Using the UCC28880EVM-615

User's Guide



Literature Number: SLUUB57
July 2014

UCC28880EVM-615 Low-Side Buck Evaluation Module

1 Introduction

The UCC28880EVM-615 evaluation module is an AC-to-DC buck or buck-boost type power supply with direct level shifted feedback. The input accepts a voltage range of 85 V_{AC} to 265 V_{AC}. The pre-set output voltage is set to ~12.5 V (typical).

The output voltage is referenced to the positive DC input (HVDC node), not to the RTN node.

In buck configuration the DC output voltage on P2 is negative with respect to HVDC, and in buck-boost configuration the DC output voltage on P2 is positive with respect to HVDC.

The evaluation module uses the UCC28880 low quiescent current switcher ic. This devices integrates a 700V FET and controller into one SOIC7 package. The device also features a high voltage current source, enabling start-up and operation directly from the rectified mains voltage. The low quiescent current of the device enables very high efficiency in non-isolated high-side buck low power converters. Additional features are low standby power and a minimum number of external components.

The PWM signal generation is based on a maximum constant ON time concept and each ON pulse is followed by a minimum OFF time to ensure the power MOSFET is not continuously driven in the ON state. The PWM signal is AND gated with the signal from a current limiter. The AND gated signal controls the power MOSFET through a driver. No internal clock is required, and the switching of the power MOSFET is load dependent. The device is also protected from failure conditions with thermal shutdown, under-voltage lockout, soft-start and overload protection.

2 Applications

The UCC28880 is suited for use in non-isolated off-line systems requiring high efficiency and advanced fault protection features. Typical applications include:

- Home Appliances
- White Goods
- E Metering
- Home Automation
- Infrastructure
- LED Lighting

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3 Features

The UCC28880EVM-615 features include:

- Preset Output Voltage of ~ 12.5 V or -12.5 V (relative to the high-voltage input)
- 0-mA to 100-mA Load Range
- Universal Off-Line Input Voltage Range
- Meets EN55022 Class B Conducted Emissions Requirements
- Overload and Output Short Circuit Protection
- Thermal Shutdown
- Controlled Start Up and Restart After Fault Protection

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, C1 and C2 must be completely discharged before the EVM can be handled. Serious injury can occur if proper safety precautions are not followed.

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4 Electrical Specifications

Table 1. UCC28880EVM-615 Electrical Specifications

PARAMETER		CONDITIONS	MIN	TYP	MAX	UNITS
Input Characteristics						
V_{IN}	Input voltage		85	115/230	265	V
f_{LINE}	Frequency		47	50/60	64	Hz
	No-load power	V_{IN} = 115 V/230 V, I_{OUT} = 0 A		13/31		mW
I_{IN}	Input current	V_{IN} = 85 V, I_{OUT} = 100 mA		50		mA
Output Characteristics						
V_{OUT1} (1)	Output voltage	V_{IN} = 85 V to 265 V, I_{OUT} = 0 mA to 100 mA	12	12.5	13	V
V_{OUT2} (2)		V_{IN} = 85 V to 265V, I_{OUT} = 0 mA to 100 mA	–12	–12.5	-13	V
I_{OUT}	Maximum output current	V_{IN} = 85V to 265V		100		mA
I_{OUT}	Output current range	V_{IN} = 85V to 265V	0	100		mA
$V_{OUT(ripple)}$	Output voltage ripple	V_{IN} = 85V to 265V, I_{OUT} = 0 mA to 100 mA		150		mVpp
P_{OUT}	Output power	V_{IN} = 85V to 265V		1.25		W
System Characteristics						
h	Maximum efficiency	V_{IN} = 115V/230V, I_{OUT} = 100 mA		81%/83%		
TOP	Operating temperature range	V_{IN} = 85V to 265V, I_{OUT} = 0 mA to 100 mA	0	25	40	°C
Environmental						
	Conducted EMI				Meets CISPR22B/EN55022B	
Mechanical Characteristics						
W	Dimensions	Width		3.5		in
L		Length		5		in
H		Component height		0.75		in

(1) Jumper J1 inserted in Buck Boost position.
(2) Jumper J1 inserted in Buck position.

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5 Schematic

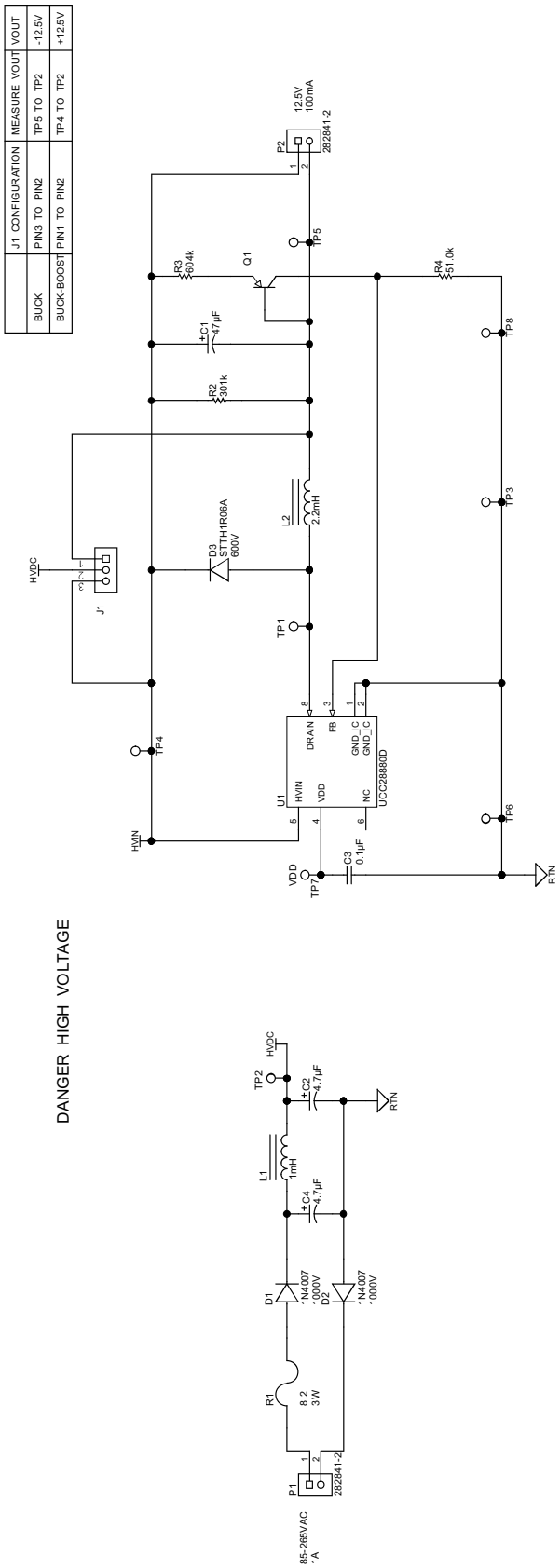

Figure 1. UCC28880EVM-615 Schematic

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6 Circuit Description

The UCC2888EVM-615 is a non-isolated AC-to-DC buck or buck-boost power supply with direct feedback.

The pre-set output voltage is set to ~12.5 V. In the buck configuration the output voltage is negative with respect to the high-voltage rectified DC (HVDC) and in the buck-boost configuration the output voltage is positive with respect to HVDC. The user can select between buck or buck-boost configurations by the position of jumper J1.

In addition to the UCC28880, the UCC2888EVM-615 contains the following key sections:

- A Half-Wave Rectifier (D1, D2)
- EMI Filter (L1, C4, C5)
- Freewheeling Diode (D4)
- Inductor (L2)
- Load Capacitor (C6) and Pre-Load Resistor (R2)
- Feedback Path (R3, Q1, R4)
- VAC Input Connector (P1)
- VDC Output Connector (P2)

There is one jumper on the board, J1, and the configuration is shown in Table 2.

Table 2. UCC28880EVM-615 Board Jumpers

DESIGNATOR	DESCRIPTION	NOTE
J1	Selects either buck or buck-boost mode of operation.	Output is measured from pin 2 to pin 1 of P2.

Table 3. UCC28880EVM-615 Test Points

DESIGNATOR	DESCRIPTION
TP1	UCC28880 Switch Node
TP2	High Voltage Rectified DC
TP3, TP6, TP8	GND
TP4	HVIN (pin 5) of UCC28880
TP5	Negative node of VOUT
TP7	VDD (pin 4) of UCC28880

Table 4. UCC28880EVM-615 Board Connectors

CONNECTOR	PIN NUMBER	DESCRIPTION
P1	L (pin1)	AC mains terminal input (line). AC mains input can be connected in either polarity. If DC is fed into this connector, then connect the positive V_{DC} to this node. Warning: This is a high-voltage node.
	N (pin2)	AC main terminal input (neutral). AC mains input can be connected in either polarity. If DC is fed into this connector, then connect negative V_{DC} to this node. Warning: This is a high-voltage node.
P2	OUT (12.5V) (pin1)	Positive output node.
	GND (pin2)	Negative output node.

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7 EVM Test Set Up

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.

Figure 2 shows the basic test setup recommended to evaluate the UCC28880EVM-615. Applying a low DC voltage (~15 V to 20 V) into the AC input (P1). The output voltage regulates to ~12.5 V on P2 (pin 1 with respect to pin 2). Once the correct output level is obtained, increase the input voltage to desired level.

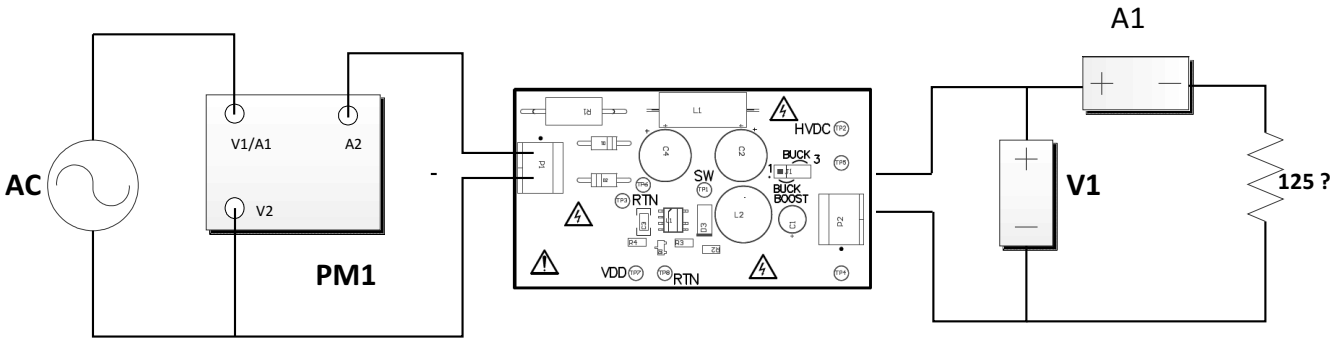

Figure 2. UCC28880EVM-615 Test Set Up

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8 Test Equipment

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 5 W and connected as shown in Figure 2. For accurate efficiency calculations, a power meter (PM1) should be inserted between the AC source and the EVM. For highest accuracy, connect the voltage terminals of the power meter directly across the power source. (Connecting the voltage terminals directly to the EVM will result in a small current error. This is very significant when measuring no-load power)

Load: The UCC28880EVM-615 is capable of delivering 100 mA of output current. A load resistance of 125 Ω is used on the output. Alternatively an electronic load may be used.

NOTE: The output is not isolated from the AC source and the electronic load must be capable of operating from a high-voltage input with a non-isolated source.

Power Meter: The power analyzer (PM1) shall be capable of measuring low-input current, typically less than 100 µA, and a long averaging mode if low-power standby mode's input-power measurements are to be taken. An example of such an analyzer is the Yokogawa WT210 Digital Power Meter.

Multimeters: Two digital multimeters are used to measure the regulated output voltage (V1) and load current (A1).

Oscilloscope: A digital or analog oscilloscope with a 500-MHz scope probe is recommended.

Recommended Wire Gauge: A minimum of AWG 24 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.

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9 Performance Data and Typical Characteristic Curves

9.1 Typical Efficiency and Load Regulation

9.1.1 12.5-V Buck

Table 5. 115-V_{AC} Regulation and Efficiency 12.5-V Buck

V_O	I_O	P_{IN}	EFFICIENCY
12.78	0	12.51	0.0
12.77	8	164	62.3
12.76	21	314	85.3
12.76	31	467	84.7
12.75	40	619	82.4
12.74	51	781	83.2
12.74	59	909	82.7
12.73	70	1077	82.7
12.73	80	1246	81.7
12.72	91	1414	81.9
12.71	99	1539	81.8

Table 6. 230-V_{AC} Regulation and Efficiency 12.5-V Buck

V_O	I_O	P_{IN}	EFFICIENCY
12.75	0	30.8	0.0
12.75	9	176	65.2
12.75	21	325	82.4
12.74	31	475	83.1
12.74	40	625	81.5
12.73	51	785	82.7
12.72	59	909	82.6
12.72	69	1075	81.6
12.71	80	1242	81.9
12.71	92	1407	83.1
12.7	100	1528	83.1

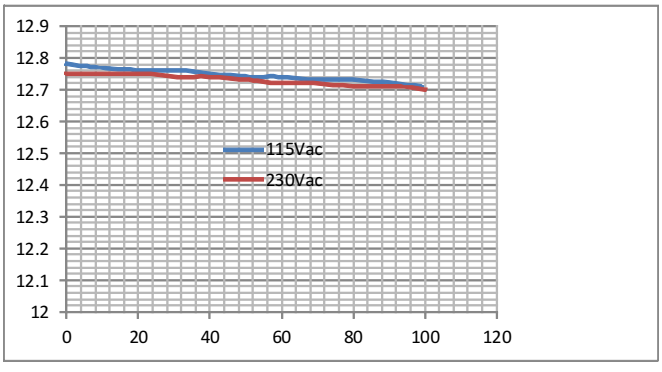

Figure 3. Load Regulation 12.5-V Buck

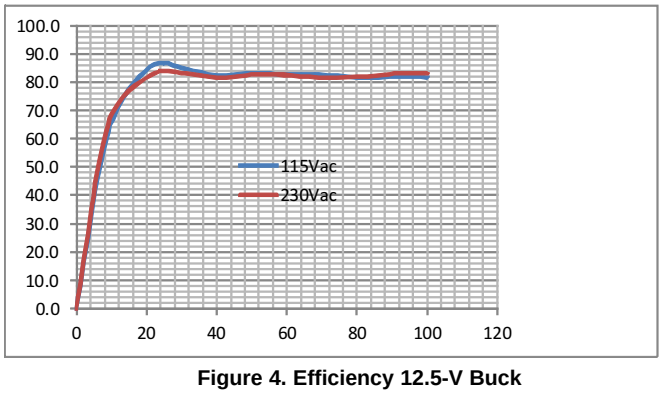

Figure 4. Efficiency 12.5-V Buck

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9.1.2 12.5-V Buck Boost

Table 7. 115-V_{AC} Regulation and Efficiency 12.5-V Buck Boost

V_O	I_O	P_{IN}	EFFICIENCY
12.76	0	12.78	0.0
12.76	8	166	61.5
12.76	21	320	83.7
12.75	31	474	83.4
12.74	41	628	83.2
12.74	48	750	81.5
12.73	60	920	83.0
12.72	69	1092	80.4
12.72	80	1262	80.6
12.71	91	1432	80.8
12.7	99	1557	80.8

Table 8. 230-V_{AC} Regulation and Efficiency 12.5-V Buck Boost

V_O	I_O	P_{IN}	EFFICIENCY
12.76	0	24.37	0.0
12.75	9	176	65.2
12.74	21	327	81.8
12.73	29	442	83.5
12.73	39	592	83.9
12.72	49	750	83.1
12.71	59	917	81.8
12.71	70	1085	82.0
12.7	78	1212	81.7
12.7	89	1376	82.1
12.7	99	1544	81.4

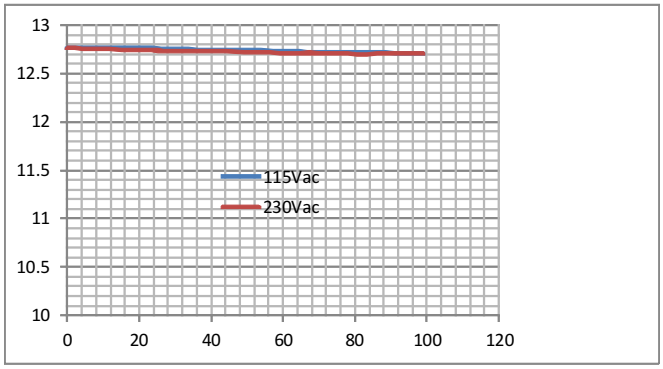

Figure 5. Regulation 12.5-V Buck Boost

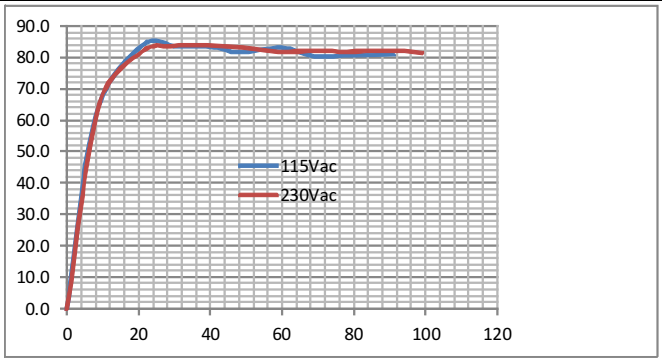

Figure 6. Efficiency 12.5-V Buck Boost

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9.2 Output Ripple

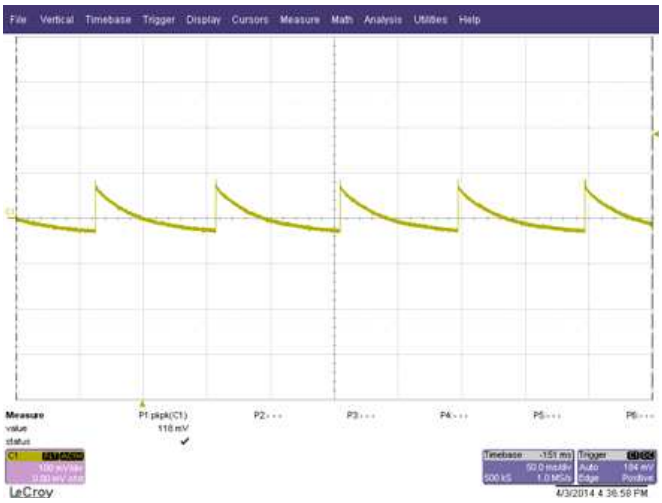

Figure 7. 100-mA Load Ripple

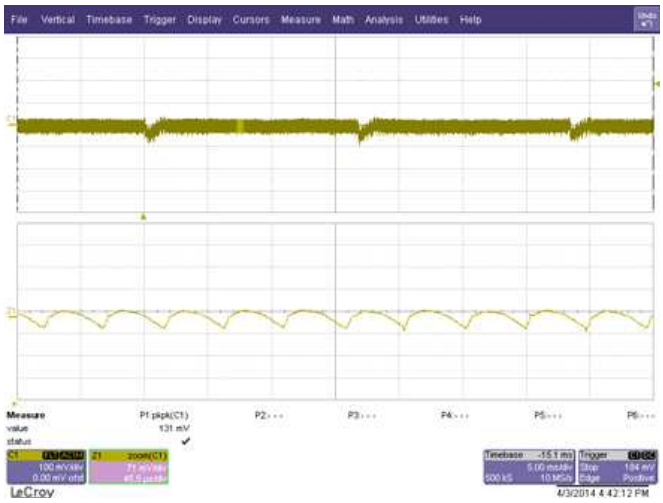

Figure 8. No-Load Ripple

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10 EVM Assembly Drawing and Layout

Figure 9 and Figure 10 show the design of the UCC28880EVM-615 printed circuit board.

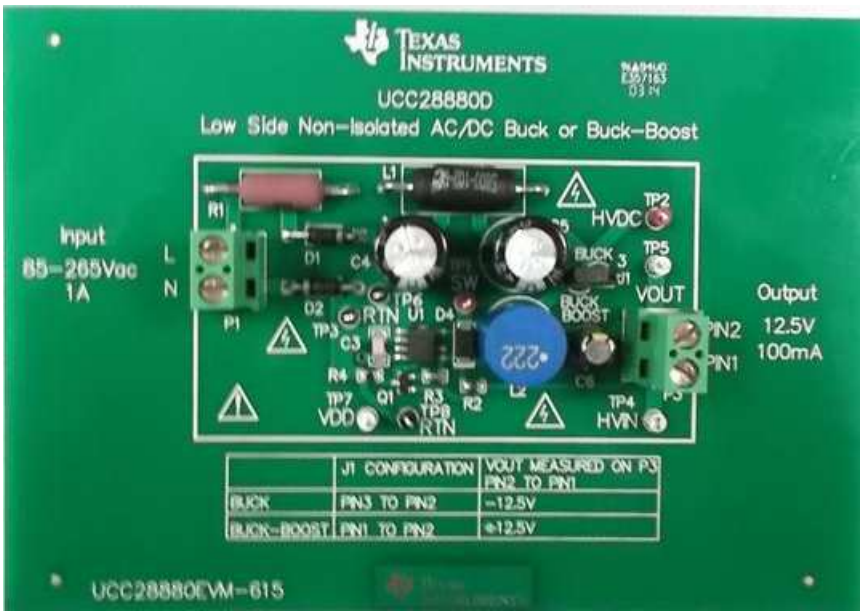

Figure 9. UCC28880EVM-615 (top view)

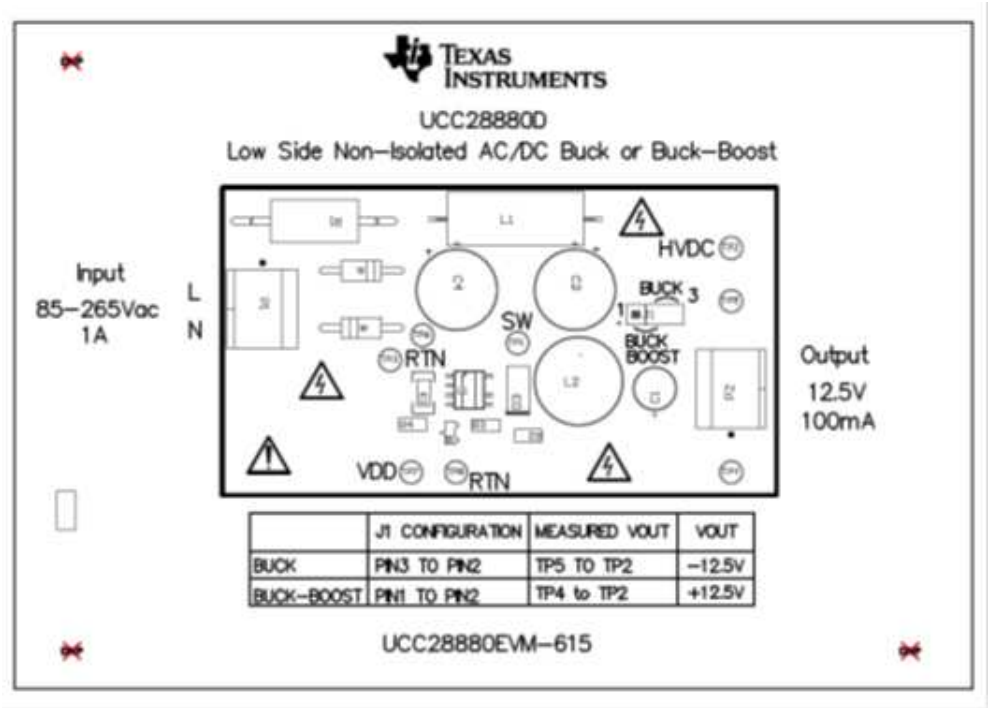

Figure 10. UCC28880EVM-615 Layout (top layer)

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11 List of Materials

Table 9. UCC28880EVM-615 List of Materials

QTY	DES	DESCRIPTION	MANUFACTURER	PART NUMBER
1	C1	Capacitor, aluminum, 47 µF, 25 V, ±20%, 0.3 Ω, TH	Panasonic	EEU-FM1E470
2	C2, C4	Capacitor, aluminum, 4.7 µF, 450 V, ±20%, TH	Kemet	ESH475M400AH2AA
1	C3	Capacitor, ceramic, 0.1 µF, 50 V, ±20%, X7R, 1206	AVX	12065C104MAT2A
2	D1, D2	Diode, P-N, 1000 V, 1 A, TH	Fairchild Semiconductor	1N4007
1	D3	Diode, ultrafast, 600 V, 1 A, SMA	ST Microelectronics	STTH1R06A
4	H1, H2, H3, H4	Bumpon, hemisphere, 0.44 x 0.20, clear	3M	SJ-5303 (CLEAR)
1	J1	Header, TH, 100 mil, 3 x 1, gold plated, 230 mil above insulator	Samtec	TSW-103-07-G-S
1	L1	Inductor, wirewound, ferrite, 1 mH, 0.2 A, 2.3 Ω, TH	Bourns	5800-102-RC
1	L2	Inductor, Wirewound, 2.2 mH, 0.33 A, 3.2 Ω, TH	TDK	TSL1112RA-222JR33-PF
2	P1, P2	Terminal block, 2 x 1, 5.08 mm, TH	TE Connectivity	282841-2
1	Q1	Transistor, PNP, 500 V, 0.15 A, SOT-23	NXP Semiconductor	PBHV9050T,215
1	R1	Resistor, 8.2 Ω, 5%, 3 W, fusible, TH	Bourns	PWR4522AS8R20JA
1	R2	Resistor, 301 kΩ, 1%, 0.063 W, 0603	TE Connectivity	1879339-3
1	R3	Resistor, 604 kΩ, 1%, 0.1 W, 0603	Yageo America	RC0603FR-07604KL
1	R4	Resistor, 51.0 kΩ, 1%, 0.1 W, 0603	Yageo America	RC0603FR-0751KL
1	SH-JP1	Shunt, 100 mil, flash gold, black	Sullins Connector Solutions	SPC02SYAN
2	TP1, TP2	Test point, miniature, red, TH	Keystone	5000
3	TP3, TP6, TP8	Test point, Miniature, Black, TH	Keystone	5001
3	TP4, TP5, TP7	Test point, miniature, white, TH	Keystone	5002
1	U1	Low Quiescent Current Switcher IC for AC-to-DC Power Supplies, D0007A	Texas Instruments	UCC28880D

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General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

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Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at its own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs Including Detachable Antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

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Important Notice for Users of EVMs Considered "Radio Frequency Products" in Japan

EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If user uses EVMs in Japan, user is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after user obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after user obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless user gives the same notice above to the transferee. Please note that if user does not follow the instructions above, user will be subject to penalties of Radio Law of Japan.

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