DRV8307 User's Guide

This document is provided with the DRV8307 customer evaluation module (EVM) as a supplement to the DRV8307 datasheet (SLVSCK2). It details the hardware implementation of the EVM.

Contents

List of Figures

List of Tables

1 Printed-Circuit Board (PCB) (Top 3D View)

Figure 1 illustrates the top view of the DRV8307 EVM PCB.

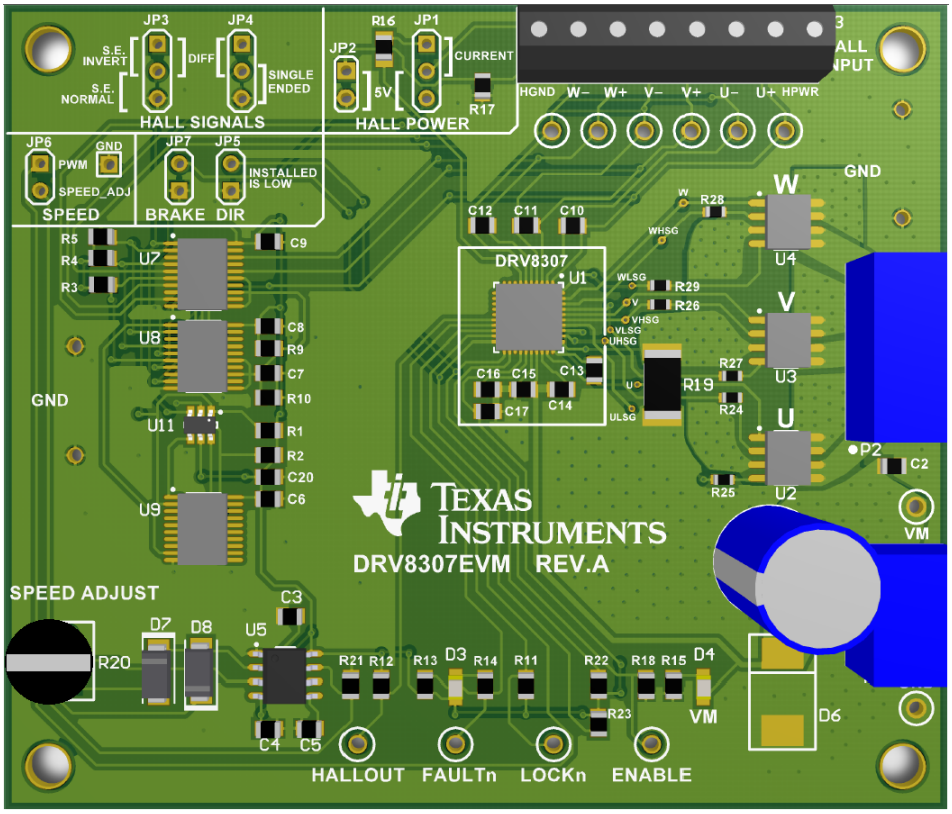

Figure 1. DRV8307EVM Top View

2 Introduction

The DRV8307EVM is a solution for evaluating the DRV8307, a brushless DC motor controller. It includes a TLC555 timer configuration to supply PWM to the DRV8307, a potentiometer to adjust the speed of the motor by varying the duty cycle of the PWM, and an external PWM input pin. The EVM also supports differential and single-ended hall sensors. The EVM includes surface-mounted test pins for all important signals on the board. The DRV8307EVM is configured so that only connections to the motor, hall sensors and power supply are required.

2.1 Power Connectors

The DRV8307EVM uses a single power supply rail which must be connected to terminal P1. Minimum recommended VM of the EVM is 8.5 V and maximum is 32 V, with a current of at least 2A. A higher current setting is recommended to maintain a stable VM voltage. Please refer to the DRV8307 datasheet (SLVSCK2) for complete voltage range information. When power is supplied to the board, a green LED (D4) in the lower left corner should light up.

2.2 Test Points

Test points are provided and labeled according to the inputs and outputs of the DRV8307 device. The signals brought out to test points are labeled HALLOUT, FAULTn, LOCKn, ENABLE, HU+/-, HV+/- HW+/- and GND (Figure 2).

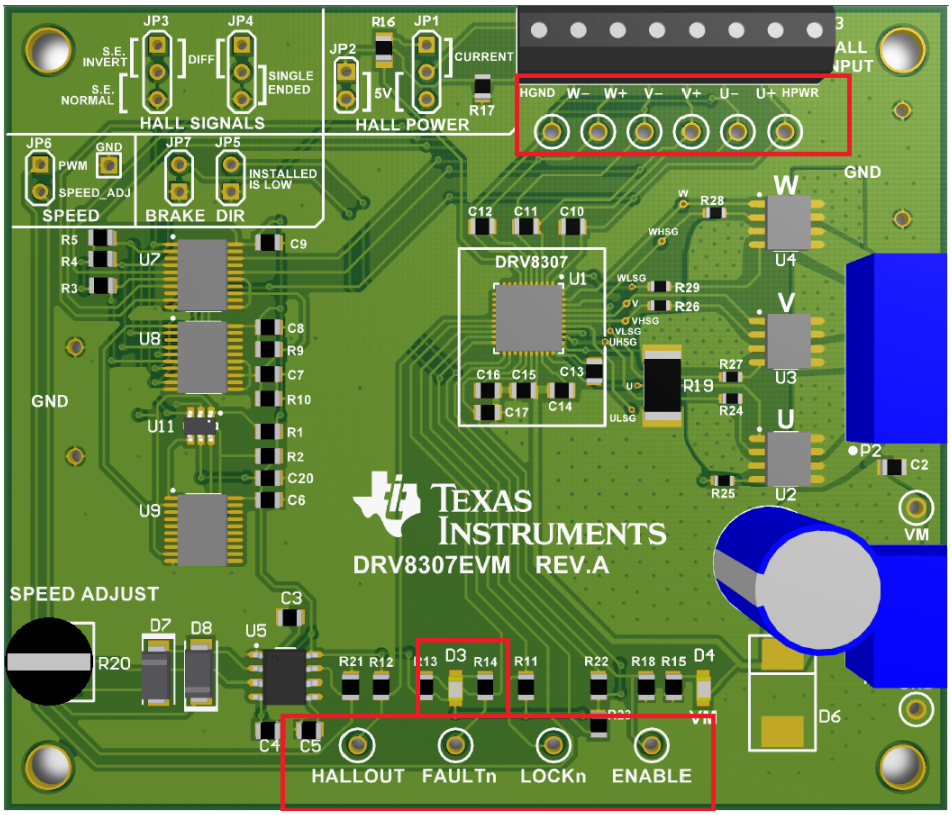

Figure 2. DRV8307EVM Test Points and FAULTn LED

The HALLOUT signal represents the motor speed and phase information.

$$RPM = (HALLOUT \times 60) / pole\ pairs \quad (1)$$

The FAULTn and LOCKn signals represent DRV8307 outputs and indicate a fault or lock condition of the driver or motor. If there is a fault condition present, a red LED (D3) lights up. LOCKn indicates whether the speed loop is locked.

The HU+/-, HV+/- HW+/- represent the corresponding hall signals. The ENABLE pin represents whether the DRV8307 is active or off.

The ENABLE signal is active low. The DRV8307 can be disabled by applying a high voltage to this pin.

2.3 Jumpers

Seven jumpers (JP1–JP7) are installed by default on the EVM.

Table 1. Jumper Descriptions

Jumper	Description
JP1	**HALL POWER**: Hall sensor power is “5V” or “current”
JP2	
JP3	**HALL SIGNALS**: Hall Signals are “Differential” or “Single Ended”
JP4	
JP5	**DIRECTION**: Motor direction is “forward” or “reverse”
JP7	**BRAKE**: Motor brake “ON” or “OFF”
JP6	**SPEED**: Speed input is from supplied “external” or “potentiometer”

The default jumper settings are JP1 2-3, JP2, JP3 1-2, JP4 2-3 and JP5, JP6, JP7 all installed. This supports "inverse" single-ended hall sensors supplied with 5 V. Speed is supplied from the potentiometer and the motor spins in a forward direction and is not braked.

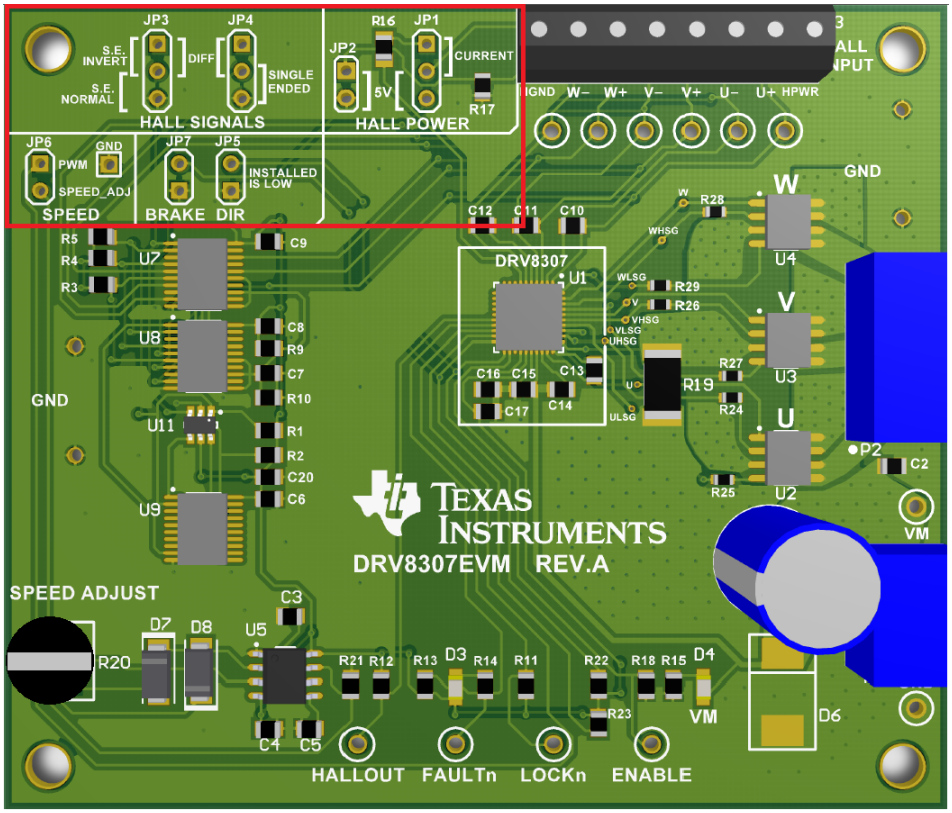

Figure 3. DRV8308EVM Jumpers

2.3.1 HALL POWER Configuration (JP1/JP2) Jumpers

Sensored BLDC motors typically use either Hall ICs or Hall elements. Most ICs can use 5-V power, while elements typically have power pins that have an equivalent circuit of a resistor, and current must be limited to about 10 mA. In order to support both Hall sensor types the hall power needs to be configured on the DRV8307EVM.

When installing JP1 2-3 and JP2, a 5-V power is supplied to terminal P3 to power the ICs. The used (VREG) voltage is only present when DRV8307 is enabled and regulated from VM (Figure 4).

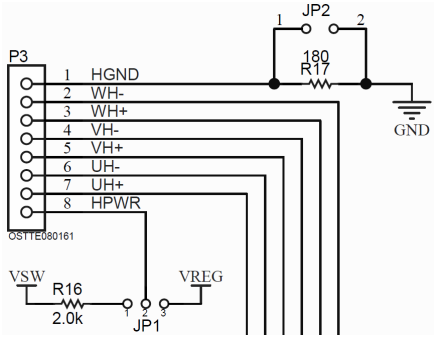

Figure 4. Hall PWR/GND Circuits

By installing JP1 1-2 and uninstalling JP2, the circuit illustrated in Figure 5 is available for the Hall elements. The used (VSW) voltage is only present when DRV8307 is enabled. VSW equals VM.

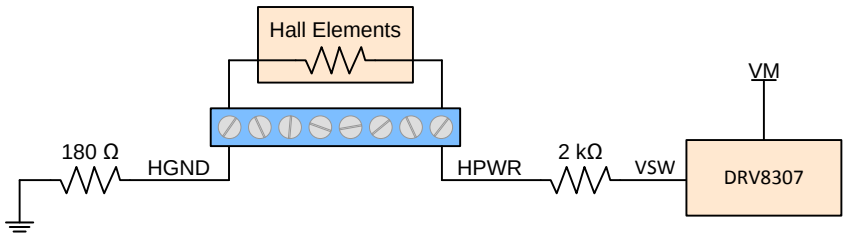

Figure 5. Circuit when Setting Hall Power to "Current"

The current can be calculated as follows: If VM is 24 V, and 3 Hall elements having a resistance of 400 Ω are connected in parallel, 10.4 mA is supplied. Always refer to your Hall element specifications to understand the proper current. The purpose of the 180-Ω resistor is to bias-up the common mode voltage of Hall element differential signals, since the DRV8307 requires VICM between 1.5 V to 3.5 V.

If you are unsure of your motor's Hall type, measure the resistance between the Hall power and ground wires. If it is < 250 Ω, they are likely Hall elements. Hall sensors are easily damaged if incorrect power is applied.

2.3.2 HALL SIGNAL Configuration (JP3/JP4) Jumpers

Hall sensors output either a differential signal pair, or a single-ended signal. You can tell which type your motor uses simply by counting the number of wires; a sensored BLDC typically has 3 phase wires, 2 Hall power wires, and 3 or 6 Hall signal wires, so 8 total means single-ended, and 11 total means differential.

The DRV8307 has differential comparators on the Hall inputs, and they can also accommodate single-ended signals with the use of a few passive components. When using differential Halls, directly connect the 6 Hall signals to the DRV8307 pins.

When using single-ended Halls, they require pull-ups. The DRV8307 comparator "-" pins should be biased with a middle voltage, so that a single-ended swing on the "+" pin is detected like a differential voltage. Connect single-ended hall wires to the "+" pins at P3 for normal Hall sensor types or to "-" pins for inverse Hall sensors.

In order to support both single ended and differential hall signals on the DRV8307EVM, the circuit in Figure 6 is implemented:

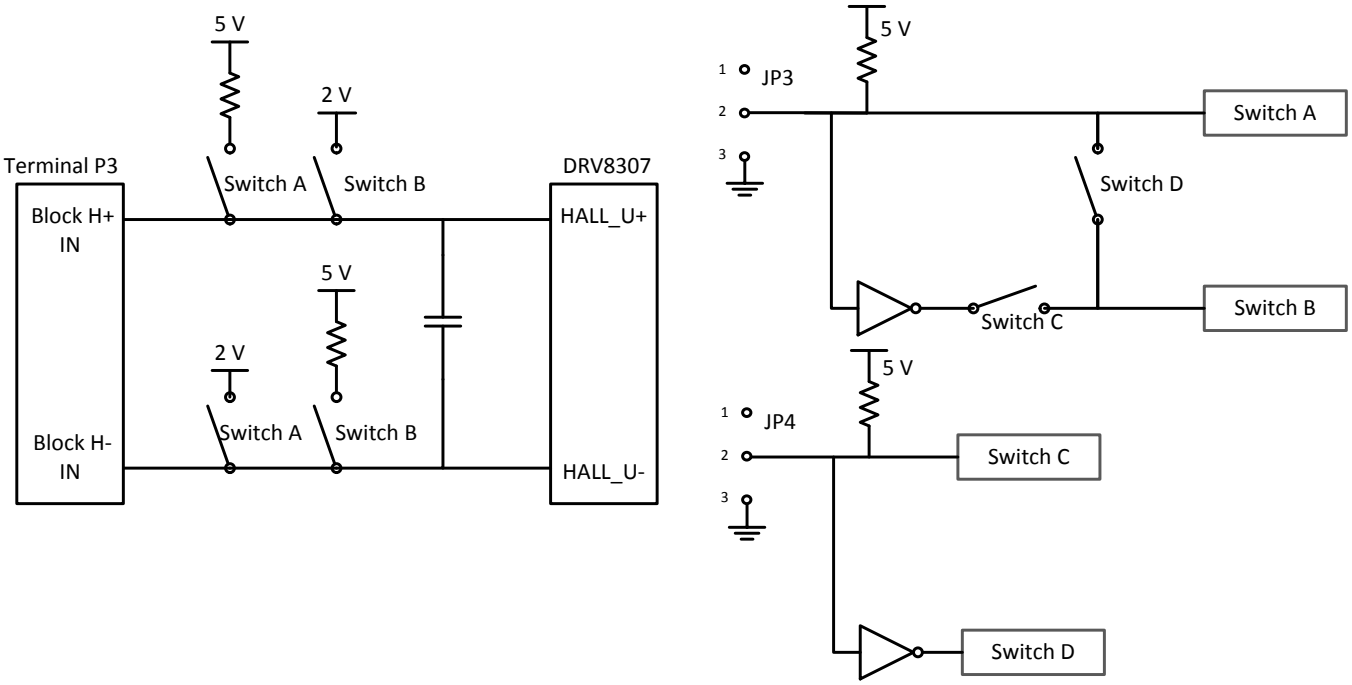

Figure 6. Switching Logic to Support Single-Ended and Differential-Hall Signals

Table 2 shows the configuration possibilities supporting a variety of hall sensors.

Table 2. Hall Sensors

Configuration	JP3	JP4	Comment	Terminal Installation
Differential Hall (Normal)	1-2	1-2	Switches A+B open	Hall wires in normal order
Differential Hall (Inverse)	1-2	1-2	Switches A+B open	Swap external Hall wires
Single Ended (Normal)	2-3	2-3	Switch A closed, B open	Hall wires to "+" pins
Single Ended (Inverse)	1-2	2-3	Switch A open, B close	Swap external Hall wires and connect to "-" pins
RESERVED	2-3	1-2	NOT ALLOWED	

2.3.3 DIR Direction (JP5) Jumper

Installing the jumper JP5 connects the DIR pin on the DRV8307 to GND. When the DIR pin is tied to GND, the DRV8307 connected motor is set to spin in the forward direction. When removed, the pin is pulled high and the motor spins in the reverse direction.

2.3.4 BRAKE (JP7) Jumper

Installing the jumper JP7 connects the BRAKE pin on the DRV8307 to GND. When the BRAKE pin is tied to GND, the DRV8307 connected motor is spinning normal without any brake action. When removed, the pin is pulled high and the motor will be braked by the DRV8307 brake functionality.

2.4 SPEED ADJUSTMENT (JP6) Jumper and (R20) Potentiometer

The DRV8307 has a dedicated speed input pin (PWM) that supplies a duty cycle to the DRV8307 to control motor speed.

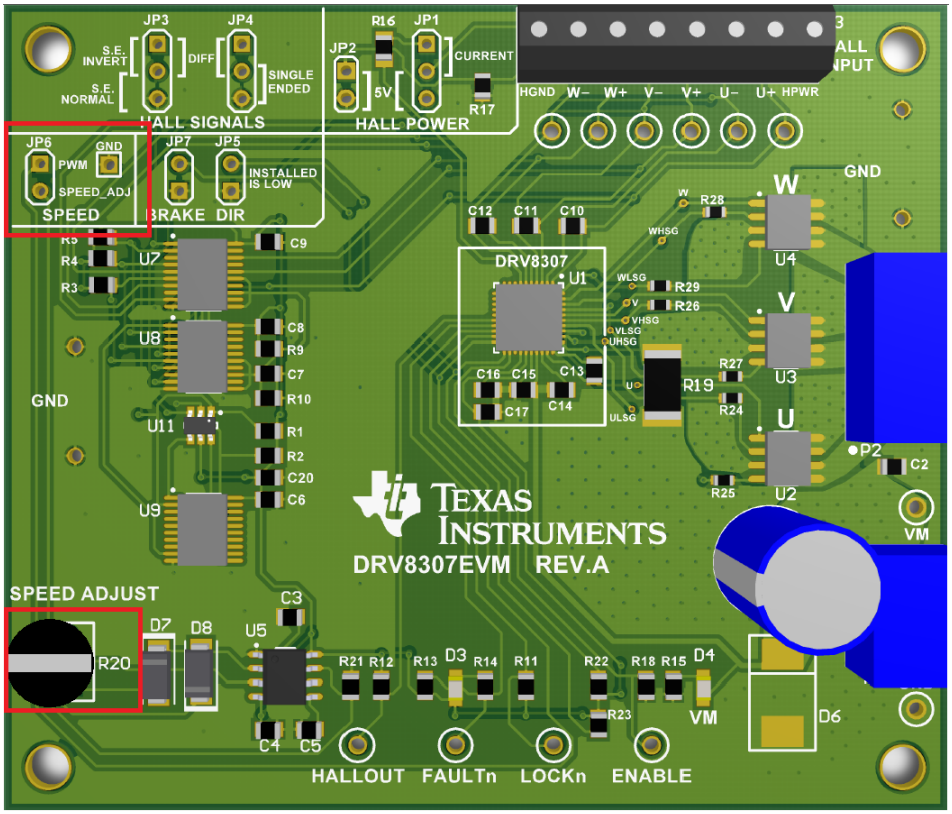

Figure 7. SPEED Adjustment Configuration

The DRV8307EVM offers two possibilities to supply this PWM input, controlled by jumper JP6.

Installing JP6 uses the speed adjust potentiometer SPEED ADJUST (R20) as shown in Figure 7 as PWM speed input. The potentiometer adjusts the duty cycle of the PWM signal which, in turn, adjusts the speed of the motor. The lower the duty cycle, therefore, the lower the speed, by turning the potentiometer counter-clockwise. In order to increase the duty cycle, thus increase the speed, turn the potentiometer clockwise.

The onboard PWM signal for the DRV8307 is generated by a circuit based upon TI's TLC555 Low-Power Timer. It is capable of approximately a 25-kHz output that can be adjusted from 5% to 95% duty cycle. This square output signal will switch from 0 V to VREG.

In order to provide an external PWM signal to the DRV8307, remove JP6 and connect the external PWM signal to JP6 pin 1 and the GND pin next to it. For more information on the PWM input required by the DRV8307, please refer to the DRV8307 datasheet (SLVSCK2).

2.5 Operation of the EVM

The following steps provide instructions for the operation of the EVM:

1. Connect a three-phase BLDC motor to terminal P2.
2. Connect the hall signals, either single ended or differential, to terminal P3.
3. Configure JP1-JP4 in order to supply the hall signals in the right manner to the DRV8307.
4. Adjust the Speed potentiometer, R20, to minimum voltage by turning it all the way counterclockwise. This minimizes the motor speed. Otherwise, connect your external PWM input to the JP6 PWM pin.
5. Check JP5 and JP7 to be installed.
6. Apply power to VM terminal P1.
7. Adjust the potentiometer clockwise or turn your external PWM source ON to increase the speed of the motor, continue adjusting as desired.
8. To change direction, uninstall JP5.
9. To start braking, uninstall JP7.

3 Schematic and Bill of Materials

Figure 8 illustrates the DRV8307EVM schematic and Table 3 is the DRV8307EVM BOM.

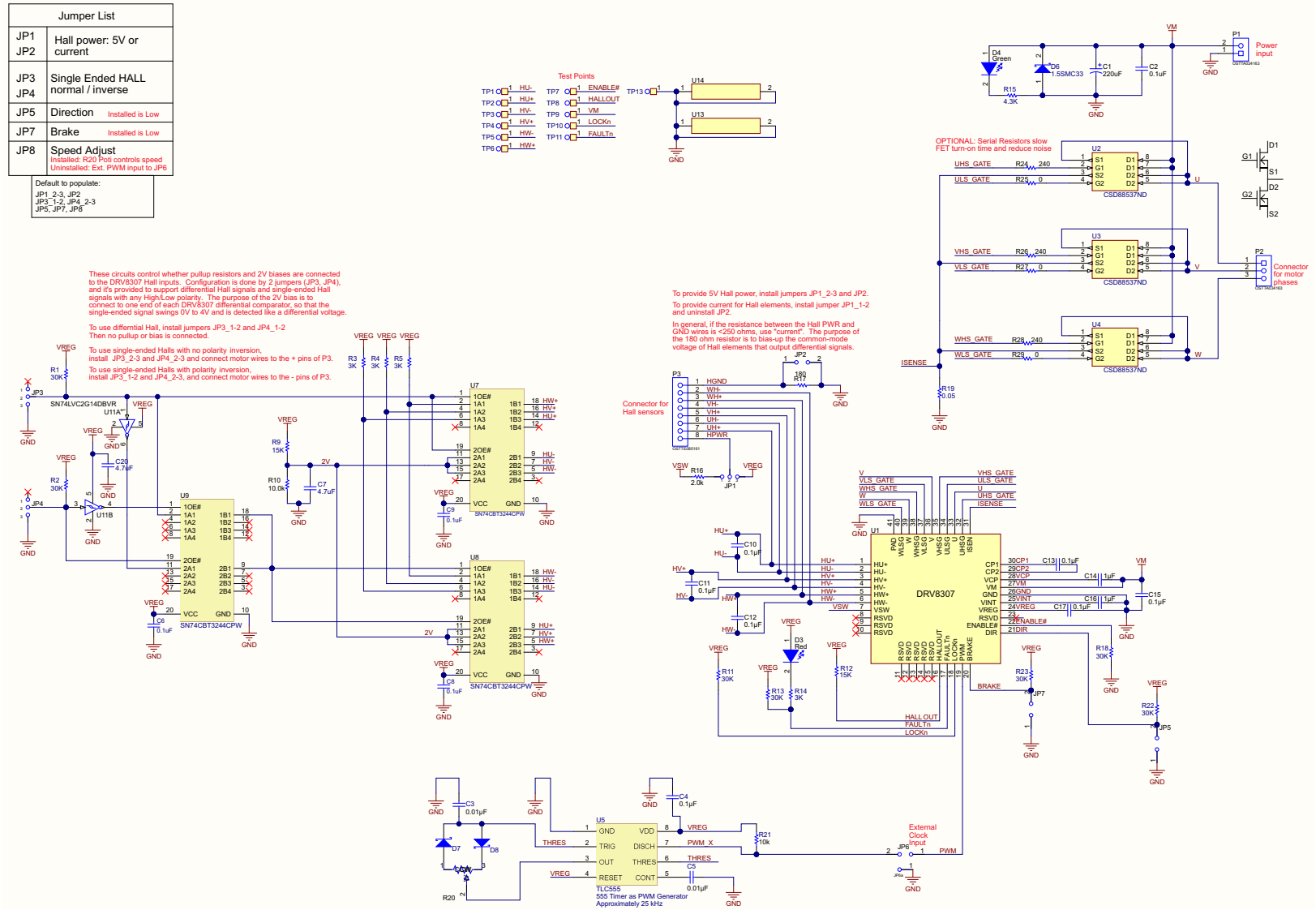

Figure 8. DRV8307EVM Schematic

Table 3. DRV8307EVM Bill of Materials

Designator	Description	Value	DigiKey Part#	Manufacturer	Qty
C1	220uF	220uF	493-1356-ND	Nichicon	1
C4, C6, C8, C9, C10, C11,C12, C13, C17	CAP CER 0.1UF 50V 10% X7R 0805	0.1uF	399-1170-2-ND	Kemet	9
C3, C5	CAP, CERM, 0.01uF, 10V, +/-10%, X5R, 0805	0.01uF	399-1158-2-ND	Kemet	2
C14, C16	CAP CER 1UF 50V 10% X7R 0805	1uF	399-7409-2-ND	Kemet	2
C7, C20	CAP CER 4.7UF 25V 10% X5R 0805	4.7uF	399-5505-2-ND	Kemet	2
C2, C15	CAP CER 0.1UF 100V 10% X7R 0805	0.1uF	399-3486-2-ND	Kemet	2
D3	LED, Red, SMD	Red	160-1415-1-ND	Lite-On	1
D4	LED, Green, SMD	Green	160-1423-1-ND	Lite-On	1
D6	Zener diode	TVS ZENER UNIDIR 1500W 33V SMC	1.5SMC33AT3GOSCT-ND	On Semiconductor	1
D7, D8	Diode, Schottky, 10V, 2A, SMA	10V	MBRA210LT3GOSCT-ND	ON Semiconductor	2
JP1, JP3, JP4	Three Pin Header	CONN HEADR BRKWAY .100 3POS STR	5-146280-3-ND	TE Connectivity	3
JP2, JP6, JP7, JP5	Two Pin Header	CONN HEADER 2POS STR .100" GOLD	3M11970-ND	3M	4
JP6a	1x1 header	CONN HEADR BRKWAY .100 1POS STR	A107006-ND	TE Connectivity	1
P1	Terminal block	TERM BLOCK 5.08MM VERT 2POS PCB	ED2580-ND	On-Shore Tech.	1
P2	Terminal block	TERM BLOCK 5.08MM VERT 3POS PCB	ED2581-ND	'On-Shore Tech.	1
P3	Terminal block	TERM BLOCK 3.5MM VERT 8POS PCB	ED2641-ND	'On-Shore Tech.	1
R1, R2, R11, R13, R18, R22,R23	RES 30K OHM 1/8W 5% 0805 SMD	30K	311-30KARTR-ND	Yageo	7
R3, R4, R5, R14	RES 3.0K OHM 1/8W 5% 0805 SMD	3K	311-3.0KARTR-ND	Yageo	4
R12, R9	RES 15K OHM 1/8W 5% 0805 SMD	15K	311-15KARCT-ND	Yageo	2
R10, R21	RES 10K OHM 1/8W 5% 0805 SMD	10K	311-10KARTR-ND	Yageo	2
R15	RES 4.3K OHM 1/4W 5% 0805 SMD	4.3K	P4.3KADCT-ND	Panasonic	1
R16	RES 2K OHM 1/8W 1% 0805 SMD	2K	P2.00KCCT-ND	Panasonic	1
R17	RES 180 OHM 1/8W 1% 0805 SMD	180	311-180CRCT-ND	Yageo	1
R19	RES 0.05 OHM 2W 1% 2512	0.05	CSRN2512FK50L0CT-ND	Stackpole El.	1
R20	POT 5.0K OHM THUMBWHEEL CERM ST	5K	3352T-502LF-ND	Bourns	1
R24, R26, R28	RES 240 OHM 1/10W 5% 0603 SMD	240	311-240GRTR-ND	Yageo	3
R25, R27, R29	RES 0.0 OHM 1/10W JUMP 0603 SMD	0	311-0.0GRTR-ND	Yageo	3
TP1, TP2, TP3, TP4, TP5,TP6, TP7, TP8, TP9, TP10, TP11	Test point	TEST POINT PC MINI .040"D ORANGE	5003K-ND	Keystone El.	11
TP13	Test point	TEST POINT PC MINI .040"D BLACK	5001K-ND	Keystone El.	1
U7, U8, U9	FET switch	IC SWITCH BUS OCTAL FET 20-TSSOP	296-19197-1-ND	Texas Instruments	3
U13, U14	1MM UNINSULATED SHORTING PLUG		952-1873-ND	HARWIN	2
U2, U3, U4	Power FET	Dual 60-V N-Channel Power MOSFETs	296-37303-2-ND	Texas Instruments	3
U5	IC OSC MONO TIMING 2.1MHZ 8-SOIC	555 Timer	296-10341-1-ND	Texas Instruments	1
U11	DUAL SCHMITT-TRIGGER INVERTER		296-13010-2-ND	Texas Instruments	1
N/A	Jumper	SHUNT JUMPER .1" BLACK GOLD	3M9580-ND	3M	7
N/A	Screw	MACHINE SCREW PAN SLOTTED M3	29311K-ND	Keystone El.	4
N/A	Standoff	HEX STANDOFF M3 ALUMINUM 10MM	24433K-ND	Keystone El.	4
U1	Motor controller	BRUSHLESS DC MOTOR PREDRIVER	supplied from TI	Texas Instruments	1

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 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 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】 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.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY WARRANTY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS AND CONDITIONS, OR ANY USE OF ANY TI EVM PROVIDED HEREUNDER, EXCEED THE TOTAL AMOUNT PAID TO TI FOR THE PARTICULAR UNITS SOLD UNDER THESE TERMS AND CONDITIONS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM AGAINST THE PARTICULAR UNITS SOLD TO USER UNDER THESE TERMS AND CONDITIONS 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

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

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