

Using the TPS56121EVM-601

User's Guide



Literature Number: SLVU445B
March 2011–Revised February 2012

4.5-V to 14-V Input High-Current Synchronous Buck Converter

1 Introduction

The TPS56121EVM-601 evaluation module (EVM) is a synchronous buck converter providing a fixed 1.0-V output at up to 15 A from a 12-V input bus. The EVM is designed to start up from a single supply; so, no additional bias voltage is required for start up. The module uses the TPS56121 High-Current Synchronous Buck Converter with integrated MOSFETs.

The TPS56121 integrates TI's high performance controller technology with TI's industry leading MOSFET technology in a standard QFN package to meet the demands of modern, high-current, and space constrained applications.

2 Description

TPS56121EVM-601 is designed to use a regulated 12-V (8-V to 14-V) bus voltage to provide a regulated 1.0-V output at up to 15 A of load current. TPS56121EVM-601 is designed to demonstrate the TPS56121 high-current integrated FET converter in a typical space-limited, 12-V bus to low-voltage point-of-load application.

2.1 Applications

- High-Current, Low-Voltage FPGA or Micro Controller Core Supplies
- High-Current Point-of-Load Modules
- Telecommunications Equipment
- Computer Peripherals

2.2 Features

- 8-V to 14-V Input Voltage Rating
- 1.0-V $\pm 2\%$ Output Voltage Rating
- 15-A Steady-State Load Current
- 500-kHz Switching Frequency
- Simple Access to Power Good, Enable/Soft-Start and Error Amplifier
- Convenient Converter Performance Test Points

3 Electrical Performance Specifications

Table 1. TPS56121EVM-601 Electrical Performance Specifications

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Input Characteristics						
V_{IN}	Input voltage		8	12	14	V
I_{IN}	Input current	$V_{IN} = 12\text{ V}$, $I_{OUT} = 15\text{ A}$		1.40		A
	No load input current	$V_{IN} = 12\text{ V}$, $I_{OUT} = 0\text{ A}$		43		mA
V_{IN_UVLO}	Input UVLO	$I_{OUT} = 15\text{ A}$		4.2		V
Output Characteristic						
V_{OUT}	Output voltage	$V_{IN} = 8\text{ V to }14\text{ V}$, $I_{OUT} = 0\text{ A to }15\text{ A}$	0.98	1.0	1.02	V
	Line regulation	$V_{IN} = 8\text{ V to }14\text{ V}$, $I_{OUT} = 15\text{ A}$		0.1%		
	Load regulation	$V_{IN} = 12\text{ V}$, $I_{OUT} = 0\text{ A to }15\text{ A}$		0.5%		
V_{RIPPLE}	Output voltage ripple	$V_{IN} = 12\text{ V}$, $I_{OUT} = 15\text{ A}$		20		mV _{PP}
I_{OUT}	Output current	$V_{IN} = 8\text{ V to }14\text{ V}$	0		15	A
Systems Characteristics						
f_{SW}	Switching frequency		450	500	550	kHz
η_{pk}	Peak efficiency	$V_{IN} = 12\text{ V}$, $I_{OUT} = 13\text{ A}$		90.5%		
η	Full-load efficiency	$V_{IN} = 12\text{ V}$, $I_{OUT} = 15\text{ A}$		90.4%		
	Operating temperature			25		°C

4 Schematic

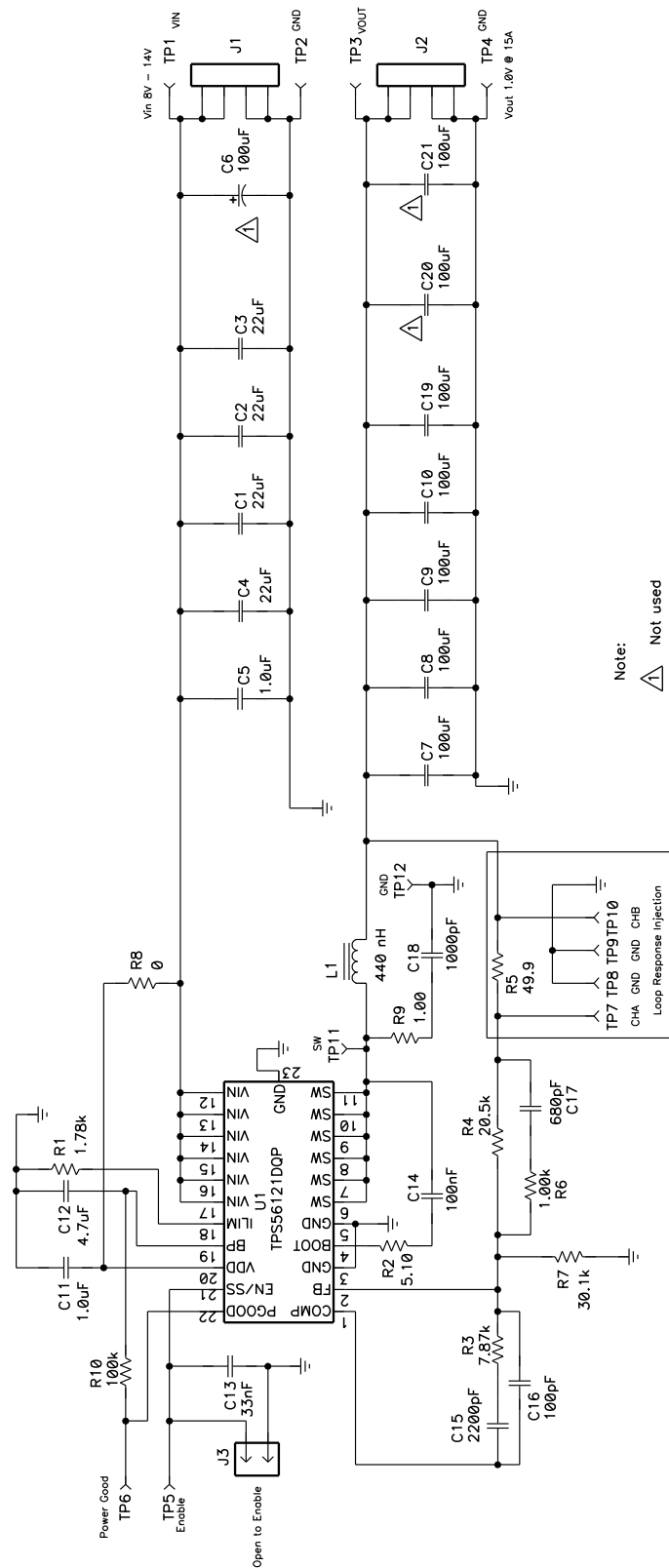


Figure 1. TPS56121EVM-601 Schematic

5 Test Setup

5.1 Test Equipment

5.1.1 Voltage Source

VIN: The input voltage source (V_{IN}) shall be a 0-V to 15-V variable DC source capable of supplying 2.5 A_{DC} .

5.1.2 Meters

- **A1:** Input current meter (0 A_{DC} to 2.5 A_{DC}).
- **V1:** Input voltage meter (0 V to 15 V).
- **V2:** Output voltage meter (0 V to 2 V).

5.1.3 Load

LOAD: Output load. Electronic load set for constant current or constant resistance mode, capable of 0 A_{DC} to 15 A_{DC} at 1.0 V_{DC} .

5.1.4 Oscilloscope

For Output Voltage Ripple: Oscilloscope shall be an analog or digital oscilloscope set for AC coupled measurement with 20-MHz bandwidth limiting. Use 20-mV/div vertical resolution, 1.0- μ s/div horizontal resolution.

For Switching Waveforms: Oscilloscope shall be an analog or digital Oscilloscope set for DC coupled measurement with 20-MHz bandwidth limiting. Use 2-V/div or 5-V/div vertical resolution and 1.0- μ s/division horizontal resolution.

5.1.5 Fan

The TPS56121EVM-601 Evaluation Module includes components that can get hot to touch when operating. Because this evaluation module is not enclosed to allow probing of circuit nodes, a small fan capable of 200 lfm to 400 lfm is recommended to reduce component temperatures when operating.

5.2 Recommended Wire Gauge

5.2.1 VIN to J1

The connection between the source voltage (V_{IN}) and J1 of TPS56121EVM-601 can carry as much as 2.5 A_{DC} of current. The minimum recommended wire size is AWG #16 with the total length of wire less than 2 feet (1 foot input, 1 foot return)

5.2.2 J2 to LOAD

The connection between the LOAD and J2 of TPS56121EVM-601 can carry as much as 15 A_{DC} of current. The minimum recommended wire size is 2xAWG #14 with the total length of wire less than 2 feet (1 foot input, 1 foot return).

5.3 Equipment Set Up Procedure

Figure 2 is the recommended test setup to evaluate the TPS56121EVM-601.

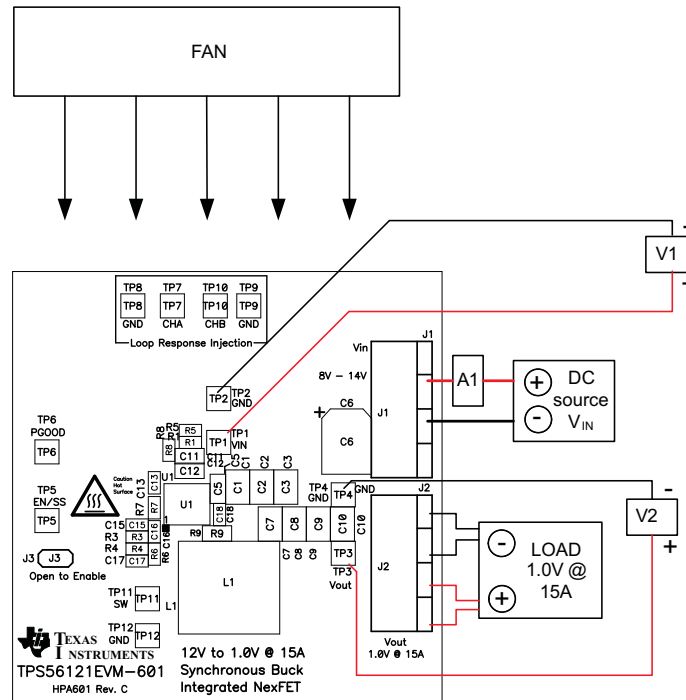


Figure 2. TPS56121EVM-601 Recommended Test Setup

1. Working at an ESD workstation, make sure that any wrist straps, bootstraps and mats are connected referencing the user to earth ground before power is applied to the EVM. Wearing electrostatic smock and safety glasses is also recommended.
2. Prior to connecting the DC input source, VIN, it is advisable to limit the source current from VIN to 3.0 A maximum. Make sure VIN is initially set to 0 V and connected as shown in Figure 2.
3. Connect VIN to J1 as shown in Figure 2.
4. Connect ammeter A1 between VIN and J1 as shown in Figure 2.
5. Connect voltmeter V1 to TP1 and TP2 as shown in Figure 2.
6. Connect voltmeter V2 to TP3 and TP4 as shown in Figure 2.
7. Place the fan as shown in Figure 2 and turn it on, ensuring that the air blows directly across the evaluation module.

6 Configurations

6.1 Enable Selection (J3)

The converter can be enabled and disabled by J3. Shorting J3 discharges the soft-start capacitor and disables the TPS56121 converter. Opening J3 enables the TPS56121 converter.

Default setting: short to disable the converter.

7 Test Point Descriptions

Table 2. Test Point Descriptions

TEST POINT	LABEL	DESCRIPTION
TP1	VIN	Measurement test point for input voltage
TP2	GND	Ground test point for input voltage
TP3	VOUT	Measurement test point for output voltage
TP4	GND	Ground test point for output voltage
TP5	EN/SS	Measurement test point for enable/soft-start
TP6	PGOOD	Measurement test point for power good
TP7	CHA	Measurement test point for channel A of loop response
TP8	SGND	Ground test point for channel A of loop response
TP9	SGND	Ground test point for channel B of loop response
TP10	CHB	Measurement test point for channel B of loop response
TP11	SW	Measurement test point for switch node voltage
TP12	GND	Ground test point for switch node voltage

7.1 Input Voltage Monitoring (TP1 and TP2)

TPS56121EVM-601 provides two test points for measuring the input voltage applied to the module. This allows the user to measure the actual input module voltage without losses from input cables and connectors. To use TP1 and TP2, connect a voltmeter positive input terminal to TP1 and negative input terminal to TP2.

7.2 Output Voltage Monitoring (TP3 and TP4)

TPS56121EVM-601 provides two test points for measuring the output voltage generated by the module. To use TP3 and TP4, connect a voltmeter positive input terminal to TP3 and negative input terminal to TP4. For output ripple monitoring, please refer to the tip and barrel measurement technique in [Section 8.2](#).

7.3 Enable/Soft-start Monitoring (TP5)

TPS56121EVM-601 provides a test point for measuring the enable/soft-start voltage of the TPS56121 converter. This test point can be monitored to observe the start-up calibration waveform, soft-start ramp or fault time-out timing.

The enable/soft-start test point should not be actively driven from an external circuit, such as a logic output of another power supply.

7.4 Power Good Monitoring (TP6)

TPS56121EVM-601 provides a test points for measuring the Power Good voltage of the TPS56121 converter.

7.5 Loop Response Testing (TP7, TP8, TP9 and TP10)

TPS56121EVM-601 provides four test points (two signals and two grounds) for measuring the control loop frequency response. This allows the user to measure the actual module loop response without modifying the evaluation board. See [Section 8.3](#) for additional detail.

7.6 Switch Node Voltage Monitoring (TP11 and TP12)

TPS56121EVM-601 provides two test points for measuring the switch node. To monitor the switch node voltage, set oscilloscope per Oscilloscope For Switching Waveforms in [Section 5.1.4](#). Connect the oscilloscope probe to TP11 and the ground lead of the probe to TP12. To monitor the voltage spike on switch node, please remove the bandwidth limit on the oscilloscope and refer to the Application Report SLPA005 (Reducing Ringing Through PCB Layout Techniques) for the measurement techniques.

8 Test Procedures

8.1 Start Up/Shut Down Procedure

1. Set up the EVM as described in [Section 5.3](#) and [Figure 2](#).
2. Ensure LOAD is set to sink 0 A_{DC}.
3. Ensure jumper J3 set per [Section 6.1](#).
4. Increase VIN from 0 V_{DC} to 12 V_{DC}. Using V1 to measure VIN voltage.
5. Open jumper J3 to enable the converter.
6. Use V2 to measure VOUT voltage, A1 to measure VIN voltage.
7. Vary LOAD from 0 A_{DC} to 15 A_{DC}, VOUT should remain in load regulation.
8. Vary VIN from 8 V to 14 V, VOUT should remain in line regulation.
9. Short jumper J3 to disable the converter.
10. Decrease VIN to 0 V.
11. Decrease LOAD to 0 A.

8.2 Output Ripple Voltage Measurement Procedure

1. Follow [Section 8.1](#) to set VIN and LOAD to desired operating condition.
2. Set oscilloscope for Output Voltage Ripple Measurement in [Section 5.1.4](#).
3. Connect oscilloscope probe with exposed metal barrel to TP3 and TP4 per [Figure 3](#). Using a leaded ground connection may induce additional noise due to the large ground loop.
4. Follow [Section 8.1](#) to power down.

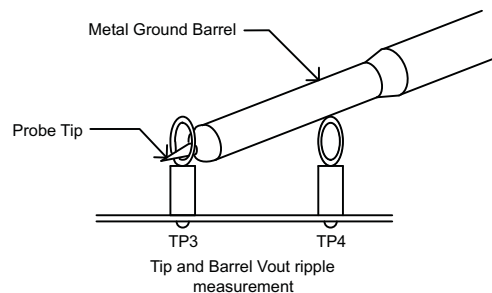


Figure 3. Tip and Barrel Output Voltage Ripple Measurement

8.3 Control Loop Gain and Phase Measurement Procedure

1. Follow Section 8.1 to set VIN and LOAD to desired operating condition.
2. Connect isolation transformer to test points TP7 and TP10 as shown in Figure 4.
3. Connect input signal amplitude measurement probe (Channel A) to TP7 as shown in Figure 4.
4. Connect output signal amplitude measurement probe (Channel B) to TP10 as shown in Figure 4.
5. Connect ground lead of Channel A and Channel B to TP8 and TP9 as shown in Figure 4, respectively.
6. Inject 10 mV or less signal through the isolation transformer.
7. Sweep the frequency from 500 Hz to 500 kHz with 10-Hz or lower post filter.

8. Control loop gain can be measured by
$$20 \times \log \left(\frac{\text{Channel B}}{\text{Channel A}} \right)$$
.
9. Control loop phase can be measured by the phase difference between Channel A and Channel B.
10. Follow Section 8.1 to power down.

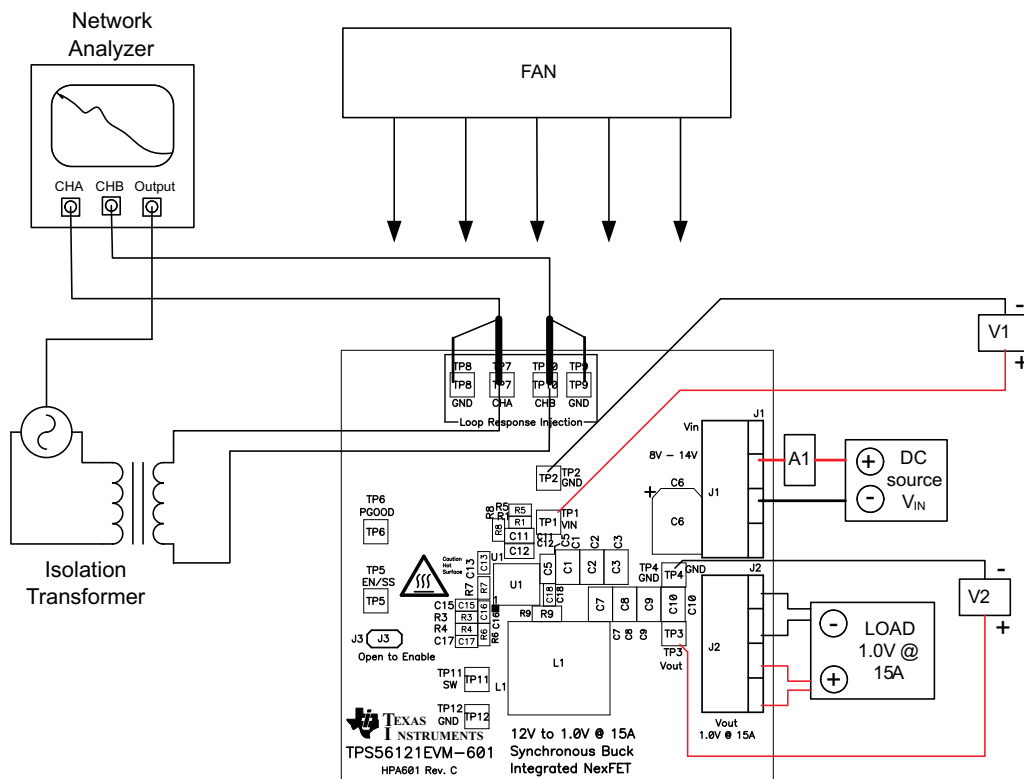


Figure 4. Control Loop Measurement Setup

8.4 Equipment Shutdown

1. Shut down VIN.
2. Shut down LOAD.
3. Shut down fan.
4. Shut down oscilloscope.

9 Performance Data and Typical Characteristic Curves

Figure 5 through Figure 16 present typical performance curves for the TPS56121EVM-601. Since actual performance data can be affected by measurement techniques and environmental variables, these curves are presented for reference and may differ from actual field measurements.

9.1 Efficiency

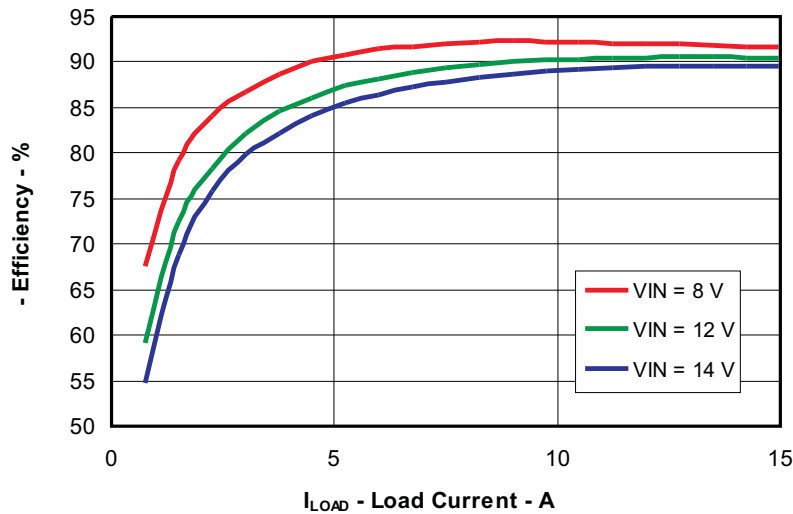


Figure 5. Efficiency

9.2 Load Regulation

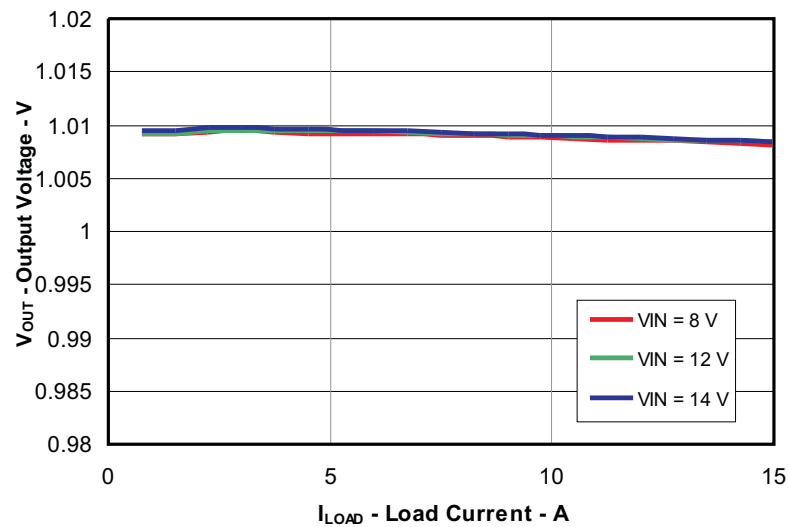


Figure 6. Load Regulation

9.3 Line Regulation

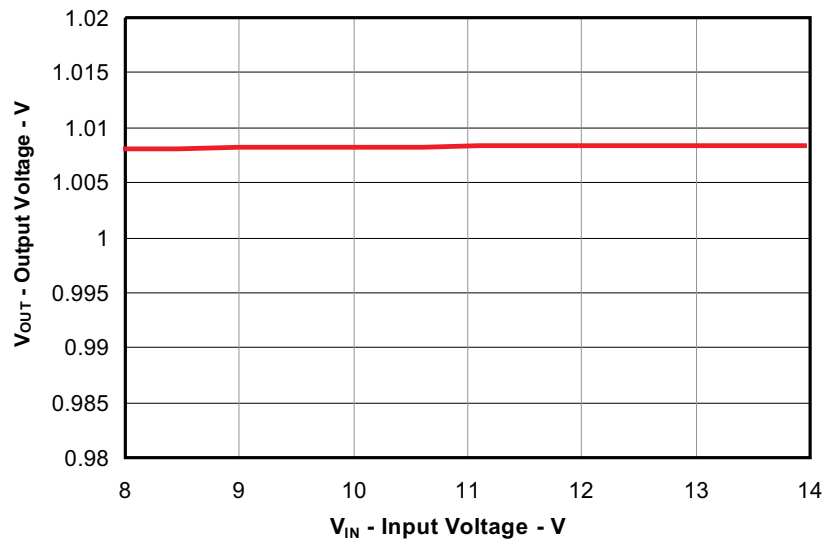


Figure 7. Line Regulation
(V_{IN} = 8 V to 14 V, V_{OUT} = 1.0 V, I_{OUT} = 15 A)

9.4 Output Voltage Ripple



Figure 8. Output Voltage Ripple
(V_{IN} = 12 V, V_{OUT} = 1.0 V, I_{OUT} = 15 A)

9.5 Switch Node

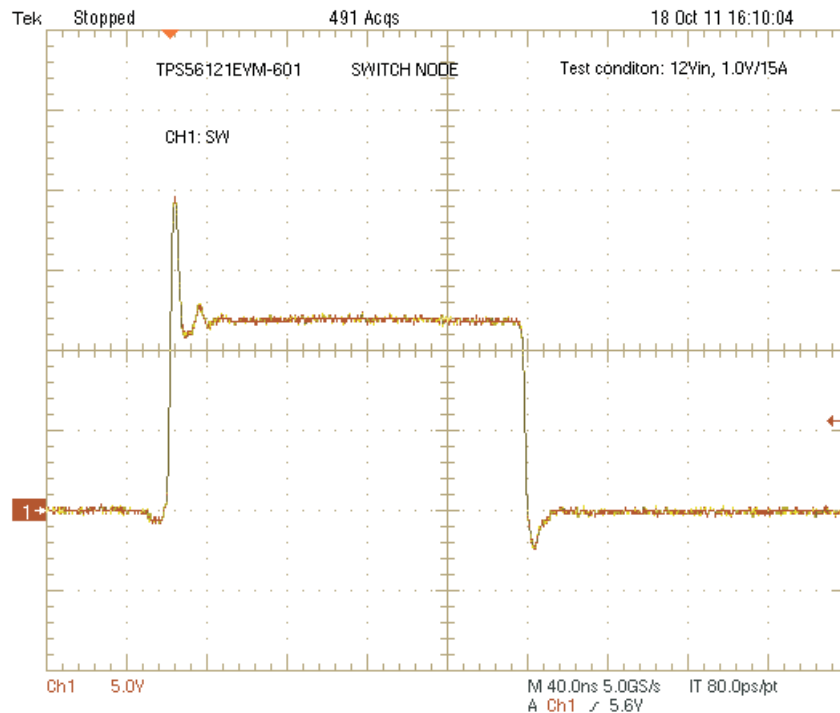


Figure 9. Switch Node Waveform Measured at Pins Using Tip and Barrel Measurement Technique (VIN = 12 V, VOUT = 1.0 V, IOU = 15 A)

9.6 Load Transient

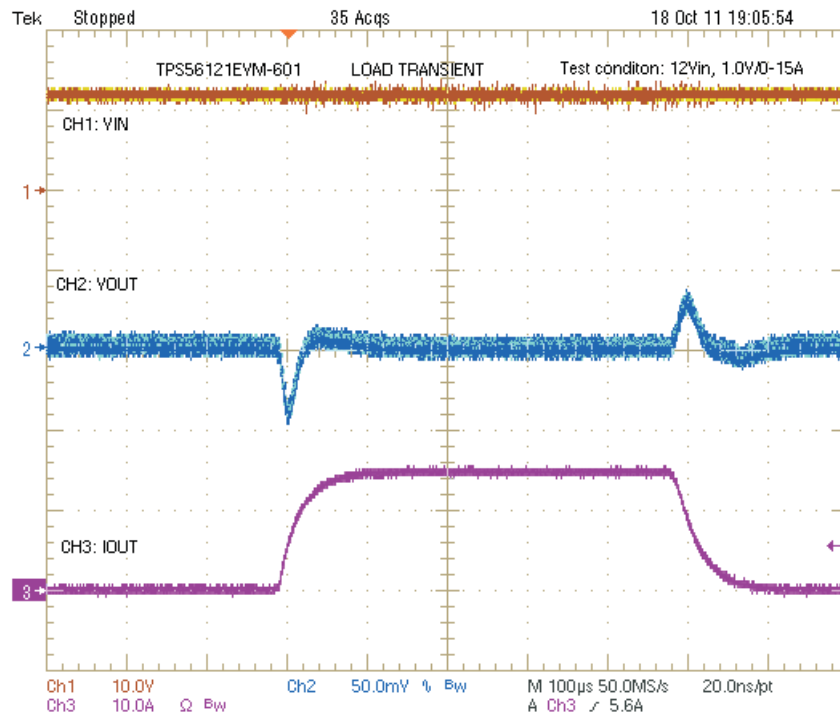


Figure 10. Load Transient (VIN = 12 V, VOUT = 1.0 V, IOU = 0 A to 15 A)

9.7 Start Up

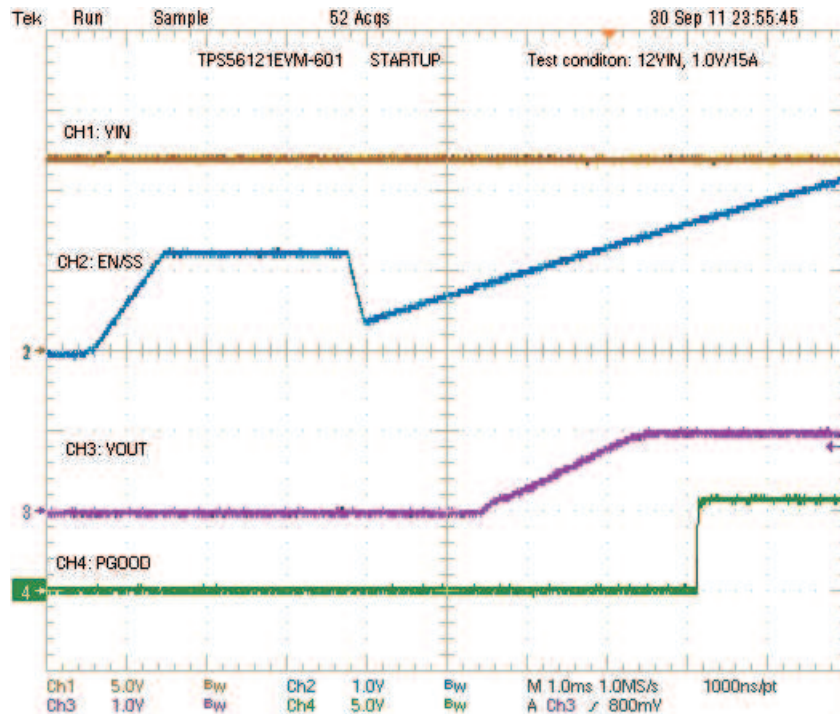


Figure 11. Start-Up Waveform
(VIN = 12 V, VOUT = 1.0 V, IOUT = 15 A)

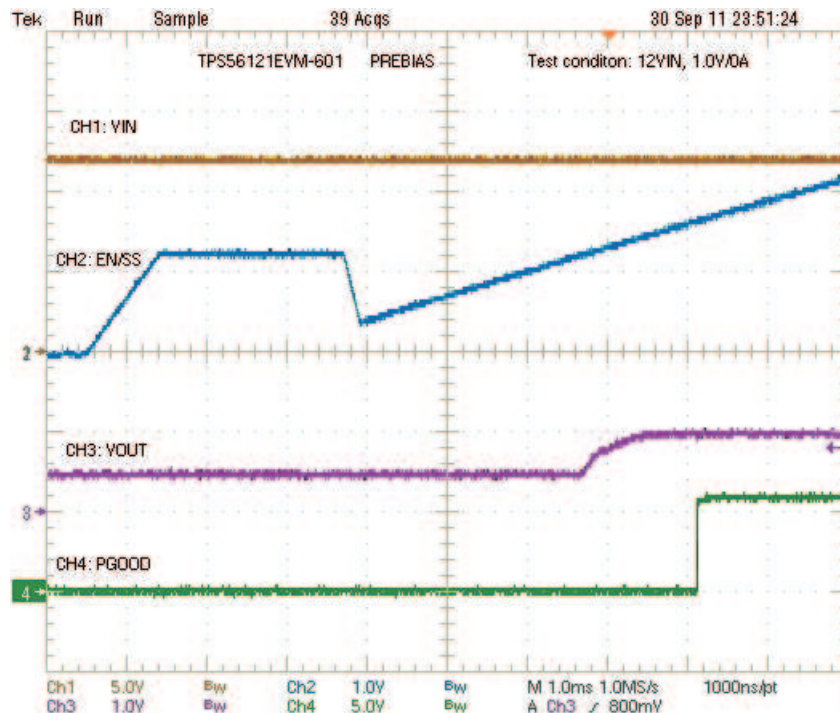


Figure 12. Pre-Biased Start-Up Waveform
(VIN = 12 V, VOUT = 1.0 V, IOUT = 0 A)

9.8 Power Off

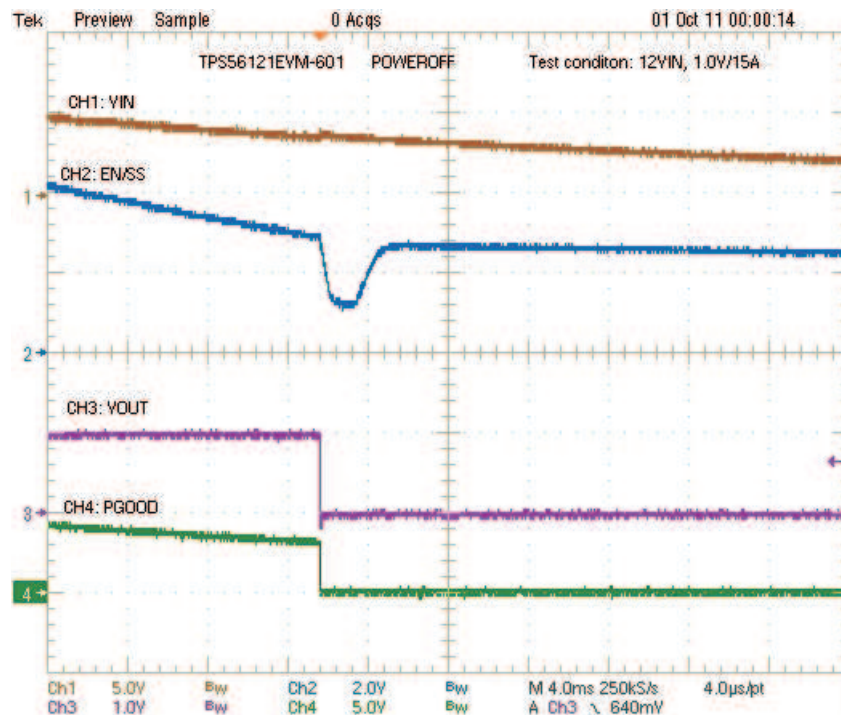


Figure 13. Power-Off Waveform
(VIN = 12 V, VOUT = 1.0 V, IOUT = 15 A)

9.9 Over-Current Protection

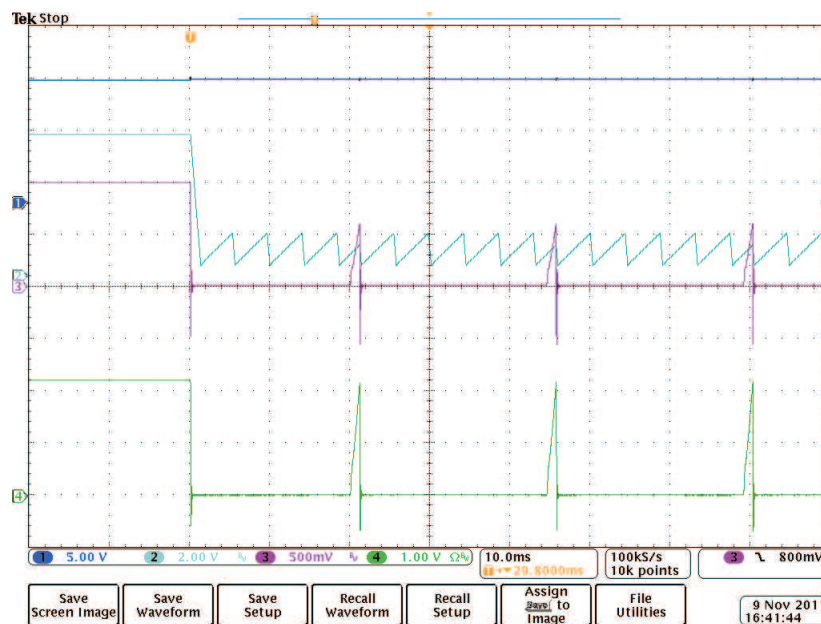


Figure 14. Over-Current Protection Waveform
(Ch1: VIN, Ch2: EN/SS, Ch3: VOUT, Ch4: IOUT (10 A/div), VIN = 12 V, VOUT = 1.0 V, IOUT = 23 A)

9.10 Control Loop Bode Plot

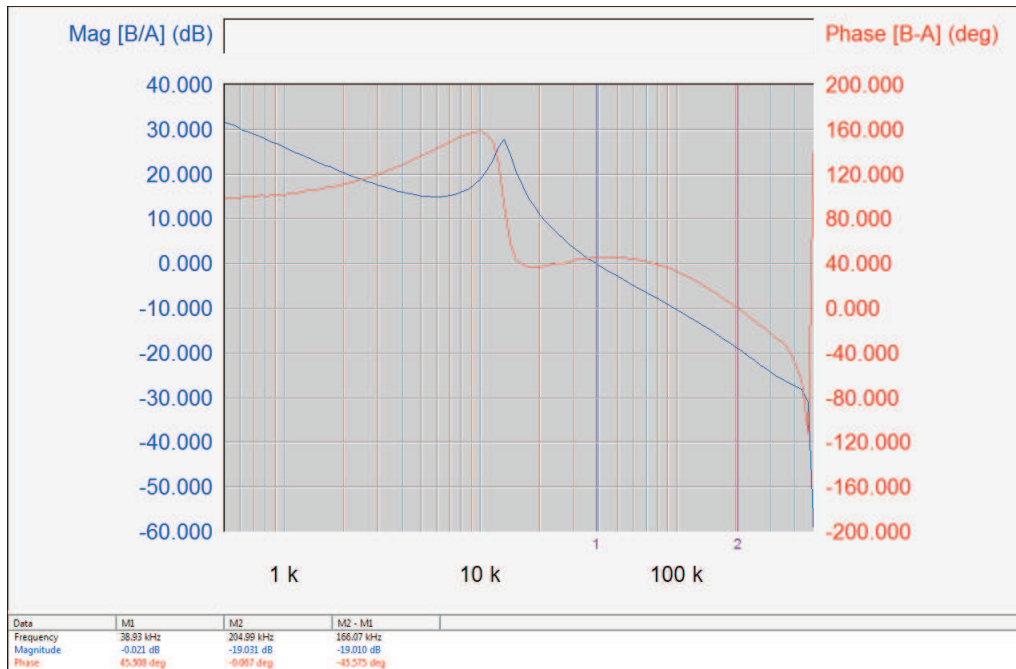


Figure 15. Loop Gain
 (VIN = 12 V, VOUT = 1.0 V, IOU = 15 A, Bandwidth: 39 kHz, Phase Margin: 46°)

9.11 Thermal Image

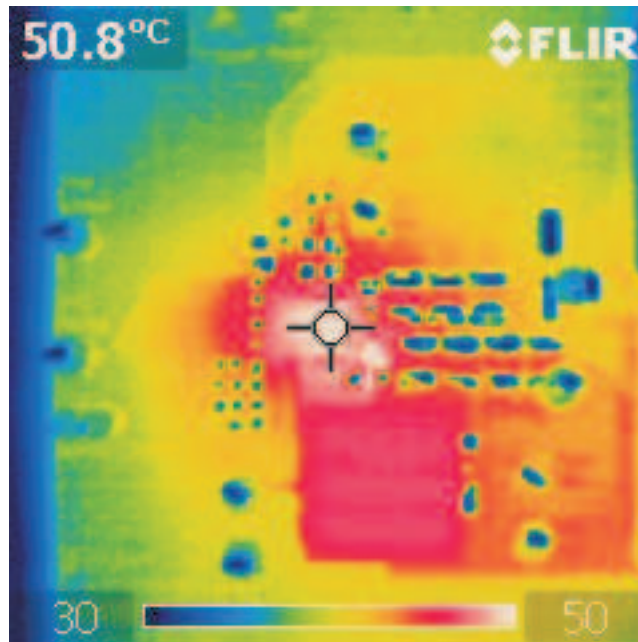


Figure 16. Thermal Image
 (VIN = 14 V, VOUT = 1.0 V, IOU = 15 A, without airflow)

10 EVM Assembly Drawings and PCB Layout

The following figures (Figure 17 through Figure 22) show the design of the TPS56121EVM-601 printed circuit board. The EVM has been designed using a 4-layer, 2-oz copper-clad circuit board 2.5" x 2.5" with components on both sides of the PCB to allow the user to view, probe and evaluate the TPS56121 high current converter with integrated FETs in a small form factor, high-current application.

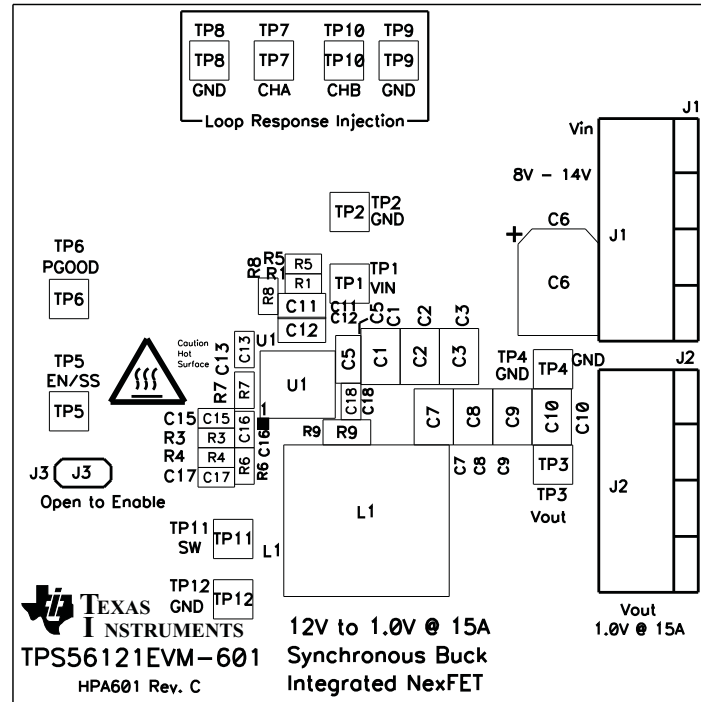


Figure 17. TPS56121EVM-601 Top Assembly Drawing (top view)

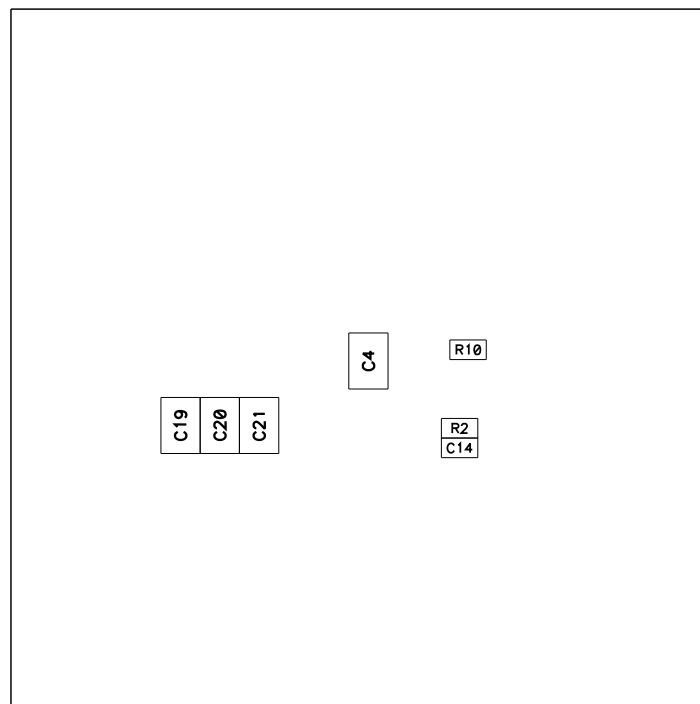


Figure 18. TPS56121EVM-601 Bottom Assembly Drawing (bottom view)

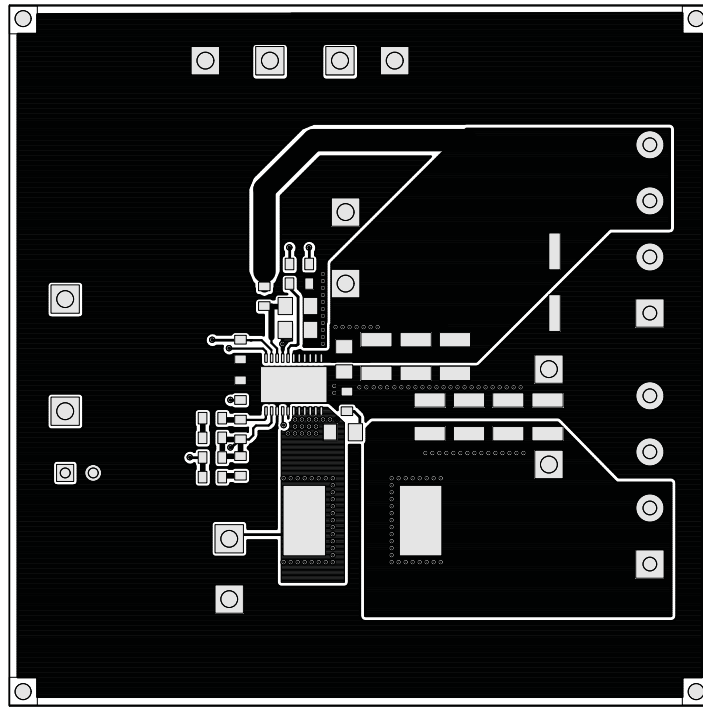


Figure 19. TPS56121EVM-601 Top Copper (top view)

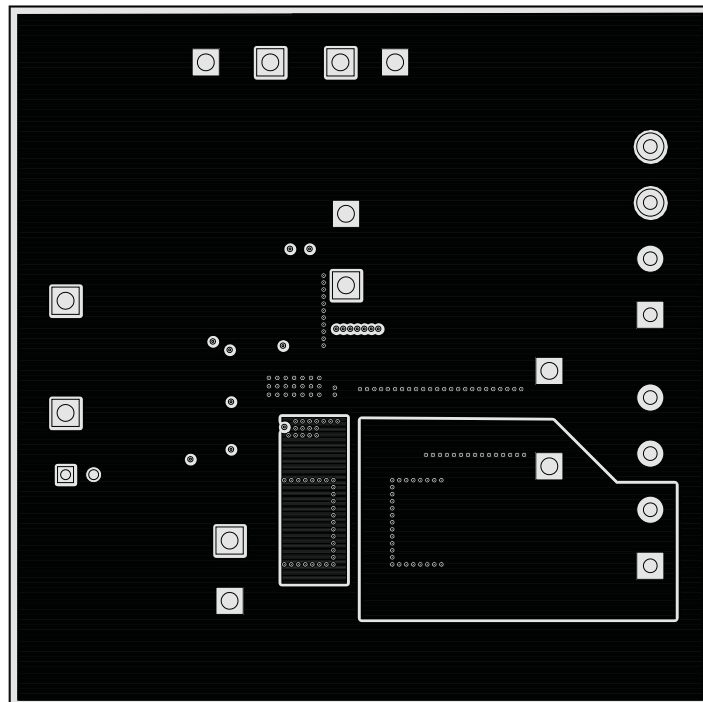


Figure 20. TPS56121EVM-601 Internal 1 (top view)

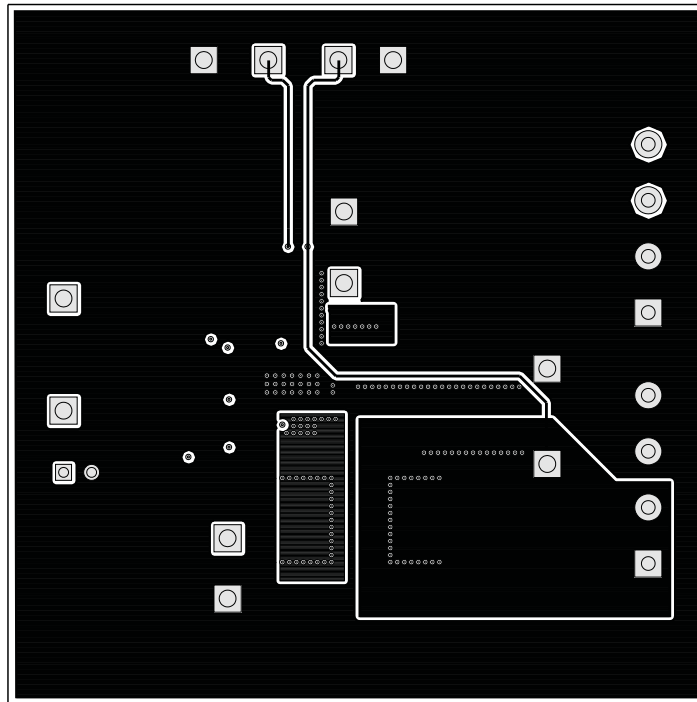


Figure 21. TPS56121EVM-601 Internal 2 (top view)

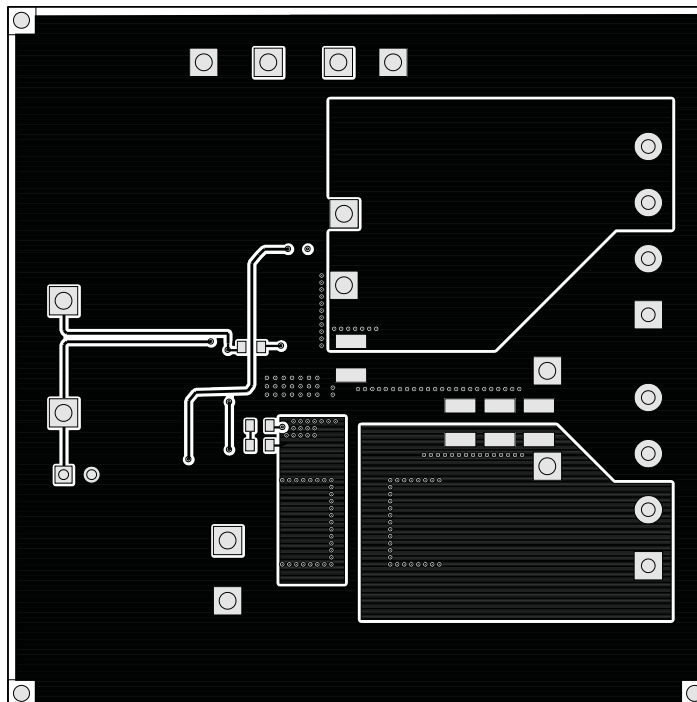


Figure 22. TPS56121EVM-601 Bottom Copper (top view)

11 List of Materials

Table 3. TPS56121EVM-601 List of Materials

QTY	REF DES	DESCRIPTION	PART NUMBER	MFR
4	C1, C2, C3, C4	Capacitor, ceramic, 25 V, X5R, 20%, 22 μ F, 1210	Std	Std
2	C5, C11	Capacitor, ceramic, 25 V, X5R, 20%, 1.0 μ F, 0805	Std	Std
0	C6	Capacitor, aluminum, 16 V _{DC} , \pm 20%, 100 μ F, code D8	EEEFP1C101AP	Panasonic
5	C7, C8, C9, C10, C19	Capacitor, ceramic, 6.3 V, X5R, 20%, 100 μ F, 1210	Std	Std
1	C12	Capacitor, ceramic, 10 V, X5R, 20%, 4.7 μ F, 0805	Std	Std
1	C13	Capacitor, ceramic, 16 V, X7R, 20%, 33 nF, 0603	Std	Std
1	C14	Capacitor, ceramic, 50 V, X7R, 20%, 100 nF, 0603	Std	Std
1	C15	Capacitor, ceramic, 50 V, X7R, 10%, 2200 pF, 0603	Std	Std
1	C16	Capacitor, ceramic, 50 V, C0G, 5%, 100 pF, 0603	Std	Std
1	C17	Capacitor, ceramic, 50 V, C0G, 5%, 680 pF, 0603	Std	Std
1	C18	Capacitor, ceramic, 50 V, X7R, 20%, 1000 pF, 0603	Std	Std
0	C20, C21	Capacitor, ceramic, 6.3 V, X5R, 20%, 100 μ F, 1210	Std	Std
2	J1, J2	Terminal block, 4 pin, 15 A, 5.1 mm, 0.80 inch x 0.35 inch	ED120/4DS	OST
1	J3	Header, male 2 pin, 100-mil spacing, 0.100 inch x 2 inch	PEC02SAAN	Sullins
1	L1	Inductor, 440 nH, 30 A, 0.32 m Ω , 440 nH, 0.530 inch x 0.510 inch	PA0513.441NLT	Pulse
1	R1	Resistor, chip, 1/16 W, 1%, 1.78 k Ω , 0603	Std	Std
1	R2	Resistor, chip, 1/16 W, 1%, 5.10 Ω , 0603	Std	Std
1	R3	Resistor, chip, 1/16 W, 1%, 7.87 k Ω , 0603	Std	Std
1	R4	Resistor, chip, 1/16 W, 1%, 20.5 k Ω , 0603	Std	Std
1	R5	Resistor, chip, 1/16 W, 1%, 49.9 Ω , 0603	Std	Std
1	R6	Resistor, chip, 1/16 W, 1%, 1.00 k Ω , 0603	Std	Std
1	R7	Resistor, chip, 1/16 W, 1%, 30.1 k Ω , 0603	Std	Std
1	R8	Resistor, chip, 1/16 W, 1%, 0 k Ω , 0603	Std	Std
1	R9	Resistor, chip, 1/8 W, 1%, 1.00 Ω , 0805	Std	Std
1	R10	Resistor, chip, 1/16 W, 1%, 100 k Ω , 0603	Std	Std
3	TP1, TP3, TP11	Test point, red, thru hole, 0.125 inch x 0.125 inch	5010	Keystone
5	TP2, TP4, TP8, TP9, TP12	Test point, black, thru hole, 0.125 inch x 0.125 inch	5011	Keystone
2	TP5, TP6	Test point, yellow, thru hole, 0.125 x 0.125 inch	5014	Keystone
2	TP7, TP10	Test point, white, thru hole, 0.125 x 0.125 inch	5012	Keystone
1	U1	4.5-V to 14-V Input 15-A Synchronous Buck Converter, QFN-22 6 mm x 5 mm	TPS56121DQP	TI
1	--	PCB, 2.5 inch x 2.5 inch x 0.062 inch	HPA601	Any
1	--	Shunt, 100 mil, black, 0.100	929950-00	3M

Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive.**

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 8 VDC to 14 VDC and the output voltage range of 0 ADC to 15 ADC.

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

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 55°C. The EVM is designed to operate properly with certain components above 55°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2012, Texas Instruments Incorporated