

EVM User's Guide: REF8EVM

REF80 Evaluation Module



Description

The REF8EVM is a precision voltage reference evaluation module that demonstrates the performance of high precision series reference device (REF80) and the internal heater from Texas Instruments. The REF80 is a family of low drift, and low noise buried zener, internal heater compensated voltage reference devices. REF80 offers low temperature drift coefficient, low flicker noise, and low long-term drift.

Get Started

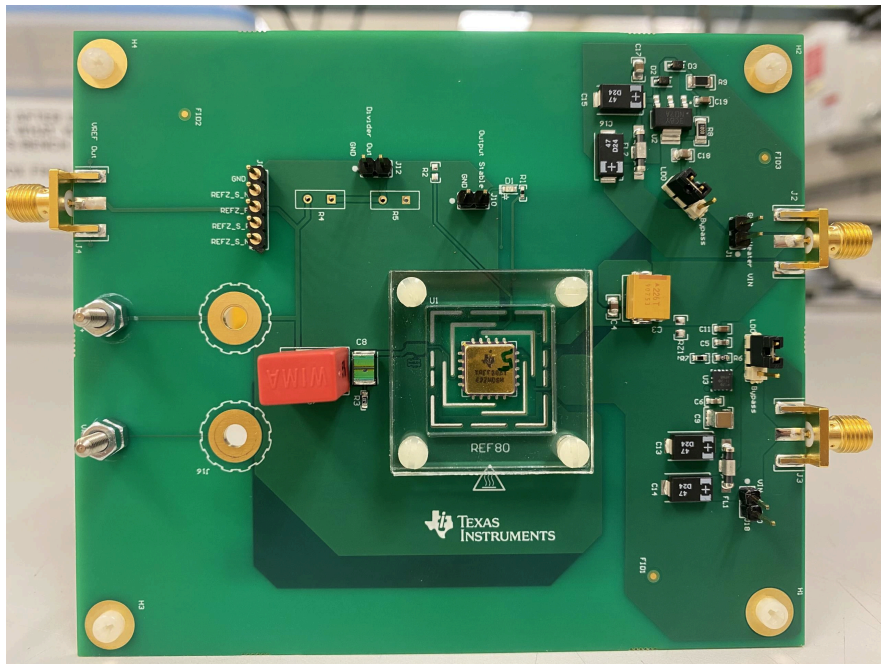
1. Order the EVM from the [REF80 tool page](#).
2. Configure EVM jumpers to select power supply method.
3. Connect VIN and heater VIN to power supplies.
4. Test the output.

Features

- Choice of powering REF80 directly from bench power supply or on board LDO.
- Integrated heater for improved performance.
- Output stable LED to indicate when the heater temperature has settled.
- Many different methods of measuring available, including banana plugs, unpopulated footprints for binding posts, and SMA connectors.
- Compatible with DAC11001B EVM via SMA connection.

Applications

- [Semiconductor test and ATE](#)
- [Digital multimeter \(DMM\)](#)
- [Signal generator](#)
- [Battery test](#)
- [Precision data acquisition systems](#)



REF8EVM Board

1 Evaluation Module Overview

1.1 Introduction

The REF8EVM is a buried zener internal heater compensated voltage reference evaluation module that demonstrates the REF80 performance in a ceramic LCCC package. The REF80 with low long-term drift and temperature drift helps meet strict performance requirements of high precision applications. This device also comes with a output stable pin that notifies the user that the internal heater temperature is stable.

This user's guide describes the characteristics, operation, and recommended use cases of the REF8EVM. This document provides examples and instructions on how to use the REF8EVM board. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the REF8EVM. This document also includes a schematic, reference printed circuit board (PCB) layouts, and a complete bill of materials (BOM).



1.2 Kit Contents

[Table 1-1](#) details the content of the EVM kit. Contact the TI Product Information Center at (972) 644-5580 if any component is missing.

Table 1-1. Kit List

Item	Quantity
REF8EVM	1

1.3 Specification

REF8EVM primary function is to evaluate the REF80 buried zener, precision voltage reference. Banana plugs enable direct connection to a 3458A DMM. A cover and TSET resistor allow for thorough performance evaluation of temperature drift. REF8EVM can be configured to be powered directly from the lab power supply or on board LDOs.

1.4 Device Information

REF80 is a buried zener, internal heater compensated voltage reference. The device is designed with an extremely low temperature drift and long-term drift. REF80 is also a low noise device. This allows REF80 to be used with the highest precision of ADCs and DACs and in many calibration applications. REF80 has a TSET pin which allows the user to set the internal temperature at a temperature different from the default temperature. REF80 does not require external resistors to set the output voltage or for other device operation, so it can greatly simplify board design.

2 Hardware

2.1 Setup

Schematic shown in [Figure 2-1](#) is representative of the REF8EVM.

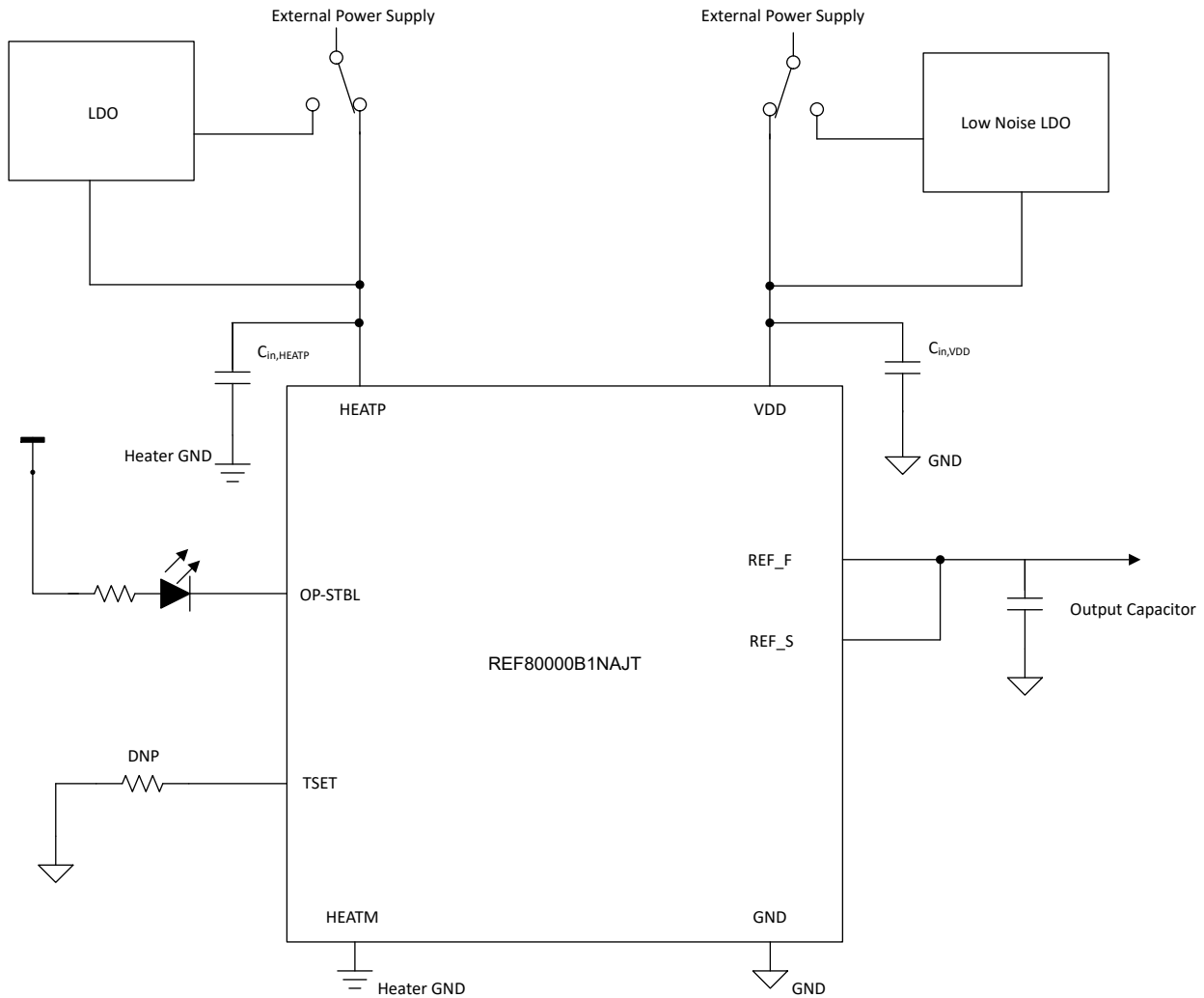


Figure 2-1. REF8EVM Setup

The REF8EVM is designed to allow users to evaluate the configuration shown in [Figure 2-1](#). Multiple power supply options are provided for the input voltage so that the user can evaluate for best performance in applications. Once the output stable LED turns off, the internal heater temperature of REF80 is stable.

2.2 EVM Connection

There are multiple options to power up REF8EVM. There are onboard LDOs provided or users can bypass the LDOs to directly power REF80 with an external power supply. The TPS7A4901DRBR, a low noise LDO, and LM317AEMP/NOPB, a high output current LDO, can be used if a low noise, regulated input voltage is desired to further isolate the noise of REF80 from the noise generated by a bench power supply. These LDOs generate voltages at about 15V. REF8EVM has been validated to meet REF80 specifications with both options. The input voltage ranges of each device can be seen below in [Table 2-1](#).

Table 2-1. Input Voltage Ranges for REF8EVM Setup

Input Setting	Device	EVM Minimum Input Voltage	EVM Maximum Input Voltage
VDD Bypass (J17)	REF80000B1NAJT (VDD Pin)	10V	16.5V
Heater Vin Bypass (J20)	REF80000B1NAJT (HEATP Pin)	10V	42V
VDD LDO (J17)	TPS7A4901DRBR	16V	35V
Heater Vin LDO (J20)	LM317AEMP/NOPB	18.5V	37V

Default EVM setup is shown in [Figure 2-2](#). The output reference voltage can also be measured in many different ways. The output reference can be measured by connecting the VREF+ and VREF- directly to an 8.5 digit multimeter, by installing user provided binding posts J14 and J16 where J14 is VREF+ and J16 is VREF-, or by measuring the output voltage using SMA connector J4. For best temperature drift performance, use low thermal EMF banana plugs to measure VREF+ and VREF- rather than SMA cables to avoid unwanted offsets due to imbalanced thermal EMF effects.

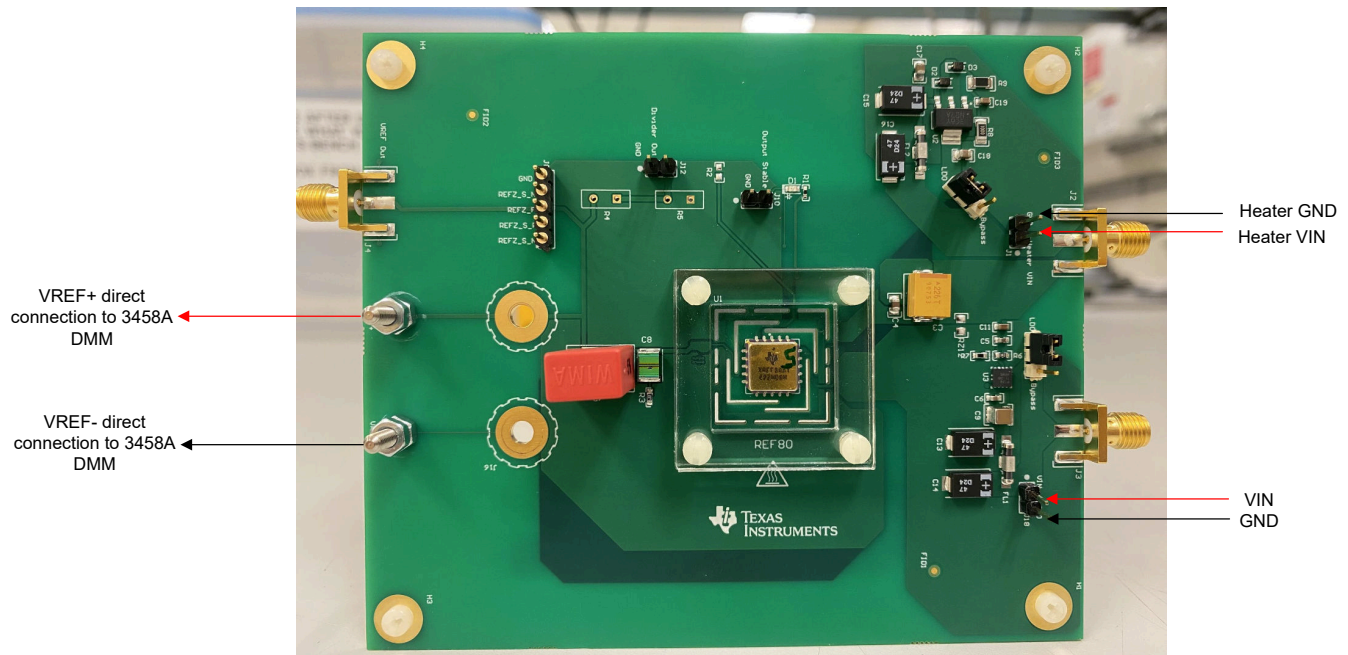


Figure 2-2. REF8EVM Default Setup

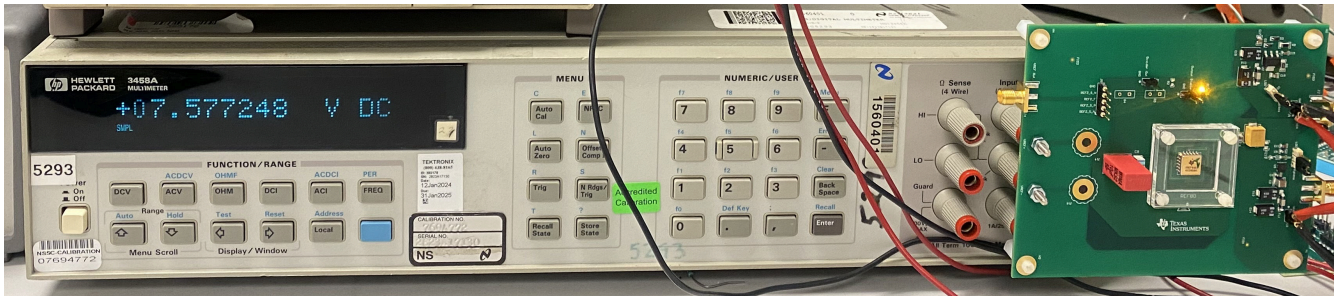


Figure 2-3. REF8EVM DMM Direct Connection

Table 2-1 lists the detailed function of VIN and Heater VIN.

Table 2-2. REF8EVM Input Connection

Terminal	Pin Connection	Function
VIN	VDD	Connect to power supply. Connect jumper on J17 to select LDO power supply or bypass.
Heater VIN	HEATP	Connect to power supply. Ground connection for heater must be connected to the GND pin on J1. Connect jumper on J20 to select LDO power supply or bypass.

There are also options to install a resistor R2 on the board to change the internal set temperature. Suggested values can be seen below in Table 2-3.

Table 2-3. TSET Resistor Values

Resistance	Internal Heater Setpoint
0	Default TSET
130kΩ	TSET - 10°C
360kΩ	TSET - 20°C
800kΩ	TSET - 30°C
Open	Default TSET

Finally, footprints are included on the board to install precision film resistors on R4 and R5 to help aid in validation, if desired.

If users want to measure the output of REF8EVM using the SMA connector, then users can remove the banana plugs, thus allowing the board to rest on the standoffs installed in each corner of the board.

REF8EVM comes with a polycarbonate ULV94-V0 rated cover that is attached covering REF80 and the slots on the EVM. This is to restrict the air flow around REF80. This helps the temperature surrounding REF80 remain more constant, thus decreasing the amount of compensation and current that the internal heater must provide and improving the temperature drift.

2.3 Jumper Information

REF8EVM can be configured to power the device directly from a bench power supply or using onboard LDOs.

Table 2-4. REF8EVM Input Connection

Terminal	Pin Connection	Jumper Function
VIN	VDD	Connect to power supply. Connect jumper on J17 to select LDO power supply or bypass.
Heater VIN	HEATP	Connect to power supply. Connect jumper on J20 to select LDO power supply or bypass.

2.4 Best Practices

- Use the power supply which has very good PSRR.
- Measure the output with high resolution instrument (DMM, oscilloscope) for best performance.
- Connect J4 VREF out to data converter EVM for best performance.
- Wait to begin measuring at least until the output voltage has settled and the LED has turned off, representing that REF80 internal heater temperature is now stable.

3 Implementation Results

3.1 Evaluation Setup

EVM is tested with the conditions listed below.

VIN and Heater VIN : Connect the Heater VIN pin to one Kiethley 2420 SMU and connect the ground from that SMU to the ground pin adjacent to the Heater VIN pin. Connect the VIN pin to a separate Kiethley2420 SMU and connect the ground from that SMU to the ground pin adjacent to the VIN pin.

VREF+ and VREF- : Connect VREF+ and VREF- to an HP 3548A DMM. For best temperature drift performance, use low thermal EMF banana plugs rather than SMA cables to avoid unwanted offsets due to imbalanced thermal EMF.

3.2 Performance Data and Results

Output voltage of REF8EVM is measured with dropout conditions meets the initial accuracy, long-term drift, and temperature drift specification limit. Device meets line regulation specification and shutdown condition for relevant tests.

4 Hardware Design Files

4.1 Schematics

The schematic for the REF8EVM is illustrated in Figure 4-1.

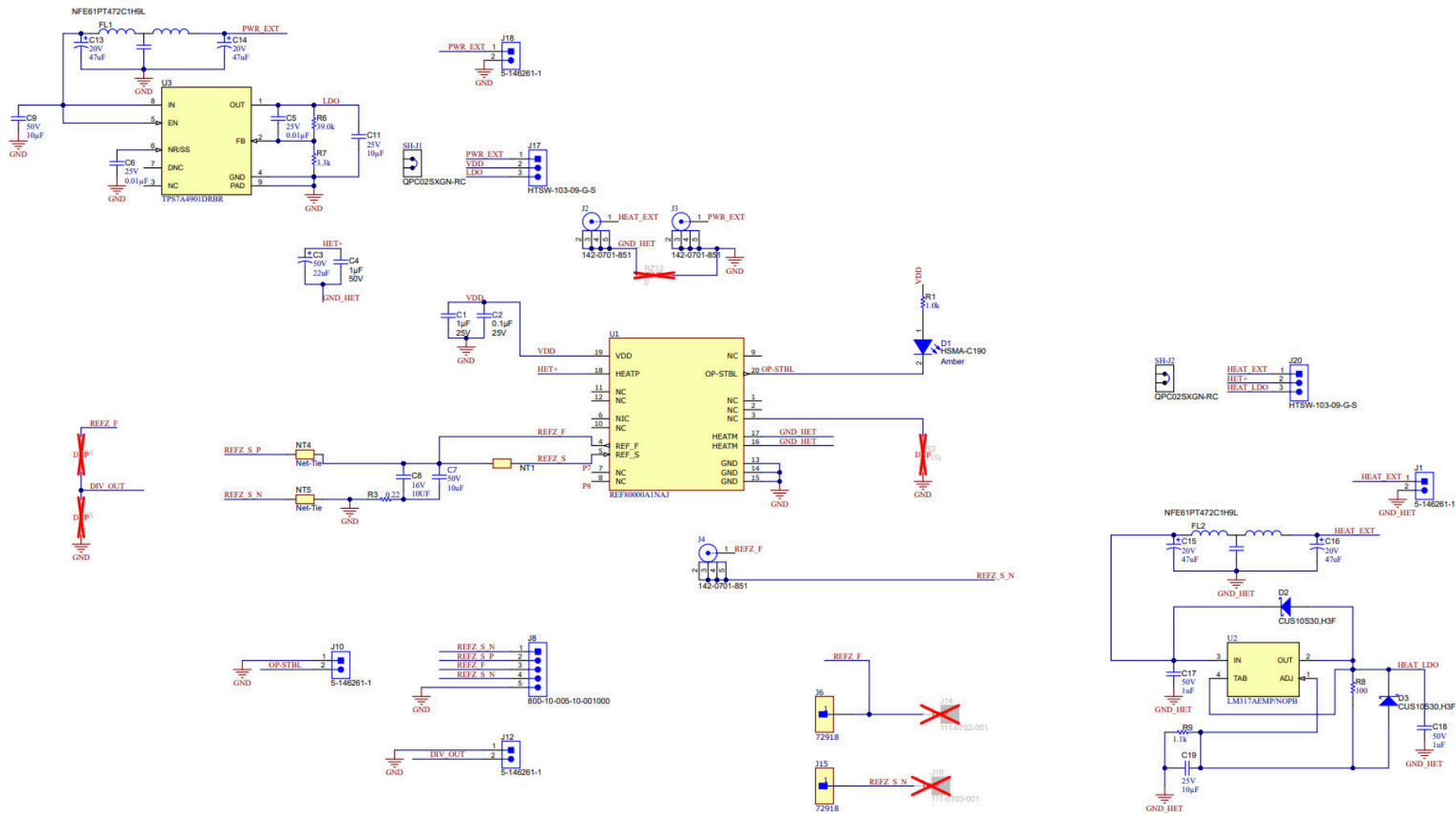


Figure 4-1. REF8EVM Schematic

4.2 PCB Layouts

REF8EVM is a four layer board. The layout is illustrated in this section.

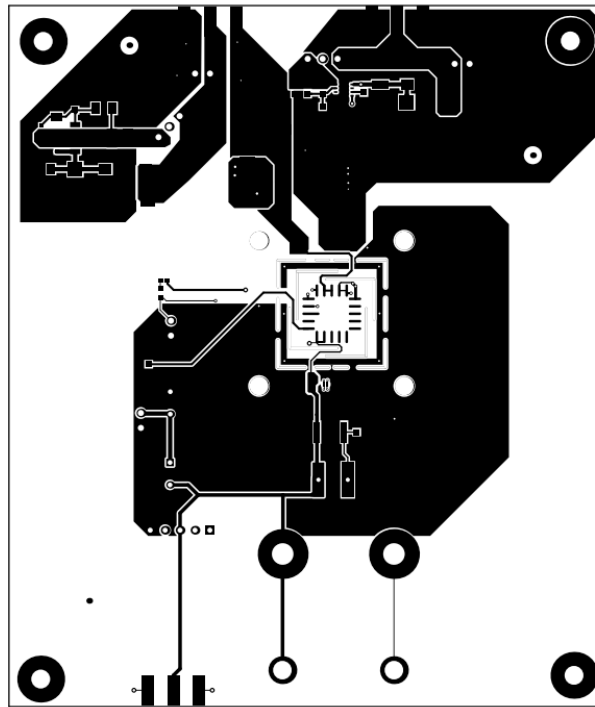


Figure 4-2. REF8EVM Top Layer

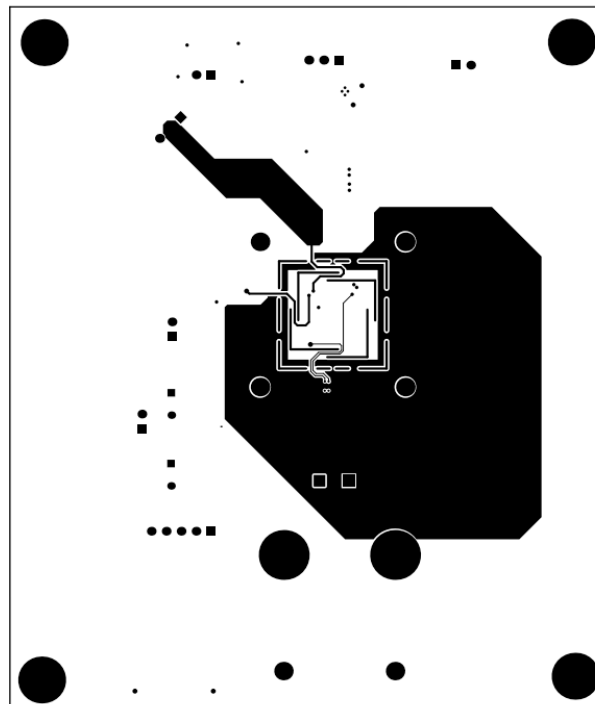


Figure 4-3. REF8EVM 2nd Layer

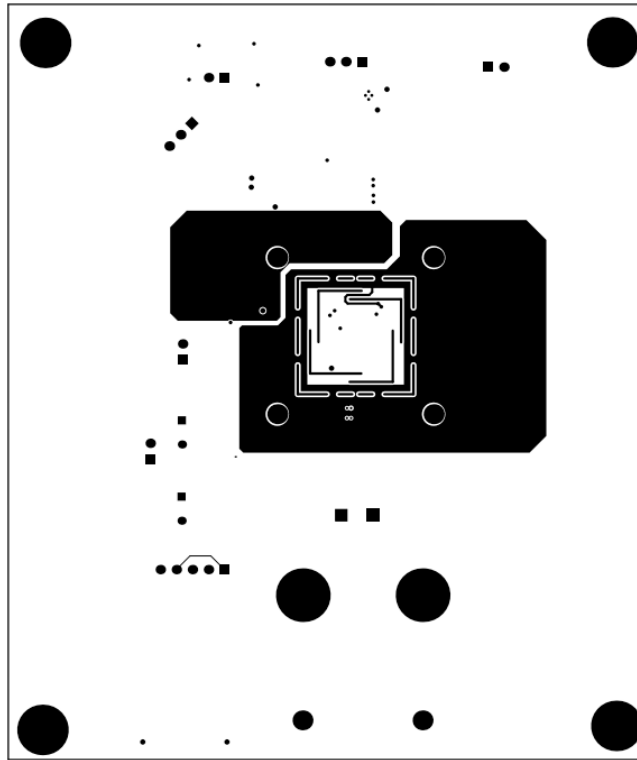


Figure 4-4. REF8EVM 3rd Layer

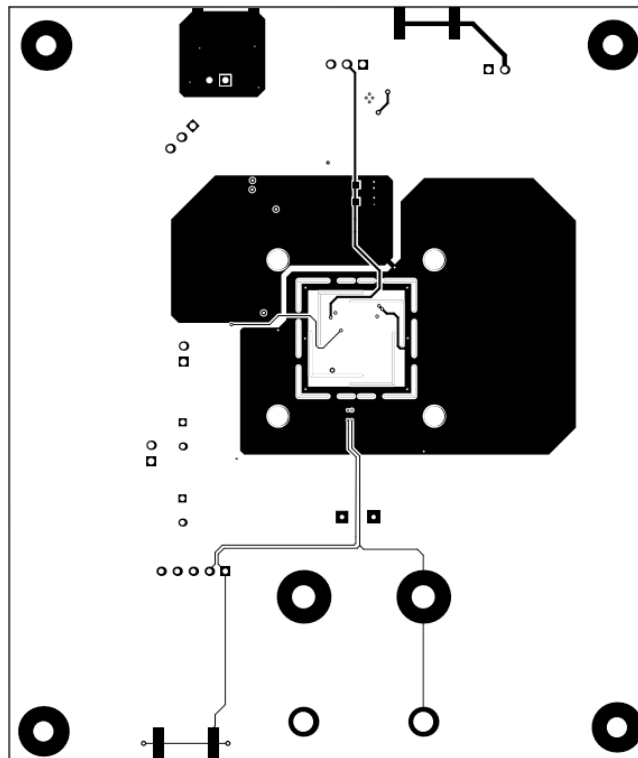


Figure 4-5. REF8EVM Bottom Layer

4.3 Bill of Materials (BOM)

Table 4-1 lists the bill of materials for REF8EVM.

Table 4-1. Bill of Materials

Designator	Qty	Description	Package Reference	Part Number	Manufacturer
C1	1	CAP CER 1UF 25V X7R 0603	0603	C1608X7R1E105K080AB	TDK Coporation
C2	1	CAP, CERM, 0.1µF, 25V,+/- 10%, X5R, 0603	0603	CL10A104KA8NNNC	Samsung Electro-Mechanics
C3	1	CAP, TA, 22uF, 50V, +/- 10%, 0.6 ohm, SMD	7361-38	TAJV226K050RNJ	AVX
C4	1	CAP, CERM, 1µF, 50V,+/- 10%, X7R, 0805	0805	CL21B105KBFNFNE	Samsung
C5, C6	2	CAP, CERM, 0.01µF, 25V,+/- 1%, COG/NP0, 0603	0603	C0603C103F3GACTU	Kemet
C7	1	10µF Film Capacitor 30V 50V Polyester, Polyethylene Terephthalate (PET), Metallized Radial	RADIAL	MKS2B051001N00JSSD	WIMA
C8	1	CAP FILM 10UF 20% 16VDC 1812	1812	16MU106MC44532	Rubycon
C9	1	CAP, CERM, 10µF, 50V,+/- 10%, X7R, 1210	1210	CL32B106KBJNNWE	Samsung Electro-Mechanics
C11, C19	2	CAP, CERM, 10µF, 25V,+/- 10%, X5R, 0603	0603	GRM188R61E106KA73D	MuRata
C13, C14, C15, C16	4	CAP, Tantalum Polymer, 47uF, 20V, +/- 20%, 0.055 ohm, 7343-20 SMD	7343-20	20TQC47MYF	Panasonic
C17, C18	2	CAP CER 1UF 50V X7R 0805	0805	CL21B105KBFNNNE	Samsung Electro-Mechanics
D1	1	LED, Amber, SMD	1.6x0.8mm	HSMA-C190	Avago
D2, D3	2	Diode, Schottky, 20V, 1A, SOD-323	SOD-323	CUS10S30,H3F	Toshiba
FL1, FL2	2	Filter LC High freq 4700PF, 2706	6.8x1.6mm	NFE61PT472C1H9L	MuRata
H1, H2, H3, H4	4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4	Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J10, J12, J18	4	Header, 100mil, 2x1, Gold, TH	Header, 2x1, 100mil	5-146261-1	TE Connectivity
J2, J3, J4	3	Connector, End launch SMA, 50 ohm, SMT	SMA End Launch	142-0701-851	Cinch Connectivity
J6, J15	2	Banana Plug Connector Standard Banana Threaded, External (Nut) -	CONNECTOR_BANANA_PLUG	72918	Pomona Electronics
J8	1	Header, 100mil, 5x1, TH	Header, 5x1, 100mil, TH	800-10-005-10-001000	Mill-Max
J17, J20	2	Header, 100mil, 3x1, Gold, TH	Header, 3x1, 2.54mm, TH	HTSW-103-09-G-S	Samtec
R1	1	RES, 1.0 k, 5%, 0.063 W, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R3	1	RES, 0.22, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3RQFR22V	Panasonic

Table 4-1. Bill of Materials (continued)

Designator	Qty	Description	Package Reference	Part Number	Manufacturer
R6	1	RES, 39.0 k, 1%, 0.1 W, 0603	0603	RC0603FR-0739KL	Yageo
R7	1	RES, 3.3 k, 5%, 0.1 W, 0603	0603	RC0603JR-073K3L	Yageo
R8	1	RES, 100, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW1206100RFKEA	Vishay-Dale
R9	1	RES, 1.1 k, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12061K10JNEA	Vishay-Dale
SH-J1, SH-J2	2	CONN JUMPER S2 (1 x 2) Position Shunt Connector Black Open Top 0.100" (2.54mm) GoldHORTING .100" GOLD	JUMPER	QPC02SXGN-RC	Sullins
U1	1	Temperature Compensated Buried Zener Reference With 0.1ppm/°C Drift and 9ppm Stability	LCCC20	REF80000A1NAJ	Texas Instruments
U2	1	3-Terminal Adjustable Regulator, 4-pin SOT-223, Pb-Free	DCY004A	LM317AEMP/NOPB	Texas Instruments
U3	1	Vin 3V to 36V, 150mA, Ultra-Low-Noise, High-PSRR Low-Dropout (LDO) Linear Regulator, DRB0008A (VSON-8)	DRB0008A	TPS7A4901DRBR	Texas Instruments
	2	Polycarbonate Spacer		PN 3124	Envision Plastics & Design
	2	Polycarbonate Cover		PN 3125	Envision Plastics & Design
	4	M3x0.5 Hex Nut 0.217" (5.51mm) Nylon		4688	Keystone Electronics
	4	M3x0.5 Pan Head Machine Screw Slotted Drive Nylon		50M030050N020	Essentra Components

5 Compliance Information

5.1 Compliance and Certifications

[REF8EVM EU Declaration of Conformity \(DoC\) for Restricting the Use of Hazardous Substances \(RoHS\)](#).

6 Additional Information

6.1 Trademarks

All trademarks are the property of their respective owners.

7 Related Documentation

The documents in [Table 7-1](#) provide information regarding Texas Instruments integrated circuits used in the assembly of the REF8EVM. This user's guide is available from the TI web site under literature number SNAU304. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions are available from the TI web site at www.ti.com, or call Evaluation Module the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

Table 7-1. Related Device Documentation

Item	Literature Number
REF80000B1NAJT product data sheet	SNAS856
TPS7A4901DRBR product data sheet	SBVS121E
LM317AEMP/NOPB product data sheet	SNVSAC2A

8 Revision History

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

Changes from Revision * (August 2024) to Revision A (October 2024)	Page
• Updated EVM Connection.....	4
• Added setup conditions to Evaluation Setup.....	7

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3 Regulatory Notices:

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/llds/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。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

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 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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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

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

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。 <https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

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.

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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.
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