# LM46002EVM User's Guide

## Introduction

The Texas Instruments LM46002EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LM46002 wide-input voltage Simple Switcher® buck regulator. The device offers configurability in a 1-V to 28-V output voltage, synchronous rectification and a 200-kHz to 2.2-MHz adjustable frequency range. It also offers external frequency synchronization, power good (PG) flag, and a precision enable to program undervoltage lockout (UVLO) and internal compensation. The LM46002EVM is configured for an output voltage of 3.3 V and a switching frequency of 500 kHz. Refer to the LM46002 datasheet for additional features, detailed description and available options.

The EVM contains one DC-DC converter (See Table 1).

**Table 1. Device and Package Configurations**

| CONVERTER | IC | PACKAGE |
|---|---|---|
| U1 | LM46002 | (PWP) HTSSOP-16 |

## Setup

This section describes the test points and connectors on the EVM and how to properly connect, set up and use the LM46002EVM. Please refer to Figure 1 for a top view of the EVM and relative placement of the different test points and edge connector.

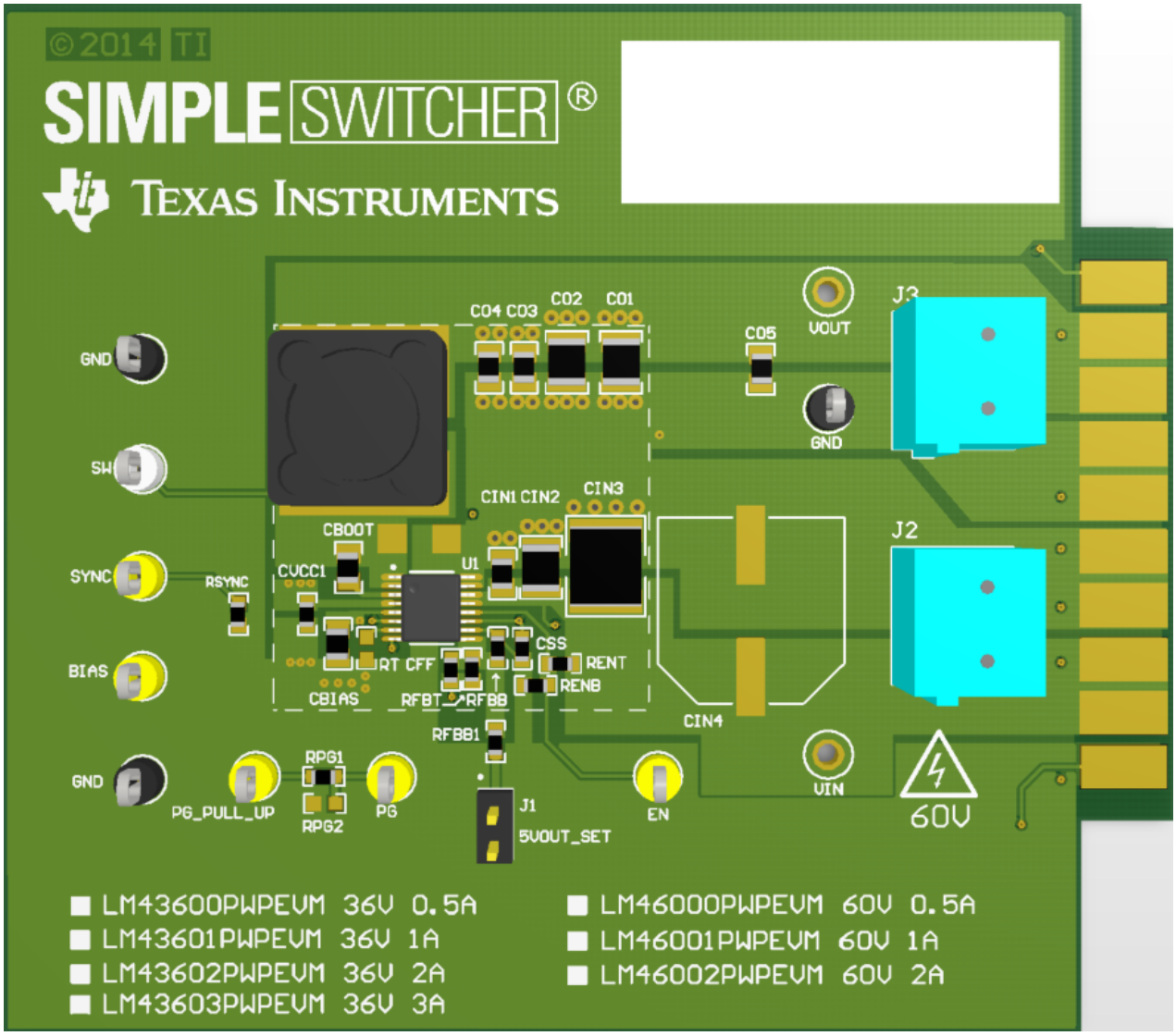



**Figure 1. Top View of LM46002EVM**

## 1 Input/Output (I/O) Connector Description

**VIN – Terminal on J2—**is the power input terminal for the converter. The terminal edge connector also provides a power (VIN) and ground (GND) connection to allow the user to attach the EVM to a cable harness.

**VOUT – Terminal on J3—**is the regulated output voltage for the converter. The terminal edge connector also provides a power (VOUT) and ground (GND) connection to allow the user to attach the EVM to a cable harness.

**GND – Terminal on J2 and J3—**are the ground reference for the converter. The terminal edge connector also provides a GND connection for attaching the EVM to a cable harness.

**EN – Testpoint—**is used to enable the converter by supplying a voltage greater than 2.2 V (typ) or just to monitor the voltage on this terminal whenever a resistor divider is in place (for precision enable applications). The LM46002EVM is built for a precision enable application with resistors RENT and RENB pre-assembled. The regulator will be enabled when VIN > 3.5 V. This threshold can be calculated by:

$$\text{Enable\_Voltage} = \text{VIH\_EN} \cdot \left(1 + \frac{\text{RENT}}{\text{RENB}}\right) \quad (1)$$

where

- VIH_EN is 2.2 V (typ)

**PG – Testpoint—**is used to monitor the power good flag. This flag indicates whether the output voltage has reached its regulation point. This terminal is an open-drain output that requires a pullup resistor to the appropriate logic voltage (any voltage less than 14 V). A pre-installed resistor RPG1 of 100 kΩ is tied to the PG terminal and brought out to the PG_PULL UP test point.

**PG_PULL UP – Testpoint—**is the top connection of the pre-assembled 100-kΩ RPG1 pullup resistor that ties directly to the open-drain PG terminal. Supply an appropriate voltage to this test point, or tie it directly to the VOUT test point to observe the PG flag operation.

**BIAS – Testpoint—**is used to monitor the BIAS voltage. A pre-installed capacitor of 4.7 µF is connected from the BIAS terminal to ground (GND). This node is connected to VOUT through a zero Ohm resistor pre-installed on the bottom layer, labeled (RBIAS).

**SYNC – Testpoint —**is the input terminal for an optional external input clock to the converter. The external clock frequency must be between 200 kHz and 2.2 MHz, if used. A pulldown resistor of 100 kΩ (RSYNC) is installed on the EVM.

**SW – Testpoint—**is used to monitor the voltage on the switch terminal and the switching frequency of the voltage regulator. Remove this test point before making any electromagnetic interference (EMI) measurements.

**VSUPPLY – Edge Connector terminal #9—**is used to supply the input voltage through an on board LC filter (if one is needed for conducted EMI/EMC measurements). The Lin and Cd component pads are located on the bottom side of the EVM. Please refer to the EVM schematic for initial suggestion of component values.

## 2 Setup

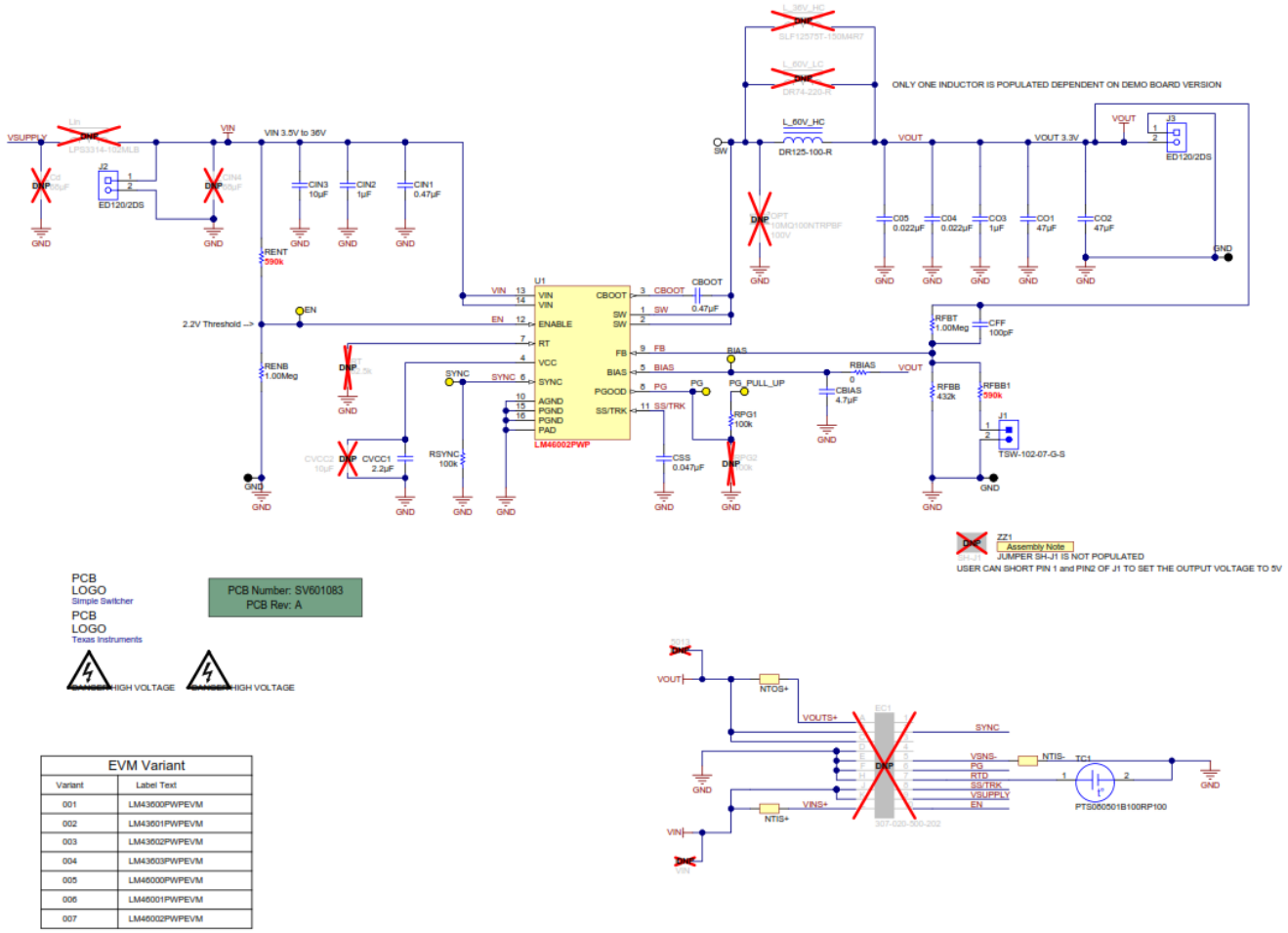
Set the input voltage (VIN) range for the converter between the operating voltage range of 3.5 V to 60 V. If a load is driven, it should be applied to the VOUT terminal and should not exceed the maximum load current of 2 A.

## 3 Operation

For proper operation of the LM46002, VIN, GND, and VOUT should be properly configured as stated above. In this configuration, the device will start up when power is applied and the output voltage of the regulator (VOUT) will come up to the proper value. The default setting for output voltage of the LM46002EVM is 3.3 V. Other output voltages can be set by replacing the feedback terminal resistor dividers RFBT and RFBB; please consult the datasheet for proper selection of these resistor values.

The default frequency for the LM46002EVM is 500 kHz. If other frequencies are desired, within the frequency range of 200 kHz and 2.2 MHz, the RT resistor value can be changed. Please consult the datasheet for proper selection of the RT resistor. You must change inductor (L_60V_HC) and total output capacitance for proper control loop operation.

## Schematic




| EVM Variant | |
|---|---|
| Variant | Label Text |
| 001 | LM43600PWPEVM |
| 002 | LM43601PWPEVM |
| 003 | LM43602PWPEVM |
| 004 | LM43603PWPEVM |
| 005 | LM46000PWPEVM |
| 006 | LM46001PWPEVM |
| 007 | LM46002PWPEVM |

**Figure 2. LM46002EVM Schematic**

## Board Layout

Figure 3 through Figure 7 show the board layout for the LM46002EVM. The EVM offers resistors, capacitors and test points to configure the output voltage, precision enable terminal, set frequency and external clock synchronization.

The PWP HTSSOP-16 package offers an exposed thermal pad which must be soldered to the copper landing on the PCB for optimal thermal performance. 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.

Test points have been provided for ease of use to connect the power supply, required load and to monitor critical signals. The 12-terminal edge connector can also be used to facilitate the use of a cable harness if one is required (refer to the Table 2 section for mating connector part number).

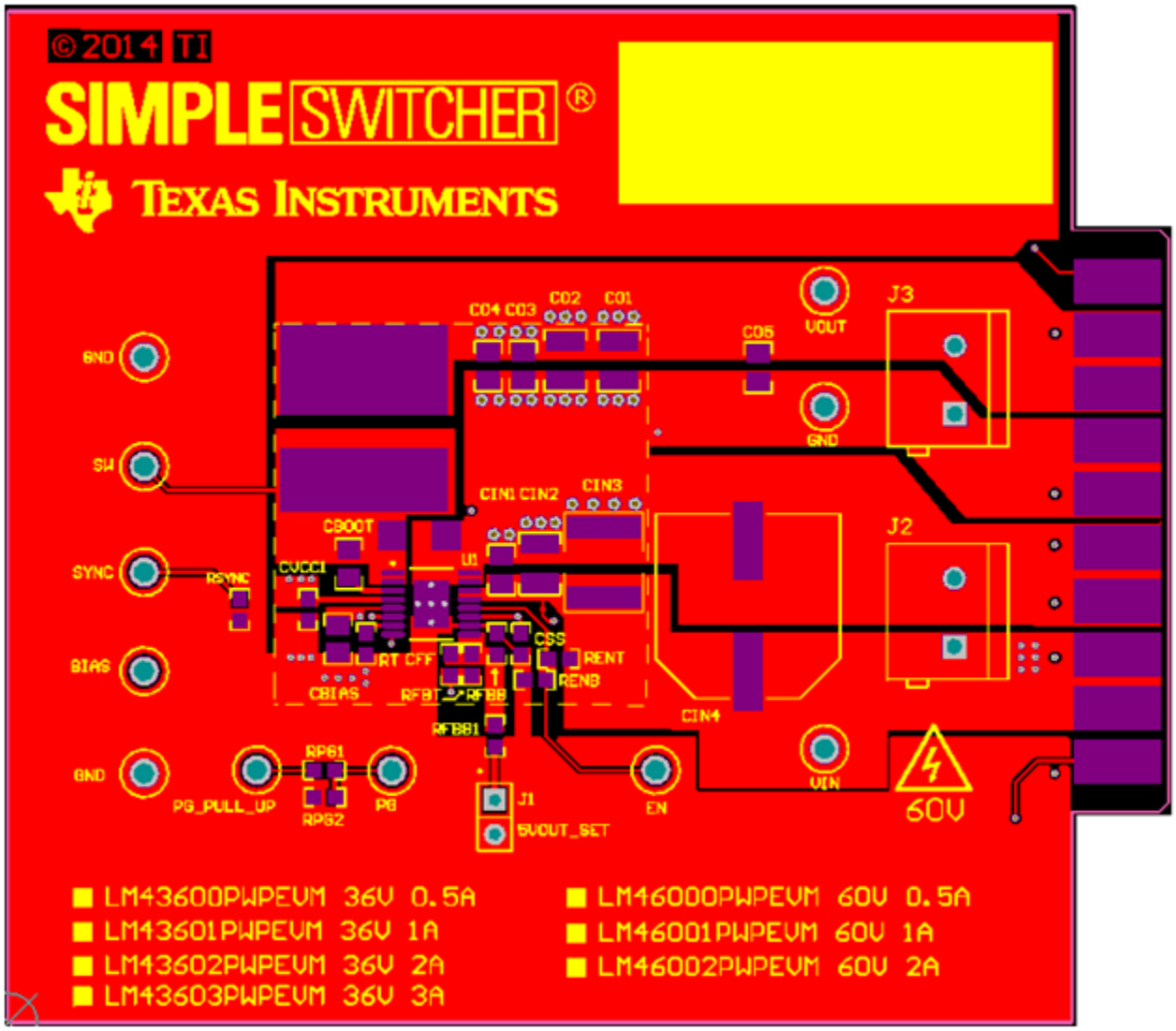



**Figure 3. Top Assembly Layer**

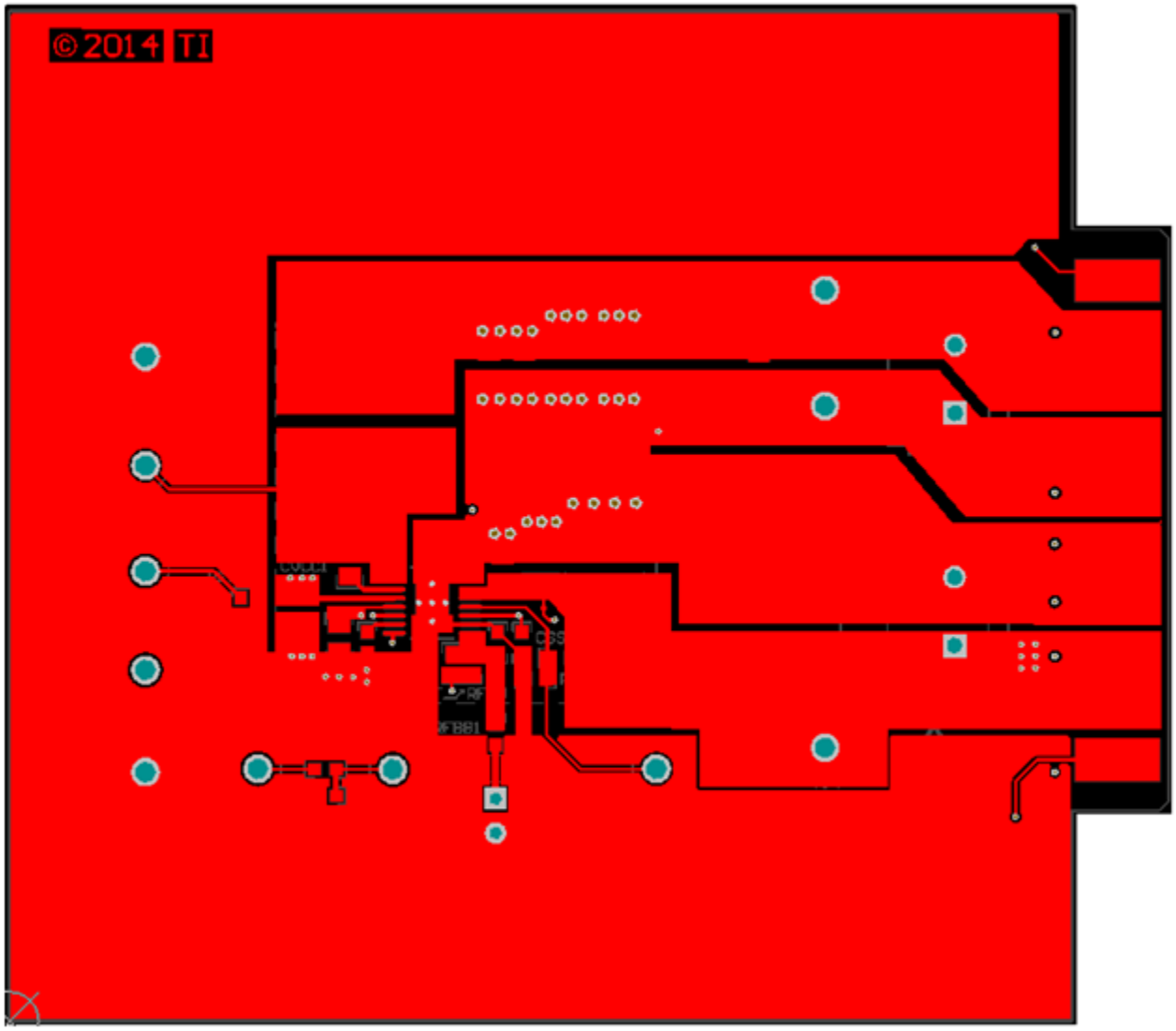



**Figure 4. Top Layer Routing**

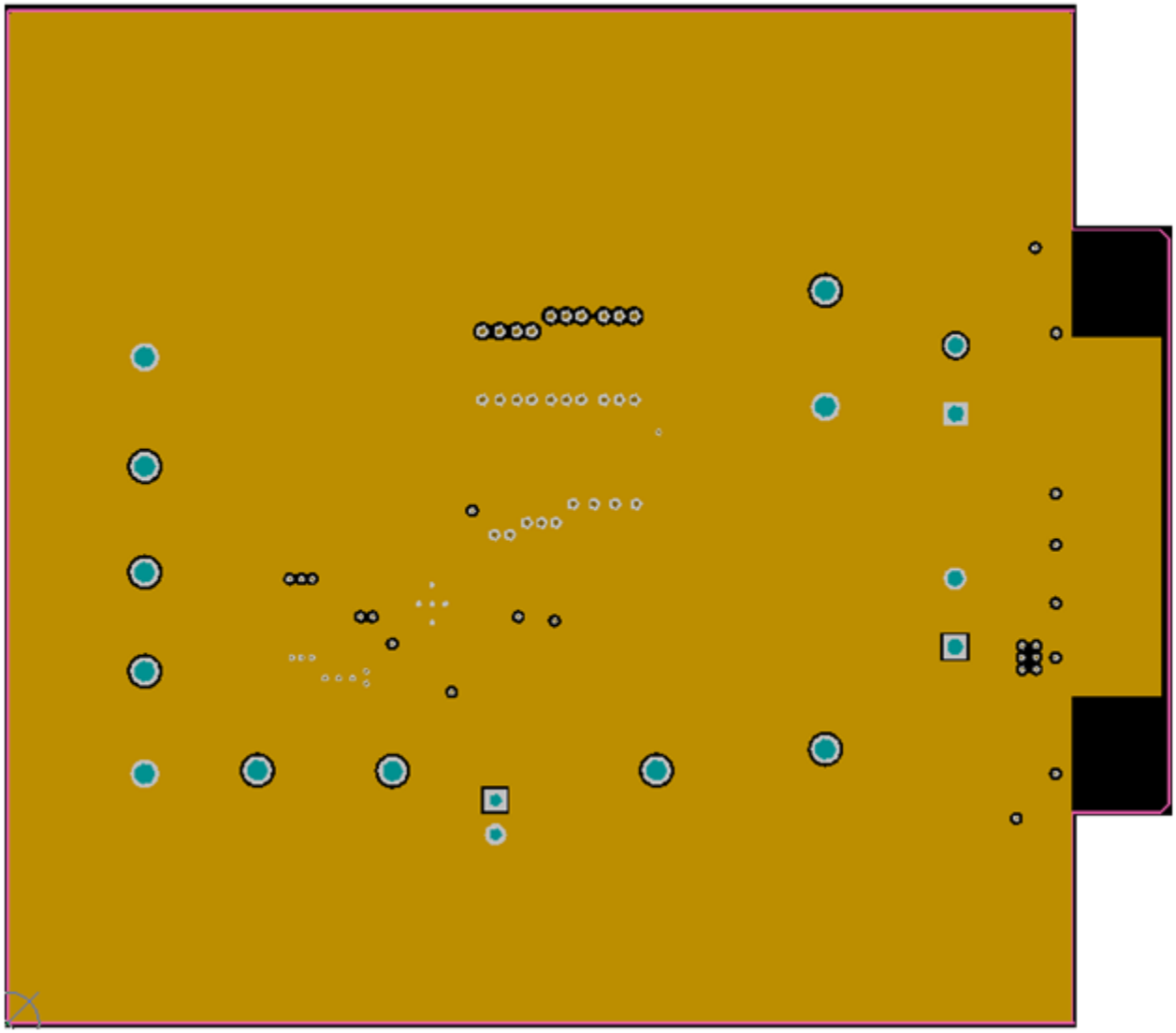


**Figure 5. Mid Layer 1 Ground Plane**

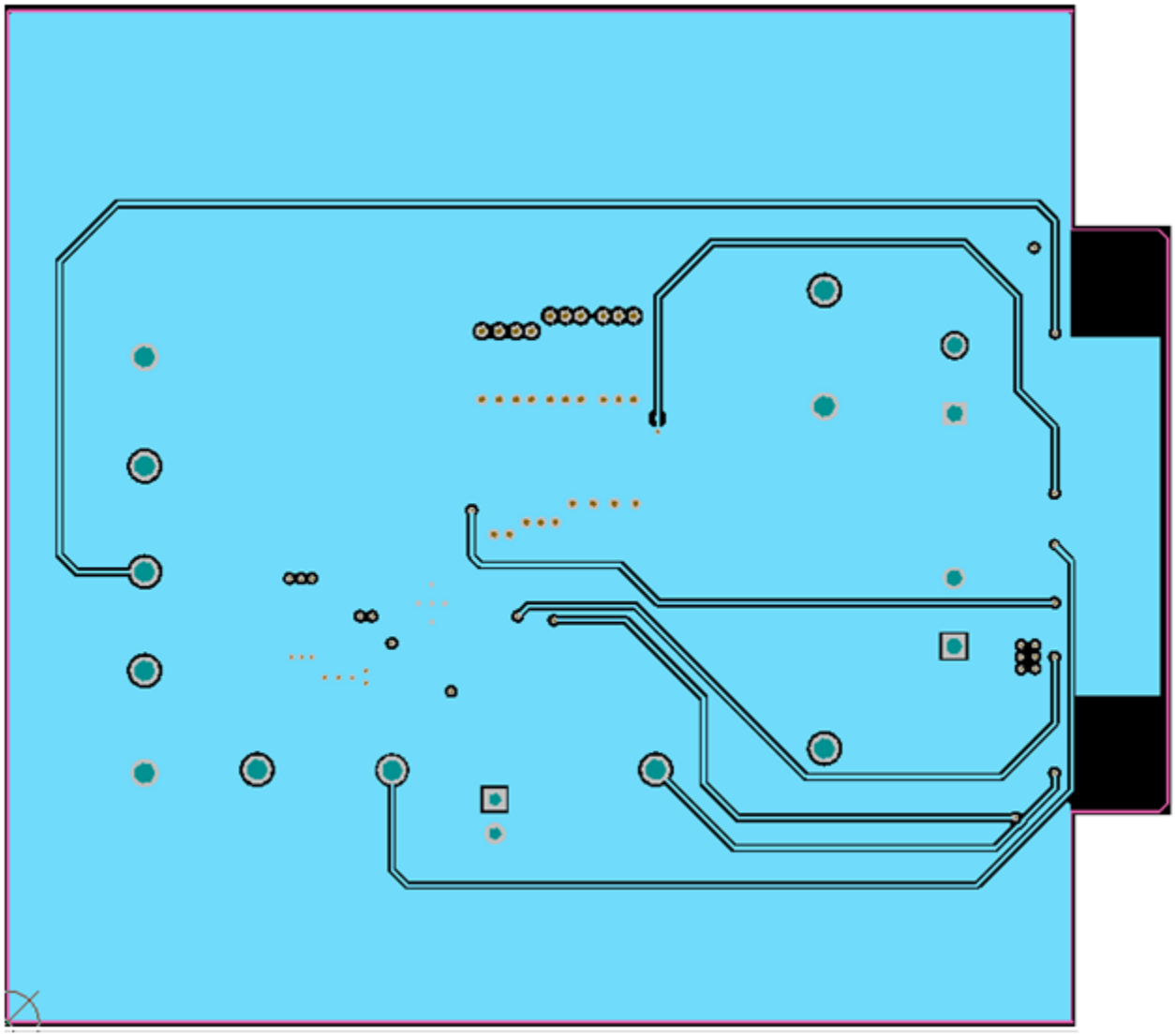


**Figure 6. Mid Layer 2 Routing**

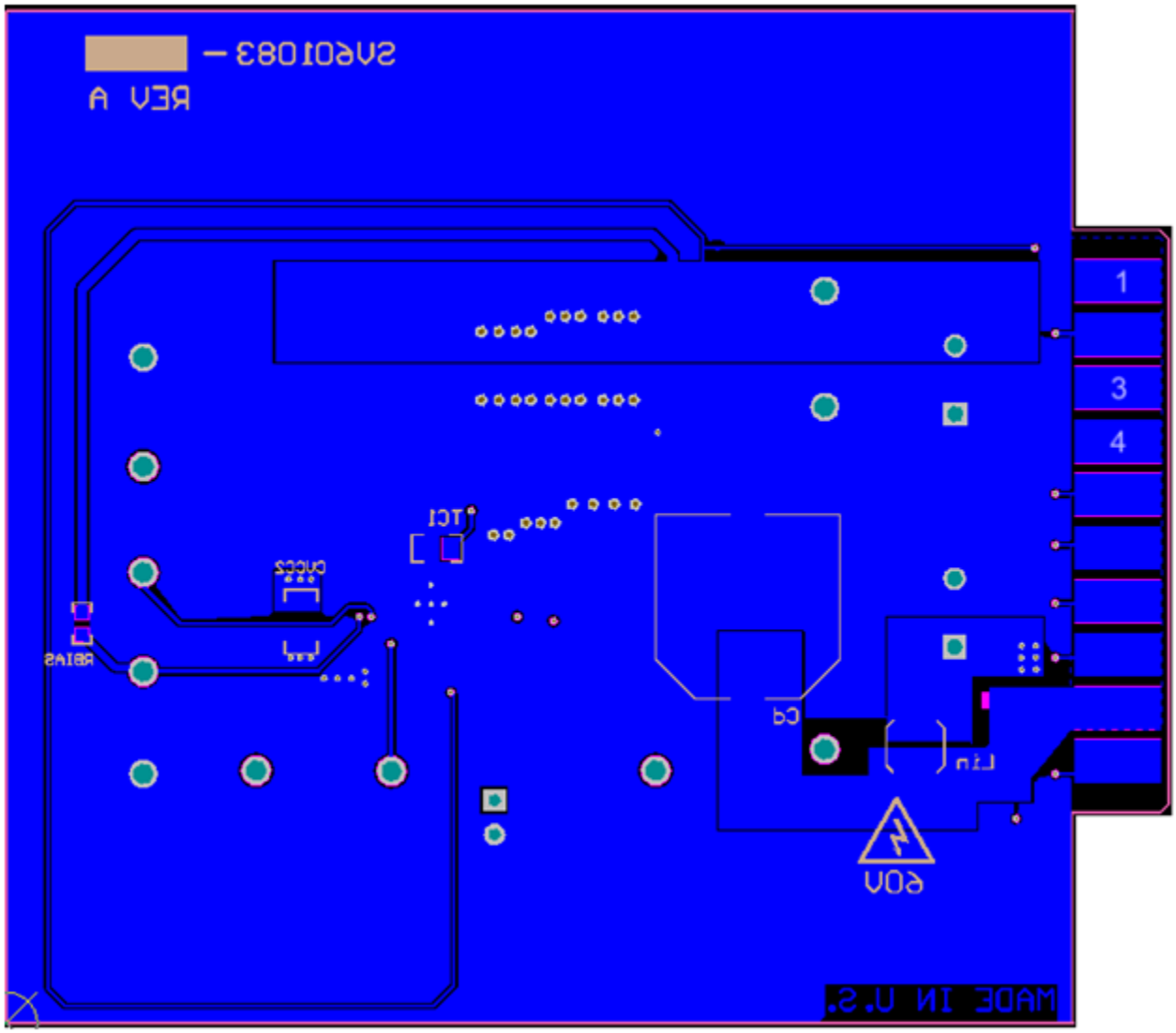



**Figure 7. Bottom Layer Routing**

**Table 2. LM46002EVM Bill of Materials (BOM) for 500 kHz Configuration**

| Designator | Description | Manufacturer | PartNumber | Quantity |
|---|---|---|---|---|
| !PCB | Printed Circuit Board | Any | SV601083 | 1 |
| C04, C05 | CAP, CERM, 0.022µF, 100V, +/-5%, X7R, 0805 | AVX | 08051C223JAT2A | 2 |
| CBIAS | CAP, CERM, 4.7µF, 50V, +/-10%, X5R, 0805 | TDK | C2012X5R1H475K125AB | 1 |
| CBOOT | CAP, CERM, 0.47µF, 16V, +/-10%, X7R, 0805 | AVX | 0805YC474KAT2A | 1 |
| CFF | CAP, CERM, 100pF, 50V, +/-5%, C0G/NP0, 0603 | MuRata | GRM1885C1H101JA01D | 1 |
| CIN1 | CAP, CERM, 0.47µF, 100V, +/-10%, X7R, 0805 | MuRata | GRM21BR72A474KA73L | 1 |
| CIN2 | CAP, CERM, 1µF, 100V, +/-10%, X7R, 1210 | MuRata | GRM32ER72A105KA01L | 1 |
| CIN3 | CAP, CERM, 10µF, 100V, +/-20%, X7S, 2220 | TDK | C5750X7S2A106M | 1 |
| CO1, CO2 | CAP, CERM, 47µF, 10V, +/-10%, X7R, 1210 | MuRata | GRM32ER71A476KE15L | 2 |
| CO3 | CAP, CERM, 1µF, 25V, +/-10%, X5R, 0805 | AVX | 08053D105KAT2A | 1 |
| CSS | CAP, CERM, 0.047µF, 50V, +/-10%, X7R, 0603 | TDK | C1608X7R1H473K | 1 |
| CVCC1 | CAP, CERM, 2.2µF, 10V, +/-10%, X7R, 0603 | MuRata | GRM188R71A225KE15D | 1 |
| J1 | Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator | Samtec | TSW-102-07-G-S | 1 |
| J2, J3 | TERMINAL BLOCK 5.08MM VERT 2POS, TH | On-Shore Technology | ED120/2DS | 2 |
| L_60V_HC | Inductor, Shielded Drum Core, Ferrite, 10µH, 5.35A, 0.0189 ohm, SMD | Coiltronics | DR125-100-R | 1 |
| RBIAS | RES, 0 ohm, 5%, 0.1W, 0603 | Vishay-Dale | CRCW06030000Z0EA | 1 |
| RENB, RFBT | RES, 1.00Meg ohm, 1%, 0.1W, 0603 | Vishay-Dale | CRCW06031M00FKEA | 2 |
| RENT, RFBB1 | RES, 590k ohm, 1%, 0.1W, 0603 | Vishay-Dale | CRCW0603590KFKEA | 2 |
| RFBB | RES, 432k ohm, 1%, 0.1W, 0603 | Vishay-Dale | CRCW0603432KFKEA | 1 |
| RPG1, RSYNC | RES, 100k ohm, 1%, 0.1W, 0603 | Vishay-Dale | CRCW0603100KFKEA | 2 |
| RTD | TEMP SENSOR RTD 100 OHM 0805 | VISHAY | PTS080501B100RP100 | 1 |
| TP1 | Test Point, TH, Multipurpose, Orange | Keystone | 5013 | 0 |
| TP2 | Test Point, TH, Multipurpose, Red | Keystone | 5010 | 0 |
| TP3 | Test Point, TH, Multipurpose, White | Keystone | 5012 | 1 |
| TP5, TP9, TP10 | Test Point, TH, Multipurpose, Black | Keystone | 5011 | 3 |
| TP6, TP7, TP8, TP10, TP11 | Test Point, TH Multipurpose, Yellow | Keystone | 5014 | 5 |
| U1 | 3.5- 60V 2A Step Down Converter | Texas Instruments | LM46002PWP | 1 |
| Cd, CIN4 | CAP, AL, 68µF, 100V, +/-20%, 0.32 ohm, SMD | Panasonic | EEV-FK2A680Q | 0 |
| CVCC2 | CAP, CERM, 10µF, 10V, +/-20%, X7R, 1206 | TDK | C3216X7R1A106M | 0 |
| Lin | Inductor, Shielded Drum Core, Ferrite, 1µH, 2A, 0.06 ohm, SMD | Coilcraft | LPS3314-102MLB | 0 |
| L_36V_LC | Inductor, Shielded, Powdered Iron, 6.8µH, 6.7A, 0.0334ohm, SMD | Vishay-Dale | IHLP3232DZER6R8M11 | 0 |
| L_60V_LC | Inductor, Shielded Drum Core, Ferrite, 22µH, 1.75A, 0.0925 ohm, SMD | Coiltronics | DR74-220-R | 0 |
| OPT | Diode, Schottky, 100V, 1.5A, SMA | International Rectifier | 10MQ100NTRPBF | 0 |
| RPG2 | RES, 100k ohm, 1%, 0.1W, 0603 | Vishay-Dale | CRCW0603100KFKEA | 0 |
| RT | RES, 82.5k ohm, 1%, 0.1W, 0603 | Vishay-Dale | CRCW060382K5FKEA | 0 |
| SH-J1 | Shunt, 100mil, Gold plated, Black | 3M | 969102-0000-DA | 0 |

## Revision History

| Changes from #IMPLIED Revision (#IMPLIED) to #IMPLIED Revision | Page |
|---|---|

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.
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**U.S. Federal Communications Commission Compliance**

**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 could void the user's authority to operate the equipment.

**FCC Interference Statement for Class A EVM devices**

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 its own expense.

**FCC Interference Statement for Class B EVM devices**

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.

**Industry Canada Compliance (English)**

**For EVMs Annotated as IC – INDUSTRY CANADA Compliant:**

This Class A or B digital apparatus complies with Canadian ICES-003.

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

**Concerning EVMs Including Radio Transmitters**

This device complies with Industry Canada licence-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.

**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.

**Canada Industry Canada Compliance (French)**

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

**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.

**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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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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