User's Guide

TPS7H1111EVM-CVAL Evaluation Module (EVM)

ABSTRACT

This user's guide describes operational use of the TPS7H1111EVM-CVAL evaluation module (EVM) as a reference design for engineering demonstration and evaluation of the TPS7H1111-SP, a 1.5-A, Ultra-Low Noise, High PSRR, Radiation-Hardness-Assured RF Low Drop Out (LDO) regulator. This user's guide provides details about the EVM, its configuration, schematics, and bill of material (BOM).

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Trademarks

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1 Introduction

The TPS7H1111-SP is an ultra-low noise, high PSRR, low dropout linear regulator (LDO) optimized for powering RF (radio frequency) devices in a space environment. It is capable of sourcing up to 1.5 A over a 0.85-V to 7-V input range with a 2.2-V to 14-V bias supply.

The EVM is configured with a default output resistor to regulate to a 1.8 V V_{OUT}, with a usable V_{IN} range of (1.8 V + V_{DO}) to 7 V with V_{BIAS} range of (V_{OUT} + 1.6 V to 14 V). Worst case V_{DO} ranges from 430mV for V_{BIAS} ≥ (V_{OUT} + 1.6 V) to 1.4 V with V_{BIAS} = V_{IN} across recommended operating conditions. The EVM is intended to aid engineers in the evaluation of the operation and performance of the TPS7H1111-SP linear regulator. The TPS7H1111-SP low-dropout regulator allows input voltages from 0.85 V to 7 V and is capable of regulating any output voltage between 0.4 V and up to 5.5 V by changing the V_{OUT} current setting resistor R8. The EVM is capable of delivering up to 1.5 A to a load. Achieving the maximum load depends on multiple variables, including the input-output power dissipation, board thermal dissipation, and heat removal.

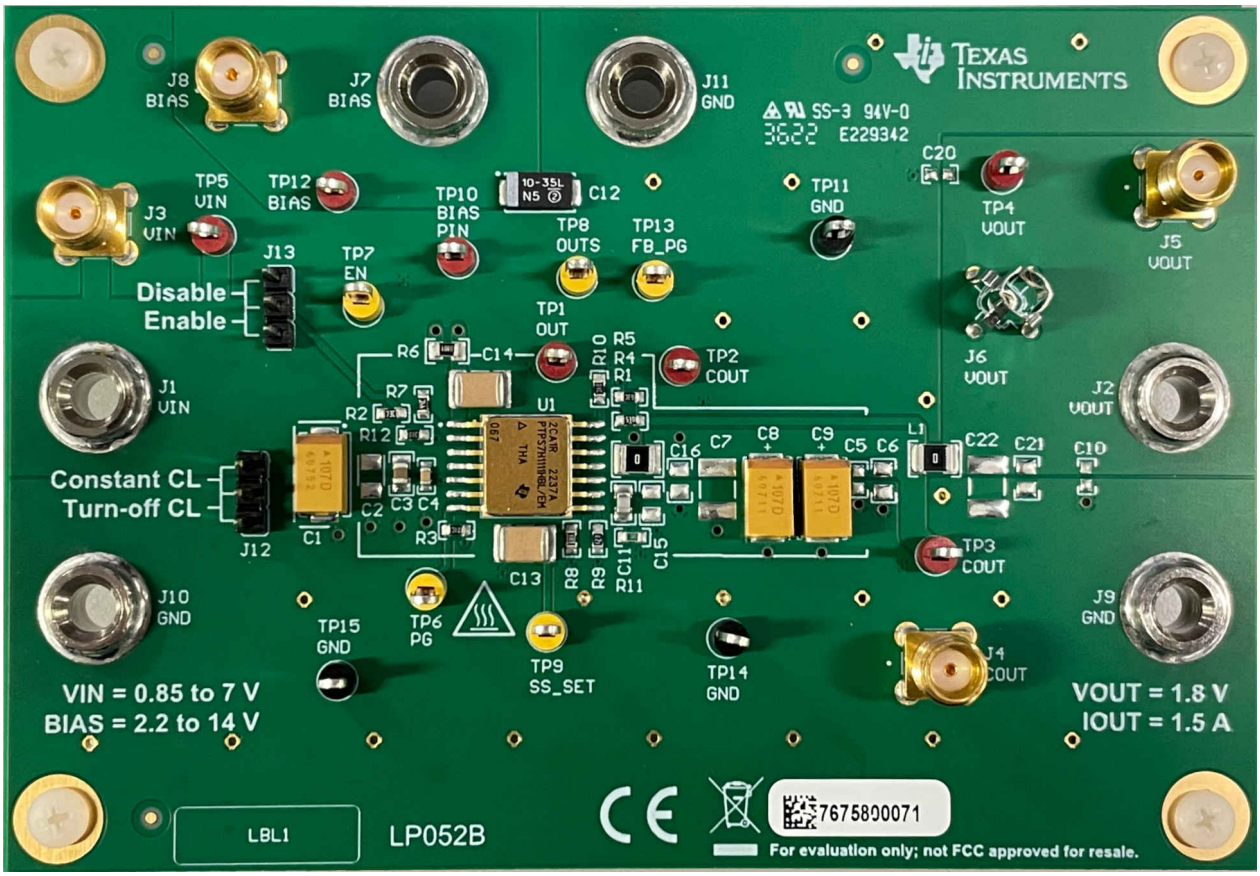


Figure 1-1. TPS7H1111EVM-CVAL (LP052B)

1.1 Related Information

- TPS7H1111-SP data sheet (SLVSFT8)

1.2 Features

- Radiation Performance
  - Radiation hardness assurance (RHA) up to a total ionizing dose (TID) of 100 krad(Si)
  - Single-event latchup (SEL), single-event burnout (SEB), and single-event gate rupture (SEGR) immune to linear energy transfer (LET) = 75 MeV-cm^2/mg
  - Single-event functional interrupt (SEFI) and single-event transient (SET) characterized to LET = 75 MeV-cm^2/mg

  Ultra-Low Noise: 1.71 μV_{RMS} (typ), 10 Hz - 100 kHz
- High power-supply rejection ratio, PSRR (typ):
  - 109 dB at 100 Hz
  - 71 dB at 100 kHz
  - 66 dB at 1 MHz
- Input voltage range from 0.85 V to 7 V
- Bias supply of 2.2 V to 14 V to minimize power dissipation
- Output voltage as low as 0.4 V
- Up to 1.5-A output current
- Excellent output accuracy over line and load:
  - +1.1% / –1.3% across temperature
  - +0.9% / -0.7% at 25°C
- Low-dropout: 215 mV (typ) at 1.5 A
- Programmable soft start control (SS_SET)
- Open-drain power good (PG) indicator
- Configurable power good threshold (FB_PG)
- Exposed control loop with the external compensation STAB pin
- Internal current limit with configurable behavior
- Capable of current sharing to enable higher currents

1.3 Applications

- Satellite electrical power system (EPS)
- Power for high-speed and high-accuracy analog circuits
  - Data Converters: ADCs and DACs (analog-to-digital and digital-to-analog converters)
  - VCOs (voltage controlled oscillators)
  - PLLs (phase-lock-loops)
  - SerDes (serializer and deserializers)
  - Imaging sensors
- Accurate supply for FPGAs (field programmable gate arrays) and DSPs (digital signal processors)
- Radiation-hardened ultra-clean analog supply for space constrained areas

2 Setup

This section describes the jumpers and connectors on the EVM as well as how to properly connect, set up, and use the TPS7H1111EVM-CVAL.

2.1 Input/Output Connectors and Jumper Descriptions

2.1.1 Jumpers

Table 2-1 contains the list of jumpers and descriptions of their function(s).

Table 2-1. Jumpers

Schematic Reference	Description
J1	V_{IN} Input power banana jack. 0.85 to 7 V.
J2	V_{OUT} Output regulated power banana jack. As configured V_{OUT} = 1.8 V.
J3	GND for V_{IN} banana jack.
J4	V_{COUT} Output regulated power SMA.
J5	V_{OUT} Output regulated power SMA.
J6	V_{OUT} Output regulated power cold nose probe connector.
J7	V_{BIAS} Bias input power banana jack. 2.2 to 14 V.
J8	V_{BIAS} Bias input power SMA.
J9	GND for V_{OUT} banana jack.
J10	GND for V_{IN} banana jack.
J11	GND for V_{BIAS} banana jack.
J12	Three pin current limit mode jumper selector. Selects "Constant current" or "Turn-off" current limit mode.
J13	Three pin enable/disable jumper selector. Pulls EN signal to V_{IN} "enable" or GND "disable". No jumper will enable LDO based on V_{IN} R2/R7 divider reaching 600mV enable threshold.

2.1.2 Test Points

Table 2-2 contains the list of test point and descriptions of their function(s).

Table 2-2. Test Points

Schematic Reference	Description
TP1	V_{OUT} Test point. This test point is prior to 0 Ω R1, and directly connected to OUT pins of LDO.
TP2, TP3	V_{COUT} Test points. These test points are after the 0 Ω R1. They are on the COUT plane. TP2 is used for Bode signal injection along with TP8.
TP4	V_{OUT} Test point. This test point is after L1 (populated with 0 Ω) in the output path. This testpoint is outside the feedback loop.
TP5	V_{IN} Test point.
TP6	PG power good test point.
TP7	EN enable test point.
TP8	Feedback OUTS test point. Used for Bode signal injection along with TP2.
TP9	SS_SET test point. This node defines V_{OUT} regulation, and soft start.
TP10	Bias test point, located on device side of the bias filter defined by R6 and C14.
TP11	GND test point.
TP12	Bias test point, located on source side of the bias filter defined by R6 and C14.
TP13	FB_PG test point.
TP14, TP15	GND test points.

2.2 Equipment Setup

The following procedure guides the setup and testing of the TPS7H1111EVM-CVAL.

The following equipment is required for this testing:

1. Power supply PS1 capable of up to 7 V and 1.5 A for suppling V_{IN}.
   - If testing current limit functionality, PS1 should be capable of 3 A.
2. Power supply PS2 capable of up to 14 V and 100 mA.
3. Eload or resistive load capable of > 1.5 A (or desired test load).
4. Voltage meter and/or oscilloscope for monitoring V_{OUT}.

The following procedure describes the connectivity, supplies, and load setup:

1. With PS1 disabled, setup with 2.5 V, and 1.5 A current limit.
2. Connect PS1 positive supply with banana cable to V_{IN} + jumper J1.
3. Connect PS1 negative supply with banana cable to V_{IN} GND jumper J10.
   - Alternately, V_{IN} can be supplied with SMA J3. Observe current ratings of SMA cable.
4. With PS2 disabled, setup with 5 V, and 100 mA current limit.
5. Connect PS2 positive supply with banana cable to V_{BIAS} + jumper J7.
6. Connect PS2 negative supply with banana cable to V_{BIAS} GND jumper J11.
   - Alternately, V_{BIAS} can be supplied with SMA J8.
7. Connect oscilloscope to SMA jack J5 if desired to monitor V_{OUT}.
   - Alternatively, the cold nose connector J6 or TP4 may be used for V_{OUT} monitoring.
8. Connect voltage meter to V_{OUT} using TP4, J6, J5, or J2 if needed.
9. Connect desired (≤1.5 A) load between the V_{OUT} connector J2, and the GND at connector J9.

Note

Large $V_{IN} – V_{OUT}$ differentials can lead to excessive internal power dissipation when operating at higher I_{LOAD} currents. Internal power dissipation power can be estimated with $V_{IN} – V_{OUT} \times I_{LOAD}$. See SLVSFT8 for more information on power calculations

3 Operation

1. Set jumper J13 to the enable position.
   - J13 can also be left open, as a resistor divider is used with V_{IN} to pull the enable pin up. Enable threshold is ~600mV. Resistor divider R2/R7 can be changed to achieve different turn on voltages for V_{IN}. By default, device will be enabled when V_{IN} > ~1.8 V for default EVM. It can also be digitally controlled from a host through J13.
2. Enable PS1, and PS2. Sequence is not important.
3. V_{OUT} should now read ~1.8 V.
   - V_{OUT} at load will likely be lower than 1.8 V when load applied. The OUTS connection for feedback regulation is located on the C_{OUT} plane closer to U1.
4. PG output (TP6) should also now be pulled up to V_{OUT} and read 1.8 V.
5. Vary the load as necessary for test purposes.

4 Adjustable Operation

The nominal output voltage for the TPS7H1111-SP is configured using equation $V_{SS\_SET} = V_{OUT} = I_{SET} \times R_{SET}$. Therefore, $R_{SET} = V_{SS\_SET} / I_{SET} = 1.8\ V / 100\ \mu A = 18\ k\Omega$. I_{SET} is determined by R_{REF}, and is designed to be 100 uA using a precision 12 kΩ resistor. See Figure 4-1 for block diagram. See Figure 7-1 for R_{SET} (R8), and R_{REF} (R9) connectivity. See SLVSFT8 for more detailed information.

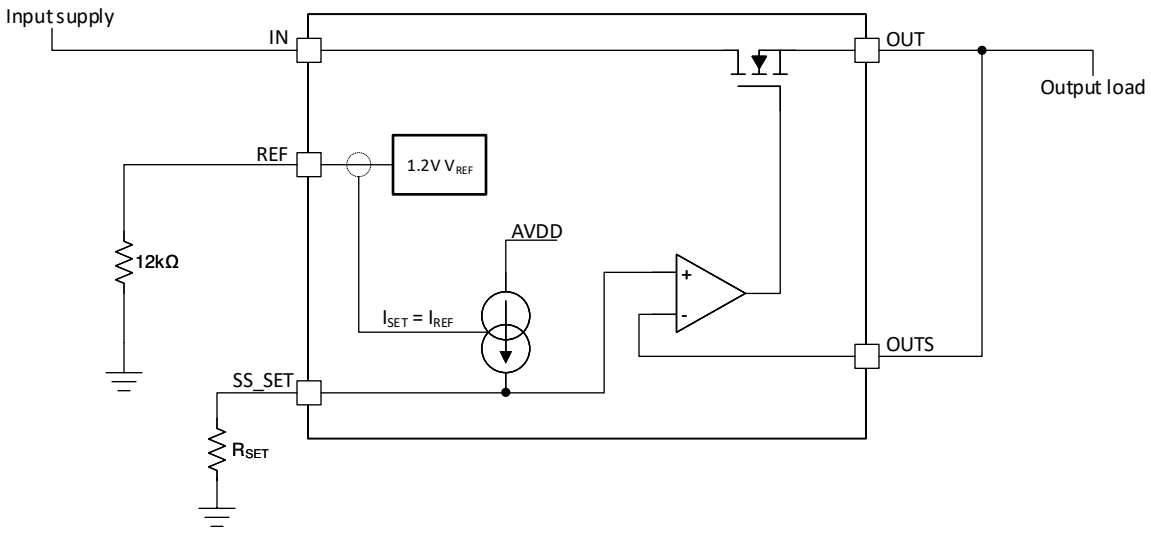


Figure 4-1. Simplified Schematic to Configure Output Voltage

It is also important to note that the TPS7H1111-SP utilizes an adjustable power good PG output threshold FB_PG. When changing the output voltage, a suitable voltage divider needs to be set on the FB_PG pin in order for the LDO to assert PG when appropriate threshold achieved. Additionally when PG is asserted, this turns off internal fast charge circuit that is part of the soft start. Thus, setting appropriate divider is important for proper startup. See SLVSFT8 for more detailed information.

5 Test Results

This section provides typical performance waveforms for the TPS7H1111EVM-CVAL with respect to stability, Noise Spectral Density (NSD), and PSRR. All performance data show is utilizing the the standard configuration of the EVM. The standard configuration is based on the following conditions: Vin = 2.5 V, Vbias = 5 V, and Vout = 1.8 V

Note

The datasheet for the TPS7H1111-SP LDO contains a wide assortment of additional performance data under various input and output conditions. See SLVSFT8

5.1 Enable and Soft Start Timing

Figure 5-1 shows the enable and soft start characteristic where V_{IN} is 2.5 V, V_{BIAS} is 5 V, EN is toggled from ground to ~800 mV while the output drives a ~1.5 A resistive load. The waveforms for EN, V_{OUT}, SS_SET, and IOUT are shown for reference. C_{SS} of 4.7uF results in a soft start time of approximately 3.7 ms.

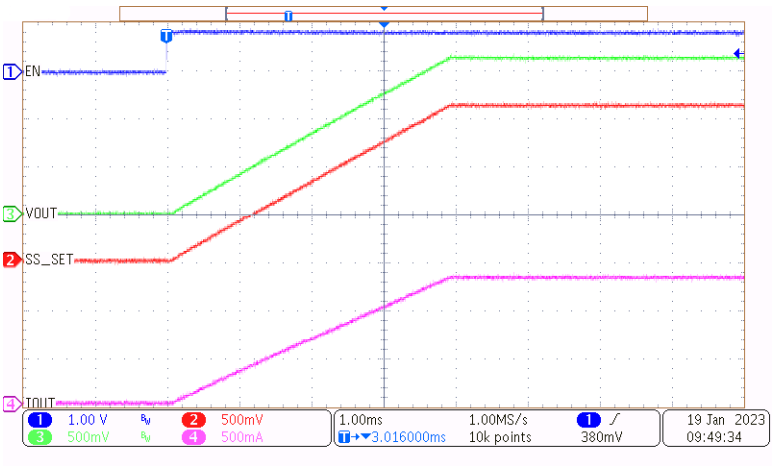


Figure 5-1. TPS7H1111 enable and soft start timing

5.2 PSRR

Figure 5-2 shows the typical PSRR performance of the TPS7H1111EVM-CVAL at various I_{OUT} loads under the following conditions: V_{IN} = 2.5 V, V_{BIAS} = 5 V, V_{OUT} = 1.8 V, C_{IN} removed.

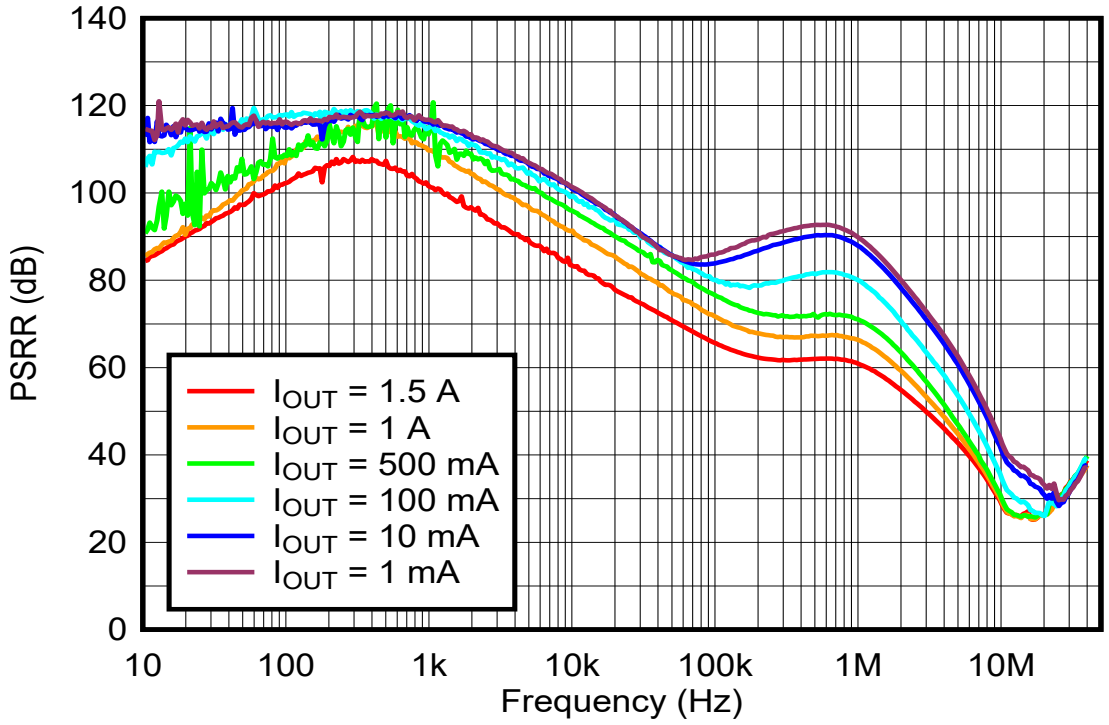


Figure 5-2. TPS7H1111EVM-CVAL PSRR vs I_{OUT}

Measuring ultra high PSRR on a device can be challenging. To obtain adequate results, the output of the LDO is fed to a wideband amplifier with approximately 50 dB of gain. Amplifying the output effectively lowers the noise floor of the measuring instrument. Once results are obtained, the gain curve of the amplifier in dBs is added to the results across the frequency span.

The injected signal on V_{IN} was -10 dBm into a 50 Ω load. This results in a 200 mV pk-pk signal. Additionally a small variable amount of injected signal attenuation was used starting at 100 kHz to minimize signal distortion at higher frequencies. Final injected signal power used was -17 dBm at approximatly 2 MHz.

5.3 Stability

Figure 5-3 shows the typical Bode gain and phase plot versus frequency for minimum no load, and maximum load of 1.5 A. Stability tests performed with the TPS7H1111EVM-CVAL operating with the following conditions: V_{IN} = 2.5 V, V_{BIAS} = 5 V, V_{OUT} = 1.8 V.

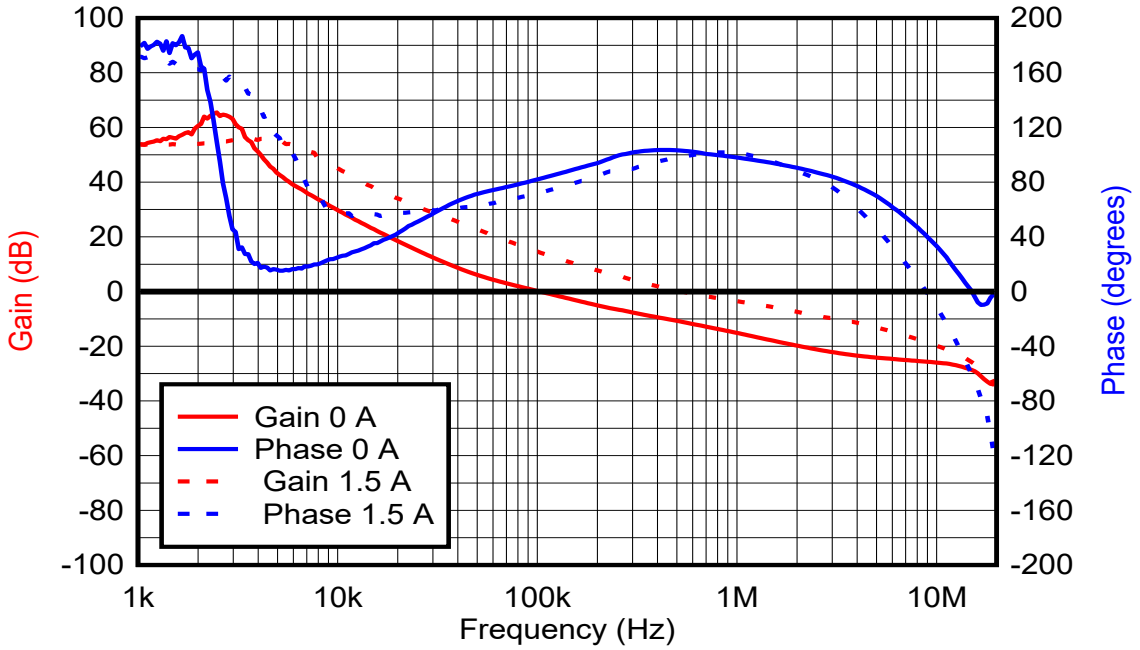


Figure 5-3. TPS7H1111EVM-CVAL Gain and Phase vs. Frequency (Bode Plot)

Measuring accurate Bode response with a high bandwidth high gain LDO required using a very small injected signal. The signal injected used a shape for injected level with an injected signal reference level of -7 dBm. This reference level was reduced to -27 dBm from 10 kHz to 200 kHz. Additionally, the entire injected signal was externally attenuated with an inline attenuator by 26 dB. This was required to prevent overdriving the signal into feedback loop and keeping response within small signal behavior.

5.4 Noise Spectral Density

Figure 5-4 shows the typical Noise Spectral Density (NSD) performance of the TPS7H1111EVM-CVAL operating with the following conditions: V_{IN} = 2.5 V, V_{BIAS} = 5 V, V_{OUT} = 1.8 V. The plot also shows the integrated 10 Hz to 100 kHz RMS noise for the various output loads.

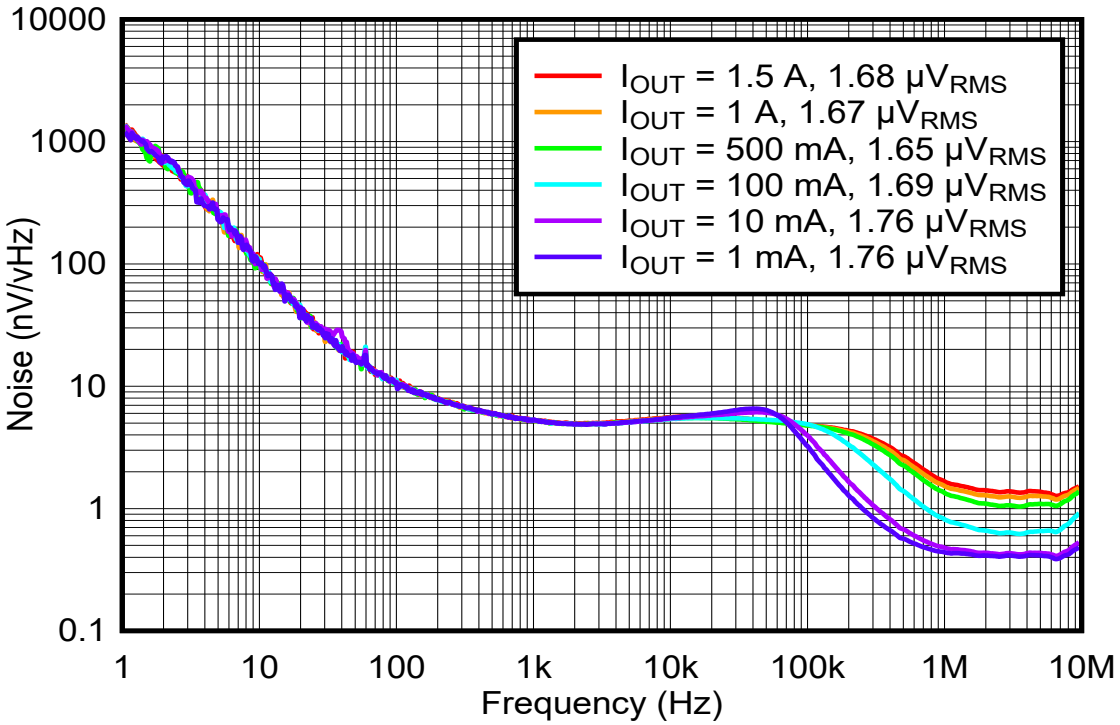
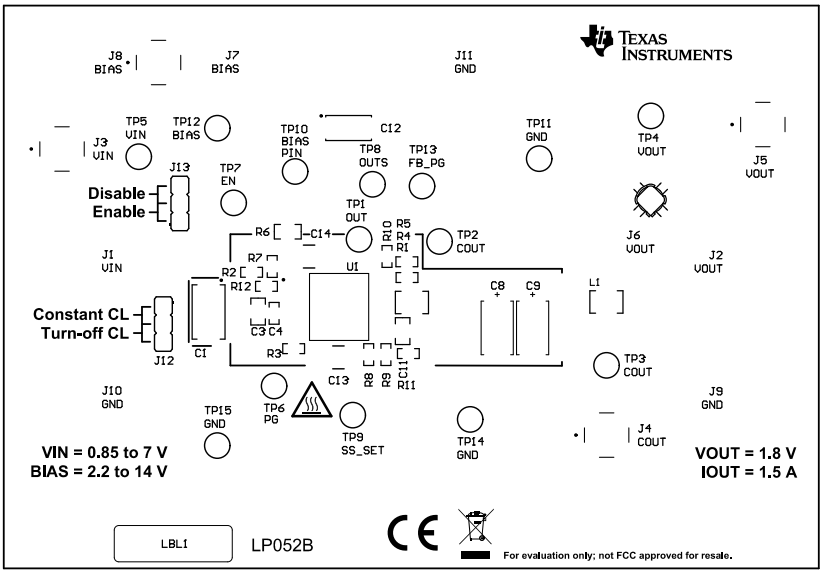


Figure 5-4. Output Noise vs. Frequency across Output Current (Noise Spectral Density)

6 Board Layout

The following images represent the board design layers.



ALL ARTWORK VIEWED FROM TOP SIDE	BOARD #: LP052	REV: B	SUN REV: Not in version control
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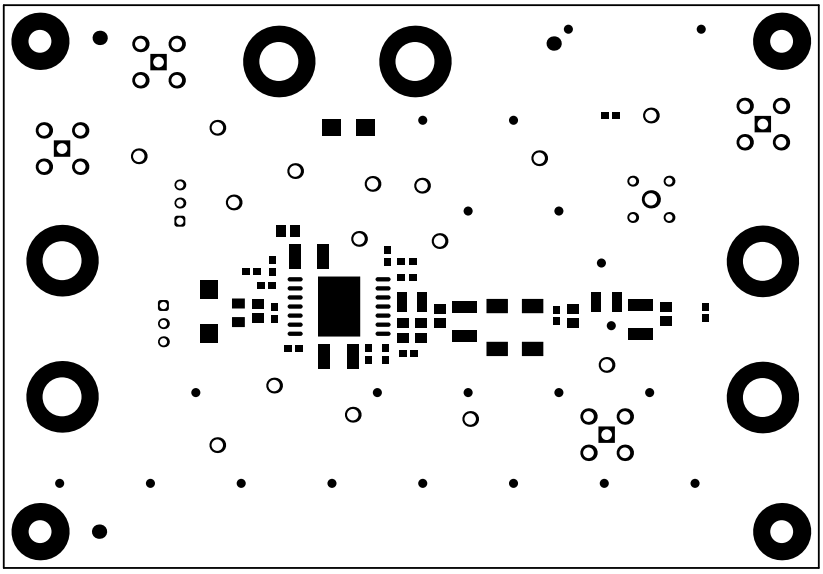
PLOT NAME = Top Overlay	GENERATED : 8/24/2022 12:55:15 PM		TEXAS INSTRUMENTS

Figure 6-1. Top Overlay Silkscreen



ALL ARTWORK VIEWED FROM TOP SIDE	BOARD #: LP052	REV: B	SUN REV: Not in version control
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PLOT NAME = Top Solder Mask	GENERATED : 8/24/2022 12:55:15 PM		TEXAS INSTRUMENTS

Figure 6-2. Top Solder Mask

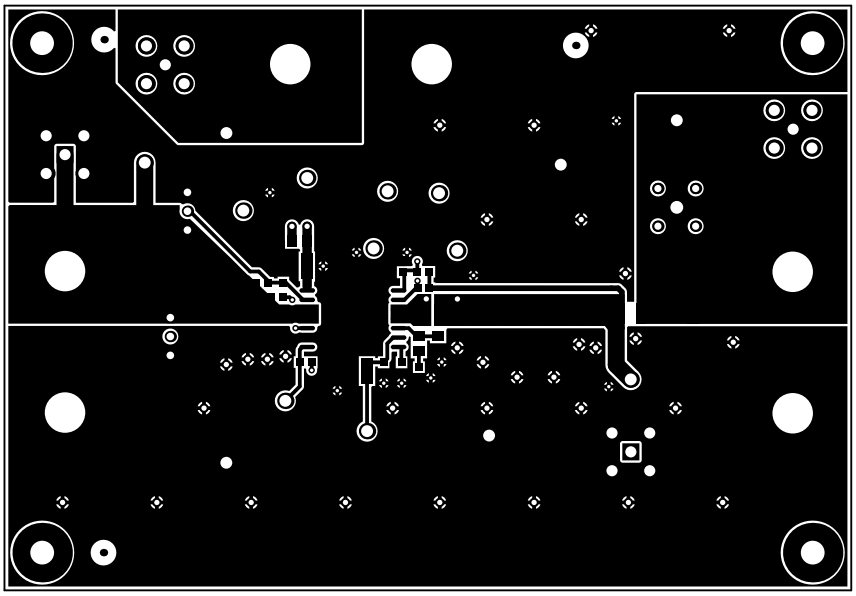

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Figure 6-3. Top Signal Layer

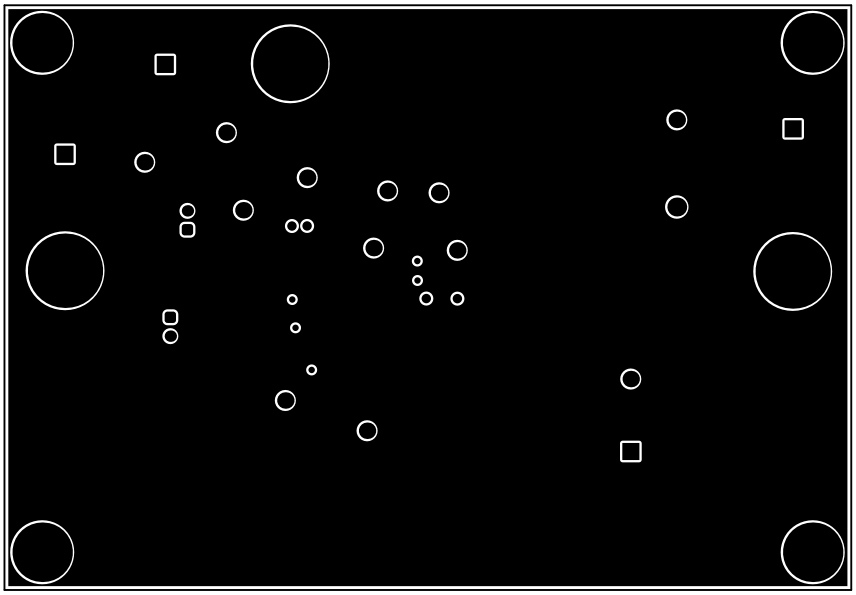

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Figure 6-4. Signal 1 Layer

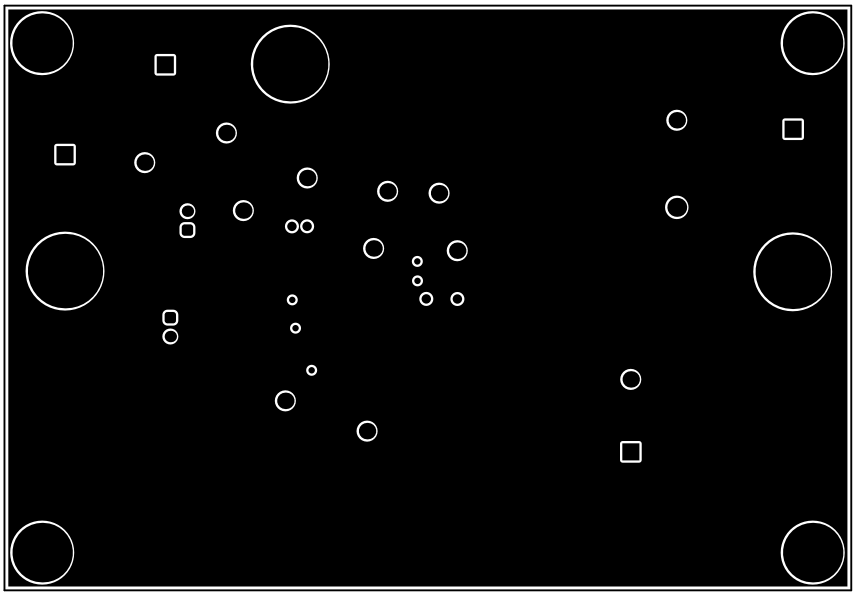

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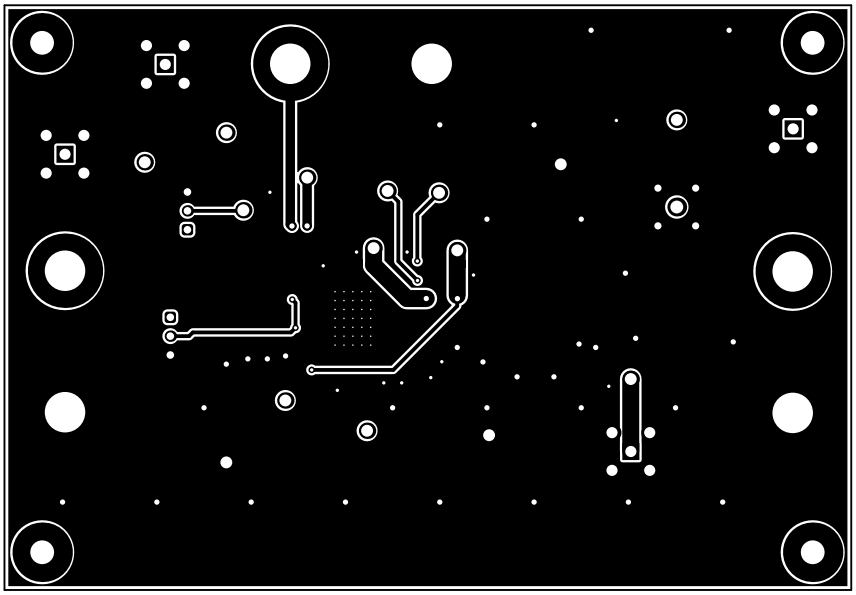
Figure 6-5. Signal 2 Layer



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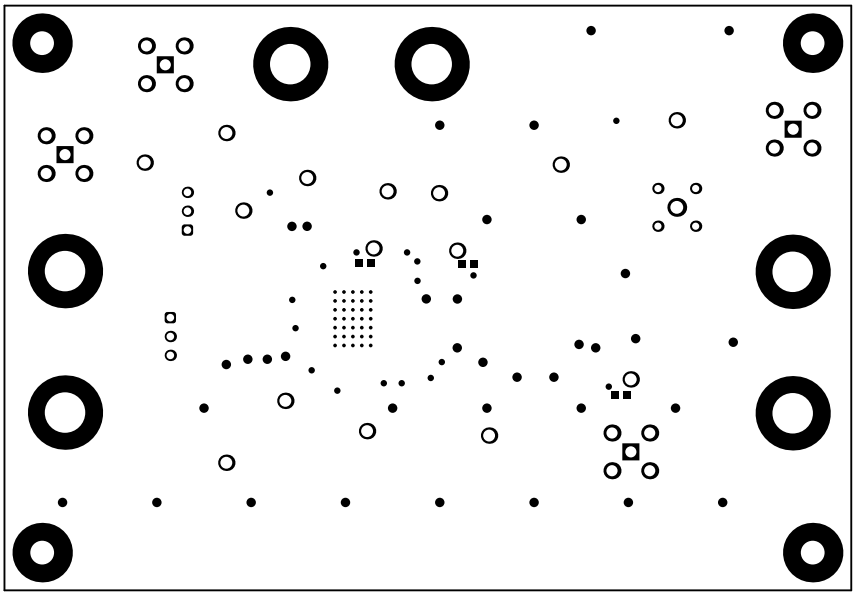
PLOT NAME = Bottom Layer	GENERATED : 8/24/2022 12:55:17 PM		TEXAS INSTRUMENTS

Figure 6-6. Bottom Signal Layer



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PLOT NAME = Bottom Solder Mask	GENERATED : 8/24/2022 12:55:17 PM		TEXAS INSTRUMENTS

Figure 6-7. Bottom Solder Layer

7 Schematic

TPS7H1111-SP EVM - Schematic

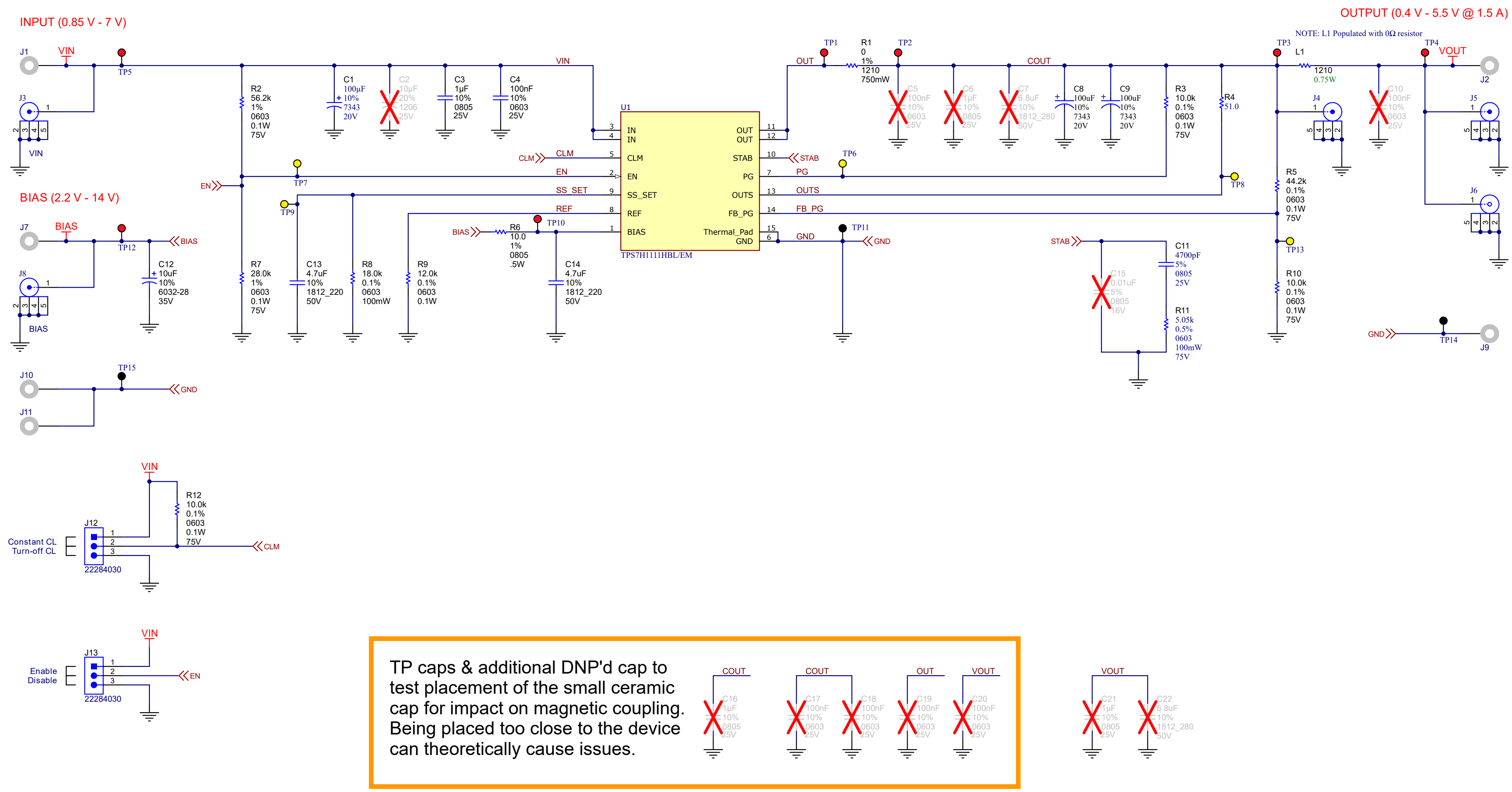

Figure 7-1. TPS7H1111EVM-CVAL (LP052B) Schematic

8 Bill of Materials

Table 8-1. Bill of Materials

Designator	Qty	Description	Part Number	Manufacturer
C1	1	Capacitor, tantalum, 100 µF, 20 V, ±10%, 0.4 Ω, AEC-Q200 Grade 1, SMD, 7343-43	TAJE107K020TNJV	AVX
C3	1	Capacitor, ceramic, 1 µF, 25 V, ±10%, X7R, 0805	TMK212B7105KG-T	Taiyo Yuden
C4	1	Capacitor, ceramic, 0.1 µF, 25 V, ±10%, X7R, 0603	8.85012E+11	Wurth Elektronik
C8, C9	2	Capacitor, tantalum Solid 100 µF 20 V E CASE 10% (7.3 x 4.3 x 4.1mm) SMD 7343-43 0.035 Ohm 125°C Bulk, 2917	TBME107K020LBLC9945	KYOCERA AVX, (alt TRME107K020R0035)
C11	1	Capacitor, ceramic, 4700 pF, 25 V, ±5%, C0G/NP0, 0805	08053A472JAT2A	AVX
C12	1	Capacitor, tantalum, 10 µF, 35 V, ±10%, 1.6 Ω, SMD, 6032-28	293D106X9035C2TE3	Vishay-Sprague
C13, C14	2	Capacitor, ceramic, 4.7 µF, 50 V, ±10%, X7R, AEC-Q200 Grade 1,	CGA8M3X7R1H475K200KB	TDK
J1, J2, J7, J9, J10, J11	6	Standard banana jack, uninsulated, 5.5 mm	575-4	Keystone
J3, J4, J5, J8	4	SMA Connector Receptacle, Female Socket 50 Ω Through Hole Solder, PTH_RF_CONN	733910060	Molex
J6	1	Compact Probe Tip Circuit Board Test Points, TH, 25 per, TH Scope Probe	131-5031-00	Tektronix
J12, J13	2	Header, 2.54 mm, 3x1, tin, TH	22284030	Molex
L1, R1	2	Resistor, 0 Ω, 1%, 0.75 W, AEC-Q200 Grade 0, 1210	CRCW12100000Z0EAHP	Vishay-Dale
R2	1	Resistor, 56.2 kΩ, 1%, 0.1 W, 0603	RC0603FR-0756K2L	Yageo
R3, R10, R12	3	Resistor, 10.0 kΩ, 0.1%, 0.1 W, 0603	RT0603BRD0710KL	Yageo America
R4	1	Resistor, 51.0 Ω, 1%, 0.1 W, 0603	RC0603FR-0751RL	Yageo
R5	1	Resistor, 44.2 kΩ, 0.1%, 0.1 W, 0603	RT0603BRD0744K2L	Yageo America
R6	1	Resistor, 10.0 Ω, 1%, .5 W, AEC-Q200 Grade 0, 0805	ERJ-P6WF10R0V	Panasonic
R7	1	Resistor, 28.0 kΩ, 1%, 0.1 W, 0603	RC0603FR-0728KL	Yageo
R8	1	Resistor, 18.0 kΩ, 0.1%, 0.1 W, 0603	RT0603BRD0718KL	Yageo America
R9	1	Resistor, 12.0 kΩ, 0.1%, 0.1 W, 0603	RT0603BRD0712KL	Yageo America
R11	1	Resistor, 5.05 kΩ, 0.5%, 0.1 W, 0603	RT0603DRE075K05L	Yageo America
TP1, TP2, TP3, TP4, TP5, TP10, TP12	7	Test point, multipurpose, red, TH	5010	Keystone Electronics
TP6, TP7, TP8, TP9, TP13	5	Test point, multipurpose, yellow, TH	5014	Keystone Electronics
TP11, TP14, TP15	3	Test point, multipurpose, black, TH	5011	Keystone Electronics
U1	1	1.5-A, Ultra-Low Noise, High PSRR, RHA, RF LDO CFP14	TPS7H1111HBL/EM	Texas Instruments
C2	0	Capacitor, tantalum polymer, 10 µF, 25 V, ± 20%, 0.15 Ω, 3216-18 SMD	TCJA106M025R0150	AVX
C5, C10, C17, C18, C19, C20	0	Capacitor, ceramic, 0.1 µF, 25 V, ±10%, X7R, 0603	C1608X7R1E104K080AA	TDK
C6, C16, C21	0	Capacitor, ceramic, 1 µF, 25 V, ±10%, X7R, 0805	TMK212B7105KG-T	Taiyo Yuden
C7, C22	0	Capacitor, ceramic, 6.8 µF, 50 V, ± 10%, X7R, AEC-Q200 Grade 1,	CGA8P3X7R1H685K250KB	TDK
C15	0	Capacitor, ceramic, 0.01 µF, 16 V, ±5%, C0G/NP0, 0805	B37947K9103J62	TDK

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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2 *Limited Warranty and Related Remedies/Disclaimers*:

   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits 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 shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

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/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。

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

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/lsds/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.

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.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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

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