# Using the UCC28740EVM-525 10 W Constant-Voltage, Constant-Current Charger Adaptor Module

# User's Guide



Literature Number: SLUUAL8
July, 2013

Using the UCC28740EVM-525 10 W Constant-Voltage, Constant-Current Charger Adapter Module

*PSS- High Performance Isolated*

**Contents**





**Figures**

**Tables**

# 1 Introduction

The UCC28740EVM-525 evaluation module is a 10 Watt off-line discontinuous mode (DCM) flyback converter that provides constant-voltage (CV) and constant-current (CC) output regulation by using an optical coupler for tight voltage regulation and improved the transient response to large load steps and primary side control for accurate constant current regulation. The target application for this converter design is USB adapters for consumer electronics. The UCC28740 uses frequency modulation, peak primary current modulation, valley switching and valley skipping in its control algorithm in order to maximize efficiency over the entire operating range.

# 2 Description

This evaluation module uses the *UCC28740 Constant-Voltage, Constant-Current Flyback Controller Using Opto-Coupled Feed-Back* in a 10 W converter to provide 2 A of constant charge current. The input accepts a voltge range of 85 VAC to 265 VAC. The output is designed for 5 V when in constant voltage mode and will deliver 2.1 A of constant charge down to an output voltage of less than 2 V. Depending upon the operating conditions, the control law algorithm will modulate the switching frequency or the peak primary current to satisfy the power transfer requirements. As the load is increased from zero, the converter will transition through a frequency modulation mode where the peak primary current is held constant at one-quarter of its full-load peak value as the switching frequency increases from a minimum value to maintain energy transfer up to 32 kHz. When the load is increased to the level at which the switching frequency reaches 32 kHz, the controller will keep the switching frequency fixed and modulate the peak primary current, increasing it from one-quarter its peak value up to its maximum full load peak current value; this area of operation is refered to as the amplitude modulation range. Further increase in load demand will transition the controller into another frequency modulation mode where the peak primary current is constant at its maximum designed value and the switching frequency is increased as needed, up to the controller's maximum 100 kHz switching frequency. Opto-coupled feed-back maintains a tightly regulated output with fast dynamic response to load transients. The controller will further enhance its efficient operation with valley switching. The UCC28740 also uses dithering of the gate drive helps to ease EMI compliance.



This user's guide provides the schematic, component list, assembly drawing, art work, and test set up necessary to evaluate the UCC28740 in a typical off-line converter application.

## 2.1 Typical Applications

The UCC28740 is suited for use in isolated off-line systems requiring high efficiency and fault protection features including:

- USB-Compliant Adapters and Chargers for Consumer Electronics such as smart phones, tablet computers, and cameras
- Stand-by Supply for TV and Desktop
- White Goods

## 2.2 Features

The UCC28740EVM-525 features include:

- AC Input Range 85 $V_{AC}$ to 265 $V_{AC}$
- DC Output of 5 V, 2.1 A
- No-Load Power Consumption less than 20 mW
- Opto-Coupled Feedback for Constant Voltage Regulation and Fast Dynamic Response
- Primary Side Control for Tight Constant Current Performance
- ± 3% Output Volage Regulation
- ± 5% Output Current Regulation
- Average Efficiency > 80%
- Output Over Current and Short Circuit Protection
- Output Over Voltage Protection
- Input Brown-Out Protection
- Auto Re-Start on Fault
- Quasi-Resonant Valley Switching
- Frequency Dither
- Internal 700V Start-Up Switch to Start up the Supply Directly From the Bulk Rail



**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 capacitors, C3 and C4, and the output capacitors, C8 and C10, 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. UCC28740EVM-525 EVM-001 Electrical Performance Specifications

| PARAMETER | TEST CONDITIONS | MIN | NOM | MAX | UNITS |
|---|---|---|---|---|---|
| **Input Characteristics** | | | | | |
| Voltage range, $V_{IN}$ | | 85 | 115/230 | 265 | $V_{RMS}$ |
| Maximum input current | $V_{IN} = V_{INmin}$, $I_{OUT} = I_{OUTmax}$ | | 0.265 | | $A_{RMS}$ |
| Line frequency | | 47 | 60/50 | 63 | Hz |
| No-load power consumption | $V_{INmin} \le V_{IN} \le V_{INmax}$, $I_{OUT}$ = 0A | | | 20 | mW |
| **Output Characteristics** | | | | | |
| Output voltage, $V_{OUT}$ | $V_{INmin} \le V_{IN} \le V_{INmax}$, 0A $\le I_{OUT} \le I_{OUTmax}$ | 4.85 | 5 | 5.15 | V |
| Output load current, CV mode, $I_{OUTmax}$ | $V_{INmin} \le V_{IN} \le V_{INmax}$ | 1.995 | 2.1 | 2.205 | A |
| Output voltage regulation | Line Regulation: $V_{INmin} \le V_{IN} \le V_{INmax}$, $I_{OUT} = I_{OUTmax}$ | | 0.1 | | % |
| | Load Regulation: 0A $\le I_{OUT} \le I_{OUTmax}$ | | 0.1 | | % |
| Output voltage ripple | $V_{INmin} \le V_{IN} \le V_{INmax}$, 0A $\le I_{OUT} \le I_{OUTmax}$ | | | 150 | mVpp |
| Output over current, $I_{OCC}$ | $V_{INmin} \le V_{IN} \le V_{INmax}$ | | | 2.5 | A |
| Minimum output voltage, CC mode | $V_{INmin} \le V_{IN} \le V_{INmax}$, $I_{OUT} = I_{OCC}$ | | 1.78 | 2 | V |
| Brown-out protection | $I_{OUT} = I_{OUTmax}$ | | 68 | | $V_{RMS}$ |
| Transient response undershoot | $I_{OUT} = I_{OUTmax}$ to 0A load transient | 4.3 | | | V |
| Transient response time | $I_{OUT} = I_{OUTmax}$ to 0A load transient | | | 20 | ms |
| **Systems Characteristics** | | | | | |
| Switching frequency, $f_{SW}$ | | 1.2 | | 71 | kHz |
| Average efficiency | 25%, 50%, 75%, 100% load average at nominal input voltages | | 81 | | % |
| Operating temperature | | | 25 | | ºC |

## 4 Schematic

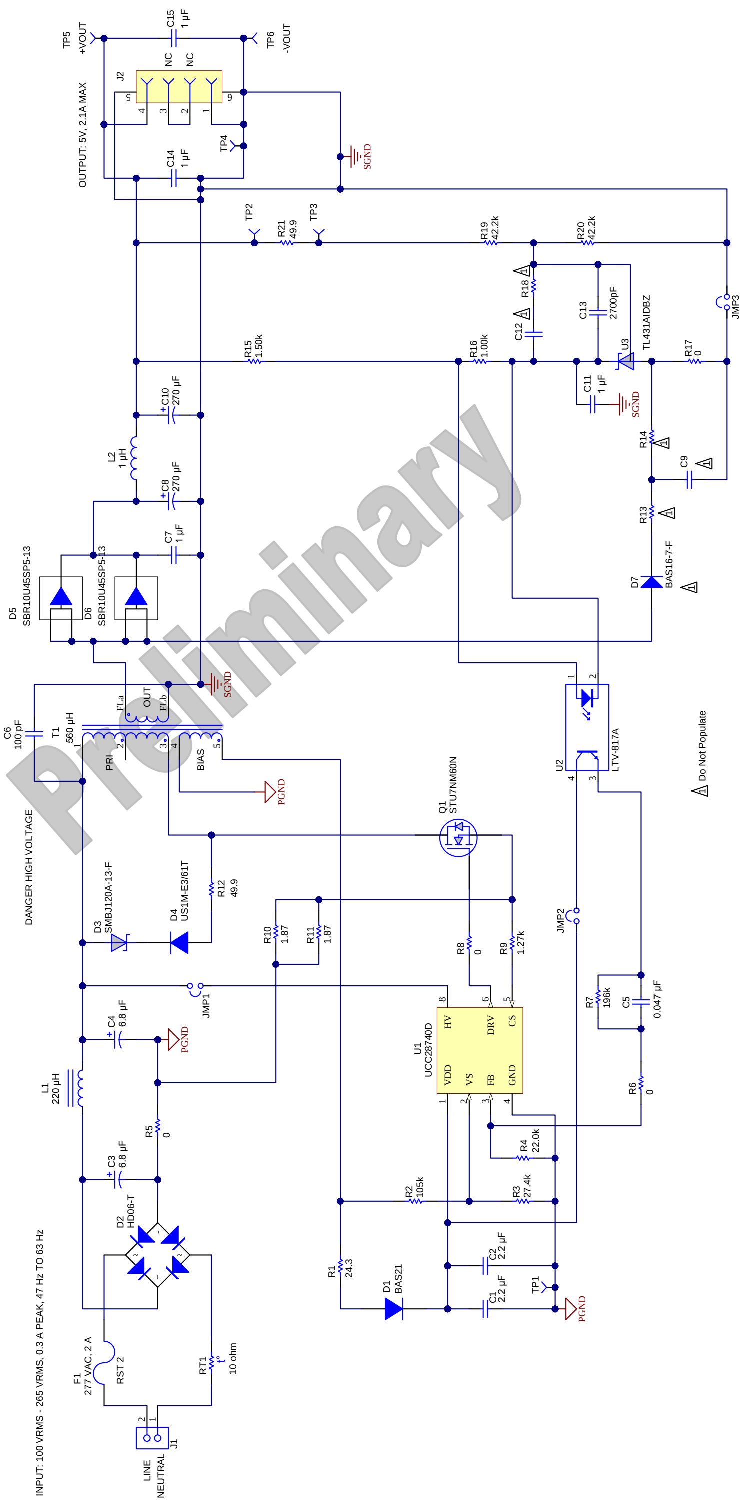


**Figure 1. UCC28740EVM-525 Schematic**

# 5 Test Setup

Figure 2 shows the equipment set up when measuring the input power consumption during no-load operation. Note the addition of the 10 Ω shunt resistor in Figure 2. During the no-load test, the power analyzer should be set for long averging mode in order the include several cycles of operation and an appropriate current scale factor for using the external shunt must be used. Figure 3 shows the recommended test equipment set up to evaluate the UCC28740EVM-525 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



**AC Voltage Source:** The input source shall be an isolated variable AC source capable of supplying between 85 $V_{AC}$ and 265 $V_{AC}$ at no less than 20 W and connected as shown in Figures 2 and 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.

**Output Load:** A programmable electronic load capable of sinking 0 A to 3 A shall be used. For constant current mode testing of the EVM, the electronic load should be set to constant resistance mode.

**Power Meter:** A power analyzer shall be capable of measuring low input current, typically less than 10mA, 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. An external 10 Ω shunt, with a current scale factor of 10 A/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:** For highest accuracy, $V_{OUT}$ can be monitored by connecting a DC voltmeter, DMM $V_1$, directly across the +VOUT and –VOUT terminals as shown in Figure 2 and Figure 3. A DC current meter, DMM $A_1$, should be placed in series with the electronic load for accurate output current measurements.

**Oscilloscope:** A digital or analog oscilloscope with 500 MHz scope probes is recommended.

**Fan:** Forced air cooling is not required.

**Recommended Wire Gauge:** a minimum of AWG 18 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 Setup

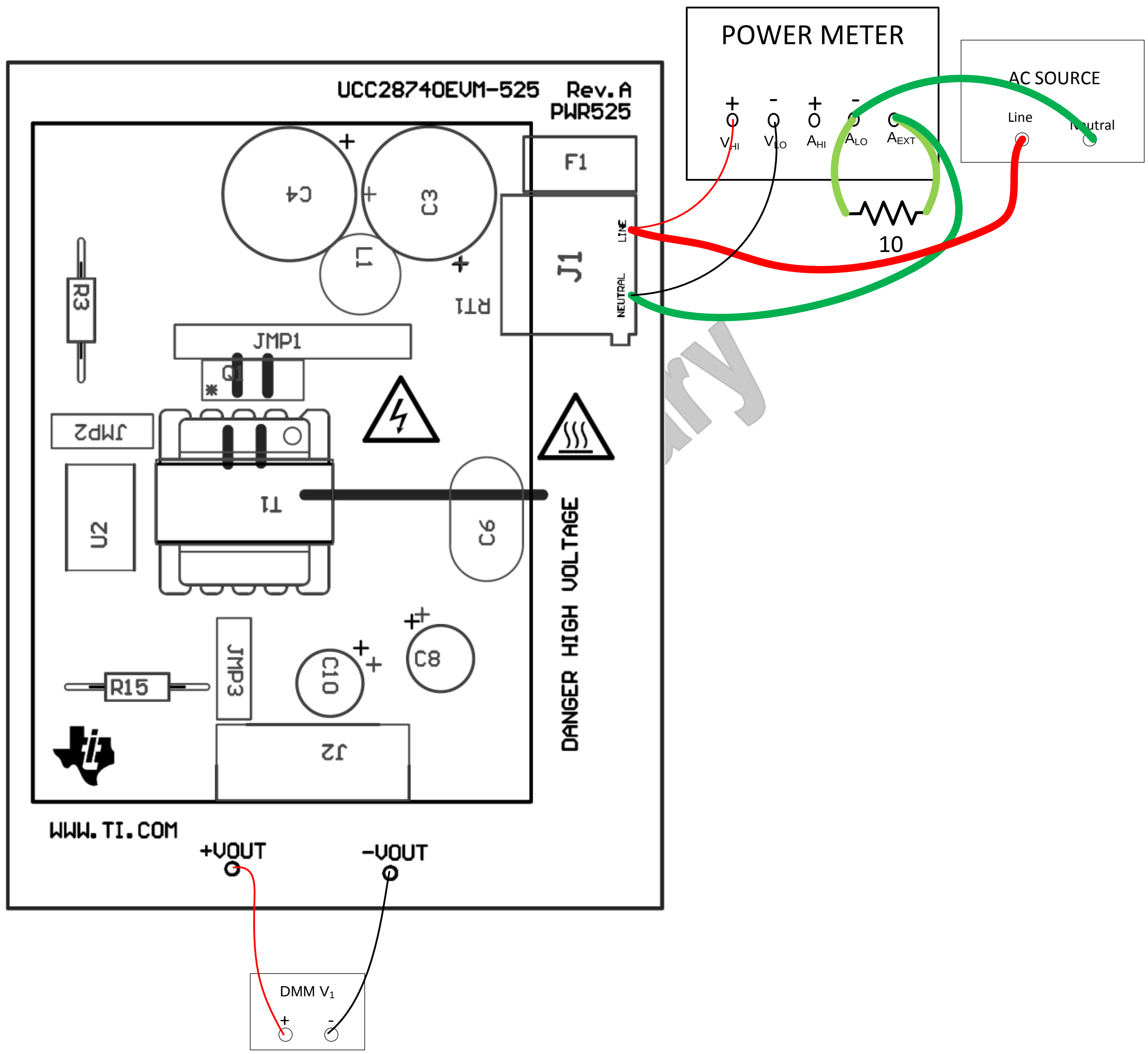


**Figure 2. UCC28740EVM-525 Recommended Test Set Up For No-Load Operation**

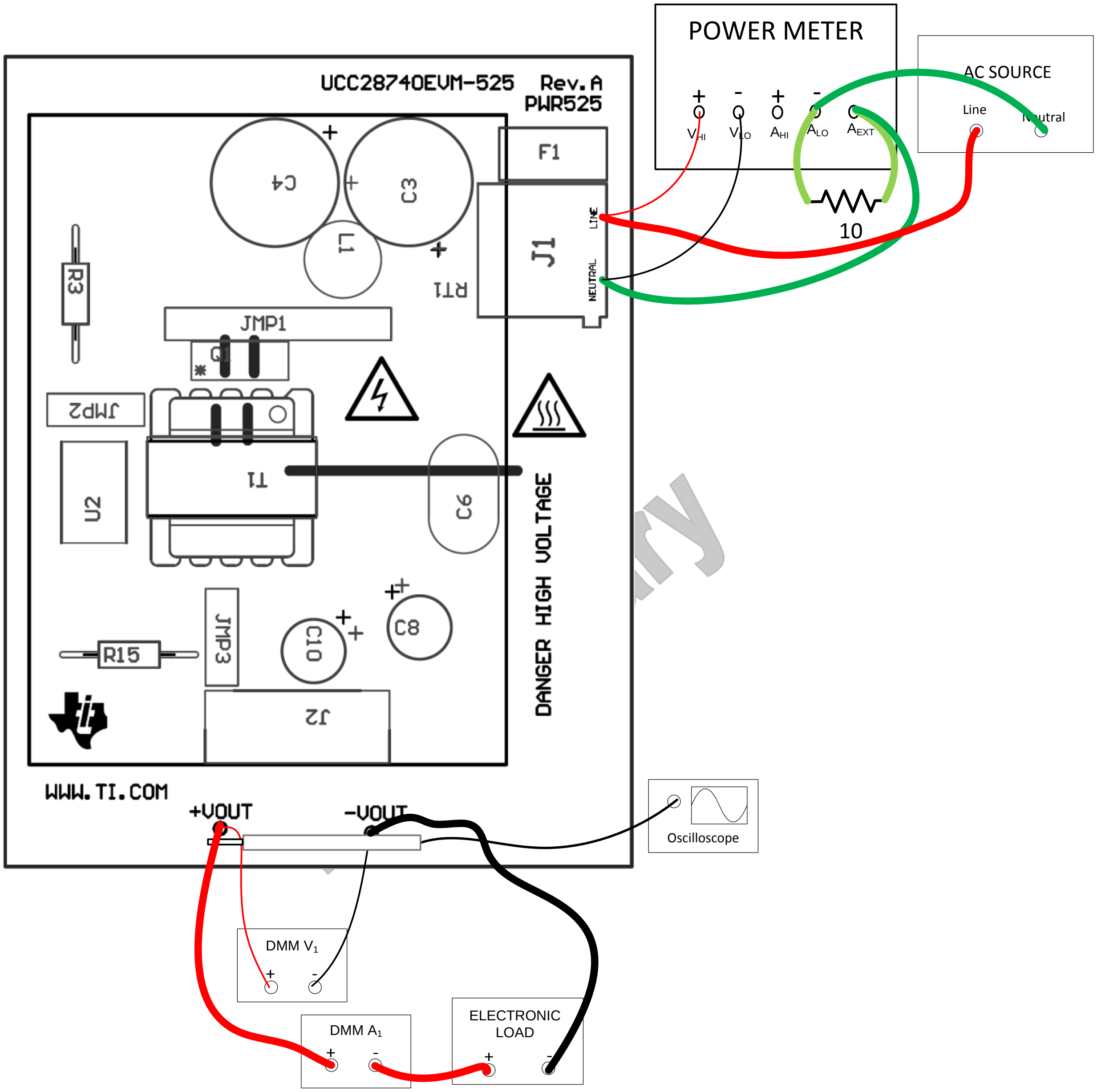


**Figure 3. UCC28740EVM-525 Recommended Test Set Up With Load**

## 5.3 List of Test Points

**Table 2. Test Point Functional Description**

| TEST POINT | NAME | DESCRIPTION |
|---|---|---|
| TP1 | PGND | Primary side power ground |
| TP2 | +LOOP | Loop injection point, EVM output |
| TP3 | -LOOP | Loop injection point |

| TEST POINT | NAME | DESCRIPTION |
|---|---|---|
| TP4 | SGND | Secondary side ground |
| TP5 | +VOUT | Positive output terminal of the EVM to the load |
| TP6 | -VOUT | Return connection of the EVM output to the load |

## 5.4 Applying Power to the EVM

1. Set up the EVM as shown in Figure 2 if testing at no-load, or Figure 3 if testing with a load.
2. If testing with a load, set the electronic load to constant resistance mode.
3. Set the AC source voltage between 85 $V_{AC}$ and 265 $V_{AC}$.
4. Monitor the output voltage on DMM $V_1$.
5. Monitor the output current on DMM $A_1$.

## 5.5 No-Load Power Consumption

1. Use the test set up shown in Figure 2.
   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 to 10,000 mV/A for the PM100 Voltech.
   c. Set the power analyzer for long averaging time to include several cycles of operation. The PM100 Voltech used for this test data was set to a long averaging time of 30 for accurate power consumption measurement.
2. Apply power to the EVM per section 5.4.
3. Monitor the input power on the power analyzer while varying thinput voltage.
4. Make sure the EVM is off and the bulk capacitors and output capacitors are completely discharged before handling the EVM.



## 5.6 Line/Load Regulation and Efficiency Measurement Procedure

1. For load regulation, use the test set up shown in Figure 3.
   a. Be sure to remove the exteranal 10 Ω 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. Vary the load so that the output current varies from 0 A up to 2.1 A, as measured on DMM $A_1$.
   d. Observe that the output voltage on DMM $V_1$ remains within 3% of the 5 V constant voltage regulation value.

e. Observe that if the constant resistance level of the electronic load is decreased lower than the full load value, the EVM will maintain constant current regulation within 5% of the programed value until the output voltge drops below 2 V. The EVM will automatically restart once the constant resistance load is increased.

2. For line regulation, use the test set up shown in Figure 3
   a. Set the constant resistance load to sink the full load current, approximately 2.38 Ω.
   b. Vary the AC source from 85 $V_{AC}$ to 265 $V_{AC}$
   c. Observe that the output voltage on DMM $V_1$ stays within 3% of the 5 V constant voltage regulation value.

## 5.7 Output Voltage Ripple

1. Expose the ground barrel of the scope probe and place the tip of the probe on TP5, +VOUT, and rest the exposed ground barrel of the probe on TP6, -VOUT, for output voltage ripple measurements.

## 5.8 Equipment Shutdown

1. To quickly discharge the output capacitors, make sure there is a load greater than 0 A on the EVM.
2. Turn off the AC source.

# 6 Performance Data and Typical Characteristic Curves

Figure 4 through 11 present typical performance curves for UCC28740EVM-525.

## 6.1 Efficiency

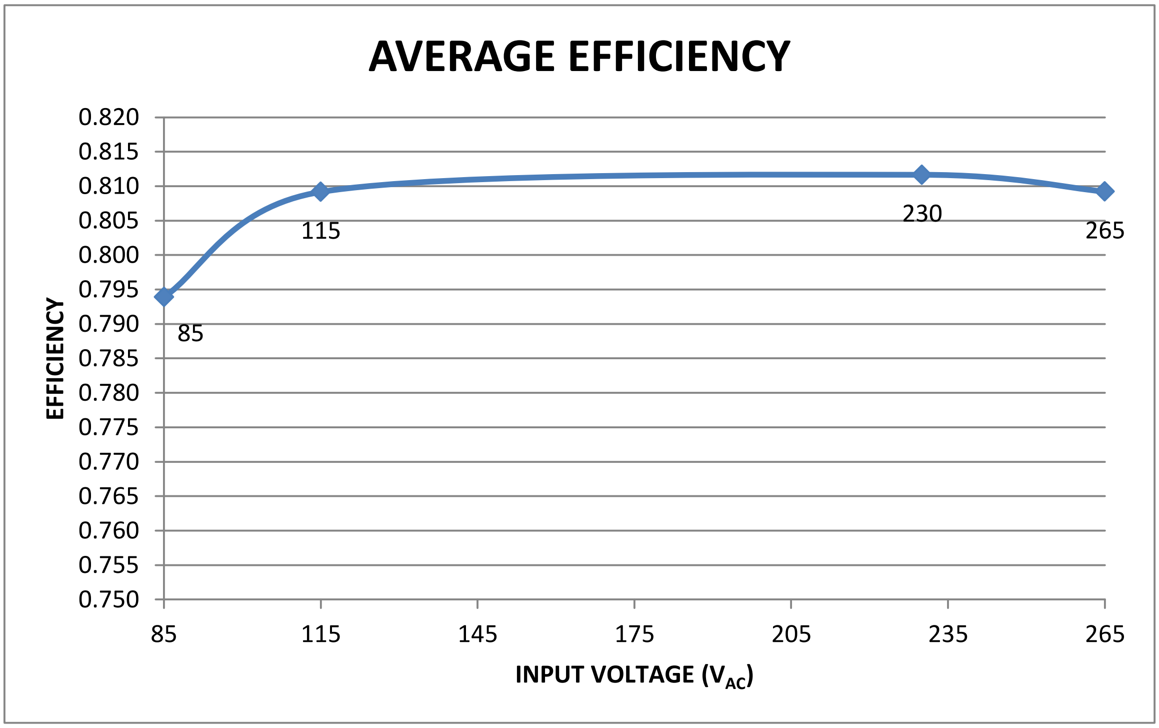


**Figure 4. UCC28740EVM-525 Average Efficiency**

The average efficiency at 115 VAC, 60 Hz nominal input and 230 VAC, 50 Hz nominal input exceeds the 0.80 design goal. Further increases in efficiency could be achieved with a transformer made with a custom core and designed to operate at lower switching frequency over the entire operating range.

## 6.2 Load Regulation

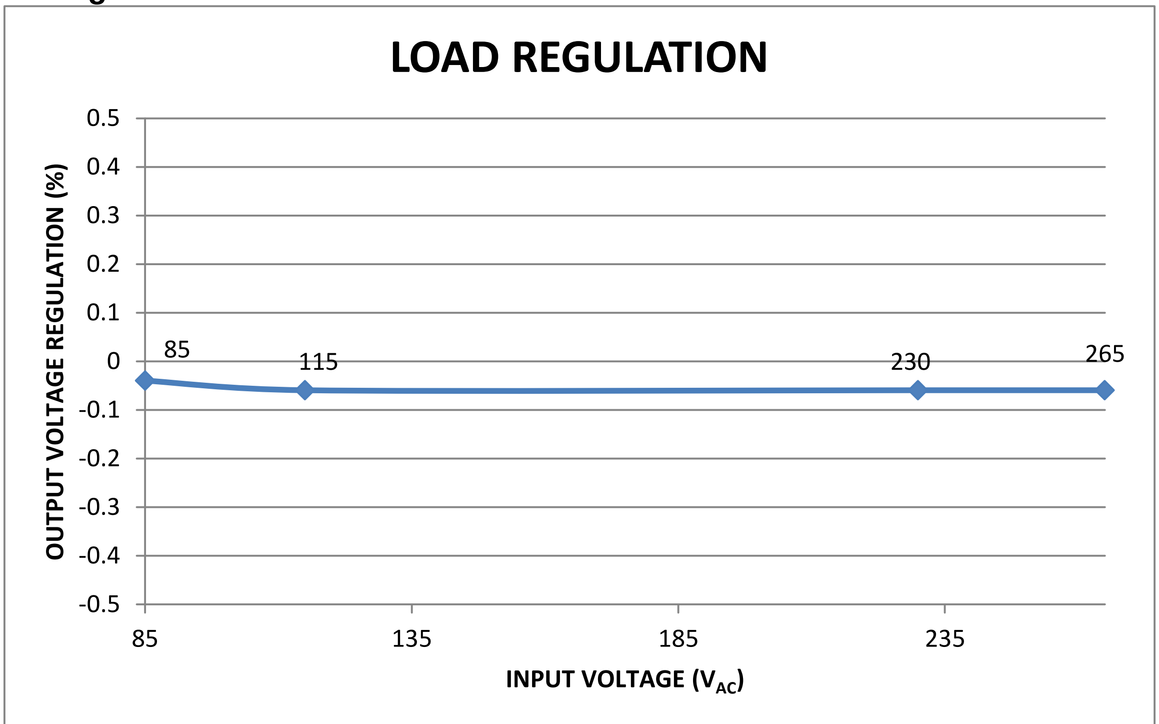


**Figure 5. UCC28740EVM-525 Load Regulation**

Figure 5 shows the actual measured load regulation exceeded the 3% design goal.

## 6.3 Line Regulation

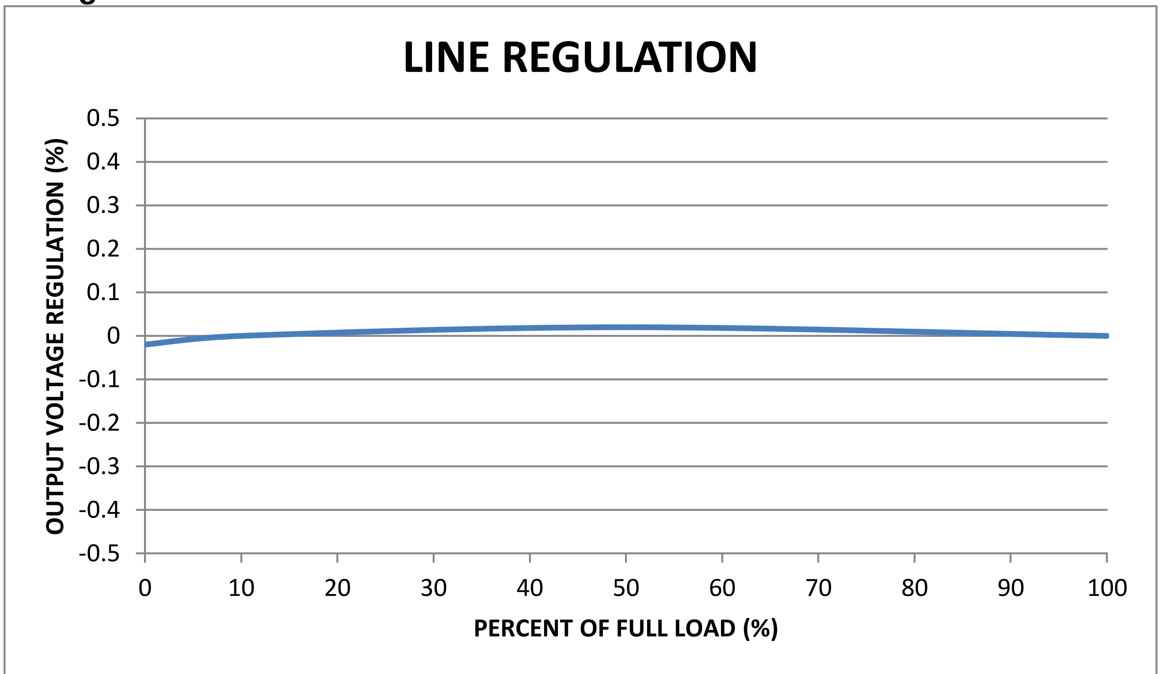


**Figure 6. UCC28740EVM-525 Line Regulation**

Figure 6 shows the actual measured line regulation exceeded the 3% design goal.

## 6.4 No-Load Power Consumption

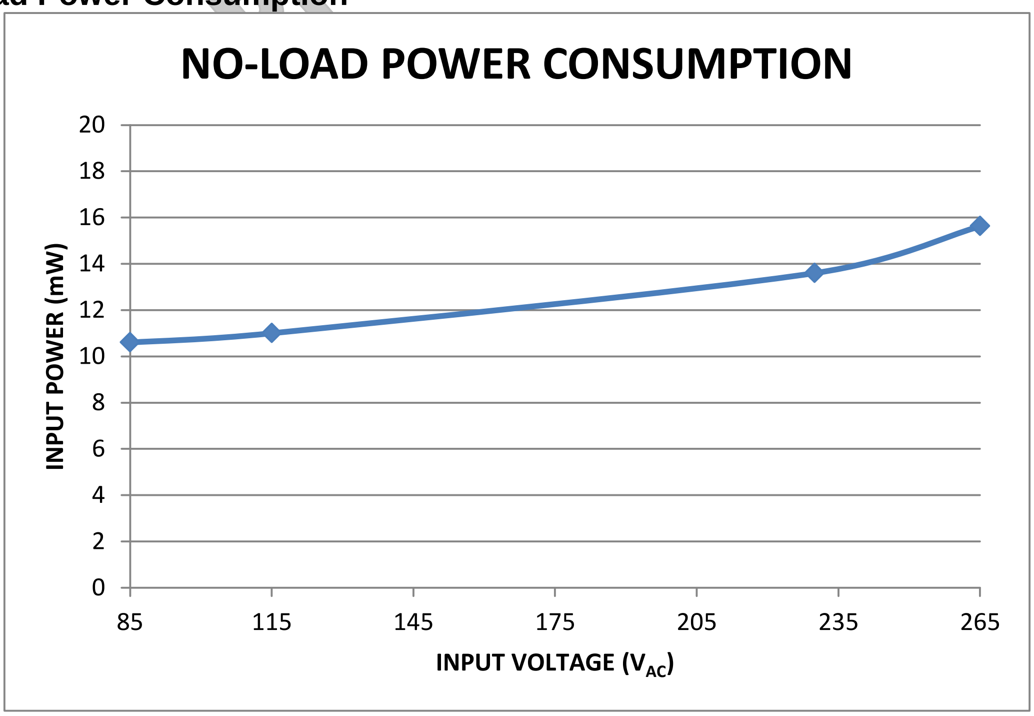


**Figure 7. UCC28740EVM-525 No-Load Power Consumption**

No load power consumption measured less than 20 mW over the entire line input range.

## 6.5 Output Voltage vs Output Current

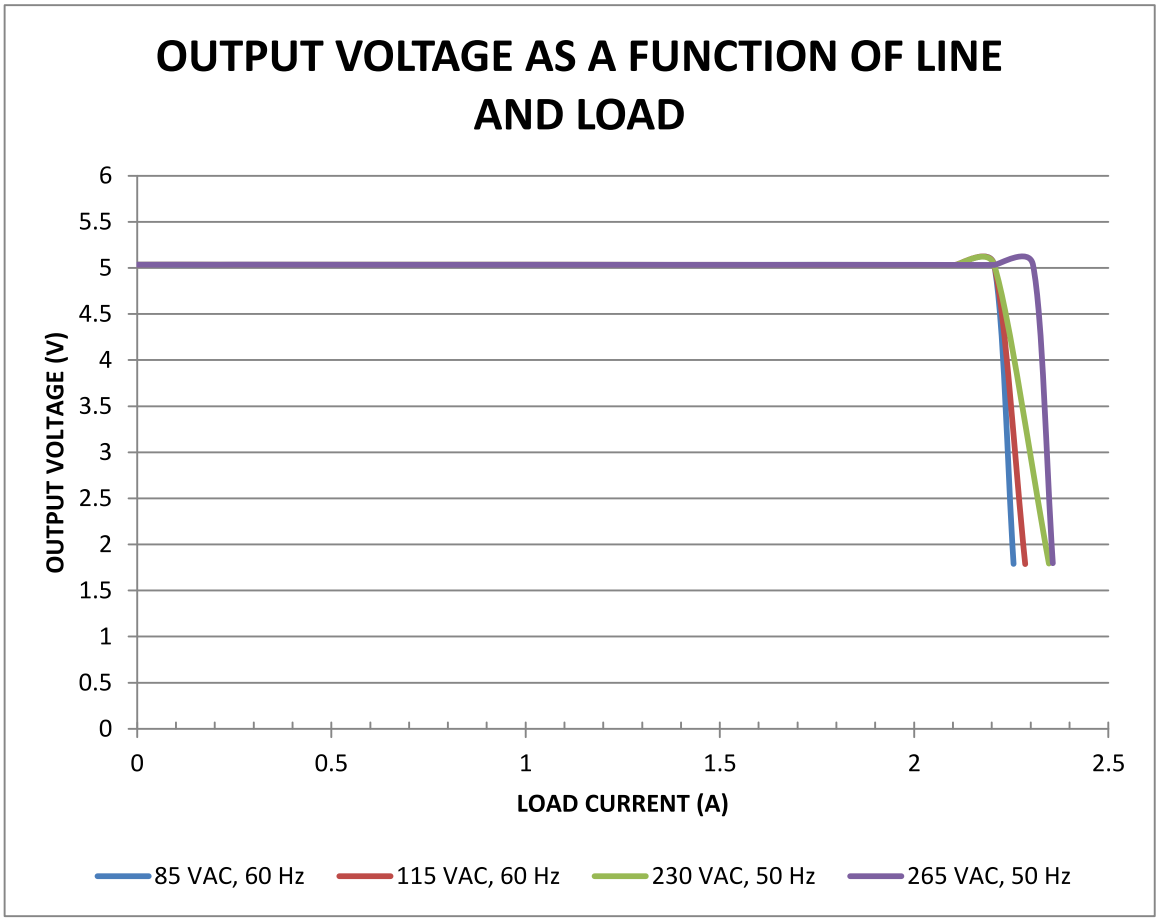


**Figure 8. UCC28740EVM-525 Output Voltage as a Function of Load Current**

In Figure 8, the converter is in constant-voltage operating mode from 0 A load up to approximately 2.2 A. Once reaching this output over-current threshold, the converter transitions into constant-current mode where the load current remains constant until the output voltge falls below 2 V, at which point the converter shuts down. If the load demand is decreased to the constant current operating region, the converter will automatically re-start.

### 6.6 Control Law

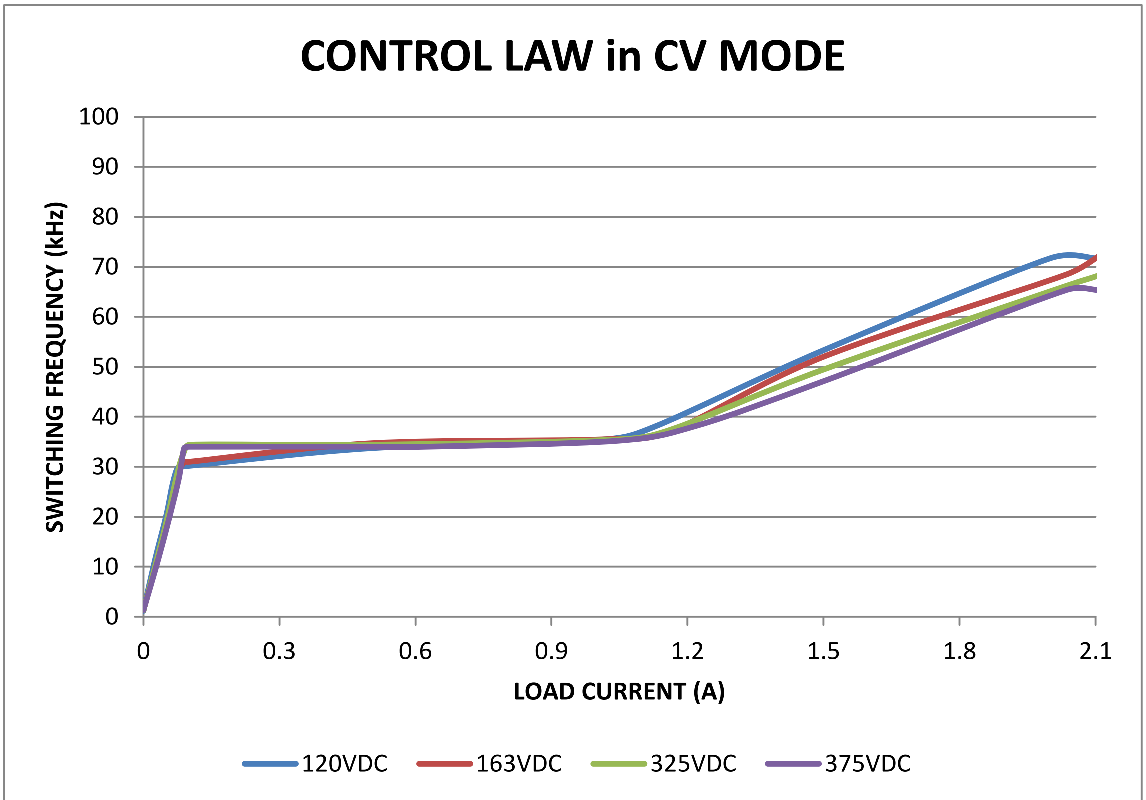




**Figure 9. UCC28740EVM-525 Control Law Showing Switching Frequency as a Function of Load Current**

As the load increases, the UCC28740 will transition from a frequency modulation mode at light load, where the peak primary current is fixed at ¼ of its maximum programmed value, into a 32 kHz fixed frequency, peak current amplitude modulation mode. Further increase in load will force a transition into another frequency modulation mode where the peak primary side current is fixed at its peak programmed value and the frequency will increase from 32 kHz up to the maimum frequency required for energy transfer. The maximum designed switching frequency for this module is 71 kHz. For ease in measuring the switching frequency, the data was taken with a DC input voltage. This reduced the frequency dithering to only the controller's EMI dithering scheme and limited the valley skipping that would have been a result of the line frequency modulating the AC input.

## 6.7 Bode Plot

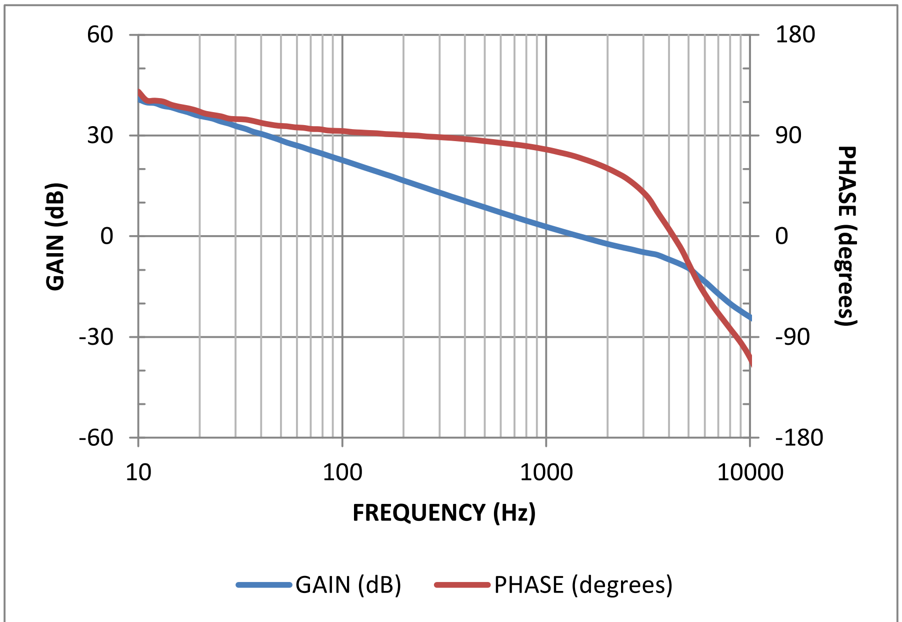


**Figure 10. UCC28740EVM-525 Loop Response Gain and Phase**

The gain, phase plot was measured with an AP Instruments Inc. Model 200 analog network analyzer. The loop result was obtained by inserting a 200mV AC signal across TP2 and TP3. The crossover frequency, with a 115 $V_{AC}$, 60 Hz input and load current of 2 A, measured 1.38 kHz with a phase margin of 71 degrees.

## 6.8 Transient Response

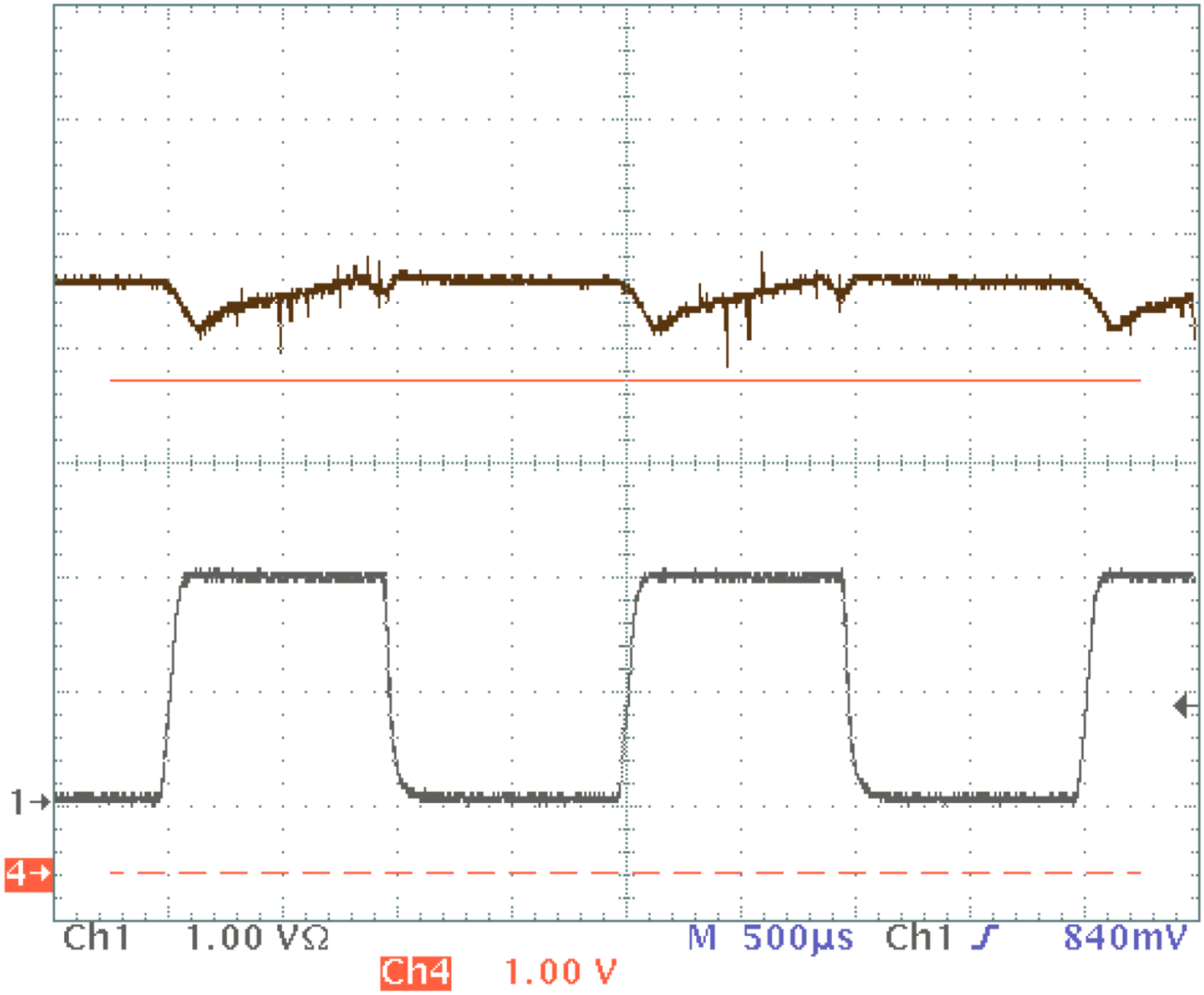


**Figure 11. UCC28740EVM-525 Load Transient**

The transient response shown in Figure 11 was taken with a 115 VAC, 60 Hz input voltage and a load transition from 0 A to full load. Channel 1 is the load current on a scale of 1 A per division, channel 4 is the otutput voltage on a scale of 1 V per division. The cursor shows the minimum acceptable voltage limit, 4.30 V, under transient conditions. Also note that the output waveform was taken with the probe on TP5 with the ground referenced to TP4 but not using the tip and barrel technique accounting for the high frequency noise seen on the waveform.

## 6.9 Output Ripple

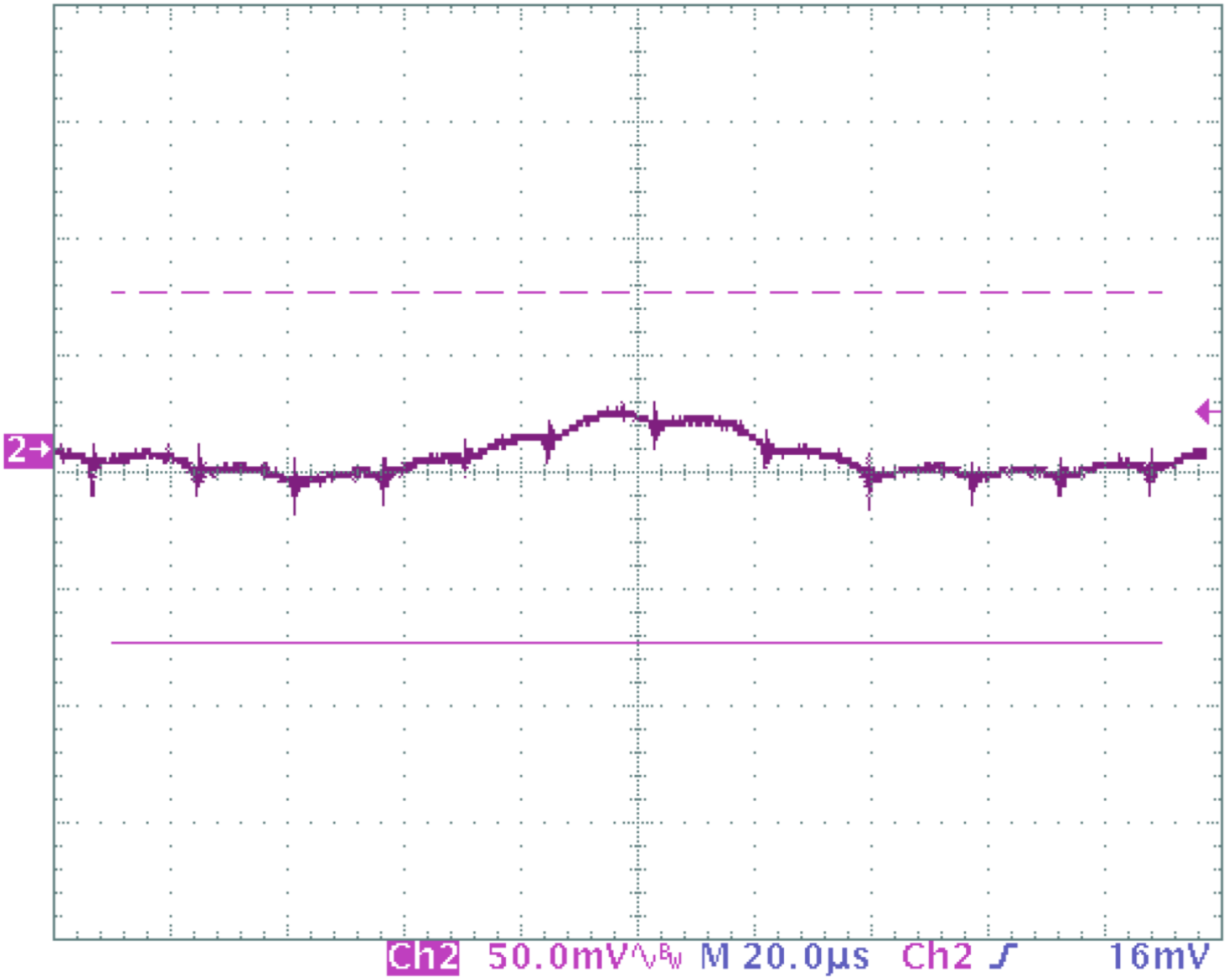


**Figure 12. Output Ripple**

Figure 12 shows the output voltage ripple, measured using tip and barrel across TP5 and TP6 on the EVM. The measurement was taken at full load with an input voltage of 85 VAC, 60 Hz and the waveform is AC coupled. The cursor shows the maximum peak to peak limit permitted for the design.

### 6.10 Turn On Waveform

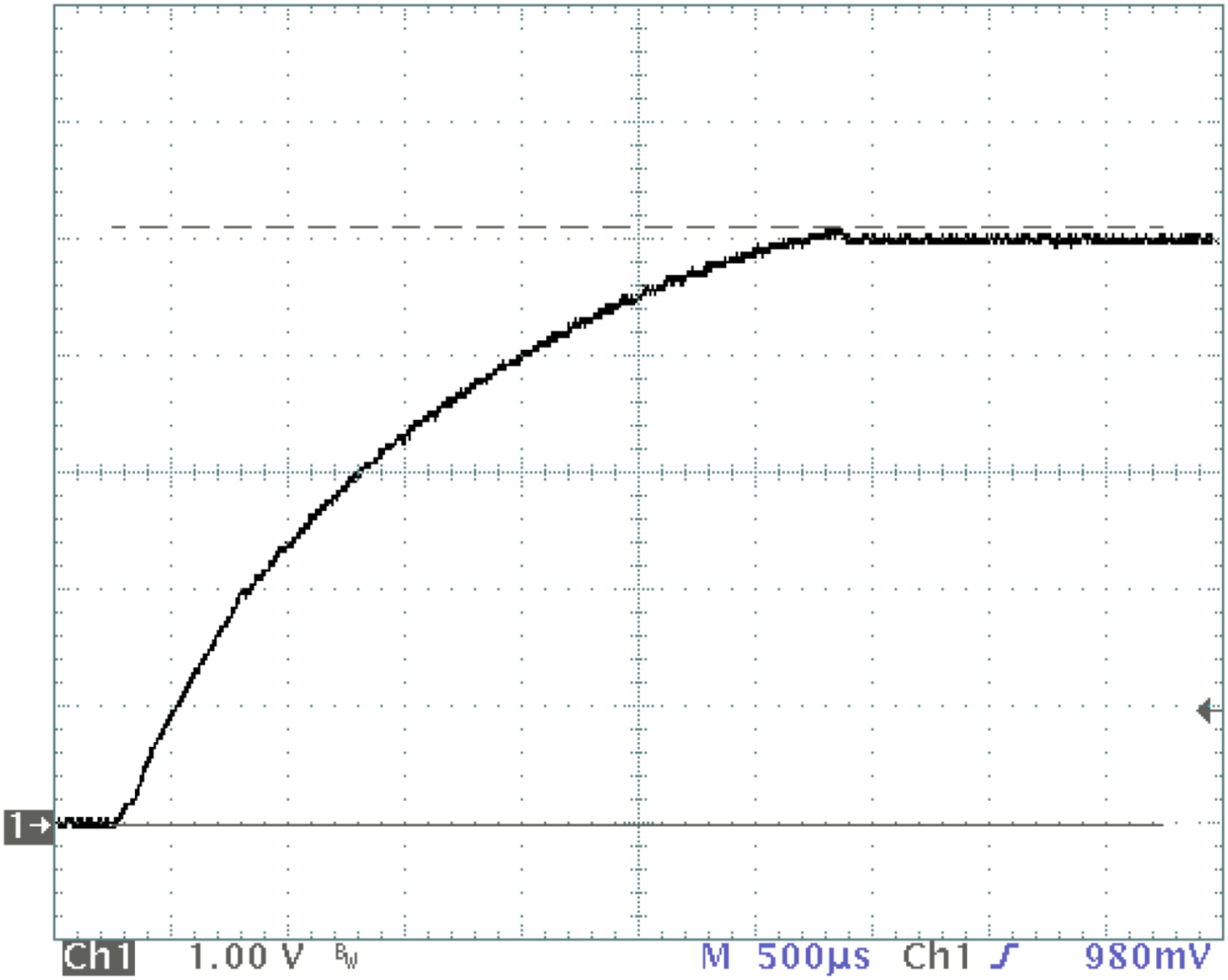


**Figure 13. Output voltage Turn On Waveform**

Figure 13 shows the output voltage at turn on under full load conditions with an input voltage of 115 $V_{AC}$, 60 Hz. The maximum voltage at the output was measured to be 5.12 $V_{DC}$.

### 6.11 Switching Waveform

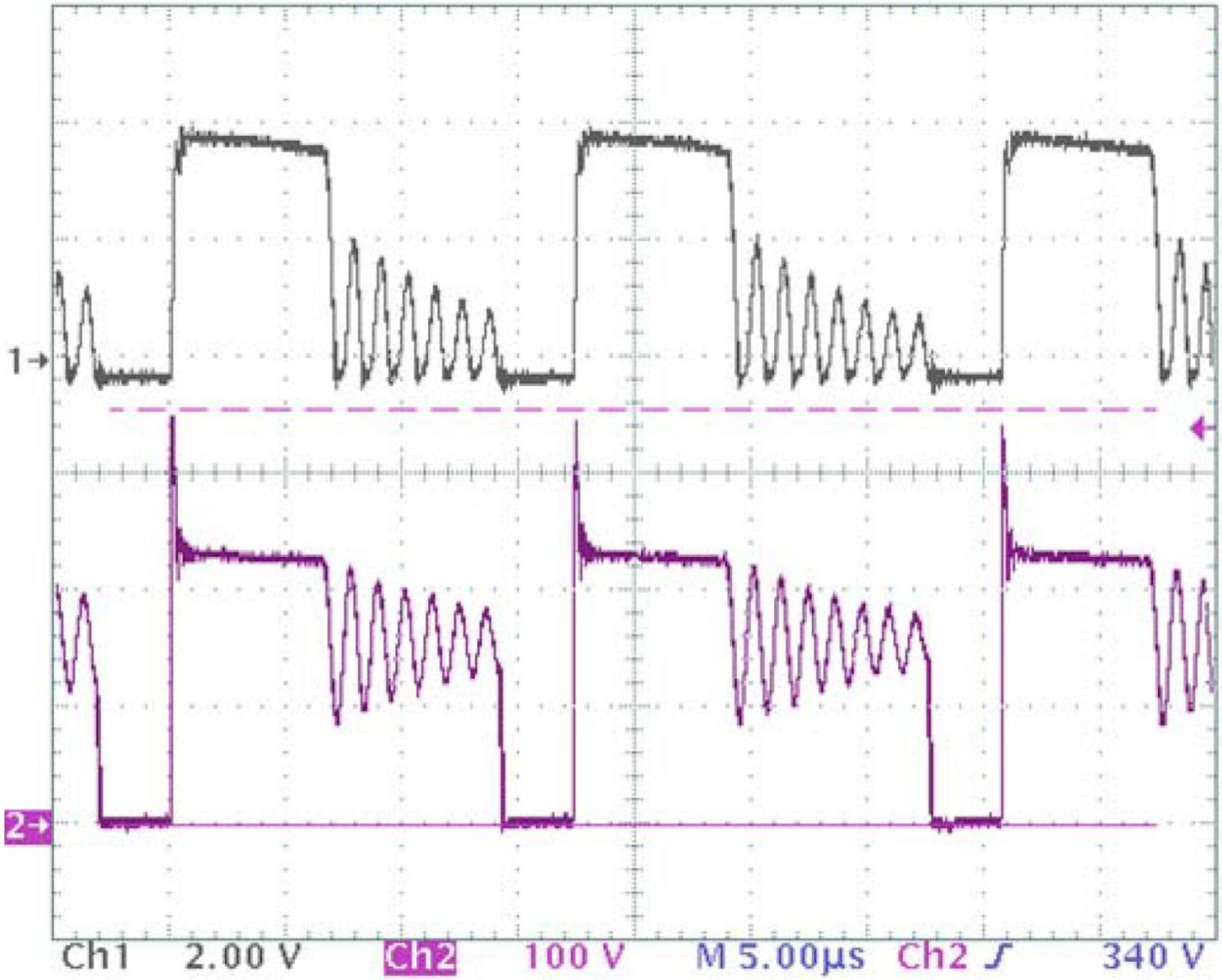


**Figure 14. Switching Waveform**

The typical switching waveform can be seen inFigure 14. Channel 1 shows the VS pin at 2 V per division and channel 2 shows the MOSFET drain to source voltage at 100 V per division. The scan was taken at 1.8 A load, 115 $V_{AC}$, 60 Hz input voltage. At this operating point, the switching frequency is dithering between 58.8 kHz and 52.6 kHz due to valley skipping.

### 6.12 EMI Dithering Waveform

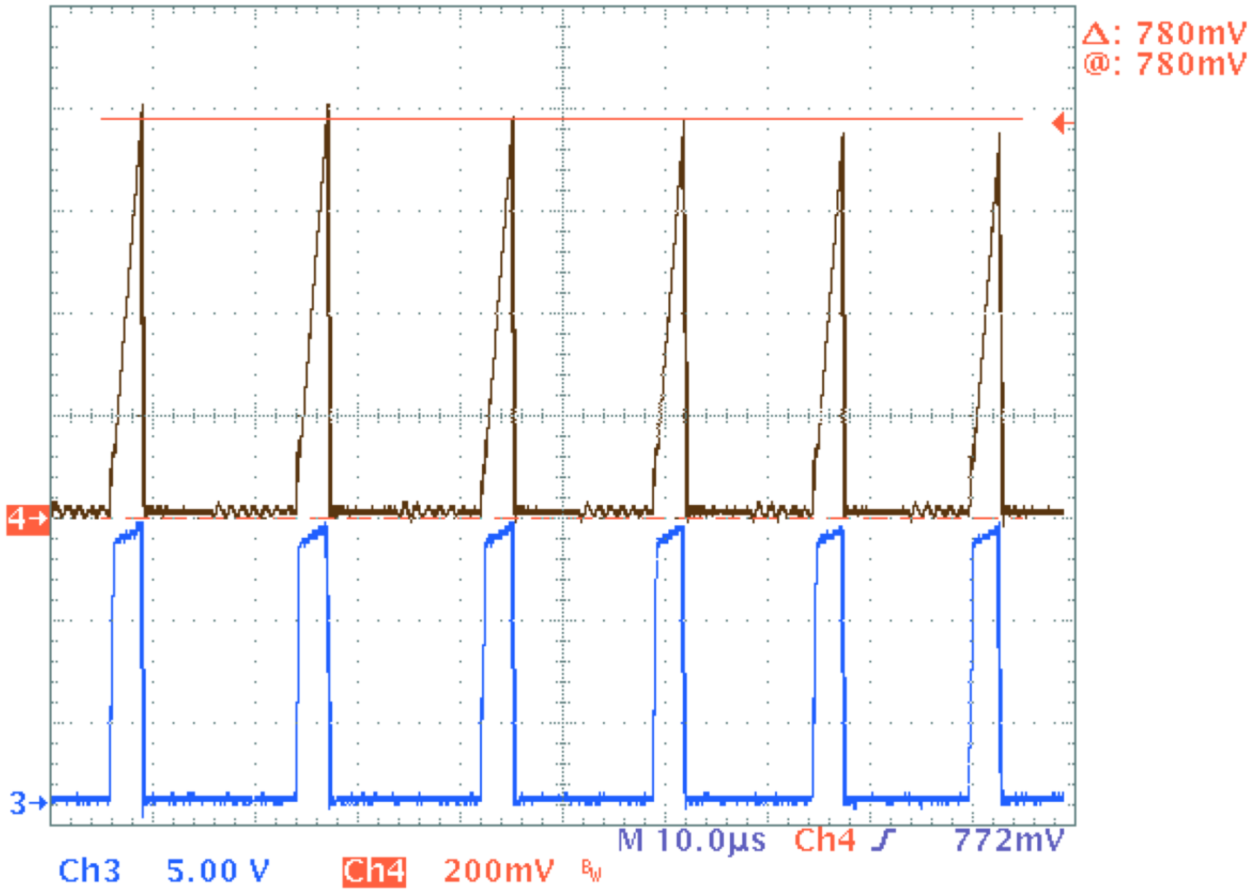


**Figure 15. EMI Dithering Waveform**

The UCC28740 controller employs a unique control mechanism to help with EMI compliance. As shown in Figure 15, the DRV pin, shown as channel 3, drives the gate of the MOSFET with a sequence of pulses in which there will be two longer pulses, two medium pulses, and two shorter pulses at any operating point starting with the amplitude modulation mode. The EMI dithering is not enabled at light load. Figure 15 shows the result of these varying pulse widths on the CS signal, shown on channel 4. The longer pulses result in a peak current threshold of 808 mV, the medium length pulses are shown measured at 780 mV, and the shorter pulses measure a threshold voltage of 752 mV. This dithering adds to the frequency jitter caused by valley skipping and results in a spread spectrum for better EMI compliance.

## 7 EVM Assembly Drawing and PCB layout

The following figures (Figure 16 through Figure 19) show the design of the UCC28740EVM-525 printed circuit board. The final dimensions of the single copper layer circuit measure 50.93 mm by 37.36 mm and the height is dominated by the USB connector at 18.4 mm.

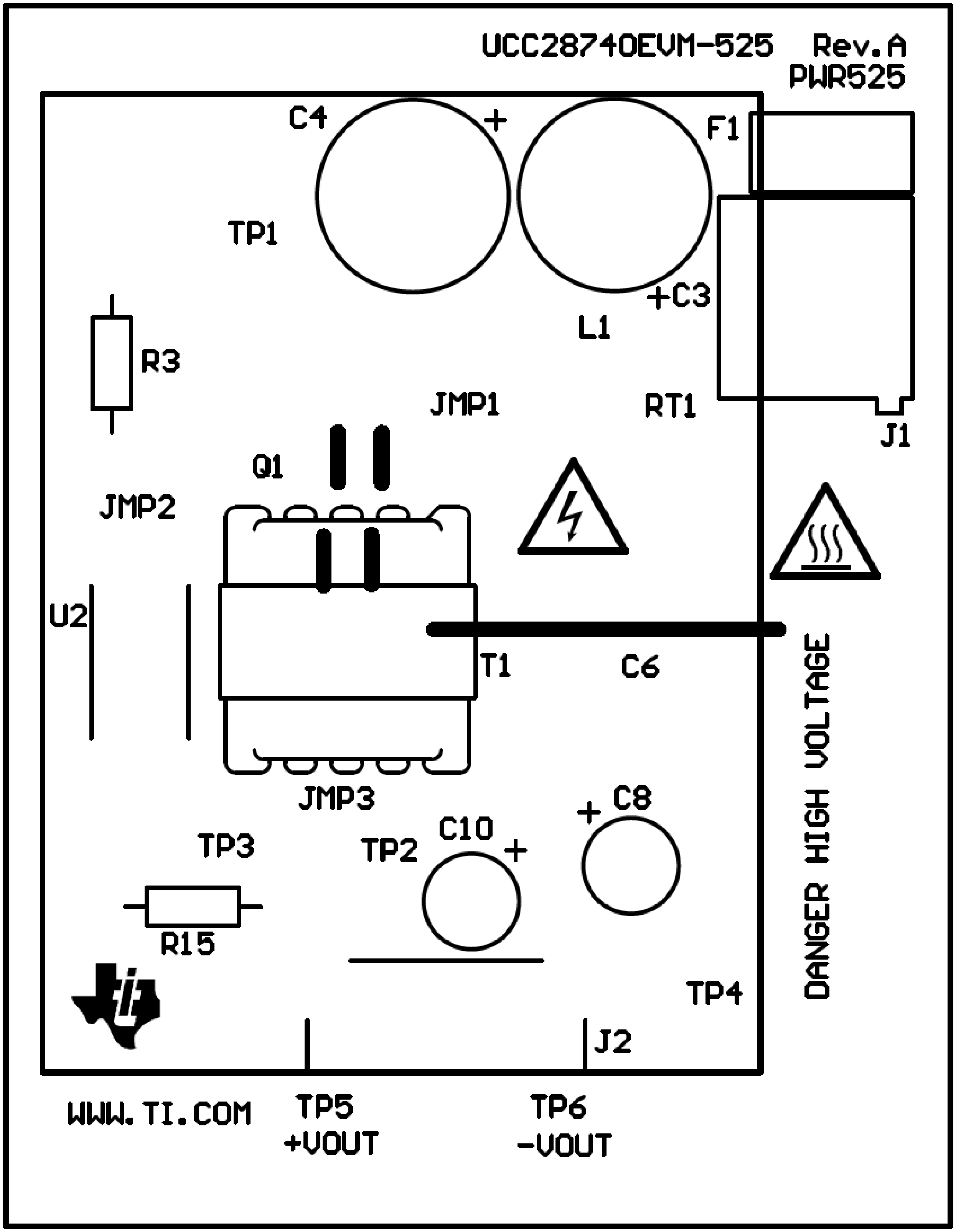


**Figure 16. UCC28740EVM-525 Top Layer Assembly Drawing (Top view)**

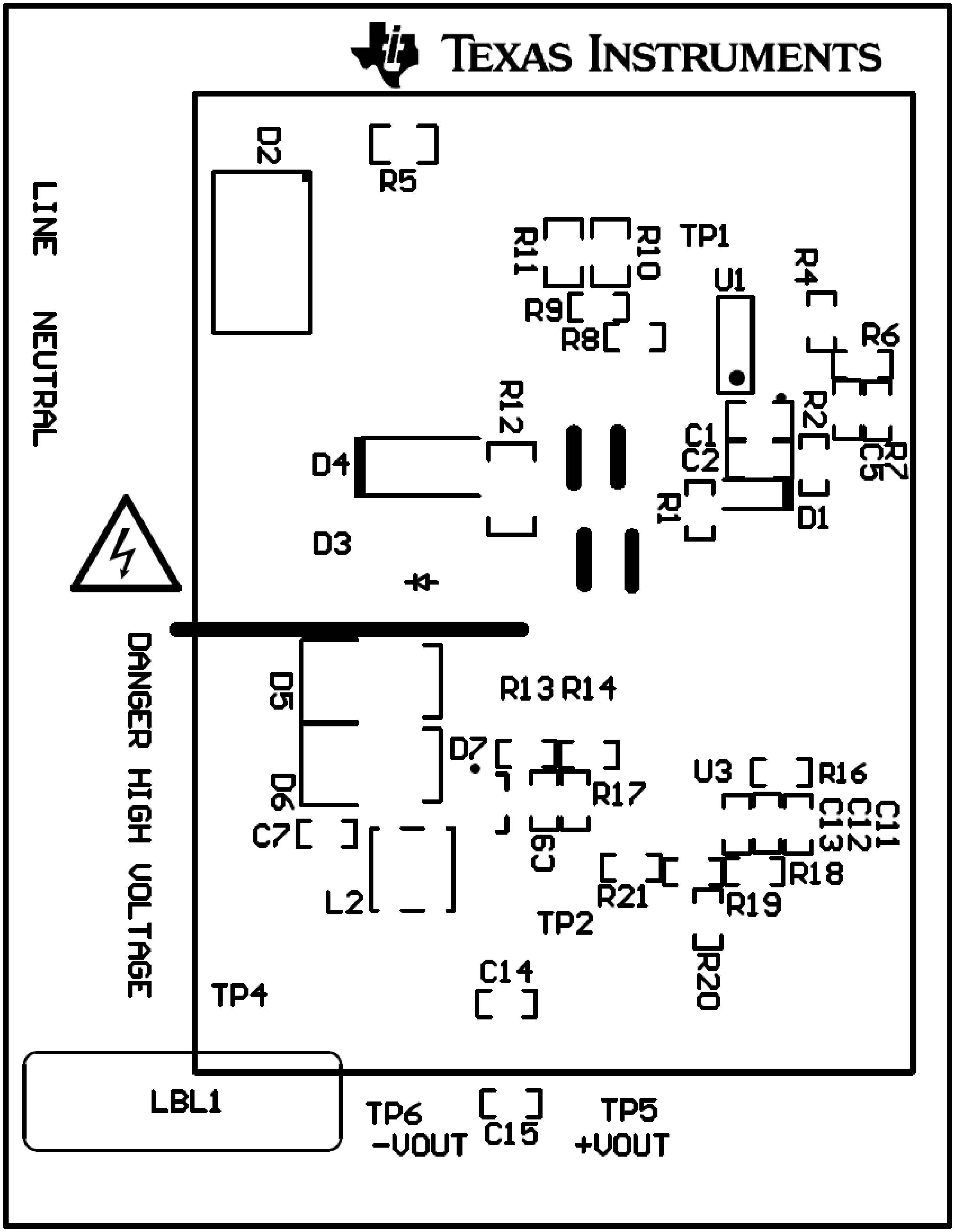


**Figure 17. UCC28740EVM-525 Bottom Layer Assembly Drawing (Bottom view)**

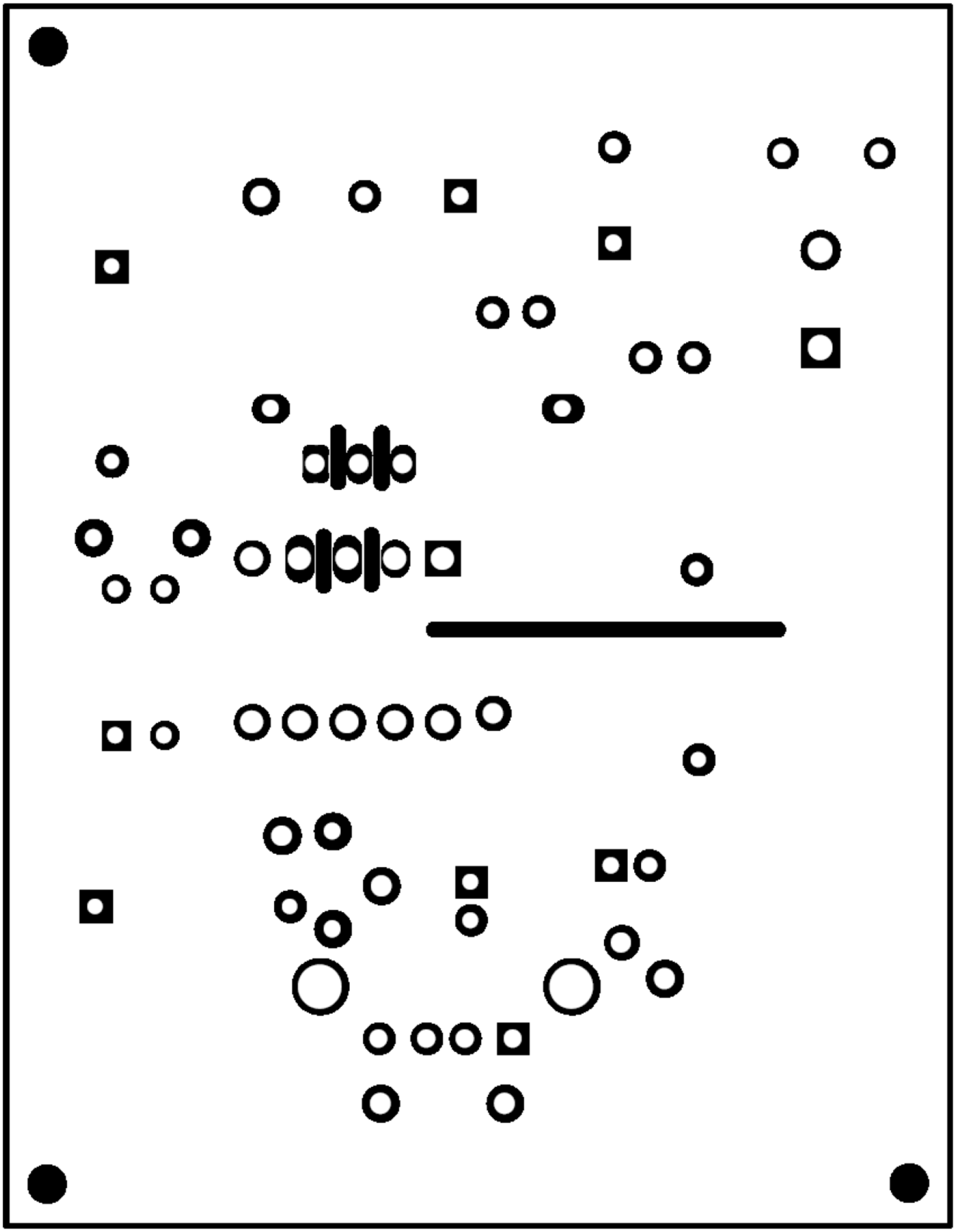

Figure 18. UCC28740EVM-525 Top Copper (Top View)

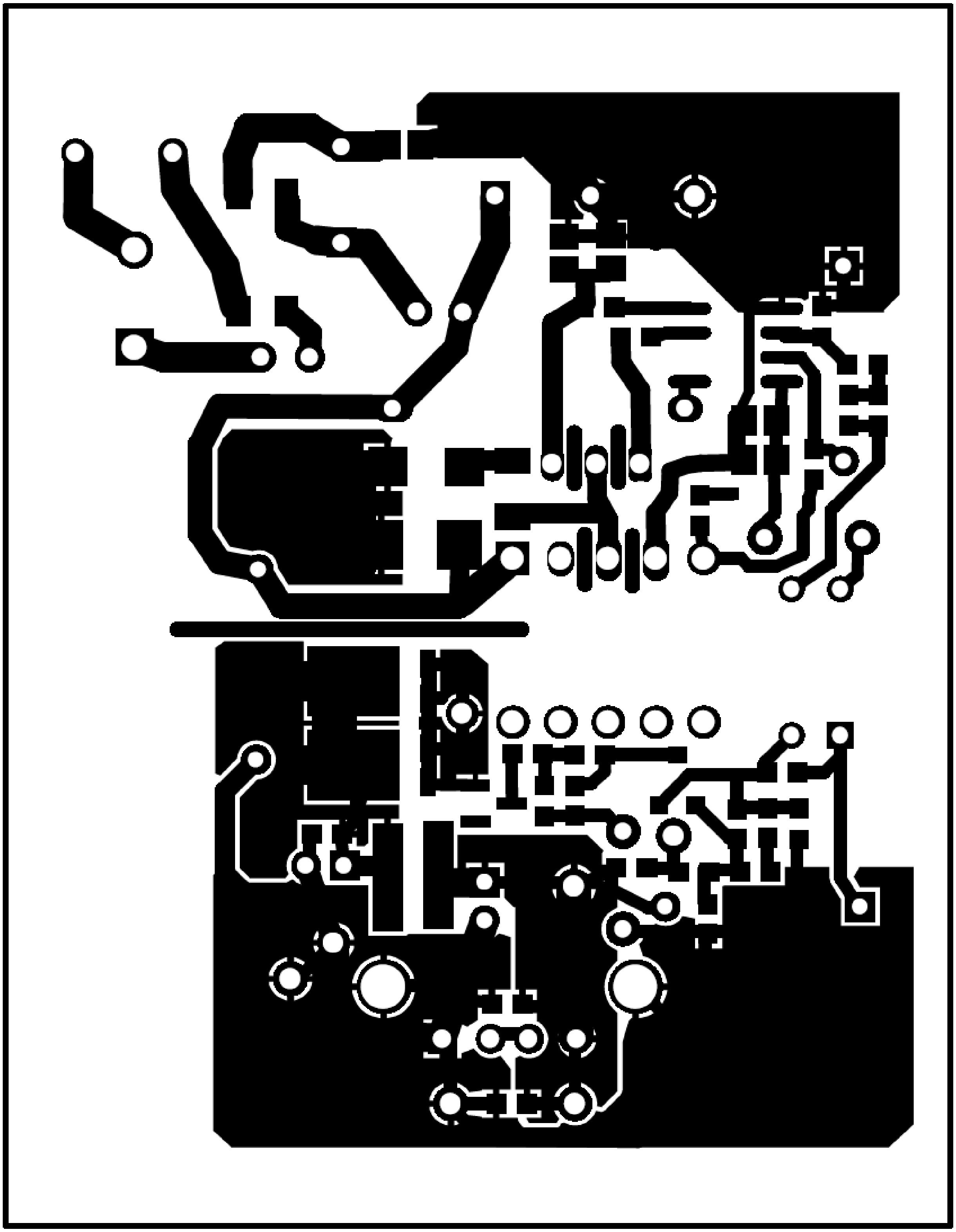

Figure 19. UCC28740EVM-525 Bottom Copper (Bottom View)

# 8 Bill of Materials

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

| QTY | REFDES | DESCRIPTION | MFR | PART NUMBER |
|---|---|---|---|---|
| 2 | C1, C2 | CAP, CERM, 2.2 µF, 50 V, X7R, ±10%, 0805 | Taiyo Yuden | UMK212BB7225KG-T |
| 2 | C3, C4 | CAP, ALUM, 6.8 µF, 400 V, ±20%, 110 mA, Radial | United Chemi-Con | EKXG401ELL6R8MJ16S |
| 1 | C5 | CAP, CERM, 0.047 µF, 25 V, X7R, ±5%, 0603 | AVX | 06033C473JAT2A |
| 1 | C6 | CAP, CERM, 100 pF, 250 V, X1Y2, ±10%, Radial, Disc | TDK Corporation | CD70-B2GA101KYNS |
| 4 | C7, C11, C14, C15 | CAP, CERM, 1 µF, 16 V, ±10%, X7R, 0603 | TDK | C1608X7R1C105K |
| 2 | C8, C10 | CAP, ALUM, 270 µF, 6.3 V, ±20%, 11 mΩ ESR, Radial | Nichicon | RNE0J271MDS1 |
| 0 | C9 | CAP, CERM, 1 µF, 16 V, ±10%, X7R, 0603 | TDK | C1608X7R1C105K |
| 0 | C12 | CAP, CERM, 4700 pF, 100 V, ±5%, X7R, 0603 | AVX | 06031C472JAT2A |
| 1 | C13 | CAP, CERM, 2700 pF, 100 V, +/-5%, X7R, 0603 | AVX | 06031C272JAT2A |
| 1 | D1 | Diode, Switching, 200 V, 250 mA, SOD-323 | Infineon Technologies | BAS 21-03W E6327 |
| 1 | D2 | Diode, Switching-Bridge, 600 V, 0.8 A, MiniDIP | Diodes Inc. | HD06-T |
| 1 | D3 | Diode, Transient Voltage Suppressor, 600 W, 120 V, SMB | Diodes Inc | SMBJ120A-13-F |
| 1 | D4 | Diode, Ultra Fast, 1000 V, 1 A, SMA | Vishay Semiconductor Diodes Division | US1M-E3/61T |
| 2 | D5, D6 | Diode, Super Barrier Rectifier, 45 V, 10 A, PowerDI5 | Diodes Inc. | SBR10U45SP5-13 |
| 0 | D7 | Diode, Ultrafast, 75 V, 0.3 A, SOT-23 | Diodes Inc. | BAS16-7-F |
| 1 | F1 | Fuse, 2 A, 250 V, TH, 8.35 x 7.7 x 4 mm | Bel Fuse Inc | RST 2 |
| 1 | J1 | Conn, Term Block, 2POS, 5.08 mm, TH | Phoenix Contact | 1715721 |
| 1 | J2 | Connector, Receptable, USB Type A, Vertical, TH | CnC Tech | 1002-021-01000 |
| 1 | JMP1 | Jumper, 0.600 inch length, PVC Insulation, AWG 22 | 3M | 923345-06-C |
| 2 | JMP2, JMP3 | Jumper, 0.200 inch length, PVC Insulation, AWG 22 | 3M | 923345-02-C |
| 1 | L1 | Inductor, RF Choke, 220 µH, ± 10%, 6 mm Dia. | Wurth Electronics Inc | 7447462221 |
| 1 | L2 | Inductor, Shielded, Composite, 1 µH, 8.7 A, 13.25 mΩ, SMD, 4 mm x 2.1 mm x 4 mm | Coilcraft | XAL4020-102MEB |
| 1 | Q1 | MOSFET, N-CH, 600 V, 5 A, 0.9 Ω, TO251-3 | STMicroelectronics | STU7NM60N |
| 1 | R1 | RES, 24.3 Ω, ±1%, 0.1 W, 0603 | Yageo America | RC0603FR-0724R3L |
| 1 | R2 | RES, 105 kΩ, ±1%, 0.1 W, 0603 | Vishay-Dale | CRCW0603105KFKEA |
| 1 | R3 | RES, 27.4 kΩ, ±1%, 0.25 W, TH | Vishay-Dale | CMF5027K400FHEB |
| 1 | R4 | RES, 22.0 kΩ, ±1%, 0.1 W, 0603 | Yageo America | RC0603FR-0722KL |
| 1 | R5 | RES, 0 Ω, ±5%, 0.125 W, 0805 | Vishay-Dale | CRCW08050000Z0EA |
| 3 | R6, R8, R17 | RES, 0 Ω, ±5%, 0.1 W, 0603 | Vishay-Dale | CRCW06030000Z0EA |

| QTY | REFDES | DESCRIPTION | MFR | PART NUMBER |
|---|---|---|---|---|
| 1 | R7 | RES, 196 kΩ, ±1%, 0.1 W, 0603 | Yageo America | RC0603FR-07196KL |
| 1 | R9 | RES, 1.27 kΩ, ±1%, 0.1 W, 0603 | Vishay-Dale | CRCW06031K27FKEA |
| 2 | R10, R11 | RES, 1.87 Ω, ±1%, 0.125 W, 0805 | Vishay-Dale | CRCW08051R87FKEA |
| 1 | R12 | RES, 49.9 Ω, ±1%, 0.25 W, 1206 | Vishay-Dale | CRCW120649R9FKEA |
| 0 | R13 | RES, 820 Ω, ±1%, 0.1 W, 0603 | Yageo America | RC0603FR-07820RL |
| 0 | R14 | RES, 2.00 kΩ, ±1%, 0.1 W, 0603 | Vishay-Dale | CRCW06032K00FKEA |
| 1 | R15 | RES, 1.50 kΩ, ±1%, 0.25 W, TH | Vishay-Dale | CMF501K5000FHEB |
| 1 | R16 | RES, 1.00 kΩ, ±1%, 0.1 W, 0603 | Yageo America | RC0603FR-071KL |
| 0 | R18 | RES, 140 kΩ, ±1%, 0.1 W, 0603 | Vishay-Dale | CRCW0603140KFKEA |
| 2 | R19, R20 | RES, 42.2 kΩ, ±1%, 0.1 W, 0603 | Vishay-Dale | CRCW060342K2FKEA |
| 1 | R21 | RES, 49.9 Ω, ±1%, 0.1 W, 0603 | Yageo America | RC0603FR-0749R9L |
| 1 | RT1 | Thermistor NTC, 10 Ω, ±20%, Leaded | Ametherm | SL03 10001 |
| 1 | T1 | Transformer, 560 µH, TH, 580 mil x 600 mil x 580 mil | Wurth Elektronik eiSos | 7508111111 Rev 001 |
| 6 | TP1, TP2, TP3, TP4, TP5, TP6 | Pin, Thru Hole, Tin Plate, for 0.062 PCB's | Vector | K24C/M |
| 1 | U1 | Constant-Voltage, Constant-Current Flyback Controller Using Opto-Coupler Feedback, D0007A | Texas Instruments | UCC28740D |
| 1 | U2 | Opto-Isolator, 1 Channel, TH, DIP-4 | Lite-On | LTV-817A |
| 1 | U3 | IC, Precision Adjustable Shunt Regulator, ±1%, SOT23-3 | Texas Instruments | TL431AIDBZ |

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**For Feasibility Evaluation Only, in Laboratory/Development Environments.** The EVM is not a complete product. It is intended solely for use for preliminary feasibility evaluation in laboratory / development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical / mechanical components, systems and subsystems. It should not be used as all or part of a production unit.

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1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
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