EVM User's Guide: LMH6518EVM

LMH6518 Evaluation Module

Description

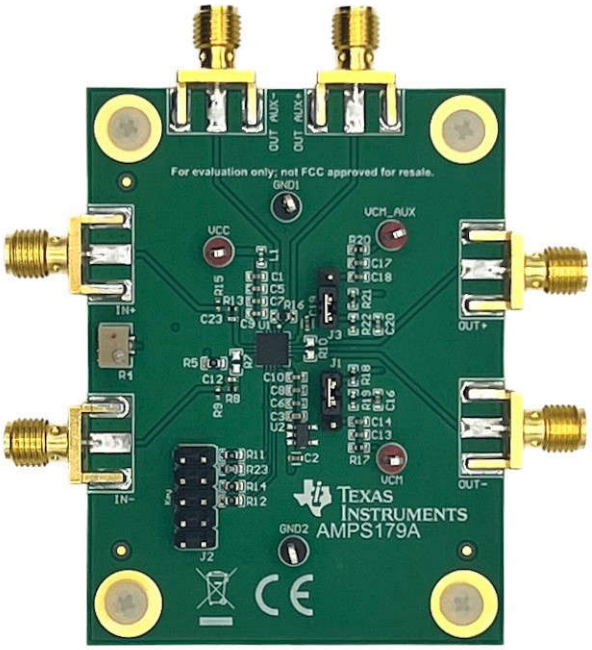
The LMH6518 Evaluation Module is designed to aid in the characterization of Texas Instrument's High Speed LMH6518 Differential Amplifier. The easy-to-use evaluation board is designed to provide a quick setup and offer high performance signal analysis. The EVM is ready to connect to power supplies, a signal source, and test instruments through the use of onboard connectors.

Get Started

1. Order the LMH6518EVM and USB2ANY Interface Adapter from ti.com.
2. Visit the USB2ANY product page and install the latest version of the USB2ANY Explorer Installer.
3. Connect USB2ANY adapter to PC with the provided USB cable and connect 10 pin header to LMH6518EVM.
4. Run the USB2ANY GUI and configure the GUI for SPI communication (instructions for this are in this user's guide).
5. Type the appropriate byte sequence to configure the LMH6518 and evaluate device.

Features

- Designed to work with user friendly USB2ANY interface adapter and GUI.
- Board is designed to be easily reconfigurable for different types of testing conditions.
- Onboard potentiometer is provided to null any output offset.
- Onboard LDO provides the required 3.3V supply for the VDD pin of the LMH6518, requiring only one 5V supply.
- Inputs and outputs include SMA connectors.
- Designed for connections to standard 50Ω test equipment.



1 Evaluation Module Overview

1.1 Introduction

The LMH6518EVM allows users to evaluate the performance of the LMH6518. The LMH6518 is programmed through a SPI compatible serial bus. The evaluation board is designed to interface with Texas Instrument's USB2ANY controller card.

This user's guide describes the characteristics, operation, and use of the LMH6518EVM evaluation board. The user's guide details how to set up and configure the board for various configurations as well as how to setup the USB2ANY adapter to interface with the LMH6518. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the LMH6518EVM. This user's guide provides information on the operating procedure, input and output connections, an electrical schematic, printed circuit board (PCB) layout drawings, and a parts list for the EVM.

1.2 Kit Contents

The following lists the contents of the EVM kit:

- LMH6518EVM
- Two shunt jumpers
- ReadMe disclaimer

This EVM kit does **not** contain TI's USB2ANY interface adapter, which this EVM is designed to interface with. However, users can still communicate with the device without the USB2ANY using any SPI.

1.3 Specification

The LMH6518EVM evaluation module is designed to be used in conjunction with TI's USB2ANY interface adapter. The LMH6518 is a digitally controlled variable differential amplifier with typical applications including oscilloscope AFEs, gain control in radio receivers, and data acquisition systems. The board can be powered from a single 5V power supply, as the 3.3V digital supply pin is powered with an onboard LDO.

1.4 Device Information

The LMH6518 device is a digitally controlled variable gain amplifier whose total gain is varied from −1.16dB to 38.8dB for a 40dB range in 2dB steps. The −3dB bandwidth is 900MHz at all gains. Gain accuracy at each setting is typically 0.1dB. The auxiliary output (+OUT AUX and −OUT AUX) follows the main output and is intended for use in oscilloscope trigger function circuitry but can have other uses in other applications. Inputs and outputs are DC-coupled. The outputs are differential with individual common mode (CM) voltage control (for main and auxiliary outputs), and have selectable bandwidth limiting circuitry (common to both main and auxiliary).

2 Hardware

2.1 Preliminary Setup

The LMH6518 is easily configured with the USB2ANY interface adapter. The USB2ANY product page provides the required software and a detailed user's guide for the adapter. The USB2ANY Explorer Software can be found under the Order & start development tab on the product's homepage. The user's guide, found under the Technical Documentation tab, highlights the general setup and operation of the adapter. The USB2ANY is shipped with a USB cable, a 10-pin cable, and a 30-pin cable. For communication with the LMH6518 evaluation board, the 10-pin cable is used as well as the USB cable to interface with the computer.

Once the software is installed follow the procedures below to configure the adapter to interface with the evaluation board.

1. Open USB2ANY Explorer software and confirm the device is recognized when plugged into the computer using the USB cable. Users receive a message in the activity log confirming the controller was connected successfully.

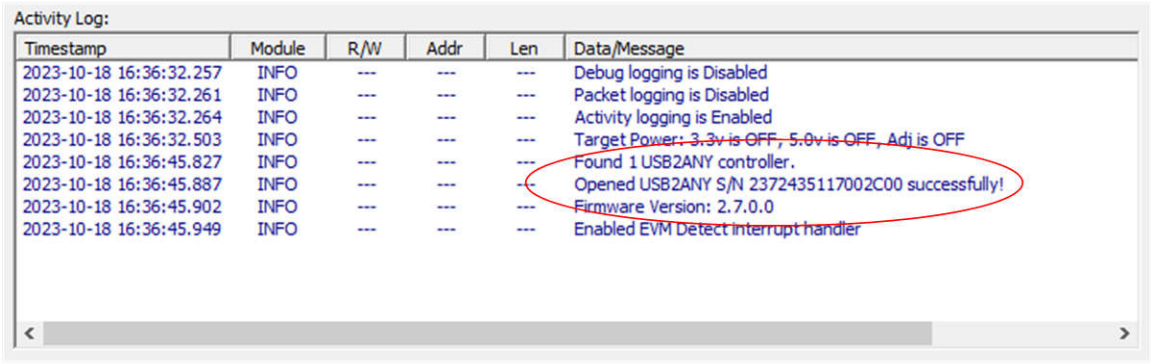


Figure 2-1. USB2ANY Detection Confirmation

2. Click the *Select Interfaces* and check the box next to *SPI*.

Figure 2-2. Adding SPI Tab to GUI

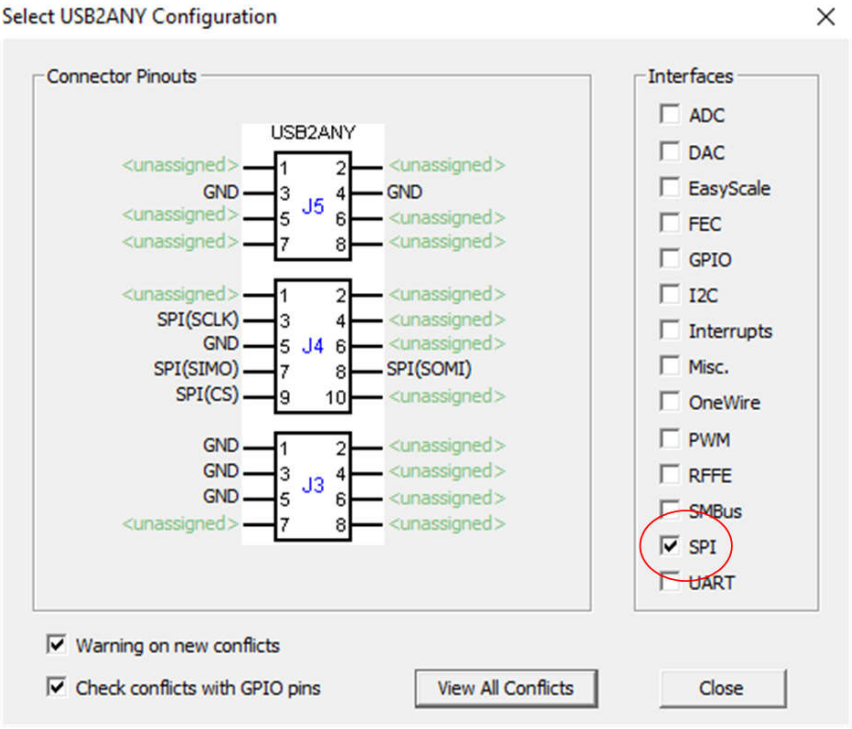


Figure 2-3. Selecting SPI Interface

3. Click on the SPI tab and select the settings as shown below that correspond to the LMH6518 SPI functionality.

Figure 2-4. SPI Tab

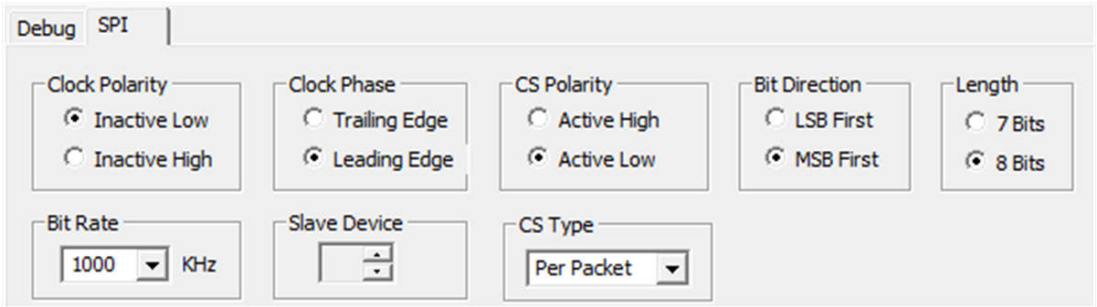


Figure 2-5. SPI Configuration

4. Set byte number to 3 bytes that corresponds to LMH6518 SPI communication length.

Figure 2-6. Setting Bytes for SPI Communication

5. Plug the 10-pin cable in the appropriate orientation into the USB2ANY adapter. The key on the 10-pin cable lines up with the USB2ANY.

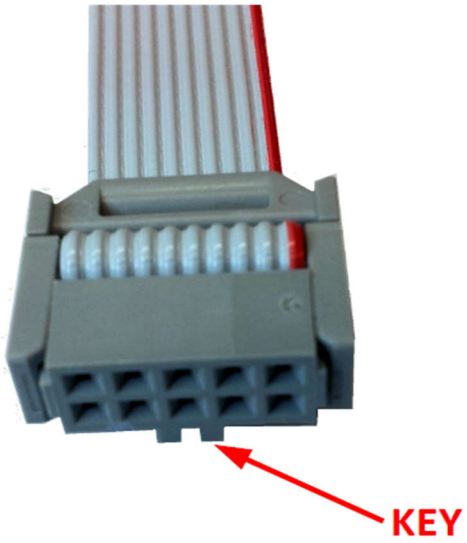


Figure 2-7. USB2ANY 10-Pin Header

6. Plug the other end of the ribbon cable into J2 of the LMH6518 evaluation board with the cable key on the side of the *key* label on the board.

2.2 Basic Operation

Inputs

The LMH6518 evaluation board is designed to be used with either differential and single-ended input configurations, however, the LMH6518 evaluation board is shipped out in a single-ended input configuration. In this configuration, the evaluation board is configured for single-ended drive (into the positive input, *IN+* SMA connector) and the undriven input is biased to VCC/2 (= 2.5V). This single-ended input must be offset to 2.5V DC (< ±1mV of the undriven input voltage at pin 7 of the LMH6518). Here are possible input sources:

- Lab generator (or other signal source) capable of 2.5V offset in the presence of milli-volt level input signal.
- Using a ground referenced (AC-coupled or no offset adjust needed) generator with a *Bias-Tee* module that allows DC value to be set to 2.5V using a fine-tuned voltage lab DC power supply.
- A Hi-Z buffer that outputs the required milli-volt level AC signal centered at 2.5V from a ground referenced input signal. In oscilloscope applications, this Hi-Z buffer is what interfaces the high-impedance oscilloscope probe to the LMH6518.

For best performance, make sure that the LMH6518 inputs (pins 6 and 7) are both close to VCC/2 (= 2.5V) and there is less than 1mV of difference in voltage between them. On the board, use a DC voltmeter to confirm DC voltage of pins 6 and 7 (top pad of the R7 and right pad of the C23). The voltage potential of pin 6 (driven input) of the LMH6518 can be controlled by varying the incoming signal offset (2.5V nominal) at the SMA connector.

As the DC offset of the inputs go beyond 1mV, measured results can be affected. Some of the side-effects of input dc offset are: output clipping, excess distortion, loss of bandwidth, or step response anomalies. Potentiometer R4 is provided to null any remnant offset, especially useful when the operating conditions change of the device. For an effective method of input offset adjustment, especially when the LMH6518 is set for high gain (HG/ 0dB attenuation), monitor OUT+ and OUT- (1.2V nominal) with a DC voltmeter and adjust R4 to minimize the voltage difference between these two outputs to less than 50mV. This effectively reduces any input voltage offset.

To configure from single-ended to differential input, remove resistor R5 and solder a 0Ω 0603 resistor to R7.

Outputs

Both the main and auxiliary output differential impedance needs to be close to 100Ω with minimal parasitic effects when being measured. As these outputs are each set to approximately 1.2V common mode level, the outputs cannot be terminated in DC coupled 50Ω directly. (similar to an oscilloscope input) AC coupled 50Ω terminated instrumentation (such as S parameter analyzers) can be connected to these SMA outputs directly for observation. With a single-ended Hi-Z input instrument, the LMH6518 outputs must be terminated in 100Ω differential, as shown in Figure 2-8.

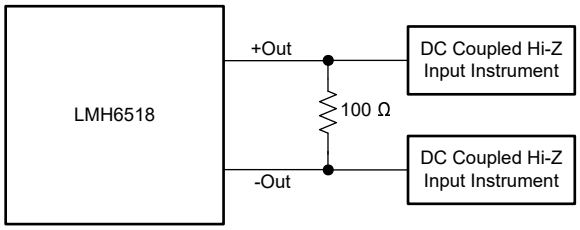


Figure 2-8. LMH6518 Output Observation With Hi-Z Instrumentation

The auxiliary outputs must be terminated in 100Ω on board by installing R16 when observing the main output. The evaluation board comes with R16 populated.

The outputs of the device need to be biased near 1.2V by applying the appropriate voltage to the VOCM (VOCM_Aux) pin for the main (auxiliary) output of the LMH6518. The board has the option of biasing these pins using onboard 1.2V reference circuitry or can be tied to an external bias such as the common mode output control of an ADC. How to configure the shunt jumpers to the appropriate positions for either configuration is shown in Section 2.3.

2.3 Jumper Information

The LMH6518 evaluation board provides the option to bias the VOCM/VOCM_AUX pins using an onboard 1.2V bias or externally bias the pins by applying a voltage potential to the respective test points. To configure the intended bias source, adjust jumpers J1 and J3. Configuring the jumpers to the inner position bias the VOCM pins to the default 1.2V onboard bias. Placing the jumpers to the outer position bias the VOCM pins to the external voltage bias set by the VCM/VCM_AUX test points located on the board. The two positions are illustrated in Figure 2-9 and Figure 2-10.

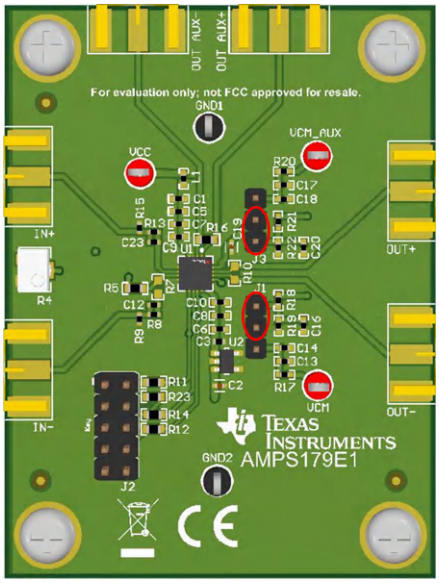


Figure 2-9. 1.2V Onboard VCM Bias Jumper Positions

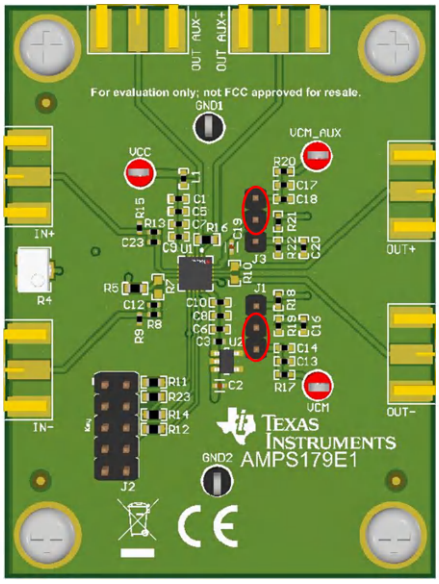


Figure 2-10. External VCM Bias Jumper Positions

2.4 SPI

The following section highlights how to get data to and from the LMH6518EVM. A tip on how to confirm the USB2ANY is properly communicating with the LMH6518 is also given in this section.

Writing to the LMH6518:

To write to the LMH6518, the first bit sent (C7) must be 0. The serial interface protocol write operation is shown in Figure 2-11. The data that is read back in the *Read data:* text field in the USB2ANY GUI needs to be the same as the data written.

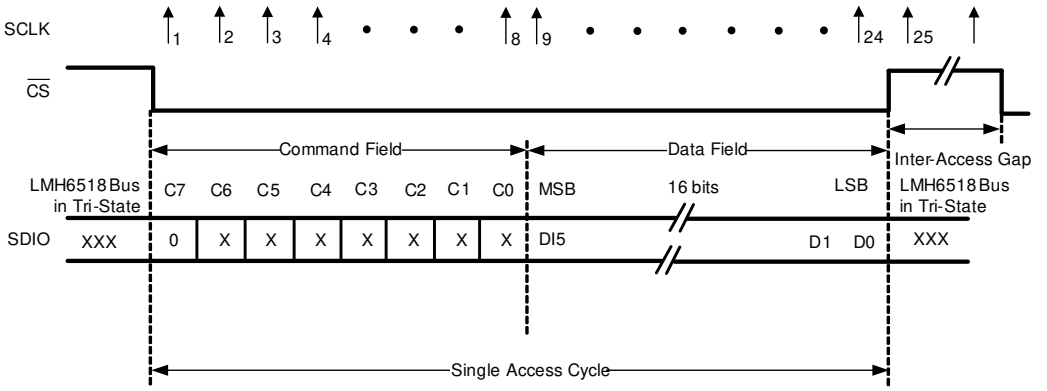


Figure 2-11. Serial Interface Protocol, Write Operation

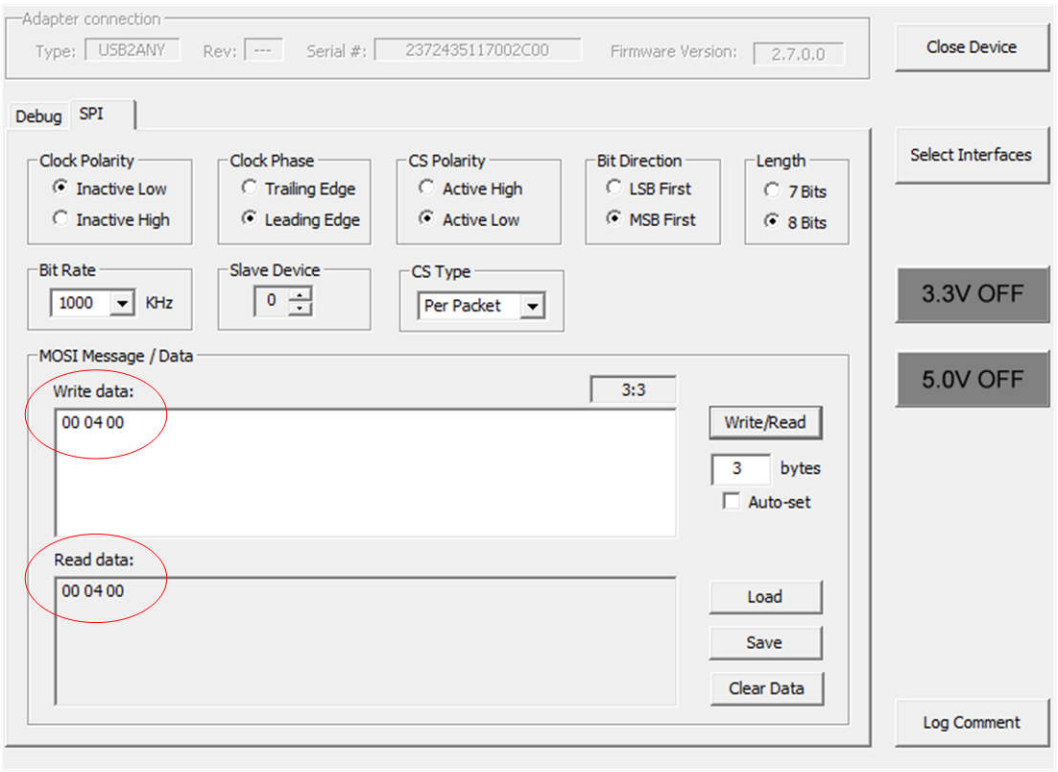


Figure 2-12. Writing Data to LMH6518

Note

A way to confirm that writing to the LMH6518 is working properly is to use bit D10 to switch between full power or auxiliary high impedance mode (Aux Hi-Z). When the device is set to Aux Hi-Z mode, the supply current of the device is reduced by about 60mA. Writing 00 04 00 to the device switches the device to Aux Hi-Z mode, and can be switched back again to full power using 00 00 00.

Reading from the LMH6518:

To read from the device, the first bit sent to the device (C7) must be 1. The serial interface protocol read operation is shown in Figure 2-13. After writing a recognizable configuration to the device, such as 00 00 EF, the device configuration can be read by writing 80 00 00 as 8 sets the very first bit (C7) to 1. The data read back for this specific configuration will be 80 00 EF as shown in Figure 2-14 and Figure 2-15.

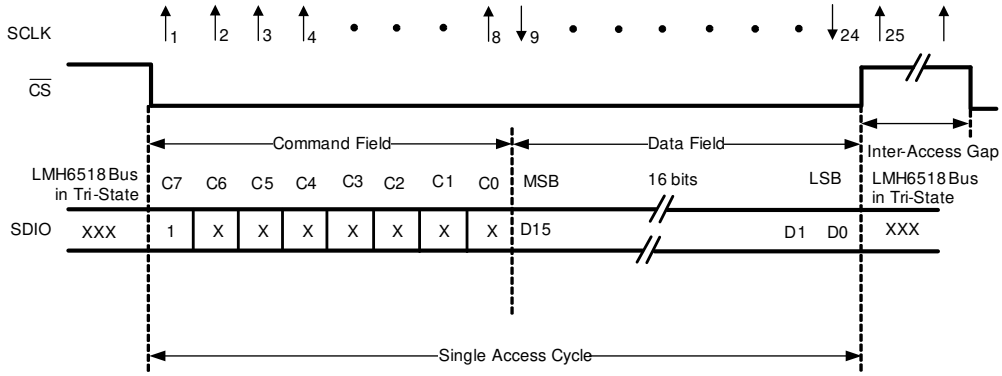


Figure 2-13. Serial Interface Protocol, Read Operation

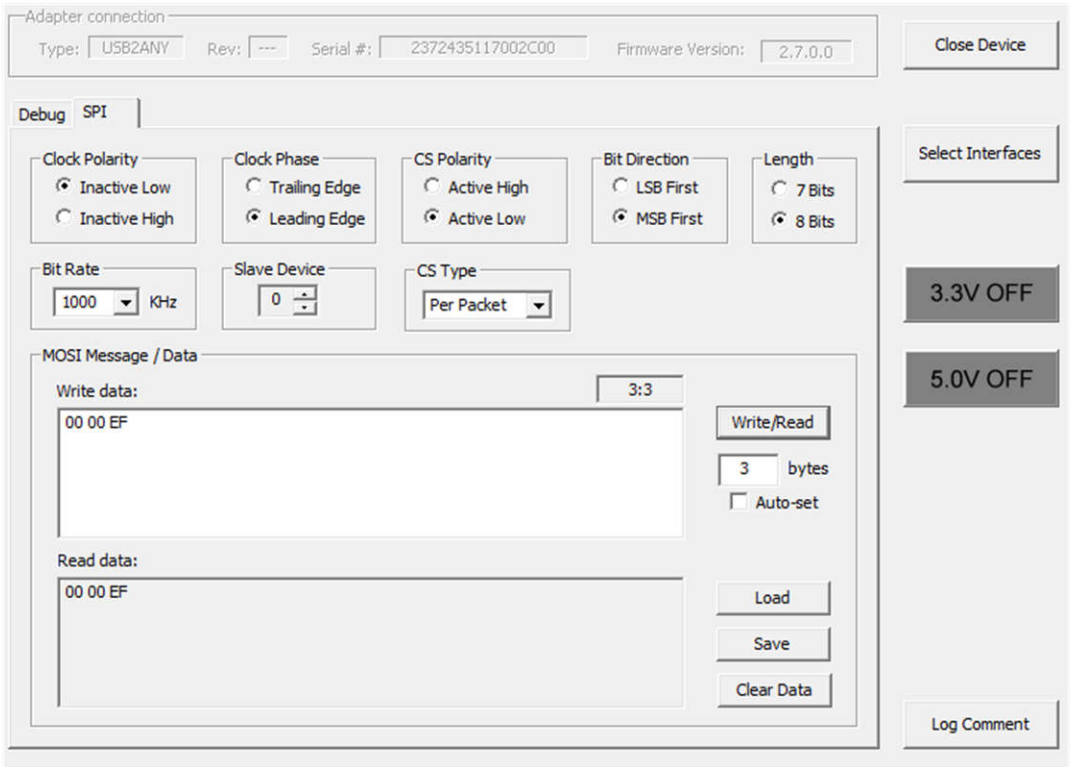


Figure 2-14. Writing Recognizable Configuration to LMH6518

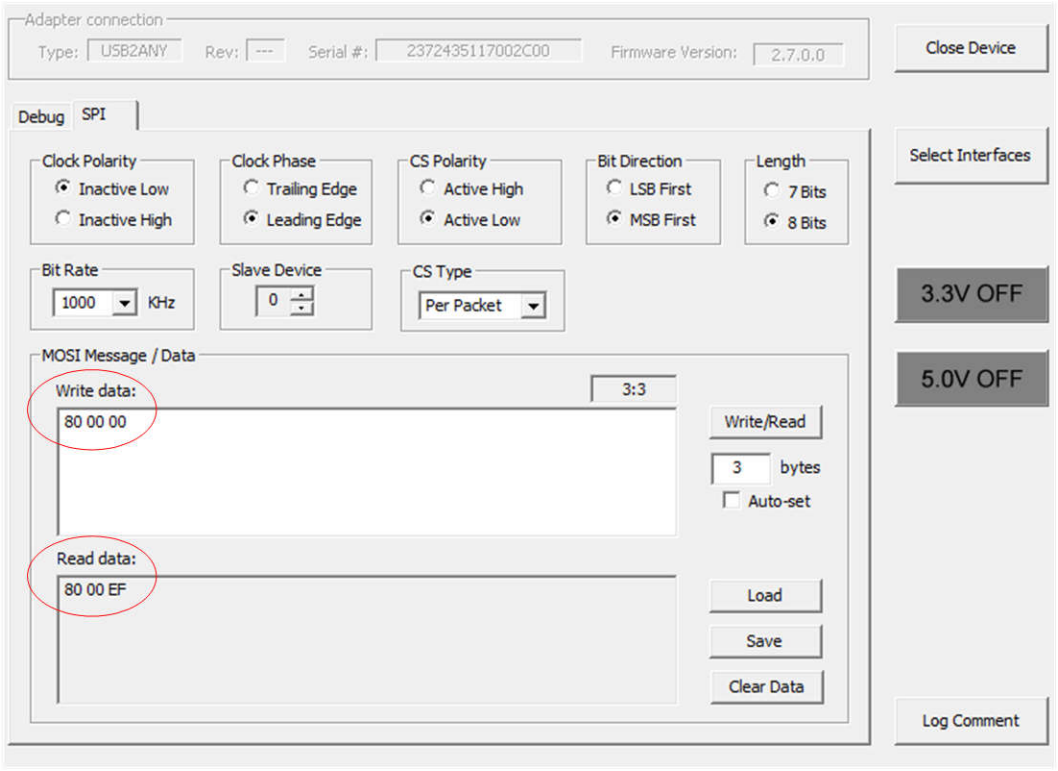


Figure 2-15. Reading Recognizable Configuration to LMH6518

Note

When initially writing to the LMH6518, if the data immediately read back is not the same as the data that is written there can be a delay. To fix this, lower the bit rate in the configuration panel found in the SPI tab. When reading from the LMH6518, if the read data is not the expected configuration, this can also be corrected by adjusting the bit rate.

2.5 Logic Function Description

This section gives a quick overview of the logic functions that are controlled with the SPI compatible bus. The data field for the LMH6518 along with the description of the functions are described below.

							FILTER				PREAMP	LADDER ATTENUATION			
D15 (MSB)	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0 (LSB)
X	0	0	0	0	0 = Full power 1 = Aux Hi-Z	0	See Table 2-1			0	0 = LG 1 = HG	See Table 2-2			

Note

Bits D5, D9, D11, D12, D13 and D14 must be 0 when writing data to LMH6518.

Power Mode: Bit D10 controls the power mode of the device (with Aux Hi-Z, the auxiliary output is turned off with an approximately 60mA reduction in 5V supply current).

Note

When the power mode is switched, the change in +5V supply current (approximately 60mA) through the power supply wiring or trace is enough to cause a noticeable difference in the voltage at *−IN* (voltage-divided from 5V supply). This can cause enough input offset difference to shift or rail the output, especially at high gains (preamp HG and little or no ladder attenuation). If this occurs, then readjust R4 to null the output offset.

Filters: The LMH6518 has selectable bandwidth limiting circuitry for both output pairs. The filter options and the corresponding bit values are shown in Table 2-1.

Table 2-1. Filter Options

FILTER			BANDWIDTH (MHz)
D8	D7	D6	
0	0	0	Full
0	0	1	20
0	1	0	100
0	1	1	200
1	0	0	350
1	0	1	650
1	1	0	750
1	1	1	Not allowed

Preamp Gain: The preamp function is to control whether the device is in the high gain (38.8dB) setting or the low gain setting (18.8dB). Bit D4 controls this state.

Ladder Attenuator: The attenuation ladder is from 0dB to 20dB in 2dB increments. The final gain of the device is the preamp gain setting the device is in minus the ladder attenuation setting. The attenuation options and the corresponding bit values are shown in Table 2-2.

Table 2-2. Attenuation Options

LADDER ATTENUATION				BANDWIDTH (dB)
D3	D2	D1	D0	
0	0	0	0	0
0	0	0	1	−2
0	0	1	0	−4
0	0	1	1	−6
0	1	0	0	−8
0	1	0	1	−10
0	1	1	0	−12
0	1	1	1	−14
1	0	0	0	−16
1	0	0	1	−18
1	0	1	0	−20
1	0	1	1	Not allowed
1	1	0	0	Not allowed
1	1	0	1	Not allowed
1	1	1	0	Not allowed
1	1	1	1	Not allowed

Note

A *not allowed* SPI state can result in undefined operation where device behavior is not verified.

The default power-on device state is shown in Table 2-3.

Table 2-3. Default Device State

							FILTER				PREAMP	LADDER ATTENUATION			
D15 (MSB)	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0 (LSB)
0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

2.6 Header Information

The header (J2) pinout for the evaluation board is shown in Table 2-4.

Table 2-4. Header Information

Header Pin	Function
2	Chip Select
3	POCI
4	PICO
5,6	GND
8	Clock
1,7,9,10	Not Connected

3 Hardware Design Files

3.1 Schematic

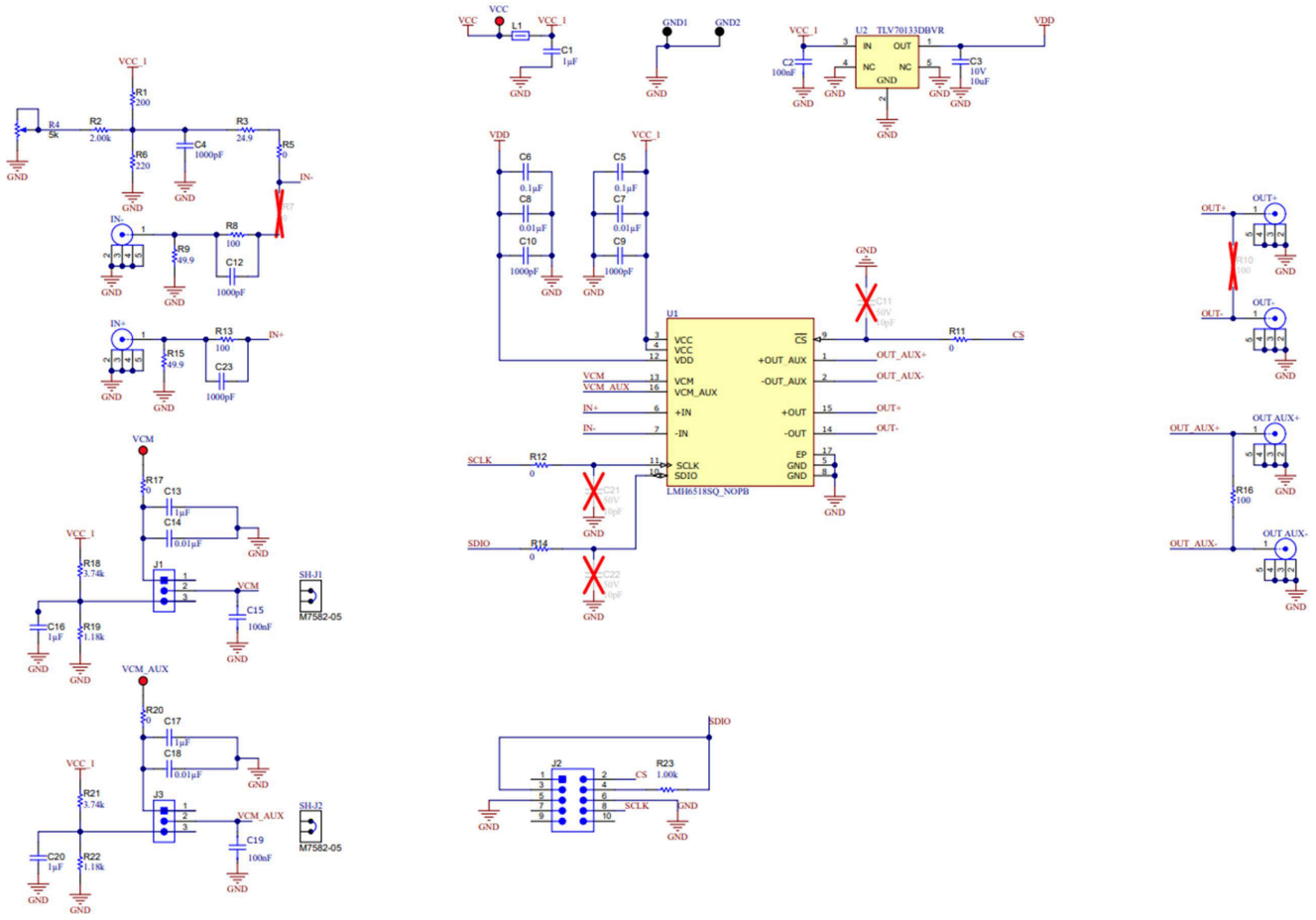


Figure 3-1. EVM Schematic

3.2 PCB Layouts

The LMH6518 evaluation board is a four-layer board; all four layers are detailed in Figure 3-2 through Figure 3-5.

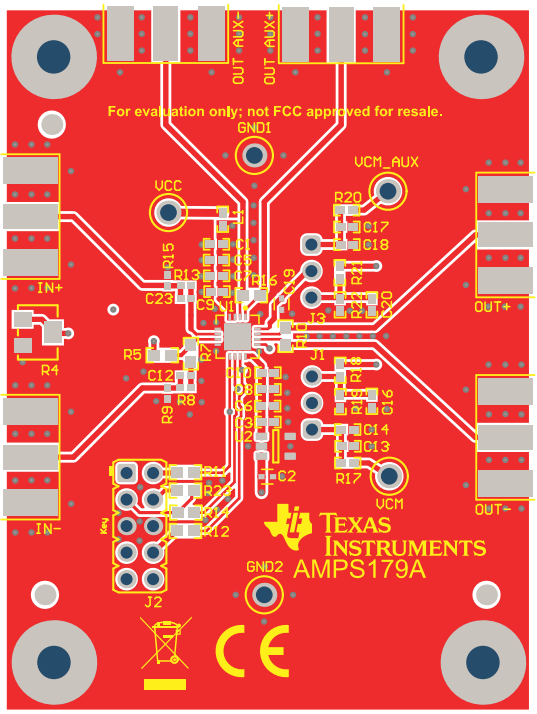


Figure 3-2. Top Layer

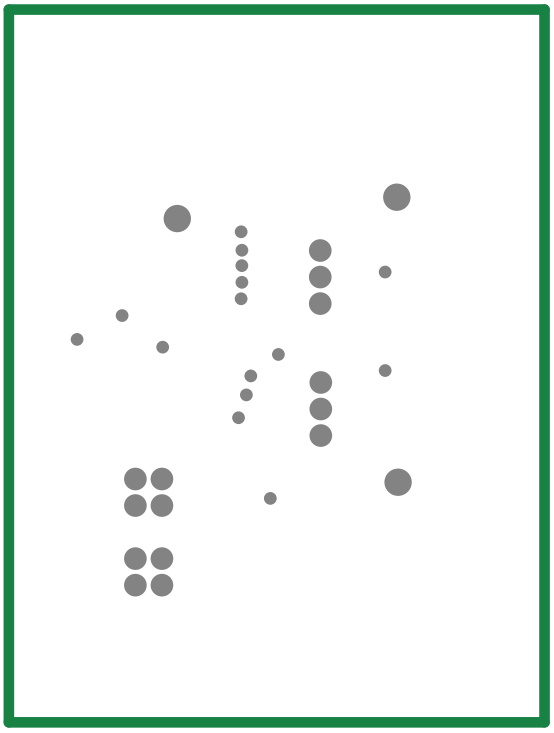


Figure 3-3. Ground Layer 2

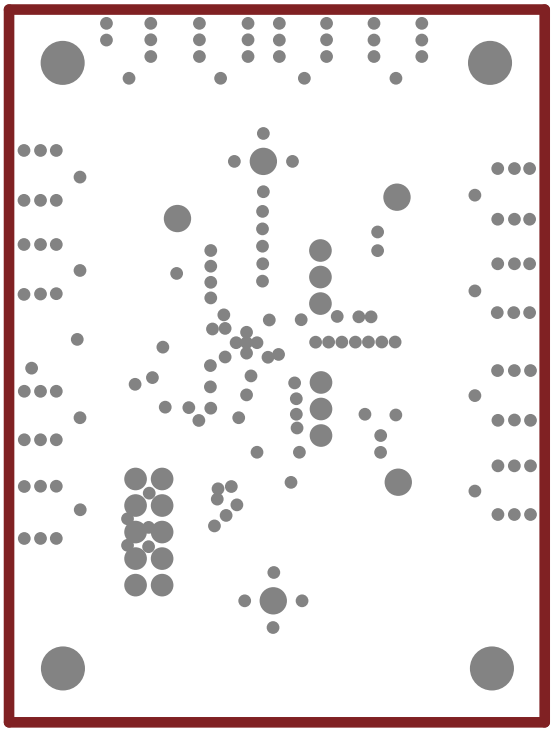


Figure 3-4. Power Layer 3

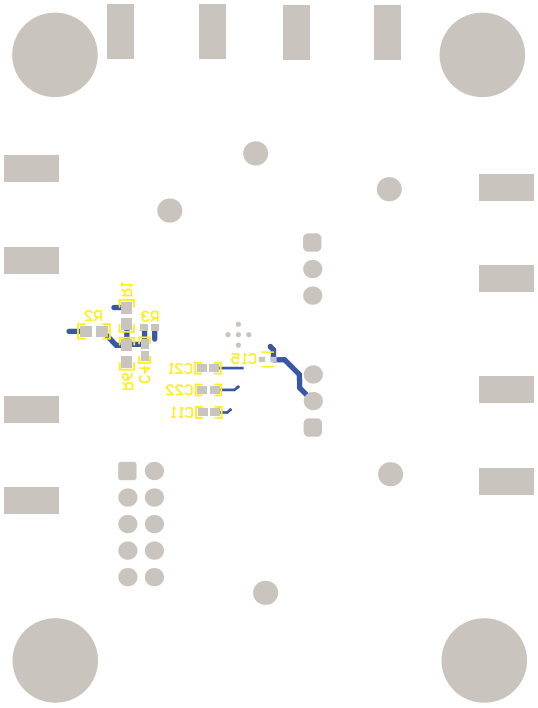


Figure 3-5. Bottom Layer

3.3 Bill of Materials (BOM)

Table 3-1. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB	1		Printed Circuit Board		AMPS179	Any
C1, C13, C16, C17, C20	5	1uF	CAP, CERM, 1µF, 25V,+/- 10%, X5R, 0402	402	CL05A105KA5NQNC	Samsung Electro-Mechanics
C2, C15, C19	3	100nF	General Purpose Ceramic Capacitor, 0402, 100nF, 5%, X7R, 15%, 16V	402	0402YC104JAT2A	AVX
C3	1	10uF	CAP, CERM, 10uF, 10V, +/- 20%, X5R, 0402	402	GRM155R61A106ME11D	MuRata
C4, C12, C23	3	1000pF	CAP, CERM, 1000pF, 25V, +/- 5%, X7R, 0402	402	C0402C102J3RACTU	Kemet
C5, C6	2	0.1uF	CAP, CERM, 0.1µF, 25V,+/- 10%, X7R, AEC-Q200 Grade 1, 0402	402	CGA2B3X7R1E104K050BB	TDK
C7, C8, C14, C18	4	0.01uF	CAP, CERM, 0.01µF, 25V,+/- 5%, X7R, 0402	402	04023C103JAT2A	AVX
C9, C10	2	1000pF	CAP, CERM, 1000pF, 50V, +/- 10%, X7R, 0402	402	GRM155R71H102KA01D	MuRata
GND1, GND2	2		Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone Electronics
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
IN-, IN+, OUT-, OUT AUX-, OUT AUX+, OUT+	6		Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
J1, J3	2		Header, 2.54mm, 3x1, Gold, TH	Header, 2.54mm, 3x1, TH	61300311121	Wurth Elektronik
J2	1		Header, 2.54mm, 5x2, Gold, TH	Header, 2.54mm, 5x2, TH	61301021121	Wurth Elektronik
L1	1	120 ohm	Ferrite Bead, 120 ohm at 100MHz, 0.4A, 0402	402	MMZ1005Y121CT000	TDK
R1	1	200	RES, 200, 1%, 0.1 W, 0603	603	RC0603FR-07200RL	Yageo
R2	1	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	603	RC0603FR-072KL	Yageo
R3	1	24.9	RES, 24.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW040224R9FKED	Vishay-Dale
R4	1	5k	TRIMMER, 5K, 0.25W, SMD	3.5x5.3x4.8mm	3224W-1-502E	Bourns
R5, R11, R12, R14	4	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R6	1	220	RES, 220, 1%, 0.1 W, 0603	603	RC0603FR-07220RL	Yageo
R8, R13	2	100	RES, 100, 0.1%, 0.1 W, AEC-Q200 Grade 0, 0402	402	MCS0402MD1000BE100	Vishay/Beyschlag
R9, R15	2	49.9	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW040249R9FKED	Vishay-Dale
R16	1	100	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo
R17, R20	2	0	RES, 0, 0%, 0.2 W, AEC-Q200 Grade 0, 0402	402	CRCW04020000Z0EDHP	Vishay-Dale

Table 3-1. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
R18, R21	2	3.74k	RES, 3.74 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW04023K74FKED	Vishay-Dale
R19, R22	2	1.18k	RES, 1.18 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	CRCW04021K18FKED	Vishay-Dale
R23	1	1.00k	RES, 1.00 k, 1%, 0.1 W, 0603	603	RC0603FR-071KL	Yageo
SH-J1, SH-J2	2		Single Operation 2.54mm Pitch Open Top Jumper Socket	Single Operation 2.54mm Pitch Open Top Jumper Socket	M7582-05	Harwin
U1	1		Variable Gain Amplifier 1 Circuit Differential 16-WQFN (4x4)	WQFN16	LMH6518SQ_NOPB	Texas Instruments
U2	1		Single Output LDO, 150mA, Fixed 3.3V Output, 2.5 to 24V Input, with Ultra-Low IQ, 5-pin SOT-23 (DBV), -40 to 85 degC, Green (RoHS & no Sb/Br)	DBV0005A	TLV70133DBVR	Texas Instruments
VCC, VCM, VCM_AUX	3		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
C11, C21, C22	0	10pF	CAP, CERM, 10pF, 50V,+/- 2.5%, C0G/NP0, AEC-Q200 Grade 1, 0402	402	04025U100CAT2A	AVX
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R7	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	603	ERJ-3GEY0R00V	Panasonic
R10	0	100	RES, 100, 1%, 0.1 W, 0603	603	RC0603FR-07100RL	Yageo

4 Additional Information

4.1 Trademarks

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

   1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM (“Software”) shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software

   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE 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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

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.

8. *Limitations on Damages and Liability:*

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

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

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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