Using the TPS51218EVM-496 High-Performance, Single Synchronous, Step–Down Controller for High-Current, Eco-mode™ Applications

The TPS51218EVM evaluation module (EVM) is used to evaluate the TPS51218, a small-size, single buck controller with adaptive on-time D-CAP™ mode, providing a fixed 1.2-V output at up to 20 A from a 12-V input bus.

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1 Description

The TPS51218EVM is designed to use a regulated 12-V bus to produce a regulated 1.2-V output at up to 20 A of load current. The TPS51218EVM is designed to demonstrate the TPS51218 in a typical, low-voltage application while providing a number of test points to evaluate the performance of the TPS51218.

1.1 Typical Applications

- High-current system converters for server and desktop power
- Switchers and routers
- Embedded computers
- In-vehicle infotainment PCs
- POS terminals
- Point-of-load modules
- Graphics cards
- Industrial control/factory automation PCs

1.2 Features

The TPS51218EVM features:

- 20-Adc steady-state current
- Support prebias output voltage start-up
- 380-kHz switching frequency
- J4 for enable function
- J3 for auto-skip and forced CCM selection
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 1. TPS51218EVM Electrical Performance Specifications

Parameter	Test Conditions	Min	Typ	Max	Units
INPUT CHARACTERISTICS					
Voltage range	VIN	8	12	14	V
Maximum input current	VIN = 8 V, Io = 20 A			3.55	A
No load input current	Vin = 14 V, Io = 0 A			50	mA
OUTPUT CHARACTERISTICS					
Output voltage VOUT			1.2		V
Output voltage regulation	Line regulation (Vin = 10 V–14 V)		1.0%		
	Load regulation (Vin = 12 V, Io = 0 A–20 A)		1.0%		
Output voltage ripple	Vin = 12 V, Io = 20 A			40	mVpp
Output load current		0		20	A
Output overcurrent			30		A
SYSTEMS CHARACTERISTICS					
Switching frequency			380		kHz
Peak efficiency	Vin = 12 V, 1.2 V/10 A		90.32%		
Full-load efficiency	Vin = 12 V, 1.2 V/20 A		88.64%		
Operating temperature			25		°C

3 Schematic

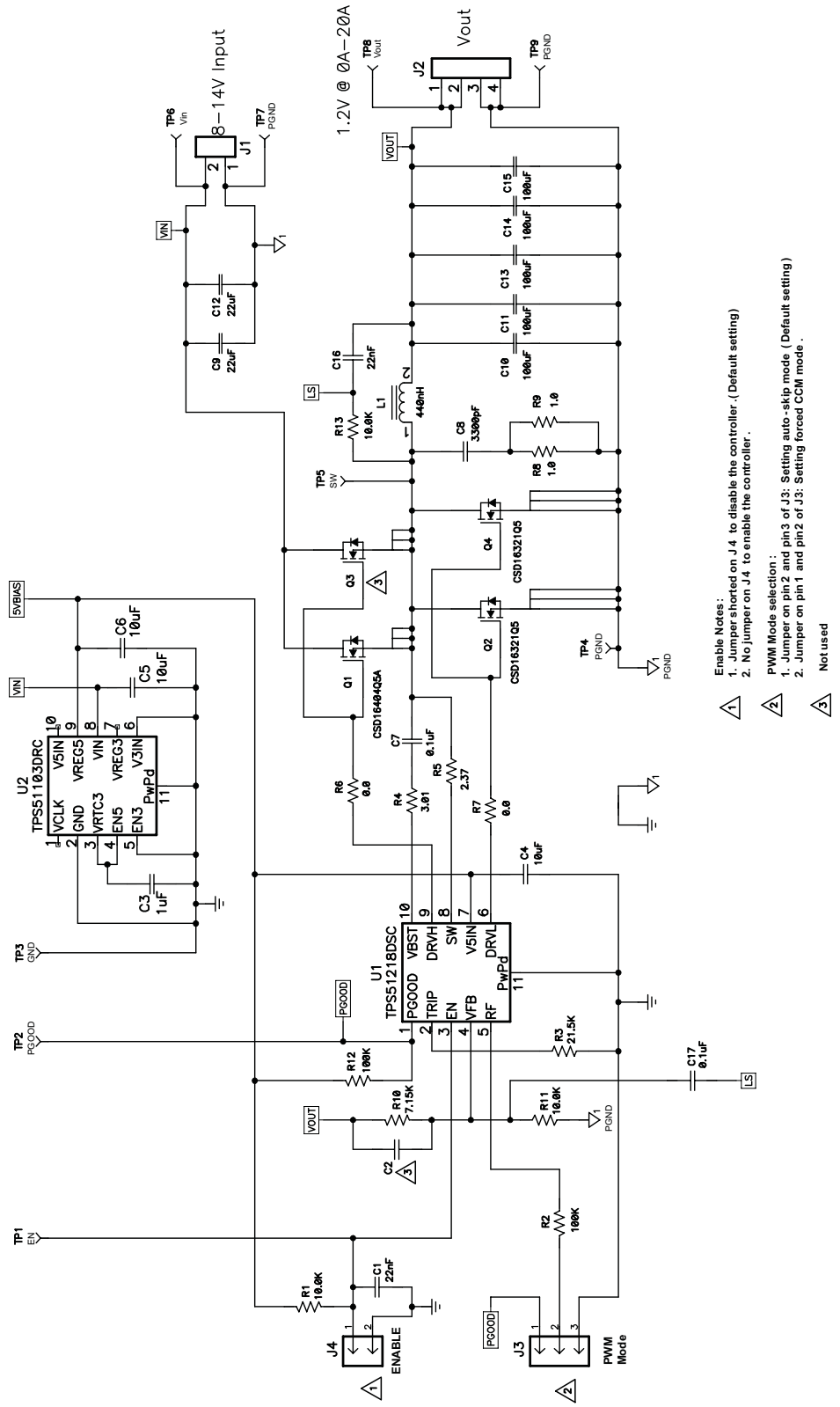

Figure 1. TPS51218EVM Schematic

4 Test Setup

4.1 Test Equipment

Voltage Source: The input voltage source Vin must be a 0-V to 14-V variable dc source capable of supplying 10 Adc. Connect Vin to J1 as shown in Figure 3.

Multimeters: A 0-V to 15-V voltmeter must be used to measure Vin at TP6 (Vin) and TP7 (PGND) and a 0-V to 5-V voltmeter for Vout measurement at TP8 (Vout) and TP9 (PGND). A 0-A to 10-A current meter (A1) as shown in Figure 3 is used for input current measurements.

Output Load: The output load must be an electronic constant resistance mode load capable of 0 Adc to 30 Adc at 1.2 V.

Oscilloscope: A digital or analog oscilloscope can be used to measure the output ripple. The oscilloscope must be set for 1-MΩ impedance, 20-MHz bandwidth, ac coupling, 2-µs/division horizontal resolution, 50-mV/division vertical resolution. Test points TP8 and TP9 can be used to measure the output ripple voltage by placing the oscilloscope probe tip through TP8 and holding the ground barrel TP9 as shown in Figure 2. Using a leaded ground connection may induce additional noise due to the large ground loop.

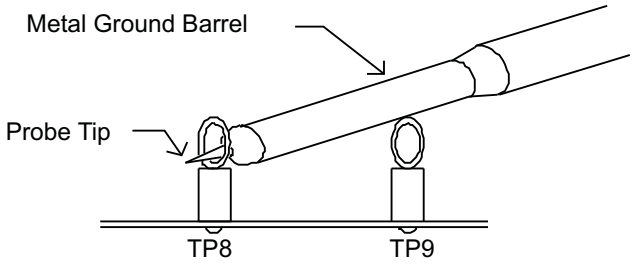

Figure 2. Tip and Barrel Measurement for Vout Ripple

Fan: Some of the components in this EVM may get hot, approaching temperatures up to 60ºC during operation. A small fan capable of 200 to 400 LFM is recommended to reduce component temperatures while the EVM is operating. The EVM must not be probed while the fan is not running.

Recommended Wire Gauge: For VIN to J1 (12-V input) the recommended wire size is 1x AWG 14 per input connection, with the total length of wire less than 4 feet (2-foot input, 2-foot return). For J2 to LOAD, the minimum recommended wire size is 2x AWG 14, with the total length of wire less than 4 feet (2-foot output, 2-foot return).

4.2 Recommended Test Setup

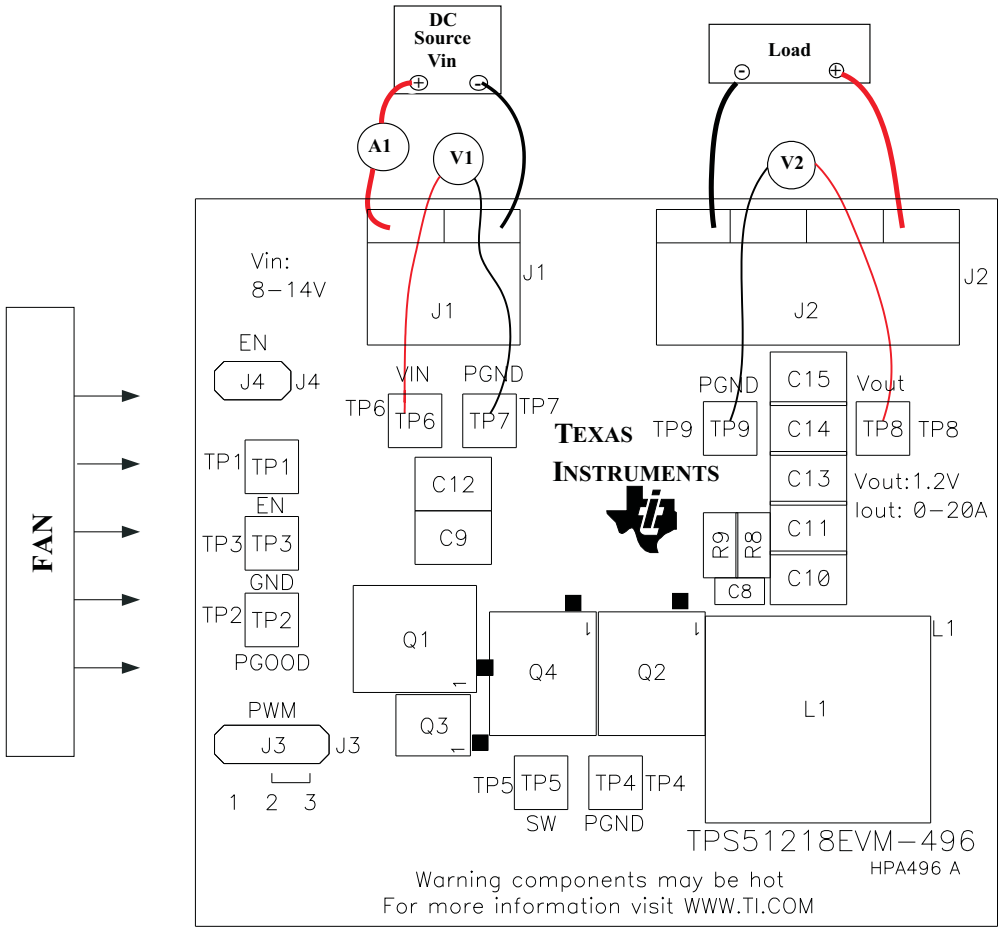

Figure 3. TPS51218EVM Recommended Test Setup

Figure 3 shows the recommended test setup to evaluate the TPS51218EVM. Working at an ESD workstation, ensure that any wrist straps, bootstraps, or mats are connected referencing the user to earth ground before power is applied to the EVM.

4.2.1 Configurations

1. EN J4 setting

   (a) No jumper enables the controller.
   (b) A jumper shorted on J4 disables the controller (default setting).
2. PWM J3 setting

   (a) A jumper on pin 2 and pin 3 of J3 set the auto-skip mode (default setting).
   (b) A jumper on pin 1 and pin 2 of J3 sets a forced CCM mode.

4.2.2 Input Connections

1. Prior to connecting the dc input source Vin, it is advisable to limit the source current from Vin to 10 A maximum. Ensure that Vin is initially set to 0 V and connected as shown in Figure 3.
2. Connect a voltmeter V1 at TP6 (Vin) and TP7 (PGND) to measure the input voltage.
3. Connect a current meter A1 to measure the input current.

4.2.3 Output Connections

1. Connect the load to J2, and set the load to constant resistance mode to sink 0 Adc before Vin is

applied.

2. Connect a voltmeter V2 at TP8 (Vout) and TP9 (PGND) to measure the output voltage.

4.2.4 Other Connections

Place a fan as shown in Figure 3 and turn it on, making sure that air is flowing across the EVM.

5 Test Procedure

5.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Ensure that the load is set to constant resistance mode and to sink 0 Adc.
2. Ensure that the jumper provided in the EVM to short J4 is on before Vin is applied.
3. Ensure that the jumper provided in the EVM to short pin 2 and pin 3 of J3 is on before Vin is applied.
4. Increase Vin from 0 V to 12 V. Use V1 to measure the input voltage.
5. Remove the jumper on J4 to enable the controller.
6. Vary the load from 0 Adc to 20 Adc. Vout must remain in load regulation.
7. Vary Vin from 8 V to 14 V. Vout must remain in line regulation.
8. Put the jumper on J4 to disable the controller.
9. Decrease the load to 0 A.
10. Decrease Vin to 0 V.

5.2 List of Test Points

Table 2. The Functions of Each Test Points

Test Points	Name	Description
TP1	EN	Enable
TP2	PGOOD	Power Good
TP3	GND	GND
TP4	PGND	PGND
TP5	SW	Switching node
TP6	Vin	Vin
TP7	PGND	GND for Vin
TP8	Vout	Vout
TP9	PGND	PGND

5.3 Equipment Shutdown

1. Shut down the load.
2. Shut down Vin.
3. Shut down the fan.

6 Performance Data and Typical Characteristic Curves

Figure 4 through Figure 12 present typical performance curves for the TPS51218EVM.

6.1 Efficiency

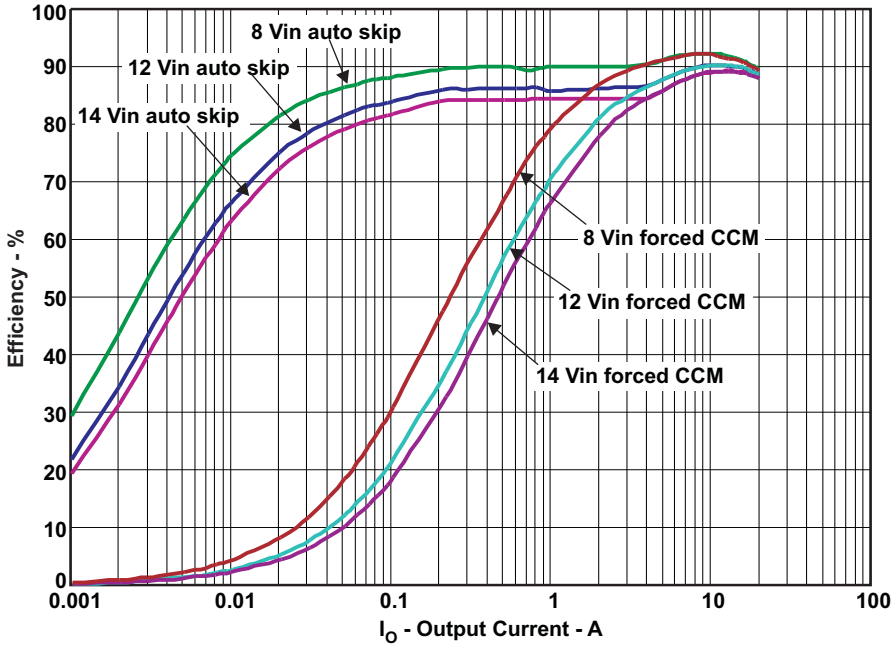

Figure 4. TPS51218EVM Efficiency

6.2 Load Regulation

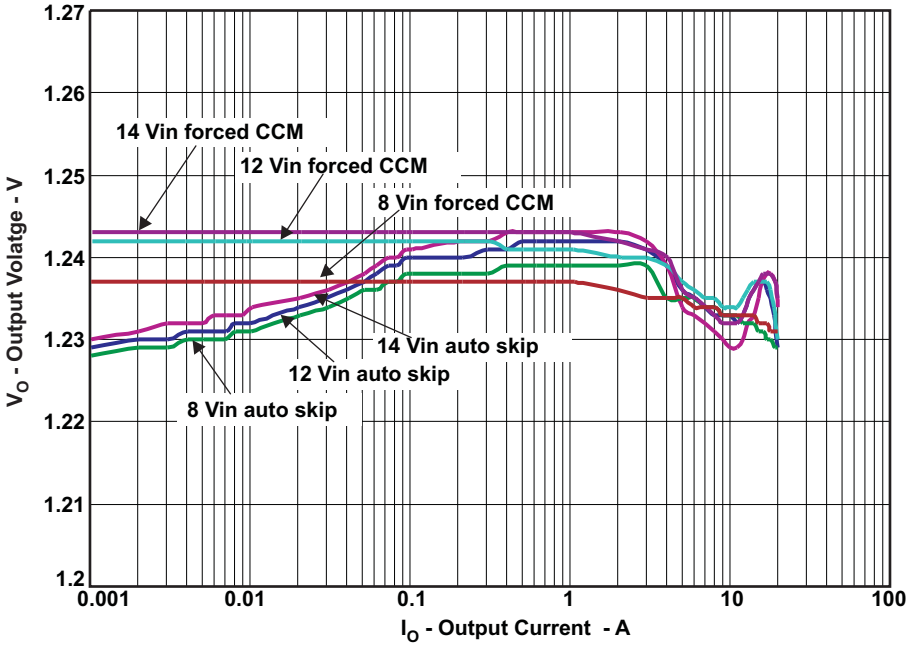

Figure 5. TPS51218 Load Regulation

6.3 Transient Response

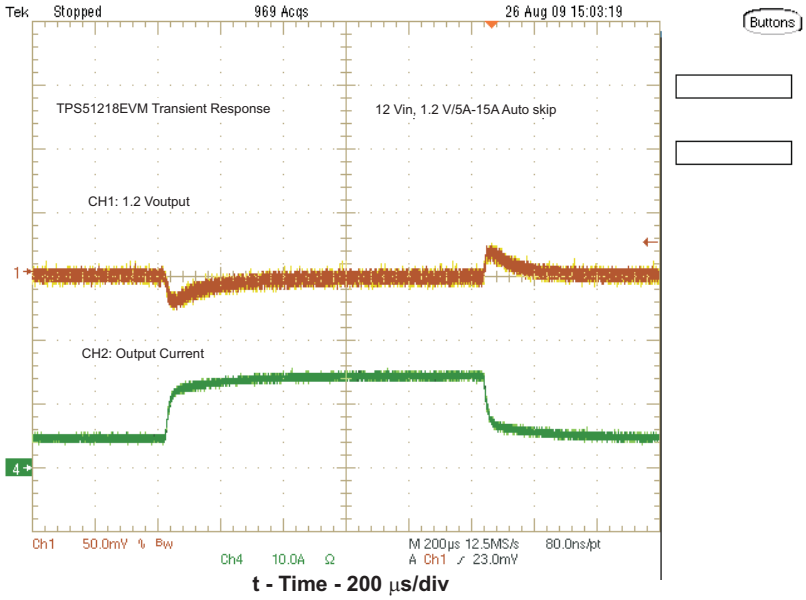

Figure 6. TPS51218EVM Load Transient

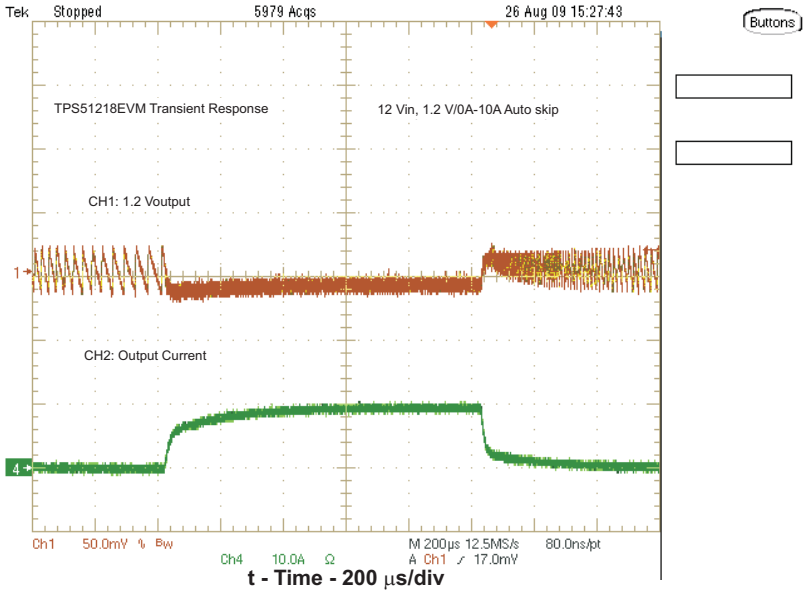

Figure 7. TPS51218EVM Load Transient

6.4 Output Ripple

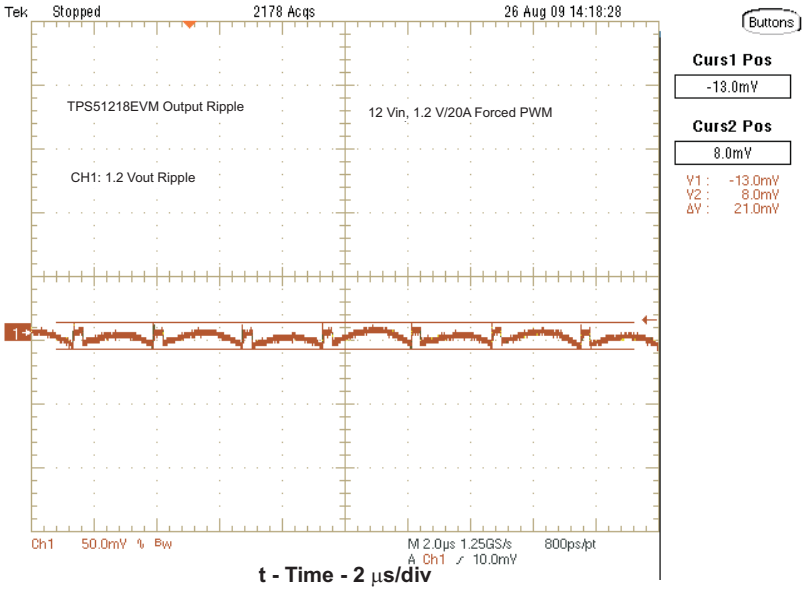

Figure 8. Output Ripple

6.5 Switch Node Voltage

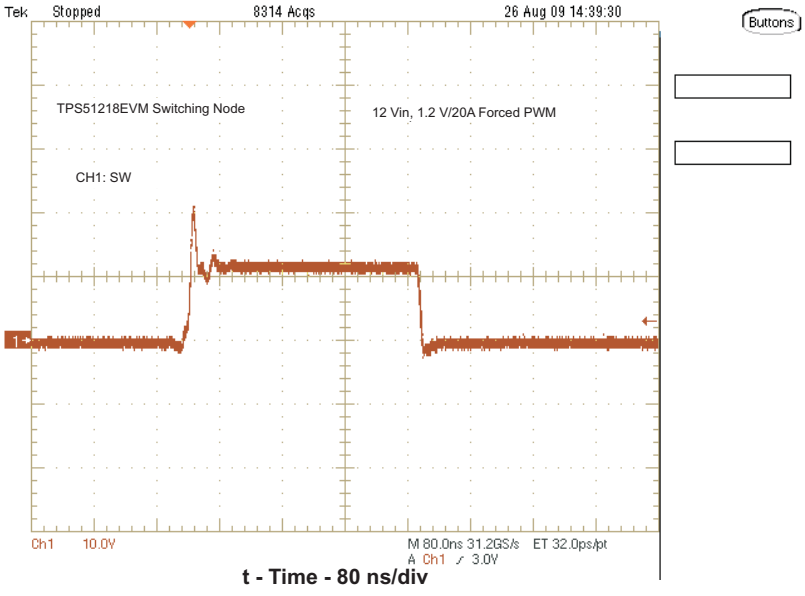

Figure 9. Switching Node Waveform

6.6 Turnon Waveform

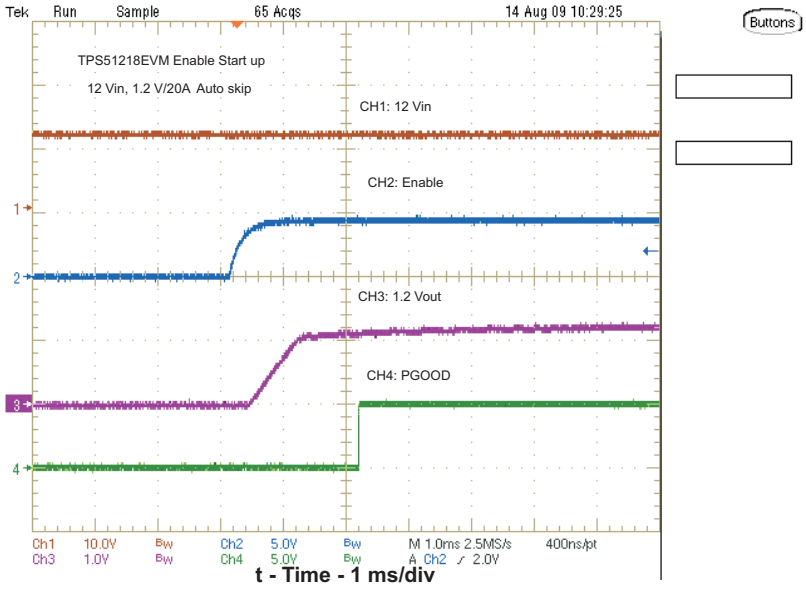

Figure 10. Enable Turnon Waveform

6.7 Turnoff Waveform

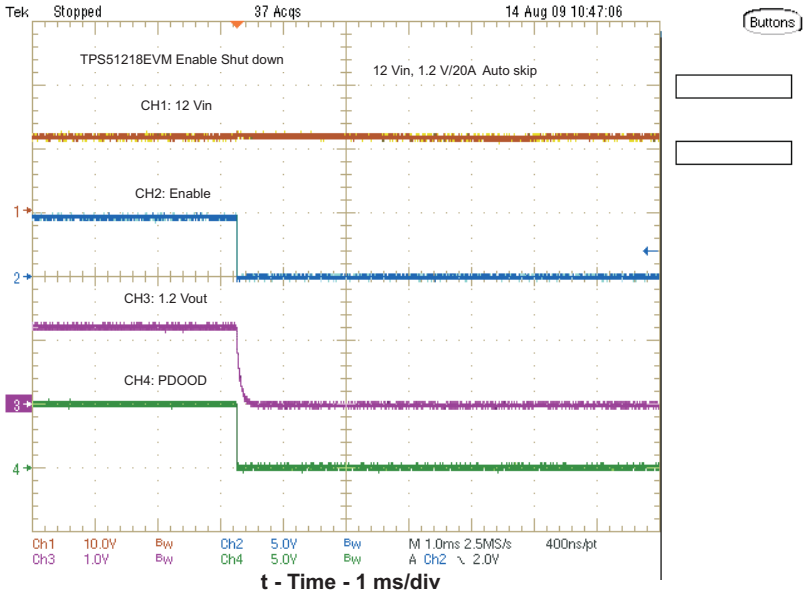

Figure 11. Enable Turnoff Waveform

6.8 Output 1.1-V Prebias Turnon

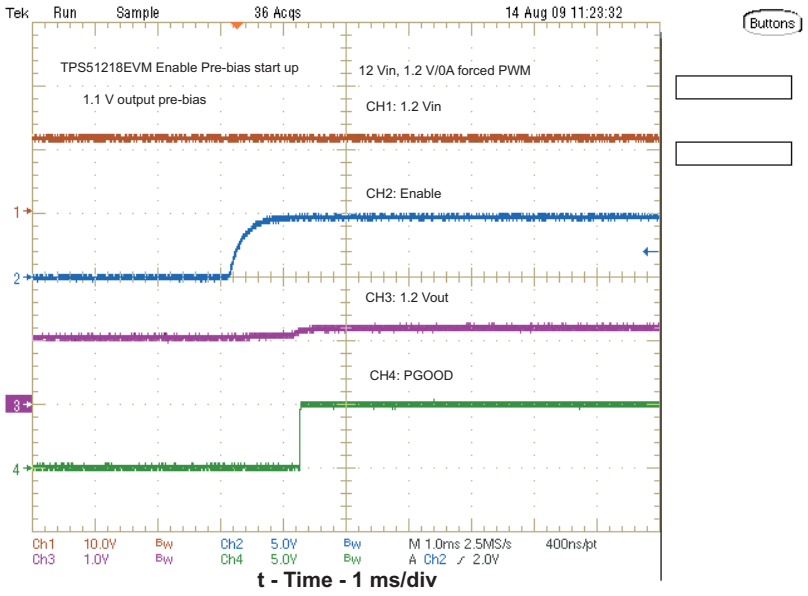

Figure 12. Output 1.1V Prebias Turnon

7 EVM Assembly Drawing and PCB Layout

Figure 13 through Figure 18 show the design of the TPS51218EVM printed-circuit board. The EVM has been designed using a four-layer, 2-oz copper circuit board.

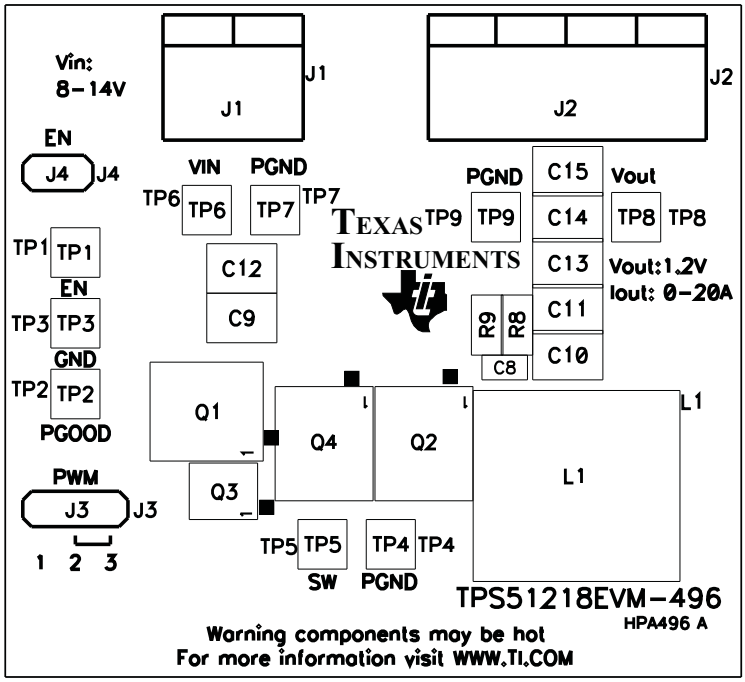

Figure 13. TPS51218EVM Top Layer Assembly Drawing, Top View

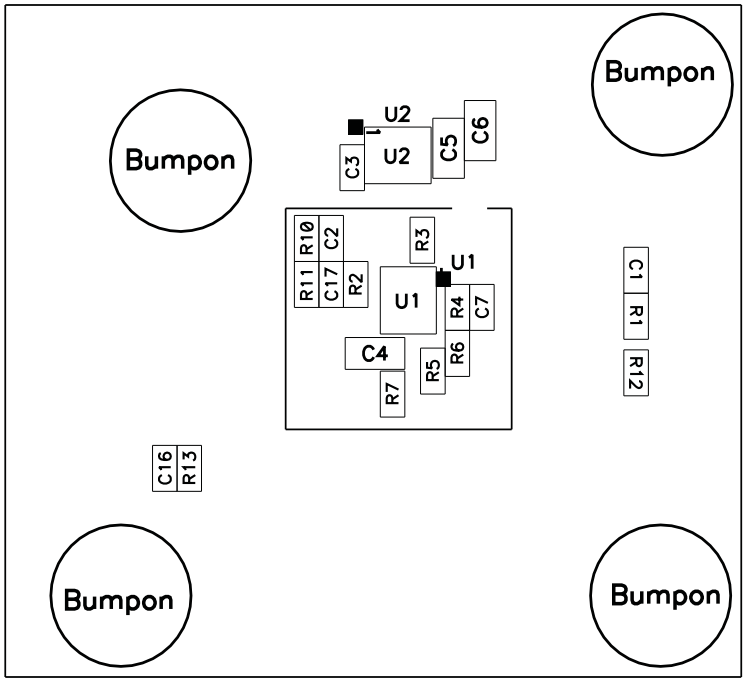

Figure 14. TPS51218EVM Bottom Assembly Drawing, Bottom View

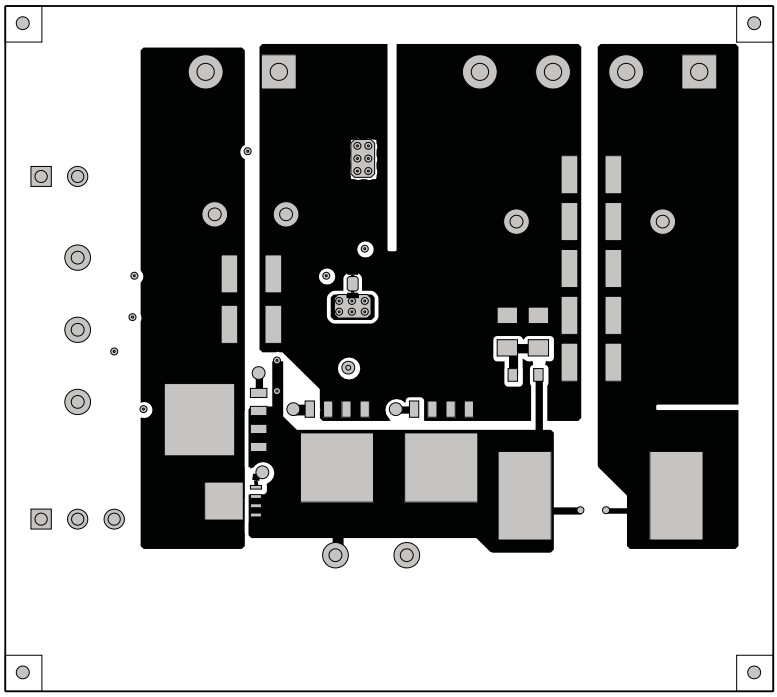

Figure 15. TPS51218EVM Top Copper, Top View

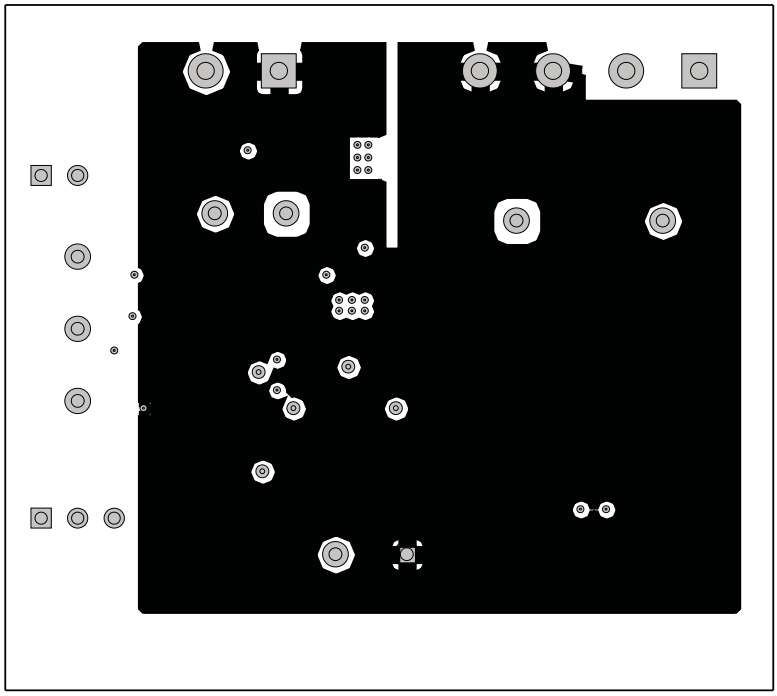

Figure 16. TPS51218EVM Internal Layer 1

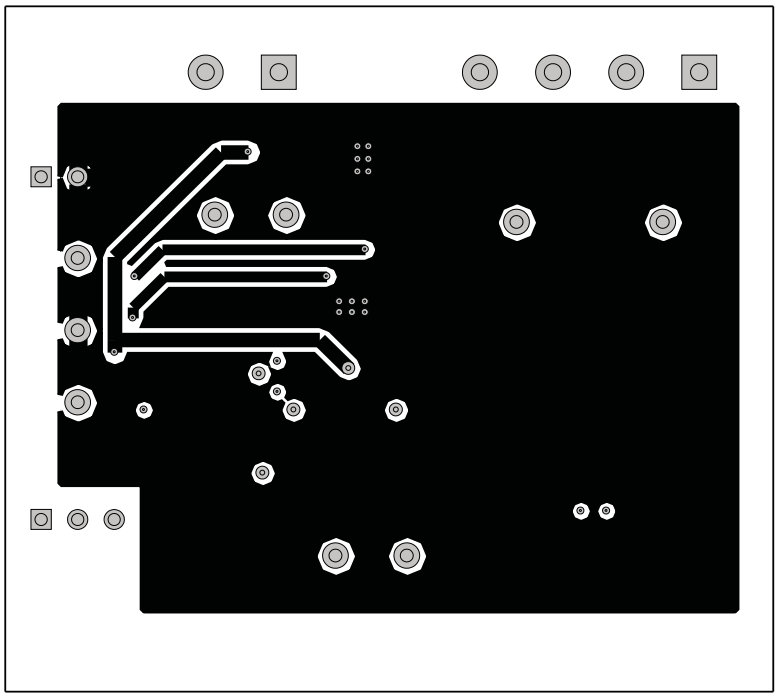

Figure 17. TPS51218EVM Internal Layer 2

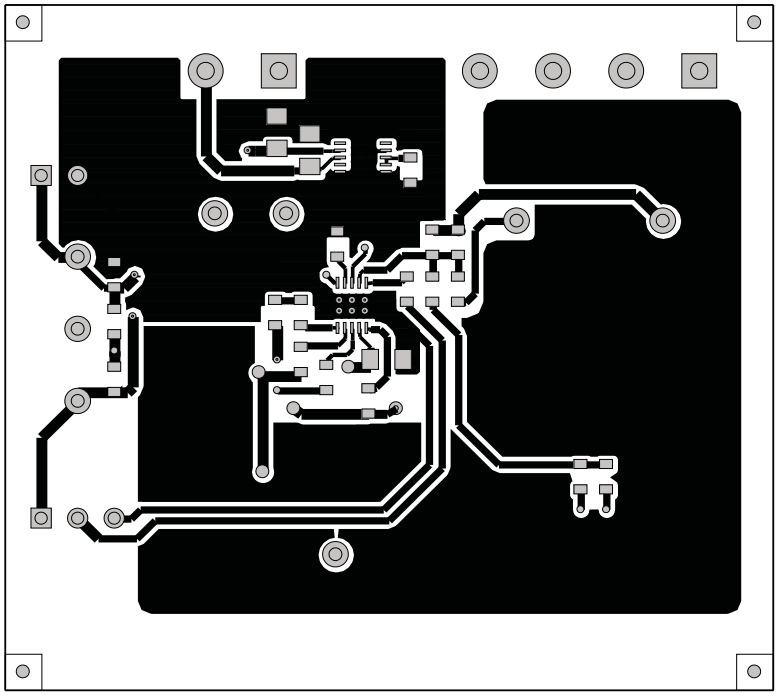

Figure 18. TPS51218EVM Bottom Layer

8 Bill of Materials

The EVM components are shown in Table 3 according to the schematic shown in Figure 1.

Table 3. Bill of Materials

QTY	REFDES	Description	MFR	Part Number
2	C9, C12	Capacitor, Ceramic, 22 µF, 16V, X5R, 10%, 1210	Murata	GRM32ER61C226KE20L
1	C3	Capacitor, Ceramic, 1 µF, 16V, X7R, 10%, 0603	STD	STD
2	C1, C16	Capacitor, Ceramic, 0.022 µF, 16V, X7R, 10%, 0603	STD	STD
1	C8	Capacitor, Ceramic, 3300 pF, 25V, X7R, 10%, 0603	STD	STD
3	C4, C5, C6	Capacitor, Ceramic, 10 µF, 16V, X5R, 10%, 0805	STD	STD
2	C7, C17	Capacitor, Ceramic, 0.1 µF, 25V, X7R, 10%, 0603	STD	STD
5	C10, C11, C13, C14, C15	Capacitor, Ceramic, 100 µF, 6.3V, X5R, 20%, 1210	Murata	GRM32ER60J107ME20L
1	L1	Inductor, SMT, 0.44 µH, 30A, 0.0032 Ω, 0.530" x 0.510"	Pulse	PA0513.441NLT
			E&E Magnetic	831-02990F
1	Q1	MOSFET, Nchan, 25V, 21A, 4.1 mΩ, QFN5X6mm	TI (Ciclon)	CSD16404Q5A
2	Q2, Q4	MOSFET, Nchan, 25V, 31A, 2.1 mΩ, QFN5X6mm	TI(Ciclon)	CSD16321Q5
3	R1, R11, R13	Resistor, Chip, 10K, 1/16W, 1%, 0603	STD	STD
1	R10	Resistor, Chip, 7.15K, 1/16W, 1%, 0603	STD	STD
1	R3	Resistor, Chip, 19.6K, 1/16W, 1%, 0603	STD	STD
2	R2, R12	Resistor, Chip, 100K, 1/16W, 1%, 0603	STD	STD
2	R6, R7	Resistor, Chip, 0, 1/16W, 1%, 0603	STD	STD
1	R4	Resistor, Chip, 3.01, 1/16W, 1%, 0603		
1	R5	Resistor, Chip, 2.37, 1/16W, 1%, 0603	STD	STD
2	R8, R9	Resistor, Chip, 1, 1/16W, 5%, 0805	STD	STD
1	U2	IC, Integrated LDO with switch-over circuit, DGS10	TI	TPS51103DRC
1	U1	IC, Synchronous step down controller, DSC10	TI	TPS51218DSC

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 8 V to 14 V and the output voltage range of 1 V to 1.4 V .

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 60° C. The EVM is designed to operate properly with certain components above 60° 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.

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