TPL0401EVM

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Trademarks

1 Features

- Works with low cost MSP430 based LaunchPad platform
- Simple GUI to control EVM
- EVM can be operated in three different modes
  - Auto run LED mode
  - Adjustable Voltage reference mode
  - Variable gain mode
- Board is powered by USB

2 Introduction

The TPL0401 is an I2C bus controlled, single channel, linear-taper digital potentiometer with 128 wiper positions. TPL0401A/B have an end-to-end resistance of 10k ohms and the low terminal internally connected to ground. The position of the wiper can be adjusted using an I^2C interface. The TPL0401 is available in a 6-pin SC-70 package with a specified temperature range of –40°C to +125°C. The part has a 10k end-to-end resistance and can operate with a supply voltage range of 2.7 V to 5.5 V.

THE TPL0401EVM also consists of multiple other TI products (port expanders, LED drivers, and so forth). However, the scope of this document is to illustrate the use of the EVM to evaluate the TPL0401. The TPL0401EVM is designed to operate with the Texas Instruments LaunchPad (MSP-EXP430G2). The TPL0401EVM comes with a preprogrammed MSP430G2553 microcontroller which is to be inserted in the DIP socket on the LaunchPad. The LaunchPad can be separately purchased at www.ti.com/launchpad .

The TPL0401EVM has three different evaluation modes:

Mode 1 – LED mode – This is the standard mode the TPL0401 comes up in when powered up. In this mode the TPL0401 devices are used to control the color mixing on the RGB LEDs. The DPOTs are used to set the current limit for the TLC59108 LED driver. This mode is and auto run mode that does not have any GUI control. The flashing lights and color mixing is controlled by the keys on the board and other TI products on the board.

Mode 2 – Adjustable voltage reference mode – in this mode the TPL0401 is used in conjunction with an LMV321 op amp as an adjustable voltage reference circuit.

Mode 3 – Variable gain mode – in this mode the TPL0401 is configured as part of a variable gain non-inverting amplifier. The gain of the amplifier can be controlled by a digital interface. This mode can be used to evaluate the bandwidth of the TPL0501.

The EVM is operated by connecting the LaunchPad to a PC that has Windows™ (with .NET) through the USB Port. Other standard lab equipment such as Signal generator, multimeter, spectrum analyzer, and so forth may be required for detailed analysis of the TPL0501 performance using this EVM.

3 Mode Selection

To setup any of these two modes, begin by connecting the EVM to the LaunchPad. Note the location of the VCC and GND pins on headers J1 and J2 on both the LaunchPad and the EVM to ensure correct installation.

1. **LED Mode**

   Connect Jumpers 1 and 2 of J6
   Connect +5-V supply to J3
   Connect LaunchPad to computer through USB cable

   NOTE: It can be possible to power up the LEDs by connecting a wire from the VCC pin of J1 to the positive pin of J3. A 5-V supply might be required because the max voltage drop across the blue LED plus the drop across the TLC59108 is larger than the supply voltage of the LaunchPad.

2. **Voltage reference mode**

   Start up the board in LED mode as described earlier
   Connect pins 1 and 2 of Jumper J7.
   Connect pins 1 and 2 of Jumper J5.
   Connect the LaunchPad and TPL0501EVM to a computer through the USB connector.

Press keys SW2 and SW3 simultaneously
Start GUI software on computer

3. **Variable Gain mode**

   Connect pins 2 and 3 of jumper J6.
   Connect pins 1 and 2 of jumper J7.
   Attach a signal generator to the EXT_IN connector (SMA or SMB connector may need to be populated).
   Press keys SW2 and SW3 simultaneously
   Start GUI software on computer
   Connect the LaunchPad and TPL0501EVM to a computer through the USB connector

4 Jumpers Connections

1. **J1 & J2 – LaunchPad Headers**

   These connectors mate with the male headers on the LaunchPad

2. **J3 – External LED Power**

   This connector is where the external +5V supply is attached to power the two RGB LEDs.

3. **J4 – TCA7408 GPIO**

   This is a pin out of the four unused GPIO pins from the TCA7408, GPIO4-GPIO7.

4. **J5 – Feedback loop**

   For the TPL0401A to function as a voltage reference circuit the negative feedback loop must be shorted, placing a jumper across this header will short the inverting input to the output.

5. **J6 – LED or Op-amp**

   This header controls what the TPL0401B is attached to. When shorted across position 1 and 2 the TPL0401B is connected in series with the external resistor to control the current through the LED driver. When shorted across position 2 and 3 the TPL0401B is connected to the inverting input of the op-amp to change the gain of the circuit.

6. **J7 – Op-amp input**

   This header controls the input to the non-inverting pin of the LMV321. When shorted across position 1 and 2, the TPL0401A in a voltage divider mode is attached to the non-inverting input of the LVM321. This setup is used to test the voltage reference setup. When shorted across pins 2 and 3, the SMA connector is attached to the non-inverting input.

7. **J9 – Test Points**

   This connector offers test points for the serial data lines, SDA, SCL and the DIN that drives the TCA5405

Table 1. Description of Connectors and Jumpers

Label	Description
J1, J2	Connectors to interface with LaunchPad
J3	External 5V for LED
J4	GPIO4-GPIO7 from TCA7408
J5	Control jumper to short feedback loop
J6	Jumper to control LED or Op-Amp
J7	Jumper to control input to Op-Amp
J8	SMA/B Footprint for external input
J9	Test points for DIN, SDA and SCL

5 Software Setup

The EVM does not require any software set up to operate in the LED mode. The keys SW1-SW4 control the blinking rate of the LEDs and the color mixing of the LEDs, without any additional software setup.

To operate the EVM in any other mode, GUI software is required. The GUI software is available in a zip file located on the TPL0401 product page on www.ti.com. Download the zip file and extract its contents to a desired location on your PC. You will see an executable file called TPL0401_GUI.exe in the extracted folder. Double click the file to open it and the GUI program should launch. **IMPORTANT:** Before launching the GUI please make sure the TPL0401EVM is setup in the desired mode and connected to the PC through a USB port.

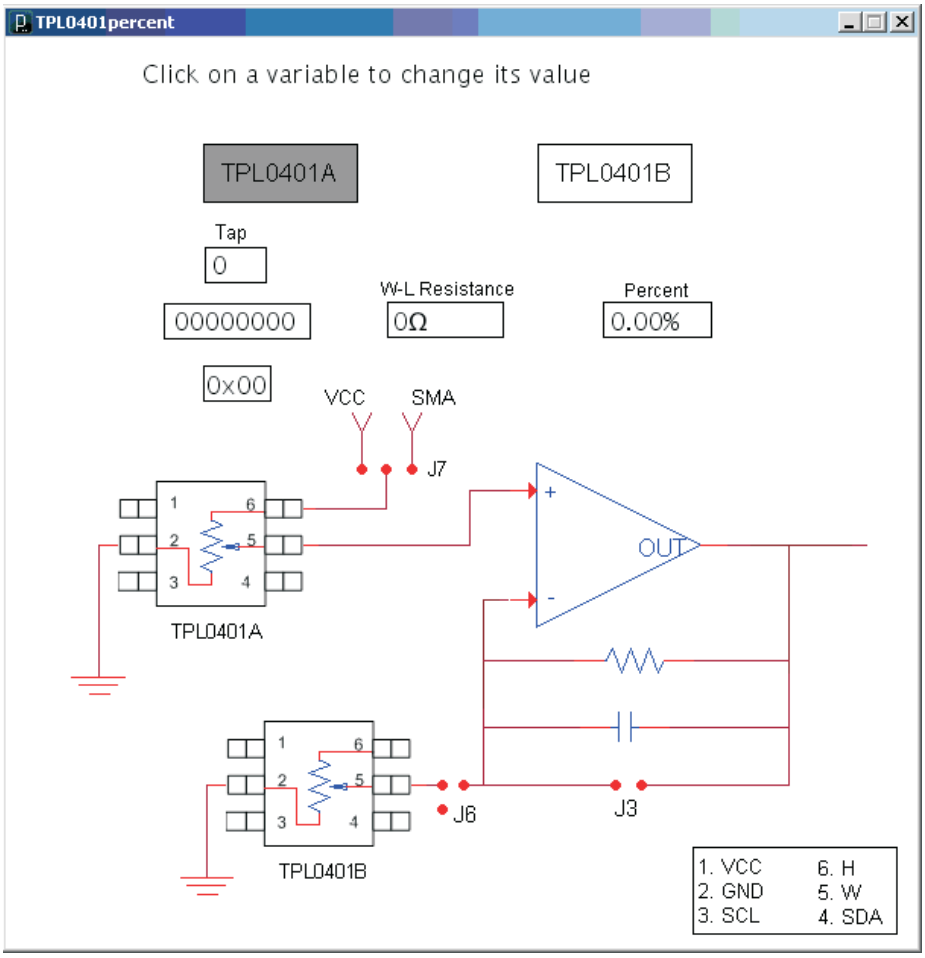

Figure 1. GUI for DPOT Control

There are three methods to adjust the value of the TPL0401A/B. Start by clicking one of the buttons circled in GREEN to select the corresponding TPL0401 device.

To adjust the tap value directly simply click the box that says tap and you will be prompted to input a tap value between 0 and 127. After typing in the desired value press enter and the tap value will be sent to the TPL0401A and the GUI will reflect the value you just entered.

To adjust the TPL0401 by inputting a wiper to low terminal resistance, click the box that says W-L Resistance. You will then be prompted to input a value between 0 and 10,000 ohms; press enter after you have input a value. The GUI will use the theoretical resistance values to find a tap that is closest to the value that was input.

NOTE: All W-L resistance values are typical values; the actual value will be within 20% of the displayed value

5.1 Voltage Reference Mode

Make sure the EVM is set up in voltage reference mode as described in Section 3. With the GUI open and TPL0401A selected you are also given the option to change the voltage divider ratio of the TPL0401A as a percent value. To do this simply click the box that says percent and you will be prompted to input a percent value between 0 and 100; decimal values can be used. After pressing enter, the GUI will find and send the tap value that is closest to the chosen percent value.

Using any of the methods to change the tap value of the TPL0401A will update the output voltage at TP1. The output will be a percent of the supply voltage, 3.6 V.

5.2 Variable Gain Mode

The 430Boost-TPL0401EVM allows for a variable gain setup to evaluate the bandwidth of the TPL0401. After following the setup instructions in Section 2, the circuit will look as follows:

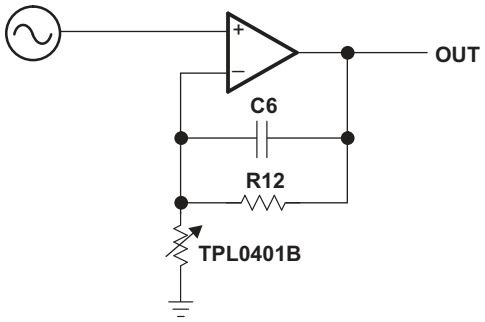

Figure 2. TPL0401B Variable Gain

The capacitor C6 and the resistor R12 are unpopulated and should be set by the user. R12 will set the possible gain values and C6 will keep the loop stable. Changing the value of the TPL0401B works the same as described in the beginning of Section 5.

6 Schematics, Layout and Bill of Materials

6.1 Schematics

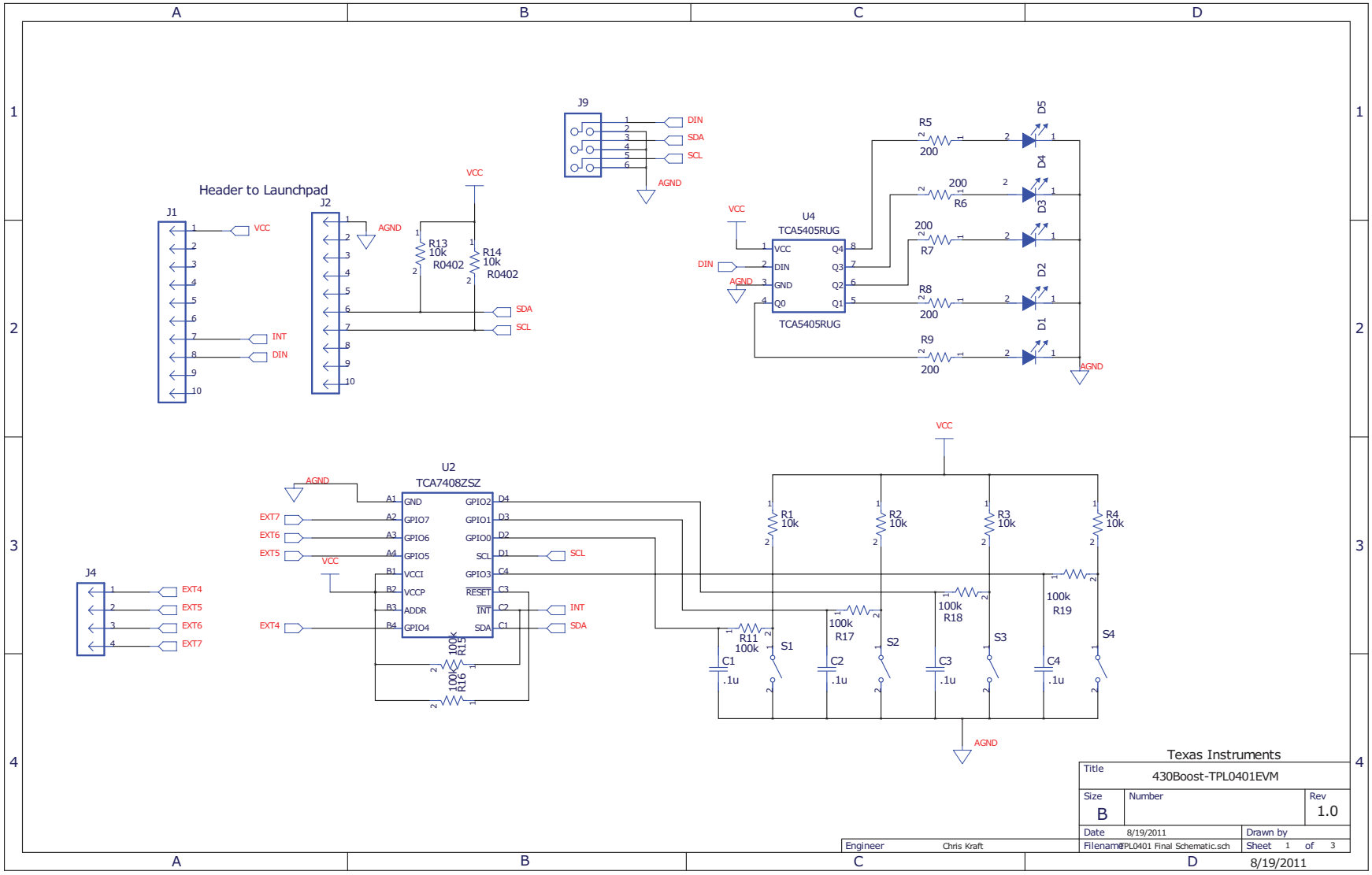

Figure 3. TCA5405, TCA7408 Schematic

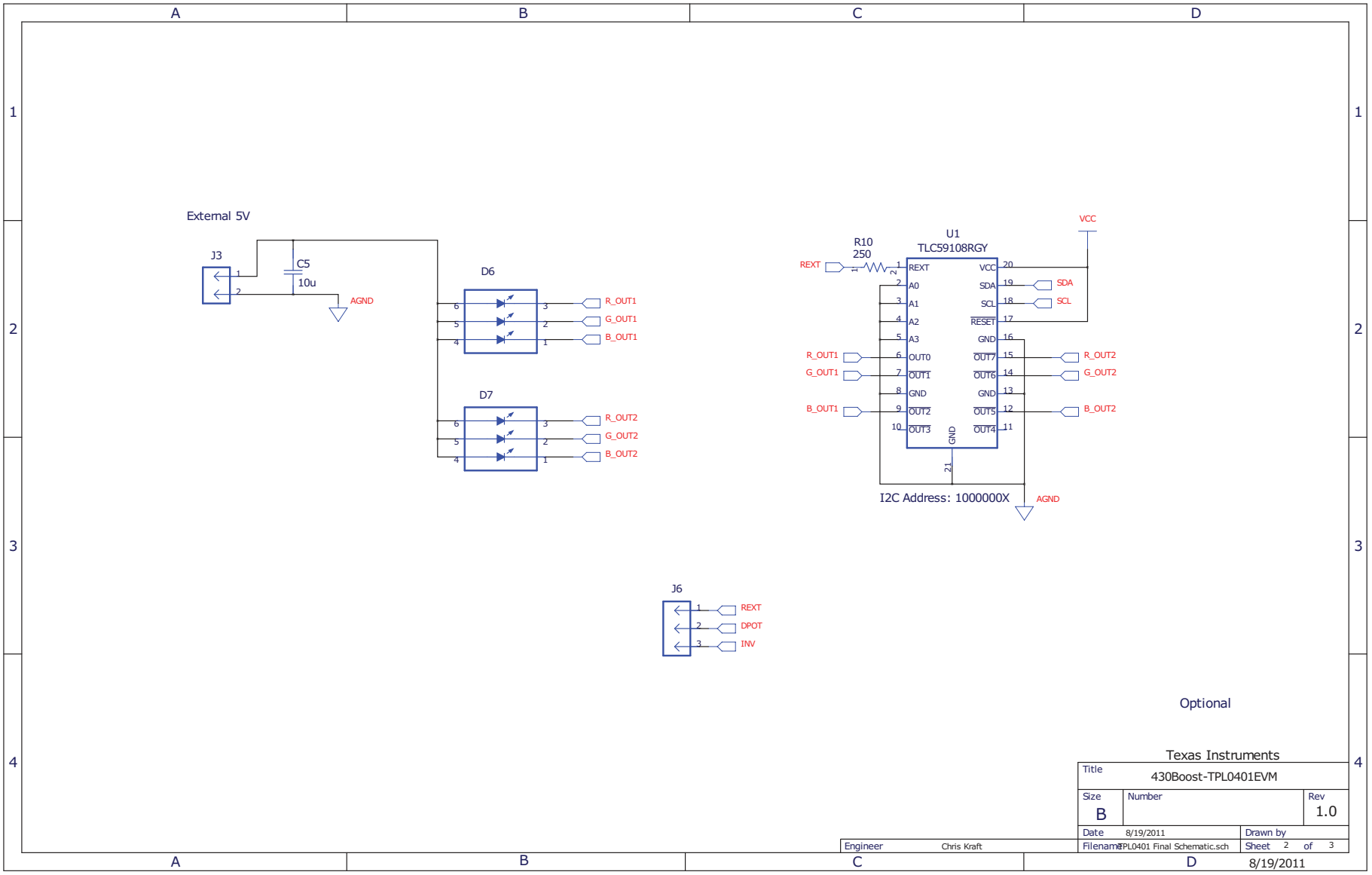

Figure 4. TLC59108 Schematic

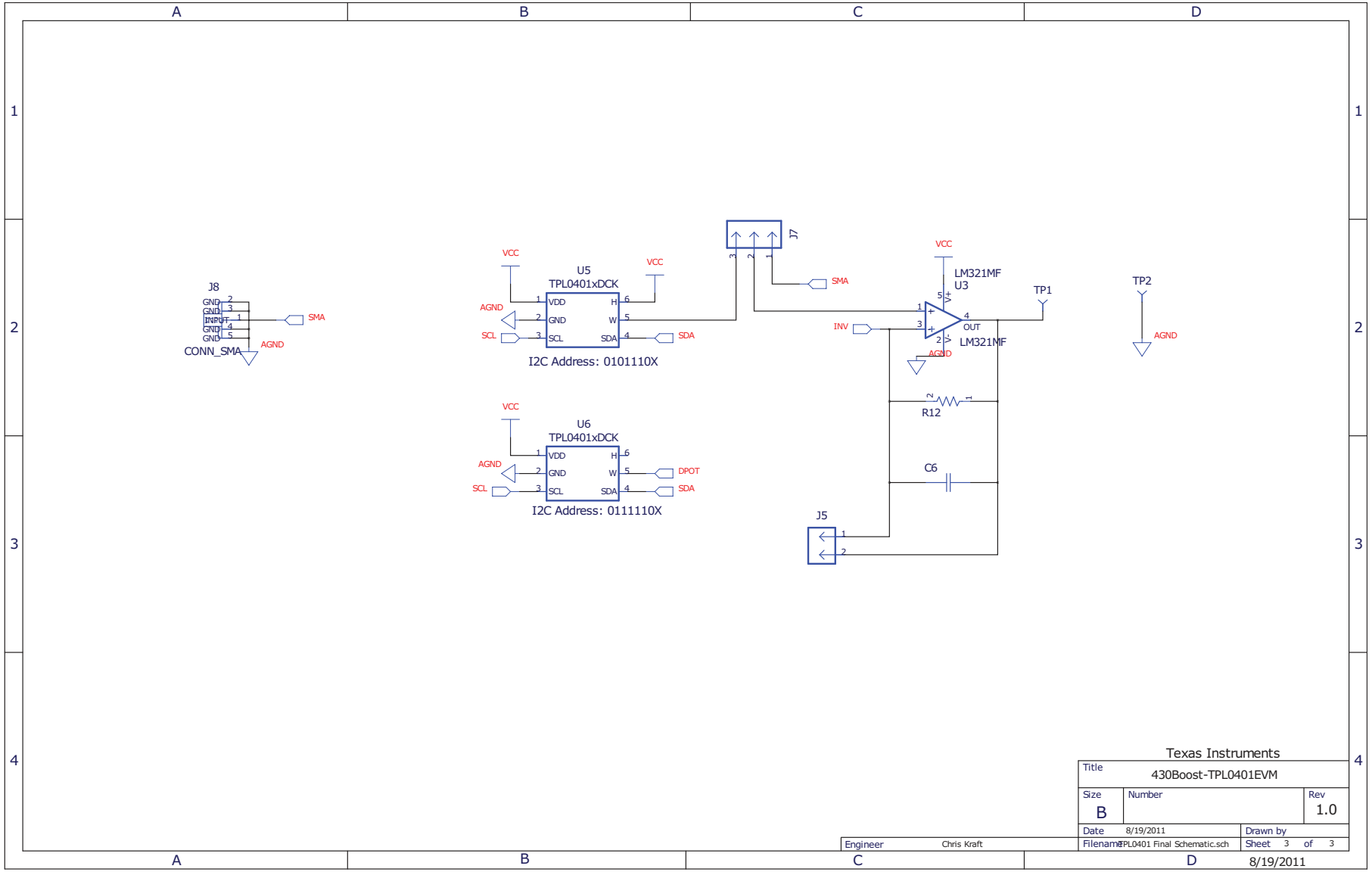

Figure 5. TPL0401 Schematic

6.2 Layouts

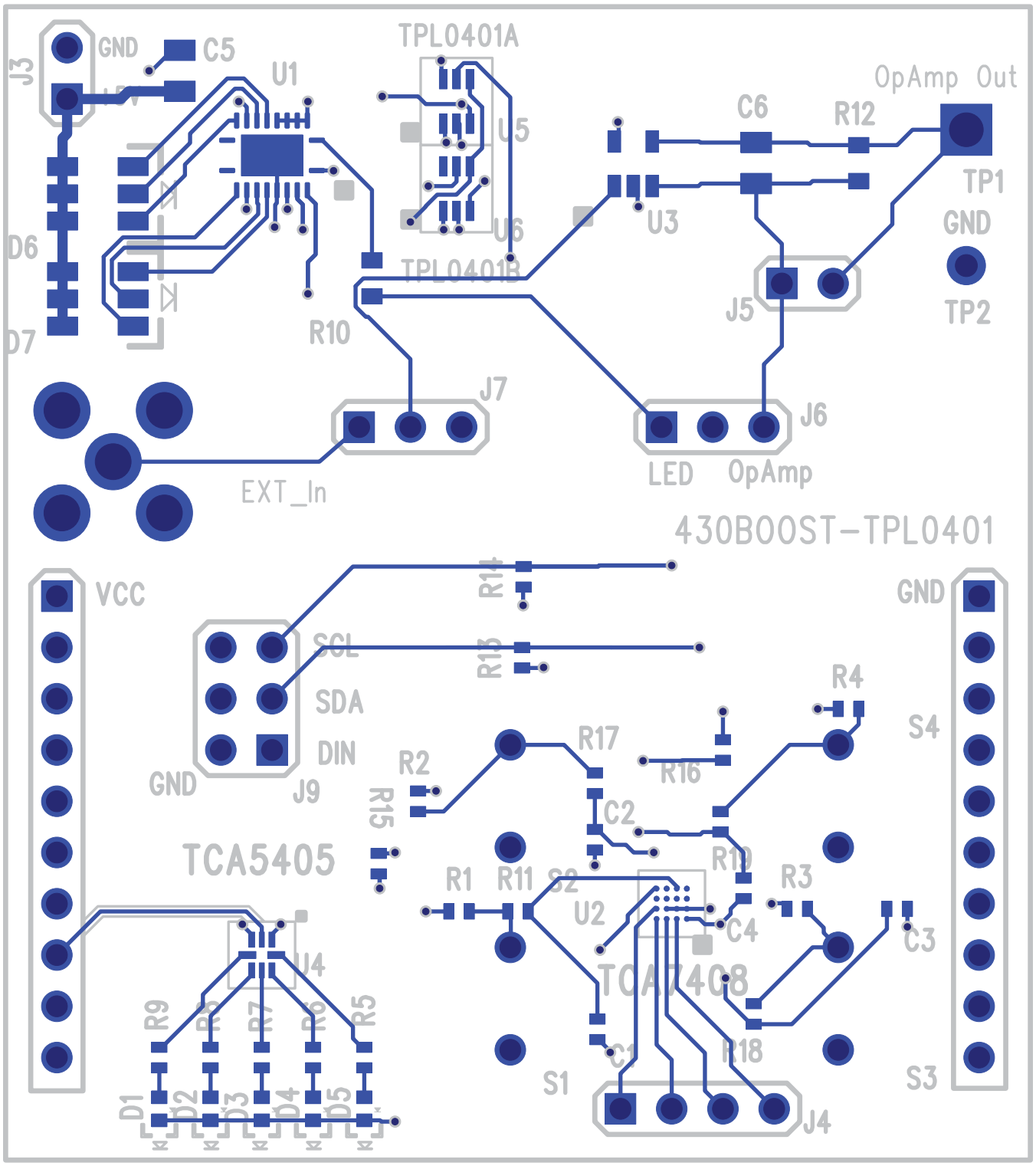

Figure 6. Routing, Assembly and Silkscreen Top

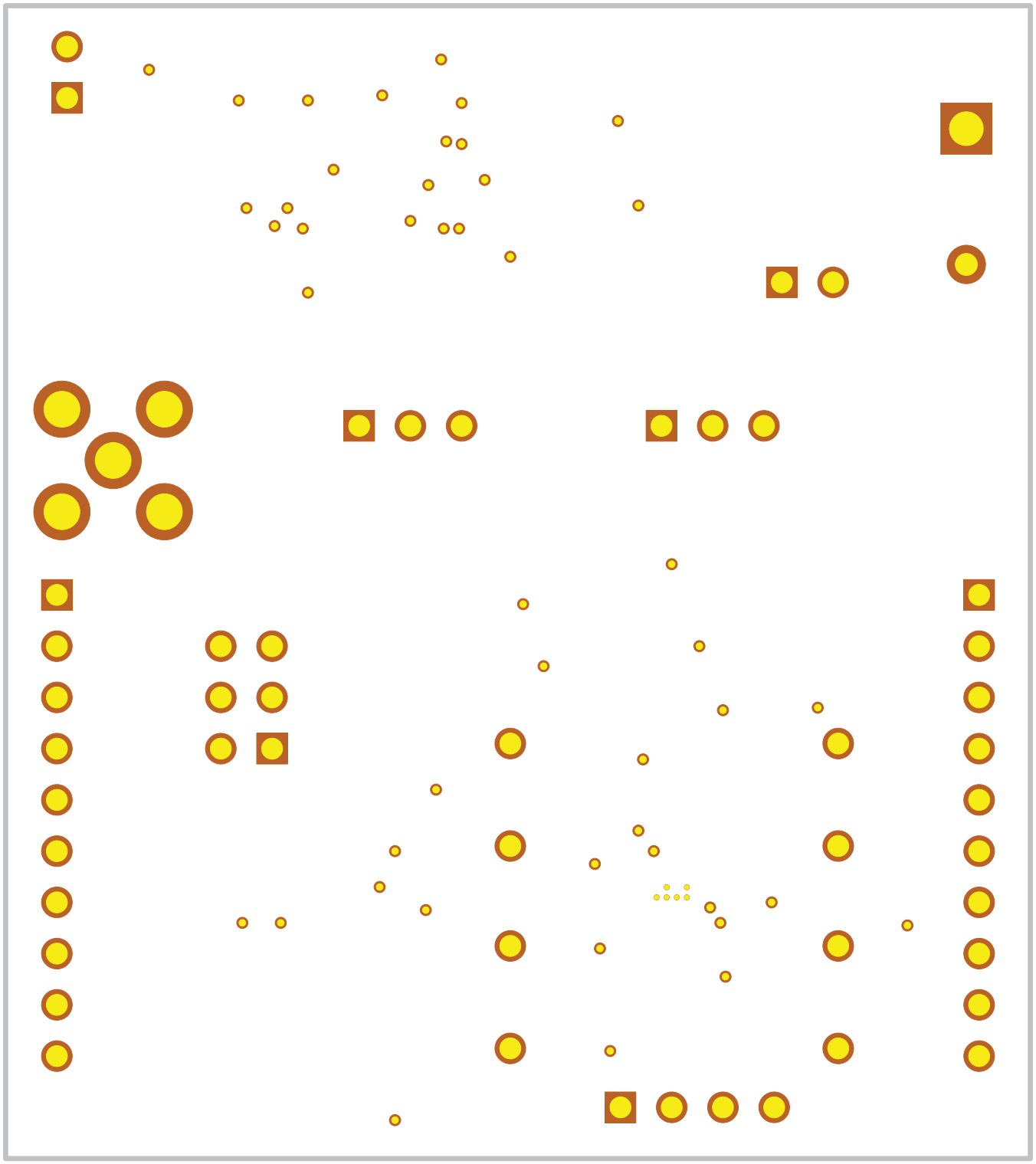

Figure 7. Layer 2 Power Plane

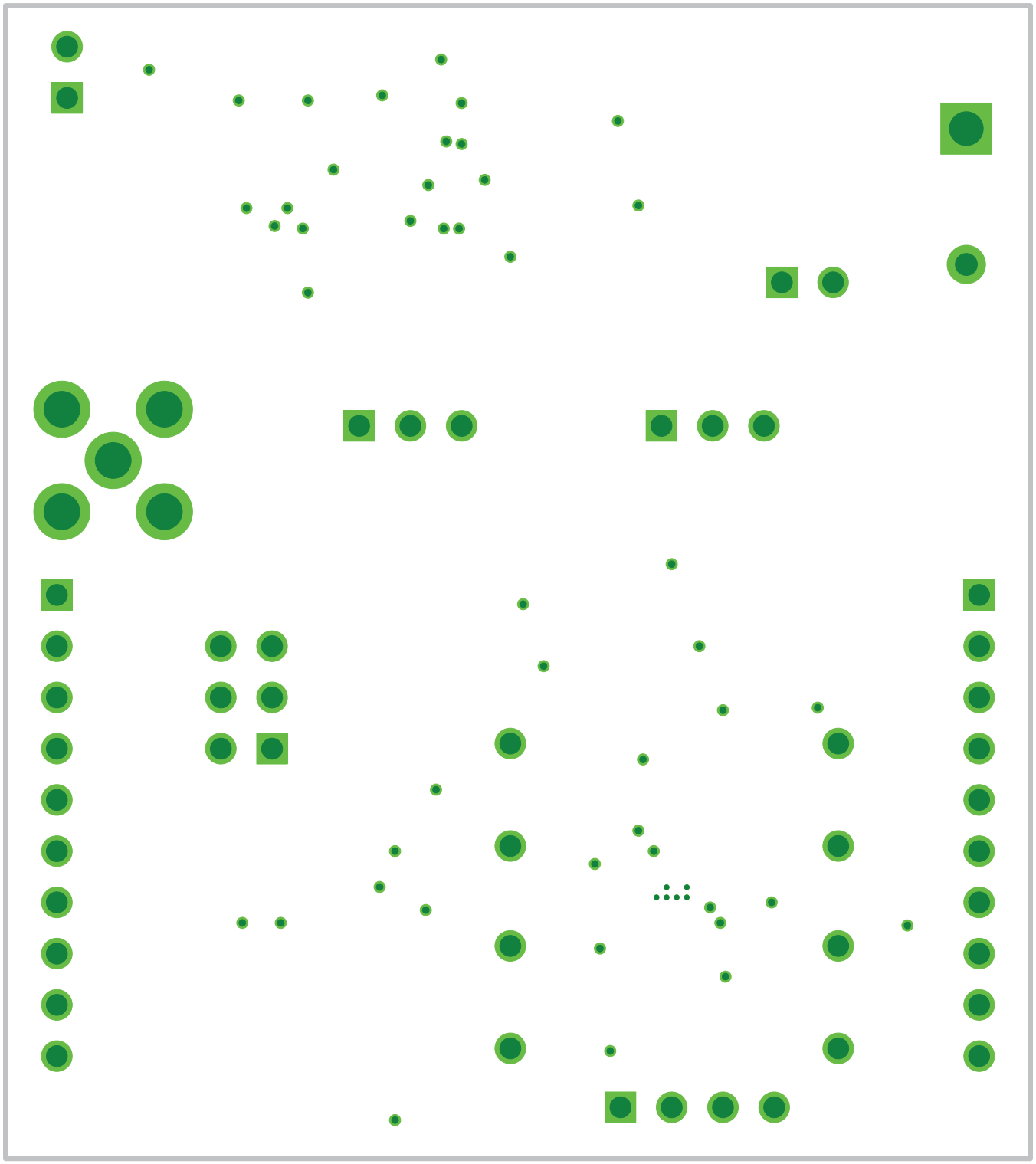

Figure 8. Layer 3 Ground Plane

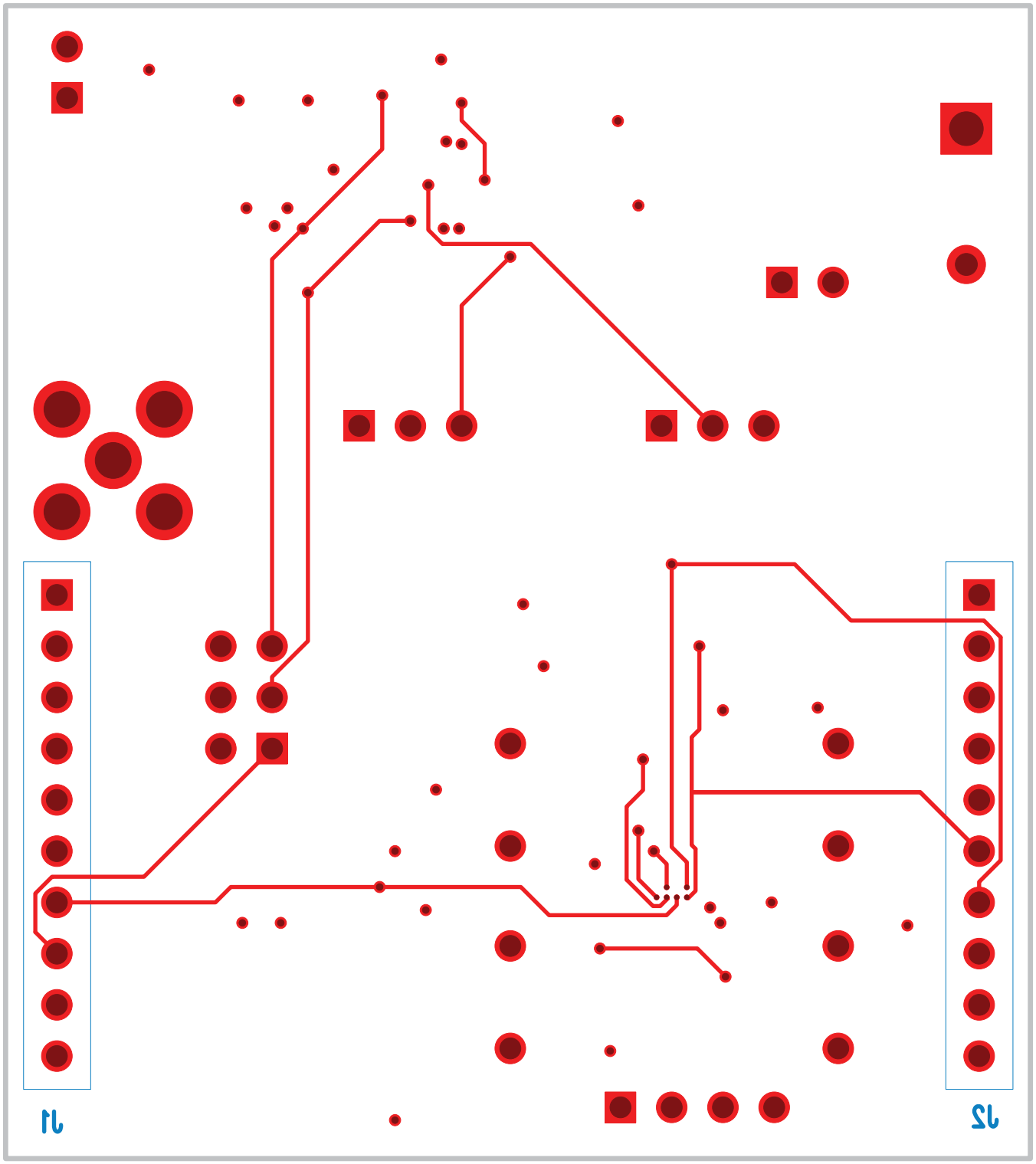

Figure 9. Routing and Assembly Bottom

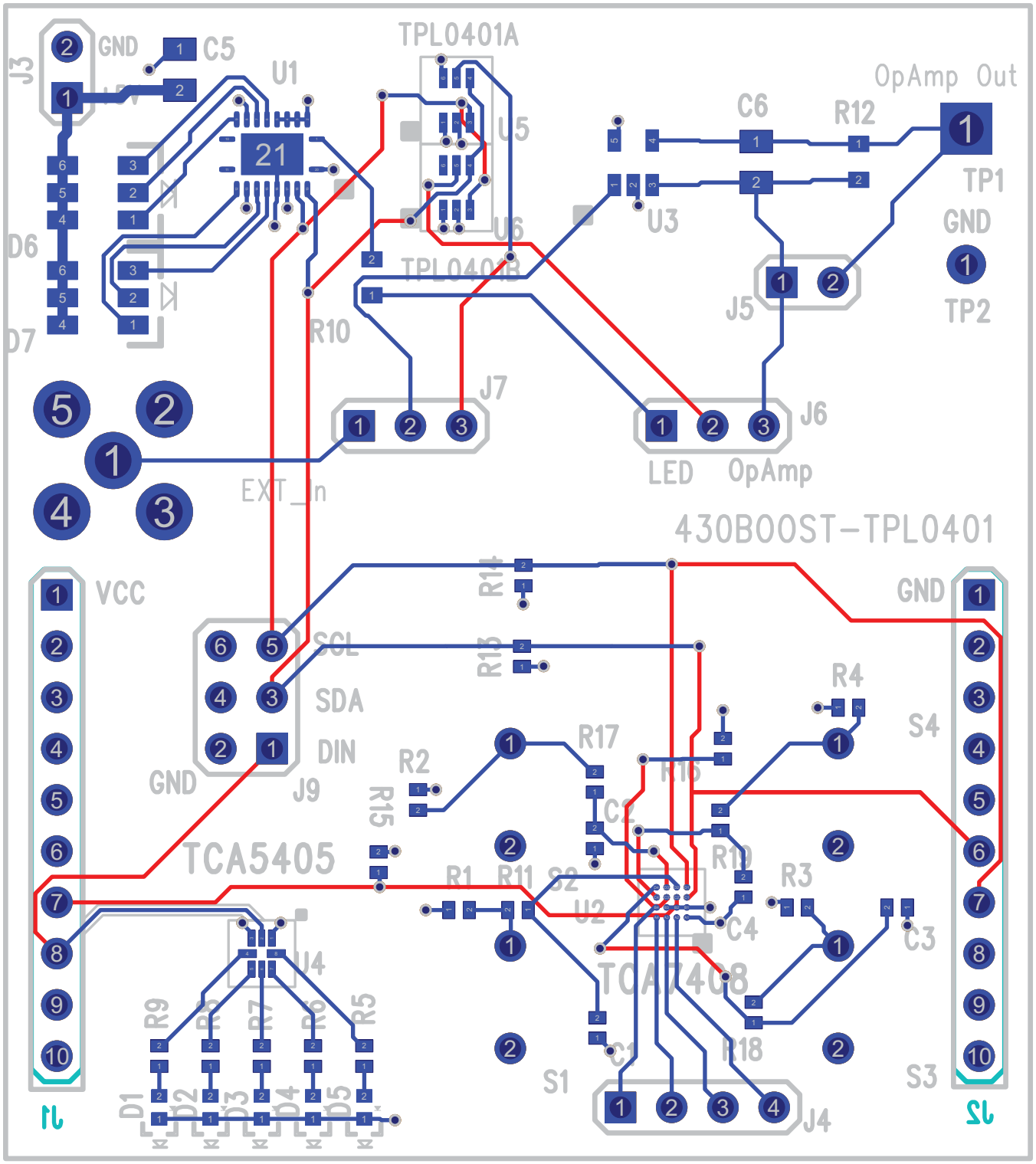

Figure 10. Routing and Assembly Top and Bottom

6.3 Bill of Materials

Table 2. 430Boost-TPL0401EVM Bill of Material

Qty	RefDes	Value	Description	Part Number	MF	Notes
4	C1-4	0.1µ	Capacitor, Ceramic,			
1	C5	10µ	Capacitor, Ceramic,			
1	C6		Capacitor, Ceramic,			DNI
1	J8		Connector, SMA , Straight, PC mount	901-144-8RFX	AMP	DNI
5	D1-5	SML-P12PTT86	Diode, LED, GREEN 2.2V 20mA	SML-P12PTT86	ROHM	
2	D6-7	APF3236SURKZGQBDC	LED SMD TRI Color	APF3236SURKZGQBDC	Kingbright	
2	J3 J5		Header, Male 2-pin, 100mil spacing,		Sullins	
2	J6-7		Header, Male 3-pin, 100mil spacing,		Sullins	
1	J4		Header, Male 4-pin, 100mil spacing,		Sullins	
2	J1-2	PPTC101LFBN-RC	Header, Female 10-pin, 100mil spacing,	PPTC101LFBN-RC	Sullins	
1	J9		Header, Male 2x3-pin, 100mil spacing		Sullins	DNI
2	R15-16	100k	Resistor, Chip, 1/16W 5%			
10	R1-4 R11 R13-14 R17-19	10k	Resistor, Chip, 1/16W 5%			
5	R5-9	200	Resistor, Chip, 1/16W 1%			
1	R10	250	Resistor, Chip, 1/16W, 1%			
1	R12	{value}	Resistor, Chip, 1/16W, 5%			DNI
1	TP2	5001	Test Point, Black, Thru Hole Color Keyed	5001	Keystone	
1	TP1	5013	Test Point, Orange, Thru Hole	5013	Keystone	
4	S1-4	EVQ221304M	Switch, SPST, 20-mA, 15-V	EVQ21304M; EVQ21305R; EVQ21307K	Panasonic	Prefer EVQ21304M if unavailable use 305R or 307K
1	U3	LMV321IDBVR	IC Low Power Single Op-amp	LMV321IDBVR	TI	
1	U4	TCA5405RUG	IC, Low Voltage 5-Bit Self-Timed, Single-Wire Output Expander	TCA5405RUG	TI	
1	U2	TCA7408ZSZ	IC, Low-Voltage 8-Bit I2C and SMBus I/O Expander	TCA7408ZSZ	TI	
1	U1	TLC59108RGY	IC, 8-BIT Fm+ I2C-Bus Constant-Current LED Sink Driver	TLC59108RGY	TI	
1	U5	TPL0401ADCK	IC, Digital POT, 1Chan, 128Tap	TPL0401ADCK	TI	
1	U6	TPL0401BDCK	IC, Digital POT, 1Chan, 128Tap	TPL0401BDCK	TI	

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0 V to 0.5V and the output voltage range of 0 V to 0.5V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's 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, some circuit components may have case temperatures greater than 50° C. The EVM is designed to operate properly with certain components above 50° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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

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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

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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.

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.

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