

## **LMR23615 EVM User's Guide**

The Texas Instruments LMR23615EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LMR23615 wide-input SIMPLE SWITCHER® buck regulator. This document describes the setup and the input / output connections of the EVM. Included are the board layout, schematic, and bill of materials.

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### **Trademarks**

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## 1 Introduction

The LMR23615 is a 36 V, 1.5 A step-down synchronous regulator with 75  $\mu$ A quiescent current. With a wide input range from 4 V to 36 V, it is suitable for a wide range of applications from automotive to industry for power conditioning from unregulated sources. The LMR23615EVM evaluation board is designed to provide the design engineer to evaluate the LMR23615 series operation and performance.

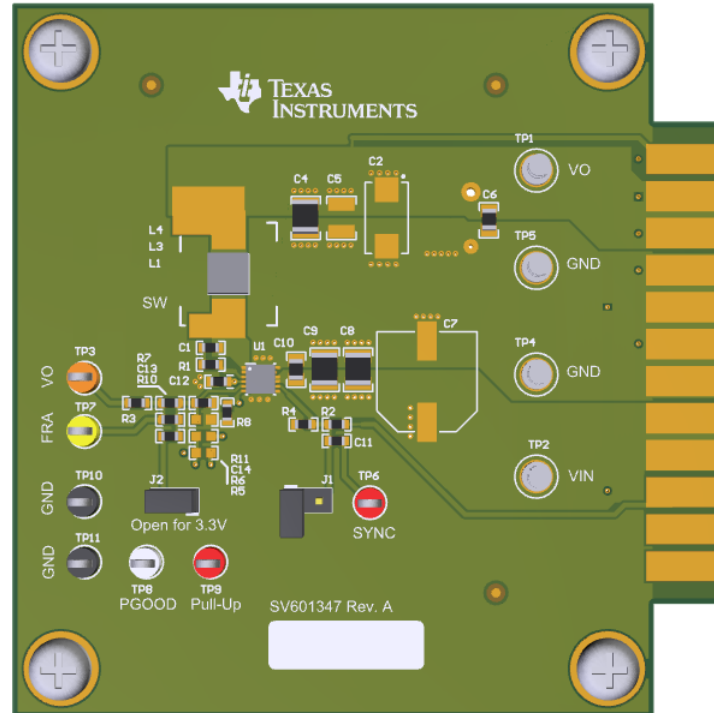


Figure 1. LMR23615EVM Board

## 2 EVM Features

- 4 V to 36 V Input Voltage Range
- Jumper Selectable Output Options (5 V or 3.3 V)
- Up to 1.5 A Output Current
- Switching Frequency 1600 kHz
- Adjustable Frequency and Synchronization to External Clock
- Hiccup Mode Short Current Protection

The EVM contains one DC-DC converter (See [Table 1](#))

Table 1. Device and Package Configurations

| CONVERTER | EVM         | IC          | PACKAGE |
|-----------|-------------|-------------|---------|
| U1        | LMR23615EVM | LMR23615DRR | WSO-12  |

### 3 Setup

This section describes the jumpers and connectors on the EVM and how to properly connect, set up and use the LMR23615EVM.

#### 3.1 Input/Output Connector Description

**VIN — Terminal TP2** – is the power input terminal for the converter. Adjacent to it is the GND reference ground. Use this terminal to attach the EVM to a cable harness.

**VOUT — Terminal TP1** – is the regulated output voltage for the converter. Adjacent to it is the GND reference ground.

**GND — Terminal TP4, TP5** – are the ground reference for the converter. Use these terminals to attach the EVM to a cable harness.

**EN — Jumper J1** – is used to enable the switch-mode converter. The device will be enabled when the jumper is not populated. When the jumper is populated, the EVM will be disabled. The EVM default system UVLO is 6.2 V (typical), it also can be programmed by changing R2 or R4. Refer to [LMR23615 datasheet](#) for enable and adjustable undervoltage lockout.

**SYNC — Terminal TP6** – is used to synchronize the switching frequency to external clock. Refer to datasheet for detail application information.

**Testpoint — TP3, TP7, TP10, TP11** – these are test points used for input/output voltage measurements and loop response measurements.

#### 3.2 Adjusting the Output Voltage

The default setting output voltage is 5.0 V. Open J2 will change output voltage from 5 V to 3.3 V.

If other outputs need to be configured, then: open J2 and adjust the feedback resistors using the following equation.

$$V_{OUT} = V_{REF} \times (1 + (R7 / R11))$$

where

- $V_{REF}$  is 1 V
- (1)

#### 3.3 Adjusting the Switching Frequency

If other frequencies are desired, within the frequency range of 200 kHz and 2.2 MHz, the RT resistor (R8) value can be changed. Please consult the datasheet for proper selection of the RT resistor (R8). You must change inductor (L1) and total output capacitance for proper control loop operation.

## 4 Board Layout

Figure 2 to Figure 5 show the board layout for the LMR23615EVM. The PCB consists of a 4-layer design. There are 2-oz copper planes on the top and bottom and 1-oz copper mid-layer planes to dissipate heat with an array of thermal vias under the thermal pad to connect to all four layers.

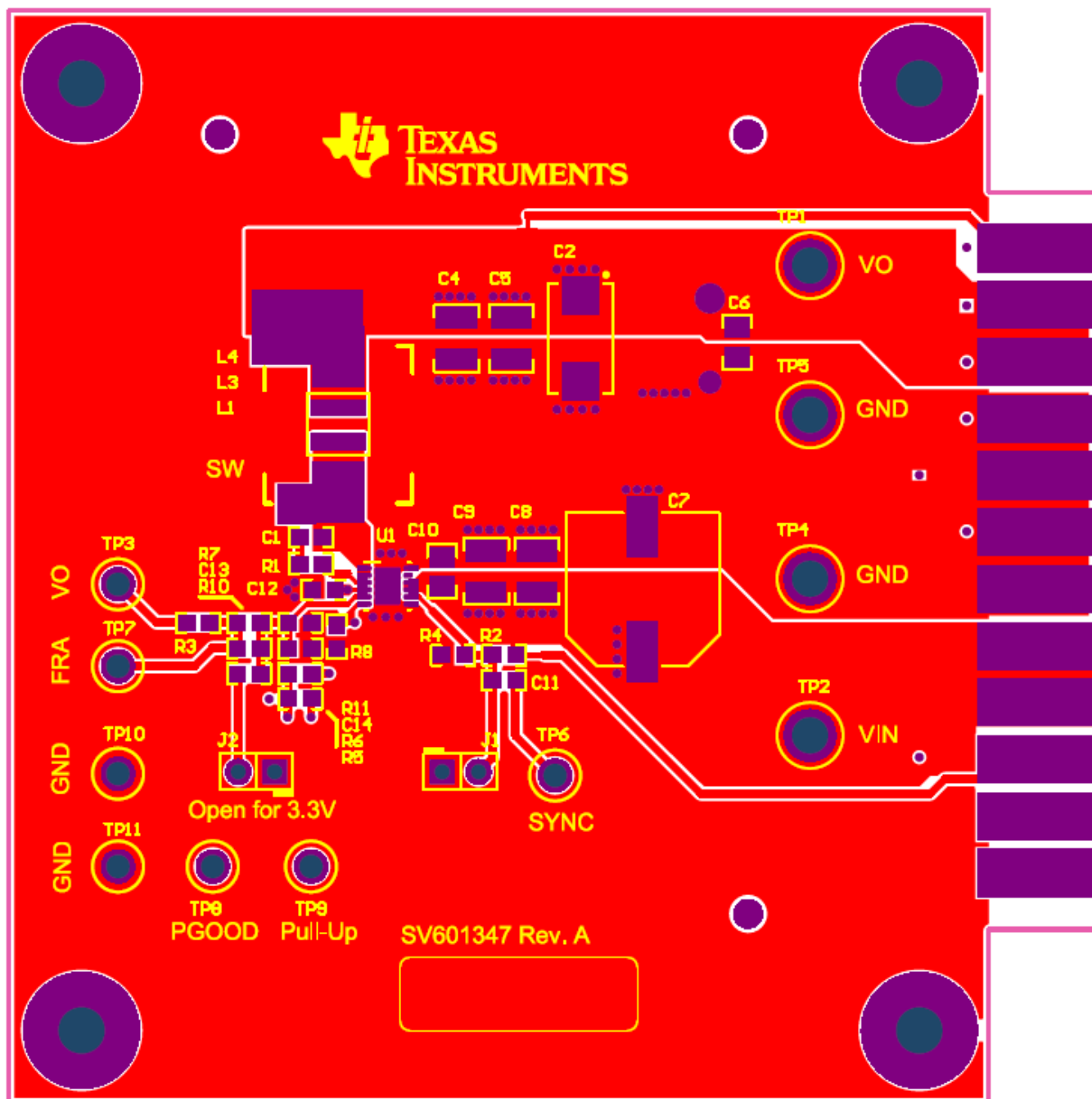
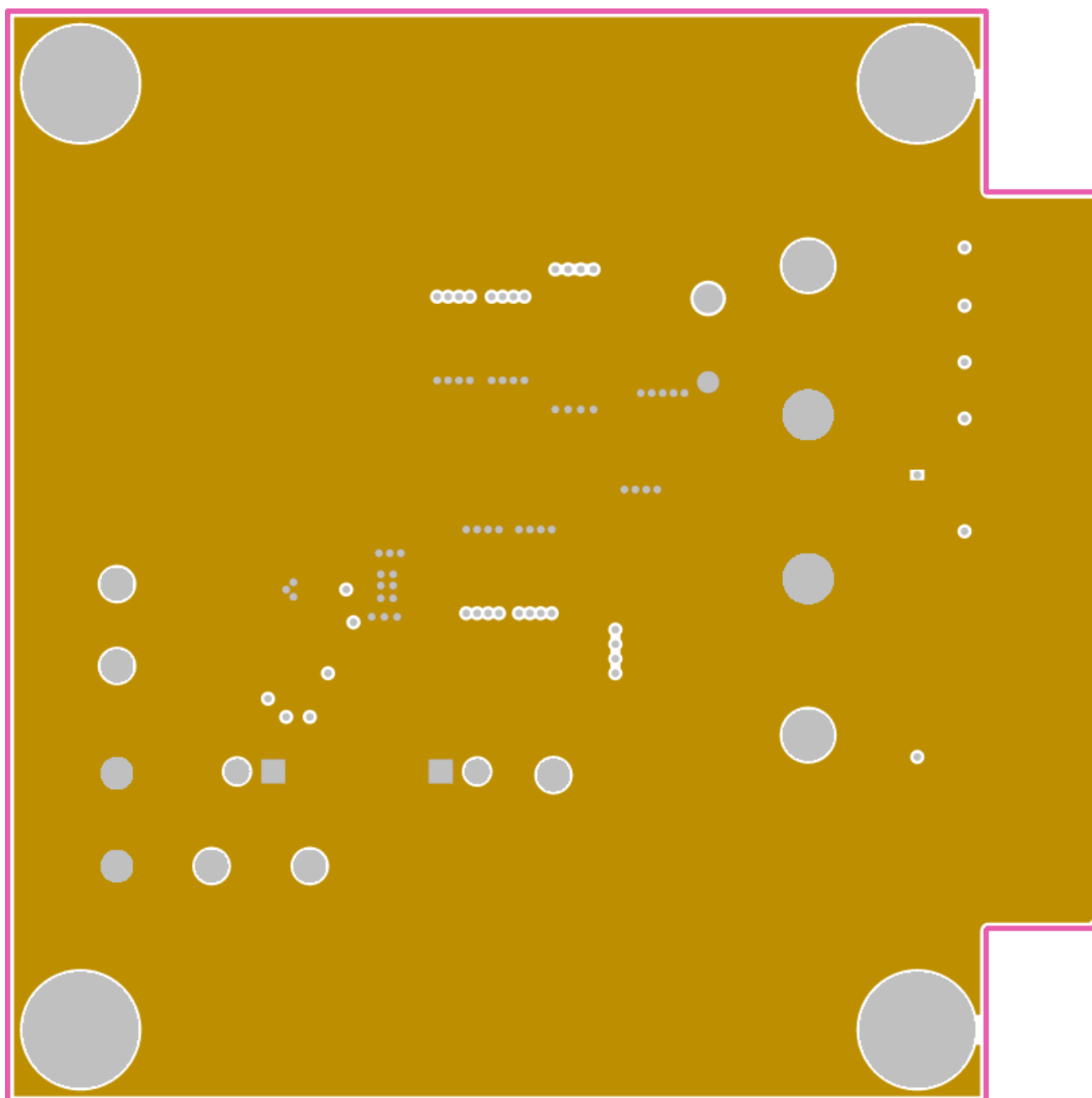
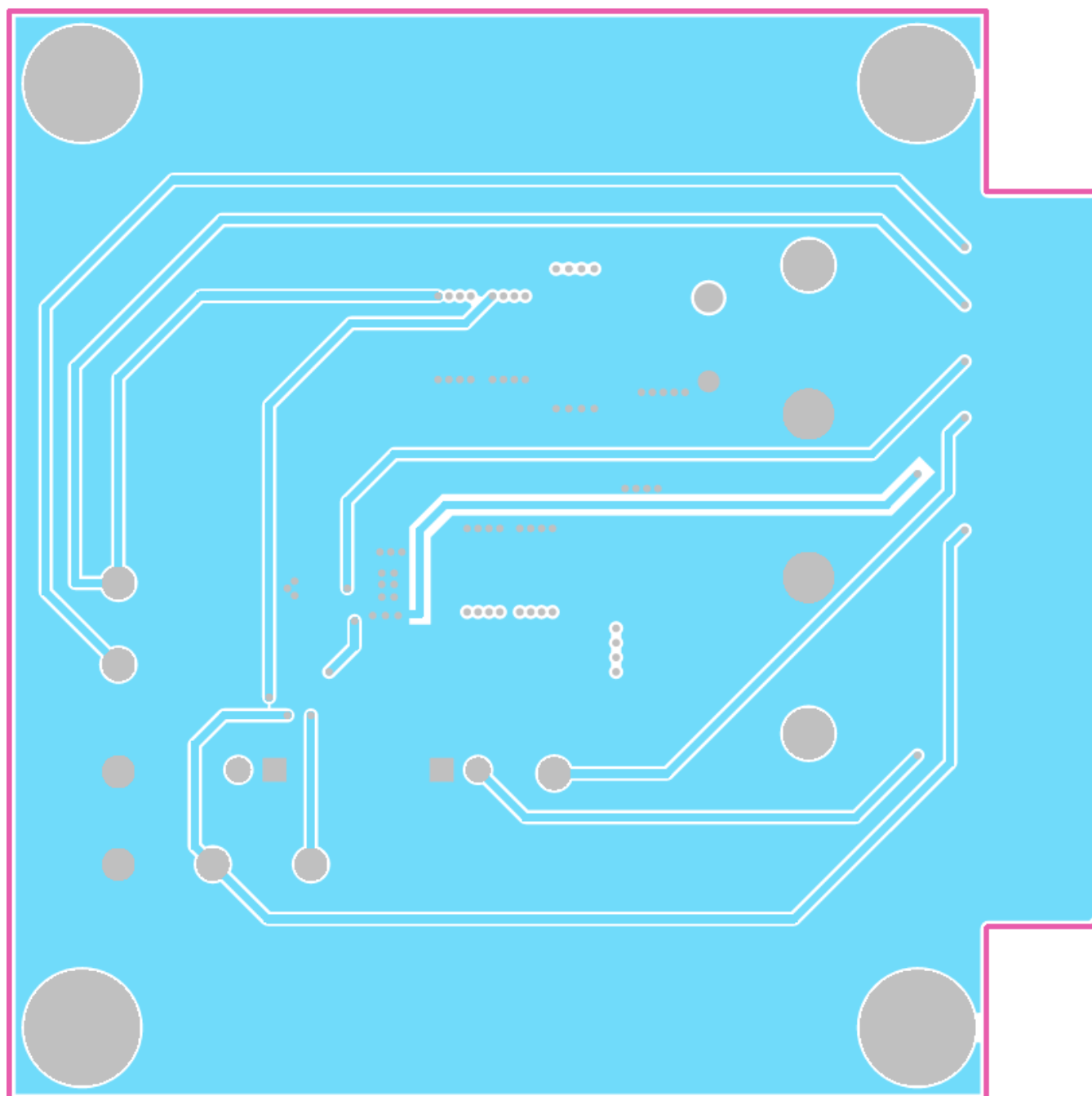


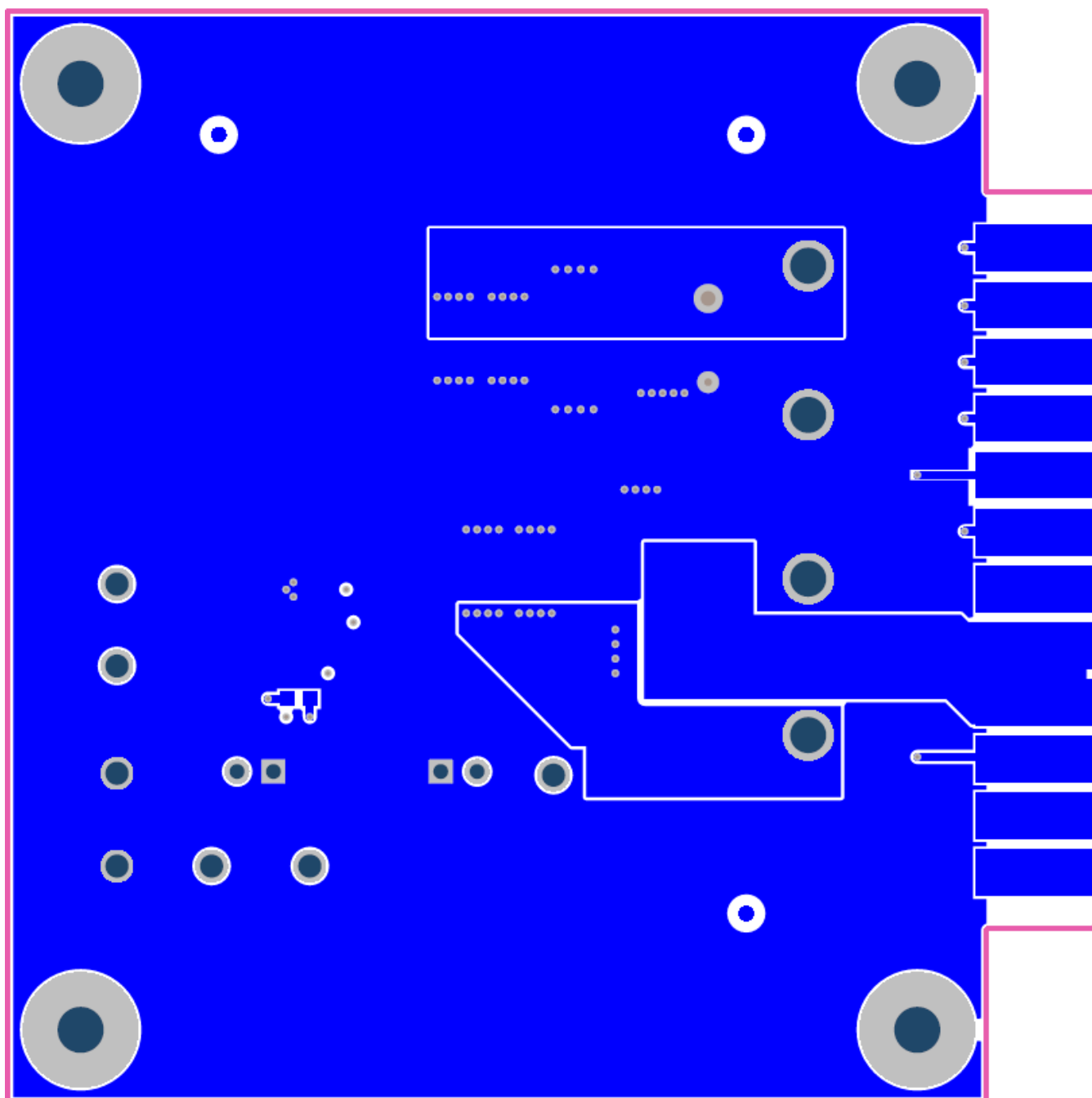
Figure 2. Top Layer



**Figure 3. Middle Layer 1**



**Figure 4. Middle Layer 2**



**Figure 5. Bottom Layer**

## 5 Schematic and Bill of Materials

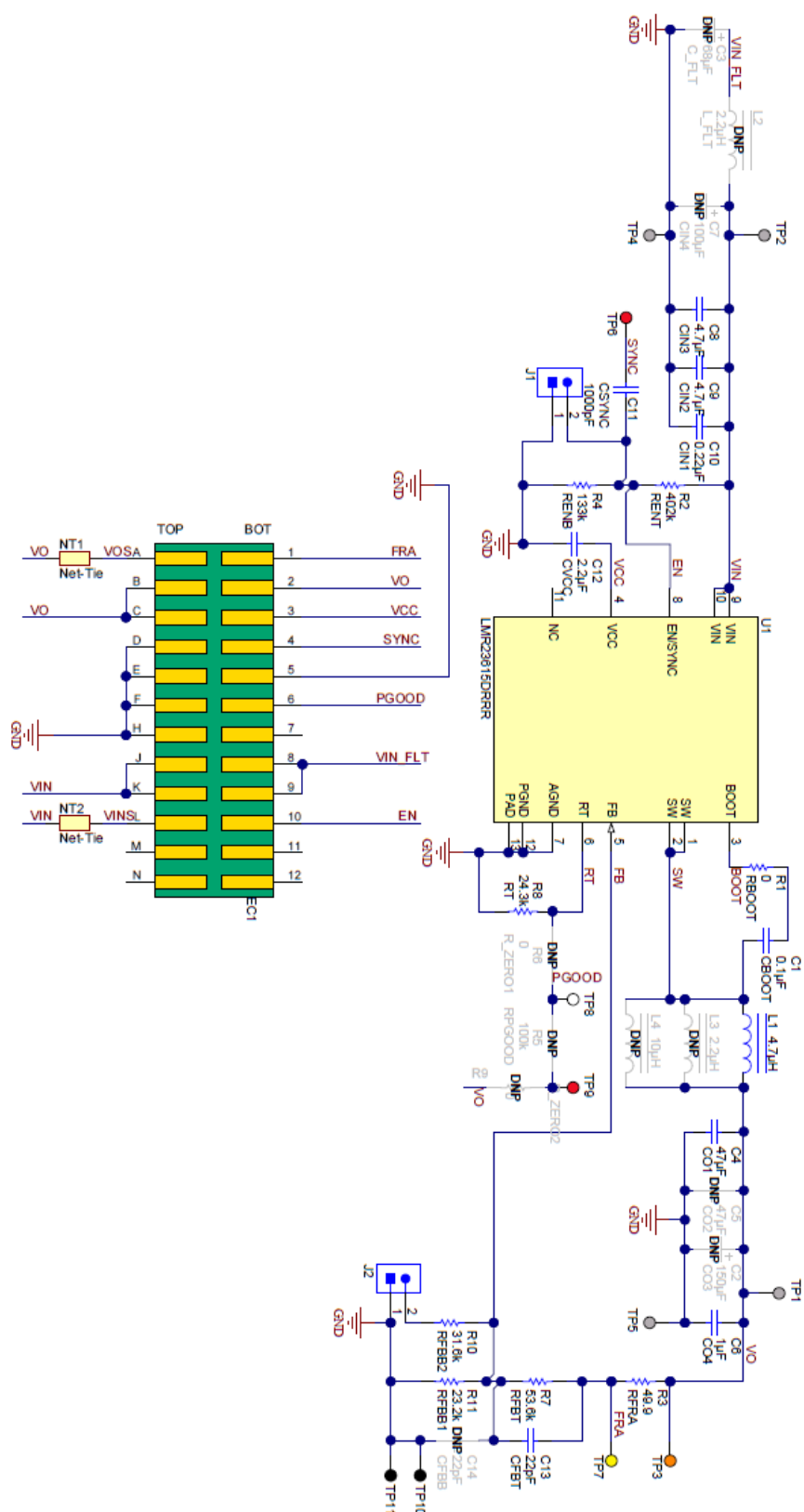


Figure 6. LMR23615EVM Schematic



**Table 2. LMR23615EVM Bill of Materials (BOM)**

| DESIGNATOR         | DESCRIPTION                                                                   | PART NUMBER        | QUANTITY |
|--------------------|-------------------------------------------------------------------------------|--------------------|----------|
| C1                 | CAP, CERM, 0.1 $\mu$ F, 25 V, +/- 10%, X7R, 0603                              | GRM188R71E104KA01D | 1        |
| C4                 | CAP, CERM, 47 $\mu$ F, 10 V, +/- 20%, X7R, 1210                               | GRM32ER71A476ME15L | 1        |
| C6                 | CAP, CERM, 1 $\mu$ F, 25 V, +/- 10%, X7R, 0805                                | GRM219R71E105KA88D | 1        |
| C8, C9             | CAP, CERM, 4.7 $\mu$ F, 50 V, +/- 10%, X7R, 1210                              | GRM32ER71H475KA88L | 2        |
| C10                | CAP, CERM, 0.22 $\mu$ F, 50 V, +/- 10%, X7R, 0805                             | GRM21BR71H224KA01L | 1        |
| C11                | CAP, CERM, 1000 pF, 50 V, +/- 10%, X7R, 0603                                  | GRM188R71H102KA01D | 1        |
| C12                | CAP, CERM, 2.2 $\mu$ F, 16 V, +/- 10%, X7R, 0603                              | GRM188Z71C225KE43  | 1        |
| C13                | CAP, CERM, 22 pF, 50 V, +/- 5%, C0G/NP0, 0603                                 | GRM1885C1H220JA01D | 1        |
| J1, J2             | Header, 100mil, 2x1, Gold, TH                                                 | TSW-102-07-G-S     | 2        |
| L1                 | Inductor, Shielded, Metal Composite, 4.7 $\mu$ H, 2.9 A, 0.076 ohm, SMD       | 74438356047        | 1        |
| LBL1               | Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll      | THT-14-423-10      | 1        |
| R1                 | RES, 0, 5%, 0.1 W, 0603                                                       | CRCW06030000Z0EA   | 1        |
| R2                 | RES, 402 k, 1%, 0.1 W, 0603                                                   | CRCW0603402KFKEA   | 1        |
| R3                 | RES, 49.9, 1%, 0.1 W, 0603                                                    | CRCW060349R9FKEA   | 1        |
| R4                 | RES, 133 k, 1%, 0.1 W, 0603                                                   | CRCW0603133KFKEA   | 1        |
| R7                 | RES, 53.6 k, 1%, 0.1 W, 0603                                                  | CRCW060353K6FKEA   | 1        |
| R8                 | RES, 24.3 k, 1%, 0.1 W, 0603                                                  | CRCW060324K3FKEA   | 1        |
| R10                | RES, 31.6 k, 1%, 0.1 W, 0603                                                  | CRCW060331K6FKEA   | 1        |
| R11                | RES, 23.2 k, 1%, 0.1 W, 0603                                                  | CRCW060323K2FKEA   | 1        |
| SH-J1, SH-J2       | Shunt, 100mil, Flash Gold, Black                                              | SPC02SYAN          | 2        |
| TP1, TP2, TP4, TP5 | Terminal, Turret, TH, Double                                                  | 1502-2             | 4        |
| TP3                | Test Point, Compact, Orange, TH                                               | 5008               | 1        |
| TP6, TP9           | Test Point, Compact, Red, TH                                                  | 5005               | 2        |
| TP7                | Test Point, Compact, Yellow, TH                                               | 5009               | 1        |
| TP8                | Test Point, Compact, White, TH                                                | 5007               | 1        |
| TP10, TP11         | Test Point, Compact, Black, TH                                                | 5006               | 2        |
| U1                 | SIMPLE SWITCHER 36V 1.5 A Synchronous Step-Down Converter, DRR0012D (WSON-12) | LMR23615DRRR       | 1        |

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    - 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.

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- *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.

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[http://www.tij.co.jp/llds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_01.page)

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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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