

DRV3201EVM

The Texas Instruments DRV3201 evaluation module (DRV3201EVM) helps designers evaluate the operation and performance of the DRV3201-Q1 bridge driver for electronic power steering applications. The DRV3201EVM can accept many of the TI micro control unit (MCU) control cards. The device with the MCU offers configurability and can turn a motor through a graphical user interface (GUI).

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1 Features

- Max 1-A (Programmable) Pre-driver with 2x Internal Programmable Gain Amplifiers for Shunt Current Sensing
- 4.75-V to 30-V Operating Supply Voltage
- 5-V Step Down Converter (2.5 A) and 3.3-V LDO (400 mA)
- N-channel MOSFETs
- Isolated 5-V Controller Area Network (CAN) Transceiver
- DIMM-100 Socket using Control Card of Texas Instruments
- Sockets for Sensor Input

2 Introduction

The DRV3201EVM is an application board to evaluate the DRV3201-Q1 device. The DRV3201-Q1 device is a field effect transistor (FET) pre-driver designed for a 3-phase brushless DC motor control, and it has many safety functions. The EVM consists of the DRV3201-Q1 device, six N-channel MOSFETs, DC/DC converters (5 V or 3.3 V), isolated CAN transceiver, and passive devices. Because this EVM has a TI control card socket, you can control a motor from an MCU control card provided by Texas Instruments. This document offers the control example using TMS570LS12 control card in DRV8301-LS12-KIT.

3 Board Layout

All parts are mounted on the top side. Almost all terminals in the DRV3201-Q1 device (except sensitive terminals) have a test point. Terminals can be checked in debug mode. Each test point is classified by the category color.

- Red → Power Line
- Black → Ground
- Orange → Signal

The DRV3201EVM is separated into functional groups that enable a complete motor drive system, these are referred to as macro blocks. Following is a list of the macro blocks present on the board and their functions:

- Control Card Socket – Socket for a control card (preferably using built-in emulation).
- PVDD and GND Terminals – Connect an external 4.75 to 30-V DC lab supply here making sure to observe correct polarity.
- DRV3201-Q1 – This module includes the DRV3201-Q1 3-phase pre-driver as well as all of the necessary external passive components.
- Current Sense – Low-side shunt current sensing on each half-bridge (optional). The current gain is x20 by default.
- Quadrature Encoder Connections – Connections are available for an optional shaft encoder to interface with the MCU QEP peripheral.
- Hall Effect Sensor Connections (Digital and Analog) – Connections are available for optional hall effect sensors.

The board layout is shown in [Figure 1](#).

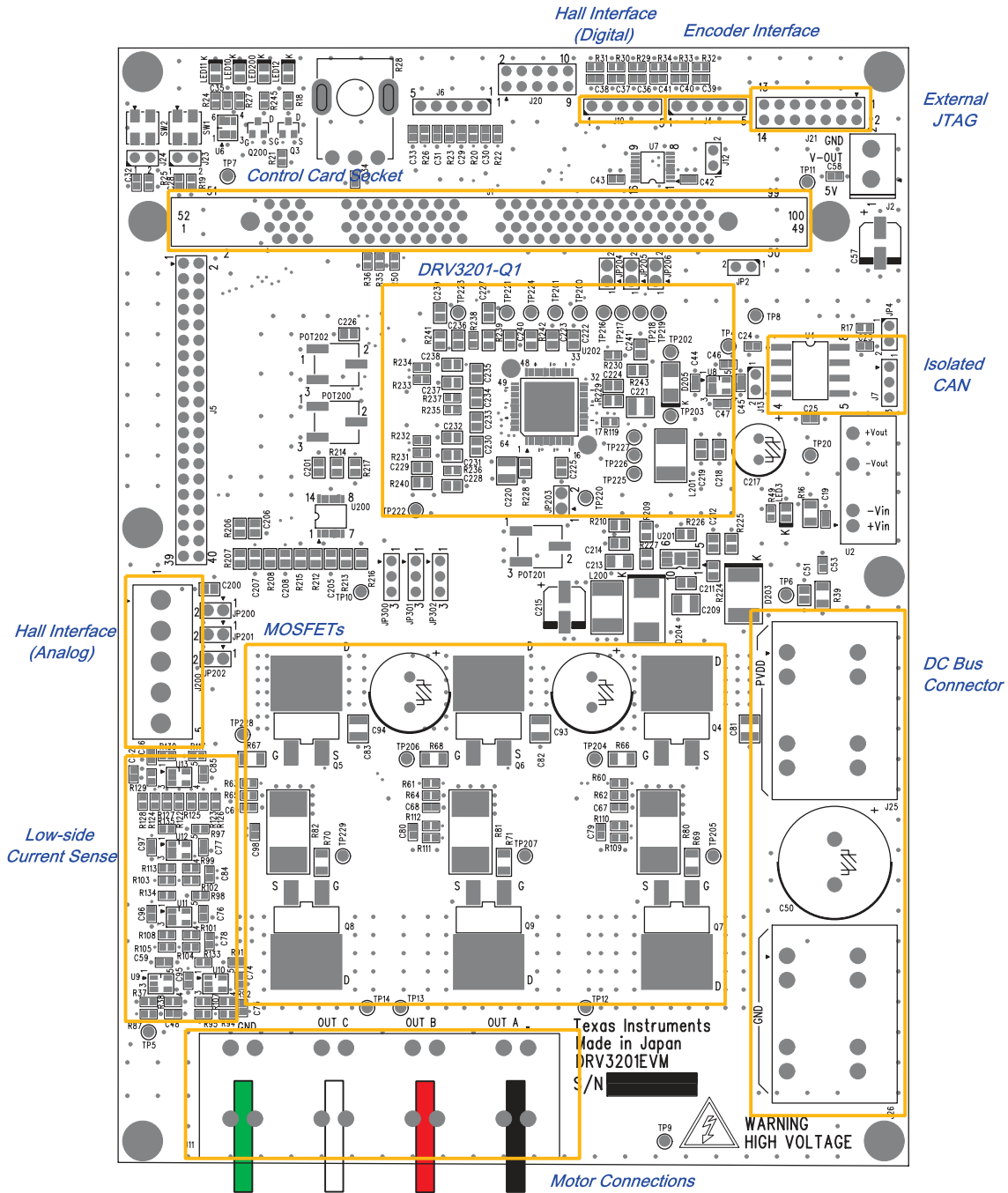


Figure 1. Board Layout (Top Side)

4 Parts Description

4.1 Headers and Connectors

Some headers and connectors connect to a control card socket (J1) directly. The headers and connectors are arranged (based on the DRV8301-LS12-KIT) on the assumption that the control card socket is used for motor control.

Table 1. Headers and Connectors

| Part No. | Description | Purpose |
|----------|--------------------|---|
| J1 | DIMM-100 Socket | Connected MCU control card of Texas Instruments |
| 25 | Connector Terminal | Power supply |
| J26 | Connector Terminal | Ground |
| J11 | Connector Terminal | Motor output |
| J2 | Connector Terminal | 5-V step down converter output |
| J21 | Header | JTAG interface |
| J4 | Header | Encoder interface |
| J10 | Header | Hall sensor interface (digital) |
| J200 | Connector Terminal | Hall sensor interface (analog) ⁽¹⁾ |
| J12 | Header | LIN interface (3.3 V) |
| J7 | Header | CAN interface (5 V, isolated) |
| J13 | Header | 3.3-V output |
| J23, J24 | Header | Output of push switch |
| J20 | Header | SPI signal to DRV3201-Q1 |

⁽¹⁾ Shared ADC inputs to MCU with the external current sense amplifiers.

4.2 LEDs

The LEDs inform the user of the current EVM state.

Table 2. LEDs

| Part No. | Description | Purpose |
|---------------------|-------------|----------------------------------|
| LED3 | GREEN | Step Down Converter (5 V) output |
| LED200 | RED | ERR signal from DRV3201-Q1 |
| LED10, LED11, LED12 | GREEN | GPIO signal from MCU |

4.3 Jumper Terminals

The jumpers in this EVM are for evaluation or customer selection. Some jumper terminals have a short socket by default.

Table 3. Jumper Terminals

| Part No. | Description | Purpose |
|---------------------|-------------|--|
| JP2 | 2 positions | Supplied 5 V to MCU ⁽¹⁾ : short |
| JP4 | 2 positions | Add a resistor between CAN-L and CAN-H: short |
| JP300, JP301, JP302 | 3 positions | Select the input to ADC in MCU control card: 2–3 short |
| JP200, JP201, JP202 | 2 positions | For calibration of analog hall sensor inputs: open |
| JP204 | 2 positions | Select the power supply to ADREF: short |
| JP205, JP206 | 2 positions | For test terminals: short |

⁽¹⁾ In case of DRV8301-LS12-KIT, this 5-V output is not used because there is a power IC in MCU.

4.4 Potentiometers

There are some potentiometers in this EVM that adjust the input voltage level. The purpose of the potentiometer is shown in [Table 4](#).

Table 4. Potentiometers

| Part No. | Description | Purpose |
|----------|---------------|---|
| R28 | 10 K Ω | Connected to ADC in MCU control card |
| POT200 | 10 K Ω | Adjust the reference voltage of analog hall sensor input |
| POT201 | 10 K Ω | Adjust the short circuit threshold (SCTH) level to DRV3201-Q1 |
| POT202 | 10 K Ω | Adjust current sense amplifier reference level to DRV3201-Q1 |

5 Evaluation Example

The DRV3201EVM is designed based on the DRV8301-LS12-KIT (available on the TI product folder www.ti.com/tool/drv8301-ls12-kit), which includes the motor, software and MCU. The connections between the MCU and each interface connector are arranged with compatible pins. The DRV8301-LS12-KIT is the easiest way to evaluate motor control with this EVM.

5.1 Setup

5.1.1 Software

In the kit, there are two DVDs. One DVD (CCS 5) is for downloading Code Composer Studio (CCS) version 5 which supplies the development environment, and the other DVD (Motor Kit) is for motor evaluation. The software from both DVDs must be installed. Please refer the detailed information from the PDF below after installing the Motor Kit.

C:\ti\Hercules\MotorWare\v1.0.3.03\sw\solutions\foc_encoder_speed\gui\docs\qsg_gui_foc_encoder_speed_wTPS.pdf

Because some parts in the control signal are different between DRV8301 and DRV3201-Q1, the GUI cannot be used in the DVD directly. Please see [Section 5.1.3](#) about GUI for the DRV3201EVM.

5.1.2 Hardware

The DRV8301-LS12-KIT includes the motor and power supply. The software for motor control in the Motor Kit DVD is specified with the motor in the kit.

1. Make sure nothing is connected to the board, and no power is being supplied to the board.
2. Insert the control card into the control card socket if not already populated.
3. Make sure the jumpers setting is in default state (see [Table 3](#)).
4. Connect the USB cable provided to your PC and directly to the TMS570LS12 control card.
5. Connect the 3-phase motor wires of the motor included in DRV8301-LS12-KIT to the DRV3201EVM screw terminal (J11).
6. Connect the 5-pin SIP connector labeled J4 to jumper J4 on the DRV3201EVM for the encoder feedback. Please note that pin 1 on this connector is indicated by a triangle on the board and should be connected to the blue wire in the SIP connector.
7. Connect the 5-pin SIP labeled J10 to jumper J10 on the DRV3201EVM for hall sensor feedback. Please note that pin 1 on this connector is indicated by a triangle on the board and should be connected to the green wire in the SIP connector.
8. Supply power to the DRV3201EVM and the control card from power supply.
9. Confirm LED3 is turned on (5 V is okay) and LED200 (DRV3201-Q1 ERR)

Please refer the following documents for detailed information after installing the Motor Kit, available from the TI product folder www.ti.com/tool/drv8301-ls12-kit:

C:\ti\Hercules\MotorWare\v1.0.3.03\sw\boards\kits\drv8301-ls12-kit\docs\drv8301-ls12-kit_README_FIRST.pdf

C:\ti\Hercules\MotorWare\v1.0.3.03\sw\boards\drive\drv8301kit_revD\docs\drv830x_hwguide.pdf

5.1.3 Specified Software for DRV3201EVM

Although DRV8301-LS12-KIT includes a graphical user interface (GUI) for motor control demonstration, the software cannot be used directly.

The user must get the DRV3201_TMS570LS12_FOC_SMO_wEncoder from the TI product folder www.ti.com/product/drv3201-q1 and upload the software for the DRV3201EVM in the following directory: C:\ti\guicomposer\webapps. Put the launcher.exe in the DRV3201_TMS570LS12_FOC_SMO_wEncoder folder.

5.2 Run FOC Speed Control Demo

This demo presents a solution for sensored field oriented control (FOC) with brushless permanent magnet motors using a Hercules TMS570x MCU. The details for FOC control in this demo are explained in the following directory:

C:\ti\Hercules\MotorWare\v1.0.3.03\sw\solutions\foc_encoder_speed\boards\drv8301kit_revD\hercules\tms570ls1227\projects\ccs5\project01\docs\for_encoder_speed_ls12.pdf

The details of the prepared GUI are shown in the following sections.

5.2.1 Main Tab

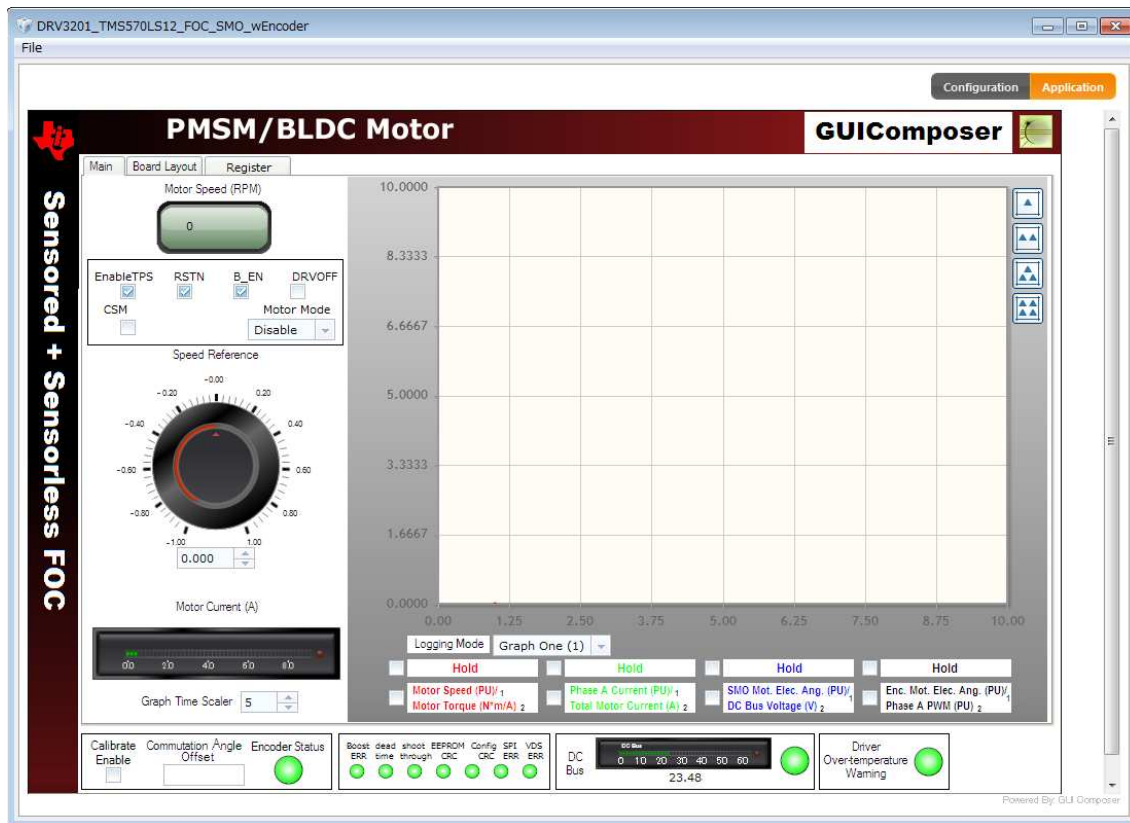


Figure 2. Main Tab

The bottom portion of the main GUI tab contains set up and status information

Fault Status—The on-screen LED turns red whenever the DRV3201-Q1 signals a fault. The LED statuses are judged from the Status register in DRV3201-Q1.

DC Bus Voltage—The measured DC bus voltage is displayed both digitally and graphically. The on-screen LED can take three states depending on whether the DC bus is in or out of range.

Driver Overtemperature Warning—The state of the DRV3201-Q1 is displayed using an on-screen LED.

The left portion of the main GUI tab contains controls that vary the motor set-points.

Enable TPS Check Box—Use the enable TPS check box with control cards that have a TPS6538x integrated safety. Prior to enabling the motor or calibrating, check this box to enable the TPS device in order to safely begin its system watchdog functions and, therefore, proper system operation.

RSTN, B_EN, DRVOFF, CSM Check Box—These check boxes are used to control the DRV3201-Q1 input ports. When RSTN is checked, the MCU performs the initial setting to DRV3201-Q1.

Motor Mode Drop Down Box—Allows the selection of two different control modes.

Disable: This mode is the default motor mode, and the motor should be disabled. To start the motor, the motor mode drop down box should be set to either torque or speed mode.

Torque: The motor is commutated using the sensed algorithm while the current (torque) is regulated using a PI controller. (Note: An unloaded motor rapidly accelerates to a very high speed in this mode.)

Speed: The motor is commutated using the sensed algorithm while the motor speed is regulated using a PI controller. The output of the speed loop is a command to the FOC torque controller.

The Speed Reference Knob—Takes on a separate function for each motor mode.

Torque: The knob adjusts the per-unit (PU) commanded current through the motor.

Speed: The knob adjusts the per-unit (PU) commanded speed reference.

Motor Speed (RPM) —The motor speed (RPM) is digitally displayed.

Graph Time Scaler—The time scale of the top data present in the graphs can be adjusted by incrementing or decrementing the graph time scaler.

The right portion of the main GUI tab is the graph section and it contains graphing related controls.

Logging Mode Drop Down Box—Controls what data can be plotted in the graph(s). It changes the variables being written into the data logger buffers. The default value is disabled mode.

Disable: This mode is the default logging mode and no data should be plotted on the graphs

Graph One (1): When logging mode is set to this graph one (1) the motor speed, phase A current, SMO motor electric angle and encoder motor electric angle can plotted on the graph(s).

Graph Two (2): When logging mode is set to this graph one (1) the motor torque, total motor current, DC bus voltage and phase A PWM can plotted on the graph(s).

Hold Data Check Box—If this check box is set, the data in the process of being plotted by the respective graph data check box is paused. If this check box is set then the graph data check box is disabled. This feature is useful to both isolate and analyze a certain data set in the data logger buffer.

Graph Data Check Box—If this check box is set, then the data set in the respective data logger buffer is graphed.

Number and Size Graphs—The number of graphs plotting data in the data logger buffers can be changed dynamically with the FOC-encoder-speed GUI. All of the data present in the data logger buffers can be displayed in single graph, plotted in two same or different sized graphs, or each can be plotted in its own graph. The graphs can be changed dynamically by clicking on one of the buttons on the right hand side of the graph section.

5.2.2 Register Tab

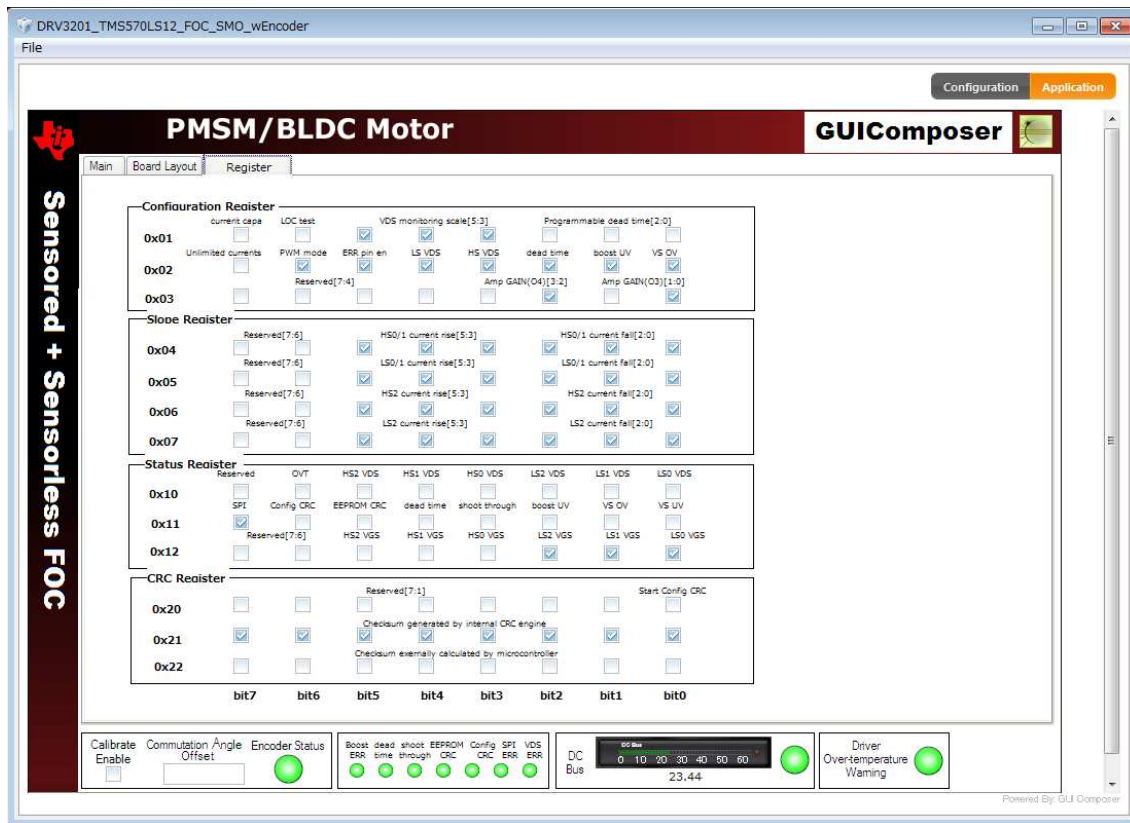
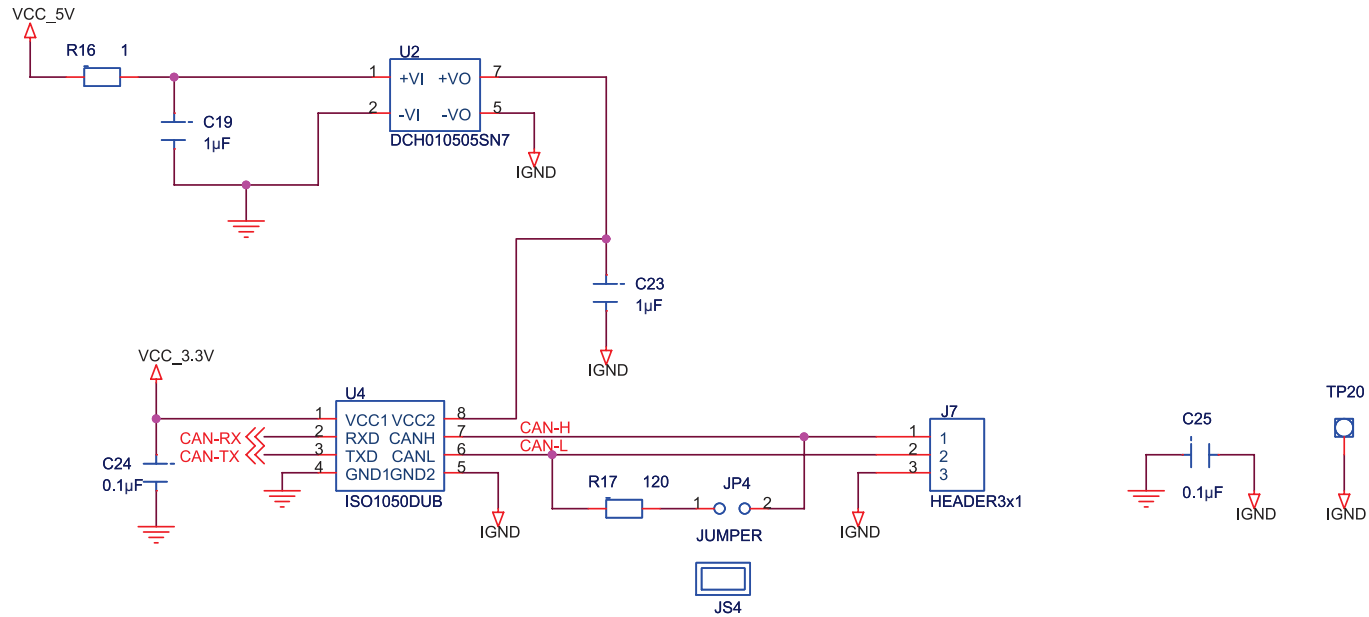
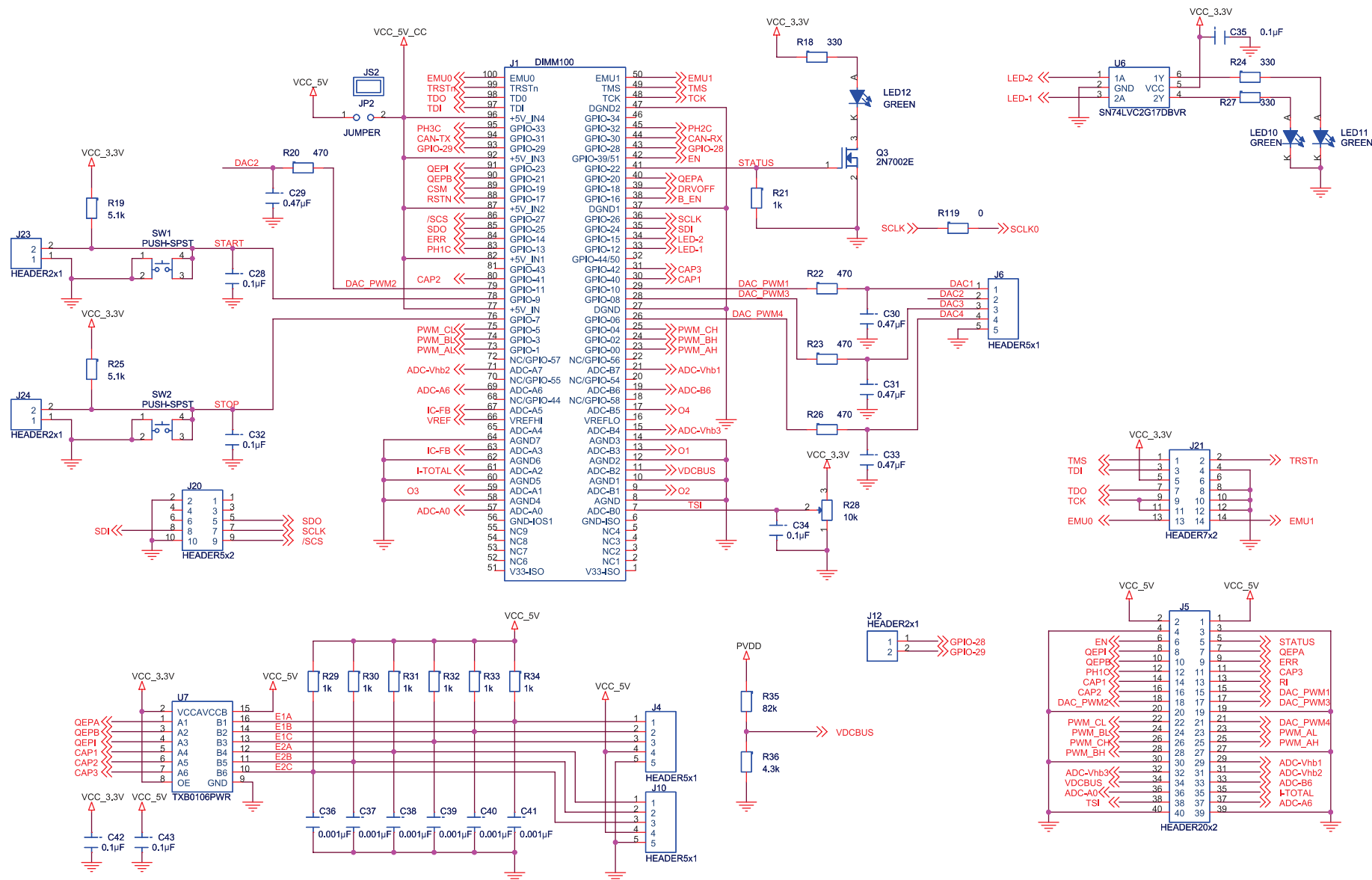


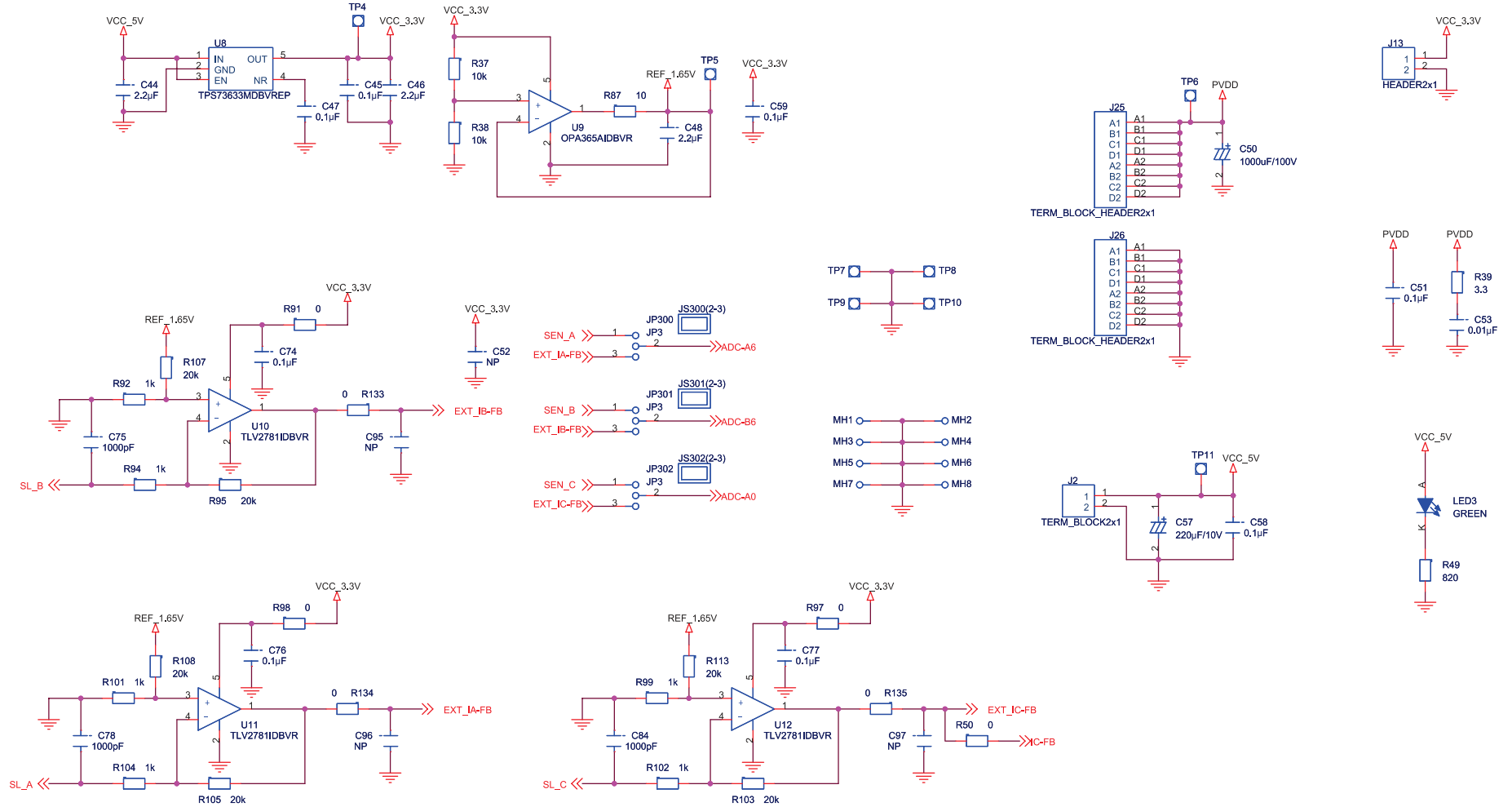
Figure 3. Register Tab

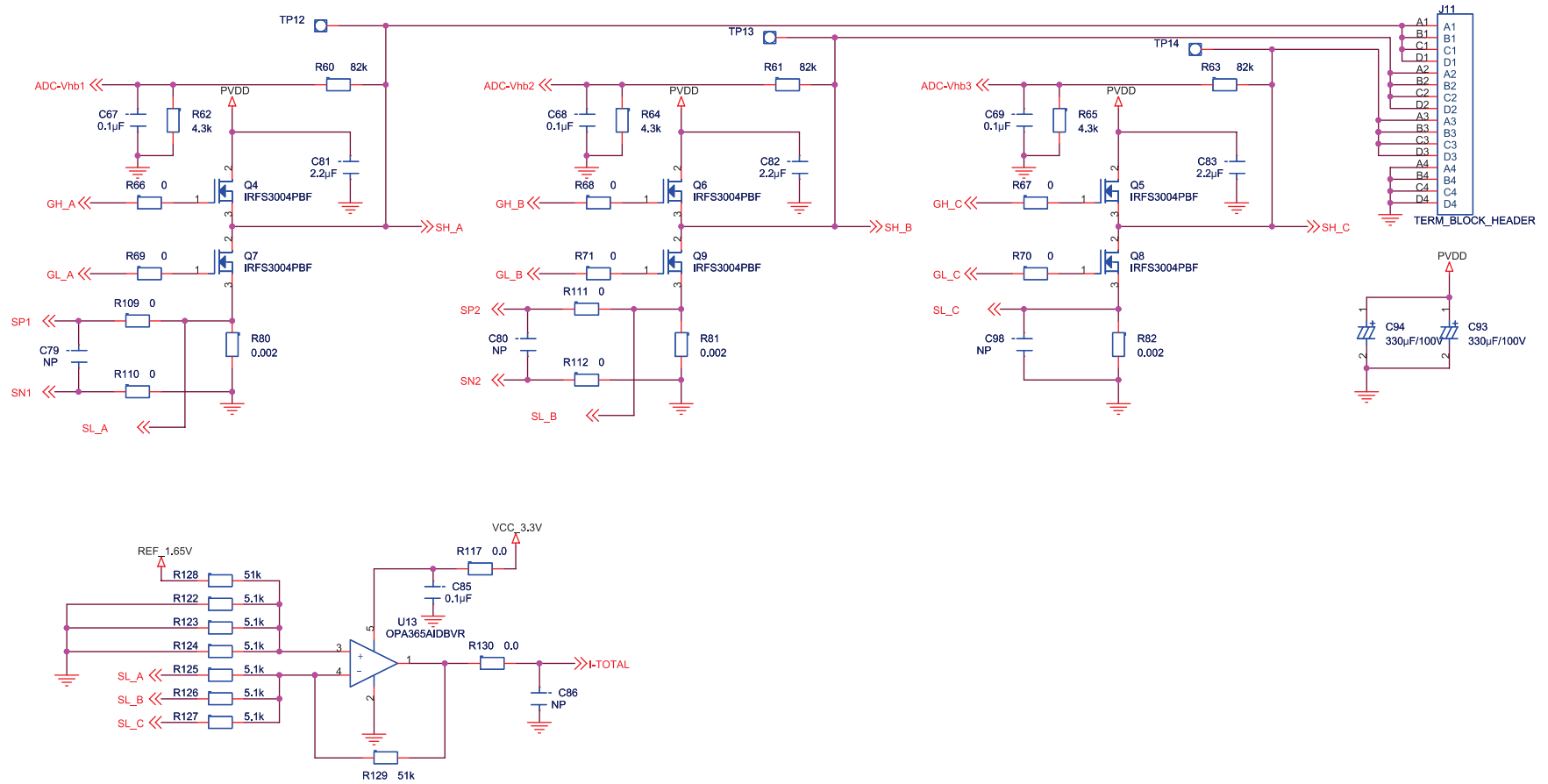
You can set the registers in DRV3201-Q1 from this GUI. When you click the check box, the MPU writes the register to DRV3201-Q1, and the MPU updates the register information regularly.

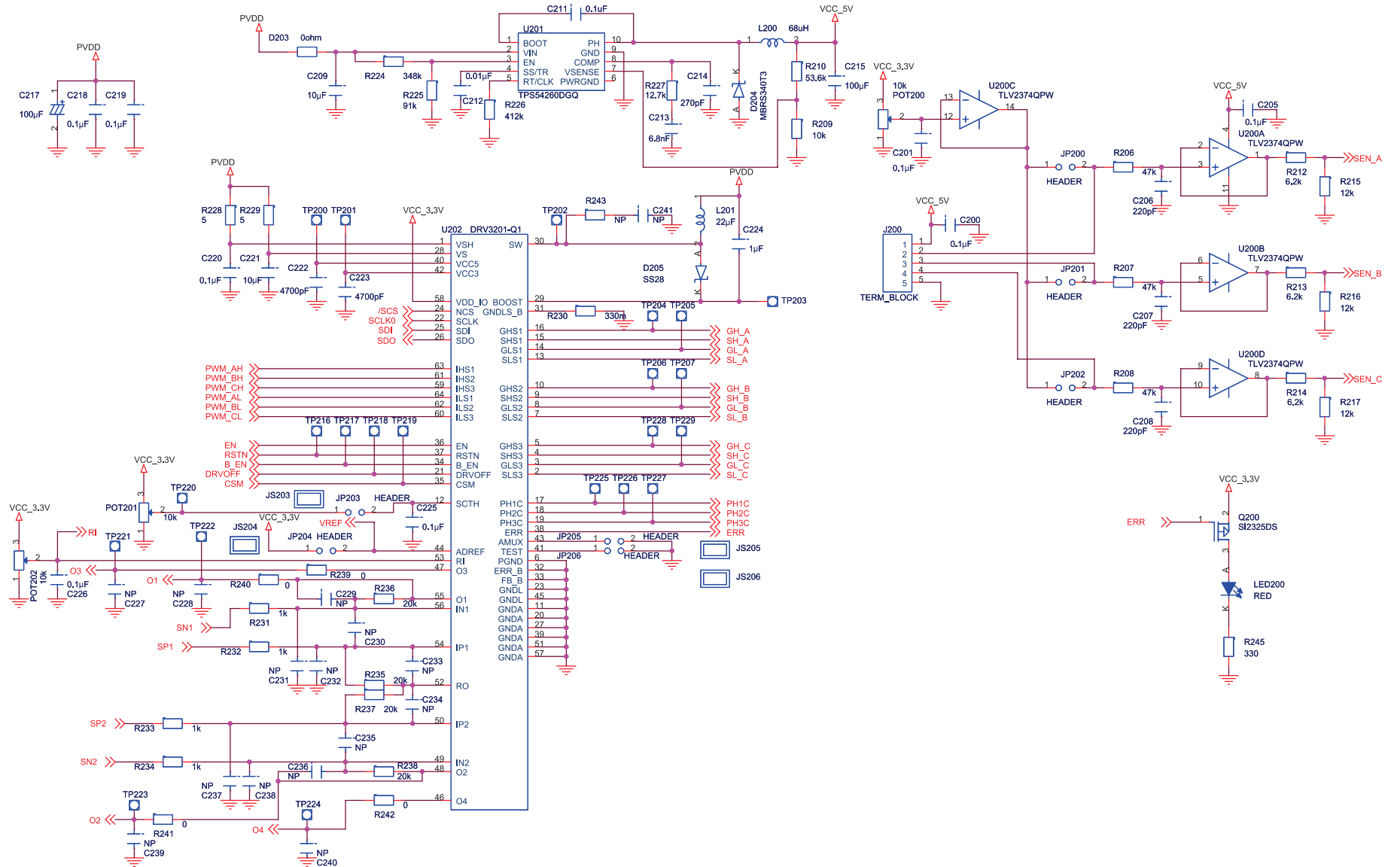
6 Schematics











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3. *Regulatory Notices:*
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 - 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.

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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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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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