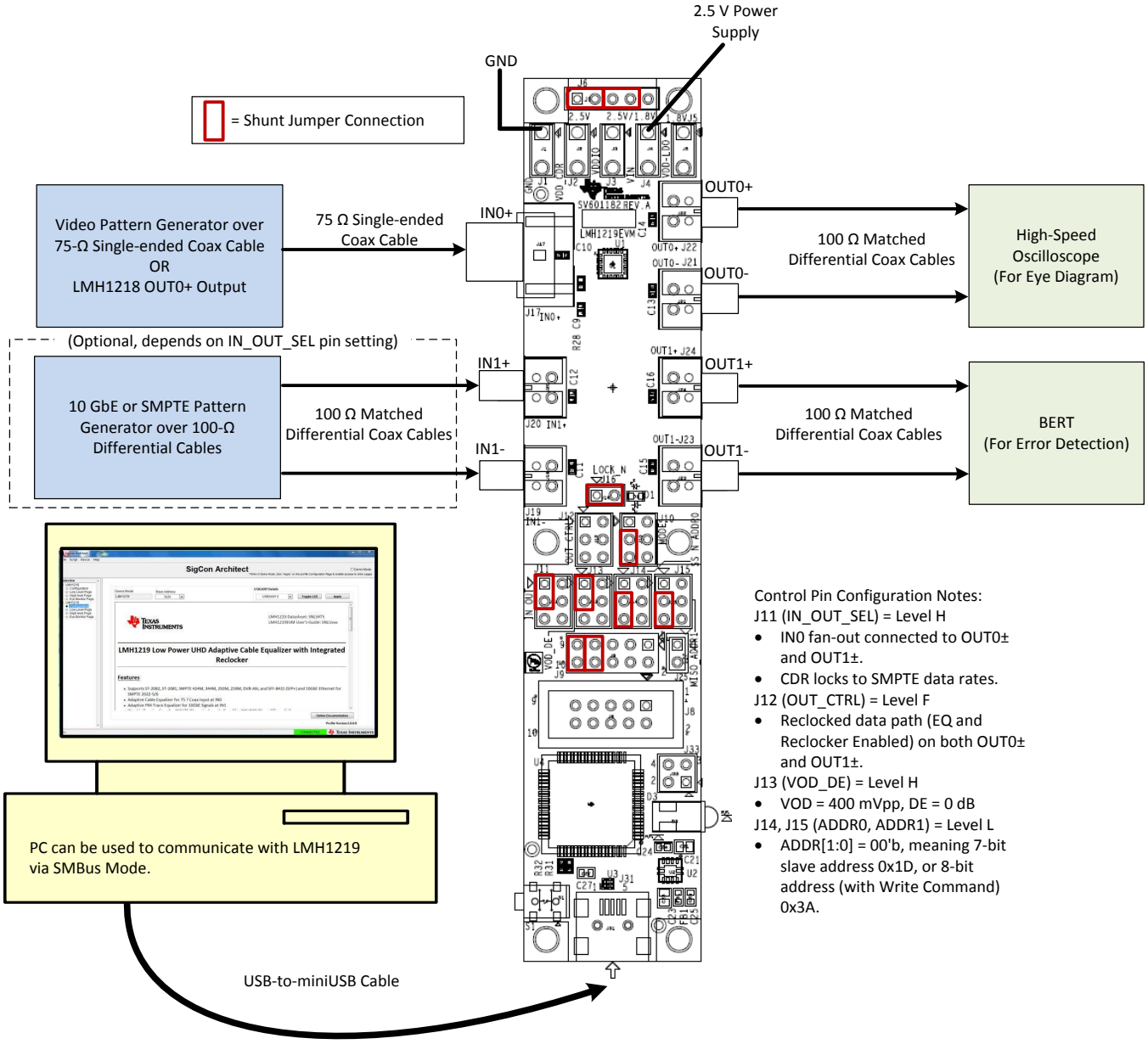

Figure 4. LMH1219EVM Default Setup for Single Supply and SMBus Operation with SigCon Architect

5.4 Retimed Output at 11.88G, 5.94G, 2.97G, 1.485G, 270M, and 10.3125G

Figure 5 to Figure 10 show the retimed output eye of differential OUT0- and OUT0+ under the following conditions:

- Input Signal: PRBS-10, 800 mV Launch Amplitude on IN0+, 800 mVpp Launch Amplitude on IN1±
- VDD = 2.5 V, T = 25°C

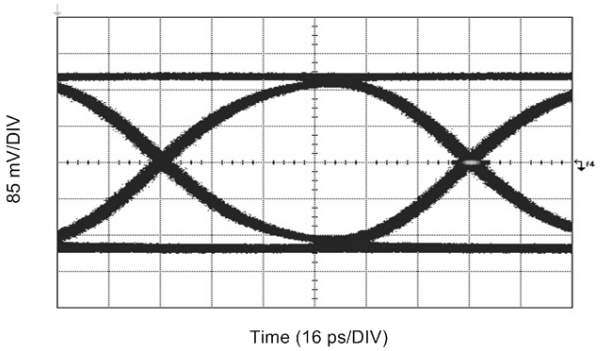

Figure 5. OUT0 Retimed Output with FR4 Input Trace on IN1± at 10.3125 Gbps

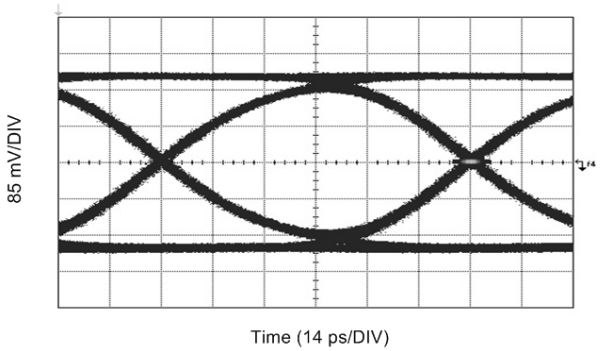

Figure 6. OUT0 Retimed Output with Belden 1694A Input Cable on IN0+ at 11.88 Gbps

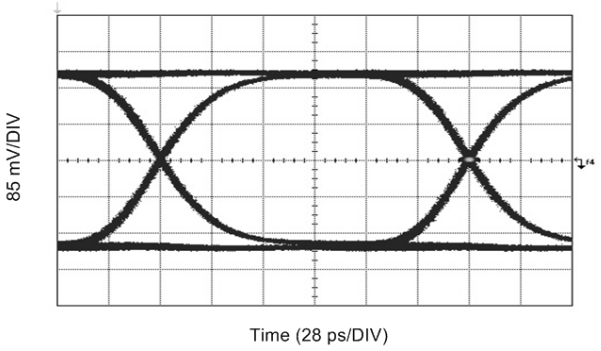

Figure 7. OUT0 Retimed Output with Belden 1694A Input Cable on IN0+ at 5.94 Gbps

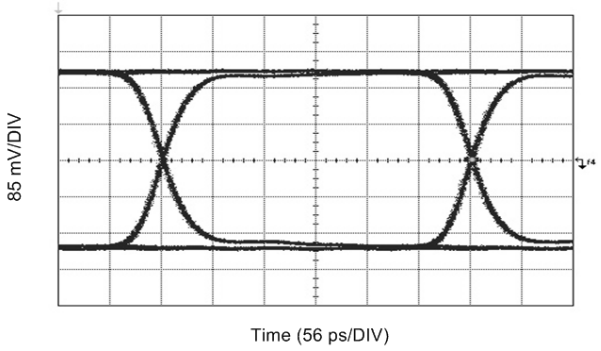

Figure 8. OUT0 Retimed Output with Belden 1694A Input Cable on IN0+ at 2.97 Gbps

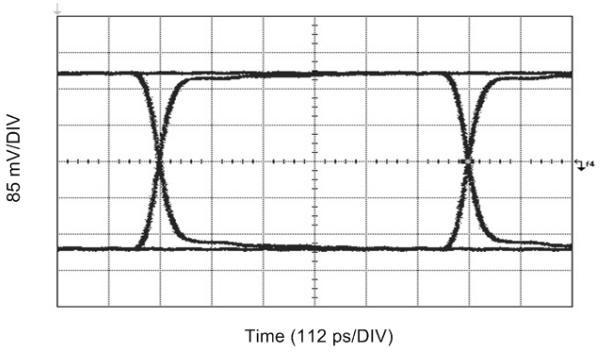

Figure 9. OUT0 Retimed Output with Belden 1694A Input Cable on IN0+ at 1.485 Gbps

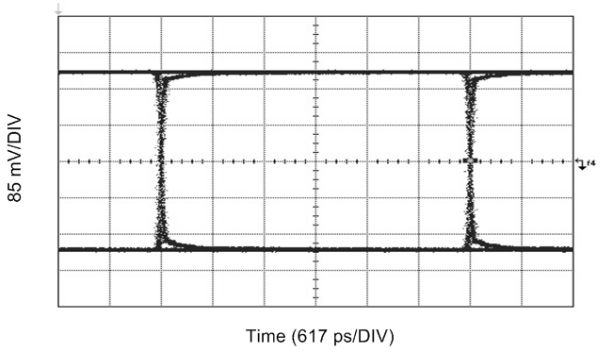

Figure 10. OUT0 Retimed Output with Belden 1694A Input Cable on IN0+ at 270 Mbps

6 Bill of Materials

#	Designator	Quantity	Description	Manufacturer	PartNumber
1	!PCB	1	Any	SV601182	Printed Circuit Board
2	C1	1	AVX	0805YD106MAT2A	CAP, CERM, 10uF, 16V, +/-20%, X5R, 0805
3	C2, C3, C4, C23	4	AVX	0805YD105KAT2A	CAP, CERM, 1uF, 16V, +/-10%, X5R, 0805, CAP, CERM, 1uF, 16V, +/-10%, X5R, 0805, CAP, CERM, 1uF, 16V, +/-10%, X5R, 0805, CAP, CERM, 1 µF, 16 V, +/- 10%, X5R, 0805
4	C5, C6, C7, C8	4	TDK	C1005X5R0J104K	CAP, CERM, 0.1 µF, 6.3 V, +/- 10%, X5R, 0402
5	C9, C10, C11, C12, C13, C14, C15, C16	8	TDK	C1005X5R1A475K050BC	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X5R, 0402
6	C17	1	TDK	C1005X5R0J105M	CAP, CERM, 1 µF, 6.3 V, +/- 20%, X5R, 0402
7	C21	1	AVX	0805YD225KAT2A	CAP, CERM, 2.2uF, 16V, +/-10%, X5R, 0805
8	C22	1	Chemi-Con	EMVE100ADA220ME55G	CAP, AL, 22 µF, 10 V, +/- 20%, ohm, SMD
9	C24	1	TDK	C1608X7R1H103K	CAP, CERM, 0.01 µF, 50 V, +/- 10%, X7R, 0603
10	C25, C31, C32, C34	4	CAP, CERM, 0.1uF, 16V, +/-5%, X7R, 0603	AVX	0603YC104JAT2A
11	C26, C27	2	CAP, CERM, 220pF, 50V, +/-1%, C0G/NP0, 0603	AVX	06035A221FAT2A
12	C28, C29	2	CAP, CERM, 30pF, 100V, +/-5%, C0G/NP0, 0603	MuRata	GRM1885C2A300JA01D
13	C30	1	CAP, CERM, 2200pF, 50V, +/-10%, X7R, 0603	Kemet	C0603X222K5RACTU
14	C33	1	CAP, CERM, 0.47uF, 10V, +/-10%, X7R, 0603	MuRata	GRM188R71A474KA61D
15	D1	1	LED, Green, SMD	Lumex	SML-LX0603GW-TR
16	D2	1	Diode, Zener, 7.5 V, 550 mW, SMB	ON Semiconductor	1SMB5922BT3G
17	D3	1	LED, Green, SMD	Lumex	SSF-LXH305GD-TR
18	FB1	1	Ferrite Bead, 60 ohm @ 100 MHz, 0.8 A, 0603	Taiyo Yuden	BK1608HS600-T
19	H1, H2, H3, H4, H5, H6	6	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	B&F Fastener Supply	NY PMS 440 0025 PH
20	H7, H8, H9, H10, H11, H12	6	Standoff, Hex, 0.5"L #4-40 Nylon	Keystone	1902C
21	J1, J2, J3, J4, J5	5	Disconnect Terminal, 5.08mm, 2x1, Tin, TH	Keystone	1212-ST
22	J6	1	Header, 100mil, 5x1, Gold, TH	Samtec	HTSW-105-07-G-S
23	J8	1	Header (shrouded), 100mil, 5x2, Gold, TH	TE Connectivity	5103308-1
24	J9	1	Header, 100mil, 5x2, Tin, TH	Sullins Connector Solutions	PEC05DAAN
25	J10, J11, J12, J13, J14, J15	6	Header, 100mil, 3x2, Tin, TH	TE Connectivity	5-146254-3
26	J16, J25	2	Header, 100mil, 2x1, Tin, TH	TE Connectivity	5-146278-2
27	J17	1	Connector, BNC Edge Mount, SMD	Samtec	BNC7T-J-P-GN-ST-EM1D
28	J19, J20, J21, J22, J23, J24	6	Connector, TH, End launch SMA 50 ohm	Emerson Network Power	142-0771-821

#	Designator	Quantity	Description	Manufacturer	PartNumber
29	J31	1	Connector, Receptacle, Mini-USB Type B, R/A, Top Mount SMT	TE Connectivity	1734035-2
30	J33	1	Header, 100mil, 2x2, Gold, TH	Samtec	TSW-102-07-G-D
31	Q1	1	MOSFET, N-CH, 50 V, 0.22 A, SOT-23	Fairchild Semiconductor	BSS138
32	R1, R2	2	RES, 2.00k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04022K00FKED
33	R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14	12	RES, 1.00k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04021K00FKED
34	R15, R16, R17, R18, R19, R20	6	RES, 20.0k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040220K0FKED
35	R21	1	RES, 220 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW0402220RJNED
36	R22, R23, R24	3	RES, 3.16k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04023K16FKED
37	R25, R26, R27	3	RES, 9.76k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04029K76FKED
38	R28	1	RES, 75.0 ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW040275R0FKED
39	R31, R32	2	RES, 33 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040233R0JNED
40	R33	1	RES, 1.5 k, 5%, 0.063 W, 0402	Vishay-Dale	CRCW04021K50JNED
41	R34, R36	2	RES, 33k ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040233K0JNED
42	R35	1	RES, 1.2Meg ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031M20JNEA
43	R37	1	RES, 200 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603200RFKEA
44	S1	1	Switch, Tactile, SPST-NO, SMT	Panasonic	EVQ-PSD02K
45	SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9, SH-J10, SH-J11	11	Shunt, 100mil, Gold plated, Black	3M	969102-0000-DA
46	U1	1	Low Power 12G UHD Adaptive Cable Equalizer with Integrated Reclocker, RTW0024A	Texas Instruments	LMH1219RTWR
47	U2	1	500mA, Low Quiescent Current, Ultra-Low Noise, High PSRR Low-Dropout Linear Regulator, DRB0008A	Texas Instruments	TPS73533DRBR
48	U3	1	ESD-Protection Array for High-Speed Data Interfaces, 4 Channels, -40 to +85 degC, 6-pin SON (DRY), Green (RoHS & no Sb/Br)	Texas Instruments	TPD4E004DRYR
49	U4	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)	Texas Instruments	MSP430F5529IPN
50	Y1	1	Crystal, 24.000MHz, 20pF, SMD	ECS Inc.	ECS-240-20-5PX-TR
51	FID1, FID2, FID3, FID4, FID5, FID6	0	Fiducial mark. There is nothing to buy or mount.	N/A	N/A

7 Schematic

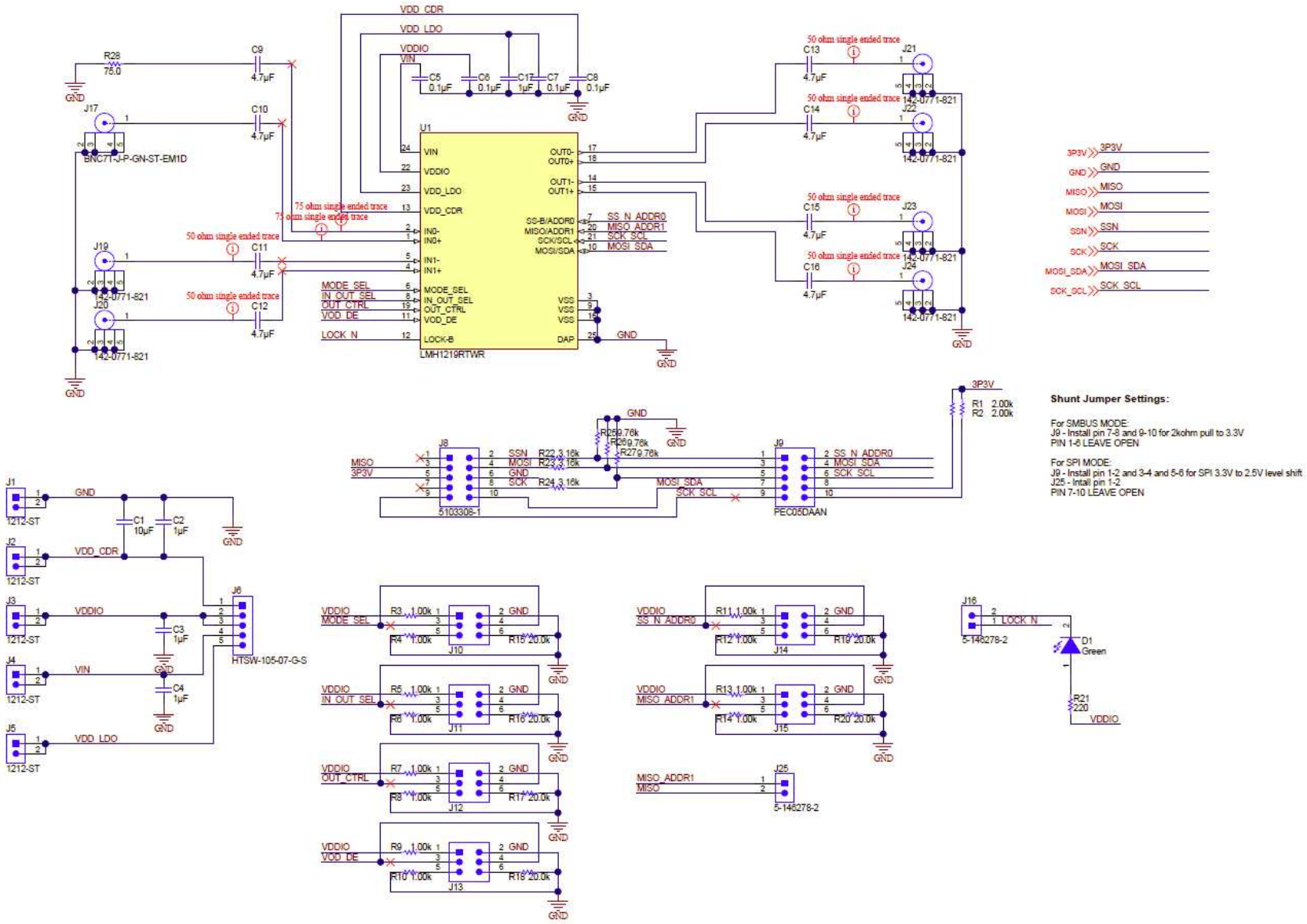

Figure 11. LMH1219 Schematic Page

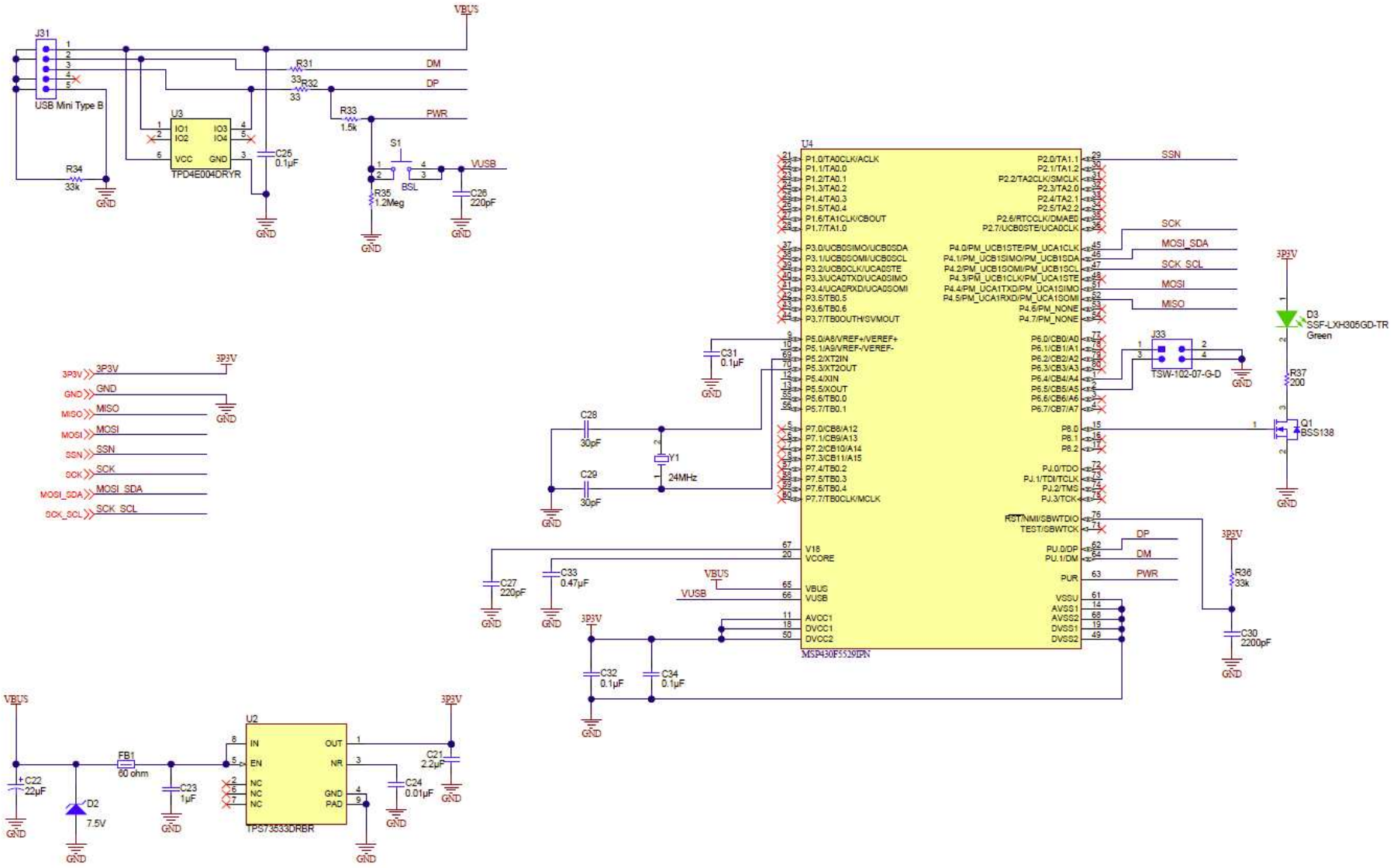

Figure 12. MSP430 USB2ANY Schematic Page

8 EVM Layout

Figure 13 and Figure 14 show the LMH1219EVM layout. The evaluation board controls signal integrity control settings via jumper pins.

The LMH1219EVM allows access to all input channels (IN0 and IN1) and output channels (OUT0 and OUT1). It is very compact and low power. The WQFN package offers an exposed thermal pad to enhance electrical and thermal performance. This must be soldered to the copper landing on the PWB.

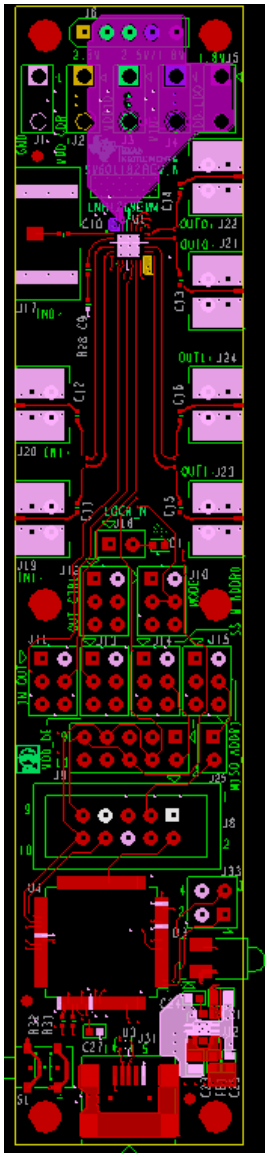

Figure 13. LMH1219EVM Top Layer

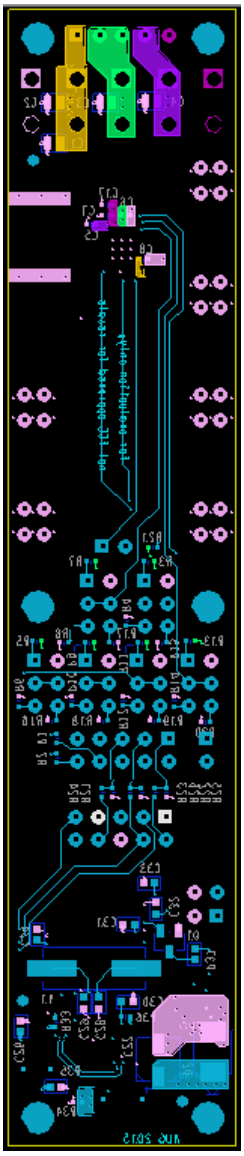

Figure 14. LMH1219EVM Bottom Layer

Revision History

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

Changes from Original (March 2016) to A Revision	Page
• First release to Web	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.

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   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/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。
http://www.tij.co.jp/lsds/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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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.

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