Using the UCC28230EVM

User's Guide

TEXAS INSTRUMENTS

Literature Number: SLUU331
July 2008

User's Guide
SLUU331–July 2008

Intermediate Bus Converter 300-W Evaluation Module

1 Introduction

The UCC28230 evaluation module, is a 300-W intermediate bus converter, providing an unregulated output voltage nominally at 9.6V at maximum 300 W of load power with basic isolation of telecom standard between the primary and the secondary, operating from a dc input between 43 V and 53 V. The EVM uses the UCC28230 intermediate bus controller which integrates built-in state of the art efficiency boost features with high-level protection features to provide cost-effective solutions for intermediate bus architecture applications.

CAUTION

Proper precautions must be taken when working with the EVM. High voltage levels and temperature higher than 60 C are present on the EVM when it is powered on.

2 Description

2.1 Typical Applications

Intermediate bus converters are key elements in intermediate bus architecture and widely used in telecom and datacom areas. The EVM provides a platform to evaluate UCC28230 intermediate bus controller from a telecom input voltage range at rated 300-W output power with possibility to extend the power rating to 500 W (consulting the factory how to make the power expansion).

2.2 Features

The UCC28230EVM features:

- 300-W Output Power Rating with Capability to Operate at 500 W (consulting factory how to make the power expansion)
- High Efficiency Peak 96.5% and Over 96% at Full Load
- Unregulated Output Nominal 9.6 V
- Input DC Voltage Range Between 43 V and 53 V
- Wide Load Capacitance Range Between 0 µF and 10,000 µF
- Plenty of Test Points to Facilitate the Device Evaluation
- Prebias Load Turn-On
- Cycle-by-Cycle Current Limit
- Output Short Circuit Protection
- Regulation Down to Zero Output Current
- Module Size Close to Industry Standard Quarter Brick form Factor with Four Layer Board Layout

3 Electrical Performance Specifications

Table 1. Electrical Performance Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics					
Voltage range	V_{IN}	43		53	V_{DC}
Input inrush current				8.5	A
Maximum input current	V_{IN} = 43 V_{DC}, I_{OUT} = 30 A			6.1	A
	V_{IN} = 53 V_{DC}, I_{OUT} = 30 A			6.1	
Output Characteristics					
Output voltage V_{OUT}	V_{IN}: 43 - 53 V_{DC}, I_{OUT}: 0 - 30 A	8	9.6	10.8	V_{DC}
Load current1	V_{IN}: 43 – 53 V_{DC}	0		30	A
Continuous output power[1]	V_{IN}: 43 - 53 V_{DC}			300	W
Line regulation	V_{IN}: 43 - 53 V_{DC}, I_{OUT} = 0 A		2		V
Load regulation	V_{IN}: 48 V_{DC}, I_{OUT}: 0 - 30 A		0.3		
Ripple and noise (20 MHz BW)	V_{IN}: 43 - 53 V_{DC}, I_{OUT} = 30 A		50	75	mVpk-pk
Start-up overshoot				5%	
Load transient deviation				300	mV
Short circuit current threshold, Io_sc	V_{IN}: 43 - 53 V_{DC}		45		A
Max power limit	V_{IN}: 43 - 53 V_{DC}		450		W
V_O pre-bias start range	V_{IN}: 43 - 53 V_{DC}	0%		100%	
Efficiency					
Peak	V_{IN} = 53 V_{DC}, I_{OUT} = 25 A		96.5%		
	V_{IN} = 43 V_{DC}, I_{OUT} = 30 A		96.2%		
Full load	V_{IN} = 48 V_{DC}, I_{OUT} = 30 A		96.3%		
	V_{IN} = 53 V_{DC}, I_{OUT} = 30 A		96.4%		
	V_{IN} = 48 V_{DC}, I_{OUT} = 0 A		4.8		
Power losses	V_{IN} = 48 V_{DC}, I_{OUT} = 15 A		6		W
	V_{IN} = 48 V_{DC}, I_{OUT} = 30 A		10.5		
Transformer turns ratio	Primary turns to secondary turns		5:1		
Operation temperature	Full load, natural convection cooling			45	C

(1) 1. The module power rating can be expanded to 500 W. Consult factory before making power rating expansion.

4 Schematics

The EVM schematic is shown in Figure 1.

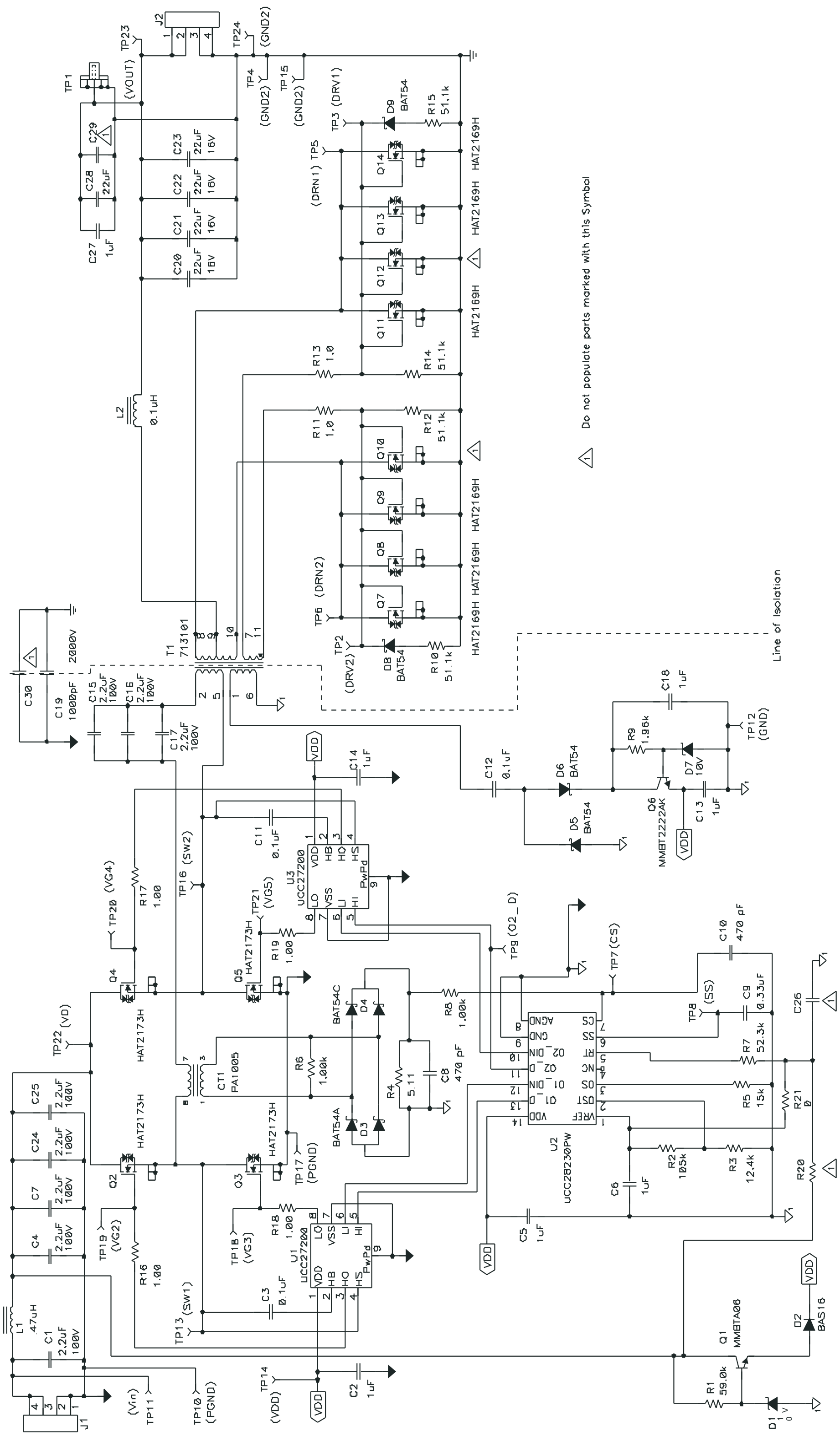

Figure 1. UCC28230EVM Schematic

5 Test Setup

5.1 List of Test Point Location

The EVM provides plenty of test points to facilitate the device's evaluation work. All test points are divided into two major groups, primary test points and secondary test points. Their locations are shown in Figure 2. The list below helps users to identify the functions of each test point.

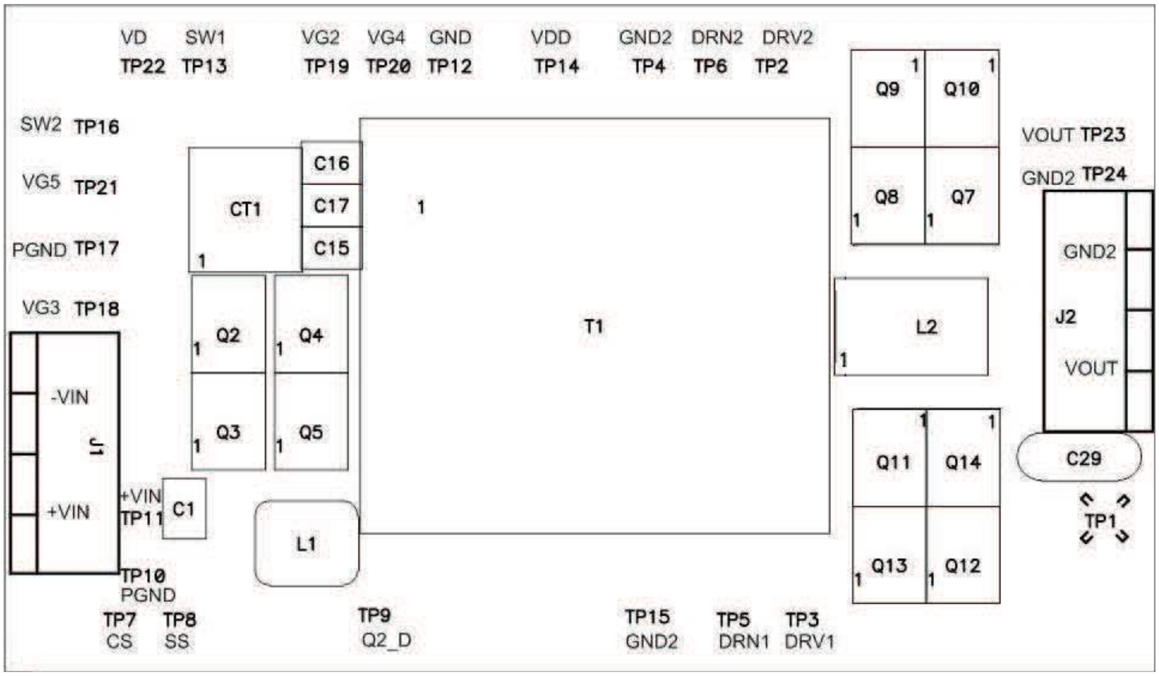

Figure 2. Test Point Locations

Table 2. List of Test Points

PRIMARY TEST POINTS			SECONDARY TEST POINTS		
NAME	REFDES	CONNECTION	NAME	REFDES	CONNECTION
Vin	TP11	Module input voltage	VOUT	TP23	Module output voltage
PGND	TP10, 17	Module power ground	GND2	TP4, 15, 24	Output power and signal ground
GND	TP12	Module signal ground	DRV1	TP3	Q11-14 gate
VDD	TP14	Device bias voltage	DRN1	TP5	Q11-14 drain
VG2	TP19	Q2 gate	DRV2	TP2	Q7-10 gate
VG3	TP18	Q3 gate	DRN2	TP6	Q7-10 drain
VG4	TP20	Q4 gate	VORIPPLE	TP1	VOUT ripple
VG5	TP21	Q5 gate			
SW1	TP13	Switch node between Q2 and Q3			
SW2	TP16	Switch node between Q4 and Q5			
Q2_D	TP9	U6 pin 11 (Q1_D)			
SS	TP8	U6 pin 6 (SS)			
CS	TP7	U6 pin 7 (CS)			

5.2 Equipment

DC Input Source: The input source shall be a variable dc source capable of supplying between 40 V_{DC} and 55 V_{DC} with 10 A_{DC} current rating.

Multimeters: Multimeters are used to measure the output voltage (DMM1), the input voltage (DMM3), the output current (DMM2) and the input load current (DMM4).

Output Load: A programmable electronic load is recommended configurable for constant current mode and capable of sinking 0 to 35 A_{DC} from 8 V_{DC} to 11 V_{DC}. The output voltage can be monitored by connecting a dc voltmeter, DMM1 to sense pins (TP23 and TP24) shown in Figure 3. A dc current meter, DMM2, may be inserted in series with the electronic load for accurate output current measurements. Similarly, the input voltage can be monitored by connecting a dc voltage meter to sense pins (TP10 and TP11). The input current can be monitored by a dc current meter too. These are shown in Figure 3.

Oscilloscope: Set the oscilloscope channel to ac coupling with 20-MHz bandwidth.

5.3 Notes of Power Up and Power Down

The following steps are guidelines for power up and power down of the EVM.

1. An ESD workstation is recommended. Make sure that an ionizer is on before the EVM is removed from the protective packaging and power is applied to the EVM. Electrostatic smock and safety glasses should also be worn.
2. Power Up
   a. Prior to connecting the dc input source, limit the source current 6.5 A maximum. Make sure the dc source is initially set between 43 V_{DC} and 53 V_{DC} prior to turning on. Connect the dc source to the EVM as shown in Figure 3.
   b. Connect the power meter as shown in Figure 3.
   c. Connect the current meters DMM2 and DMM4 as shown in Figure 3.
   d. Connect the volt meter DMM1 and DMM3 as shown in Figure 3.
   e. For operation with a load, connect the electronic load to the EVM as shown in Figure 3. Set the LOAD to constant current mode with initial value of 0 A.
   f. Turn on the dc source and observe the output voltage. Since this is an output unregulated converter, its output voltage is varying with both input voltage and load. Its output voltage varying range is between 8.0 V_{DC} and 10.8 V_{DC}.
   g. Vary the Load between 0 A and 30 A. The module is able to operating with higher current. For operating with load current greater than 30 A, please consult the factory before doing so.
3. Power Down
   a. Turn off the dc source.
   b. Turn off the load.

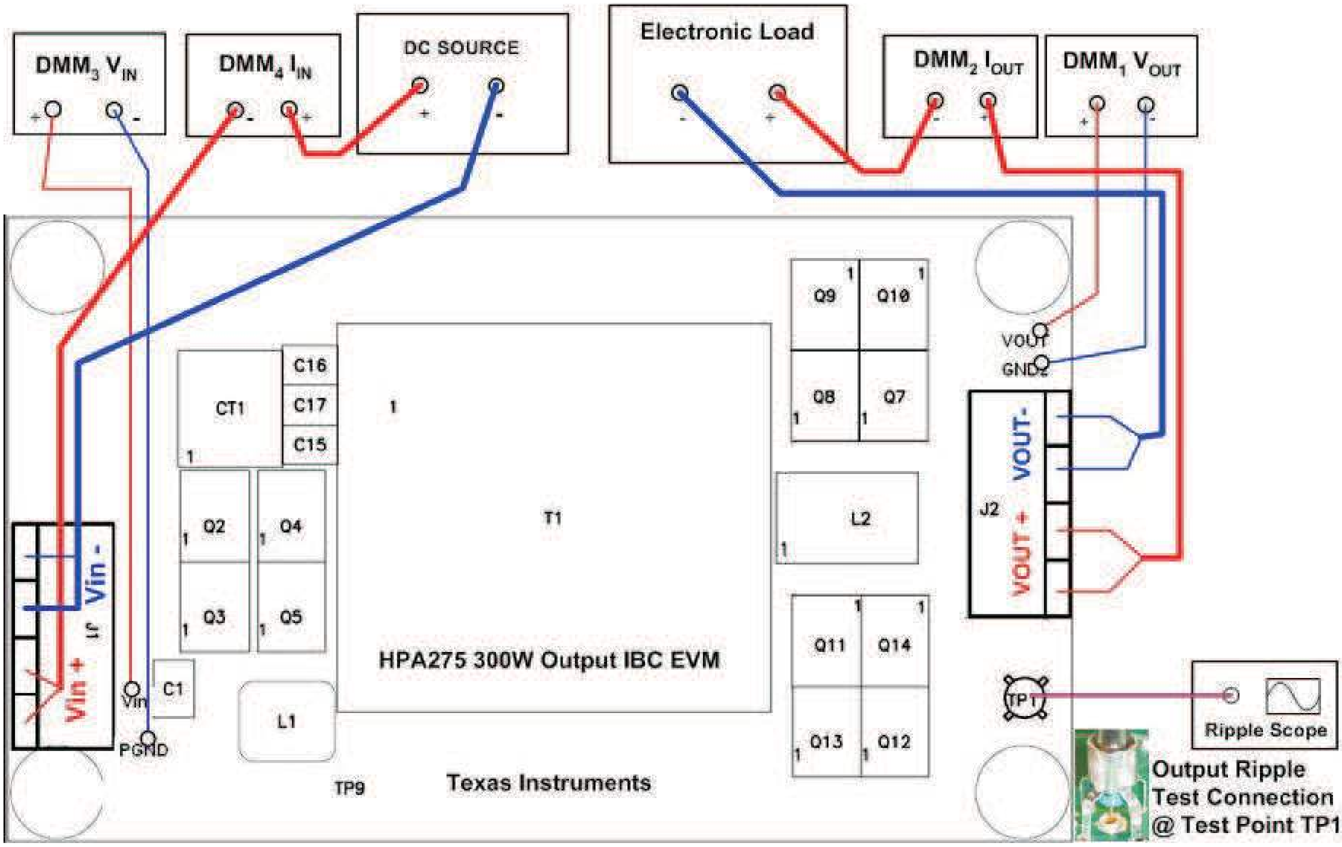

Figure 3. Test Set Up for EVM Operation

6 Test Procedure

Setup the EVM with equipment as shown in Figure 3 and following the test set up directions described in Test Setup Section.

6.1 Line and Load Regulation

Set up the load to zero amperes and input voltage between 43 V and 53 V. Prior to turning on the power, set up the input source current limit to 6.5 A to avoid potential damage, although the EVM has its power limit typical 450 W. Turn on the input source. Reference test results of line and load regulation can be found from Performance Data and Characteristic Curves Section.

6.2 Output Ripple

Along with the measurement of line and load regulation, the output voltage ripple can be measured at the same time. The method of tip-and-barrel should be used for the output voltage ripple measurement. The EVM provides such type of test point to facilitate the measurement for the type of oscilloscopes from Tectronix as shown in Figure 3. Reference test results of the output voltage ripple can be found in Performance Data and Characteristic Curves Section.

6.3 Efficiency

The efficiency may be calculated based on the test data obtained from Line and Load Regulation Section. To correctly measure input and output voltage for the efficiency calculation, test points TP10 and TP11 should be used for input voltage measurement, and test points TP23 and TP24 should be used for output voltage measurement. Reference results of efficiency can be found in Performance Data and Characteristic Curves Section.

6.4 Others

The EVM provides plenty of test points to facilitate the device's evaluation work. Table 2 presents a list of test points. Users can use these test points to make measurement to the functions of their interest. The test points are divided into two groups, namely primary side group and secondary side group. During the measurement setup, be aware of the setup especially for different ground pick up. The EVM is designed with 1500-V basic insulation of telecom standard between the primary and the secondary. As such there is no common ground as reference point for the measurement to be made on both sides. In other words, each side has its own ground to be used for measurement reference point. On the secondary side, the ground is called GND2 with test points TP4, 15, and 24. On the primary side, two grounds are provided, GND from test point TP12 as signal ground and PGND from test point TP10 and 17 as power ground. During measurement, signal functions should be referenced to signal ground and power functions should be referenced to power ground. In EVM design the two grounds are connected at one point, U6, connecting pin 8 and pin 9 will connect GND and PGND together. This is the only location connecting the two primary grounds. Performance Data and Characteristic Curves Section provides reference test results of critical waveforms.

7 Performance Data and Characteristic Curves

7.1 Line Regulation

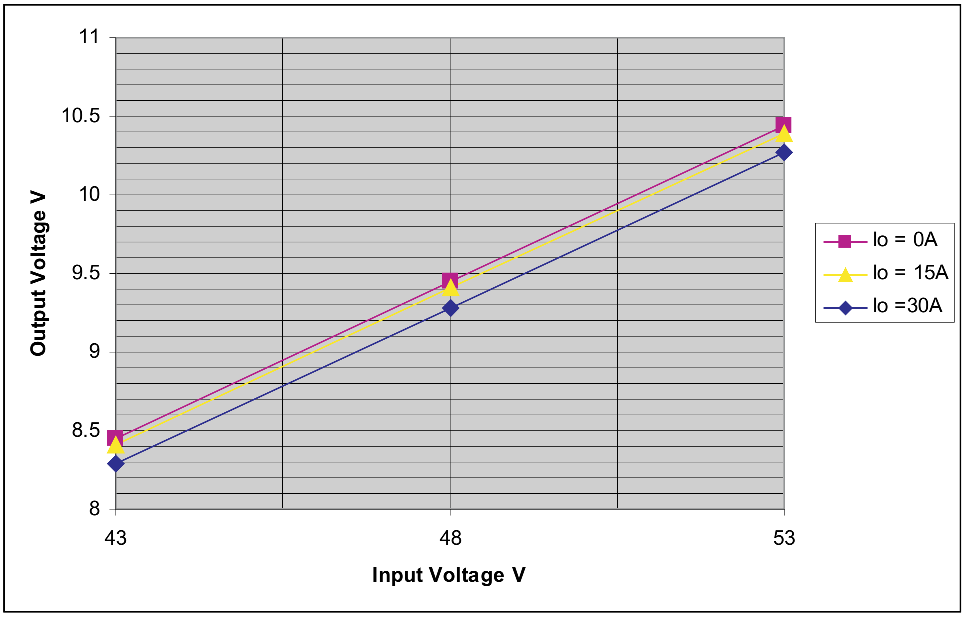

Figure 4.

7.2 Load Regulation

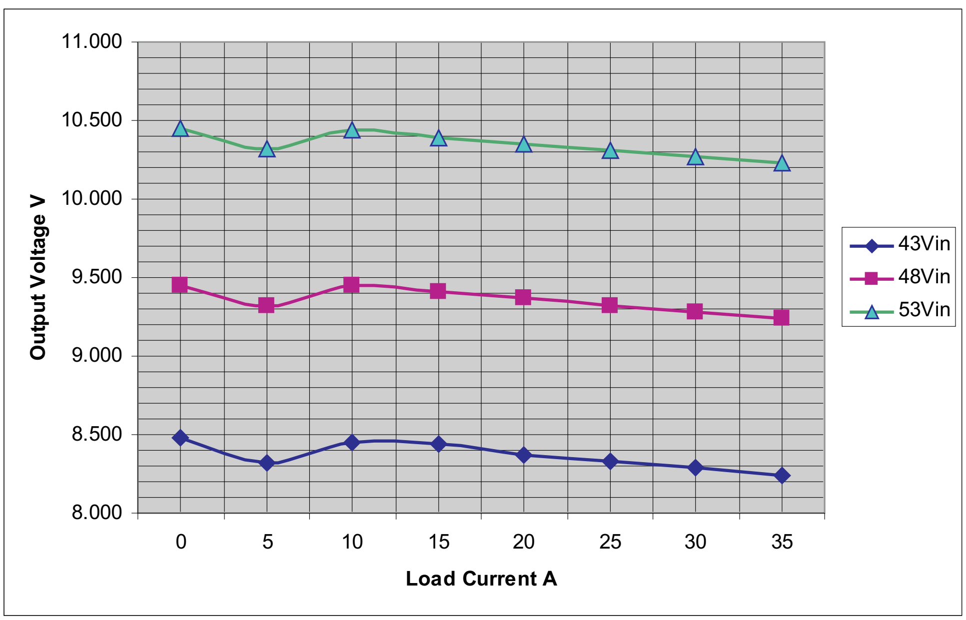

Figure 5.

7.3 Efficiency

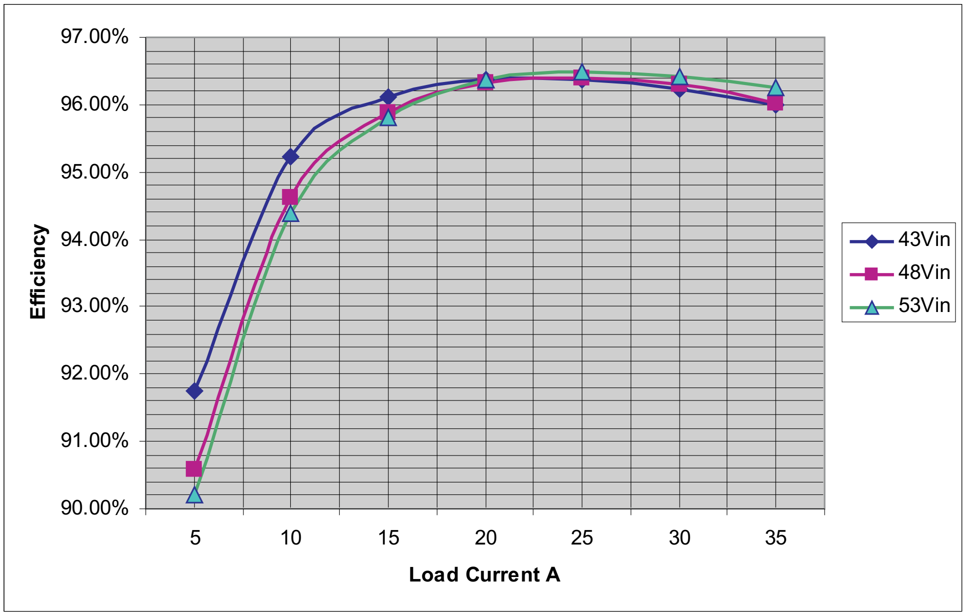

Figure 6.

7.4 Power Losses

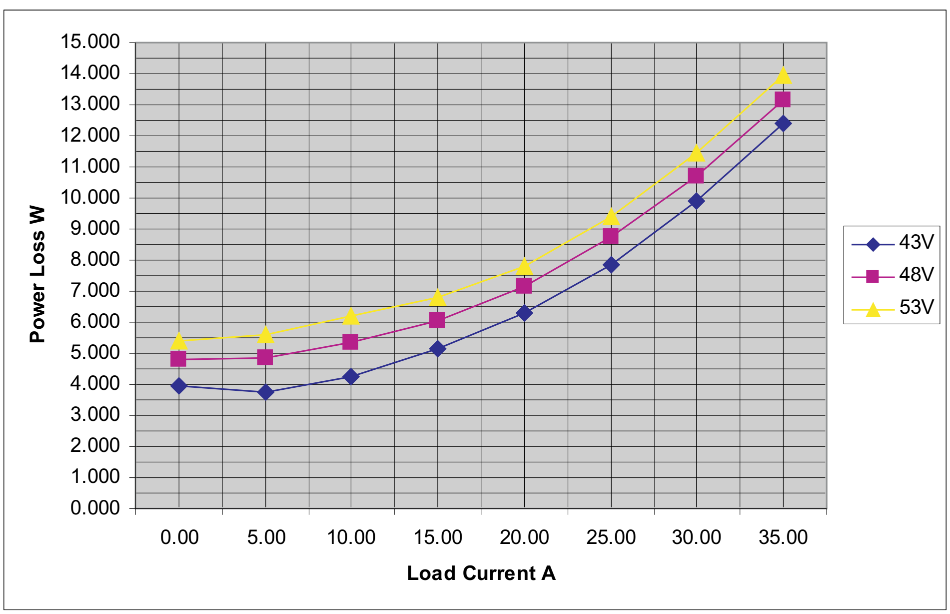

Figure 7.

7.5 Output Voltage Ripple

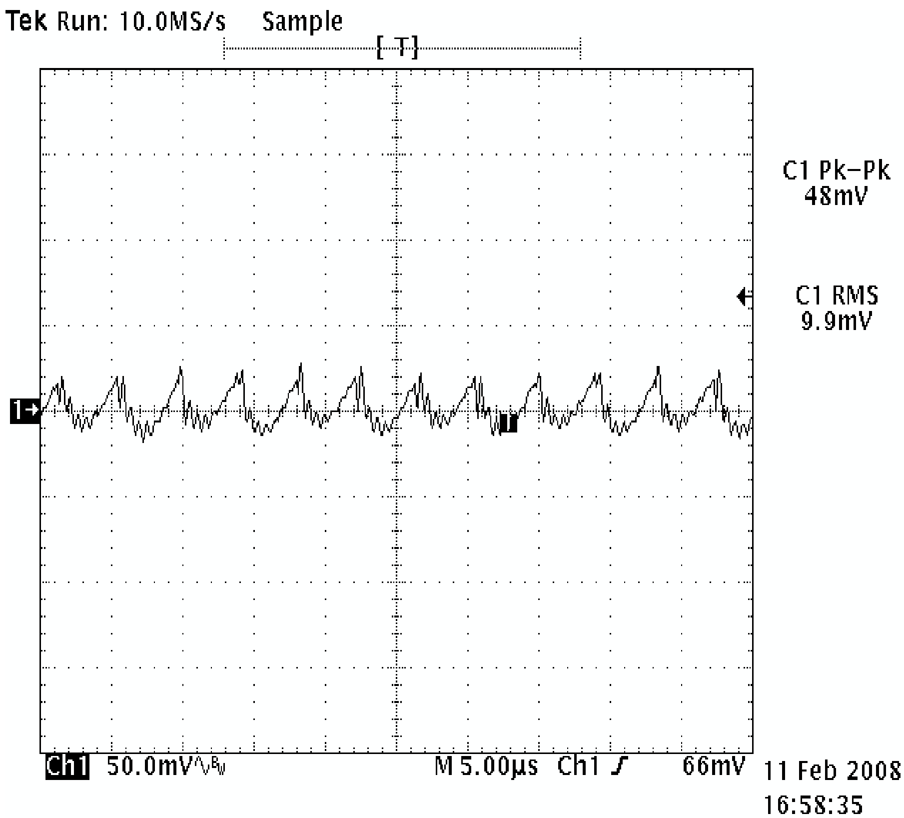

Figure 8. Test Condition V_{IN} = 48 V, I_O = 10 A

7.6 Typical Waveforms

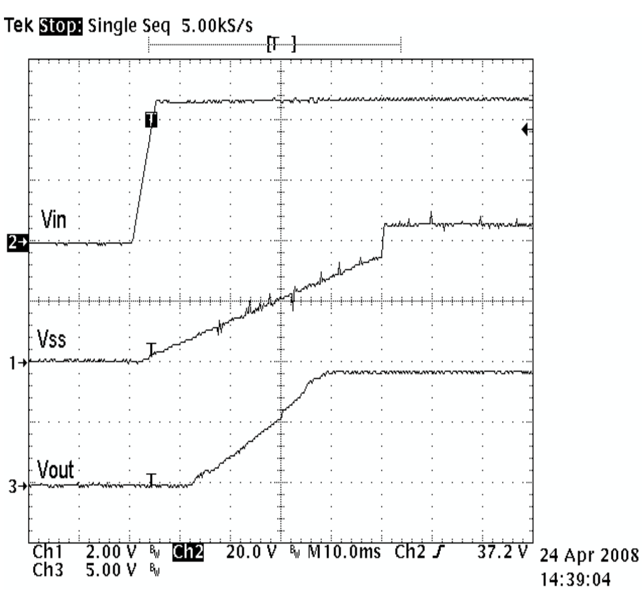

Figure 9. Test Condition: V_{IN} = 48 V, I_O = 10 A

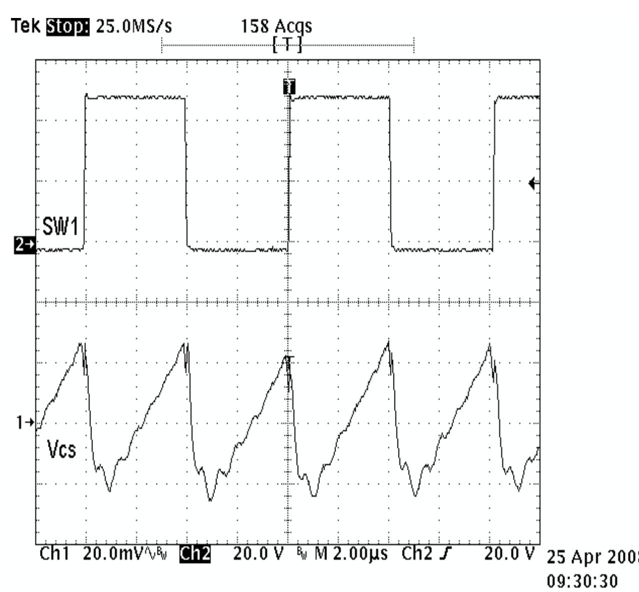

Figure 10. Top: Q3 V_{DS}; Bottom: CS Pin Test Condition: V_{IN} = 48 V, I_O = 10 A

8 EVM Assembly Drawing and PCB Layout

Figure 11 through Figure 16 show the layout of the four-layer printed circuit board used for the EVM.

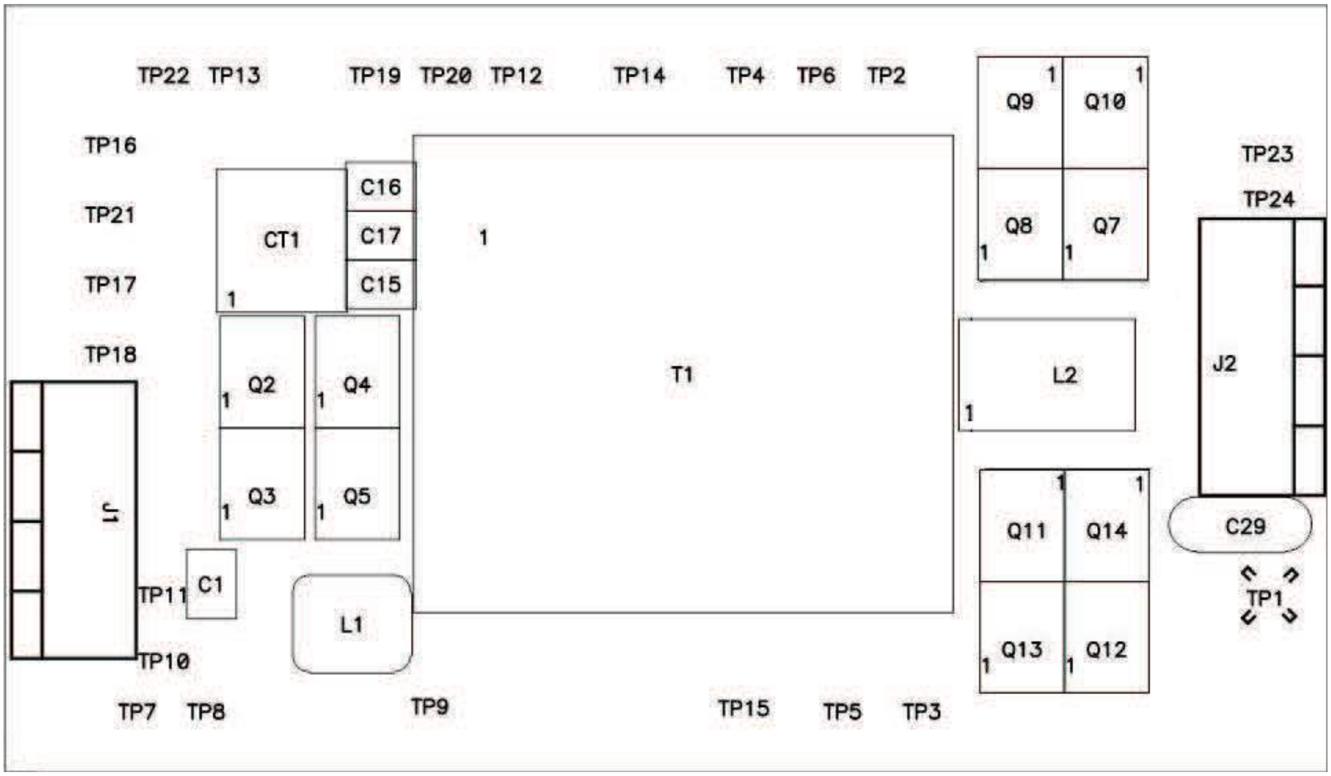

Figure 11. PCB Top Assembly

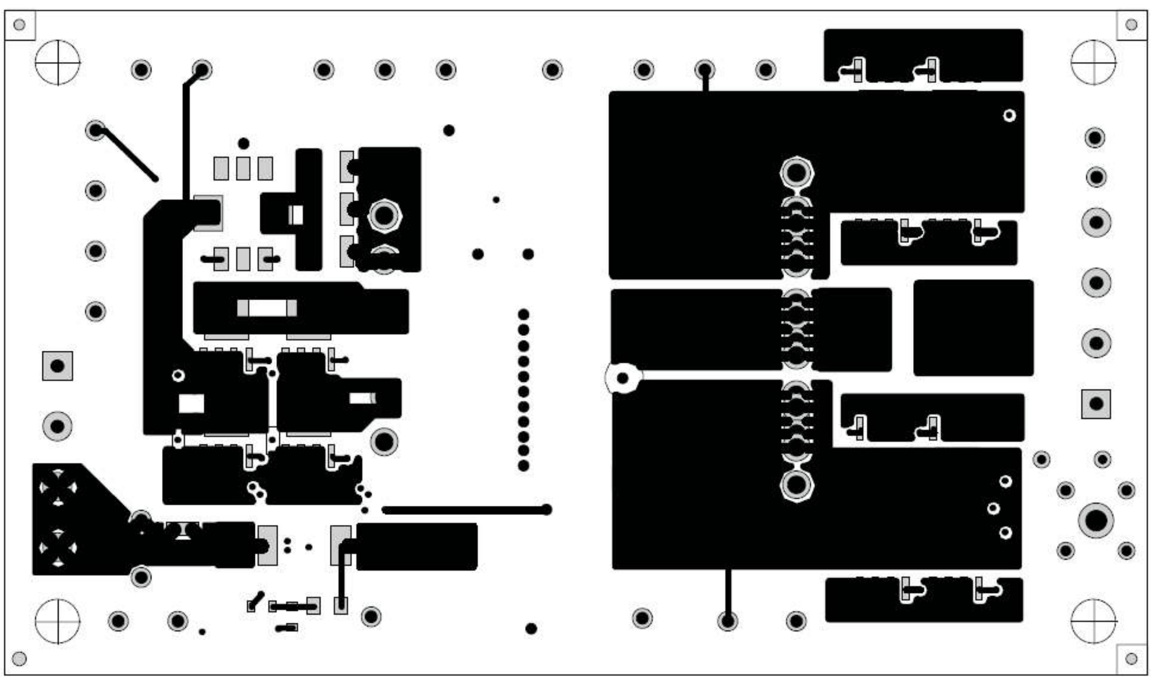

Figure 12. PCB Top Copper

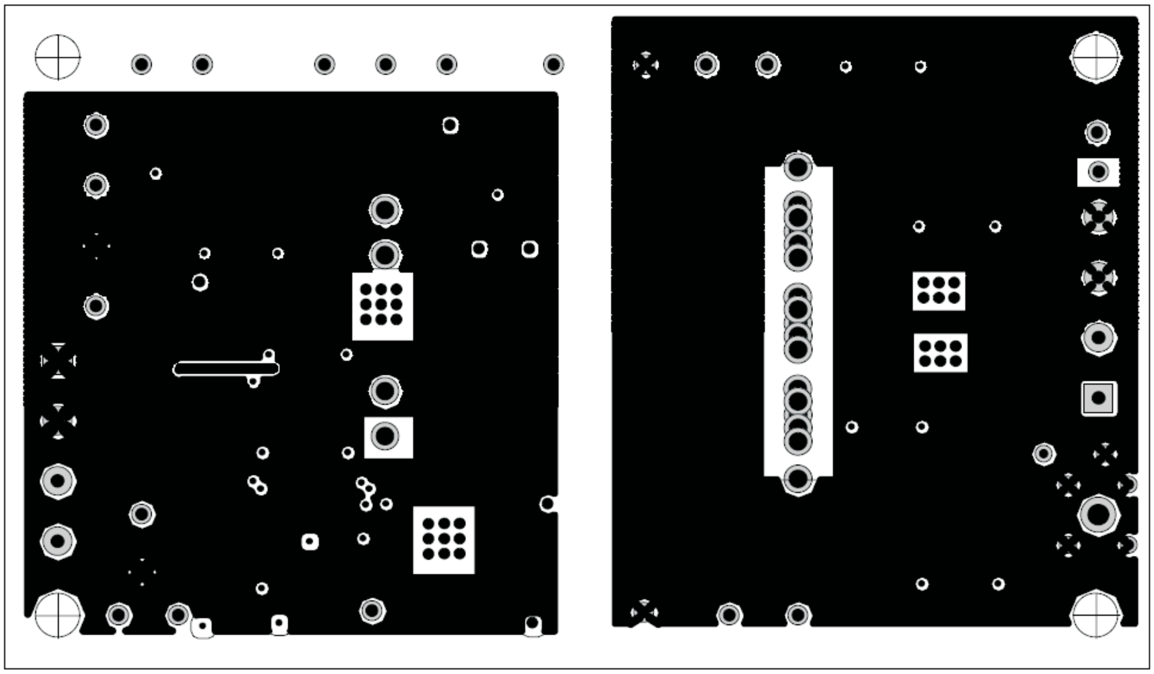

Figure 13. PCB Internal Layer 1 Copper

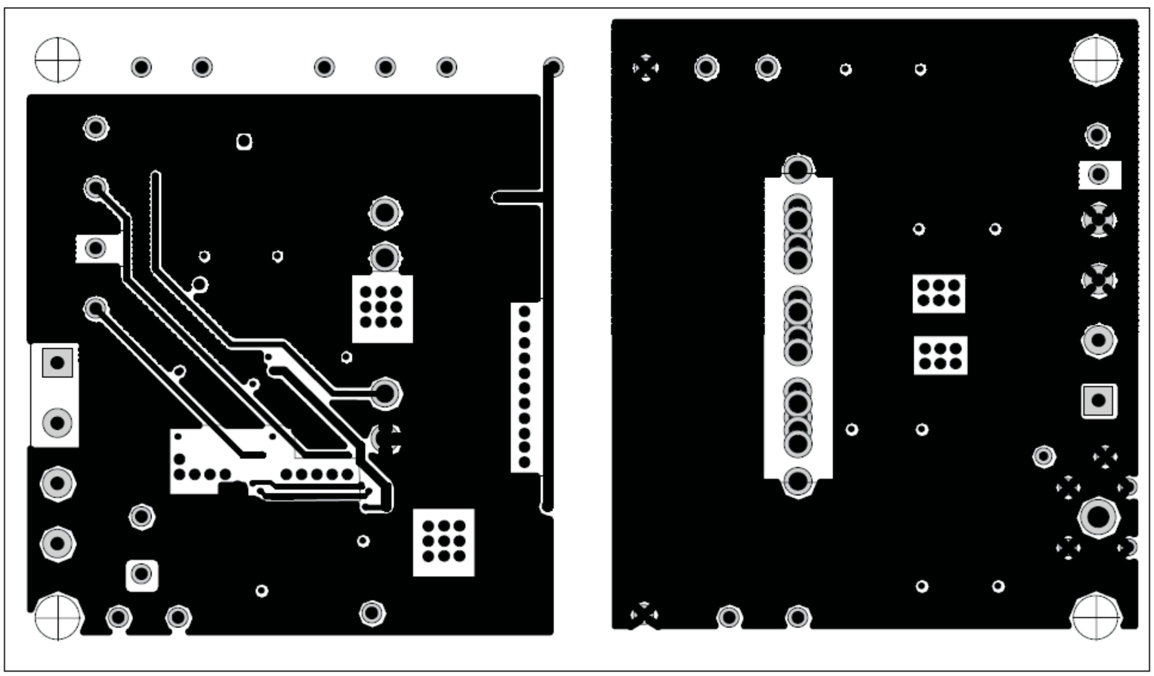

Figure 14. PCB Internal Layer 2 Copper

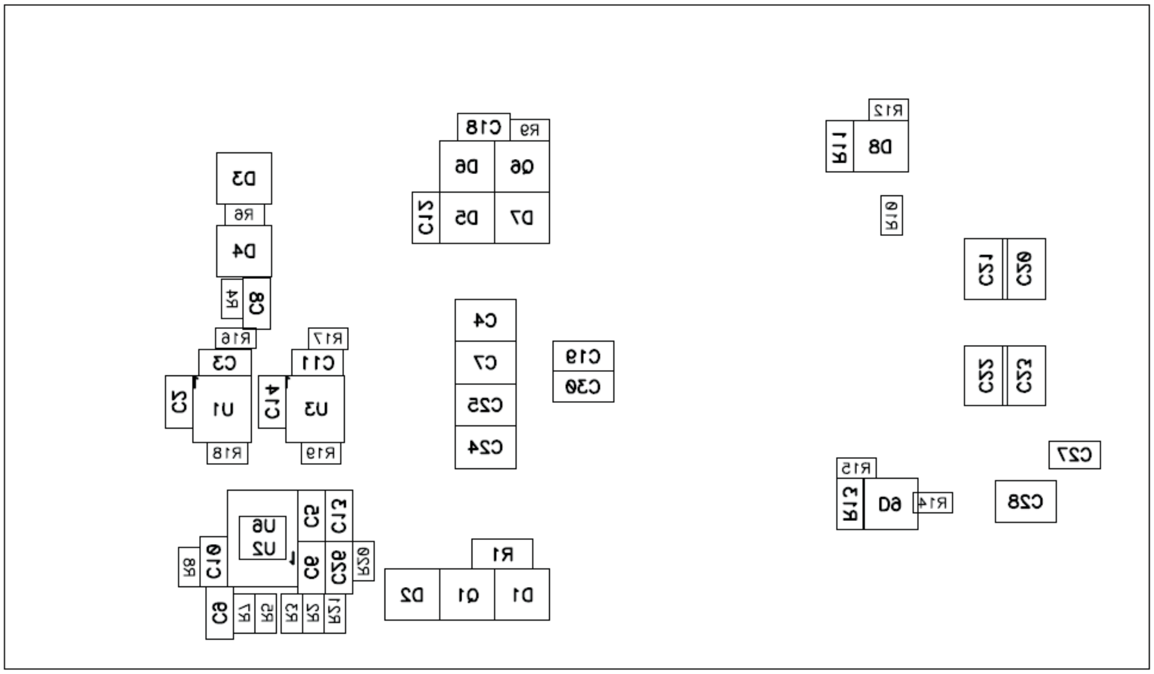

Figure 15. PCB Bottom Assembly

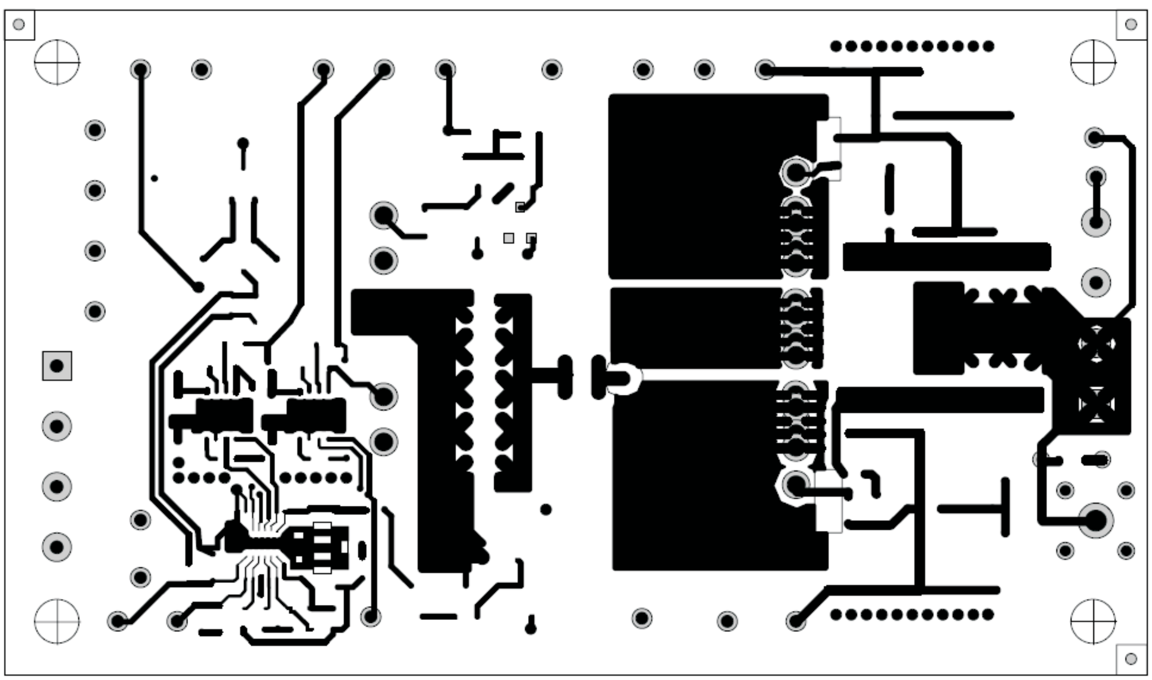

Figure 16. PCB Bottom Copper

9 List of Material

Table 3. UCC28230 List of Material

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
8	C1, C4, C7, C15, C16, C17, C24, C25	Capacitor, ceramic, 100 V, X7R, 10%, 2.2 μF, 1210	Murata	GRM32ER72A225KA35
1	C19	Capacitor, ceramic, 2000 V, 1000 pF, 1206	Johanson Dielectrics	202R18W102MV4E
7	C2, C5, C6, C13, C14, C18, C27	Capacitor, ceramic, 16 V, X5R, 10%, 1 μF, 805	Murata	GRM216R61C105KA88
5	C20, C21, C22, C23, C28	Capacitor, ceramic, 16 V, X5R, 10%, 22 μF, 1210	Murata	GRM32ER61C226KE20
1	C26	Open, 805	STD	STD
1	C29	Open, 0.150 x 0.400 in	STD	STD
3	C3, C11, C12	Capacitor, ceramic, 25 V, X7R, 10%, 0.1 μF, 805	Murata	GRM21BR71E104KA01K
1	C30	Open, 1206	STD	STD
2	C8, C10	Capacitor, ceramic, 50 V, X7R, 10%, 470 pF, 805	Panasonic	ECJ-2VB2A471K
1	C9	Capacitor, ceramic, 16 V, X7R, 10%, 0.33 μF, 805	Murata	GRM21BR71C334KA01K
1	CT1	Transformer, current sense, 20 A, 1:100, PA1005, SMD	Pulse	PA1005.100
2	D1, D7	Diode, Zener, 20 mA, 225 mW, 5%, 10 V, SOT23	Onsemi	BZX84C10LT1G
1	D2	Diode, switching, 75 V, 200 mA, SOT23, BAS16	Onsemi	BAS16LT1G
1	D3	Diode, dual schottky, 300 mA, 30 V, BAT54A, SOT23	ST	BAT54A
1	D4	Diode, dual schottky, 200 mA, 30 V, BAT54C, SOT23	Vishay	BAT54C
4	D5, D6, D8, D9	Diode, schottky, 200 mA, 30 V, BAT54, SOT23	Diodes Inc	BAT54-7-F
1	L1	Inductor, SMT, 26 A, 4.2 mΩ, 0.47 μH, 0.255 x 0.270 in	Vishay	IHLP-2525CZ-01
1	L2	Inductor, SMT, 84 A, 0.96 mΩ, open, 0.51 x 0.51 in	Vishay	IHLP5050
1	L3	Inductor, SMD, 48 A, 0.29 mΩ, 0.1 uH, 0.283 x 0.433 in	Vitec	59PR9871N
1	Q1	Bipolar, NPN, 80 Vceo, 500 mA, 350 mW, MMBTA06, SOT23	Fairchild	MMBTA06
2	Q10, Q12	Open	STD	STD
4	Q2, Q3, Q4, Q5	MOSFET, N-channel, 100 V, 25 A, 12 mΩ, HAT2173H, LFPAK	Renesas	HAT2173H
1	Q6	Bipolar, NPN, 40 Vceo, 600 mA, 350 mW, MMBT2222AK, SOT23	Fairchild	MMBT2222AK
6	Q7, Q8, Q9, Q11, Q13, Q14	MOSFET, N-channel, 40 V, 50 A, 2.8 mΩ, HAT2169H, LFPAK	Renesas	HAT2169H

Table 3. UCC28230 List of Material (continued)

QTY	REFDES	DESCRIPTION	MFR	PART NUMBER
1	R1	Resistor, chip, 59.0 kΩ, 1/4 W, 1%, 59.0 k, 1206	Panasonic	ERJ-8ENF5903V
4	R10, R12, R14, R15	Resistor, chip, 51.1 kΩ, 1/16 W, 1%, 603	Yageo	RC0603FR-0751K1L
2	R11, R13	Resistor, chip, 1.0 Ω, 1/8 W, 1%, 805	Panasonic	ERJ-6ENF1R0V
4	R16, R17, R18, R19	Resistor, chip, 1.0 Ω, 1/16 W, 1%, 603	Yageo	RC0603FR-071R00L
1	R2	Resistor, chip, 105 kΩ, 1/16 W, 1%, 603	Yageo	RC0603FR-07105KL
3	R20, R22, R24	Open, 603	STD	STD
1	R21	Resistor, chip, 0.0 Ω, 1/16 W, 1%, 603	Yageo	RC0603FR-070R00L
1	R3	Resistor, chip, 12.4 kΩ, 1/16 W, 1%, 603	Yageo	RC0603FR-0712K4L
1	R4	Resistor, chip, 5.11 Ω, 1/16 W, 1%, 603	Yageo	RC0603FR-075R11L
1	R5	Resistor, chip, 15 kΩ, 1/16 W, 1%, 1603	Yageo	RC0603FR-0715K0L
2	R6, R8	Resistor, chip, 1.00 kΩ, 1/16 W, 1%, 603	Yageo	RC0603FR-071k00L
1	R7	Resistor, chip, 52.3 kΩ, 1/16 W, 1%, 603	Yageo	RC0603FR-0752K3L
1	R9	Resistor, chip, 1.96 kΩ, 1/16 W, 1%, 603	Yageo	RC0603FR-071K96L
1	T1	Transformer, planar magnetic, 1.34 x 1.50in	Payton	71310
2	U1, U3	Device, 3-A peak, high-side low-side driver	TI	UCC27200DRM
1	U2	Device, unregulated dc-to-dc IBC, TSSOP-14	TI	UCC28230PW

10 References

1. *UCC28230 Advanced PWM Controller for Bus Converters*, datasheet, SLUS814, June 2008.