

LM5145EVM-HD-20A High Density Evaluation Module

The [LM5145EVM-HD-20A](#) 100-W high density 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 24 V to 72 V providing a regulated 5-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 3.3 V to 8 V as needed.

The module design uses the LM5145 75-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 220 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 [LM5145](#) is available in a 20-pin VQFN package with 3.5-mm × 4.5-mm footprint to enable DC-DC solutions with high density and low component count. Please consult the [LM5145 6-V to 75-V Synchronous Buck DC-DC Controller With Wide Duty Cycle Range](#) data sheet for more information. Use the LM5145 with [WEBENCH® Power Designer](#) to create a custom regulator design. Furthermore, the user can download the [LM5145 Quickstart Calculator](#) to optimize component selection and examine predicted efficiency performance across line and load ranges.

Contents

1	High Density EVM Description	3
	1.1 Typical Applications	3
	1.2 Features and Electrical Performance	3
2	EVM Performance Specifications	4
3	Application Circuit Diagram	5
4	EVM Photo	6
5	Test Setup and Procedure	6
	5.1 Test Setup	6
	5.2 Test Equipment	8
	5.3 Recommended Test Setup	8
	5.4 Test Procedure	8
6	Test Data and Performance Curves	9
	6.1 Conversion Efficiency	9
	6.2 Operating Waveforms	10
	6.3 Thermal Performance	16
7	EVM Documentation	17
	7.1 Schematic	17
	7.2 Bill of Materials	18
	7.3 PCB Layout	19
	7.4 Assembly Drawings	21
8	Device and Documentation Support	22
	8.1 Device Support	22
	8.2 Documentation Support	22

List of Figures

1	LM5145 Synchronous Buck Regulator Simplified Schematic	5
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2	LM5145 EVM Photo	6
3	EVM Test Setup	7
4	Conversion Efficiency, FPWM Mode (SYNCIN Tied High).....	9
5	Conversion Efficiency, Diode Emulation Mode Enabled (SYNCIN Tied Low)	9
6	SW Node Voltage and Output Ripple, $I_{OUT} = 20\text{ A}$, $V_{IN} = 48\text{ V}$	10
7	SW Node and SYNCOUT Voltages, $V_{IN} = 48\text{ V}$	10
8	Load Transient Response, $V_{IN} = 48\text{ V}$, FPWM, 10 A to 20 A at 1 A/ μs	11
9	Load Transient Response, $V_{IN} = 48\text{ V}$, FPWM, 0 A to 20 A at 1 A/ μs	11
10	Input Voltage Rising Transient from 12 V to 72 V, $I_{OUT} = 10\text{ A}$ (ENABLE Terminal Tied High)	12
11	Input Voltage Falling Transient From 72 V to 12 V, $I_{OUT} = 10\text{ A}$ (ENABLE Terminal Tied High).....	12
12	ENABLE ON, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive	13
13	ENABLE OFF, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive	13
14	Start-Up, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive	14
15	Shutdown, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive	14
16	Pre-Biased Start-up, $V_{IN} = 48\text{ V}$, $I_{OUT} = 0\text{ A}$	15
17	Thermal Performance at $V_{IN} = 48\text{ V}$, $I_{OUT} = 10\text{ A}$, 200 LFM Airflow	16
18	Thermal Performance at $V_{IN} = 48\text{ V}$, $I_{OUT} = 15\text{ A}$, 200 LFM Airflow	16
19	EVM Schematic	17
20	Top Copper (Top View)	19
21	Layer 2 Copper (Top View)	19
22	Layer 3 Copper (Top View)	20
23	Bottom Copper (Top View).....	20
24	Top Assembly.....	21
25	Bottom Assembly	21

List of Tables

1	Electrical Performance Specifications.....	4
2	EVM Connections.....	6
3	Bill of Materials	18

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1 High Density EVM Description

The [LM5145EVM-HD-20A](#) high density EVM is designed to use a regulated or non-regulated high-voltage input rail ranging from 24 V to 72 V to produce a tightly-regulated output voltage of 5 V at load currents up to 20 A. This wide V_{IN} range DC-DC solution offers oversized voltage rating and operating margin to withstand supply rail voltage transients.

The free-running switching frequency is 220 kHz and is synchronizable to an external clock signal at a higher or lower frequency. A high-current edge connector is available to connect VIN, VOUT, and GND power terminals. The power-train passive components selected for this EVM, including buck inductor and ceramic input and output capacitors, are available from multiple component vendors.

1.1 Typical Applications

- Distributed point-of-load (POL) regulator modules
- Industrial and commercial vehicles
- Battery-powered drones
- Network and computing voltage regulators
- RF power amplification, PoE, and IP camera systems

1.2 Features and Electrical Performance

- Tightly-regulated output voltage of 5 V with better than $\pm 1\%$ setpoint accuracy
- Wide input voltage operating range of 24 V to 72 V
- Full load current of 20 A available with recommended airflow of 200 LFM
- Switching frequency of 220 kHz externally synchronizable up or down
- Ultra-high power conversion efficiency across wide load current range
 - Full load efficiency of 94% and 92.5% at $V_{IN} = 24$ V and 48 V, respectively
 - 93% efficiency at half-rated load, $V_{IN} = 48$ V
- 24-mA no-load supply current at $V_{IN} = 48$ V
- Input π -stage EMI filter with resistive damping
 - Meets EN55022 / CISPR 22 EMI standards
- Voltage-mode control architecture provides fast line and load transient response
 - PWM line feedforward
 - Forced PWM (FPWM) or diode emulation mode operation
 - 94dB, 6.5-MHz voltage-loop error amplifier
- 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-k Ω 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 turnon and turnoff voltage difference
 - Input UVLO set to turn on and off at V_{IN} of **22 V and 19 V**, respectively
- Fully assembled, tested, and proven PCB layout with 50-mm \times 30-mm total footprint

2 EVM Performance Specifications

Table 1. Electrical Performance Specifications

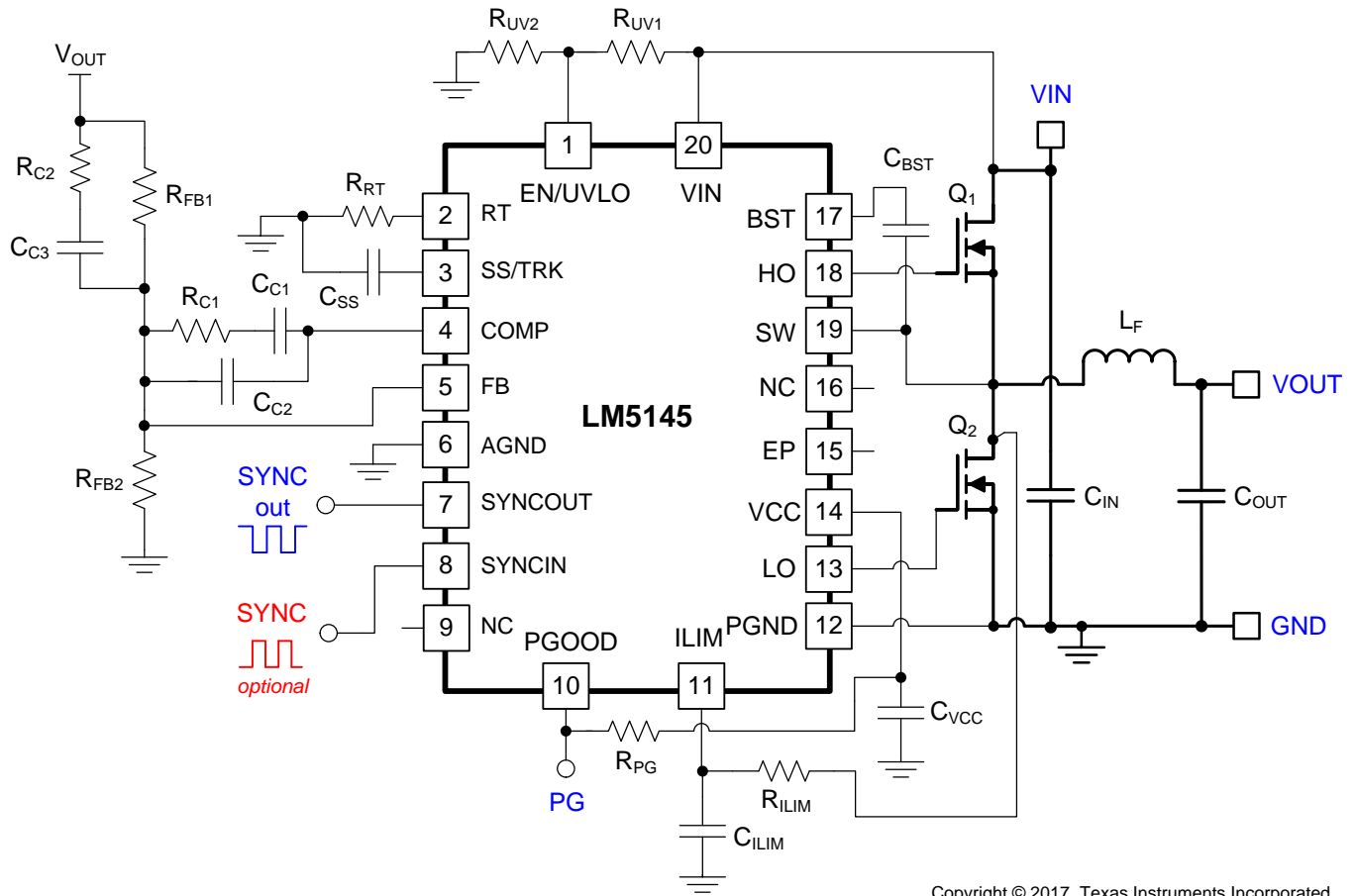
PARAMETER	TEST CONDITIONS		MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS						
Input voltage range, V_{IN}	Operating		24	48	72	V
Input voltage turnon, $V_{IN(ON)}$	Adjusted using EN/UVLO divider resistors		22			V
Input voltage turnoff, $V_{IN(OFF)}$			19			V
Input voltage hysteresis, $V_{IN(HYS)}$			3			V
Input current, no load, $I_{IN(NL)}$	$I_{OUT} = 0$ A	$V_{IN} = 24$ V	26			mA
		$V_{IN} = 48$ V	24			mA
		$V_{IN} = 72$ V	20			mA
Input current, disabled, $I_{IN(OFF)}$	$V_{EN} = 0$ V	$V_{IN} = 48$ V	1			mA
OUTPUT CHARACTERISTICS						
Output voltage, $V_{OUT}^{(1)}$			4.95	5.0	5.05	V
Output current, I_{OUT}	$V_{IN} = 24$ V to 75 V, Airflow = 200LFM ⁽²⁾		0		20	A
Output voltage regulation, ΔV_{OUT}	Load regulation	$I_{OUT} = 0$ A to 20 A	0.2%			
	Line regulation	$V_{IN} = 24$ V to 72 V	0.2%			
Output voltage ripple, $V_{OUT(AC)}$	$V_{IN} = 48$ V, $I_{OUT} = 10$ A		25			mVrms
Output overcurrent protection, I_{OCP}	$V_{IN} = 48$ V		25			A
Soft-start time, t_{SS}	$C_{SS} = 47$ nF		4			ms
SYSTEM CHARACTERISTICS						
Switching frequency, $F_{SW(nom)}$	$V_{IN} = 48$ V		220			kHz
Half-load efficiency, $\eta_{HALF}^{(1)}$	$I_{OUT} = 10$ A	$V_{IN} = 24$ V	95.5%			
		$V_{IN} = 36$ V	94.5%			
		$V_{IN} = 48$ V	94%			
		$V_{IN} = 72$ V	91%			
Full load efficiency, η_{FULL}	$I_{OUT} = 20$ A	$V_{IN} = 24$ V	94%			
		$V_{IN} = 36$ V	93.5%			
		$V_{IN} = 48$ V	92.5%			
		$V_{IN} = 72$ V	90.5%			
LM5145 junction temperature, T_J			-40		125	°C

⁽¹⁾ The default output voltage of this EVM is 5 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 10 A is 200 LFM.

3 Application Circuit Diagram

Figure 1 shows the schematic of an LM5145-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.



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Figure 1. LM5145 Synchronous Buck Regulator Simplified Schematic

Referencing the EVM connections described in [Table 2](#), the recommended test setup to evaluate the LM5145EVM-HD-20A 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.

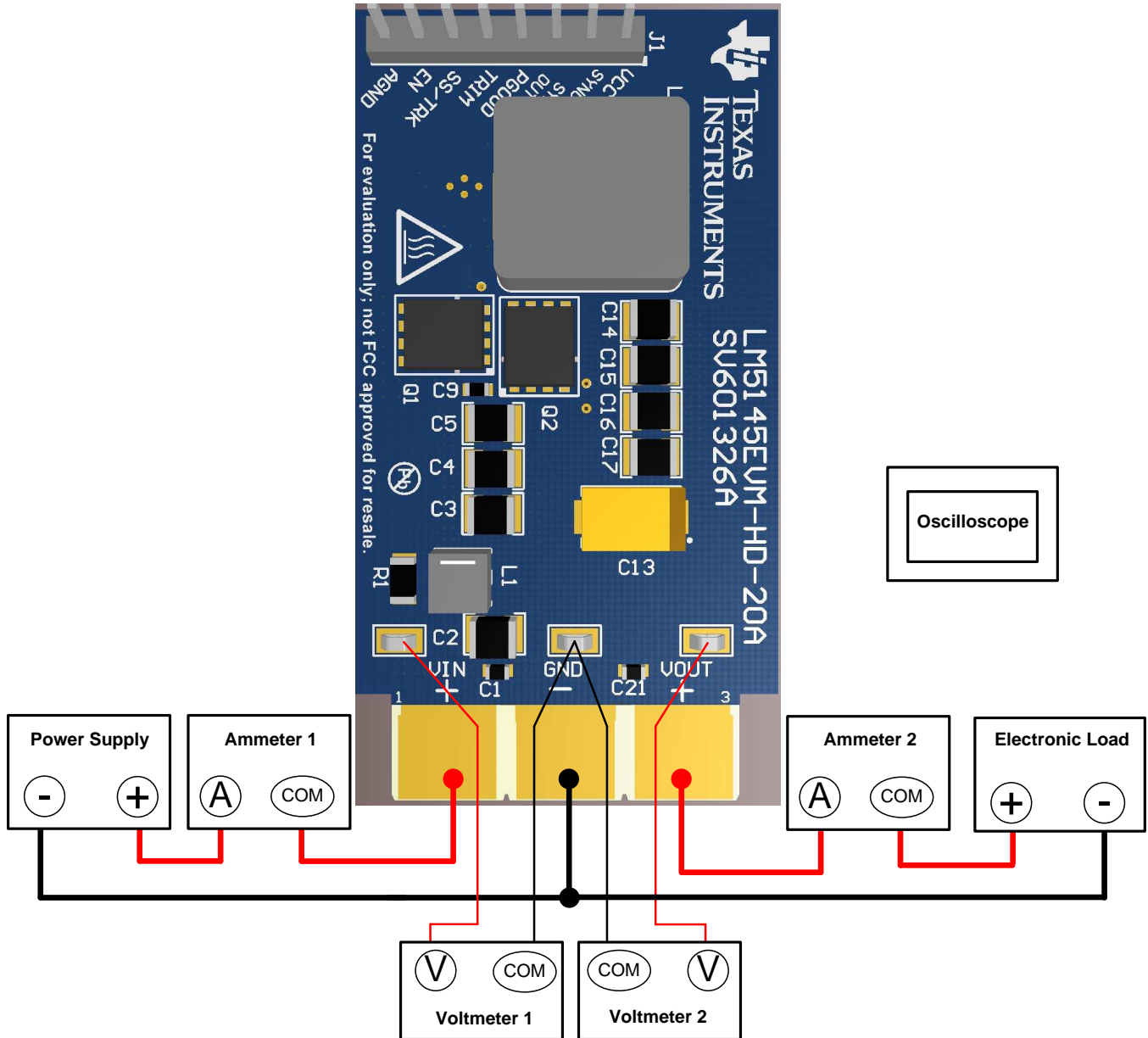


Figure 3. EVM Test Setup

CAUTION

Refer to the [LM5145](#) datasheet, [LM5145 Quickstart Calculator](#) and [WEBENCH® Power Designer](#) for additional guidance pertaining to component selection and converter operation.

5.2 Test Equipment

Voltage Source: The input voltage source V_{IN} should be a 0–72-V variable DC source capable of supplying 10 A.

Multimeters:

- **Voltmeter 1:** Input voltage at VIN to GND. Set voltmeter to an input impedance of 100 M Ω .
- **Voltmeter 2:** Output voltage at VOUT to GND. Set voltmeter to an input impedance of 100 M Ω .
- **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 20 Adc at 5 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 GND 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 GND 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 GND 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 GND 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 10A.
- Using voltmeter 2 to measure the output voltage, V_{OUT} , vary the load current from 0 to 20 A DC; V_{OUT} should remain within the load regulation specification.
- Set the load current to 10 A (50% rated load) and vary the input source voltage from 24 V to 72 V; V_{OUT} should remain within the line regulation specification.
- Decrease load to 0 A. Decrease input source voltage to 0 V.

6 Test Data and Performance Curves

Figure 4 through Figure 13 present typical performance curves for the LM5145EVM-HD-20A. 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

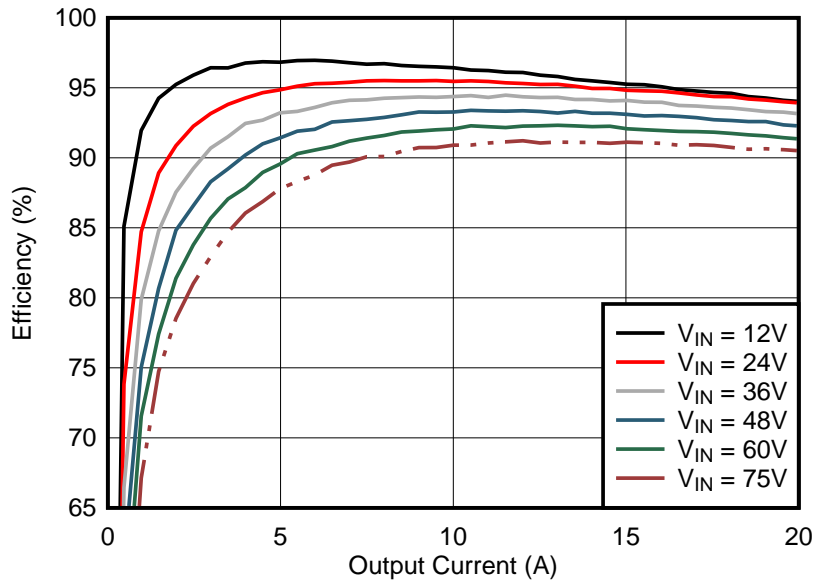


Figure 4. Conversion Efficiency, FPWM Mode (SYNCIN Tied High)

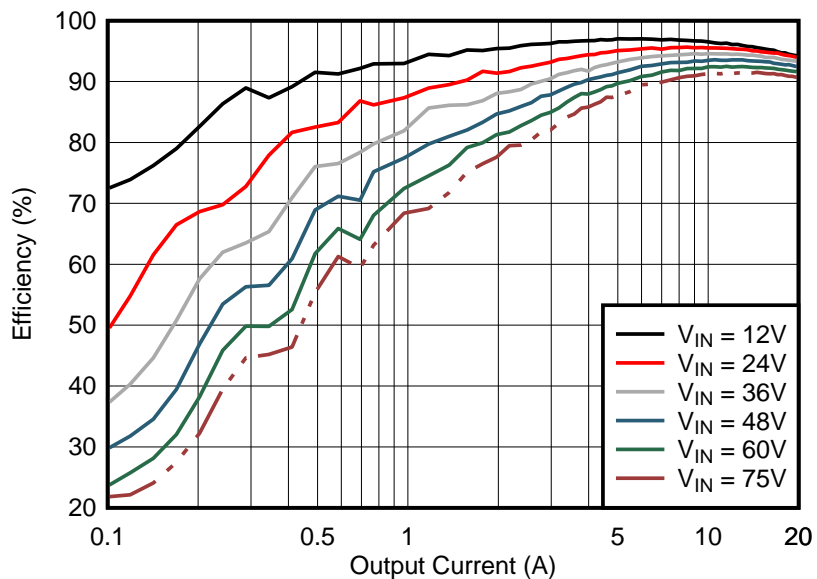


Figure 5. Conversion Efficiency, Diode Emulation Mode Enabled (SYNCIN Tied Low)

6.2 Operating Waveforms

6.2.1 Switching

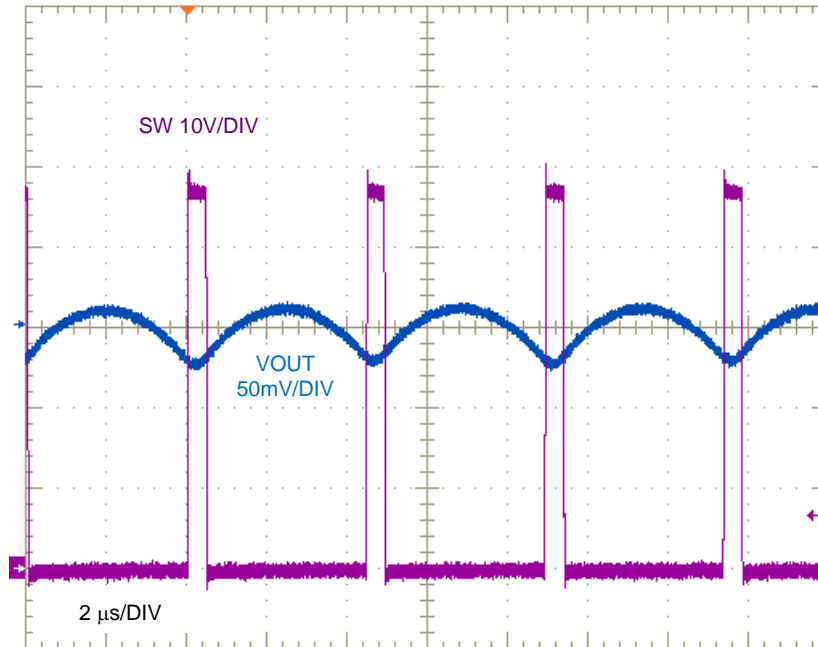


Figure 6. SW Node Voltage and Output Ripple, $I_{OUT} = 20\text{ A}$, $V_{IN} = 48\text{ V}$

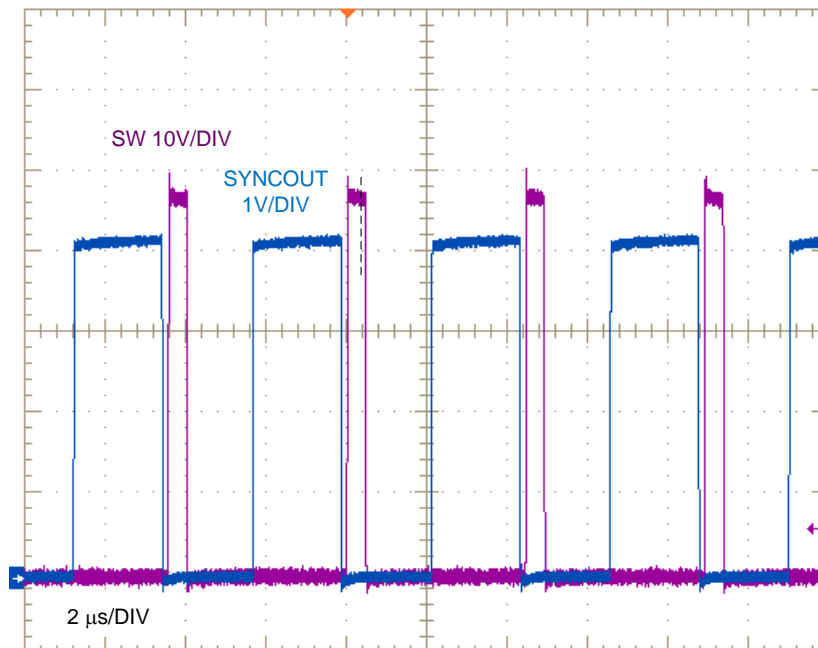


Figure 7. SW Node and SYNCOUT Voltages, $V_{IN} = 48\text{ V}$

6.2.2 Load Transient Response

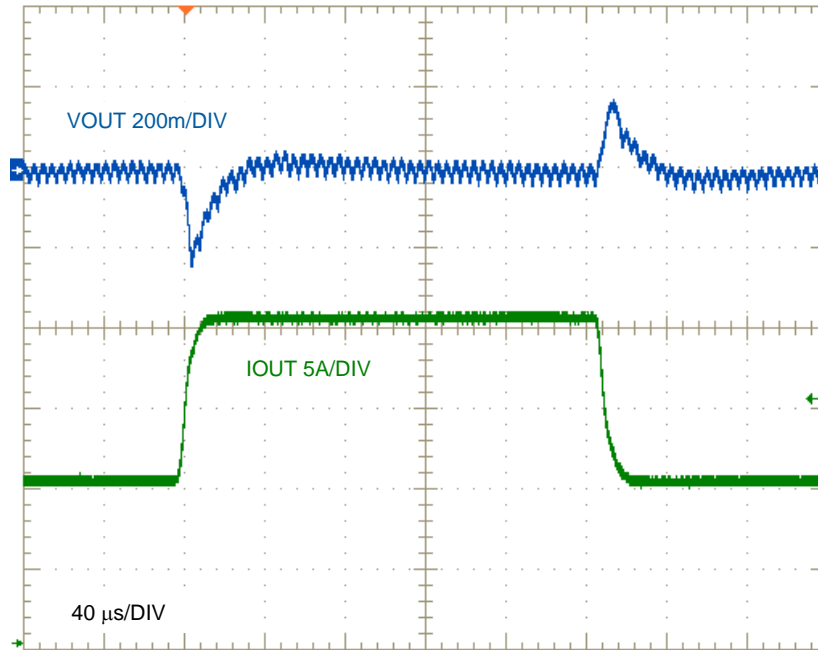


Figure 8. Load Transient Response, $V_{IN} = 48\text{ V}$, FPWM, 10 A to 20 A at 1 A/μs

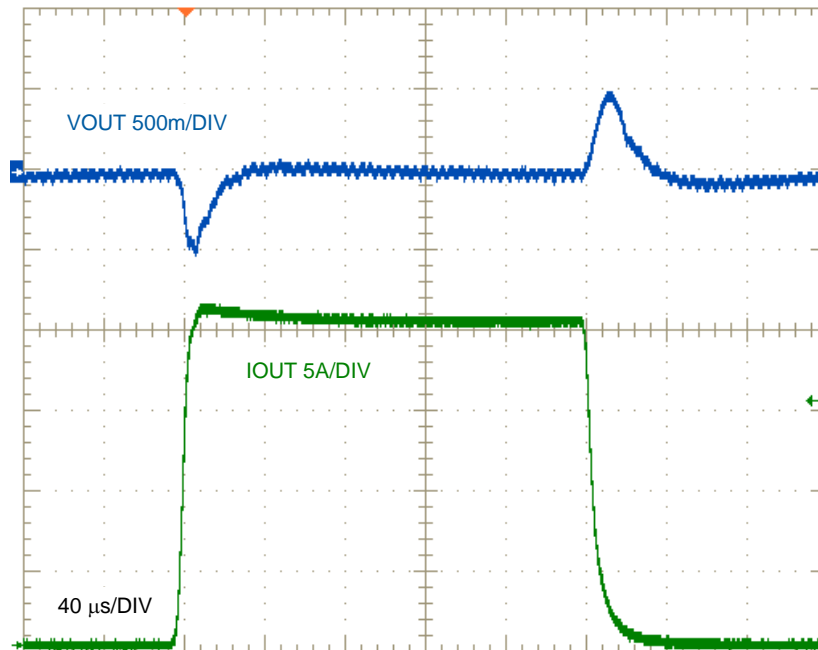


Figure 9. Load Transient Response, $V_{IN} = 48\text{ V}$, FPWM, 0 A to 20 A at 1 A/μs

6.2.3 Line Transient Response

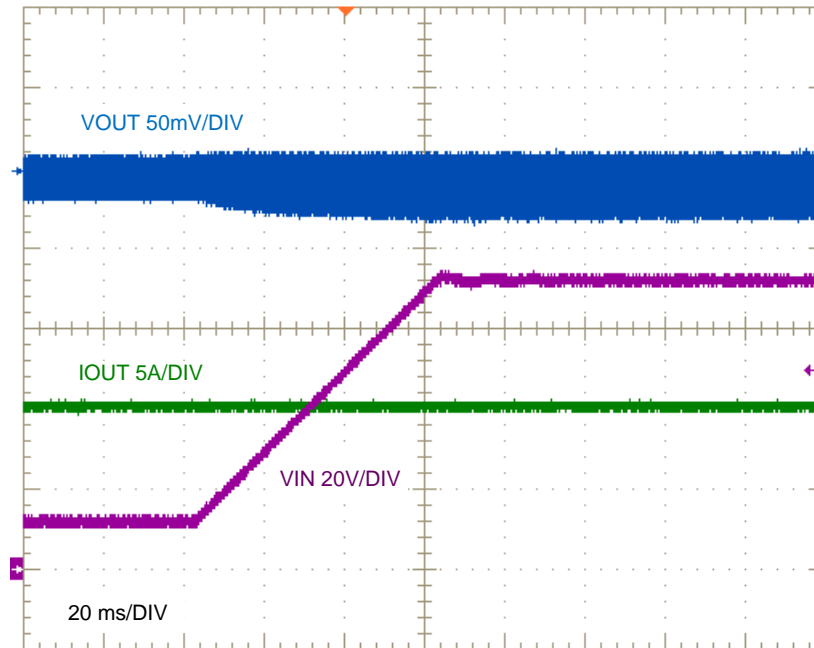


Figure 10. Input Voltage Rising Transient from 12 V to 72 V, $I_{OUT} = 10\text{ A}$ (ENABLE Terminal Tied High)

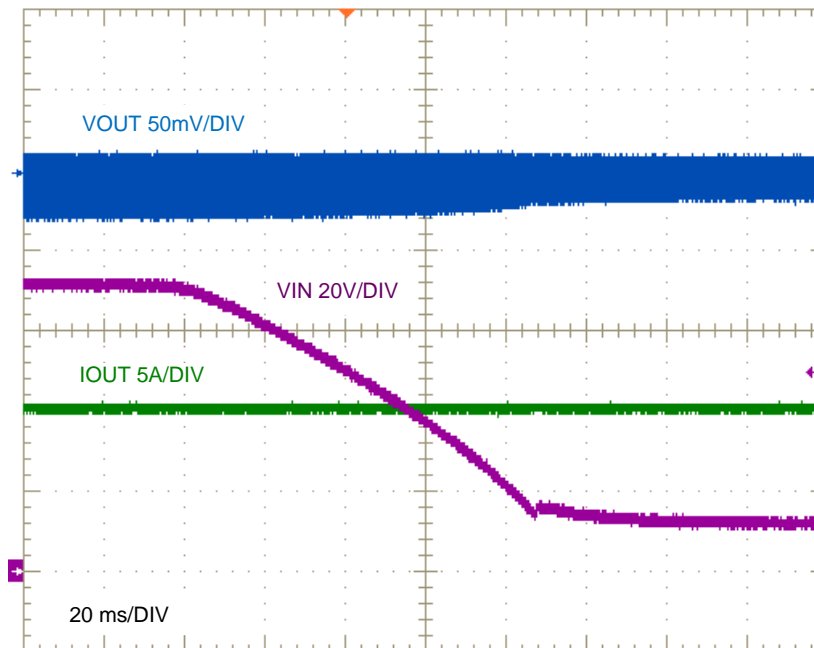


Figure 11. Input Voltage Falling Transient From 72 V to 12 V, $I_{OUT} = 10\text{ A}$ (ENABLE Terminal Tied High)

6.2.4 ENABLE ON and OFF

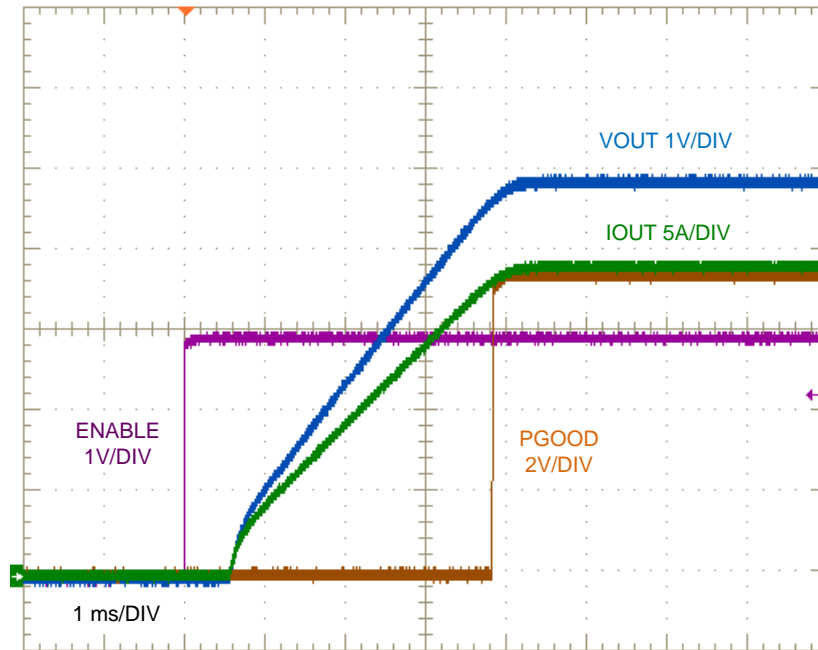


Figure 12. ENABLE ON, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive

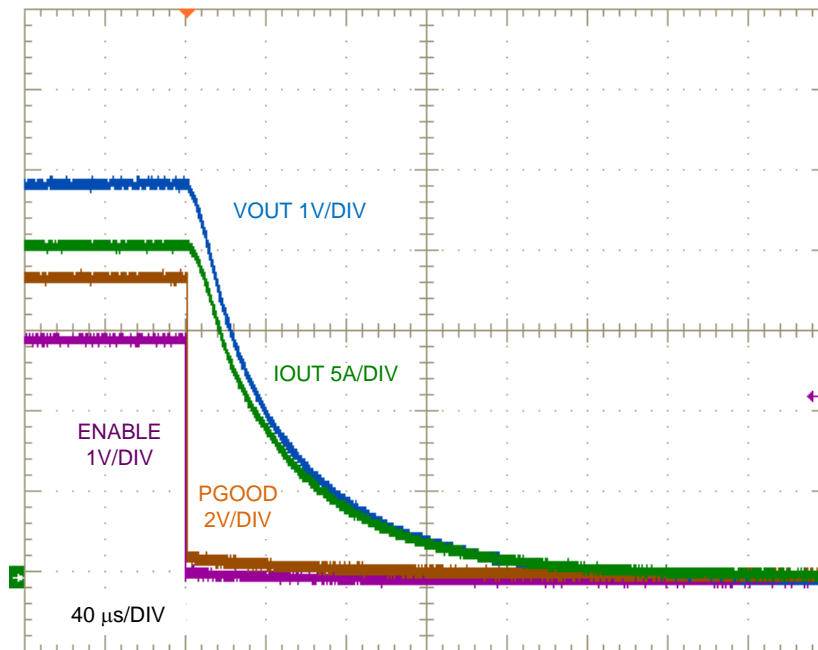


Figure 13. ENABLE OFF, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive

6.2.5 Start-Up

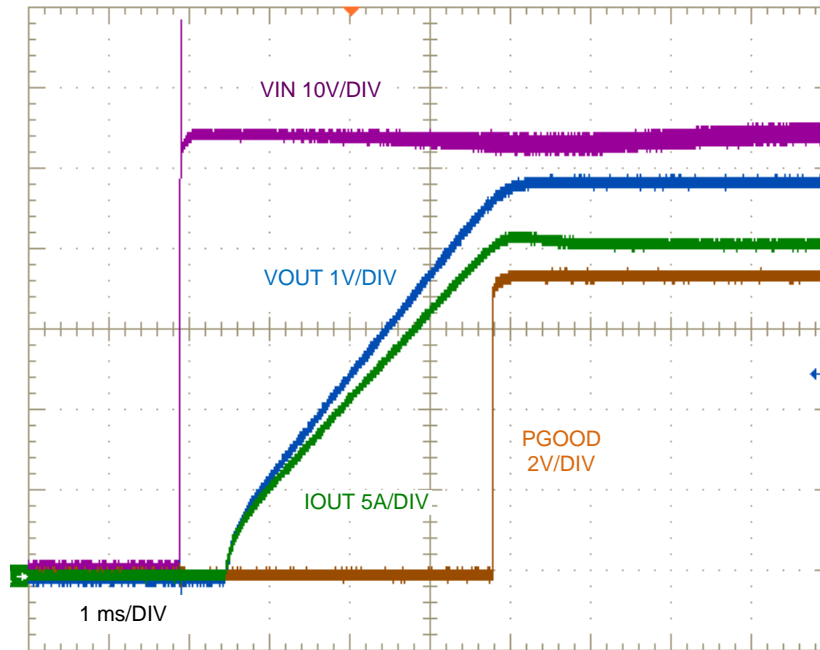


Figure 14. Start-Up, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive

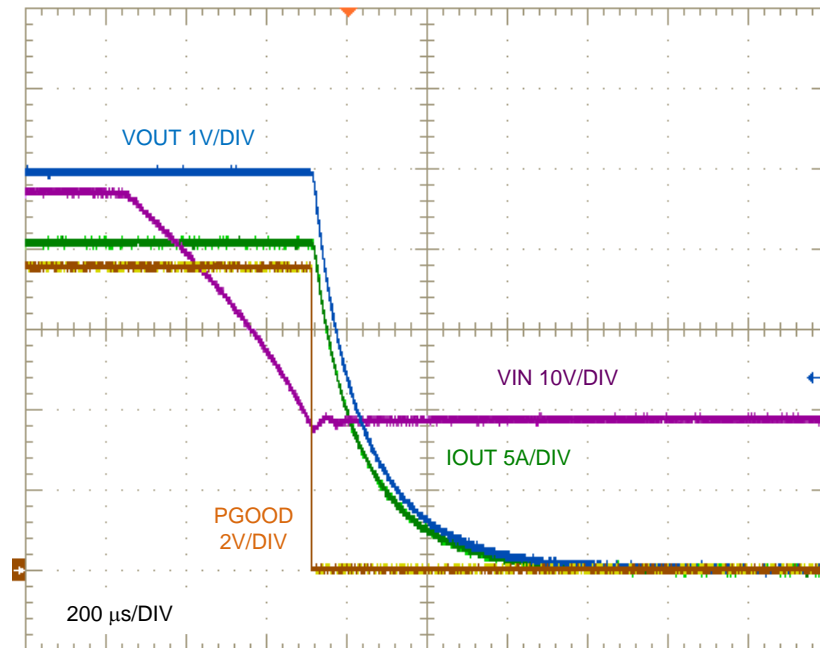


Figure 15. Shutdown, $V_{IN} = 48\text{ V}$, $I_{OUT} = 20\text{ A}$ Resistive

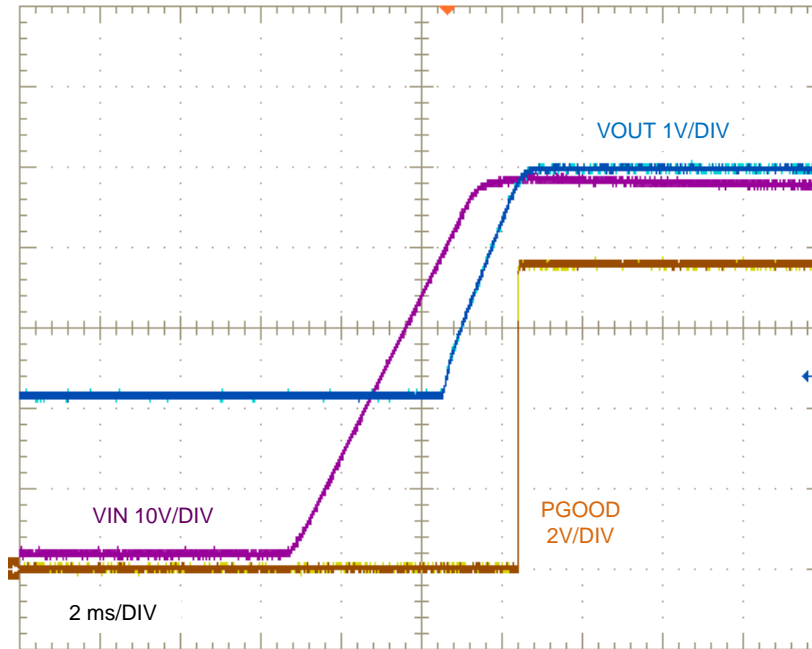


Figure 16. Pre-Biased Start-up, $V_{IN} = 48\text{ V}$, $I_{OUT} = 0\text{ A}$

6.3 Thermal Performance

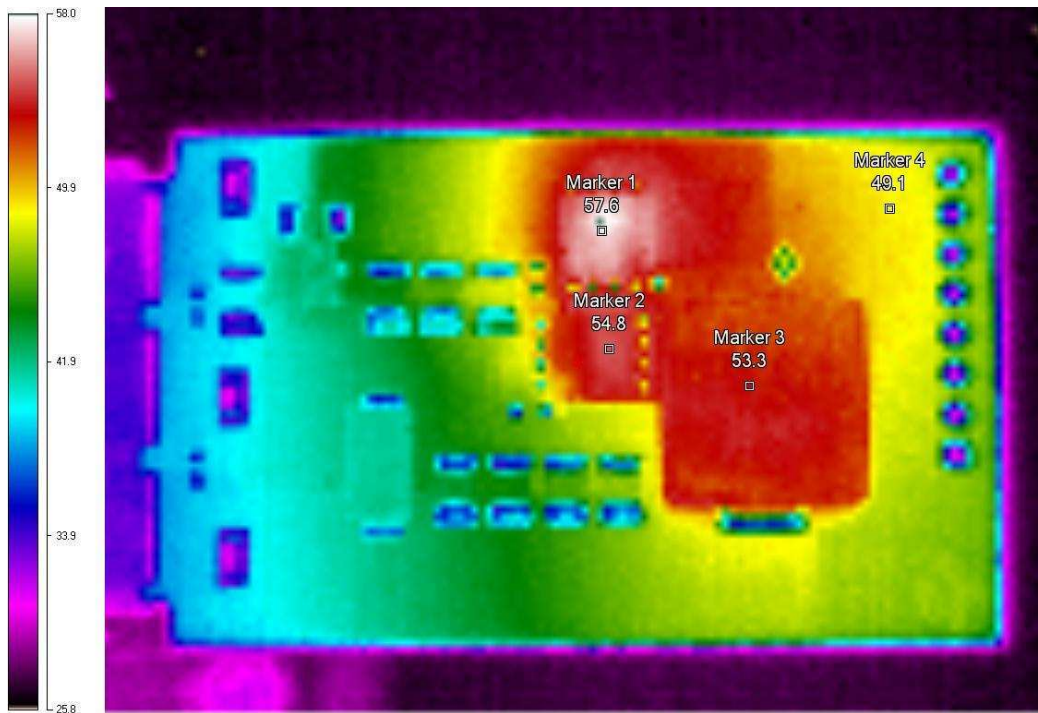


Figure 17. Thermal Performance at $V_{IN} = 48\text{ V}$, $I_{OUT} = 10\text{ A}$, 200 LFM Airflow

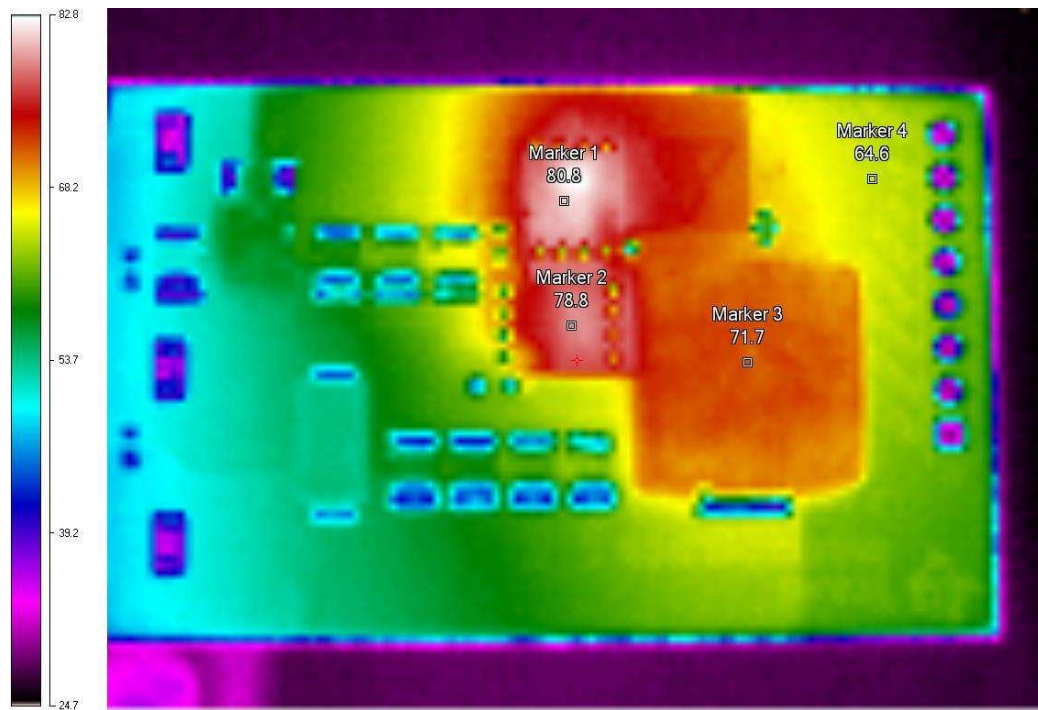
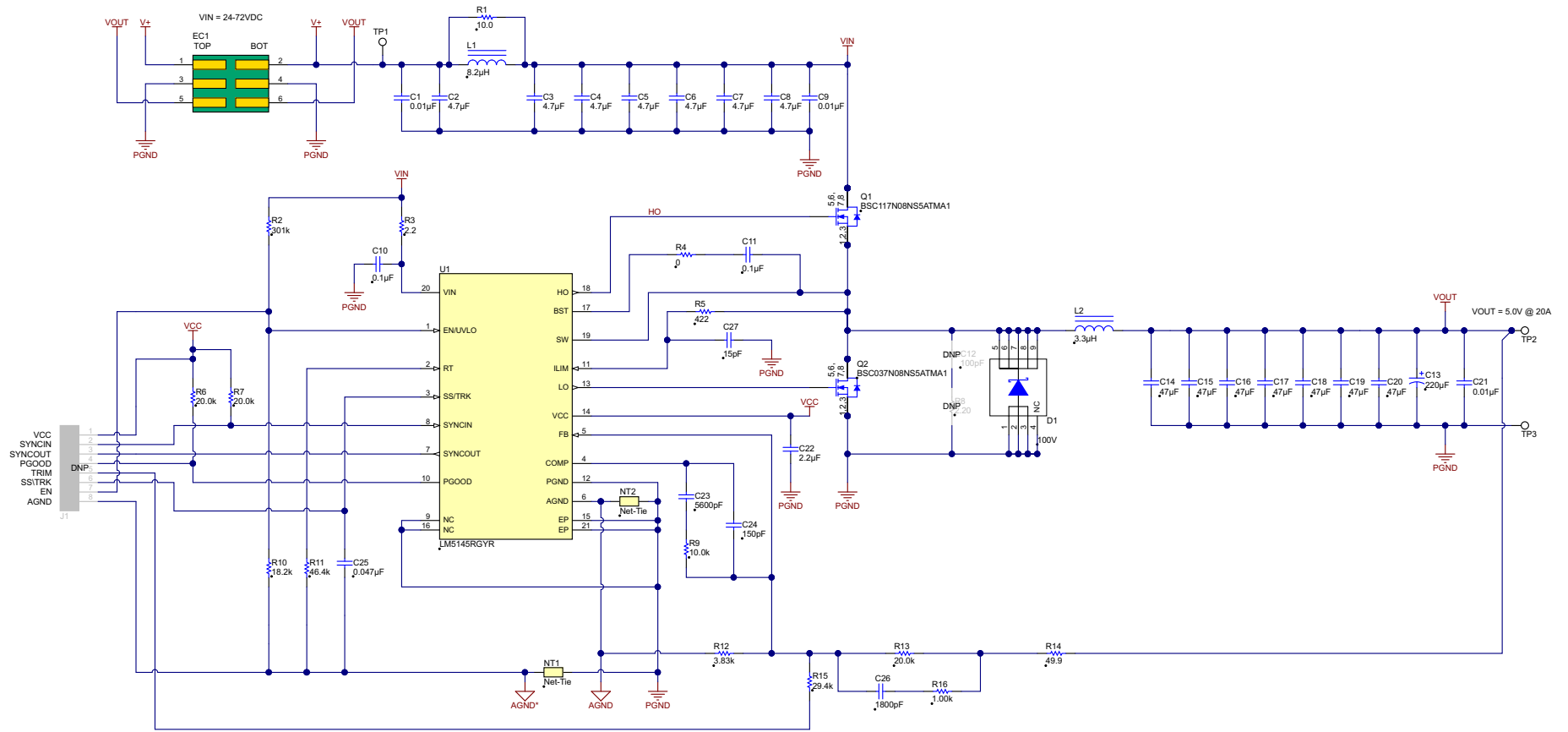


Figure 18. Thermal Performance at $V_{IN} = 48\text{ V}$, $I_{OUT} = 15\text{ A}$, 200 LFM Airflow

7 EVM Documentation

7.1 Schematic



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Figure 19. EVM Schematic

7.2 Bill of Materials

Table 3. Bill of Materials

COUNT	REF DES	DESCRIPTION	PART NUMBER	MFR
3	C1, C9, C21	Capacitor, Ceramic, 10nF, 100V, X7R, 0603	Std	Std
7	C2, C3, C4, C5, C6, C7, C8	Capacitor, Ceramic, 4.7μF, 100V, X7S, 1210	C3225X7S2A475M200AB	TDK
			GRJ32DC72A475KE11L	Murata
1	C10	Capacitor, Ceramic, 0.1μF, 100V, X7R, 0603	C1608X7R1A105K080AC	TDK
1	C11	Capacitor, Ceramic, 0.1μF, 25V, X7R, 0603	Std	Std
1	C13	Capacitor, Polymer Aluminum, 220μF, 6.3V, 7343, 10mΩ ESR	ECASD60J227M010K00	Murata
		Capacitor, Tant Polymer, 220μF, 10V, 7343, 18mΩ ESR	10TCE220MIL	Panasonic
7	C14, C15, C16, C17, C18, C19, C20	Capacitor, Ceramic, 47μF, 10V, X7R, 1210	GRM32ER71A476KE15L	Murata
			LMK325B7476MM-TR	Taiyo Yuden
			1210ZC476KAT2A	AVX
1	C22	Capacitor, Ceramic, 2.2μF, 16V, X7R, 0603	EMK107BB7225MA-T	Taiyo Yuden
		Capacitor, Ceramic, 2.2μF, 16V, X7S, 0603	GRM188C71C225KE11D	Murata
1	C23	Capacitor, Ceramic, 5.6nF, 16V, X7R, 10%, 0603	Std	Std
1	C24	Capacitor, Ceramic, 150pF, 16V, X7R, 10%, 0603	Std	Std
1	C25	Capacitor, Ceramic, 47nF, 16V, X7R, 10%, 0603	Std	Std
1	C26	Capacitor, Ceramic, 1.8nF, 16V, X7R, 10%, 0603	Std	Std
1	C27	Capacitor, Ceramic, 15pF, 100V, X7R, 10%, 0603	Std	Std
1	D1	Schottky Diode, 100V, 6A	ST	STPS6M100
1	L1	Inductor, 8.2μH ±20%, 60mΩ max, 3.4A Isat, 4mm max	XAL4040-822MEC	Coilcraft
1	L2	Inductor, 3.3μH ±20%, 3.75mΩ typ, 42A, 6.5mm max	CMLS136E-3R3MS	Cyntec
		Inductor, 3.3μH, 5.7mΩ typ, 32 A, 6.5mm max	744373965033	Würth Elektronik
		Inductor, 3.0μH, 5.86mΩ typ, 37 A, 5mm max	XAL1350-302MED	Coilcraft
1	Q1	MOSFET, N-Channel, 80V, 12mΩ	BSC117N08NS5	Infineon
1	Q2	MOSFET, N-Channel, 80V, 4mΩ	BSC037N08NS5	Infineon
1	R1	Resistor, Chip, 10Ω, 1/8W, 5%, 1206	Std	Std
1	R2	Resistor, Chip, 301kΩ, 1/16W, 1%, 0805	Std	Std
1	R3	Resistor, Chip, 2.2Ω, 1/16W, 1%, 0603	Std	Std
1	R4	Resistor, Chip, 0Ω, 1/16W, 1%, 0603	Std	Std
1	R5	Resistor, Chip, 422Ω, 1/16W, 1%, 0603	Std	Std
3	R6, R7, R13	Resistor, Chip, 20kΩ, 1/16W, 1%, 0603	Std	Std
1	R9	Resistor, Chip, 10kΩ, 1/16W, 1%, 0603	Std	Std
1	R10	Resistor, Chip, 18.2kΩ, 1/16W, 1%, 0603	Std	Std
1	R11	Resistor, Chip, 46.4kΩ, 1/16W, 1%, 0603	Std	Std
1	R12	Resistor, Chip, 3.83kΩ, 1/16W, 1%, 0603	Std	Std
1	R14	Resistor, Chip, 49.9Ω, 1/16W, 1%, 0603	Std	Std
1	R15	Resistor, Chip, 29.4kΩ, 1/16W, 1%, 0603	Std	Std
1	R16	Resistor, Chip, 1kΩ, 1/16W, 1%, 0603	Std	Std
1	U1	IC, LM5145 , Wide V_{IN} Synchronous Buck Controller, VQFN-20	LM5145RGYR	TI
1	PCB1	PCB, FR4, 4 layer, 2 oz, 50 mm x 30 mm	PCB	–
0	J1	Connector, SMT for VCC, SYNCIN, SYNCOUT, PGOOD, TRIM, SS/TRK, EN, AGND	PEC08SAAN	Sullins
0	J2	Connector for VIN, VOUT, GND	6651712-1	TE Connectivity
			1766685-1	

7.3 PCB Layout

Figure 20 through Figure 25 show the design of the LM5145 4-layer PCB with 2-oz copper thickness. The EVM is a two-sided design with plated edge terminals for VIN, VOUT and GND connections.

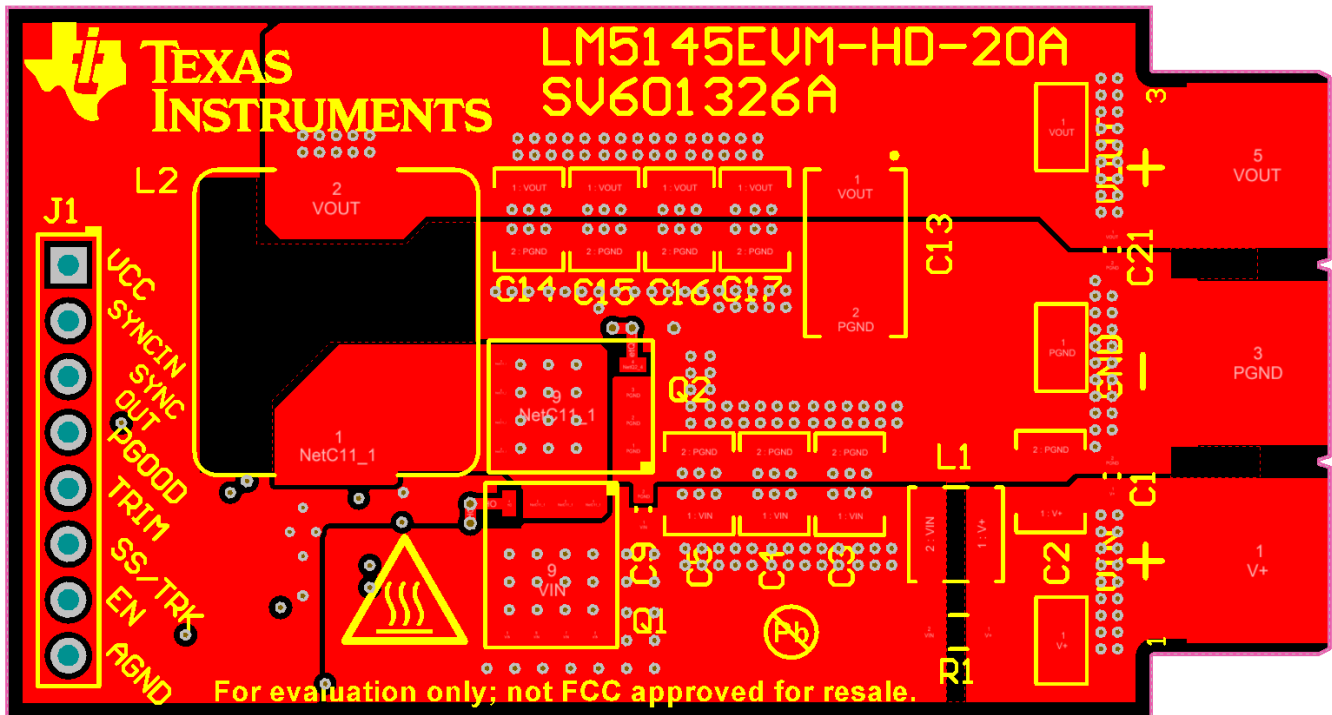


Figure 20. Top Copper (Top View)

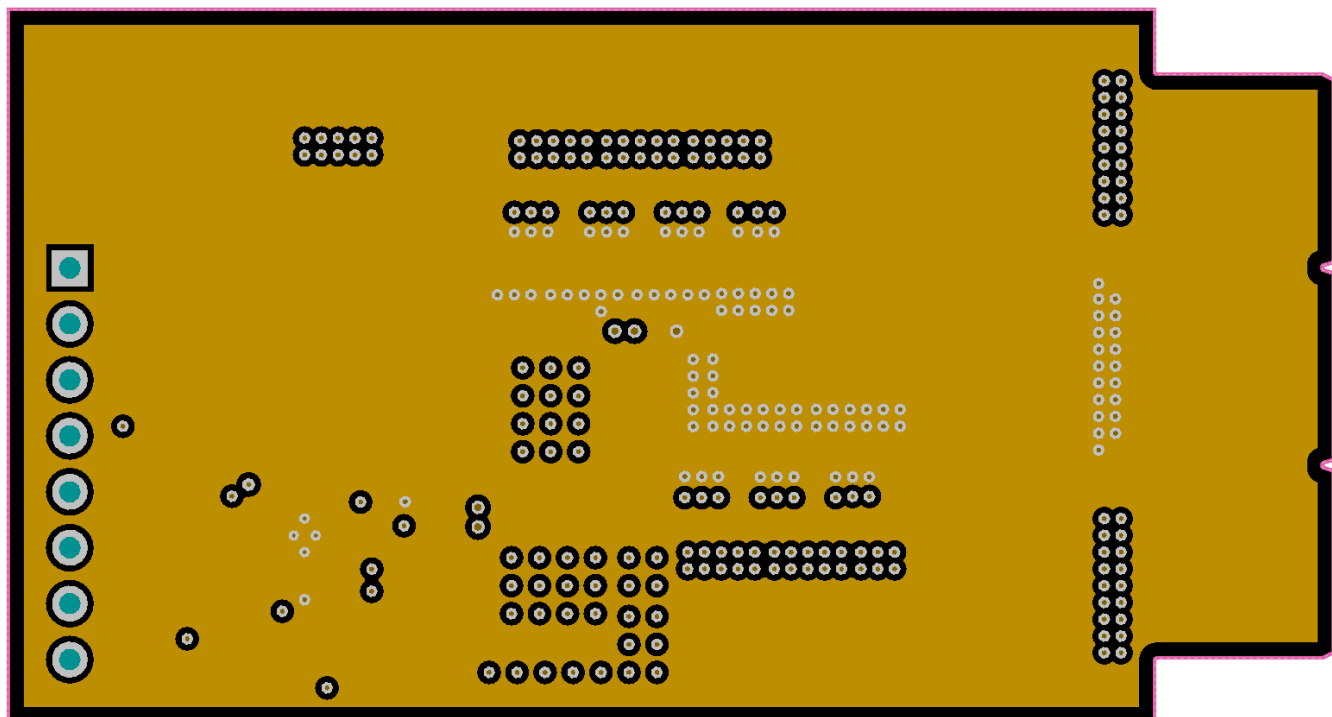


Figure 21. Layer 2 Copper (Top View)

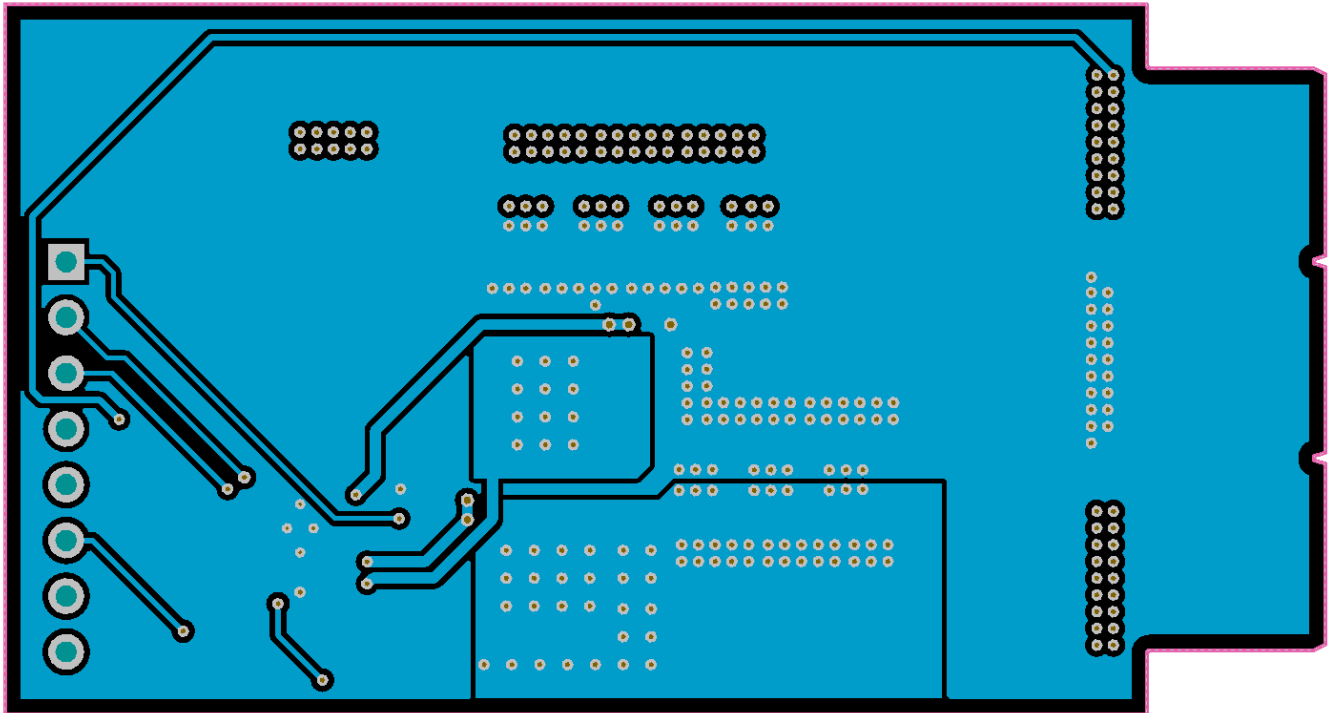


Figure 22. Layer 3 Copper (Top View)

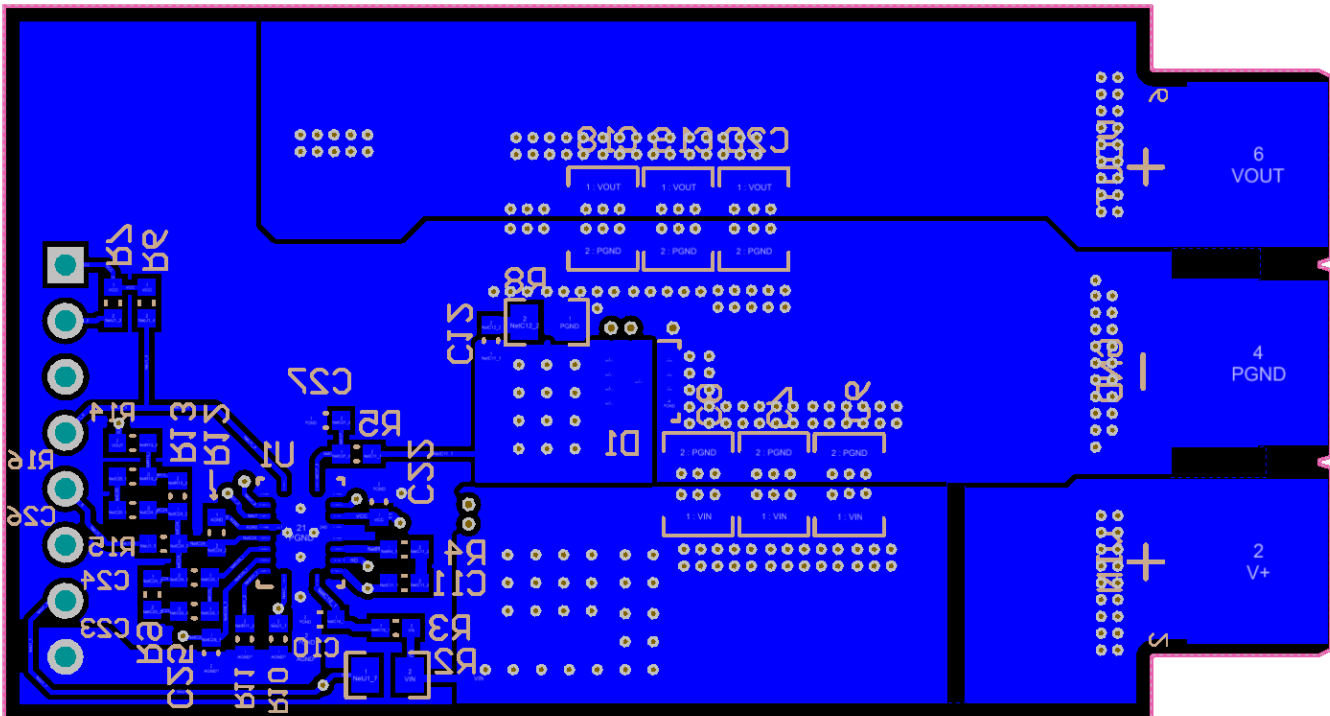


Figure 23. Bottom Copper (Top View)

7.4 Assembly Drawings

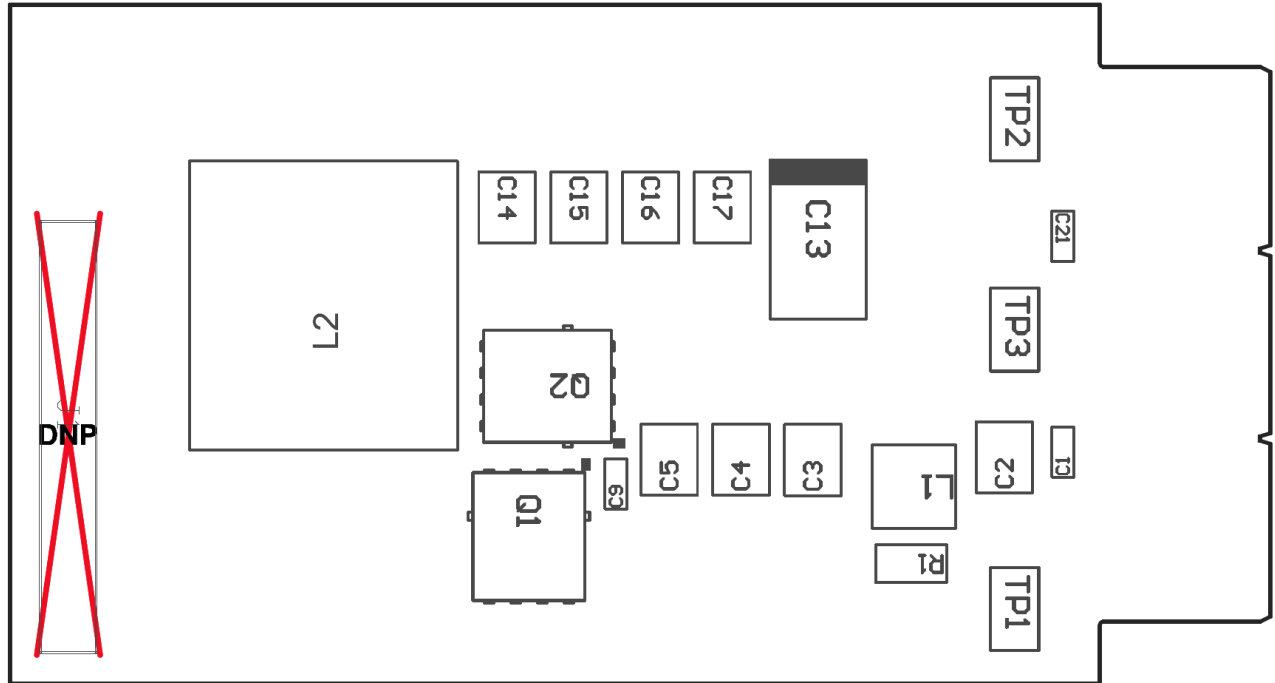


Figure 24. Top Assembly

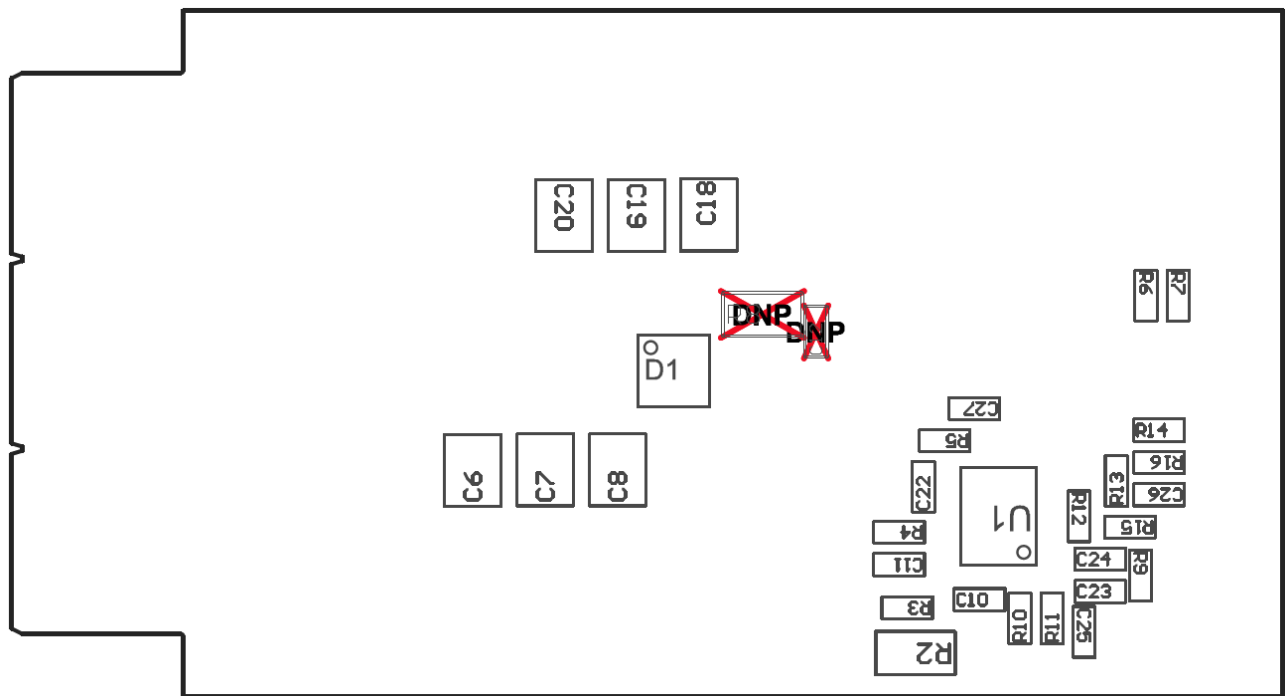


Figure 25. Bottom Assembly

8 Device and Documentation Support

8.1 Device Support

8.1.1 Third-Party Products Disclaimer

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8.1.2 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](#)
- LM5145 DC-DC Controller [Quickstart Calculator](#) and [PSPICE](#) simulation model

8.2 Documentation Support

8.2.1 Related Documentation

For related documentation see the following:

- [AN-1713 LM5116 Evaluation Board](#) (SNVA285)
- [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)

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)

Revision History

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

Changes from Original (May 2017) to A Revision	Page
• Added high temp logo, thermal performance plots, and new EVM photo	1

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CAUTION

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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

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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.

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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.

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http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page

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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):

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2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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