LM5146-Q1 EVM User's Guide

The LM5146-Q1-EVM12V evaluation module (EVM) is a synchronous buck DC/DC regulator that employs synchronous rectification to achieve high conversion efficiency in a small footprint. It operates over a wide input voltage range of 15 V to 85 V providing a regulated 12-V output. The output voltage has better than 1% setpoint accuracy and is adjustable using an external resistor or voltage source, permitting the user to customize the output voltage from 8 V to 15 V as needed.

The module design uses the LM5146-Q1 100-V synchronous buck controller with wide input voltage (wide V_{IN}) range, wide duty cycle range, voltage-mode PWM control loop, integrated high-side and low-side MOSFET gate drivers, cycle-by-cycle overcurrent protection, precision enable, and power supply tracking features. The EVM's free-running switching frequency is 400 kHz and is synchronizable to a higher or lower frequency if required. Moreover, a synchronization output signal (SYNCOUT) 180° phase-shifted relative to the internal clock is available for master-slave configurations. VCC voltage rail UVLO protects the converter at low input voltage conditions, and the EN/UVLO pin supports adjustable input UVLO for application specific power-up and power-down requirements.

The LM5146-Q1 is available in a 20-pin VQFN package with 4.5-mm × 3.5-mm footprint to enable DC/DC solutions with high density and low component count. See the *LM5146-Q1 data sheet* for more information. Use the LM5146-Q1 with WEBENCH® Power Designer to create a custom regulator design. Furthermore, the user can download the *LM5146-Q1 Quickstart Calculator* to optimize component selection and examine predicted efficiency performance across line and load ranges.

User's Guide
SNVU591–November 2018

Important General TI High Voltage Evaluation User Safety Guidelines

WARNING

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and the safety of those working around you. Contact TI's Product Information Center http://support.ti.com for further information.

Save all warnings and instructions for future reference.

Failure to follow warnings and instructions may result in personal injury, property damage, or death due to electrical shock and/or burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed-circuit board assembly. It is intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise, and knowledge of electrical safety risks in development and application of high-voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments. If you are not suitably qualified, you should immediately stop from further use of the HV EVM.

- **Work Area Safety:**
  - Maintain a clean and orderly work area.
  - Qualified observer(s) must be present anytime circuits are energized.
  - Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
  - All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50 V_{RMS}/75 VDC must be electrically located within a protected Emergency Power Off (EPO) protected power strip.
  - Use a stable and non-conductive work surface.
  - Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
- **Electrical Safety:**

  As a precautionary measure, it is always a good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
  - De-energize the TI HV EVM and all its inputs, outputs, and electrical loads before performing any electrical or other diagnostic measurements. Confirm that TI HV EVM power has been safely de-energized.
  - With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
  - When EVM readiness is complete, energize the EVM as intended.

WARNING: While the EVM is energized, never touch the EVM or its electrical circuits as they could be at high voltages capable of causing electrical shock hazard.

- **Personal Safety:**
  - Wear personal protective equipment, for example, latex gloves and/or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.
- **Limitation for Safe Use:**
  - EVMs are not to be used as all or part of a production unit.

Safety and Precautions

The EVM is designed for professionals who have received the appropriate technical training, and is designed to operate from an AC power supply or a high-voltage DC supply. Please read this user guide and the safety-related documents that come with the EVM package before operating this EVM.

CAUTION

Do not leave the EVM powered when unattended.

WARNING

Hot surface! Contact may cause burns. Do not touch!

WARNING

High Voltage! Electric shock is possible when connecting board to live wire. Board should be handled with care by a professional.

For safety, use of isolated test equipment with overvoltage and overcurrent protection is highly recommended.

Contents

List of Figures

List of Tables

Trademarks

WEBENCH is a registered trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

1 High Density EVM Description

The LM5146-Q1-EVM12V high density EVM is designed to use a regulated or non-regulated high-voltage input rail ranging from 15 V to 85 V to produce a tightly-regulated output voltage of 12 V at load currents up to 8 A. This wide V_{IN} range DC-DC solution offers outsized voltage rating and operating margin to withstand supply rail voltage transients.

The free-running switching frequency is 400 kHz and is synchronizable to an external clock signal at a higher or lower frequency. A terminal-block connector is available to connect VIN+ and VIN– terminals, whereas banana plugs are used for VOUT+ and VOUT– power connections. The power-train passive components selected for this EVM, including buck inductor and ceramic input and output capacitors, are automotive AEC-Q200 rated and are available from multiple component vendors. The 100-V power MOSFETs are automotive AEC-Q101 rated.

1.1 Typical Applications

- High-current automotive DC/D regulators
- HEV/EV power compliant to LV-124 and LV-148
- Automotive motor drives

1.2 Features and Electrical Performance

- Tightly-regulated output voltage of 12 V with better than ±1% setpoint accuracy
- Wide input voltage operating range of 15 V to 85 V
- Full load current of 8 A available with recommended airflow of 200 LFM
- Switching frequency of 400 kHz externally synchronizable up or down
- Ultra-high power conversion efficiency across wide load current range
  - Full load efficiency of 97% and 96% at V_{IN} = 24 V and 48 V, respectively
  - 97.5% efficiency at half-rated load, V_{IN} = 48 V
- 18-mA no-load supply current at V_{IN} = 48 V when VOUT feeds bias power to VCC
- Input π-stage EMI filter with electrolytic capacitor for parallel damping
  - Meets EN55025 / CISPR 25 EMI standards
  - Optional two-piece board-mounted shield for improved radiated EMI signature
- Voltage-mode control architecture provides fast line and load transient response
  - PWM line feedforward
  - Forced PWM (FPWM) or diode emulation mode operation
  - Voltage error amplifier with 94dB A_{VOL} and 6.5-MHz GBW
- Integrated high-side and low-side power MOSFET gate drivers
  - 2.3-A and 3.5-A sink/source drive current capability
  - 14-ns adaptive dead-time control reduces power dissipation and MOSFET temperature rise
- Overcurrent protection (OCP) with valley current sensing using low-side MOSFET $R_{DS(on)}$
- Monotonic prebias output voltage start-up
- User-adjustable soft-start time set to 4 ms by 47-nF capacitor connected between SS/TRK and AGND
  - Option for output voltage tracking using master track signal connected to SS/TRK
- SYNCOUT signal 180° out-of-phase with internal clock
- PGOOD indicator with 20-kΩ pullup resistor to VCC
- Selectable forced-PWM (FPWM) or diode emulation (DEM) modes using SYNCIN pin
- Resistor-programmable input voltage UVLO with customizable hysteresis for applications with wide turn-on and turn-off voltage difference
  - Input UVLO set to turn on and off at V_{IN} of 14 V and 13 V, respectively
- Fully assembled, tested, and proven PCB layout with 80-mm × 63-mm total footprint

2 EVM Performance Specifications

Table 1. Electrical Performance Specifications

PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS						
Input voltage range, V_{IN}	Operating		15	48	85	V
Input voltage turnon, $V_{IN(ON)}$	Adjusted using EN/UVLO divider resistors			14		V
Input voltage turnoff, $V_{IN(OFF)}$	Adjusted using EN/UVLO divider resistors			13		V
Input voltage hysteresis, $V_{IN(HYS)}$	Adjusted using EN/UVLO divider resistors			1		V
Input current, no load, $I_{IN(NL)}$	I_{OUT} = 0 A	V_{IN} = 24 V		20		mA
		V_{IN} = 48 V		18.5		
		V_{IN} = 72 V		18		
Input current, disabled, $I_{IN(OFF)}$	V_{EN} = 0 V	V_{IN} = 48 V		250		µA
OUTPUT CHARACTERISTICS						
Output voltage, V_{OUT} [1]			11.9	12.0	12.1	V
Output current, I_{OUT}	V_{IN} = 15 V to 85 V, Airflow = 200LFM [2]		0		8	A
Output voltage regulation, ΔV_{OUT}	Load regulation	I_{OUT} = 0 A to 8 A		0.2%		
	Line regulation	V_{IN} = 15 V to 85 V		0.2%		
Output voltage ripple, $V_{OUT(AC)}$	V_{IN} = 48 V, I_{OUT} = 8 A			25		mVrms
Output overcurrent protection, I_{OCP}	V_{IN} = 48 V			12		A
Soft-start time, t_{SS}	C_{SS} = 47 nF			4		ms
SYSTEM CHARACTERISTICS						
Switching frequency, $F_{SW(nom)}$	V_{IN} = 48 V			400		kHz
Half-load efficiency, η_{HALF} [1]	I_{OUT} = 4 A	V_{IN} = 24 V		97.5%		
		V_{IN} = 36 V		96.7%		
		V_{IN} = 48 V		96%		
		V_{IN} = 75 V		93.5%		
Full load efficiency, η_{FULL}	I_{OUT} = 8 A	V_{IN} = 24 V		97.5%		
		V_{IN} = 36 V		96.5%		
		V_{IN} = 48 V		96%		
		V_{IN} = 75 V		94.5%		
LM5146-Q1 junction temperature, T_J			–40		150	ºC

(1) The default output voltage of this EVM is 12 V. Efficiency and other performance metrics can change based on operating input voltage, load current, externally-connected output capacitance, and other parameters.

(2) The recommended airflow when operating at output currents greater than 6 A is 200 LFM.

3 Application Circuit Diagram

Figure 1 shows the schematic of an LM5146-Q1 based synchronous buck regulator (EMI filter stage not shown). Soft start (SS), current limit (ILIM), and UVLO (EN/UVLO) components are shown that are configurable as required by the specific application.

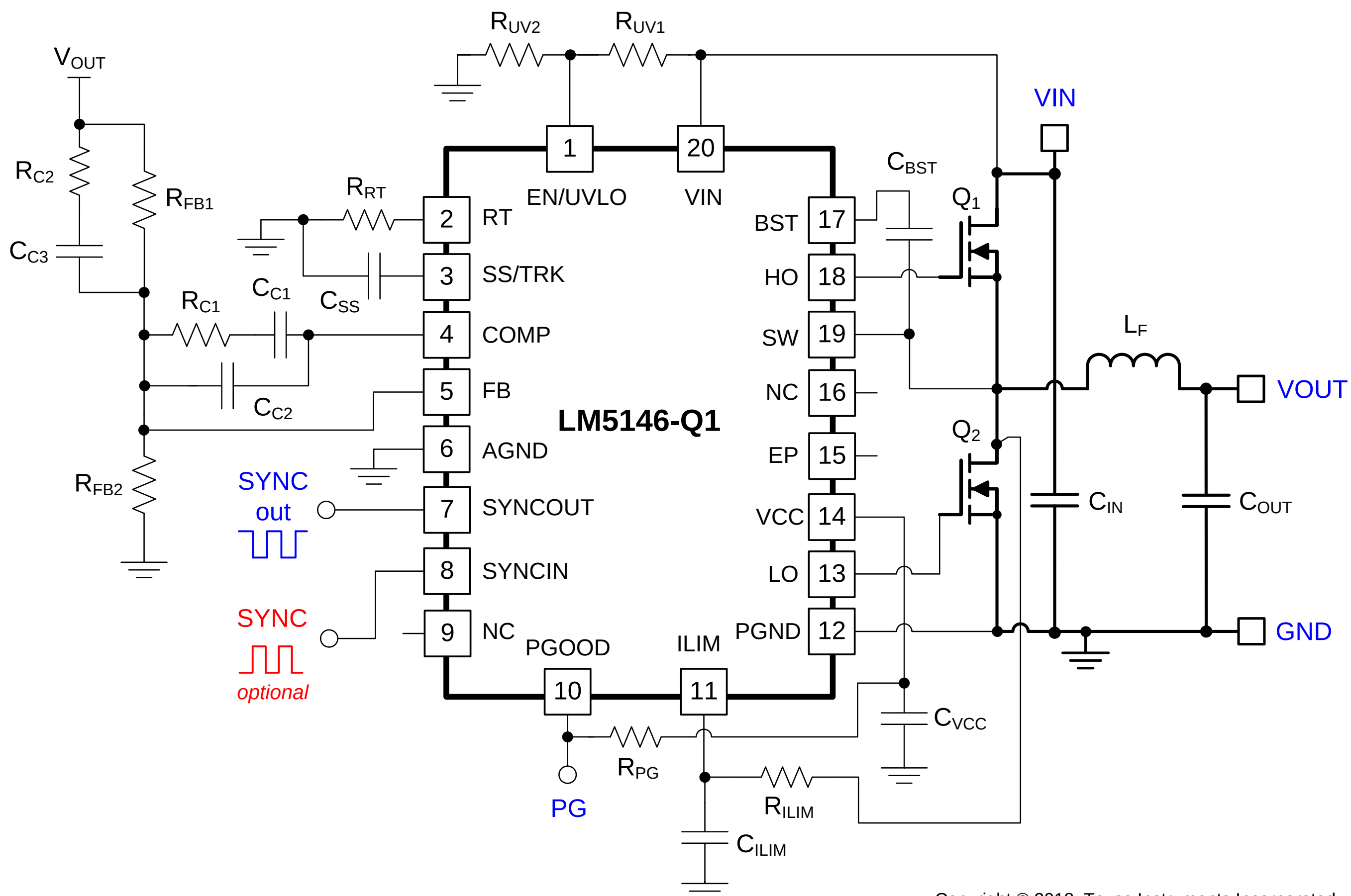


Figure 1. LM5146-Q1 Synchronous Buck Regulator Simplified Schematic

4 EVM Photo

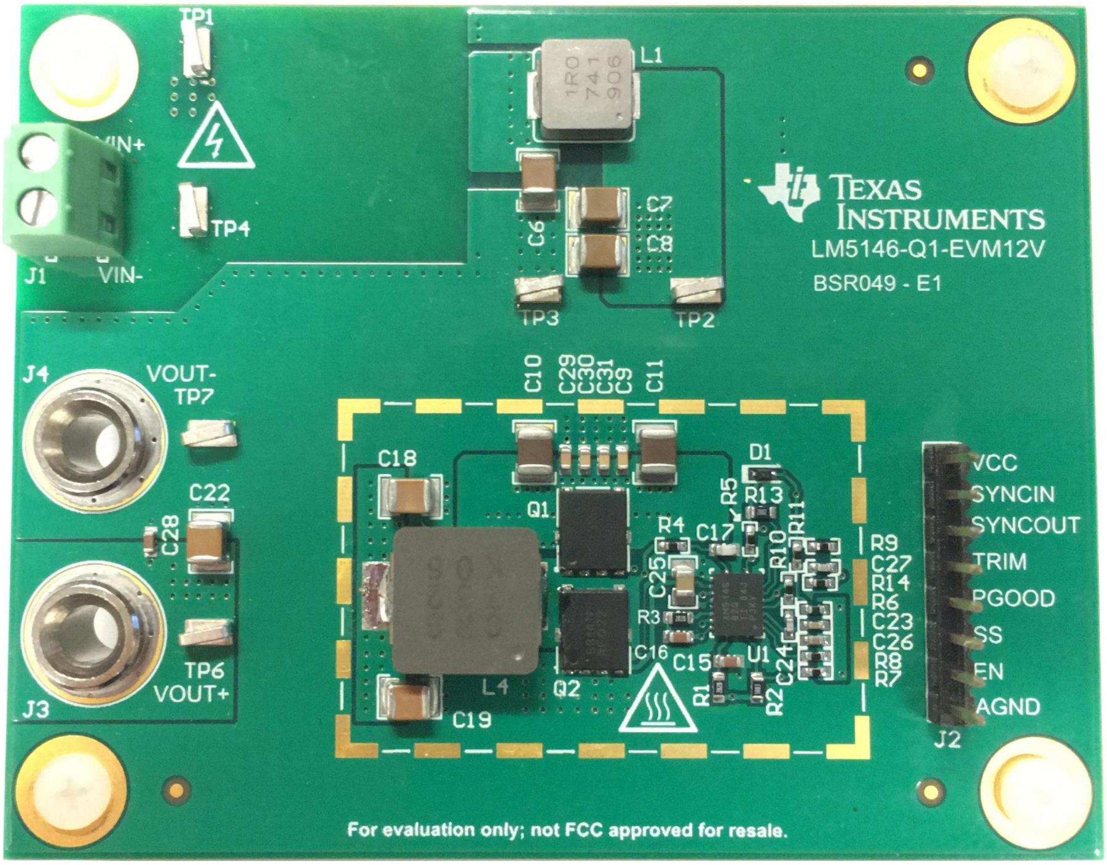


Figure 2. LM5146-Q1 EVM Photo

CAUTION

Caution Hot surface.
Contact may cause burns.
Do not touch.

5 Test Setup and Procedure

5.1 EVM Connections

Referencing the EVM connections described in Table 2, the recommended test setup to evaluate the LM5146-Q1-EVM12V is shown in Figure 3. Working at an ESD-protected workstation, make sure that any wrist straps, boot straps, or mats are connected and referencing the user to earth ground before power is applied to the EVM.

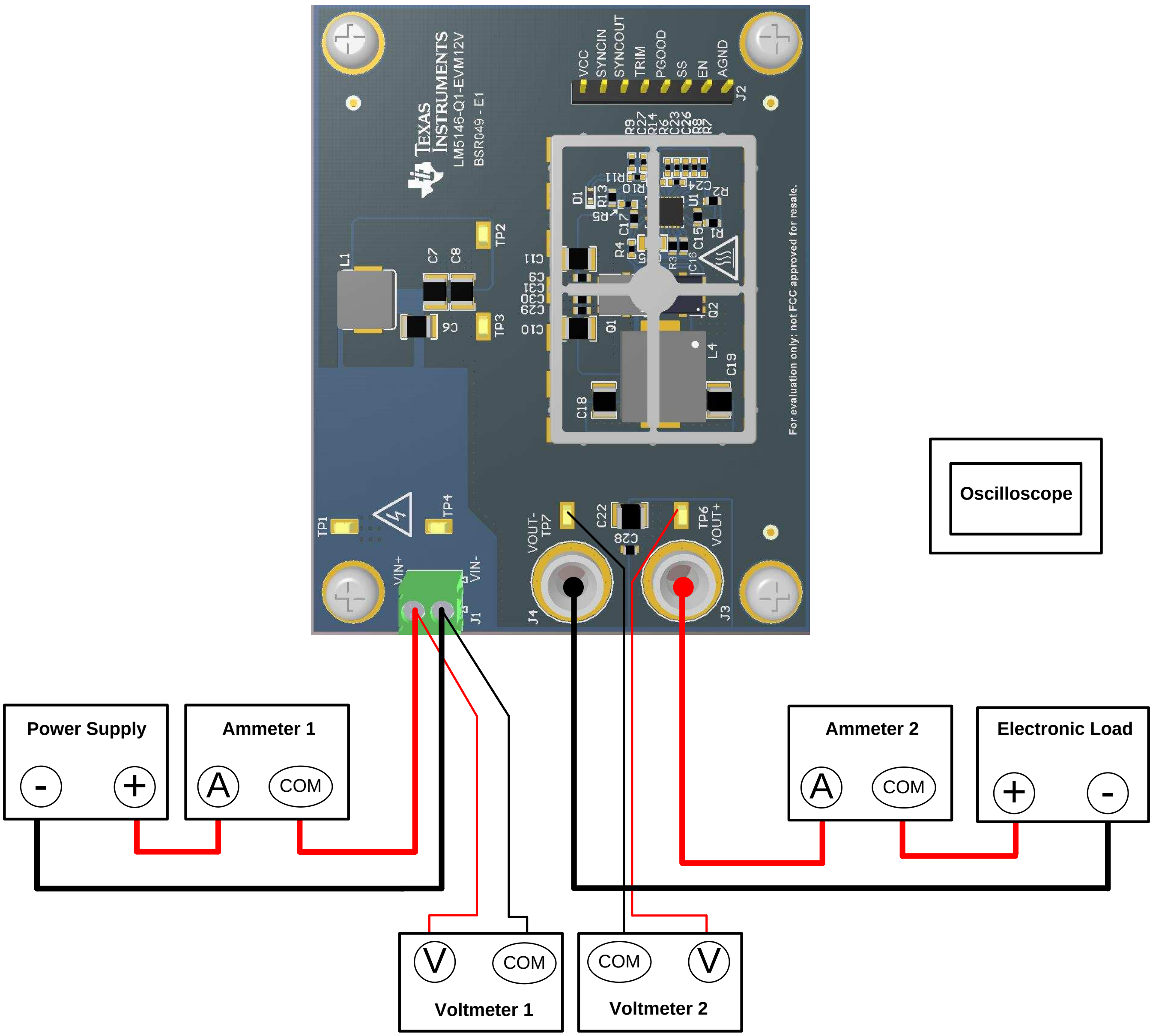


Figure 3. EVM Test Setup

CAUTION

Refer to the LM5146-Q1 datasheet, LM5146-Q1 Quickstart Calculator and WEBENCH® Power Designer for additional guidance pertaining to component selection and converter operation.

Table 2. EVM Power Connections

LABEL	DESCRIPTION
VIN+	Positive input voltage power and sense connection
VIN-	Negative input voltage and output voltage power and sense connection
VOUT+	Positive output voltage positive power and sense connection
VOUT–	Negative output voltage positive power and sense connection

Table 3. EVM Signal Connections

LABEL	DESCRIPTION
VCC	External bias supply connection (through a diode)
SYNCIN	Synchronization input
SYNCOUT	Synchronization output
PGOOD	Power Good output
TRIM	Trim input for output voltage adjust
SS/TRK	Tracking signal input
EN	ENABLE input – tie to AGND to disable converter
AGND	Analog GND connection

5.2 Test Equipment

Voltage Source: The input voltage source V_{IN} should be a 0–85-V variable DC source capable of supplying 10 A.

Multimeters:

- **Voltmeter 1:** Input voltage at VIN+ to VIN–. Set voltmeter to an input impedance of 100 MΩ.
- **Voltmeter 2:** Output voltage at VOUT+ to VOUT–. Set voltmeter to an input impedance of 100 MΩ.
- **Ammeter 1:** Input current. Set ammeter to 1-second aperture time.
- **Ammeter 2:** Output current. Set ammeter to 1-second aperture time

Electronic Load: The load should be an electronic constant-resistance (CR) or constant-current (CC) mode load capable of 0 Adc to 8 Adc at 12 V. For a no-load input current measurement, disconnect the electronic load as it may draw a small residual current.

Oscilloscope: With the scope set to 20-MHz bandwidth and AC coupling, measure the output voltage ripple directly across an output capacitor with a short ground lead normally provided with the scope probe. Place the oscilloscope probe tip on the positive terminal of the output capacitor, holding the probe's ground barrel through the ground lead to the capacitor's negative terminal. TI does not recommend using a long-leaded ground connection because this may induce additional noise given a large ground loop. To measure other waveforms, adjust the oscilloscope as needed.

Safety: Always use caution when touching any circuits that may be live or energized.

5.3 Recommended Test Setup

5.3.1 Input Connections

- Prior to connecting the DC input source, set the current limit of the input supply to 0.1 A maximum. Ensure the input source is initially set to 0 V and connected to the VIN+ and VIN– connection points as shown in Figure 3. An additional input bulk capacitor is recommended to provide damping if long input lines are used.
- Connect voltmeter 1 at VIN+ and VIN– connection points to measure the input voltage.
- Connect ammeter 1 to measure the input current and set to at least 1-second aperture time.

5.3.2 Output Connections

- Connect an electronic load to VOUT+ and VOUT– connections. Set the load to constant-resistance mode or constant-current mode at 0 A before applying input voltage.
- Connect voltmeter 2 at VOUT+ and VOUT– connection points to measure the output voltage.
- Connect ammeter 2 to measure the output current.

5.4 Test Procedure

5.4.1 Line and Load Regulation, Efficiency

- Set up the EVM as described above.
- Set load to constant resistance or constant current mode and to sink 0 A.
- Increase input source from 0 V to 48 V; use voltmeter 1 to measure the input voltage.
- Increase the current limit of the input supply to 6 A.
- Using voltmeter 2 to measure the output voltage, V_{OUT}, vary the load current from 0 A to 8 A DC; V_{OUT} should remain within the load regulation specification.
- Set the load current to 4 A (50% rated load) and vary the input source voltage from 15 V to 85 V; V_{OUT} should remain within the line regulation specification.
- Decrease load to 0 A. Decrease input source voltage to 0 V.

CAUTION

Extended operation at high output power can raise some component temperatures above 55°C. To avoid the risk of a burn injury, do not touch the components until they have cooled sufficiently after disconnecting power.

6 Test Data and Performance Curves

Figure 4 through Figure 12 present typical performance curves for the LM5146-Q1-EVM12V. Because actual performance data may be affected by measurement techniques and environmental variables, these curves are presented for reference and may differ from actual field measurements.

6.1 Conversion Efficiency

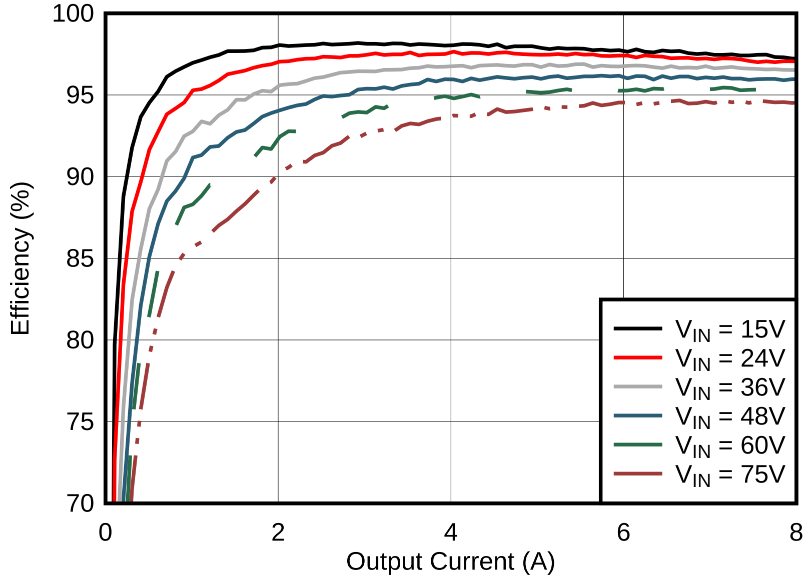


Figure 4. Conversion Efficiency, CCM (SYNCIN Tied High)

6.2 Operating Waveforms

6.2.1 Output Voltage Ripple

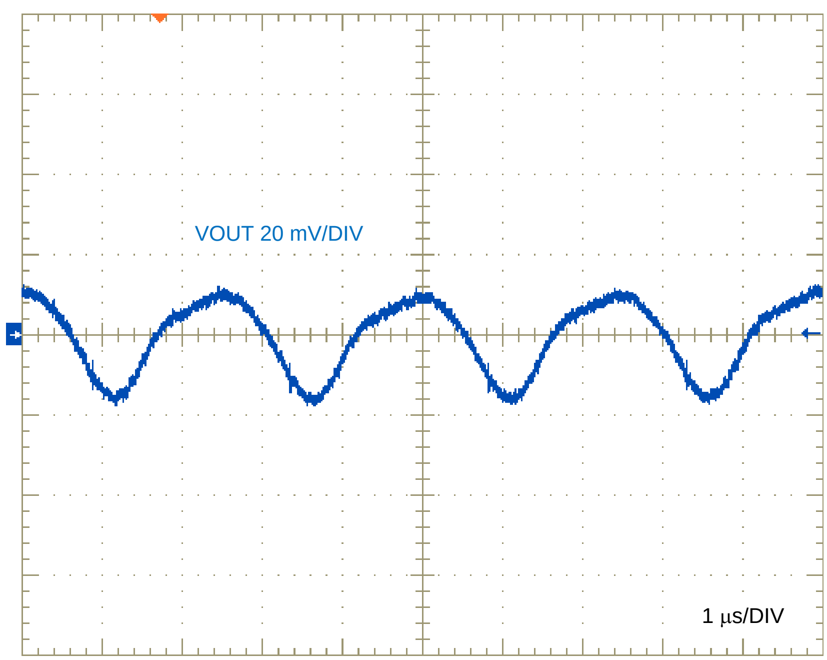


Figure 5. Output Voltage Ripple, V_{IN} = 48 V, I_{OUT} = 8 A

6.2.2 Switching

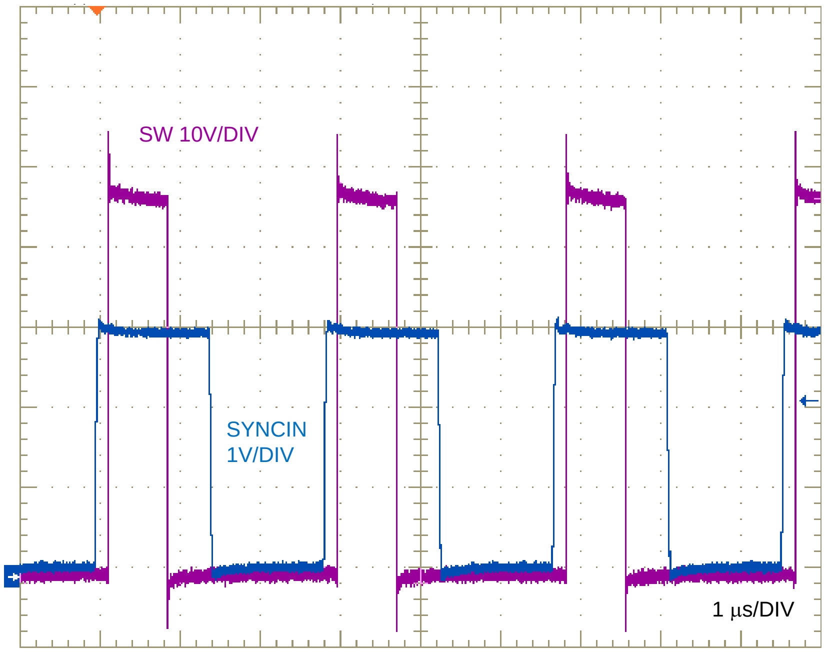


Figure 6. SW Node and SYNCIN Voltages, V_{IN} = 48 V, I_{OUT} = 8 A, F_{SW} = 350 kHz

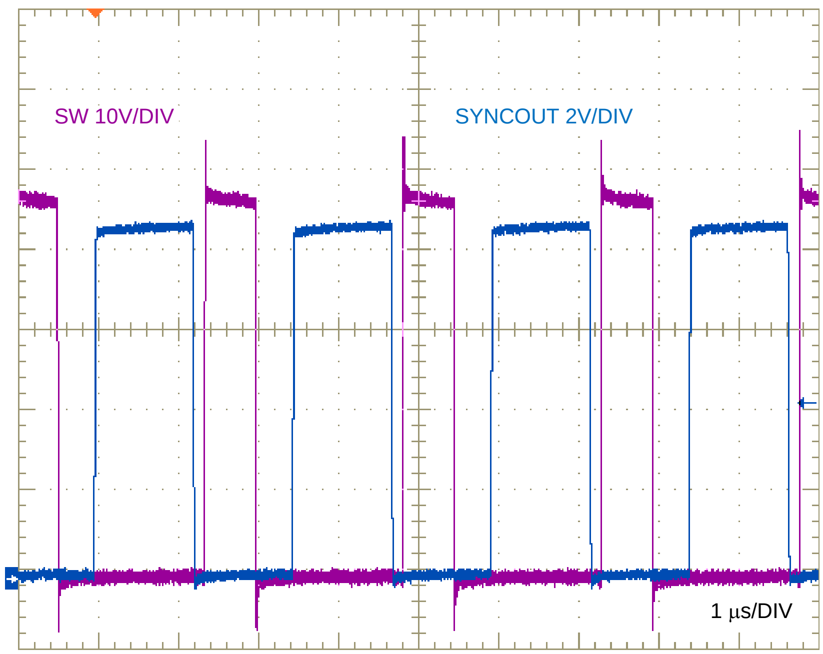


Figure 7. SW Node and SYNCOUT Voltages, V_{IN} = 48 V, I_{OUT} = 8 A

6.2.3 ENABLE ON and OFF

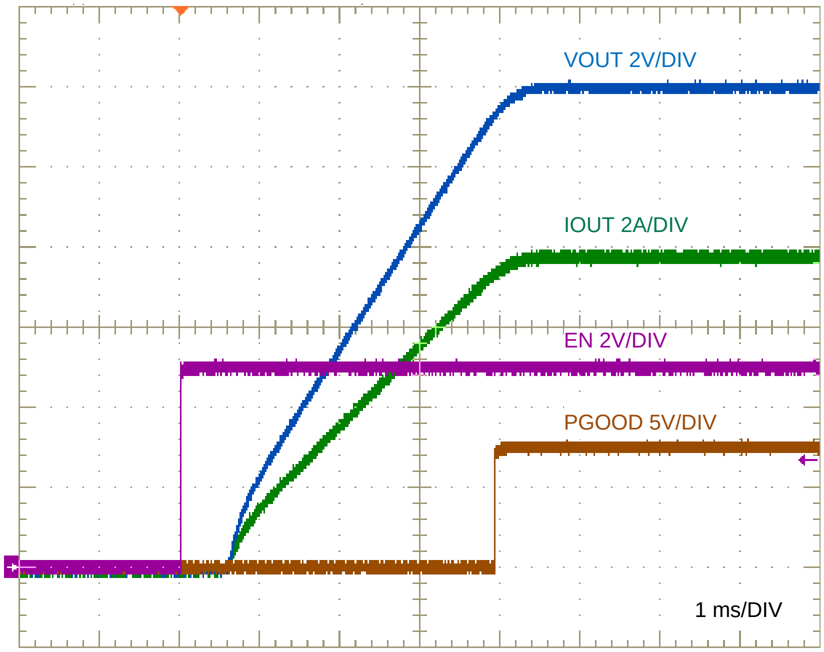


Figure 8. ENABLE ON, V_{IN} = 48 V, I_{OUT} = 8 A Resistive

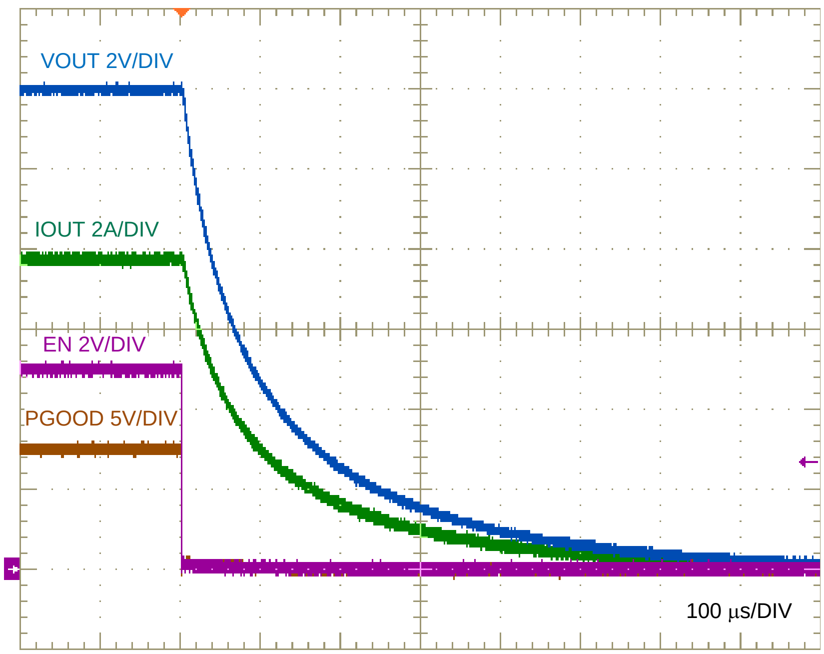


Figure 9. ENABLE OFF, V_{IN} = 48 V, I_{OUT} = 8 A Resistive

6.2.4 Start-Up and Shutdown

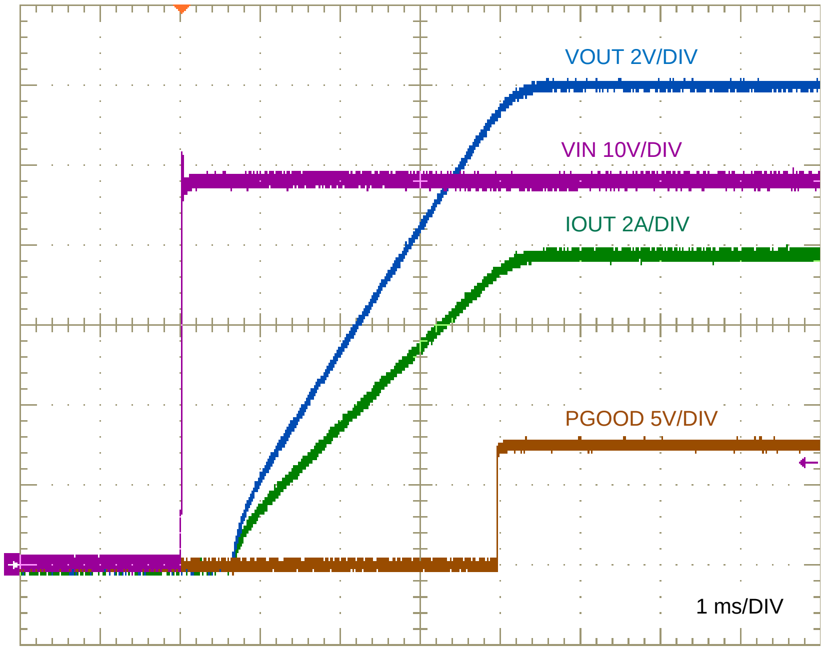


Figure 10. Start-Up, V_{IN} = 48 V, I_{OUT} = 8 A Resistive

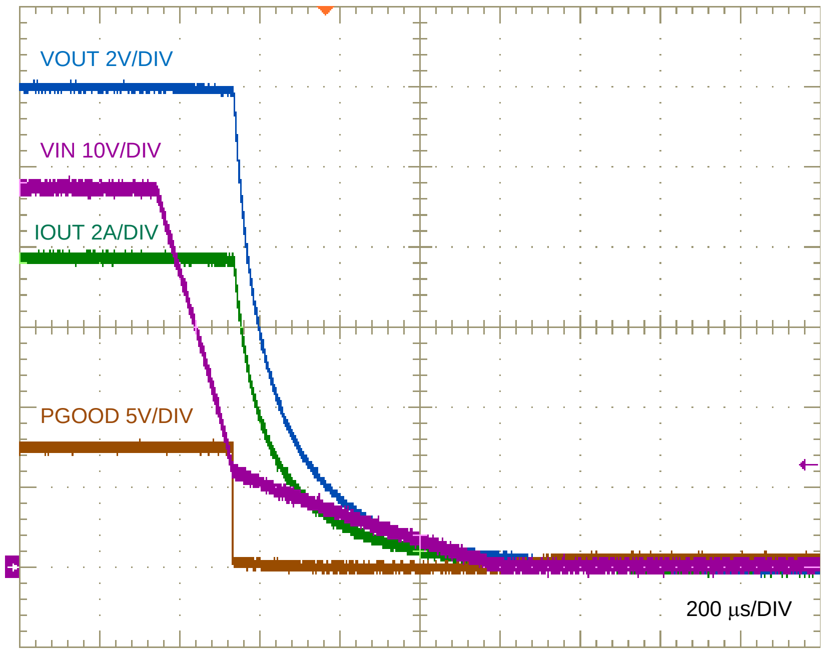


Figure 11. Shutdown, V_{IN} = 48 V, I_{OUT} = 8 A Resistive

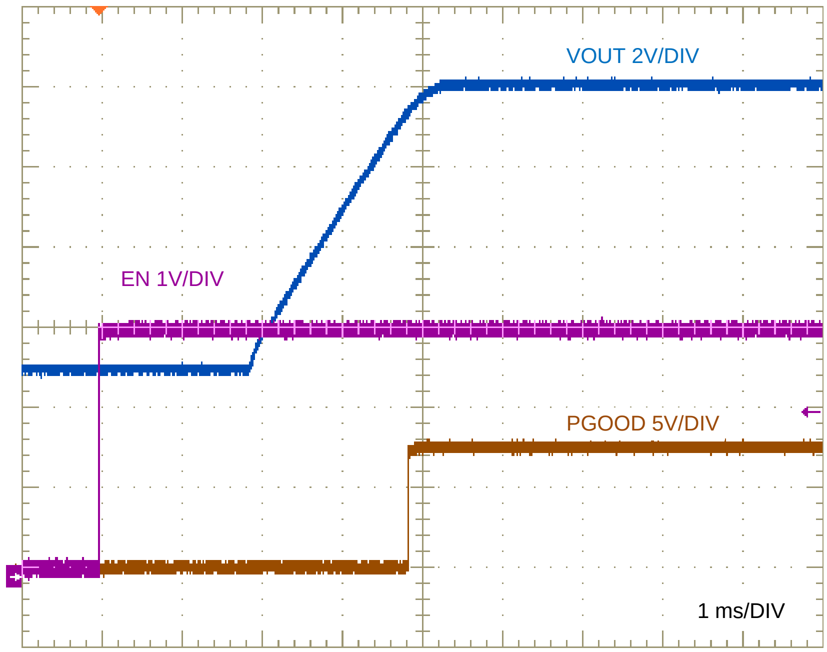


Figure 12. Pre-Biased Start-up, V_{IN} = 48 V, I_{OUT} = 0 A, $V_{OUT(PRE-BIAS)}$ = 5 V

6.2.5 Line Transient Response

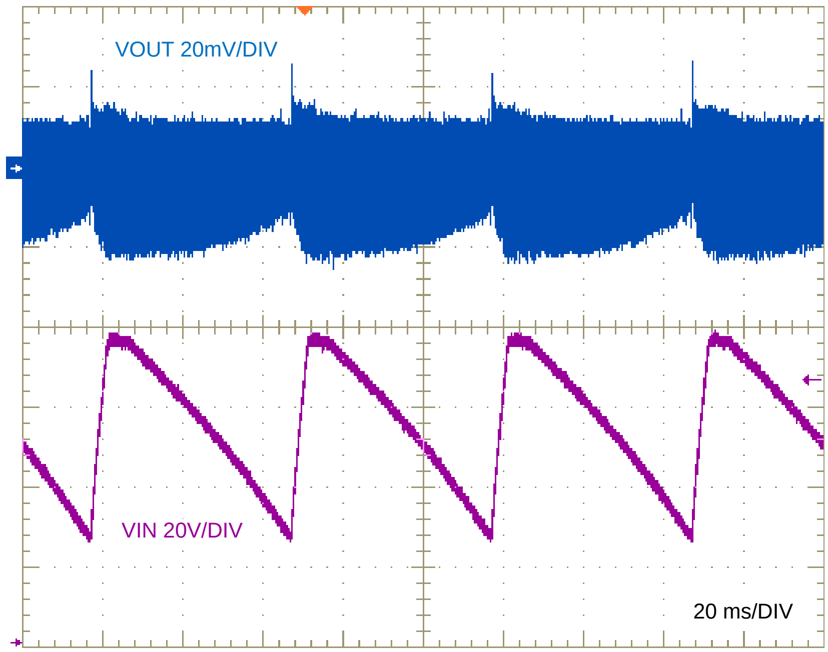


Figure 13. Input Voltage Repetitive Transient from 24 V to 75 V, I_{OUT} = 4 A

6.2.6 Load Transient Response

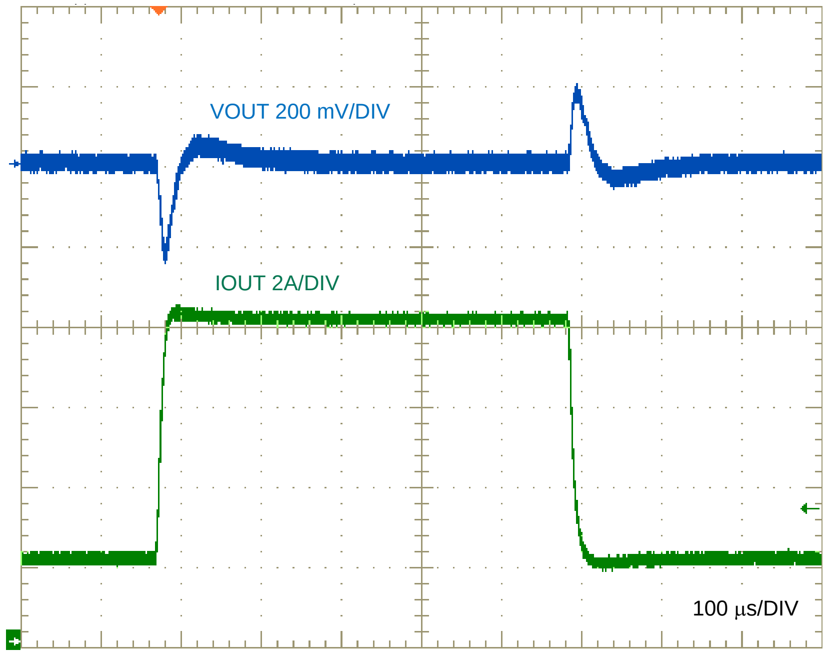


Figure 14. Load Transient Response, V_{IN} = 48 V, 2 A to 8 A at 1 A/µs

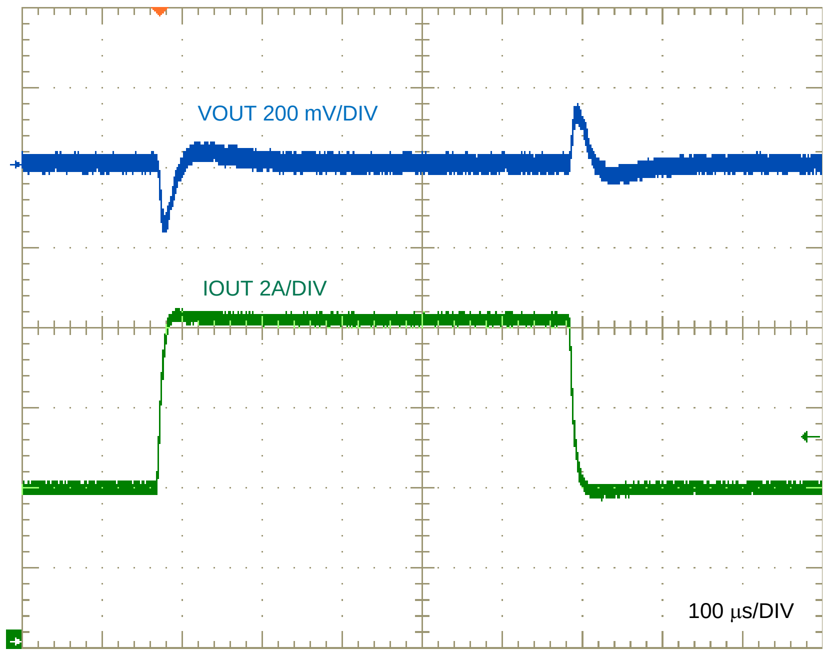


Figure 15. Load Transient Response, V_{IN} = 48 V, 4 A to 8 A at 1 A/µs

6.3 Thermal Performance

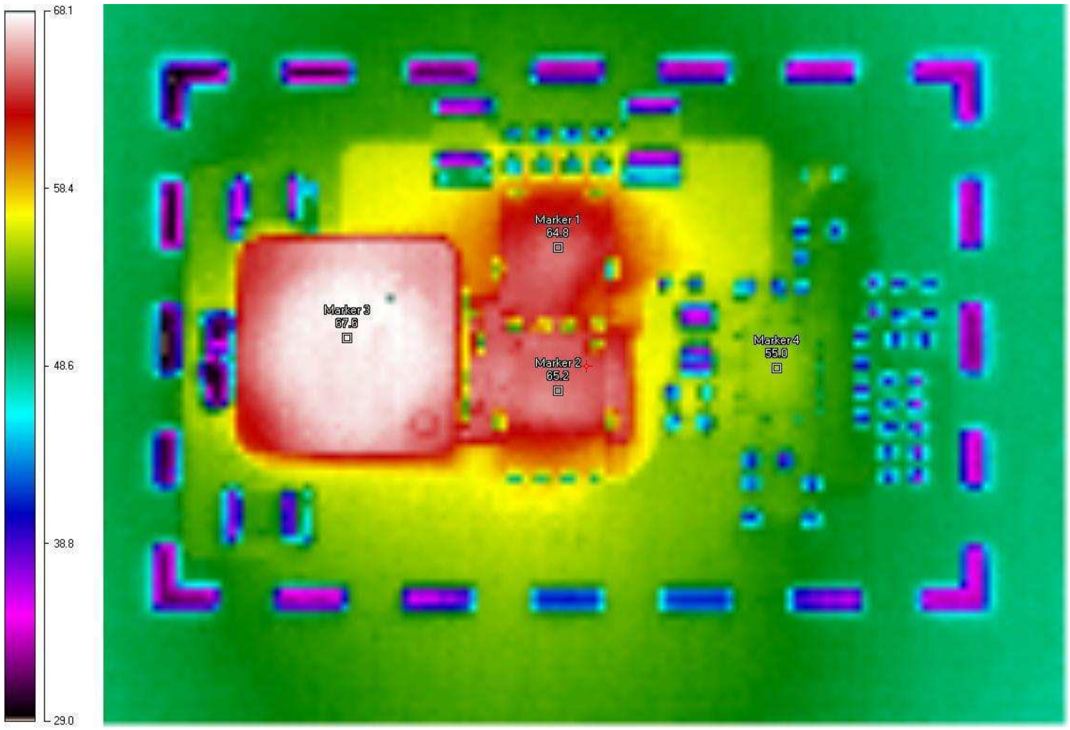


Figure 16. Thermal Performance at V_{IN} = 24 V, I_{OUT} = 8 A, No Airflow

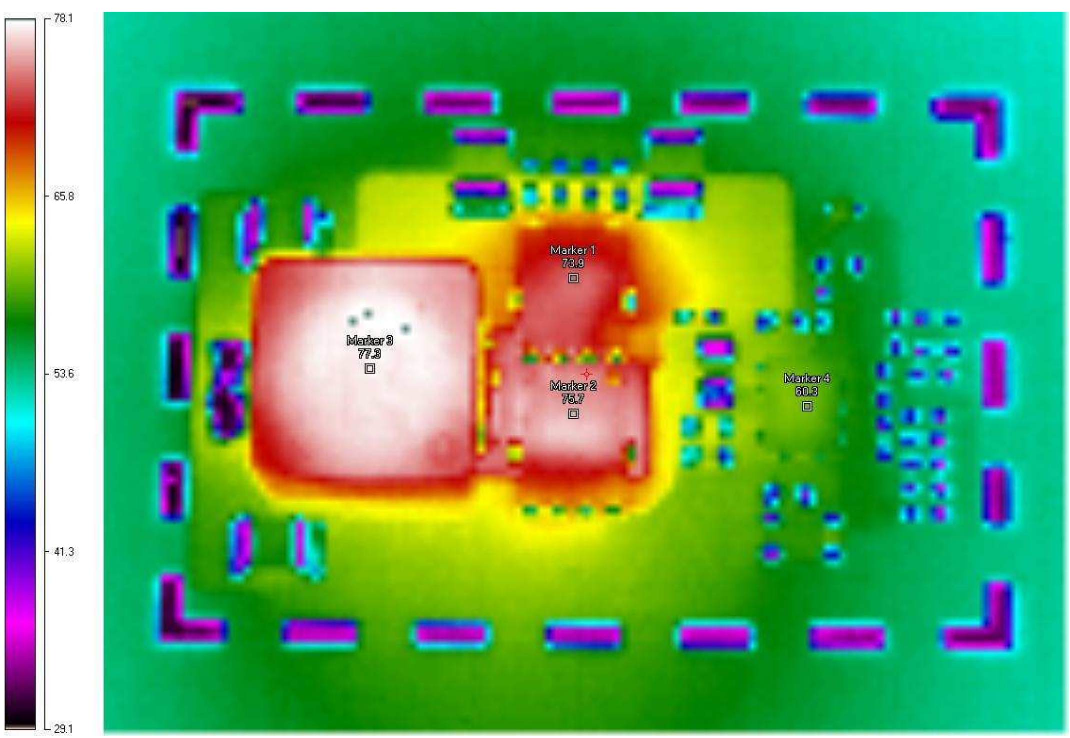
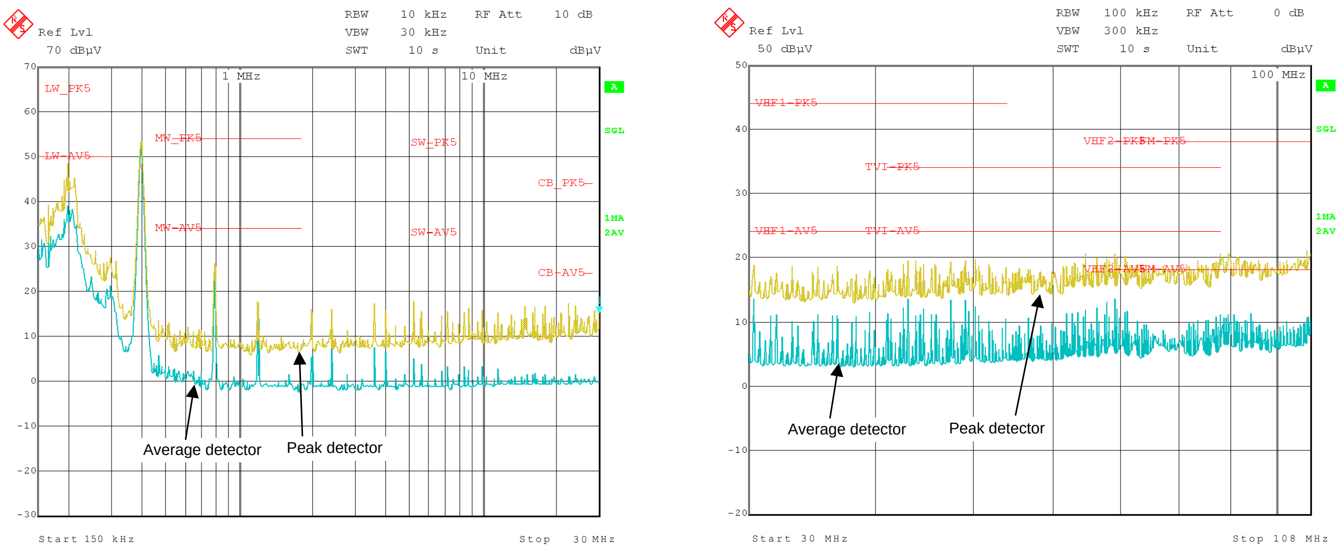


Figure 17. Thermal Performance at V_{IN} = 48 V, I_{OUT} = 8 A, No Airflow

6.4 CISPR 25 EMI Performance

Figure 18 represents the EMI performance of the LM5146-Q1 EVM for conducted emissions over a frequency range of 150 kHz to 108 MHz using a 5-µH LISN according to the CISPR 25 specification. CISPR 25 Class 5 peak and average limits are denoted in red. The yellow and blue spectra are measured using peak and average detection, respectively. The only modification to the EVM is that an EMI shield, denoted S1 in Table 4, is installed on the pads provided on the PCB.



(a) (b)

Figure 18. CISPR 25 Class 5 Conducted Emissions Plot, V_{IN} = 48 V, I_{OUT} = 6 A, (a) 150 kHz to 30MHz, (b) 30MHz to 108 MHz

7 EVM Documentation

7.1 Schematic

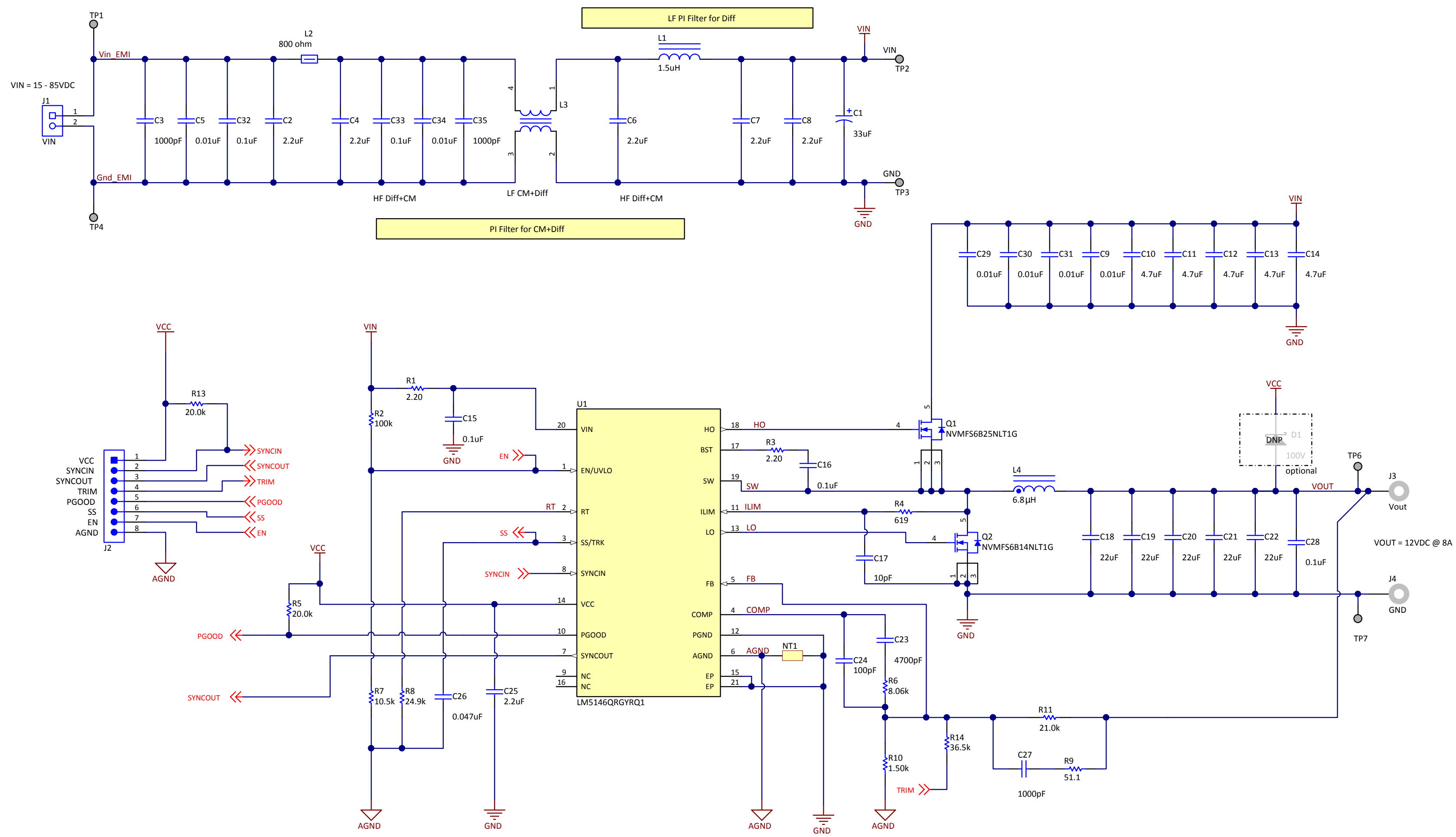


Figure 19. EVM Schematic

7.2 Bill of Materials

Table 4. Bill of Materials

COUNT	REF DES	DESCRIPTION	PART NUMBER	MFR
3	C1, C9, C21	Capacitor, Ceramic, 10nF, 100V, X7R, 0603	Std	Std
1	C1	Capacitor, AL, 33 µF, 100 V, ±20%, AEC-Q200	EEE-FK2A330P	Panasonic
5	C2, C4, C6, C7, C8	Capacitor, Ceramic, 2.2µF, 100V, X7R, 1210, AEC-Q200	CGA6N3X7R2A225K	TDK
			HMK325B7225KM-P	Taiyo Yuden
		Capacitor, Ceramic, 2.2µF, 100V, X7S, 1206, AEC-Q200	GCM31CC72A225KE02	Murata
2	C3, C35	Capacitor, Ceramic, 1nF, 100V, X7R, 10%, 0603	Std	Std
6	C5, C9, C29, C30, C31, C34	Capacitor, Ceramic, 10nF, 100V, X7R, 10%, 0603	Std	Std
5	C15, C16, C28, C32, C33	Capacitor, Ceramic, 100nF, 100V, X7R, 10%, 0603	Std	Std
1	C17	Capacitor, Ceramic, 10pF, 100V, X7R, 10%, 0603	Std	Std
5	C18, C19, C20, C21, C22	Capacitor, Ceramic, 22µF, 25V, X7R, 1210, AEC-Q200	GCM32EC71E226KE36	Murata
			TMK325B7226KMHT	Taiyo Yuden
			CGA6P3X7R1E226M	TDK
1	C23	Capacitor, Ceramic, 4.7nF, 16V, X7R, 10%, 0402	Std	Std
1	C24	Capacitor, Ceramic, 100pF, 50V, C0G, 10%, 0402	Std	Std
1	C25	Capacitor, Ceramic, 2.2µF, 25V, X7R, 0805	Std	Std
1	C26	Capacitor, Ceramic, 47nF, 16V, X7R, 10%, 0402	Std	Std
1	C27	Capacitor, Ceramic, 1nF, 50V, X7R, 10%, 0402	Std	Std
1	D1	Schottky Diode, 100V, 0.2A, SOD523	BAT41KFILM	ST
4	H1, H2, H3, H4	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	NY PMS 440 0025 PH	B & F Fastener Supply
4	H5, H6, H7, H8	Standoff, Hex, 0.5"L #4-40 Nylon Standoff	1902C	Keystone
1	L1	Inductor, 1.5µH ±20%, 12.5mΩ max, 9A Isat, AEC-Q200	VCMT063T-1R5MN5	Cyntec
		Inductor, 1.5µH ±20%, 9.6mΩ max, 15A Isat, AEC-Q200	XEL6030-152MEC	Coilcraft
1	L2	Ferrite Bead, 800 Ω @ 100 MHz, 8 A, 2220	HR2220V801R-10	Laird
1	L3	Common-Mode Choke, 8A, 700 Ω @ 100 MHz, 6 mΩ, AEC-Q200	ACM12V-701-2PL-TL00	TDK
1	L4	Inductor, 6.8µH ±20%, 12mΩ typ, 13.5A, 5.2mm max, AEC-Q200	VCHA105D-6R8MS6	Cyntec
		Inductor, 6.8µH ±20%, 13.3mΩ typ, 21.45A, 6.5mm max, AEC-Q200	SPM10065VT-6R8M-D	TDK
1	Q1	MOSFET, N-Channel, 100V, 22mΩ, SON 5 × 6, AEC-Q101	NVMFS6B25NLT1G	ON Semiconductor
1	Q2	MOSFET, N-Channel, 100V,10mΩ, SON 5 × 6, AEC-Q101	NVMFS6B14NLT1G	ON Semiconductor
2	R1, R3	Resistor, Chip, 2.2, 0.1W, 1%, 0603	Std	Std
1	R2	Resistor, Chip, 100kΩ, 0.1W, 1%, 0603	Std	Std
1	R4	Resistor, Chip, 619Ω, 1/16W, 1%, 0402	Std	Std
1	R5	Resistor, Chip, 20kΩ, 1/16W, 1%, 0402	Std	Std
1	R6	Resistor, Chip, 8.06kΩ, 1/16W, 1%, 0402	Std	Std
1	R7	Resistor, Chip, 9.31kΩ, 1/16W, 1%, 0402	Std	Std
1	R8	Resistor, Chip, 24.9kΩ, 1/16W, 1%, 0402	Std	Std
1	R9	Resistor, Chip, 51.1Ω, 1/16W, 1%, 0402	Std	Std
1	R10	Resistor, Chip, 1.5kΩ, 1/16W, 1%, 0402	Std	Std
1	R11	Resistor, Chip, 21kΩ, 1/16W, 1%, 0402	Std	Std
1	R13	Resistor, Chip, 20kΩ, 0.1W, 1%, 0603	Std	Std
1	R14	Resistor, Chip, 36.5kΩ, 1/16W, 1%, 0402	Std	Std
1	U1	IC, LM5146-Q1, Wide V_{IN} Synchronous Buck Controller, VQFN-20	LM5146QRGYRQ1	TI
1	PCB1	PCB, FR4, 4 layer, 2 oz, 80 mm x 63 mm	PCB	–
1	J1	Terminal Block Connector, 3.5mm, 2 × 1 for VIN+, VIN–	1984617	Phoenix Contact
0	J2	Header, SMT for VCC, SYNCIN, SYNCOUT, PGOOD, TRIM, SS, EN, AGND	TSW-108-07-G-S	Samtec
2	J3, J4	Standard Banana Jack, Uninsulated, 8.9mm	575-8	Keystone
0	S1	Two-Piece Shield, SMT, 38mm × 25.4mm × 6mm	BMI-S-205-F	Laird Technologies
4	TP1, TP2, TP3, TP4	Connector, SMT	5017	Keystone

7.3 PCB Layout

Figure 20 through Figure 25 show the design of the LM5146-Q1 EVM using a 4-layer PCB with 2-oz copper thickness. The EVM is essentially a single-sided design except for some filtering components located on the bottom side.

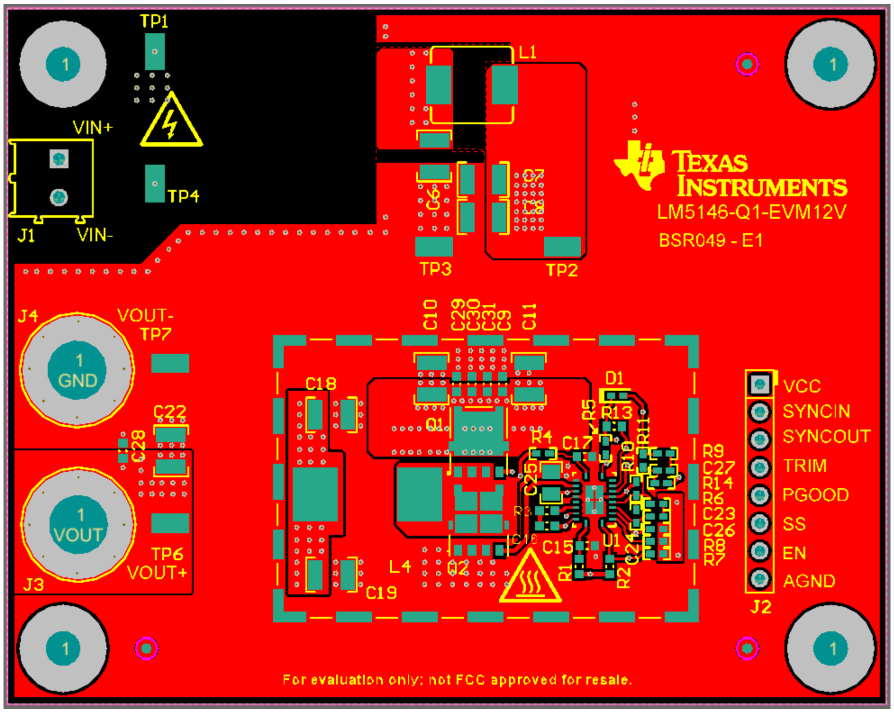


Figure 20. Top Copper (Top View)

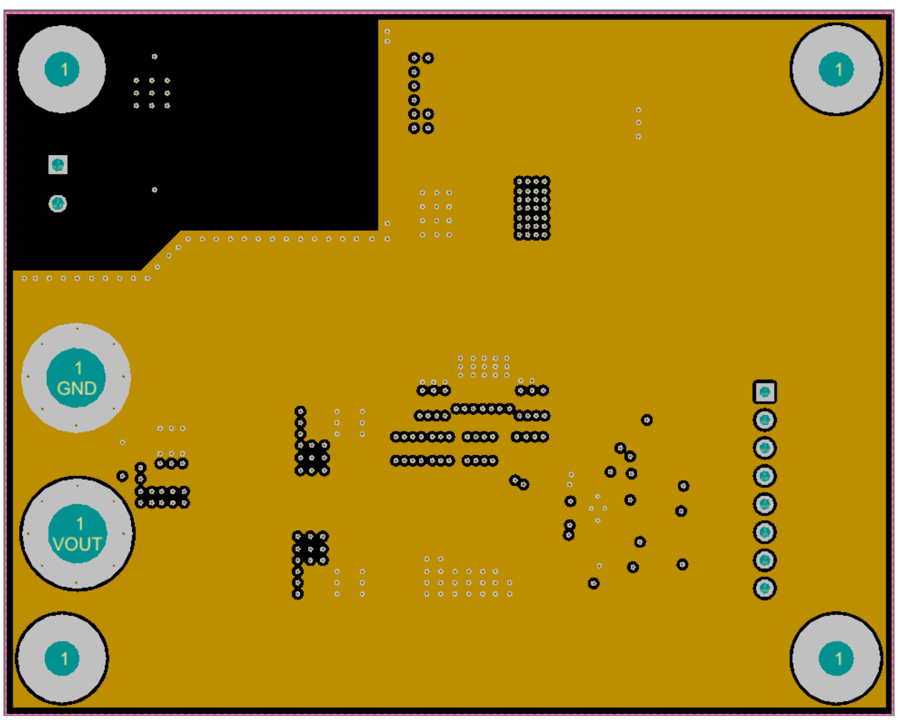


Figure 21. Layer 2 Copper (Top View)

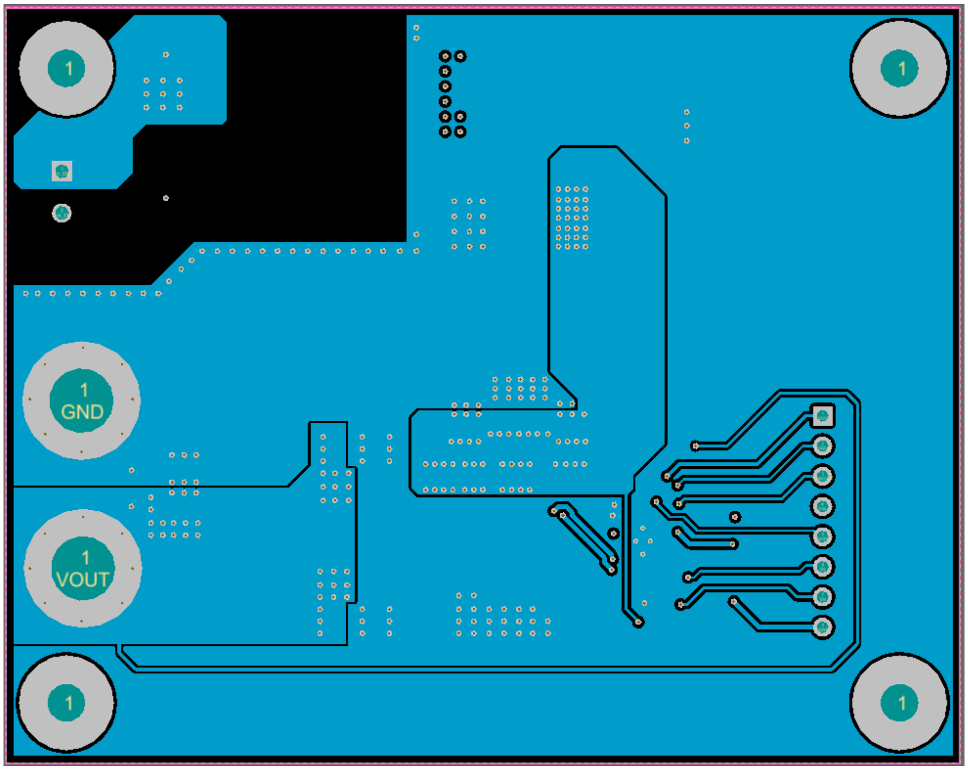


Figure 22. Layer 3 Copper (Top View)

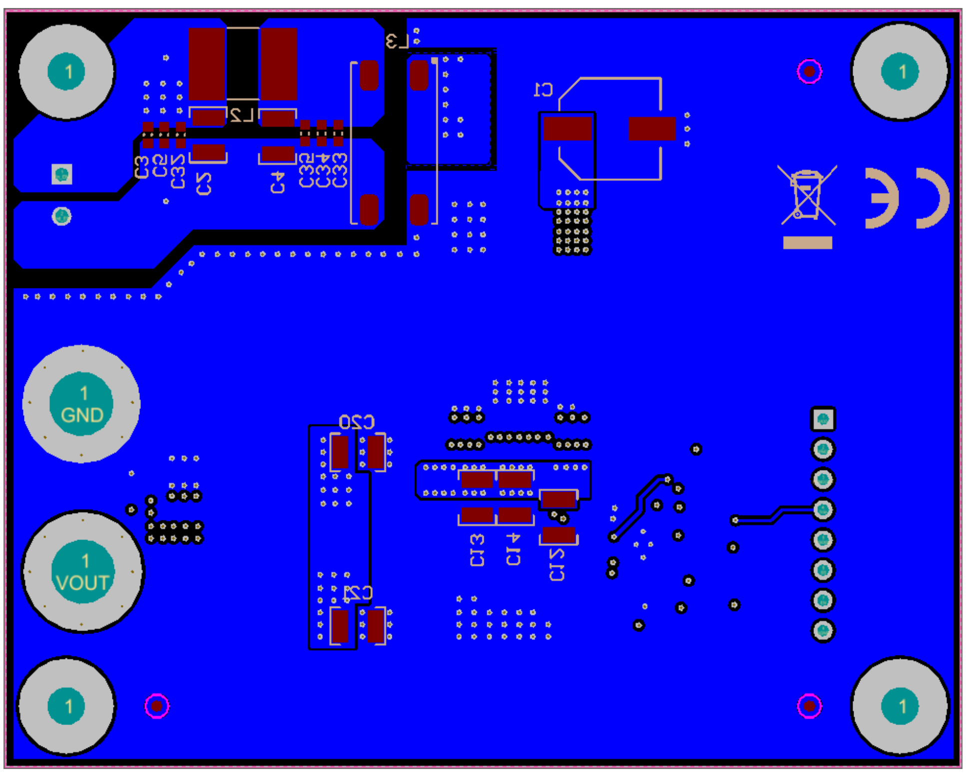


Figure 23. Bottom Copper (Top View)

7.4 Assembly Drawings

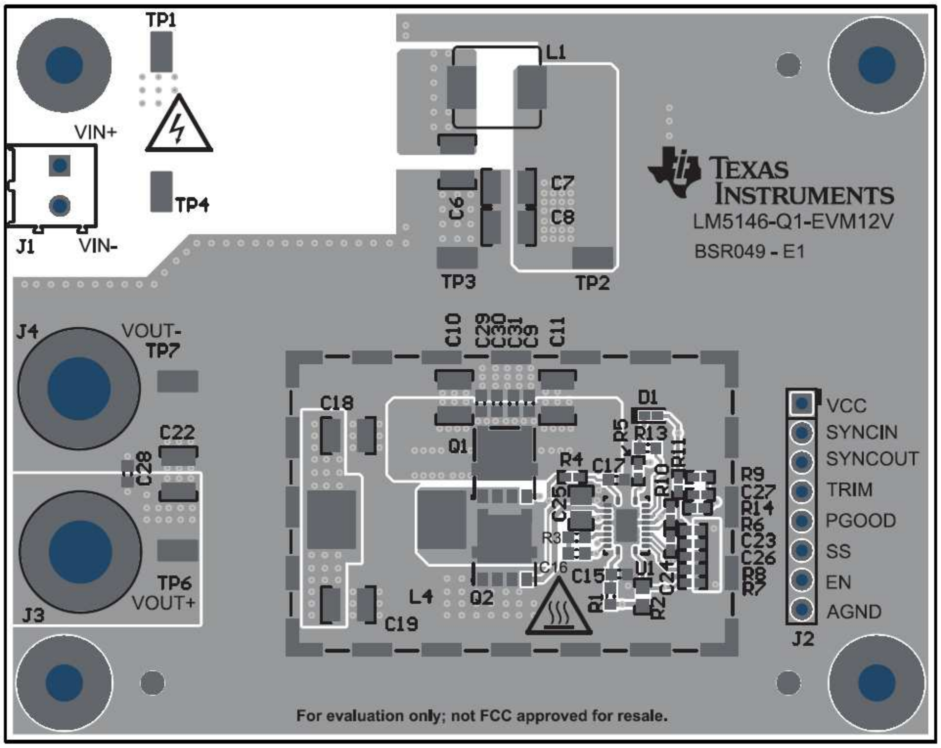


Figure 24. Top Component Drawing

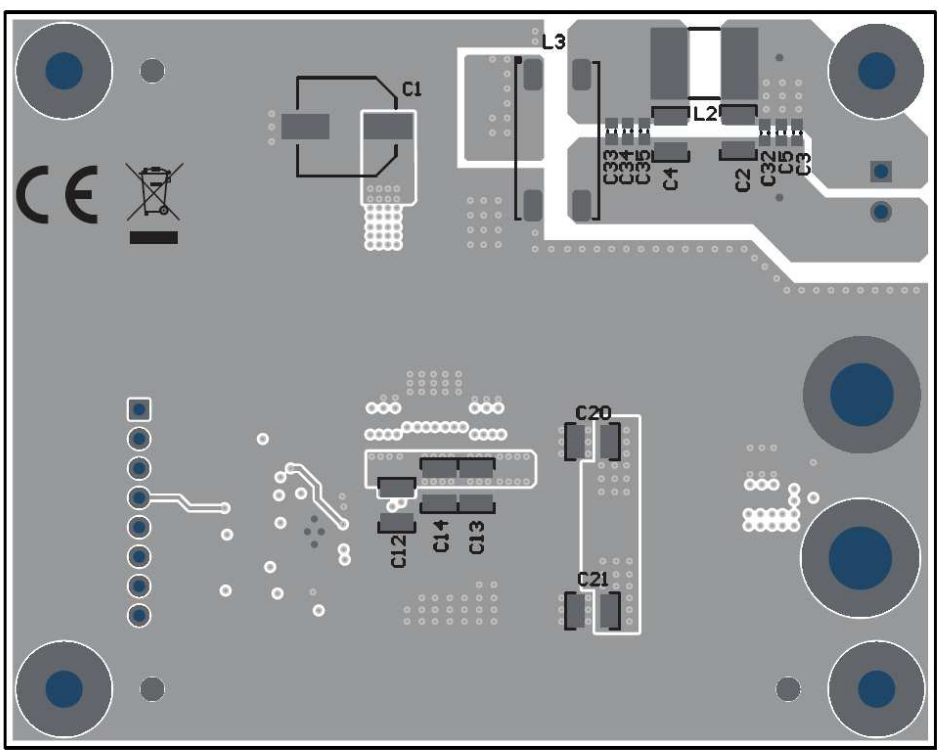


Figure 25. Bottom Component Drawing

8 Device and Documentation Support

8.1 Device Support

8.1.1 Development Support

For development support see the following:

- For TI's reference design library, visit TI Designs
- For TI's WEBENCH Design Environments, visit the WEBENCH® Design Center
- LM5146-Q1 DC-DC Controller Quickstart Calculator and PSPICE simulation model

8.2 Documentation Support

8.2.1 Related Documentation

For related documentation see the following:

- *LM5146-Q1 100-V Synchronous Buck Controller Data Sheet* (SNVSB32)
- *LM5145 EVM User's Guide* (SNVU545)
- *Reduce Buck Converter EMI and Voltage Stress by Minimizing Inductive Parasitics* (SLYT682)
- *AN-2162 Simple Success with Conducted EMI from DC-DC Converters* (SNVA489)
- White Papers:
  – *Valuing Wide VIN, Low EMI Synchronous Buck Circuits for Cost-driven, Demanding Applications* (SLYY104)
  – *An Overview of Conducted EMI Specifications for Power Supplies* (SLYY136)
  – *An Overview of Radiated EMI Specifications for Power Supplies* (SLYY142)
- Power House Blogs:
  – *Synchronous Buck Controller Solutions Support Wide V_{IN} Performance and Flexibility*

8.2.1.1 PCB Layout Resources

- *AN-1149 Layout Guidelines for Switching Power Supplies* (SNVA021)
- *AN-1229 Simple Switcher PCB Layout Guidelines* (SNVA054)
- *Constructing Your Power Supply – Layout Considerations* (SLUP230)
- *Low Radiated EMI Layout Made SIMPLE with LM4360x and LM4600x* (SNVA721)
- Power House Blogs:
  – *High-Density PCB Layout of DC-DC Converters*

8.2.1.2 Thermal Design Resources

- *AN-2020 Thermal Design by Insight, Not Hindsight* (SNVA419)
- *AN-1520 A Guide to Board Layout for Best Thermal Resistance for Exposed Pad Packages* (SNVA183)
- *Semiconductor and IC Package Thermal Metrics* (SPRA953)
- *Thermal Design Made Simple with LM43603 and LM43602* (SNVA719)
- *PowerPAD Thermally Enhanced Package* (SLMA002)
- *PowerPAD Made Easy* (SLMA004)
- *Using New Thermal Metrics* (SBVA025)