Using the UCC24610EVM-563

User's Guide

Literature Number: SLUU434
August 2010

5-V, 25-W Flyback Converter With Secondary-Side Synchronous Rectification

1 Introduction

The UCC24610EVM-563 evaluation module is a 25-W off-line Discontinuous Mode (DCM) flyback converter providing an output voltage of 5 V at 5-A maximum load current, operating from a universal AC input. The module is controlled by the UCC28610 Green-Mode Flyback Controller on the primary side which uses a cascoded architecture that allows fully integrated current control without an external sense resistor. Secondary-side synchronous rectification is controlled by the UCC24610 GREEN Rectifier™ Controller. The UCC24610 senses the drain-to-source voltage of the synchronous rectifier MOSFET in order to drive the GATE signal. The GATE output duty cycle is dependent upon the system line and load conditions, as well as the programmed minimum on-time and off-time. The converter maintains discontinuous mode operation over the entire operating range. This innovative approach results in efficiency, reliability, and system cost improvements over a conventional flyback.

2 Description

This evaluation module uses the UCC24610 GREEN Rectifier™ Controller (TI Literature Number SLUSA87) in a 25-W DCM flyback converter that exceeds Energy Star™ EPS version 2.0 for efficiency during active load and no-load power consumption for low voltage AC-to-DC external power supplies. The input accepts a voltage range of 85 VAC to 265 VAC. The output provides a regulated output voltage of 5 VDC at a load current of up to 5 A. The converter will transition through three operating modes: Green Mode (GM), Amplitude Modulation (AM), and Frequency Modulation (FM), depending upon the power level and FB current of the primary-side controller. In FM Mode, which occurs between approximately 25% and 100% rated load, the on time is fixed, resulting in a fixed peak primary current at each cycle, and the switching frequency is increased with increasing load. In AM Mode, which occurs from approximately 2% rated load up to 25% rated load, the switching frequency is fixed at 30 kHz and the peak primary current is modulated with the on time as with any typical PWM controller. Green Mode operation, at loads less than 2%, consist of burst packets of 30-kHz pulses with a fixed on time and peak primary currents of 33% the maximum programmed level.

The conduction time of the synchronous rectifier MOSFET (SR-MOSFET) is determined by comparing the SR-MOSFET’s drain-to-source voltage against internal turn-on and turn-off thresholds. Secondary-side control features automatic light-load management based upon internal timing conditions and the $R_{DS(on)}$ of the SR-MOSFET. The UCC24610 requires a minimal amount of simple, low-power external components to provide a cost effective, efficient solution for low-voltage power supplies.

This user’s guide provides the schematic, component list, assembly drawing, art work, and test set up necessary to evaluate the UCC24610 in a typical off-line DCM Flyback converter application.

2.1 Applications

The UCC24610 is suited for use in isolated off-line systems requiring high efficiency and advanced fault protection features including:

- 5-V AC-to-DC Adaptors
- Housekeeping and Auxiliary 5-V Bias Supplies
- Low-Voltage Rectification Circuits

2.2 Features

The UCC24610EVM-563 features include:

- Isolated 5-V, 25-W Output
- Universal Off-Line Input Voltage Range
- Exceeds Energy Star™ EPS Version 2.0 Requirements (for active load efficiency and no-load power consumption for low voltage external power supplies)
- Cascoded Configuration on Primary Side (allows fully integrated current control without an external sense resistor)
- Multiple Operating Modes (for optimum efficiency over entire operating range)
- Automatic Light-Load Management
- Output Short-Circuit Protection
- Improved Efficiency Over Traditional Output Diode Applications

CAUTION

High voltage levels are present on the evaluation module whenever it is energized. Proper precautions must be taken when working with the EVM. The large bulk capacitor, C5, must be completely discharged before the EVM can be handled. Serious injury can occur if proper safety precautions are not followed.

3 Electrical Performance Specifications

Table 1. UCC24610EVM-563 Electrical Performance Specifications

PARAMETER		NOTES AND CONDITIONS	MIN	NOM	MAX	UNITS
Input Characteristics						
V_{IN}	Input voltage		85		265	VRMS
I_{IN}	Input current	V_{IN} = 115 V_{RMS}, I_{OUT} = 5 A		0.6		A
		V_{IN} = 115 V_{RMS}, I_{OUT} = 0 A		0.03		
V_{UVLO}	Brown out	I_{OUT} = 5 A		69		V
Output Characteristics						
V_{OUT}	Output voltage	V_{IN} = 85 V_{RMS} to 265 V_{RMS}, I_{OUT} = 0 A to 5 A	4.5	5	5.6	V
V_{RIPPLE}	Output voltage ripple	V_{IN} = 115 V_{RMS}, I_{OUT} = 5 A		200		mVpp
I_{OUT}	Output current	V_{IN} = 85 V_{RMS} to 265 V_{RMS}	0		5	A
I_{OCP}	Output over current inception point	V_{IN} = 115 V_{RMS}		7		
V_{OVP}	Output OVP	I_{OUT} = 0 A to 5 A		6.5		V
	Transient response voltage over shoot	V_{IN} = 115 V_{RMS}, I_{OUT} = 0 A to 5 A		600		mV
System Characteristics						
f_{SW}	Switching frequency		26.3		140.4	kHz
h_{PEAK}	Peak efficiency	V_{IN} = 115 V_{RMS}, I_{OUT} = 1.75 A		82.7%		
h_{AVG}	Average efficiency	V_{IN} = 115 V_{RMS}, I_{OUT} = 25%, 50%, 75%, 100% rated load		82.3%		
		V_{IN} = 230 V_{RMS}, I_{OUT} = 25%, 50%, 75%, 100% rated load		82.3%		
	No-load power consumption	V_{IN} = 115 V_{RMS}		181		mW
		V_{IN} = 230 V_{RMS}		368		
	Operating temperature range	V_{IN} = 85 V_{RMS} to 265 V_{RMS}, I_{OUT} = 0 A to 5 A		25		°C
Mechanical Characteristics						
Width	Dimensions			2.3		inches
Length				3.5		
Height		Component height		1		

4 Schematic

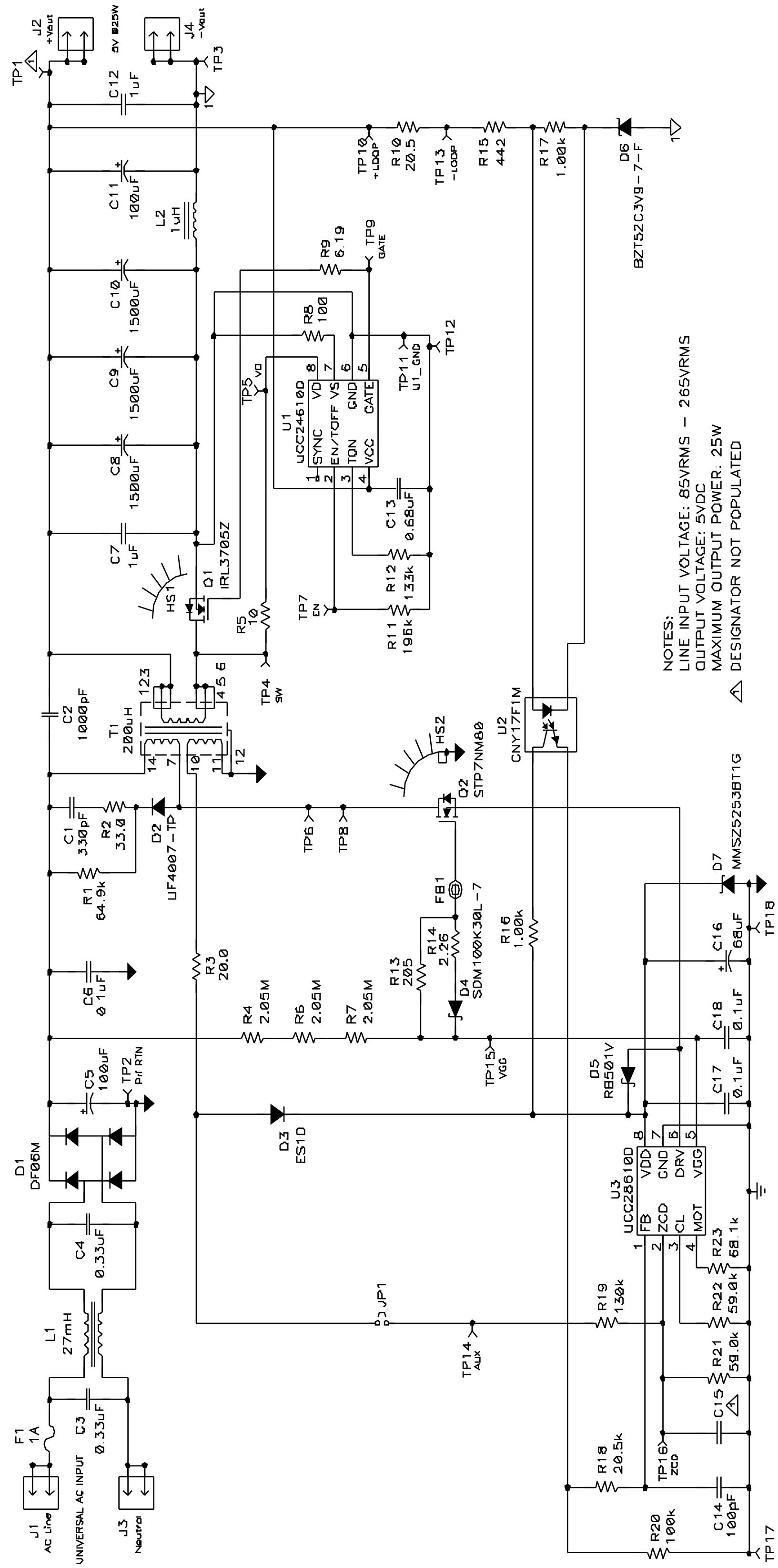

Figure 1. UCC24610EVM-563 Schematic

4.1 Circuit Description

Diode bridge D1, input capacitor C5, transformer (a.k.a. flyback inductor) T1, HV MOSFET Q2, UCC28610 controller U3, synchronous rectification MOSFET Q1, output capacitors C8, C9, and C10 form the power stage of the converter. Note that the UCC28610 U3 is part of the power stage. This is because the DRV and GND pins carry the full-peak primary-side current of the converter.

UCC24610 controller U1 drives the synchronous rectification MOSFET Q1, R11 sets the minimum time that Q1 will remain off, ignoring any resonant ringing that may inadvertently trigger the turn-on detection circuit. Resistor R12 performs a similar function in regards to the on-time of Q1 by programming the minimum time that Q1 will remain on despite any ringing due to noise that may inadvertently trigger a turn-off response. Resistor R9 dampens any resonant tank ringing on the gate of Q1. To reduce the current drawn out of VD, resistor R5 is added between VD and the drain of Q1. Because VD and VS are inputs to a differential comparator, a resistor, R8, is also needed between VS and the source of Q1. Bench testing concluded that using a slightly larger value for R8 on VS extended the on-time of Q1, and reduced the body diode conduction time.

Capacitors C6, C7, and C12 filter the high-frequency noise directly across the electrolytic input and output capacitors.

The input EMI filter is made up of X2 capacitors, C3 and C4, and common mode inductor L1. Excessive surge current protection is provided by a slow blow fuse, F1.

Resistor R1, capacitor C1, and diode D2 make up the primary side voltage clamp for the HV MOSFET. The clamp prevents the drain voltage on Q2 from exceeding its maximum rating. The integrated snubber, composed of R2 and C1, reduces the ringing on the primary-side windings that might inadvertently trigger the light-load shutdown point of the UCC24610 gate drive.

Resistors R4, R6, and R7 supply start-up bias current to the VGG shunt regulator of U3. Schottky diode D5 is required to provide initial start up to VDD from VGG at start up.

Operating bias to the UCC28610 controller is provided by the auxiliary winding on T1, diode D3, and bulk capacitor C16. The zener diode, D7, maintains the bias voltage on U3 VDD below the absolute maximum rating at full load.

Primary switch gate drive circuitry is composed of gate drive resistor R13, used for damping oscillations during turn on. Resistor R14 and diode D4 are required to provide a current path at turn off because the gate is shorted to the source of the HV MOSFET during each switching cycle. Ferrite bead FB1 reduces the high ringing on VGG at turn off.

Capacitors C17, C18, and C13 are decoupling capacitors which should always be good quality low ESR/ESL type capacitors placed as close to the controller device pins as possible and returned directly to the device ground reference.

C2 filters the common mode noise between the primary and secondary sides.

Inductor L2, with capacitor C11, reduces the output voltage ripple.

Resistors R19 and R21 program the over voltage threshold. Capacitor C15 can be used to add a small delay to U3 ZCD, to align the turn-on time of the primary switch with the resonant valley of the primary winding.

Resistor R23 programs the maximum on time of the primary side HV MOSFET.

Resistor R22 sets the maximum value for the peak-primary current.

Resistor R18 and capacitor C14 provide a filter for the U3 FB signal while resistor R20 ensures that the optocoupler emitter current can go to 0 A. Output voltage regulation is provided by diode D6, resistors R15 and R17, and the optocoupler U2. Using an opto with a low current transfer ratio provides better noise immunity. Resistor R10 is used as an injection point for small signal frequency response testing.

5 EVM Test Set Up

Figure 2 shows the equipment set up when measuring the input power consumption during no load.

Notice the addition of the 10-Ω shunt resistor in Figure 2.

During the no-load test, the power analyzer should be set for long averaging in order to include several cycles of operation and an appropriate current scale factor for using the external shunt must be used. Figure 3 shows the basic test set up recommended to evaluate the UCC24610EVM-563 with a load.

WARNING

High voltages that may cause injury exist on this evaluation module (EVM). Please ensure all safety procedures are followed when working on this EVM. Never leave a powered EVM unattended.

5.1 Test Equipment

See Figure 2 and Figure 3 for recommended test set ups.

- **AC Input Source:** The input source shall be an isolated variable AC source capable of supplying between 85 V_{RMS} and 265 V_{RMS} at no less than 30 W and connected as shown in Figure 2 and Figure 3. For accurate efficiency calculations, a power meter should be inserted between the neutral line of the AC source and the Neutral terminal of the EVM. For highest accuracy, connect the voltage terminals of the power meter directly across the Line and Neutral terminals of the EVM.
- **Load:** For the output load, a programmable electronic load set to constant current mode and capable of sinking 0 to 5 A_{DC} at 5 V_{DC} shall be used. For highest accuracy, V_{OUT} can be monitored by connecting a DC voltmeter, DMM V1, directly across the V_{OUT}+ and V_{OUT}– terminals as shown in Figure 3. A DC current meter, DMM A1, should be placed in series with the electronic load for accurate output current measurements.
- **Power Meter:** The power analyzer shall be capable of measuring low input current, typically less than 50 mA, and a long averaging mode if low power standby mode input power measurements are to be taken. An example of such an analyzer is the Voltech PM100 Single Phase Power Analyzer. To measure the intermittent bursts of current and power drawn from the line during no-load operation, an external 10-Ω shunt, with a current scale factor of 10A/V, was used at a high sample rate over an extended period of time in order to display the averaged results (refer to Figure 2).
- **Multimeters:** Two digital multimeters are used to measure the regulated output voltage (DMM V1) and load current (DMM A1).
- **Oscilloscope:** A digital or analog oscilloscope with a 500-MHz scope probe is recommended.
- **Fan:** Forced air cooling is not required.
- **Recommended Wire Gauge:** a minimum of AWG18 wire is recommended. The wire connections between the AC source and the EVM, and the wire connections between the EVM and the load should be less than two feet long.

5.2 Recommended Test Set Up for Operation Without a Load

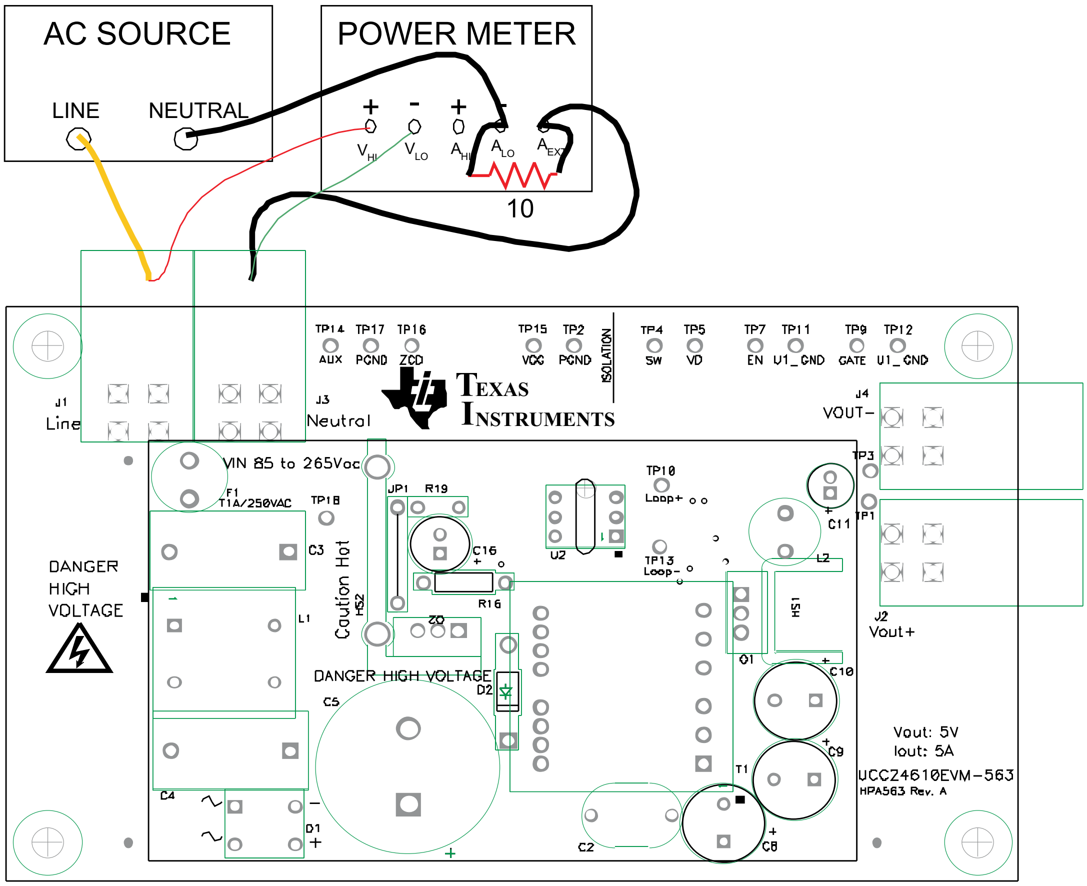

Figure 2. Recommended Test Set Up Without a Load.

5.3 Recommended Test Set Up for Operation With a Load

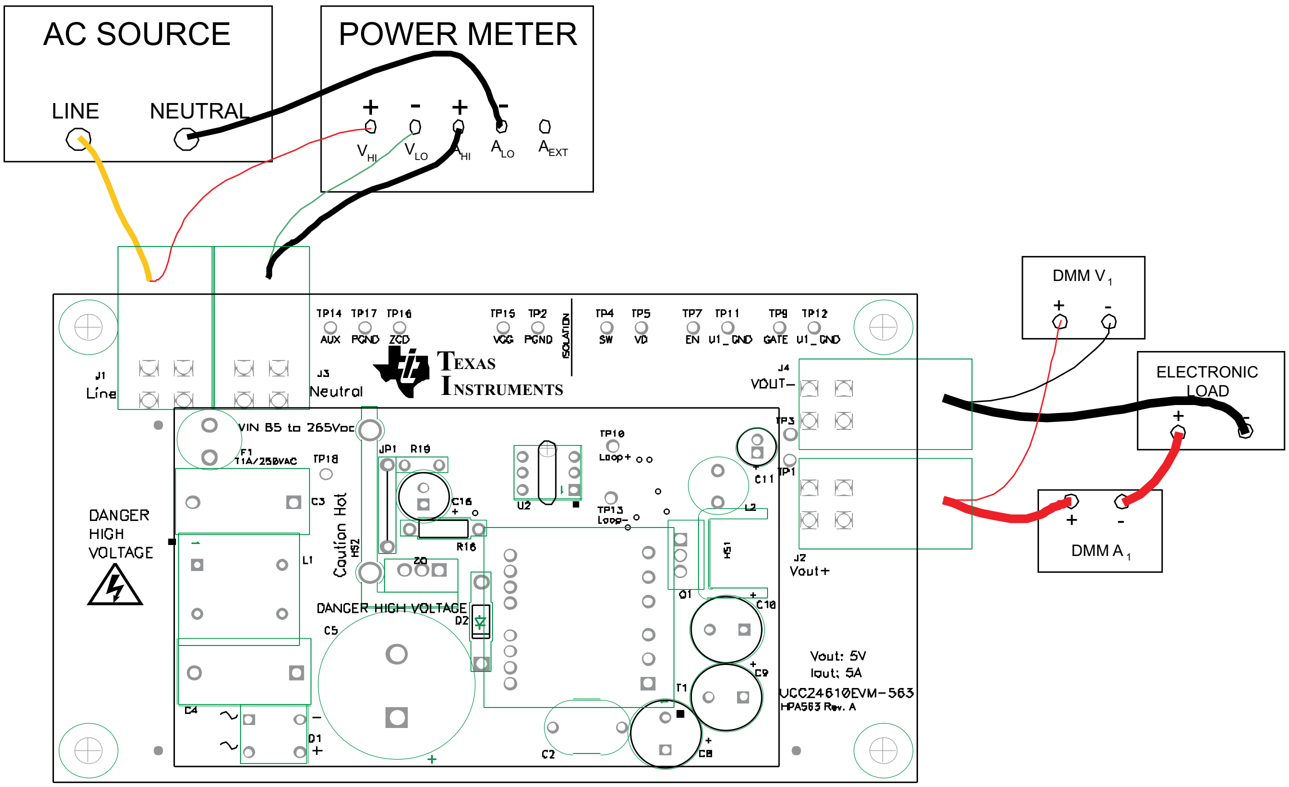

Figure 3. Recommended Test Set Up With a Load.

5.4 List of Test Points

Table 2. Test Point and Connector Functional Descriptions

TEST POINT	NAME	DESCRIPTION
TP1	Vout+	Output voltage of EVM; this designator is not populated with a pin in order to facilitate tip and barrel output ripple voltage measurements in conjunction with TP3, Vout-.
TP2	PGND	Primary side power ground. Use this pin as a reference for TP15, VGG.
TP3	Vout-	Output return of EVM; use this pin to facilitate tip and barrel output ripple voltage measurements in conjunction with TP1, Vout+.
TP4	SW	Secondary side switch node, reference the probe to U1_GND, TP11 or TP12.
TP5	VD	VD pin, U1. Reference the probe to U1_GND, TP11 or TP12.
TP6	-	Located on the drain trace of the primary side HV MOSFET, the user can cut the trace between this test point and TP8 to insert their own current loop to monitor primary side drain current.
TP7	EN	EN/TOFF pin, U1, shorting this pin to U1_GND (TP11 or TP12) will disable the GATE of U1 resulting in body diode conduction.
TP8	-	Located on the drain trace of the primary side HV MOSFET, the user can cut the trace between this test point and TP6 to insert their own current loop to monitor primary side drain current.
TP9	GATE	Gate pin, U1. Reference the probe to U1_GND, TP11 or TP12.
TP10	+LOOP	Loop injection point, EVM output.
TP11	U1_GND	GND pin of U1, use as a return for TP4, TP5, TP7, and TP9.
TP12	U1_GND	GND pin of U1, use as a return for TP4, TP5, TP7, and TP9.
TP13	-LOOP	Loop injection point
TP14	AUX	Auxiliary winding of T1. Reference the probe to TP17, PGND.
TP15	VGG	VGG pin, U3. Reference the probe to TP2, PGND.
TP16	ZCD	ZCD pin, U3. Reference the probe to TP17, PGND.
TP17	PGND	Primary side power ground. Use this pin as a reference for TP14, AUX, and TP16, ZCD.
TP18	-	PGND, can be used as a reference when probing the drain pin of Q2
J1	Line	Line input from AC source
J2	Vout+	Positive output terminal of the EVM to the load
J3	Neutral	Neutral input from the AC Source
J4	Vout-	Return connection of the EVM output to the load

6 Test Procedure

All tests should use the set up as described in Section 5 of this user's guide. The following test procedure is recommended primarily for power up and shutting down the evaluation module. Never leave a powered EVM unattended for any length of time.

6.1 Applying Power to the EVM

1. Set up the EVM as shown in Section 5 of this user's guide.
   (a) If no-load input power measurements are to be made, set the power analyzer to long averaging and external shunt mode. Insert a shunt, such as a 10-Ω resistor as shown in Figure 2, in series with the Neutral terminal of the EVM. Set the appropriate current scale on the power analyzer.
   (b) For operation with a load, as shown in Figure 3, set the electronic load to constant current mode to sink 0 A.
2. Prior to turning on the AC source, set the voltage to between 85 V_{AC} and 265 V_{AC}.
3. Turn on the AC source.
4. Monitor the output voltage on DMM V1.
5. Monitor the output current on DMM A1.
6. The EVM is now ready for testing.

6.2 No-Load Power Consumption

1. Use the test set up shown in Section 5
   (a) Set the power analyzer to external shunt mode.
   (b) Set the appropriate current scale factor for using an external shunt on the power analyzer. A 10-Ω shunt scales at 10,000 mV/A for the PM100 Voltech.
   (c) Set the power analyzer long averaging time to include several cycles of operation. The PM100 Voltech should be set to a long averaging time of 10 or more for accurate Burst Mode measurements.
2. Apply power to the EVM per Section 6.1.
3. Monitor the input power on the power analyzer while varying the input voltage.
4. Make sure the input power is off and the bulk capacitor and output capacitors are completely discharged before handling the EVM.

6.3 Output Voltage Regulation and Efficiency

1. For load regulation:
   (a) Use the test set up shown in Figure 3.
      (i) Be sure to remove the external shunt from the power analyzer and set the analyzer to normal mode (not long averaging).
   (b) Set the AC source to a constant voltage between 85 V_{AC} and 265 V_{AC}.
   (c) Apply power to the EVM per Section 6.1.
   (d) Vary the load current from 0 A up to 5 A, as measured on DMM A1.
   (e) Observe that the output voltage on DMM V1 remains within 15% of 5 V_{DC}.
2. For line regulation:
   (a) Set the load to sink 5 A.
   (b) Vary the AC source from 85 V_{AC} to 265 V_{AC}.
   (c) Observe that the output voltage on DMM V1 remains within 15% of 5 V_{DC}.
3. Make sure the input power is off and the bulk capacitor and output capacitors are completely discharged before handling the EVM.

6.4 Output Voltage Ripple

1. Expose the ground barrel of the scope probe. Insert the tip of the probe into the plated via located on the V_{OUT}+ pad of the EVM (TP1) and lean the probe so that the exposed ground barrel is resting on the test point on the Vout- pad of the EVM (TP3) for a tip and barrel measurement as shown in the example depicted in Figure 4.
2. Apply power to the EVM per Section 6.1.
3. Monitor the output voltage ripple on the oscilloscope.

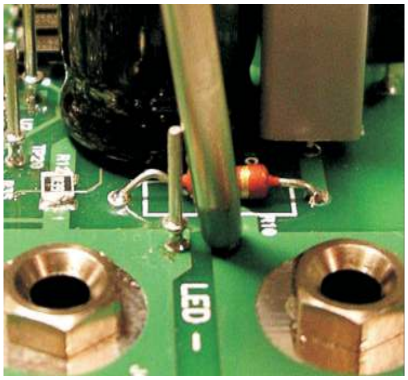

Figure 4. Typical Example of Tip and Barrel Measurement Technique

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NOTE: This photo was not taken on the UCC24610EVM specifically but serves as a visual aid to perform the test measurement.

6.5 Equipment Shutdown

1. Ensure the load is at maximum of 5 A; this will quickly discharge the output capacitors.
2. Turn off the AC source.

7 Typical Characteristic Curves

Figure 5 through Figure 10 present typical performance curves for the UCC24610EVM-563.

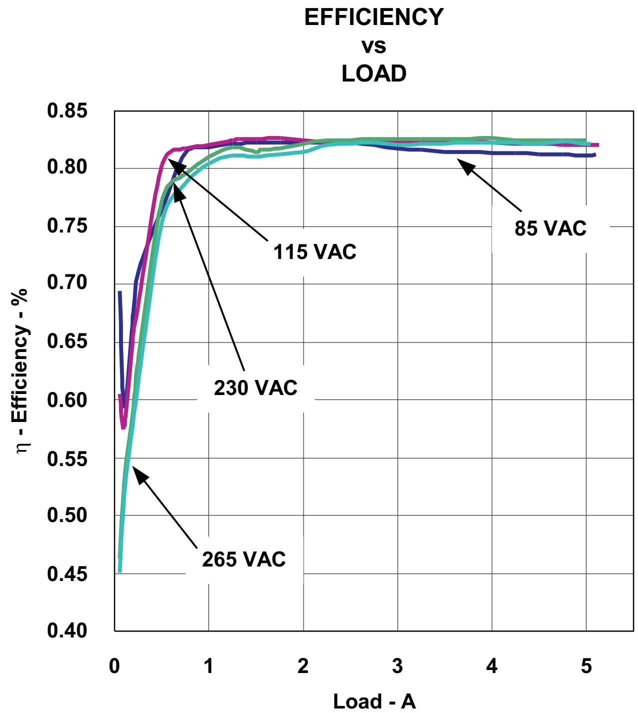

Figure 5. Efficiency (as a function of load current and input voltage)

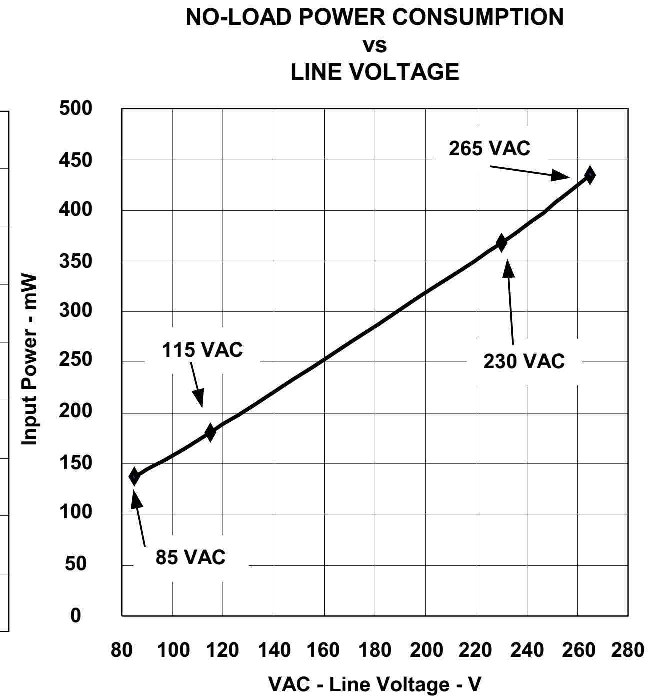

Figure 6. No-Load Input Power (as a function of input voltage)

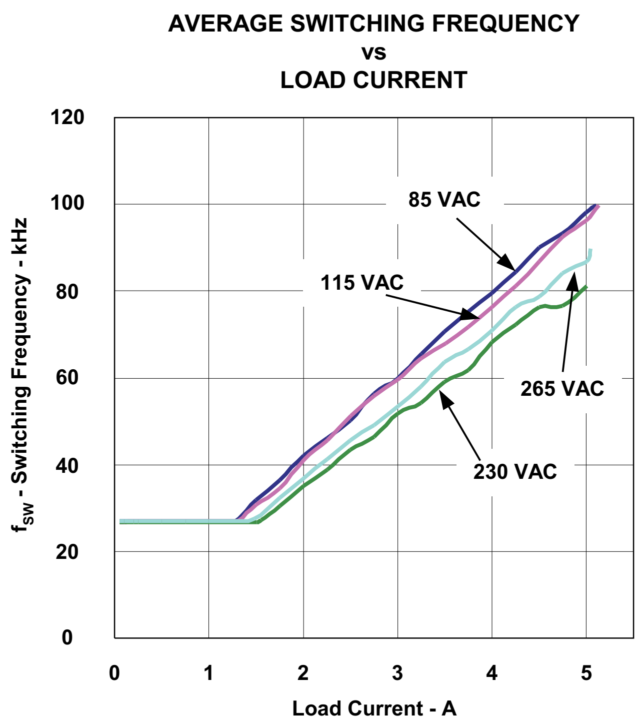

Figure 7. Average Switching Frequency (as a function of load current)

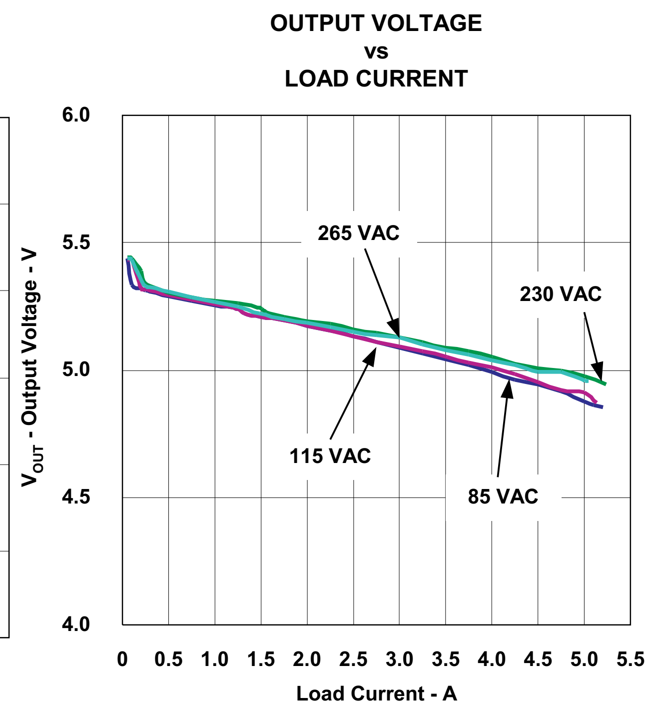

Figure 8. Output Voltage (as a function of load current and line voltage)

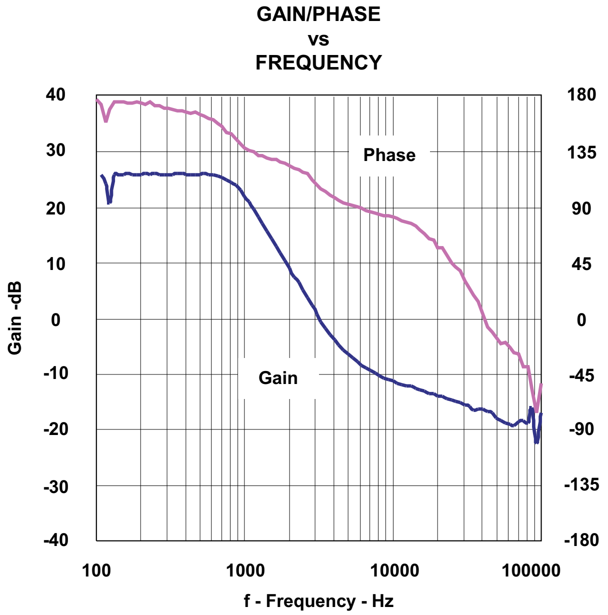

Figure 9. Gain Phase Bode Plot (Input voltage = 115-V_{AC}, 5-A load.)

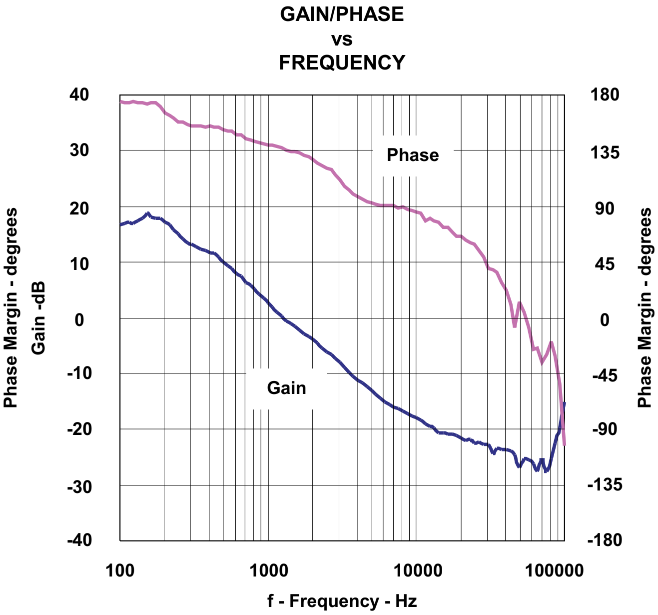

Figure 10. Gain Phase Bode Plot (Input voltage = 230-V_{AC}, 5-A load.)

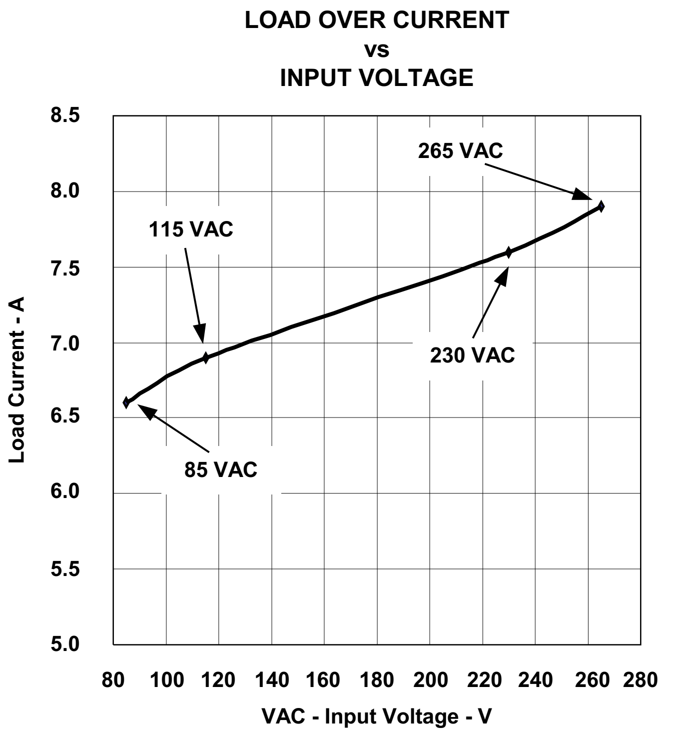

Figure 11. Overcurrent Threshold as a Function of Line Voltage

8 Performance Data

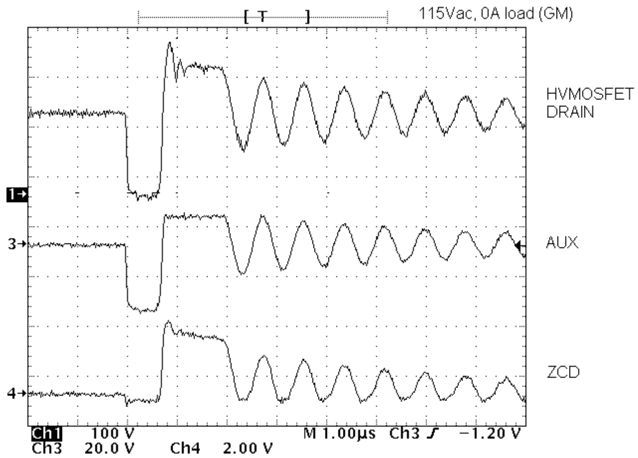

Figure 12. Primary-Side Waveforms (Input voltage = 115-V$_{AC}$, no load, Green Mode operation.)

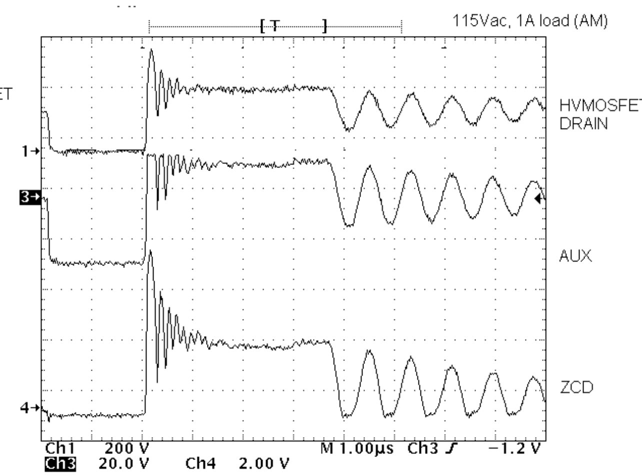

Figure 13. Primary-Side Waveforms (Input voltage = 115-V$_{AC}$, 1-A load, Amplitude Modulation Mode.)

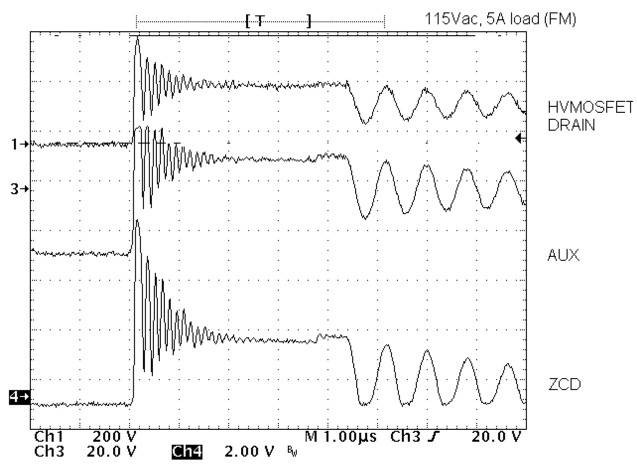

Figure 14. Primary-Side Waveforms (Input voltage = 115-V$_{AC}$, 5-A load, Frequency Modulation Mode.)

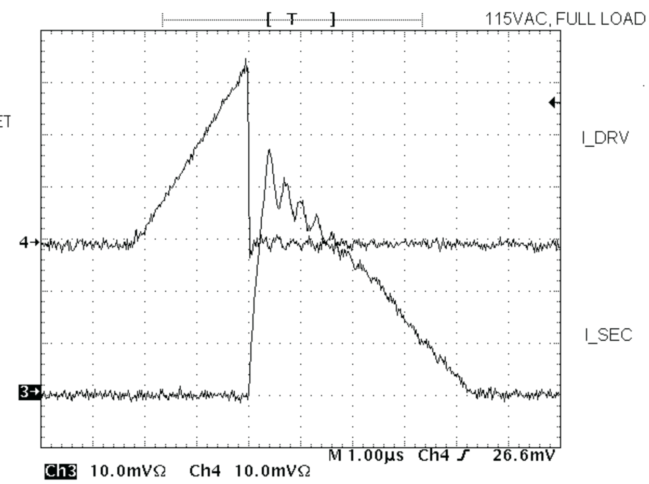

Figure 15. Primary and Secondary Currents (Current loops were added to EVM in the HV MOSFET drain and the trace from the transformer to the SR FET drain. Input voltage = 115-V$_{AC}$, 5-A load.)

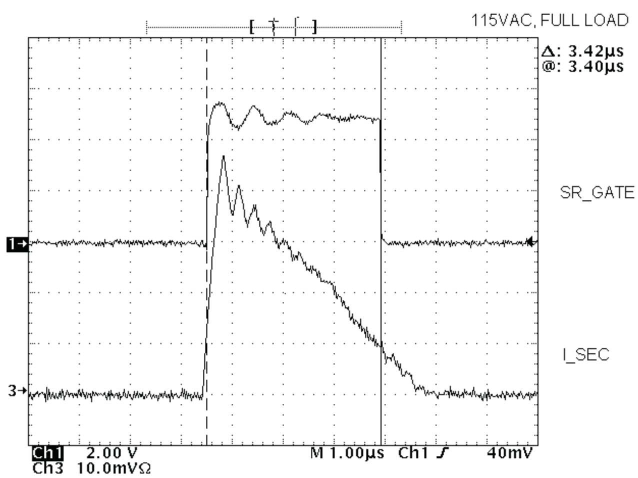

Figure 16. Secondary-Side Current (Current loop added between transformer and drain of SR FET and SR GATE signal, Input voltage = 115-V$_{AC}$, 5-A load.)

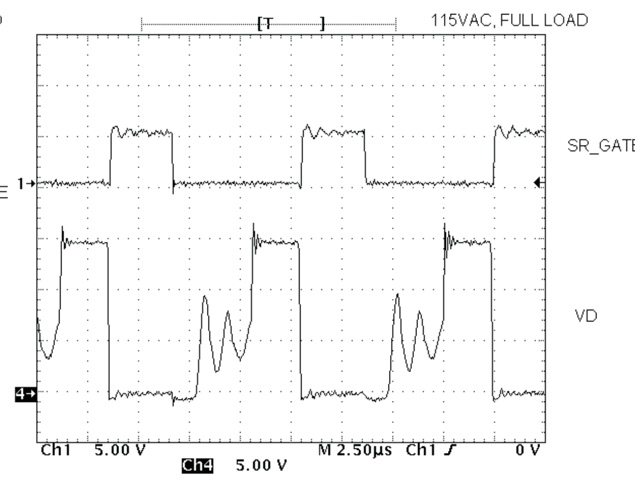

Figure 17. Secondary-Side Waveforms (Input voltage = 115-V$_{AC}$, 5-A load.)

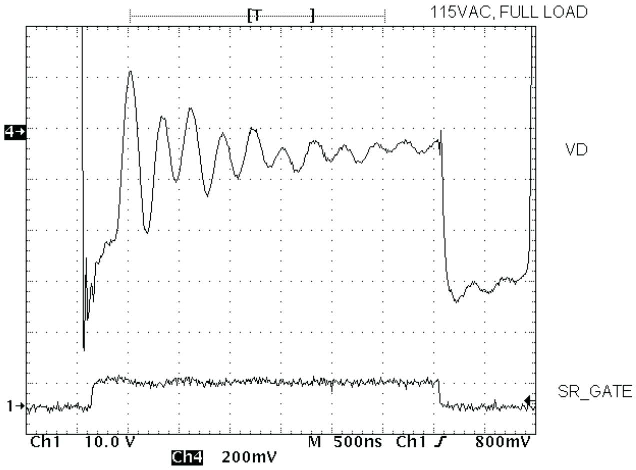

Figure 18. Close-Up View of VD and SR GATE (Input voltage = 115-V_{AC}, 5-A load.)

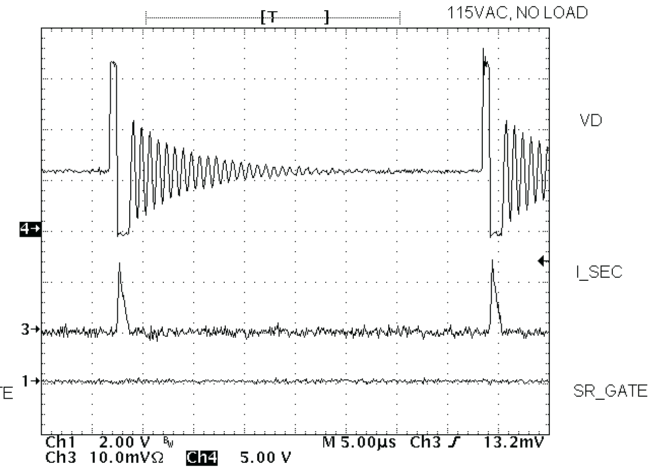

Figure 19. Secondary-Side Waveforms (Current loop added from transformer to SR FET gate. Input voltage = 115-V_{AC}, 0-A load, Green Mode.)

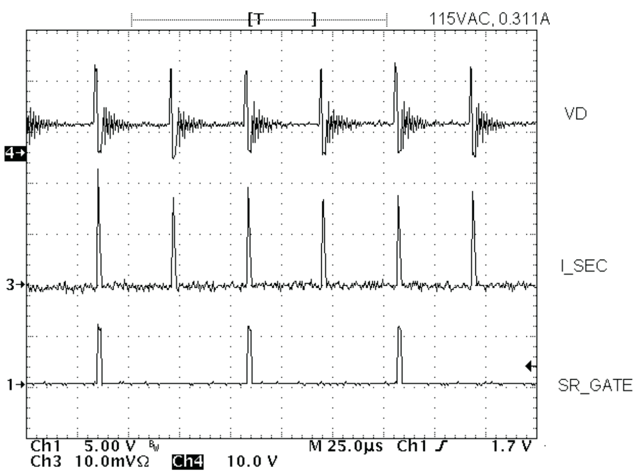

Figure 20. Secondary-Side Waveforms (Current loop added between transformer and SR FET gate. Low power mode. Input voltage = 115-V_{AC}, 0.311-A load.)

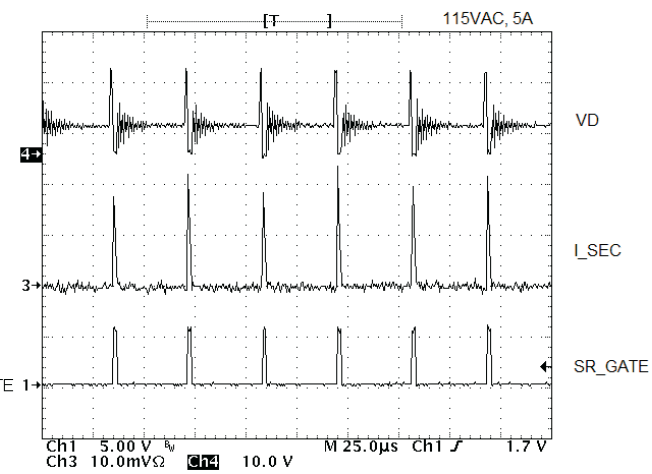

Figure 21. Secondary-Side Waveforms (Current loop added between transformer and SR FET gate. Normal operating mode. Input voltage = 115-V_{AC}, 5-A load.)

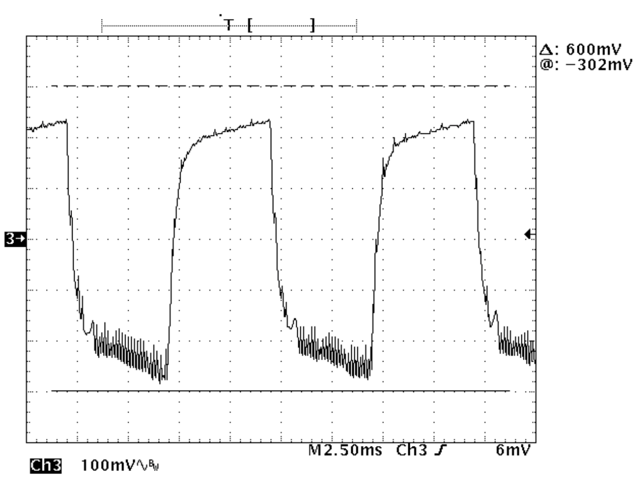

Figure 22. Output Voltage During Transient Load (0% to 100% load transient, input voltage = 115-V_{AC}.)

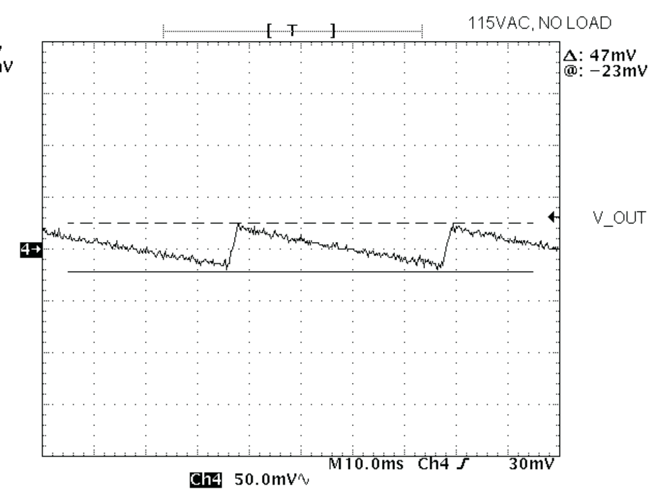

Figure 23. Output Voltage Ripple (Input voltage = 115-V_{AC}, 0-A load.)

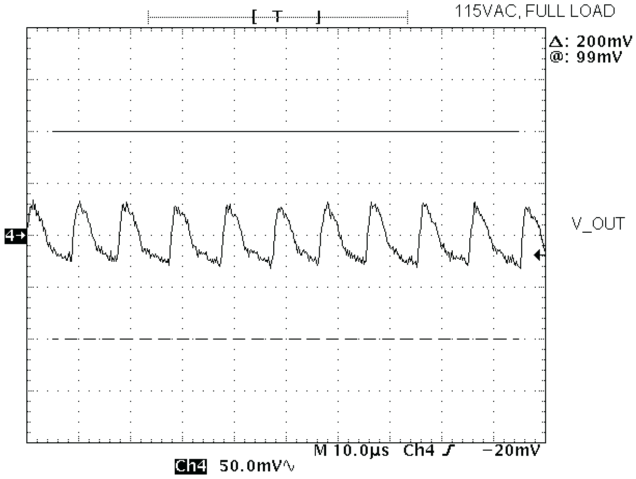

Figure 24. Output Voltage Ripple (Input voltage = 115-V_{AC}, 5-A load.)

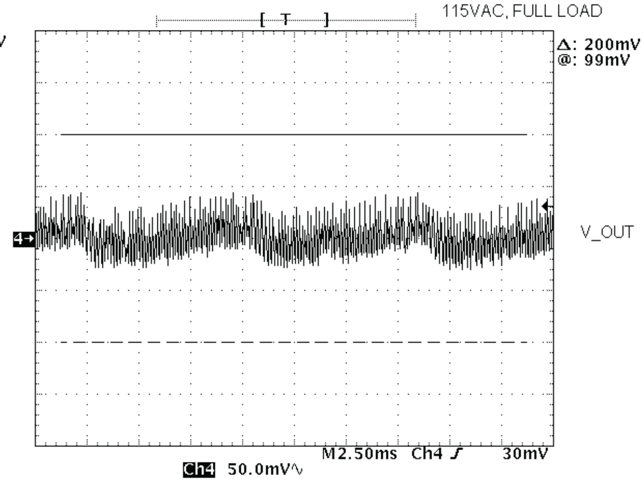

Figure 25. Low Frequency Output Voltage Ripple (Input voltage = 115-V_{AC}, 5-A load.)

9 EVM Assembly Drawing and PCB Layout

Figure 26 through Figure 34 present EVM Assembly Drawing and PCB Layout drawings for the UCC24610EVM-563.

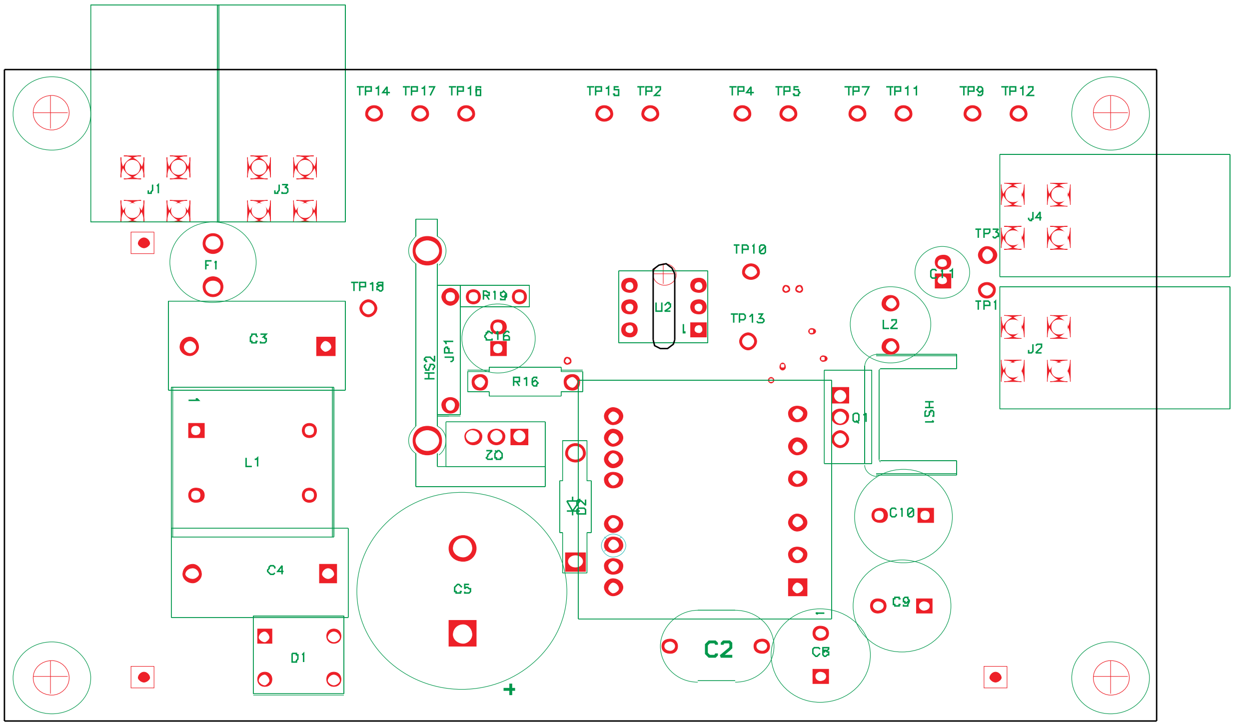

Figure 26. Top Assembly

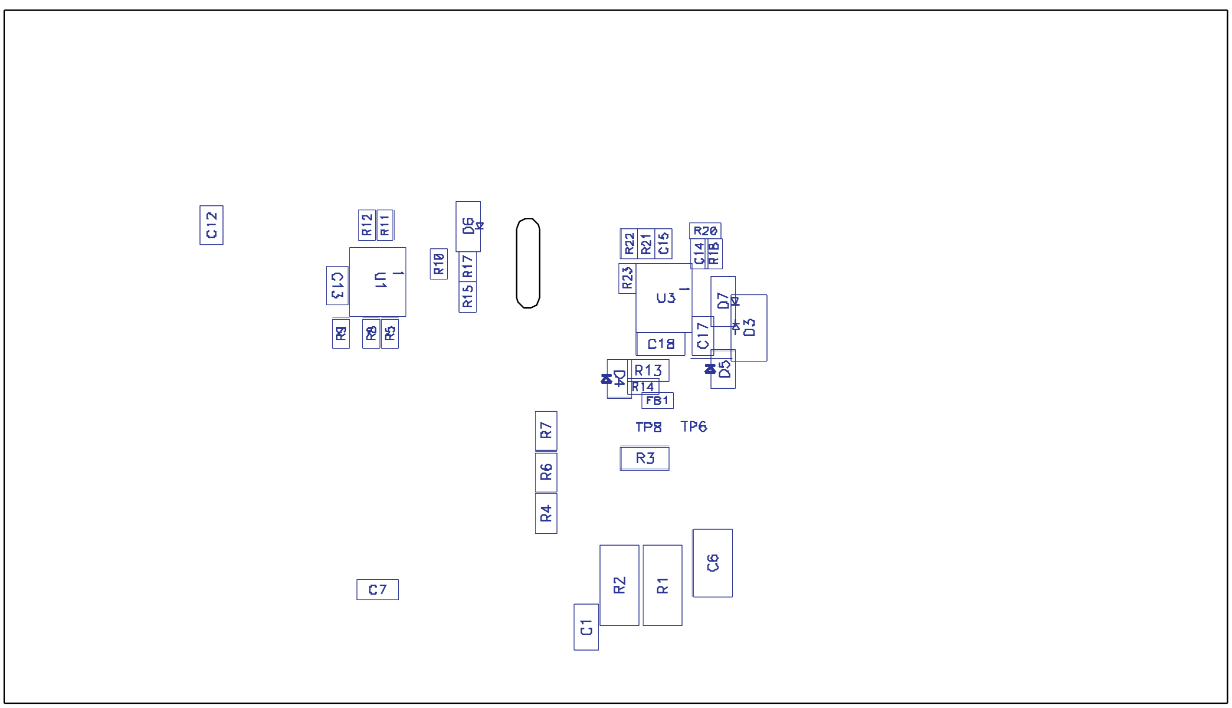

Figure 27. Bottom Assembly

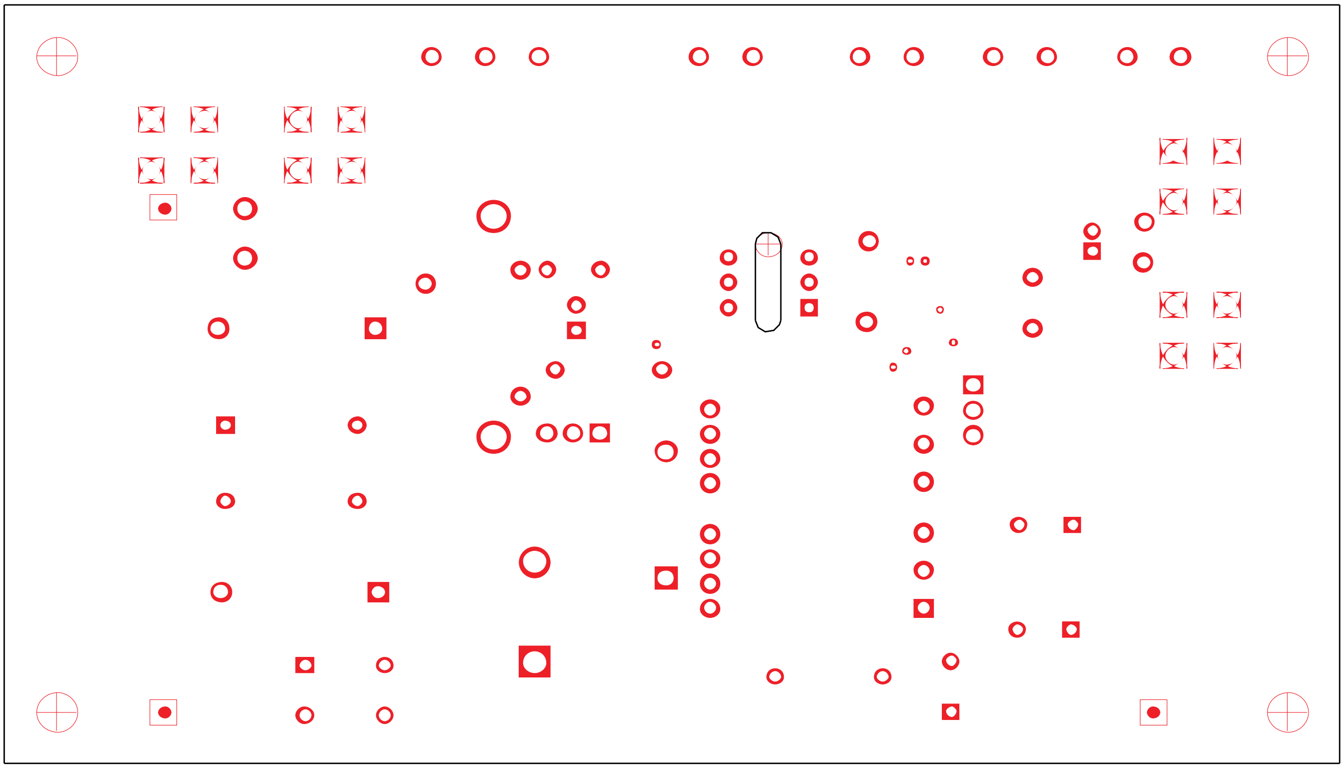

Figure 28. Top Paste

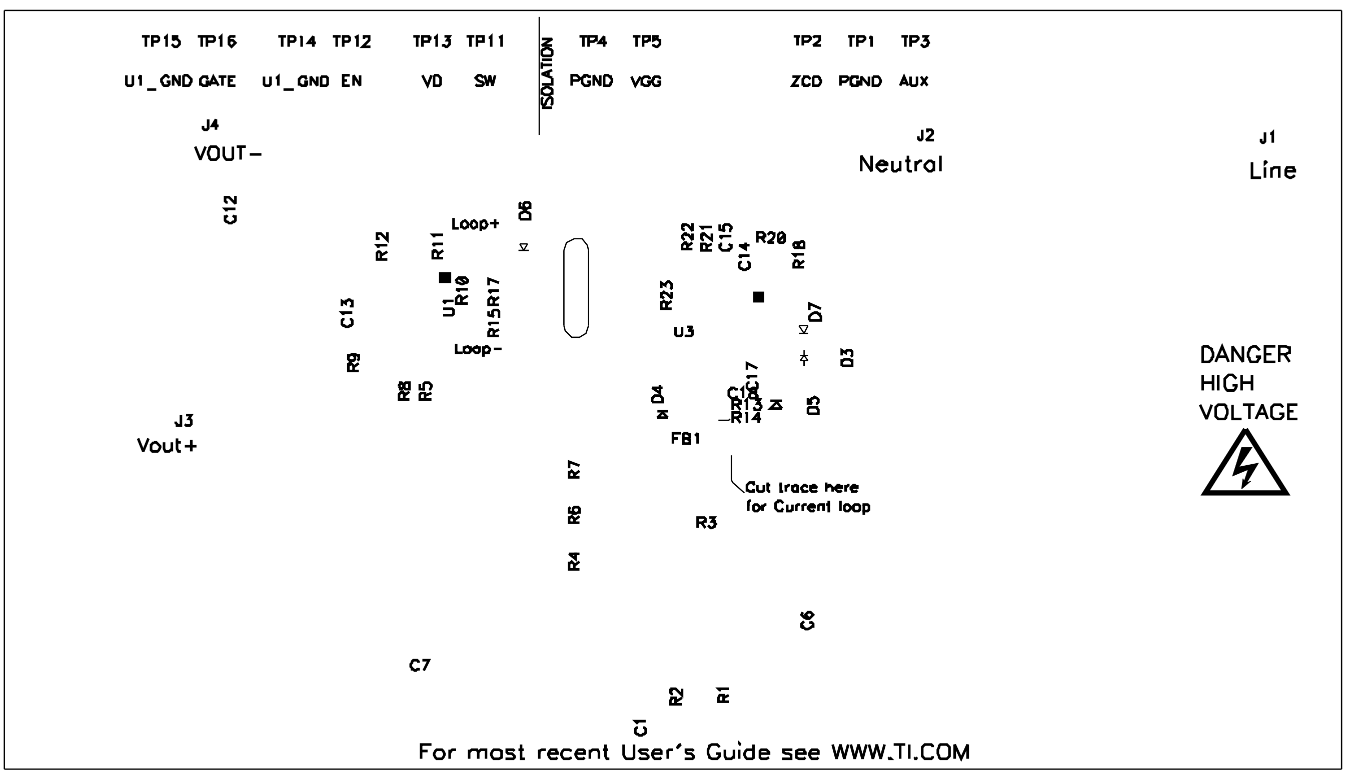

Figure 29. Bottom Silk

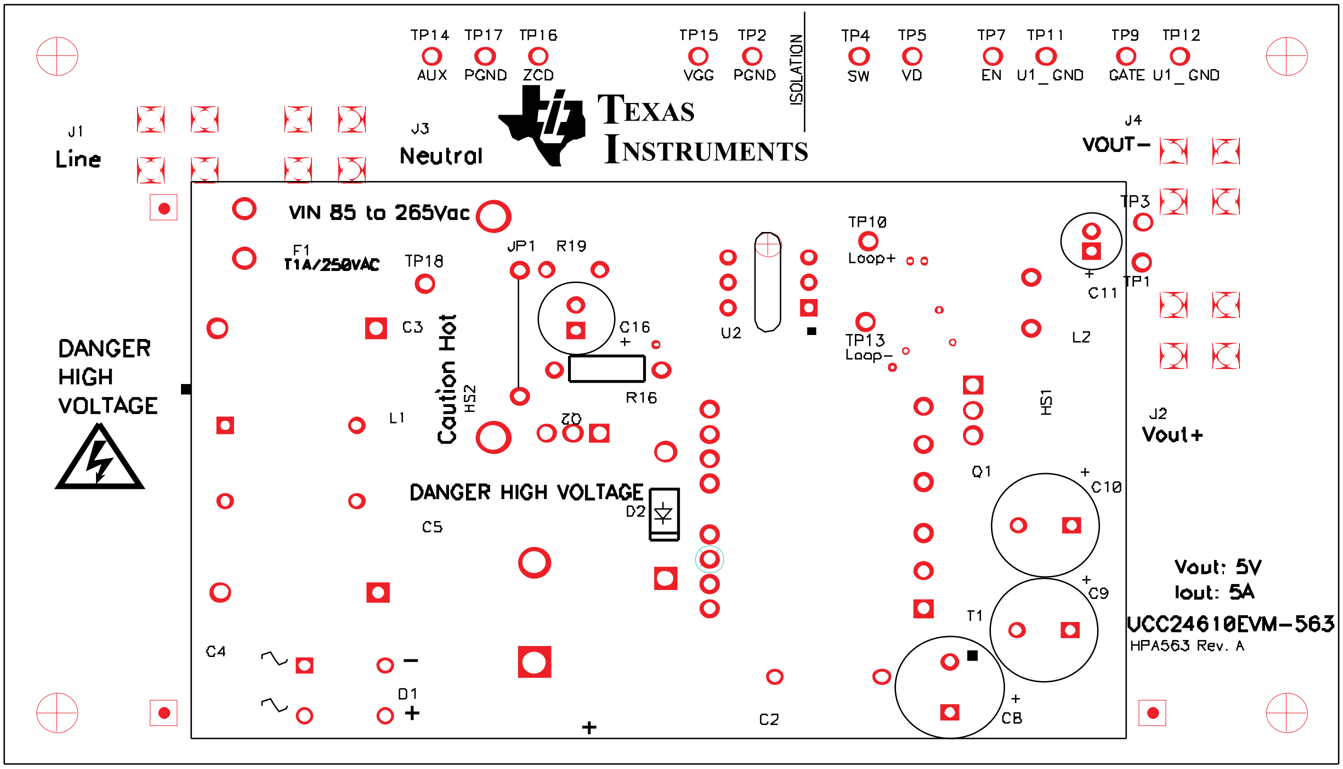

Figure 30. Top Silk

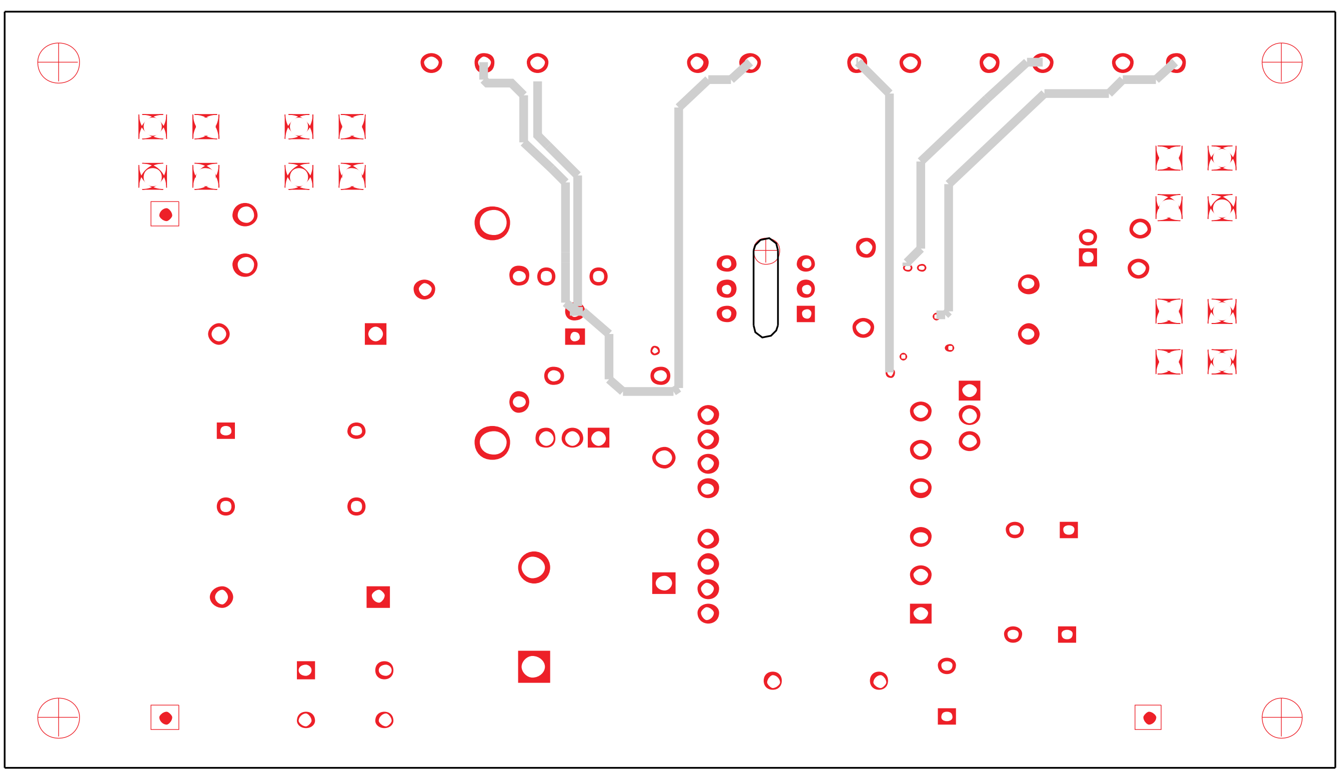

Figure 31. Layer 3 Copper

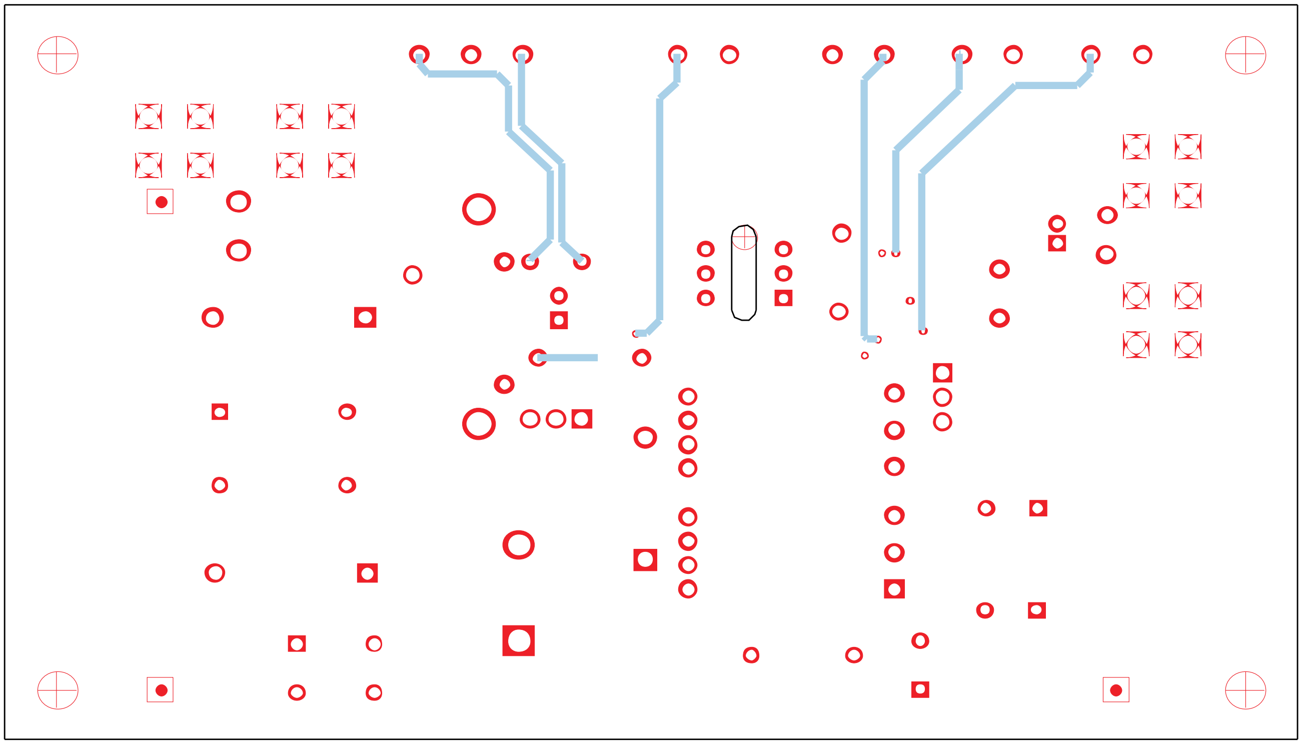

Figure 32. Layer 2 Copper

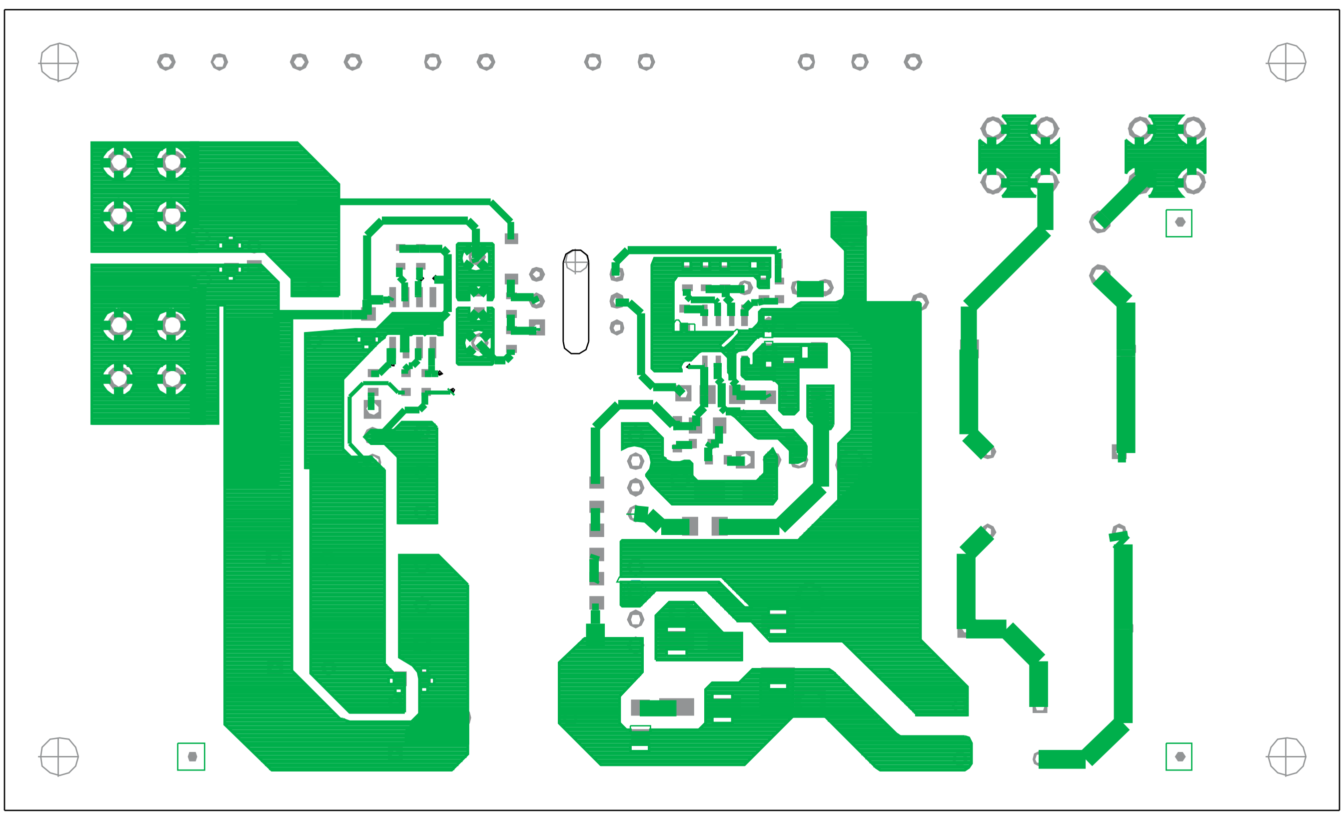

Figure 33. Bottom Layer Copper

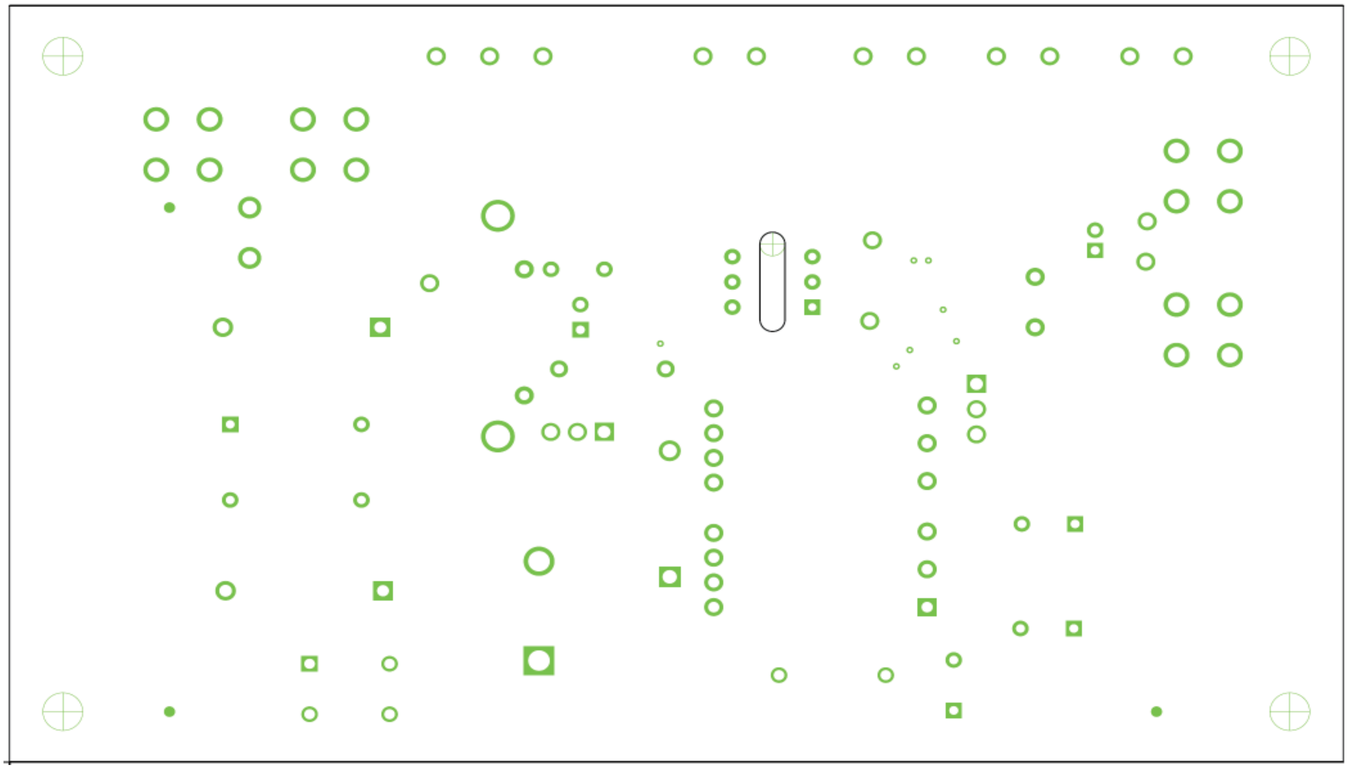

Figure 34. Top Layer Copper

10 List of Materials

Table 3. List of Materials for UCC24610EVM-563

COUNT	REF DES	DESCRIPTION	PART NUMBER	MFR
1	C1	Capacitor, ceramic, 330 pF, 630 V, C0G, NP0, ±5%, 1206	Std	Std
1	C2	Capacitor, ceramic disk, 1000 pF, 250 V, X1/Y1, ±20%, 0.394 inch x 0.315 inch	ECK-ANA102MB	Panasonic
2	C3, C4	Capacitor, film, 0.33 µF, 275 VAC, X2, ±20%, 15 mm pitch, 0.690 inch x 0.374 inch	ECQ-U2A334ML	Panasonic
1	C5	Capacitor, aluminum electrolytic, 100 µF, 400 VDC, ±20%, 105°C, 25 mm x 20 mm	EET-HC2G101BA	Panasonic
1	C6	Capacitor, ceramic, 0.1 µF, 630 V, X7R, ±10%, 1812	C4532X7R2J104K	TDK Corporation
2	C7, C12	Capacitor, ceramic, 1 µF, 25 V, X5R, ±10%, 0805	Std	Std
3	C8, C9, C10	Capacitor, aluminum electrolytic, 1500 µF, 6.3 V, ±20%, 105°C, 10 mm x 25 mm	EEU-FM0J152	Panasonic
1	C11	Capacitor, aluminum electrolytic, 100 µF, 6.3 V, ±20%, 5.0 mm x 11.0 mm	UPW0J101MDD	Nichicon
1	C13	Capacitor, ceramic, 0.68 µF, 25 V, X5R, ±10%, 0805	Std	Std
1	C14	Capacitor, ceramic, 100 pF, 50 V, NP0, ±5%, 0603	Std	Std
0	C15	Capacitor, ceramic, no pop., 50 V, NP0, ±5%, 0603	Std	Std
1	C16	Capacitor, aluminum electrolytic, 68 µF, 35 V, ±20%, 105°C, 6.3 mm x 11.2mm	EEU-FM1V680	Panasonic
1	C17	Capacitor, ceramic, 0.1 µF, 50 V, X7R, ±10%, 0805	Std	Std
1	C18	Capacitor, ceramic, 0.1 µF, 100 V, X7R, ±10%, 1206	Std	Std
1	D1	Diode, bridge, 1 A, 600 V, DF-M	DF06M	Diodes Inc.
1	D2	Diode, fast recovery glass passivated, 1 A, 1 kV, DO-41	UF4007-TP	Micro Commercial Co.
1	D3	Diode, super fast rectifier, 1 A, 200 V, 0.220 inch x 0.115 inch	ES1D-13-F	Diodes Inc.
1	D4	Diode, Schottky, 1 A, 30 V, SOD-323	SDM100K30L-7	Diodes Inc.
1	D5	Diode, Schottky, 100 mA, 40 V, SOD-323	RB501V-40TE-17	Rohm Semiconductor
1	D6	Diode, Zener, 3.9 V, 500 mW, SOD-123	BZT52C3V9-7-F	Diodes Inc.
1	D7	Diode, Zener, 25 V, 500 mW, SOD-123	MMSZ5253BT1G	On Semiconductor
1	F1	Fuse, slow blow, 1 A, 250 V, 0.335 inch diameter	38211000410	Littelfuse / Wickmann
1	FB1	Bead, SMD ferrite, 70 Ω at 100 MHz, 4 A, ±25%, 0603	BLM18SG700TN1D	Murata Electronics
1	HS1	Heatsink, TO-220, vertical mount, 0.5 inch x 0.750 inch	577102B00000G	Aavid
1	HS2	Heatsink, alloy 1110 copper, 0.530 inch x 1.200 inch	HS001	NH Stamp
2	J1, J3	Connector, 4-mm safety jack, white, 1000 V, 25 A, 0.530 inch x 0.950 inch	CT3151-9	Cal Test Electronics
1	J2	Connector, 4-mm safety jack, red, 1000 V, 25 A, 0.530 inch x 0.950 inch	CT3151-2	Cal Test Electronics
1	J4	Connector, 4-mm safety jack, black, 1000 V, 25 A, 0.530 inch x 0.950 inch	CT3151-0	Cal Test Electronics
1	JP1	Jumper, 0.500 inch length, PVC insulation, AWG 22	923345-05-C	3M
1	L1	Inductor, AC line, common choke, 27 mH, 1 A, 0.660 inch x 0.670 inch	54PR512-276	Vitec Electronics Corp.
1	L2	Inductor, ferrite core, 1.0 µH, 7.5 A, ±10%, 0.521 inch x 0.502 inch	744772010	Wuerth Elektronik
1	Q1	MOSFET, N-channel, logic level gate, 55 V, 75 A, 8 mΩ, TO-220AB	IRL3705ZPBF	International Rectifier
1	Q2	MOSFET, N-channel, 800 V, 6.5 A, 0.95 Ω, TO-220V	STP7NM80	STMicroelectronics

Table 3. List of Materials for UCC24610EVM-563 (continued)

COUNT	REF DES	DESCRIPTION	PART NUMBER	MFR
1	R1	Resistor, chip, 64.9 kΩ, 1 W, ±1%, 2512	Std	Std
1	R2	Resistor, chip, 33 Ω, 1 W, ±5%, 2512	Std	Std
1	R3	Resistor, chip, 20 Ω, 1/4 W, ±1%, 1206	Std	Std
3	R4, R6, R7	Resistor, chip, 2.05 MΩ, 1/8 W, ±1%, 0805	Std	Std
1	R5	Resistor, chip, 10 Ω, 1/10 W, ±1%, 0603	Std	Std
1	R8	Resistor, chip, 100 Ω, 1/10 W, ±1%, 0603	Std	Std
1	R9	Resistor, chip, 6.19 Ω, 1/10 W, ±1%, 0603	Std	Std
1	R10	Resistor, chip, 20.5 Ω, 1/10 W, ±1%, 0603	Std	Std
1	R11	Resistor, chip, 196 kΩ, 1/10 W, ±1%, 0603	Std	Std
1	R12	Resistor, chip, 133 kΩ, 1/10 W, ±1%, 0603	Std	Std
1	R13	Resistor, chip, 205 Ω, 1/8 W, ±1%, 0805	Std	Std
1	R14	Resistor, chip, 2.26 Ω, 1/10 W, ±1%, 0603	Std	Std
1	R15	Resistor, chip, 442 Ω, 1/10 W, ±1%, 0603	Std	Std
1	R16	Resistor, metal film, 1.00 kΩ, 1/4 W, ±1%, TH-400	Std	Std
1	R17	Resistor, chip, 1.00 kΩ, 1/10 W, ±1%, 0603	Std	Std
1	R18	Resistor, chip, 20.5 kΩ, 1/10 W, ±1%, 0603	Std	Std
1	R19	Resistor, metal film, 130 kΩ, 1/4 W, ±1%, 0.300 inch x 0.100 inch	Std	Std
1	R20	Resistor, chip, 100 kΩ, 1/10 W, ±1%, 0603	Std	Std
2	R21, R22	Resistor, chip, 59.0 kΩ, 1/10 W, ±1%, 0603	Std	Std
1	R23	Resistor, chip, 68.1 kΩ, 1/10 W, ±1%, 0603	Std	Std
1	T1	Transformer, flyback, 200 µH, ±10%, 24.5 mm x 24.5 mm	G104070LF	GCi
1	U1	Secondary-Side Synchronous Rectifier Controller, SO-8	UCC24610D	Texas Instruments
1	U2	Optocoupler, CTR 40% - 80%, 70 V_{CEO}, 5000 V_{RMS}, DIP6	CNY17F1M	Fairchild Optoelectronics
1	U3	Green-Mode Flyback Controller, SO-8	UCC28610D	Texas Instruments

11 References

1. UCC24610 *GREEN Rectifier™ Controller Devic*e, Datasheet, SLUSA87
2. UCC28610 *Green-Mode Flyback Controller*, Datasheet, SLUS888
3. *Standby and Low Power Measurements*, VOLTECH$_{NOTES}$, VPN 104-054/1, http://www.voltech.com/Downloads/PMAppNotes/Low%20Power%20Standby.pdf

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 85 VAC to 265 VAC and the output voltage range of 5 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 50° C. The EVM is designed to operate properly with certain components above 50° 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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