

BOOSTXL-DRV8305EVM User's Guide

This document is provided with the BOOSTXL-DRV8305EVM customer evaluation module (EVM) as a supplement to the DRV8305 data sheet ([DRV8305 Three Phase Gate Driver With Current Shunt Amplifiers and Voltage Regulator](#)). This user's guide provides details on the setup and hardware implementation of the BoosterPack™ plug-in module.

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1 BOOSTXL-DRV8305EVM

1.1 PCB 3-D Views

Figure 1 shows the top view of the BOOSTXL-DRV8305EVM board. Figure 2 shows the BoosterPack header signals.

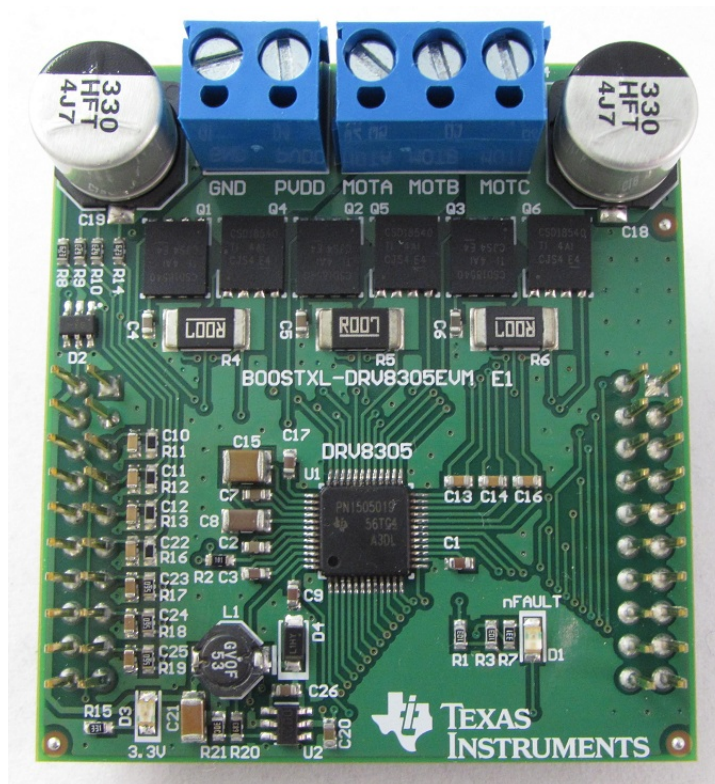


Figure 1. PCB Image (From Above)

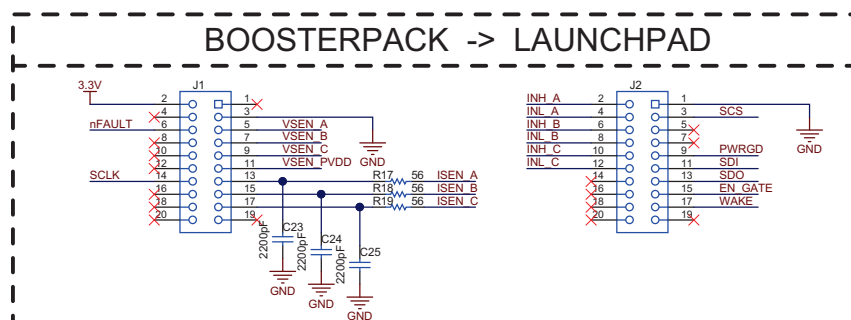


Figure 2. BoosterPack Header Signals

1.2 PCB 3-D Views

Figure 3 and Figure 4 show the top and bottom three-dimensional PCB views.

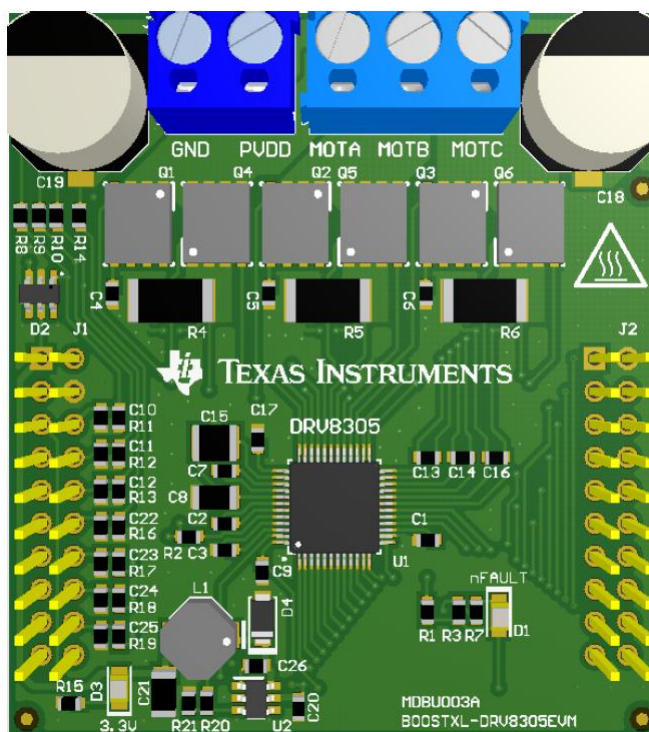


Figure 3. 3-D Top View

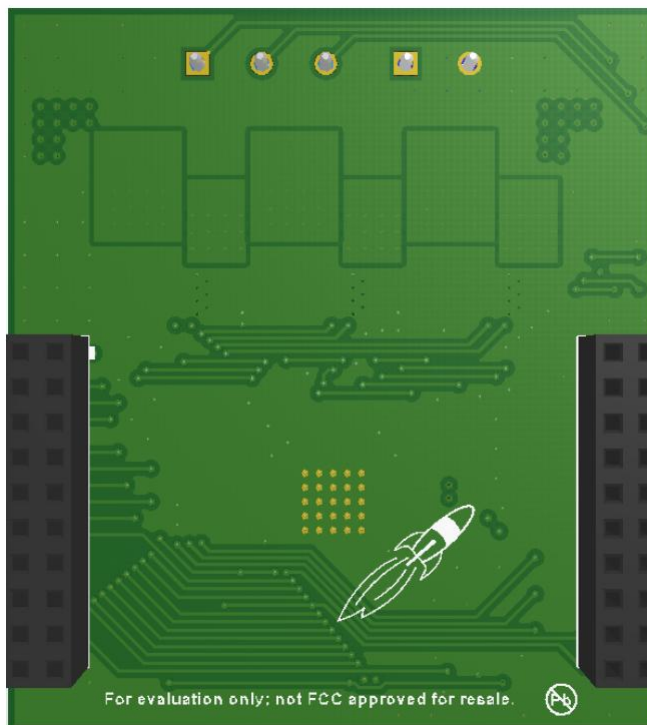


Figure 4. 3-D Bottom View

2 Introduction

The BOOSTXL-DRV8305EVM BoosterPack is a complete 3-phase driver stage in order to evaluate motor application with the DRV8305 motor gate driver. It utilizes a compact and modular form factor for ease of use and is designed to dock with compatible TI LaunchPad™ development kits for a complete motor control system.

2.1 Features

The following lists the BOOSTXL-DRV8305EVM features:

- Complete 3-phase drive stage in a compact form factor (2.0 in × 2.2 in)
- Supports 4.4- to 45-V voltage supply and up to 15-A RMS (20-A peak) drive current
- 6x CSD18540Q5B N-Channel NexFET™ Power MOSFETs (1.8 mΩ)
- Individual motor phase and DC bus voltage sense
- Low-side current shunt sense for each half-bridge
- Fully protected drive stage including short circuit, thermal, shoot-through, and undervoltage protection
- LMR16006 wide voltage input, 0.6-A step down buck regulator for MCU supply
- Combine with compatible LaunchPad XL kits to create a complete 3-phase motor control platform
- Optimized for the Piccolo™ LAUNCHXL-F28027F LaunchPad to support the InstaSPIN-FOC™ sensorless motor control solution

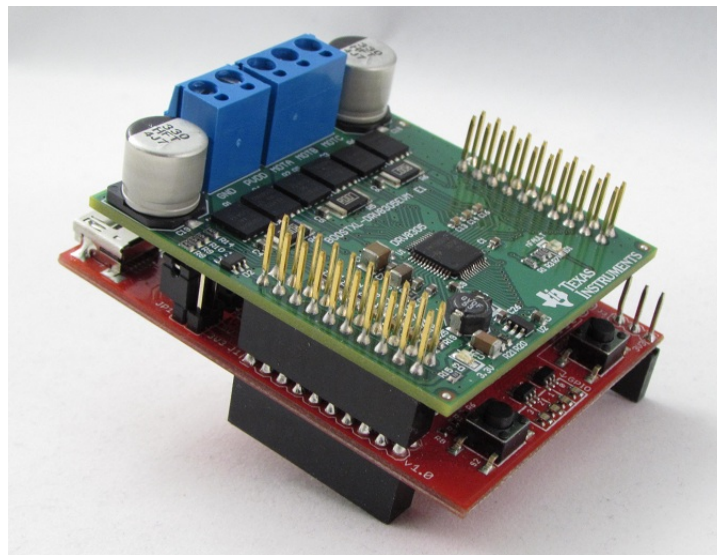


Figure 5. BOOSTXL-DRV8305EVM With LAUNCHXL-F28027F

2.2 Pinout

The BOOSTXL-DRV8305EVM brings out a mixture of power, control, and feedback signals to the XL LaunchPad headers.

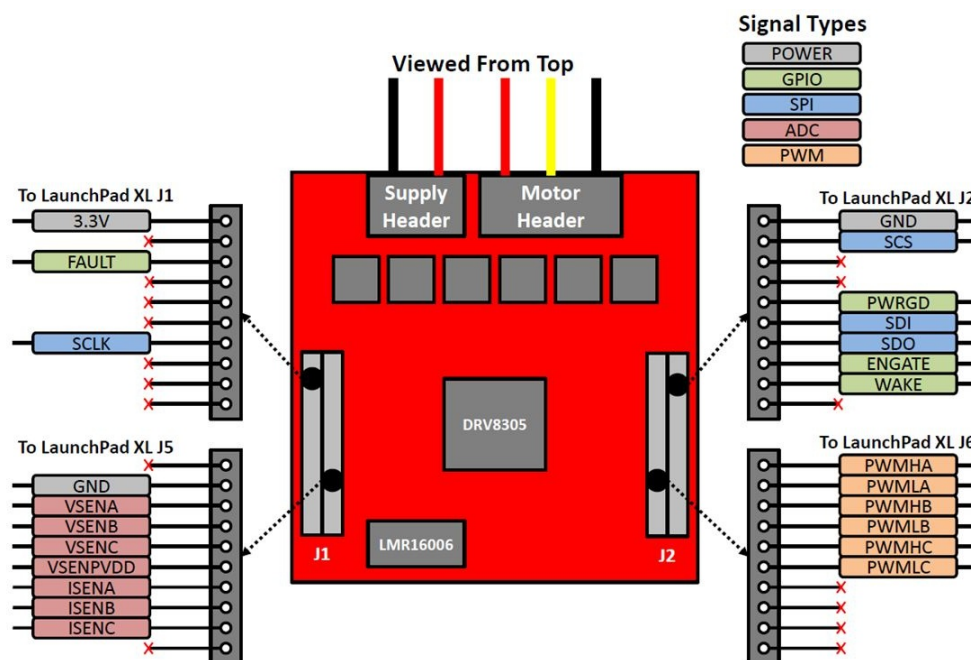


Figure 6. BOOSTXL-DRV8305EVM Pinout

- Terminal block headers for the power supply and motor connections
- Onboard LM16006 step-down buck regulator to provide 3.3-V power to the LaunchPad
- Fault reporting through the nFAULT and PWRGD signals
- SPI to set device configuration, operating parameters, and read out diagnostic information
- Voltage sense for the voltage supply bus and each phase output (scaled for 4.4- to 45-V operation)
- Low-side current shunt sensing on each phase (scaled for 0- to 20-A peak current operation)

2.3 Operating Conditions

Table 1 lists the operating conditions.

Table 1. Operating Conditions

Parameter	Minimum	Maximum	Unit
Operating supply voltage	4.4	45	V
Operating supply current (EN_GATE = Low)		150	mA
Operating temperature	–40	125	°C

3 Getting Started

3.1 Requirements

The BOOSTXL-DRV8305EVM is **not a standalone** motor control kit and requires a compatible XL LaunchPad to provide the appropriate motor control signals. The BOOSTXL-DRV8305EVM has been specifically designed for the LAUNCHXL-F28027F InstaSPIN-FOC LaunchPad. In addition to the BoosterPack and a compatible XL LaunchPad, a 3-phase motor and sufficient power supply are required.

3.2 Configuring the LaunchPad

The BOOSTXL-DRV8305EVM BoosterPack **supplies 3.3 V to the LaunchPad** through the onboard LMR16006 0.6-A, step-down buck regulator. It is recommended to **remove the jumpers on the LaunchPad that connect the emulation and controller power supplies**. The LaunchPad communication lines should also be configured to ensure proper operation from the host PC.

Example: LAUNCHXL-F28027F

For the LAUNCHXL-F28027F LaunchPad, remove the JP1 (3.3 V), JP2 (GND), and JP3 (5 V) jumpers to isolate the two power supply domains (MCU and Emulator).

The S1 switch should be set to the ON-ON-ON position to allow for a JTAG debug connection. The S4 switch should be moved to the OFF position to allow for the nFAULT pin from the DRV8305 to report correctly.

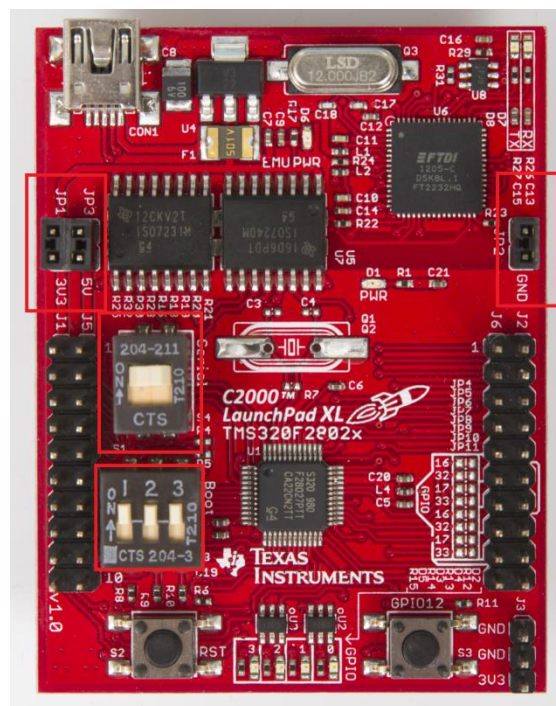


Figure 7. LAUNCHXL-F28027F Configuration

3.3 Connecting the Hardware

Use the following steps to connect the hardware:

1. Plug the BOOSTXL-DRV8305EVM BoosterPack onto the LaunchPad as shown in [Figure 5](#). The terminal block headers should be oriented towards the USB connector and the 20-pin headers (J1 and J2) should align properly.
2. Connect the 3-phase motor to the terminal block header J4. The motor connections have been labeled with A, B, and C but can be connected in any order.
3. Connect the power supply, that will power the BoosterPack's DRV8305 3-phase gate driver, 3-phase power stage, and LMR16006 buck regulator to the terminal block header J3. The connections have been labeled PVDD and GND. For full performance, ensure the supply can support as much current as your motor may demand. The BoosterPack has a designed operating range from 4.4- to 45-V with up to 15-A RMS (20-A peak) of phase output current.

WARNING

At high currents the drive stage can increase to high temperatures. Use proper handling procedures.

4. Enable the power supply. A fault may appear on the nFAULT LED. This is normal and should be cleared when the status registers are read or EN_GATE is taken HIGH.
5. Enable the control algorithm and begin spinning the motor. The BOOSTXL-DRV8305EVM BoosterPack combined with a compatible XL LaunchPad will provide a complete motor drive and control evaluation platform. With the Piccolo LAUNCHXL-F28027F LaunchPad you can take full advantage of **TI's InstaSPIN™-FOC sensorless control solution**. To get started with InstaSPIN-FOC (<http://www.ti.com/instaspin-foc>) download and run the MotorWare™ software (<http://www.ti.com/tool/motorware>), reviewing the LAUNCHXL and BOOSTXL resources.

4 Demo Application

The BOOSTXL-DRV8305EVM BoosterPack has been optimized to work together with the Piccolo LAUNCHXL-F28027F LaunchPad to provide a complete motor drive and control evaluation platform. To quickly get your 3-phase motor spinning, see TI's InstaSPIN-FOC sensorless control solution at <http://www.ti.com/tool/motorware>. Multiple projects, labs, and an easy to use GUI are available with TI MotorWare available at <http://www.ti.com/tool/motorware>, with detailed documentation and user guides.

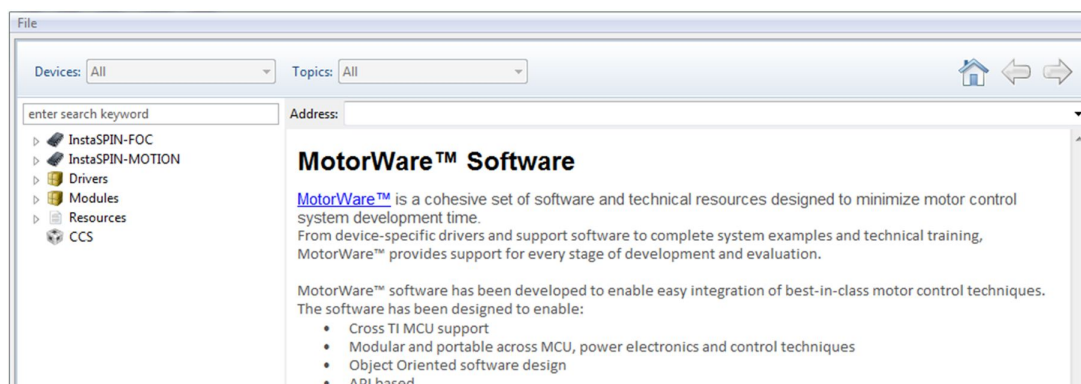


Figure 8. MotorWare™ Software

5 Detailed Hardware Description

The BOOSTXL-DRV8305EVM BoosterPack is a complete drive stage for 3-phase motor applications. The design consists of the DRV8305 motor gate driver, CSD18540Q5B N-Channel NexFET Power MOSFETs, and LMR16006 buck regulator. See the respective data sheets for the DRV8305 ([SLVSCX2](#)), CSD18540Q5B ([SLPS488](#)), and LMR16006 ([SNVSA24](#)) for more information concerning each device.

5.1 DC Bus and Phase Voltage Sense

The BoosterPack has been designed with voltage sense circuits on the DC bus (PVDD) and each half-bridge outputs (phases A, B, and C). These circuits, shown [Figure 9](#), consist of a voltage divider with a filtering capacitor to reduce high frequency noise on the ADC pins. These circuits have been scaled to support 4.4 to 45 V. The high-side resistors for the phase outputs are located near the motor output header (J4) while the low-side resistors and filtering capacitors are located near the ADC pins on the BoosterPack to LaunchPad header (J1) for improved noise reduction purposes.

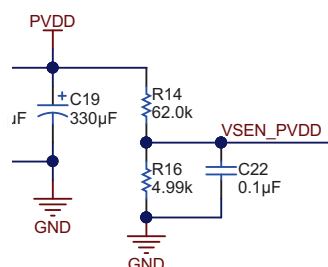


Figure 9. Voltage Sense

To achieve higher resolution voltage feedback, the scaling can be adjusted by replacing the high-side resistors with a lower value.

Example: For a 12-V system, R8, R9, R10, and R14 could be replaced with 22-kΩ resistors to approximately triple the voltage resolution. The new full scale voltage would be 17.85 V.

5.2 Low-Side Current Shunt Sense

The BoosterPack has low-side current shunt sense for each half-bridge (phases A, B, and C). The current sense setup takes advantage of the DRV8305's triple shunt current amplifiers (phases A, B, and c). The configuration for the low-side sense is shown in [Figure 9](#). The differential amplifier senses voltage across a 0.007-Ω power sense resistor with differential connections. The differential voltage is then amplified by 10 V/V and centered at 1.65 V to allow for sensing both positive and negative currents. The sense resistor has been scaled for 0- to 20-A peak currents.

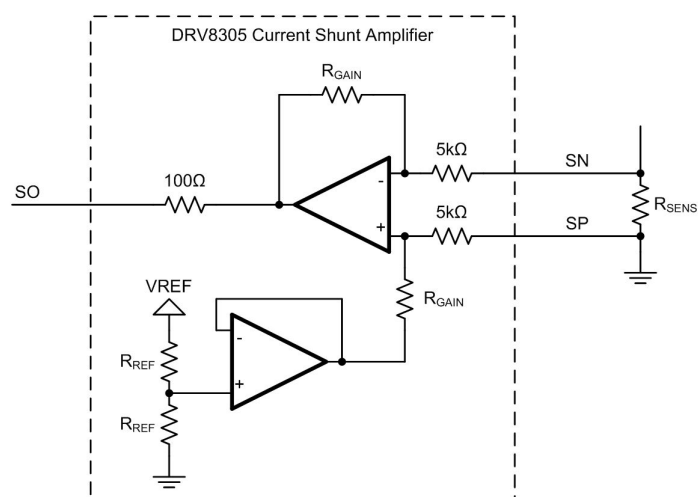


Figure 10. Current Sense

5.3 BoosterPack GPIO Signals

The Motor Drive BoosterPack brings out the GPIO signals for the DRV8301 to the LaunchPad XL. These signals are described in detail in the following list and further information can be found in the DRV8301 data sheet.

1. **nFAULT:** Fault indicator, specific FAULT status can be obtained through the status registers
2. **PWRGD:** Watchdog and LDO regulator status indicator
3. **EN_GATE:** Enables gate driver and current shunt amplifiers
4. **WAKE:** Used to bring the device out of its low power sleep mode.

5.4 DRV8305 Status and Control Registers

The DRV8305 provides extensive fault reporting and device configuration through an SPI interface and internal registers. There are two categories of registers: status and control. Status registers provide information about device faults and warnings. This information can include items ranging from IC overtemperature to MOSFET overcurrent events. The control registers allow various device parameters to be modified to suit system requirements. These parameters include but are not limited to gate drive current, dead times, current shunt amplifier configurations, and fault reporting modes. For specific information concerning the DRV8305 registers, refer to the data sheet ([SLVSCX2](#)).

The InstaSPIN GUI allows easy access to read and modify the DRV8305's internal registers. These can be accessed on the DRV8305 tab of the InstaSPIN Universal GUI.

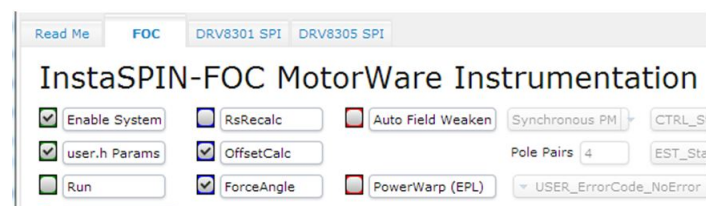
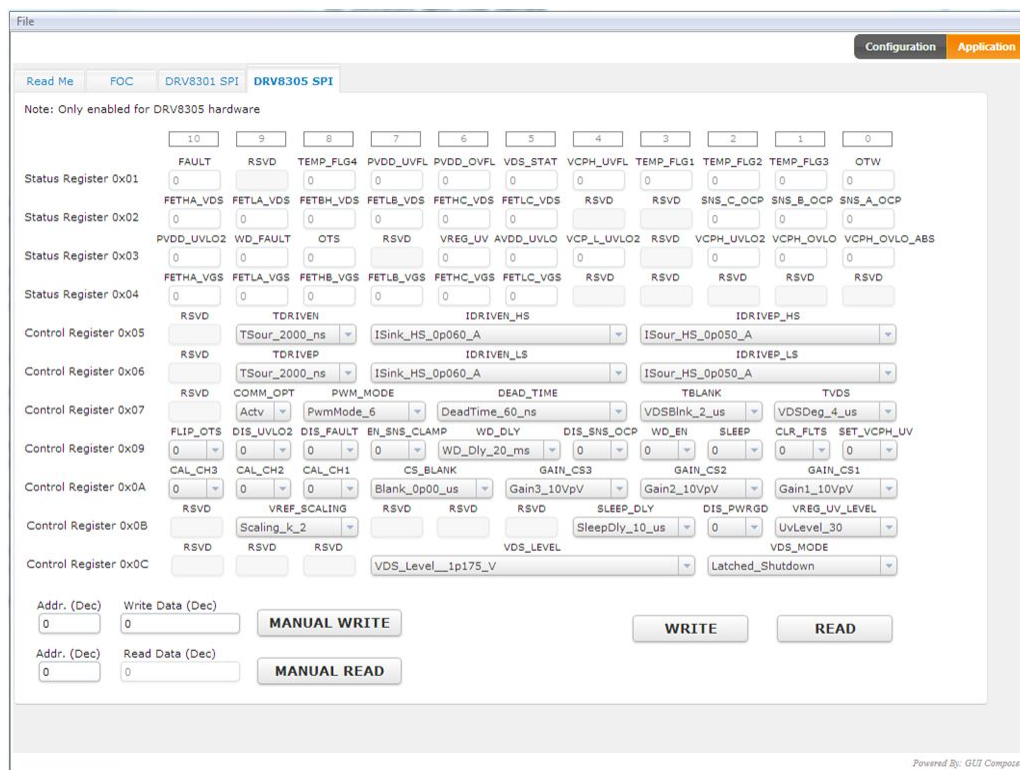


Figure 11. Enable System

Power to the BoosterPack needs to be supplied and **Enable System** needs to be checked to allow SPI reads and writes. The DRV8305 SPI tab displays a map of the DRV8305 internal registers, both status and control. To read from the registers, select the **Read** button. The register map will update with the current register values. To write to the registers, make the desired change in the map and select the **Write** button. Manual reads or writes to individual registers can be made with the **Manual Write** and **Manual Read** buttons (in decimal).



Note: Only enabled for DRV8305 hardware

Register	10	9	8	7	6	5	4	3	2	1	0
Status Register 0x01	FAULT	RSVD	TEMP_FLG4	PVDD_UVFL	PVDD_OVFL	VDS_STAT	VCPH_UVFL	TEMP_FLG1	TEMP_FLG2	TEMP_FLG3	OTW
Status Register 0x02	FETHA_VDS	FETLA_VDS	FETBH_VDS	FETLB_VDS	FETHC_VDS	FETLC_VDS	RSVD	RSVD	SNS_C_OCP	SNS_B_OCP	SNS_A_OCP
Status Register 0x03	PVDD_UVLO2	WD_FAULT	OTS	RSVD	VREG_UV	AVDD_UVLO	VCP_L_UVLO2	RSVD	VCPH_UVLO2	VCPH_OVLO	VCPH_OVLO_ABS
Status Register 0x04	FETHA_VGS	FETLA_VGS	FETBH_VGS	FETLB_VGS	FETHC_VGS	FETLC_VGS	RSVD	RSVD	RSVD	RSVD	RSVD
Control Register 0x05	RSVD	TORIVEN	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS	IDRIVEN_HS
Control Register 0x06	RSVD	TORIVEP	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS	IDRIVEN_LS
Control Register 0x07	RSVD	COMM_OPT	PWM_MODE	DEAD_TIME	DEAD_TIME	DEAD_TIME	DEAD_TIME	DEAD_TIME	DEAD_TIME	DEAD_TIME	DEAD_TIME
Control Register 0x09	FLIP_OTS	DIS_UVLO2	DIS_FAULT	EN_SNS_CLAMP	WD_DLY	DIS_SNS_OCP	WD_EN	SLEEP	CLR_FLTS	SET_VCPH_UV	SET_VCPH_UV
Control Register 0x0A	CAL_CH3	CAL_CH2	CAL_CH1	CS_BLANK	GAIN_CS3	GAIN_CS2	GAIN_CS1	GAIN_CS1	GAIN_CS1	GAIN_CS1	GAIN_CS1
Control Register 0x0B	RSVD	VREF_SCALING	RSVD	RSVD	RSVD	SLEEP_DLY	DIS_PWRGD	VREG_UV_LEVEL	VREG_UV_LEVEL	VREG_UV_LEVEL	VREG_UV_LEVEL
Control Register 0x0C	RSVD	RSVD	RSVD	VDS_LEVEL	VDS_LEVEL	SleepDly_10_us	0	UvLevel_30	UvLevel_30	UvLevel_30	UvLevel_30

Addr. (Dec) Write Data (Dec) 0 0 **MANUAL WRITE** **WRITE** **READ**

Addr. (Dec) Read Data (Dec) 0 0 **MANUAL READ**

Powered By: GUI Composer

Figure 12. DRV8305 SPI Registers

5.5 BOOSTXL-DRV8305EVM Schematic

Figure 13 shows the BOOSTXL-DRV8305EVM schematic.

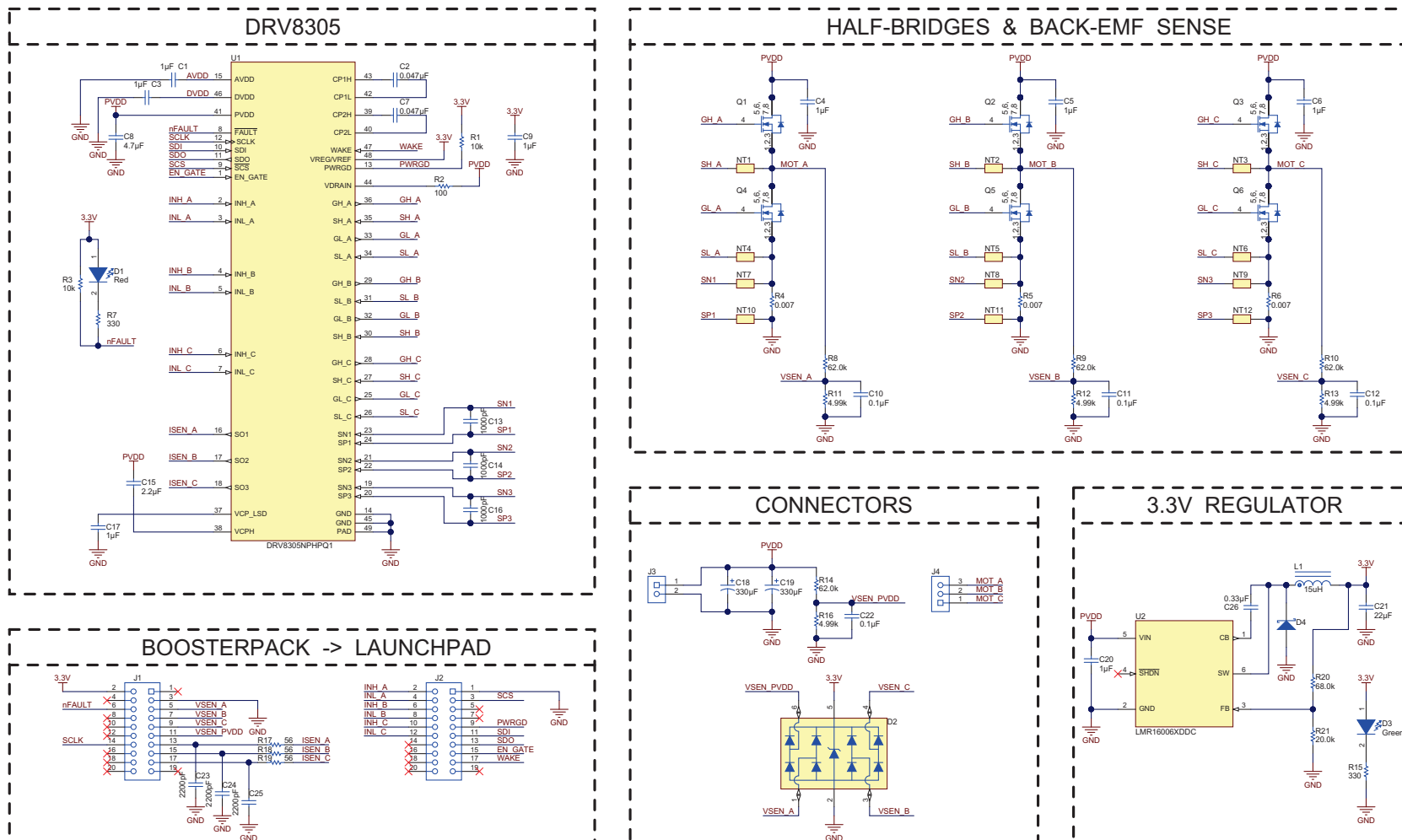


Figure 13. BOOSTXL-DRV8305EVM Schematic

5.6 Hardware Source Files

The complete design files can be found on the tool folder, including the schematic, Gerbers, designs files, PCB views, and bill of materials.

Revision History

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

Changes from Original (August 2015) to A Revision	Page
• Added the <i>Operating Conditions</i> section	5

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- 3.1 *United States*

- 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

- 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

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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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