Using the LMG5200: GaN Half-Bridge Power Stage EVM

User's Guide

Literature Number: SNVU461
March 2015

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General TI High Voltage Evaluation User Safety Guidelines

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and the safety of those working around you. Contact TI's Product Information Center http://support/ti./com for further information.

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and/or burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments. If you are not suitably qualified, you should immediately stop from further use of the HV EVM.

- **Work Area Safety:**
  - Maintain a clean and orderly work area .
  - Qualified observer(s) must be present anytime circuits are energized.
  - Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
  - All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50 V_{RMS}/75 VDC must be electrically located within a protected Emergency Power Off (EPO) protected power strip.
  - Use a stable and non-conductive work surface.
  - Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
- **Electrical Safety:**

  As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
  - De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Confirm that TI HV EVM power has been safely de-energized.
  - With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
  - When EVM readiness is complete, energize the EVM as intended.

  WARNING: While the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.

- **Personal Safety:**
  - Wear personal protective equipment, for example, latex gloves and/or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.
- **Limitation for Safe Use:**
  - EVMs are not to be used as all or part of a production unit.

Safety and Precautions

The EVM is designed for professionals who have received the appropriate technical training, and is designed to operate from an AC power supply or a high-voltage DC supply. Please read this user guide and the safety-related documents that come with the EVM package before operating this EVM.

CAUTION

Do not leave the EVM powered when unattended.

WARNING

Hot surface! Contact may cause burns. Do not touch!

WARNING

High Voltage! Electric shock is possible when connecting board to live wire. Board should be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

Using the LMG5200EVM-01A GaN Half-Bridge Power Stage EVM

The LMG5200 device is a 80-V Gallium Nitride (GaN) half-bridge power module with an integrated driver. It provides an integrated power stage solution using enhancement-mode GaN FETs. The LMG5200 device consists of two GaN FETs driven by one high-frequency GaN FET driver in a half-bridge configuration. The guide shows a circuit and the list of materials describing how to power the board up and how to set the board up for a certain regulation voltage. The EVM board is designed to accelerate the evaluation of the LMG5200. This board is not intended to be used as a standalone product but it intended to evaluate the switching performance of LMG5200.

1 Description

The LMG5200 evaluation module is a small, easy-to-use power stage with an external PWM signal. The board can be configured as a buck converter, boost converter or other converter topology using a half bridge. Because this is an open loop board with an external PWM signal, do not use it to evaluate transient response. It can be used to evaluate the performance of the LMG5200 as a hard-switched converter to sample measurements such as efficiency, switching speed and dv/dt. The EVM features a LMG5200 half-bridge power module with two 18-mΩ GaN FETs and a half-bridge driver. The module can deliver up to 10 A of current if the application includes adequate thermal management (monitor case temperature and ensure adequate airflow is present if required). The thermal management considerations include forced air, heat sink and lower operating frequency in order to minimize the power dissipation in the module.

1.1 Featured Application

LMG5200EVM-01A features include:

- Input voltage operates up to 80 V DC
- Integrated 80-V, 18-mΩ GaN FET with driver
- Single-input, on-board for PWM signal with 8 ns dead time
- Configurable on-board dead-time adjustment by simple resistance change
- On-board LDO for generating 5-V VCC supply from a poorly regulated supply between 5.5 V and 6.5 V
- Kelvin sense capability for efficiency measurements for input and output voltage

CAUTION

High-voltage levels are present on the evaluation module whenever it is energized. Proper precautions must be taken when working with the EVM.

1.2 Typical Applications

The LMG5200 is suited for use in high frequency DC-DC converters converters. It is simple to use and has a low-external component count.

- High-speed, synchronous buck converters
- Class D amplifiers for audio
- 48-V point-of-load converters for industrial, computing and telecom

2 Schematic

Figure 1 shows the schematic of the EVM.

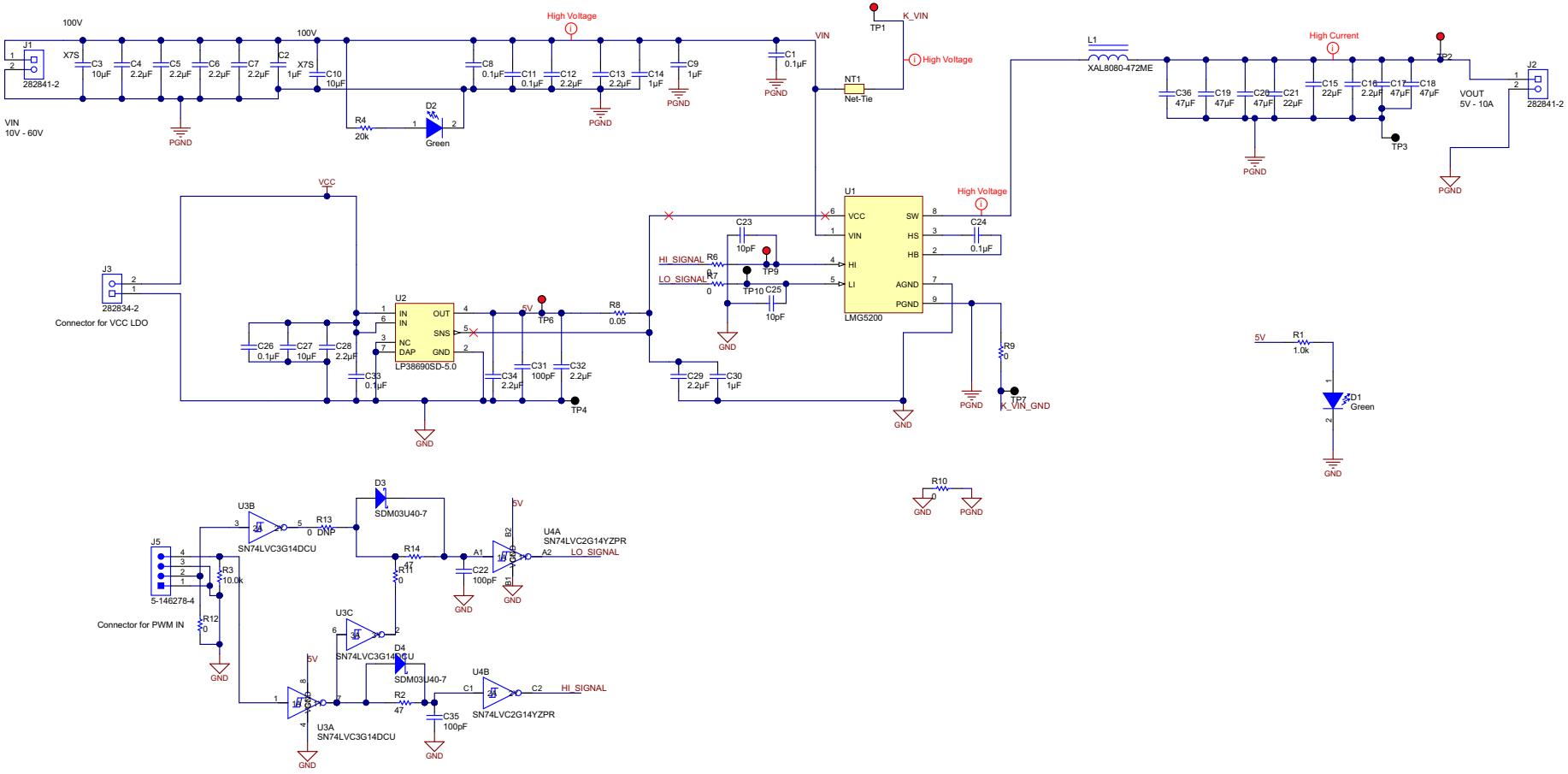


Figure 1. LMG5200EVM-01A Schematic

3 EVM Kit Contents

The kit contains the following:

- *Using the LMG5200 GaN Half-Bridge Power Module EVM* (this user's guide)
- Safety instructions
- LMG5200 specifications

4 Electrical Performance Specifications

The inductor used in this EVM is a 4.7-µH inductor. The switching frequency is set by an external PWM signal (between 0 V and 5 V). The duty cycle of this PWM signal sets the duty cycle of the half-bridge module.

4.1 Test Setup

Figure 2 and the procedure to setup the hardware for evaluation.

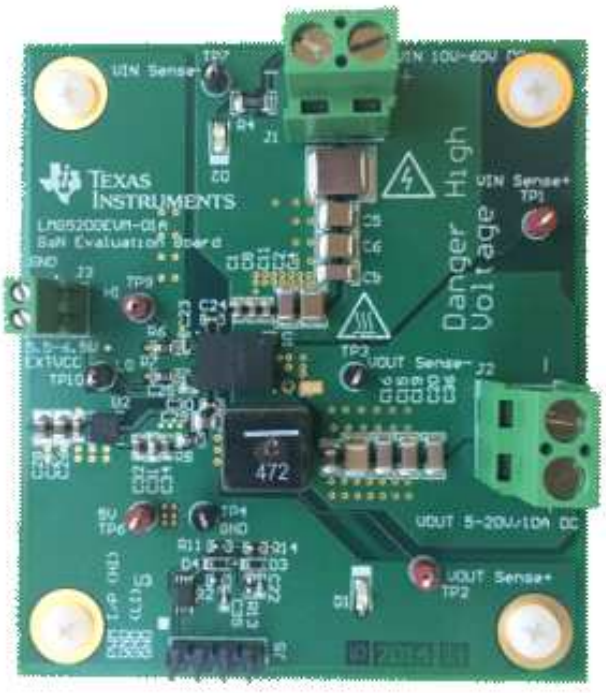


Figure 2. LMG5200EVM-01A Board Top View

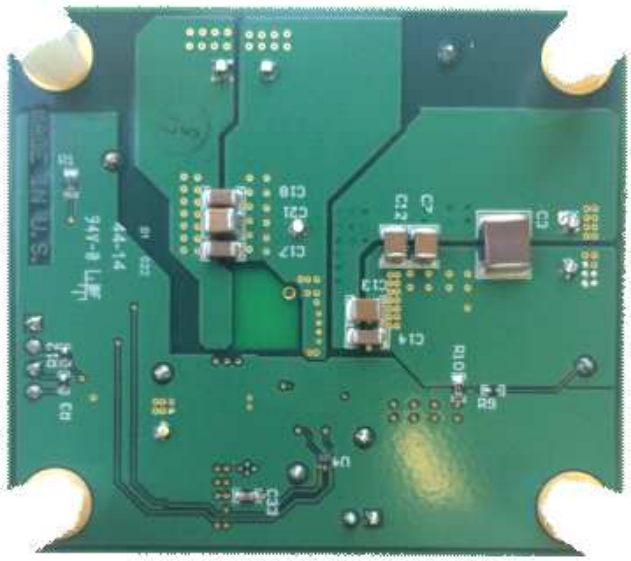


Figure 3. LMG5200EVM-01A Board Bottom View

WARNING

High voltages that may cause injury exist on this evaluation module (EVM). Please ensure all safety procedures are followed when working on this EVM. Never leave a powered EVM unattended.

4.1.1 List of Test Points

Table 1. Test Point Functional Description

TEST POINT	NAME	DESCRIPTION
TP1	TP1	Sense connection for the input supply
TP2	TP2	Sense connection for output voltage
TP3	TP3	Sense connection for output ground
TP4	TP4	Analog Ground sense connection
TP6	TP6	5V sense connection for LDO output
TP7	TP7	Sense connection for the input supply ground
TP9	TP9	HI input to LMG5200
TP10	TP10	LO input to LMG5200
J1	J1	VIN power connector (10-60V DC)
J2	J2	VOUT power connector (5-20V, 10A)
J3	J3	EXTVCC connection (5.5V-6.5V)

4.1.2 Key Connections

The following test procedure is recommended primarily for powering up and shutting down the evaluation module. Never leave a powered EVM unattended for any length of time. Also, the unit should never be handled while power is applied to it.

WARNING

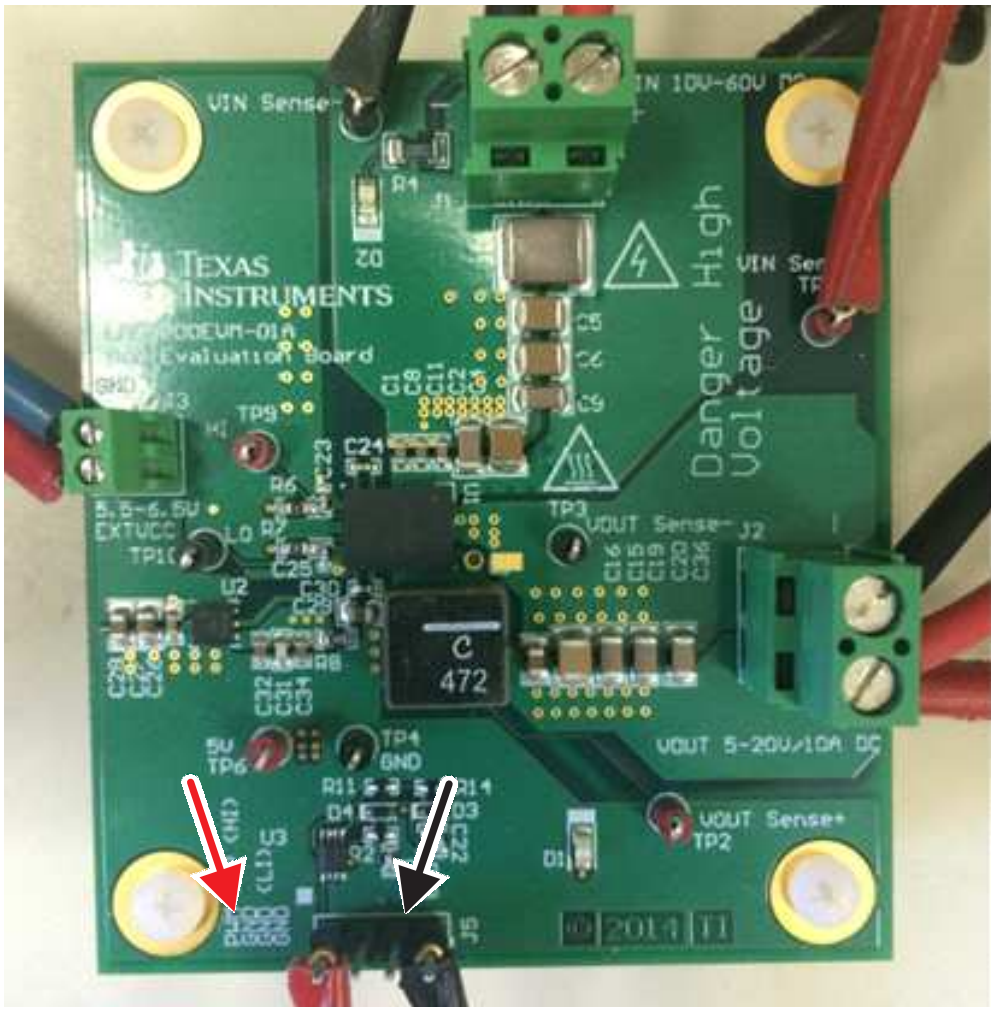
There are very high voltages present on the EVM. Some components reach temperatures above 50°C. Precautions must be taken when handling the board.

4.1.2.1 Connect a Supply to J3 Connector

There is the bias supply EXTVCC (between 5.5 V and 6.5 V) for the LMG5200 driver. This driver supply is regulated to 5 V by the series LDO U2 (LP3869). This regulation ensures that the bias supply for the LMG5200 is accurate and is not exceeded beyond the gate voltage specifications. This User's Guide refers to this supply as the driver bias supply. It is critical to ensure that the EXTVCC supply is powered up before the VIN supply (J1) to ensure safe operation. Similarly during power down, it is important to ensure that the VIN supply (J1) is powered down before the bias supply (EXTVCC).

4.1.2.2 PWM Input

Provide the PWM input using a function generator that is capable of providing the desired switching frequency and duty cycle. This function generator output should be connected to the J5 connector as shown in the Figure 4. The red arrow shows +Ve the and black arrows show the GND PWM connections. Pin 4 is the positive input of the PWM supply and the remaining three pins are GND pins in the default state of the board.



A Red and black arrows show the +ve and GND PWM connections, respectively.

Figure 4. PWM Connection on J5

4.1.2.3 J1 Connector

Connect the input voltage to the J1 connector ensure that the +ve and –ve supply is connected appropriately - the +ve and -ve terminals are marked on the board. The sense connection for the input supply is via the TP1 and TP7 test points respectively. This is useful when doing efficiency calculations as this will ensure that the resistive losses to the board are taken into account and the losses calculated are related to the board and the LMG5200 half bridge.

The output load is connected to the J2 connector. The +ve and –ve sense signals are TP2 and TP3 respectively.

4.1.3 Power-Up Procedure

4.1.3.1 Step 1: Driver Bias Supply

Power up the driver bias supply (5.5 V to 6.5 V) first. The D1 diode lights up after the driver bias supply comes up. After this step, observe the PWM signals on test points TP9 and TP10. Insure that the PWM signal for the high and low side are of the desired frequency (100 kHz to 5MHz depending on the input voltage and load). Also observe the default dead time between the high-to-low and low-to-high PWM transitions.

4.1.3.2 Step 2: Input Supply

Power up the input supply (10 V to 60 V). The D2 diode lights up after the input supply is powered up.

Observe the output voltage on the sense signals (TP2, TP3). Adjust the PWM duty cycle such that the output is of the desired voltage. Load the output with an appropriate electronic load.

NOTE: The PWM duty cycle must be adjusted to compensate for the losses when the supply is loaded

4.1.3.3 Step 3

To observe the SW node connect a probe with a small pigtail to the via next to the SW pin, as shown in Figure 5. This ensures that the measurement loop is small and hence accurately reflects the behavior of the SW node. If a large loop is used to the high dv/dt on the SW node and the parasitic impedance (inductance) of the loop a large amount of ringing will be observed on the SW node which is not representative of the device performance but is measurement artifact. The probe connection should be made prior to the board being powered up and one should ensure that appropriate safety precautions are taken.

Connect the scope probe to measure the SW node as shown in Figure 5. Notice the small pigtail used to minimize the ground loop as shown in Figure 6.

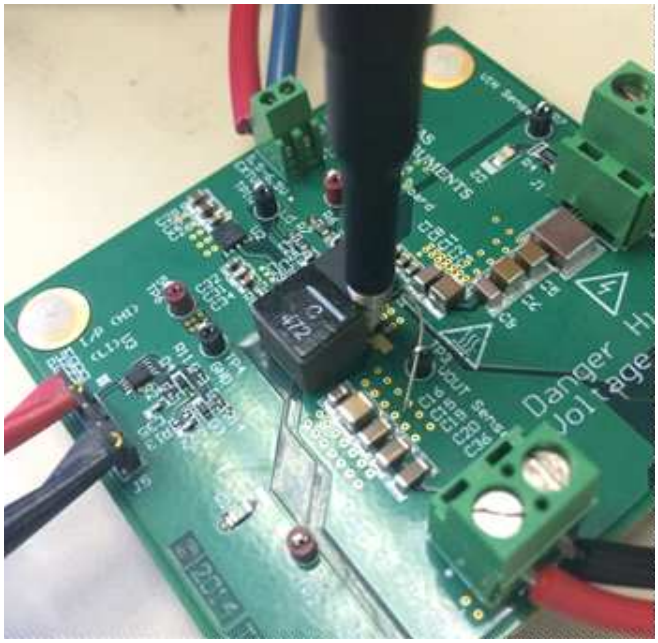


Figure 5. Measuring the SW Node

Figure 6. Small GND Loop

4.1.3.4 Setting Dead-Time

Dead times are set by the RC delays between the inverted and non-inverted PWM input connected to jumper J3. The dead time typically does not require to be changed, however to evaluate impact of dead time on efficiency, you can vary the RC delay, its easy to change resistors R14 and R2 to get the appropriate dead time. Ensure that the dead time is not reduced so much that it causes a shoot-through condition.

4.1.4 Power-Down Procedure

To power down the board the power up procedures should be followed in reverse. Hence the load should be turned off first. Next the input supply should be turned off. Followed by the PWM signal and finally the driver bias supply.

4.2 Results

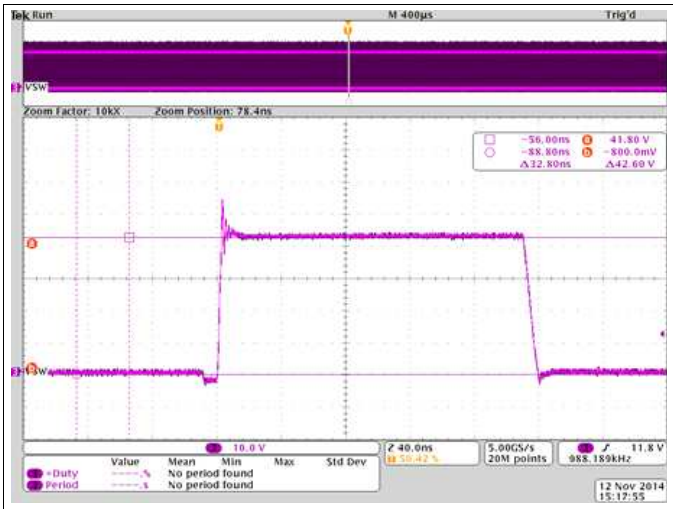


Figure 7. SW Node Behavior Showing the Dead Time and the Overshoot in the SW Node

Figure 8. Zoom in of the SW Node Showing the Dead Time of 7.7-ns (Converter Loaded With 2 A)

NOTE: Visit the E2E forum Gallium Nitride Solutions for more information regarding LMG5200 or LMG5200 hard-switched EVM.

5 List of Materials

Table 2. LMG5200EVM-01A List of Materials[(1)]

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
PCB1	1		Printed circuit board		SV601148	Any
C1, C8, C11	3	0.1 µF	Capacitor, ceramic, 0.1 µF, 100 V, ±10%, X7R, 0603	0603	GRM188R72A104KA35D	MuRata
C2, C9, C14	3	1 µF	Capacitor, ceramic, 1 µF, 100 V, ±20%, X7R, 1206	1206	C3216X7R2A105M160AA	TDK
C3, C10	2	10 µF	Capacitor, ceramic, 10 µF, 100 V, ±20%, X7S, 2220	2220	C5750X7S2A106M	TDK
C4, C5, C6, C7, C12, C13	6	2.2 µF	Capacitor, ceramic, 2.2 µF, 100 V, ±10%, X7R, 1210	1210	GRM32ER72A225KA35L	MuRata
C15, C21	2	22 µF	Capacitor, ceramic, 22 µF, 25 V, ±10%, X5R, 1210	1210	GRM32ER61E226KE15L	MuRata
C16	1	2.2 µF	Capacitor, ceramic, 2.2 µF, 16 V, ±10%, X7R, 0805	0805	C2012X7R1C225K	TDK
C17, C18, C19, C20, C36	5	47 µF	Capacitor, ceramic, 47 µF, 25 V, ±20%, X5R, 1206	1206	C3216X5R1E476M160AC	TDK
C22, C35	2	100 pF	Capacitor, ceramic, 100pF, 50 V, ±5%, C0G/NP0, 0402	0402	CC0402JRNPO9BN101	Yageo America
C23, C25	2	10 pF	Capacitor, ceramic, 10pF, 50 V, ±5%, C0G/NP0, 0402	0402	GRM1555C1H100JA01D	MuRata
C24	1	0.1 µF	Capacitor, ceramic, 0.1 µF, 10 V, ±10%, X5R, 0402	0402	C1005X5R1A104K	TDK
C26, C33	2	0.1 µF	Capacitor, ceramic, 0.1 µF, 16 V, ± 5%, X7R, 0603	0603	0603YC104JAT2A	AVX
C27	1	10 µF	Capacitor, ceramic, 10 µF, 25 V, ±10%, X5R, 0805	0805	C2012X5R1E106K125AB	TDK
C28, C29	2	2.2 µF	Capacitor, ceramic, 2.2 µF, 16 V, ±10%, X7R, 0805	0805	C0805C225K4RACTU	Kemet
C30	1	1 µF	Capacitor, ceramic, 1 µF, 25 V, ±10%, X5R, 0402	0402	C1005X5R1E105K050BC	TDK
C31	1	100 pF	Capacitor, ceramic, 100 pF, 25 V, ±10%, X7R, 0603	0603	06033C101KAT2A	AVX
C32, C34	2	2.2 µF	Capacitor, ceramic, 2.2 µF, 10 V, ±10%, X7R, 0603	0603	GRM188R71A225KE15D	MuRata
D1, D2	2	Green	LED, Green, SMD	LED_0805	LTST-C170KGKT	Lite-On
D3, D4	2	40 V	Diode, Schottky, 40 V, 0.03A, SOD-523	SOD-523	SDM03U40-7	Diodes Inc.
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
J1, J2	2		Terminal Block, 2x1, 5.08mm, TH	10.16x15.2x9mm	282841-2	TE Connectivity
J3	1		Terminal Block, 2x1, 2.54mm, TH	Terminal Block, 2x1, 2.54mm, TH	282834-2	TE Connectivity
J5	1		Header, 100mil, 4x1, Tin, TH	Header, 4x1, 100mil, TH	5-146278-4	TE Connectivity
L1	1	4.7 µH	Inductor, Shielded, Composite, 4.7uH, 10.5A, 8.89 ohm, SMD	8.1 x 8 x 8.6mm	XAL8080-472ME	Coilcraft

(1) Unless otherwise noted, all parts may be substituted with equivalents.

Table 2. LMG5200EVM-01A List of Materials[(1)] (continued)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
R1	1	1.0 kΩ	Resistor, 1.0 kΩ, 5%, 0.1W, 0603	0603	CRCW06031K00JNEA	Vishay-Dale
R2, R14	2	47	Resistor, 47 Ω, 5%, 0.063W, 0402	0402	CRCW040247R0JNED	Vishay-Dale
R3	1	10.0k	Resistor, 10.0 kΩ, 1%, 0.063W, 0402	0402	CRCW040210K0FKED	Vishay-Dale
R4	1	20k	Resistor, 20 kΩ, 5%, 0.25W, 1206	1206	CRCW120620K0JNEA	Vishay-Dale
R6, R7, R10	3	0	Resistor, 0 Ω, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R8	1	0.05	Resistor, 0.05 Ω, 1%, 0.1W, 0603	0603	ERJ-L03KF50MV	Panasonic
R9, R11, R12	3	0	Resistor, 0 Ω , 5%, 0.063W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
TP1, TP2, TP6, TP9	4	Red	Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP3, TP4, TP7, TP10	4	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
U1	1		LMG5200AMOF, MOF0009A	MOF0009A	LMG5200AMOF	Texas Instruments[(2)]
U2	1		1-A Low Dropout CMOS Linear Regulators, 6-pin LLP	SDE06A	LP38690SD-5.0	Texas Instruments
U3	1		IC, Tripple Schmitt-Trigger Inverter	VSSOP	SN74LVC3G14DCU	Texas Instruments[(2)]
U4	1		IC, Dual Schmitt-Trigger Inverter	WCSP-6	SN74LVC2G14YZPR	Texas Instruments[(2)]
R13	0	0	Resistor, 0 ohm, 5%, 0.063W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale

(2) No alternate component manufacturer.

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   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 and conditions 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 and conditions 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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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:*

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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 are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

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】

本開発キットは技術基準適合証明を受けておりません。

本製品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２４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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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 WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (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 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 AND CONDITIONS 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 MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.

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 AND CONDITIONS. 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 ANDCONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, 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 ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.

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9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

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