User's Guide
SLLU203A–June 2014–Revised March 2015

DRV8846 Evaluation Module

This document is provided with the DRV8846 customer evaluation module (EVM) as a supplement to the DRV8846 (SLLSEK2) datasheet. It details the hardware implementation of the EVM.

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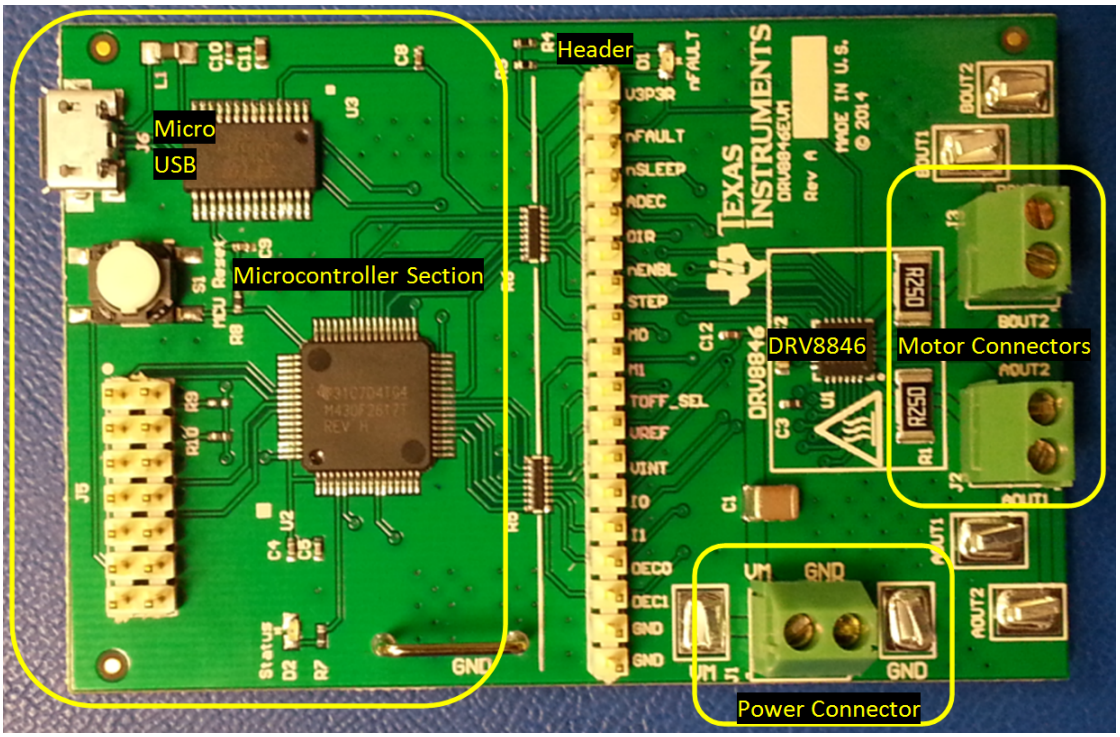
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1 PCB (Top View)



2 Introduction

The DRV8846 customer EVM is a platform revolving around the DRV8846, a low voltage dual H-bridge driver and highly configurable power stage. This device has been optimized to drive a single bipolar stepper with up to 32 degrees of internally generated microstepping.

The EVM houses an MSP430 microcontroller and a USB interface chip. The USB chip allows for serial communications from a PC computer where a Microsoft® Windows® application is used to schedule serial commands. These commands can be used to control each of the device's signals, and drive the stepper motor by issuing the step commands at the desired rate.

The microcontroller firmware operates using internal index mode.

This user's guide details the operation of the EVM, as well as the hardware configurability of the evaluation module.

2.1 Connectors

The DRV8846EVM offers access to VM (motor voltage) power rail via a terminal block (J1). A set of test clips in parallel with the terminal block allows for the monitoring of the input power rail.

Apply VM according to datasheet-recommended parameters.

NOTE: VDD for the microcontroller is derived from the micro USB connector.

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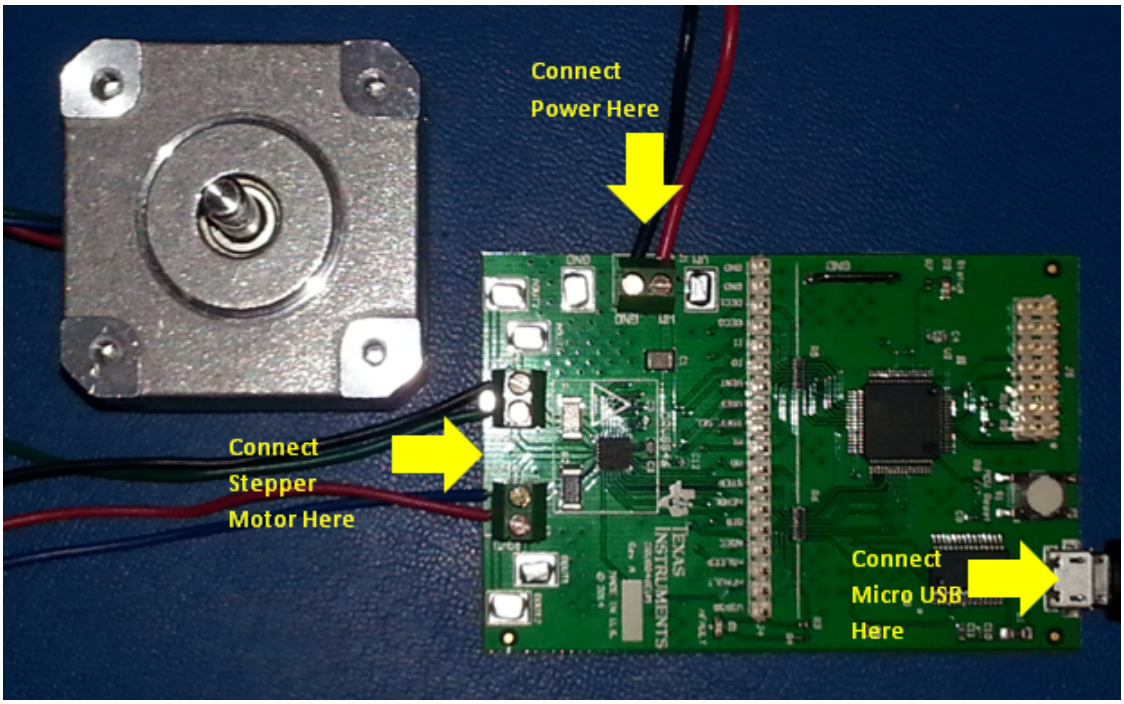


Figure 1. Connections

2.2 Test Points

A 0.100 in pitch header connector (J4) is used to provide access to every device signal in the event a different microcontroller is to be employed. To disconnect the internal MSP430 microcontroller, remove resistor packs R5 and R6. Table 1 describes the connections available on the J4 header. Each header pin is labeled on the evaluation module, and matches the pin of the DRV8846.

Table 1. Descriptions of the Connections Available on the J4 Header

Header Label	Description
V3P3R	3.3 V after 33-Ω resistor
nFAULT	Fault output
nSLEEP	Sleep Mode input
RSVD	Adaptive DECay input
DIR	Direction input
nENBL	Stepper motor enable
STEP	Step input
M0	Step mode
M1	Step mode
TOFF_SEL	Off-time selection
VREF	Scale voltage to set IFS
VINT	Internal supply voltage
I0	Torque (current level)
I1	Torque (current level)
DEC0	Decay mode
DEC1	Decay mode
GND	Ground
GND	Ground

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2.3 Jumpers

There are no jumpers on the DRV8846EVM module.

2.4 Motor Outputs

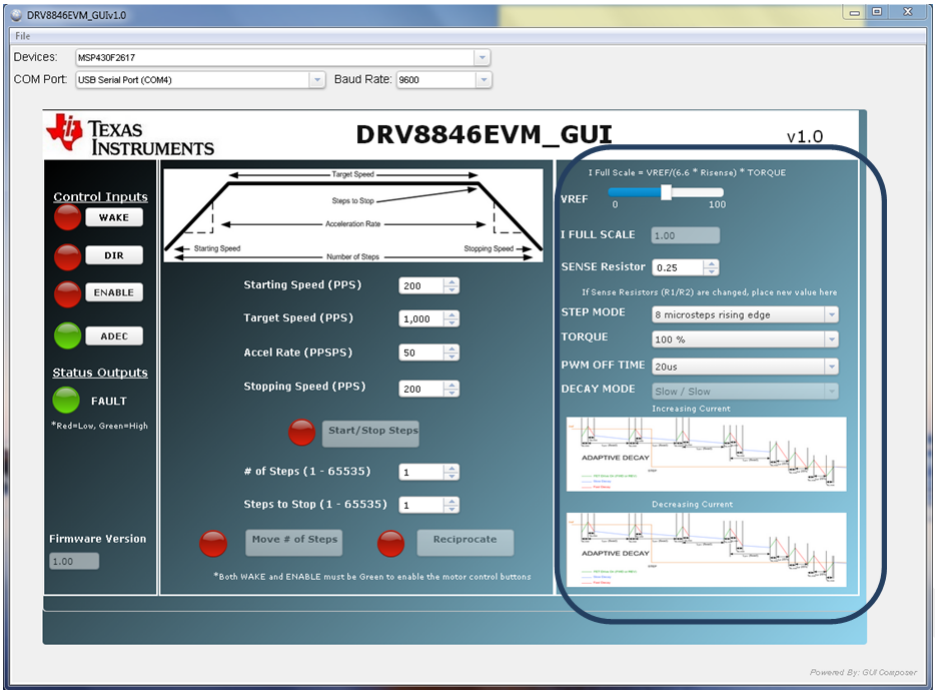
Two motor connectors are provided. Connectors J2 and J3 are available as shown in Figure 1.

2.5 Operation of the EVM

Use the following steps to operate the EVM.

1. Install the drivers and GUI. Refer to Appendix A at the end of this document for instructions.
2. Connect the wires of the stepper motor to terminals AOUT1, AOUT2, BOUT1, and BOUT2.
3. Connect the VM power supply but do not apply power at this step.
4. Connect the USB between the PC and the EVM. Open the GUI by selecting the launcher.exe file. It may take up to 15 seconds to establish connection.

   (a) Once the USB connection is established, the Status LED will begin to blink.
5. Apply 12 V to the VM and GND connections.
6. Configure the current settings, step and decay modes, torque, and pwm off time as desired as shown in the following image:



The current is calculated using the VREF slider, the Sense resistor value, the Torque setting, and the Step mode setting using the formula.

$$I_{FS} = \frac{VREF}{6.6 \times RISENSE} \times TORQUE \times StepModifier \quad (1)$$

Where ***StepModifier*** is 0.71 for full step and 1.0 for other STEP MODE settings

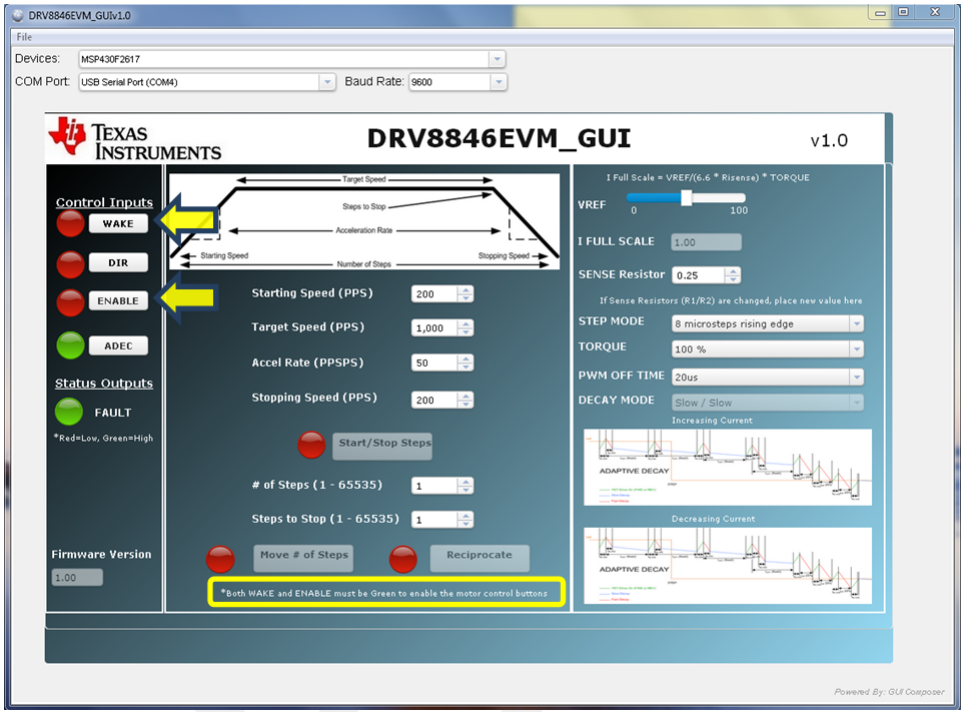
The 12-bit DAC channel 0 is connected to the DRV8846 analog input VREF. Changing the DAC digital value from 0 to 4092 in steps of 4, changes the analog voltage at the VREF pin from 0 V to VINT V. See Equation 2.

$$VREF = \frac{VINT}{4095} \times (VREF_slider \times 4) \quad (2)$$

Where VINT is the output of the DRV8846 pin and VREF_slider is the slider value from 0 to 1023.

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7. Wake and Enable the device for operation.
   (a) After setting up the controls signals for the DRV8846, enabling the DRV8846 requires selecting both the WAKE and ENABLE buttons. When the WAKE button or ENABLE button are selected, the circle to the left of the button will toggle from red to green.
   (b) The WAKE button, which controls the nSLEEP pin, is used to wake the DRV8846. The ENABLE button, which controls the nENBL pin, is used to enable the DRV8846 outputs.
   (c) A message which states that **Both WAKE and ENABLE must be Green to enable the motor control buttons* will be visible until both the WAKE and ENABLE buttons are activated. Once these two buttons have been activated, the message disappears and the Start/Stop and Move Steps buttons will be available.
   (d) If the WAKE or ENABLE buttons are selected during motor operation, the motor is immediately stopped and the STEP control signal from the microcontroller is reset.



8. The DRV8846 EVM is now awake and can be commanded to turn the motor. This can be done by either selecting the *Start/Stop Steps*, *Move # of Steps*, or *Reciprocate* buttons.

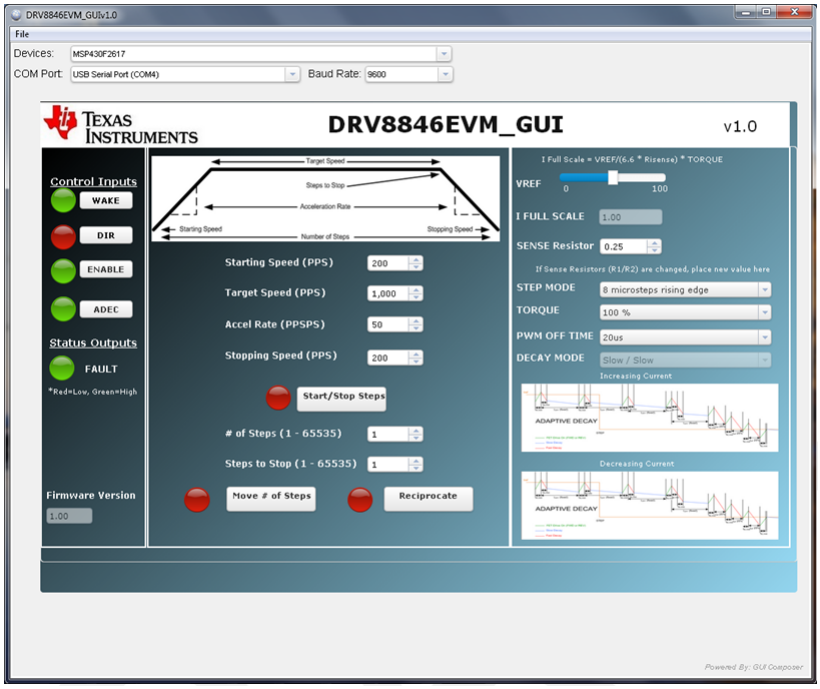
   The *Start/Stop Steps* button is used to run the motor indefinitely. The motor will accelerate to the target speed and run until the *Start/Stop Steps* button is selected. When the *Start/Stop Steps* button is selected, the red button will change to green, and the *Move Steps* and *Reciprocate* buttons will be disabled.

   The *Move Steps* button is used to allow movement of an exact number of steps. When the *Move Steps* button is selected, the red button to the left of *Move Steps* will turn green, and the *Start/Stop Steps* and *Reciprocate* buttons are disabled until the number of steps have completed.

   The *Reciprocate* button is a special case of the *Move Steps*. When selected, the motor will advance the specified number of steps in the direction initially set by the control inputs. After a short pause, the motor will then advance the same number of steps in the opposite direction. This sequence is repeated until the *Reciprocate* button is selected.

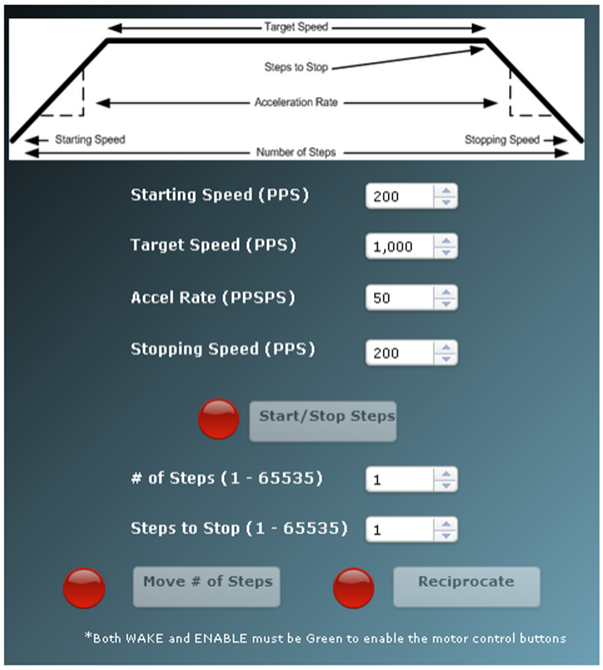
   When the *Reciprocate* button is selected, the red button to the left of *Reciprocate* will turn green, and the *Start/Stop Steps* and *Move # of Steps* buttons are disabled until the number of steps have completed.

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2.6 Motor Control Frame (Includes Start/Stop Steps and Move Steps)

The GUI has an area which offers access to a series of very useful stepper control algorithms. This area allows for determining the best current settings during running at various speeds, and when holding torque is applied.



Motor motion can only happen by using an acceleration profile which will be detailed later on. A detailed explanation of each stepper control section follows.

This frame allows the configuration and running of the stepper with the direction as specified by the DIR checkbox, with the current decay mode as specified under the *Decay Mode* checkbox and the microstepping resolution as specified under the *Step Mode* drop down box.

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The *Motion Control* frame gathers user information regarding stepping rate, or motor speed. An acceleration profile is employed to start at a programmable speed and increase stepping rate until reaching the programmable desired speed.

An internal 8-MHz timer is used to measure time and generate the steps on a timely manner. The GUI will send the information to the microcontroller as PPS, and the microcontroller will transform it into the respective clock cycles needed for the timer to generate accurate STEP pulse timing.

2.6.1 Start/Stop Steps

The acceleration profile is coded inside of the microcontroller to accept both the starting speed PPS and target speed PPS as a clock cycle number. When the start steps command is issued (*Starts/Steps* button is selected), the PWM timer generates steps at a rate specified by the start speed PPS parameter.

When accelerating or decelerating, PPS is adjusted every 32 ms, based on the integer value of PPSPS/32 ms. If a non-zero value of PPSPS is entered, a minimum value of 1 is used. The step rate is increased by the calculated value until the target speed is reached.

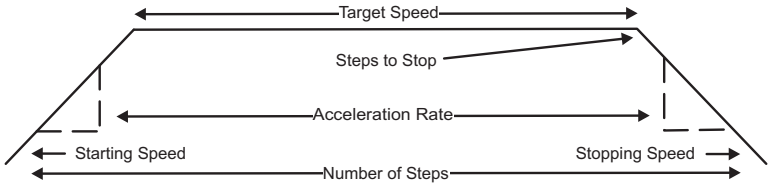
The very same start steps command computes how frequent automatic speed updates are issued and a second timer is used to change the speed according to the programmed acceleration rate profile.

Once the target speed (PPS) is reached, the acceleration profile ends and the motor stays running until the stop stepper command is issued (*Start/Stop Steps* button is selected again). When the stepper is commanded to stop, the controller does exactly as it did while accelerating, but in reverse to decelerate until the stop speed PPS is reached, in which case the motor fully stops.

A second motor actuation is provided by the *Move # of Steps* and *Reciprocate* commands in which a programmed number of steps are issued and then the motor stopped. The acceleration and deceleration profiles work similarly as before, except when the deceleration starts and when the motor actually stops are a function of the *Steps to Stop* and deceleration rate parameters.

This second motor actuation is adjusted automatically for rising edge or rising and falling edge settings in the STEP MODE.

The following figure shows the acceleration profile and the role each parameter plays during speed computation:



2.6.2 Move Steps

If the user desires to move the stepper a certain number of steps, this can be accomplished by using the move steps function. Parameters from the other frames are reused and its utilization is as explained previously. Two new parameters have been added to properly control the limited number of steps actuation.

Number of Steps: Number of steps the controller will issue.

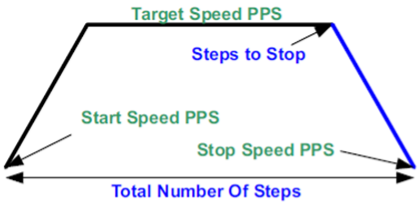
Steps to Stop: The controller is continuously monitoring the step being issued and when the current step is equal to the steps to stop parameter, a deceleration profile is issued. If *Steps to Stop* is larger than the number of steps, then the motor stops abruptly and without undergoing a deceleration profile.

When a deceleration profile is issued, the controller decreases the speed until reaching the stop speed value. If the number of steps parameter is met before the deceleration profile is complete, then the motor stops at the current speed. If the stop speed is met before all the number of steps is issued, then the motor rotates at the stop speed value until all the steps are executed.

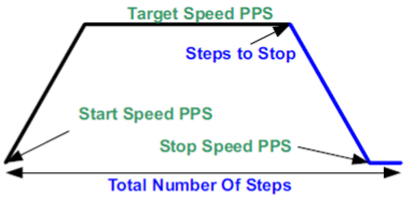
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Ideally, the system should be tuned to resemble the case in which the controller executes all the commanded steps at a speed as close as possible to the stop speed. In the event this is not possible, due to the particular parameters being chosen, stopping the motor at a speed very close to the stop speed is often good enough to ensure good motion quality and application performance.

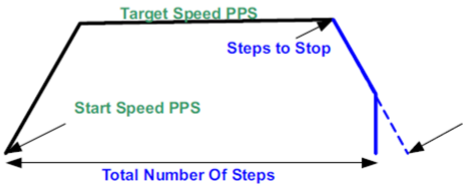
The following figure shows the three conditions possible when stopping and the action taken:



Motor Reaches Stop Speed at the Stop Speed



Motor Reaches Stop Speed before the Stop Speed is reached



Motor runs out of Steps before reaching Stop Speed

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2.7 Schematic and Bill of Materials (BOM)

2.7.1 DRV8846 Schematic

Figure 2 and Figure 3 illustrate the schematics for this EVM.

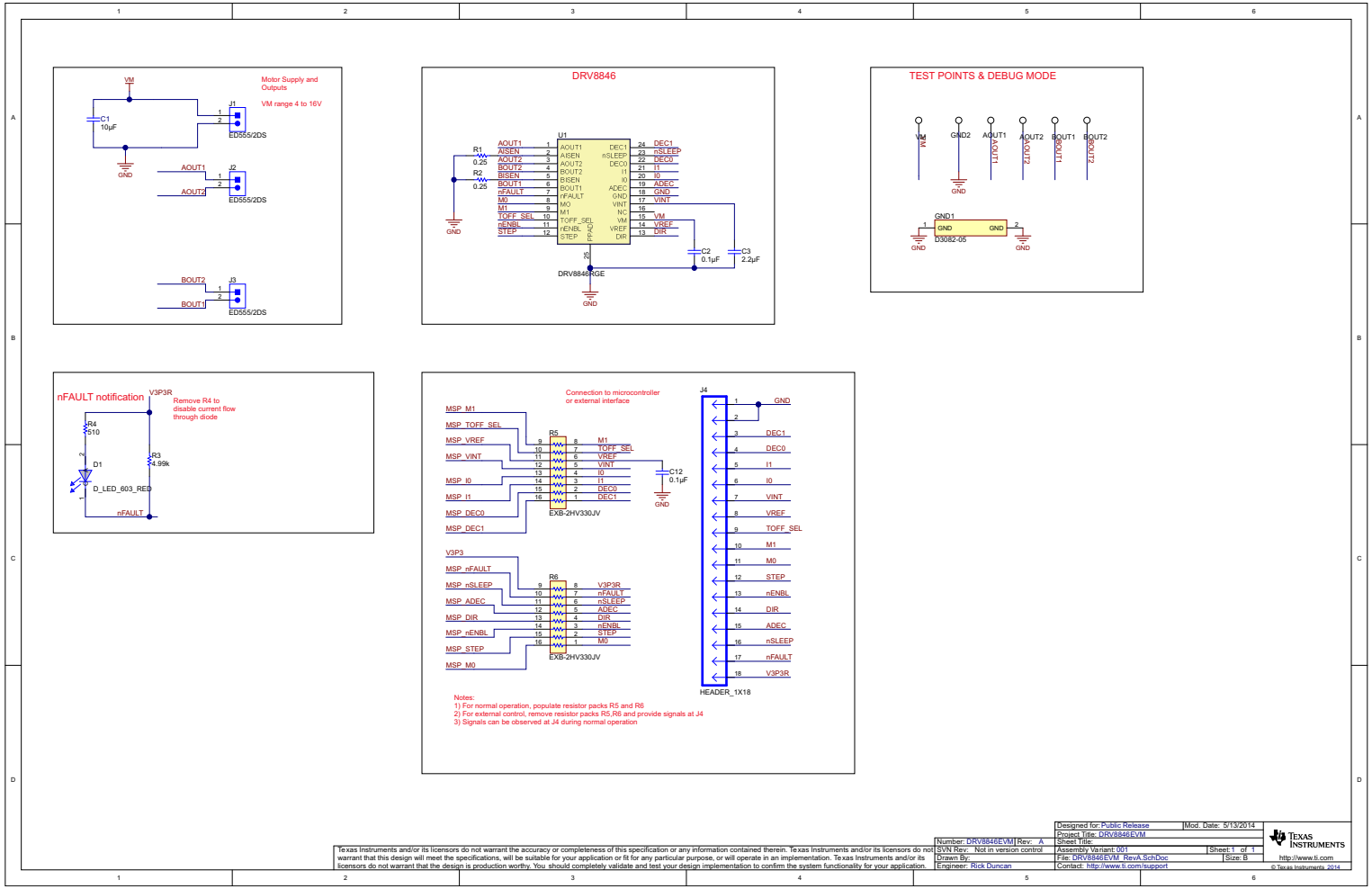


Figure 2. DRV8846 Schematic (1 of 2)

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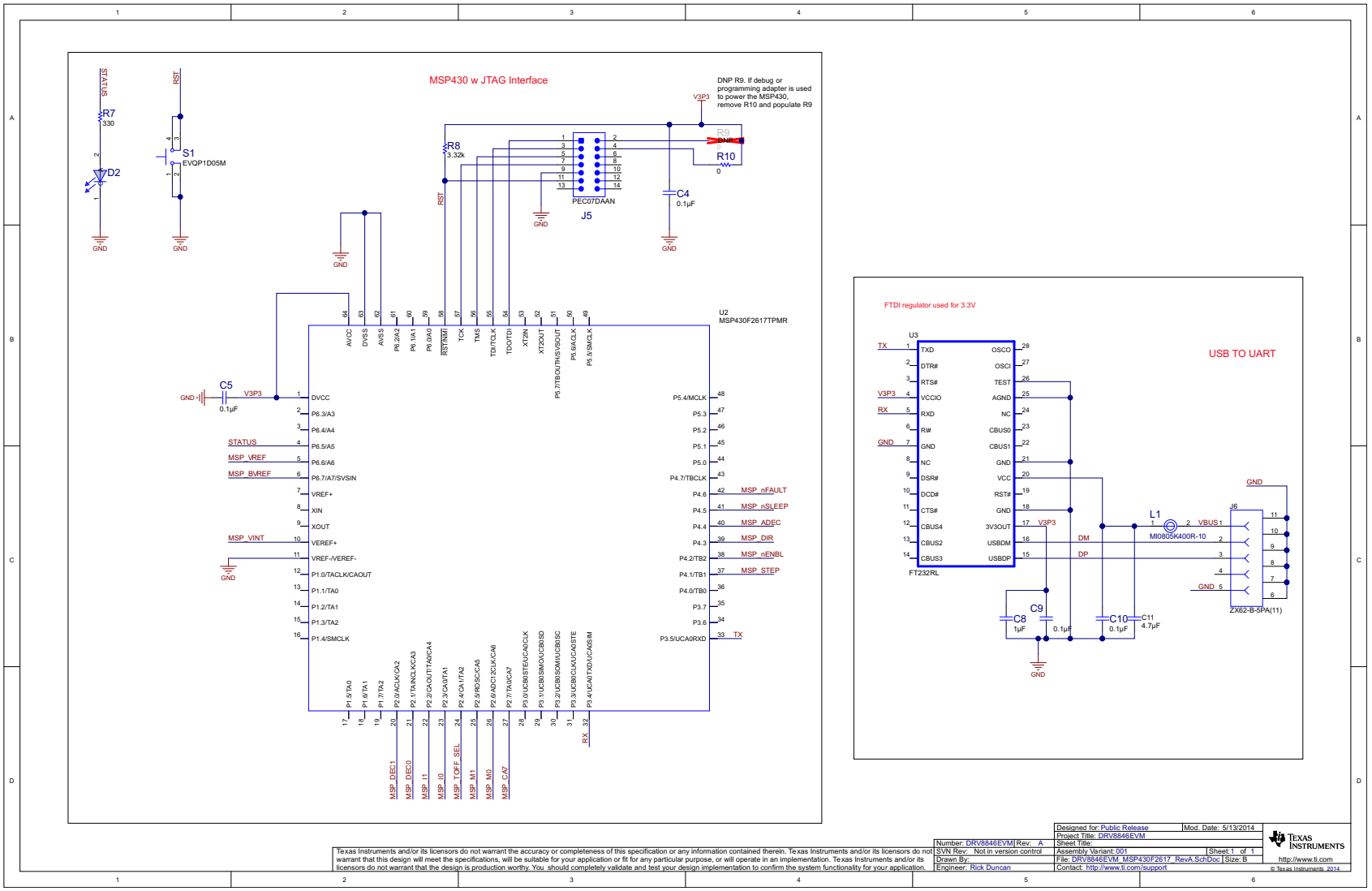


Figure 3. DRV8846 Schematic (2 of 2)

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2.7.2 Bill of Materials (BOM)

Table 2 lists the BOM for this EVM.

Table 2. DRV8846 Bill of Materials

Designator	Description	Manufacturer	PartNumber	Qty
!PCB	Printed Circuit Board	Any	DRV8846EVM	1
AOUT1, AOUT2, BOUT1, BOUT2, GND2, VM	Test Point, Compact, SMT	Keystone	5016	6
C1	CAP, CERM, 10uF, 35V, +/-20%, X7R, 1210	Taiyo Yuden	GMK325AB7106MM-T	1
C2	CAP, CERM, 0.1uF, 50V, +/-10%, X7R, 0603	AVX	06035C104KAT2A	1
C3	CAP, CERM, 2.2uF, 25V, +/-10%, X5R, 0402	TDK	C1005X5R1E225K050BC	1
C4, C5, C9, C10	CAP, CERM, 0.1uF, 10V, +/-10%, X5R, 0402	MuRata	GRM155R61A104KA01D	4
C8	CAP, CERM, 1uF, 10V, +/-10%, X5R, 0402	MuRata	GRM155R61A105KE15D	1
C11	CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0603	TDK	CGB3B1X5R1A475K055AC	1
C12	CAP, CERM, 0.1uF, 6.3V, +/-10%, X5R, 0402	TDK	C1005X5R0J104K	1
D1	Diode, LED, Red, 2.1-V, 20-mA, 6-mcd	Lite On	LTST-C190CKT	1
D2	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	Lite On	LTST-C190GKT	1
GND1	Shorting Plug	Harwin	D3082-05	1
J1, J2, J3	Terminal Block, 6A, 3.5mm Pitch, 2-Pos, TH	On-Shore Technology	ED555/2DS	3
J4	Header, Male 18-pin, 100mil spacing,	STD	PEC18SAAN	1
J5	Header, 100mil, 7x2, Tin plated, TH	Sullins Connector Solutions	PEC07DAAN	1
J6	Connector, micro USB Type B, Receptacle, R/A, SMD	Hirose Electric Co. Ltd.	ZX62-B-5PA(11)	1
L1	Bead, Ferrite, yymA	Steward	MI0805K400R-10	1
R1, R2	RES, 0.25 ohm, 1%, 1W, 2010	Stackpole Electronics Inc	CSRN2010FKR250	2
R3	RES, 4.99k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04024K99FKED	1
R4	RES, 510 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW0402510RJNED	1
R5, R6	RES, 33 ohm, 5%, 0.0625W, Resistor Array - 8x1	Panasonic	EXB-2HV330JV	2
R7	RES, 330 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW0402330RJNED	1
R8	RES, 3.32k ohm, 1%, 0.063W, 0402	Vishay-Dale	CRCW04023K32FKED	1
R10	RES, 0 ohm, 5%, 0.063W, 0402	Panasonic	ERJ-2GE0R00X	1
S1	Switch, Tactile, SPST-NO, 0.05A, 12V, SMT	Panasonic	EVQP1D05M	1
U1	IC, Motor Driver	Texas Instruments	DRV8846RGE	1
U2	IC, Mixed Signal Microcontroller, xKB+256B Flash Memory, 1KB RAM	TI	MSP430F2617TPMR	1
U3	IC, USB UART	Future Techonology Devices	FT232RL	1

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Driver Installation Instructions

1. Installing the DRV8846 Evaluation Board Application Software:
   Download and install the latest version (must be v5.5 or later) of *GUI Composer Runtime*. Register for a TI account if you don't already have one. The link to *GUI Composer Runtime* is:
   http://processors.wiki.ti.com/index.php/Category:GUI_Composer#GUI_Composer_Downloads
2. Installing the FTDI Driver:
   Download the driver from the DRV8846EVM software file (SLLC446), in the DRV8846EVM folder. Unzip it and install the USB driver:
   - If using Windows XP, run \USB driver\CDM v2.10.00 WHQL Certified.exe
   - If using Windows 7, go to the folder \USB driver\, right-click CDM v2.10.00 WHQL Certified.exe, select *Properties*, go to the *Compatibility* tab, check "Run this program in compatibility mode for", select "Windows XP (Service Pack 2)", OK. Then, run CDM v2.10.00 WHQL Certified.exe and click "Yes" in the pop-up window.
3. Running the Application Software:
   Go to the unzipped folder \Application\ and move the folder DRV8846EVM_GUIv1.0 into the C:\ti\guicomposer\webapps\ directory. (Note: if you chose a non-default installation directory in Step 1, the C:\ti\ part will be different.) When completed as desired, a shortcut can be created to C:\ti\guicomposer\webapps\DRV8846EVM_GUIv1.0\launcher.exe by clicking and dragging the file while holding the Alt key.

   When complete, the folder C:\ti\guicomposer\webapps\DRV8846EVM_GUIv1.0 should exist with the following files in the folder:

Name	Type
.settings	File folder
Images	File folder
.appsettings	APPSETTINGS File
app.css	Cascading Style Sheets
app.html	HTML Document
app.js	JScript Script File
app.json	JSON File
appInitScript.js	JScript Script File
appProgram.out	OUT File
index.html	HTML Document
launcher	File
launcher.exe	Application

Revision History

Changes from Original (June 2014) to A Revision	Page
• Changed caption, fixed typo.	10
• Changed format, new template.	12

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

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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

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   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.

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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

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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.

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