Using the UCC28880EVM-616

User's Guide

Literature Number: SLUUB56A
July 2014–Revised August 2014

UCC28880EVM-616 High-Side Buck Evaluation Module

1 Introduction

The UCC28880EVM-616 evaluation module is an offline high-voltage buck-type power supply that provides 13 V_{DC} at a maximum output of 100 mA. The input accepts a voltage range of 85 V_{AC} to 265 V_{AC}. The evaluation module also has the option to deliver 5-V_{DC} output using a simple jumper arrangement for the purpose of quick demonstration (additional power-stage optimization needed for optimal 5-V output performance).

The evaluation module uses the UCC28880 low quiescent current switcher device. This device integrates a 700-V 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. Thereby 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

3 Features

The UCC28880EVM-616 features include:

- Preset Output Voltage of ~13 V (JP1 not installed)
  (modify to ~5-V output voltage by installing jumper J1)
- No Load to 100-mA Load Range
- Universal Off-Line Input Voltage Range
- Meets EN55022 ClassB 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.

4 Electrical Performance Specifications

Table 1. UCC28880EVM-616 Electrical Performance Specifications (13-V Output)

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 mA		27/38		mW
I_{IN}	Input current	V_{IN} = 85 V, I_{OUT} = 100 mA		50	100	mA
Output Characteristics						
V_{OUT1} (1)	Output voltage	V_{IN} = 85 V to 265 V, I_{OUT} = 0 mA to 100 mA	12.65	12.6	13.25	V
I_{OUT}	Maximum output current	V_{IN} = 85 V to 265 V		100		mA
I_{OUT}	Output current range	V_{IN} = 85 V to 265 V	0		100	mA
V_{OUT_ripple}	Output voltage ripple	V_{IN} = 85 V to 265 V, I_{OUT} = 0 mA to 100 mA		200		mVpp
P_{OUT}	Output power	V_{IN} = 85 V to 265 V		1.3		W
Systems Characteristics						
h	Maximum efficiency	V_{IN} = 115 V/230 V, I_{OUT} = 100 mA	-	80/82	-	%
TOP	Operating temperature range	V_{IN} = 85 V to 265 V, 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) JP1 removed

Table 2. UCC28880EVM-616 Electrical Performance Specifications (5-V Output)

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		14/24		mW
I_{IN}	Input Current	V_{IN} = 85 V, I_{OUT} = 100 mA		25	50	mA
Output Characteristics						
V_{OUT1} (1)	Output Voltage	V_{IN} = 85 V to 265 V, I_{OUT} = 0 mA to 100 mA	4.25	4.35	6.35	V
I_{OUT}	Maximum Output Current	V_{IN} = 85 V to 265 V		100		mA
I_{OUT}	Output Current Range	V_{IN} = 85 V to 265 V	0		100	mA
$V_{OUT(ripple)}$	Output Voltage Ripple	V_{IN} = 85 V to 265 V, I_{OUT} = 100 mA		150		mVpp
P_{OUT}	Output Power	V_{IN} = 85 V to 265 V		0.43		W
Systems Characteristics						
h	Maximum Efficiency	V_{IN} = 115 V/230 V, I_{OUT} = 100 mA		62%/61 %		
TOP	Operating Temperature Range	V_{IN} = 85 V to 265 V, 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) JP1 inserted.

5 Schematic

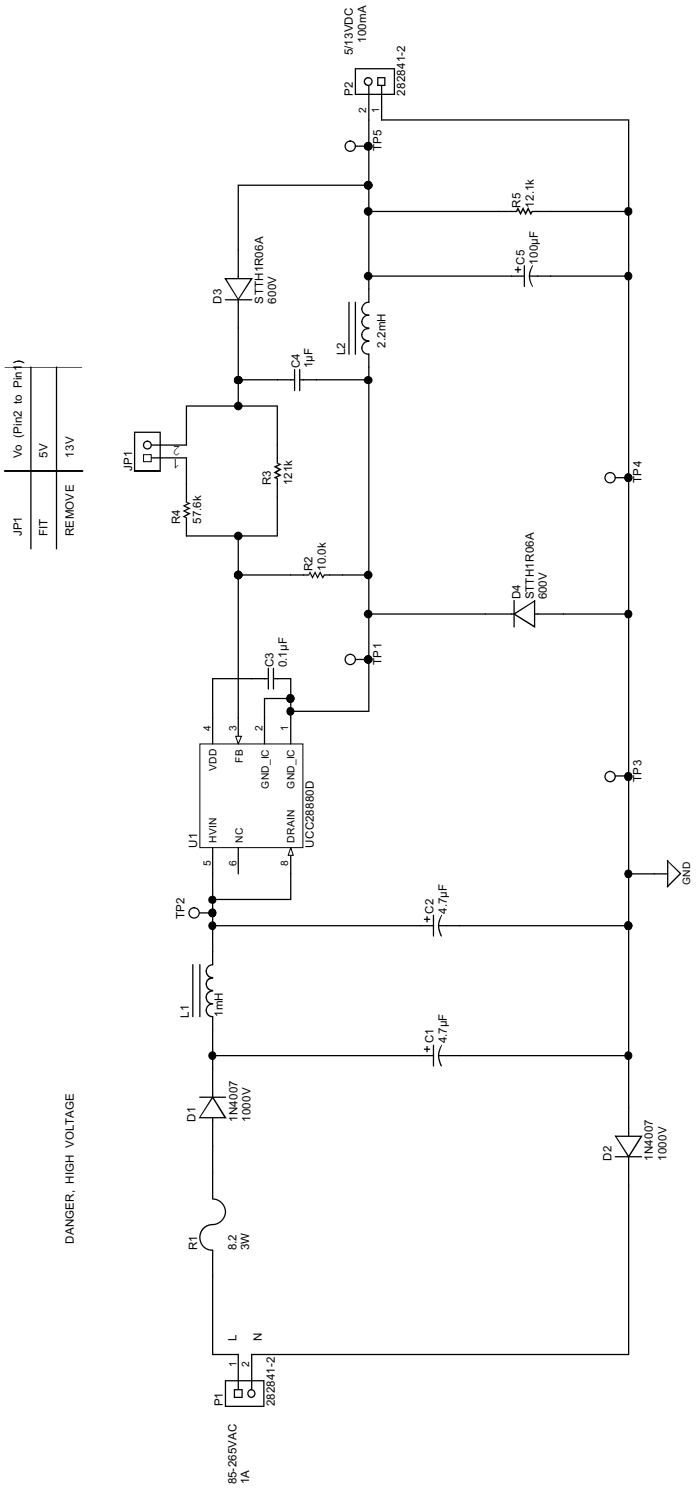

Figure 1. UCC28880EVM-616 Schematic

6 Circuit Description

The UCC28880EVM-616 is a non-isolated AC-to-DC high-side buck configuration with direct feedback. The EVM, on the input side, has a half-wave rectifier assembled for rectification of AC-to-DC, followed by an EMI filter.

The pre-set output voltage is set to ~13 V (typical) if jumper J3 is not connected, or ~5 V (typical) when the jumper is inserted. In the high-side buck configuration the output at OUT pin of connector P2 is positive with respect to GND.

NOTE: The GND node is one diode drop (D2) above the input neutral (N) node.

In addition to the UCC28880 device, the EVM holds the following key components:

- A Half-Wave Rectifier (D1, D2)
- EMI Filter (L1, C1, C2)
- Freewheeling Diode (D4)
- Inductor (L2)
- Load Capacitor (C5) and Pre-Load Resistor (R5)
- Feedback Path (C4, D5, R2, R3, R4, J3)
- V_{AC} Input Connector (P1)
- V_{DC} Output Connector (P2)

Table 3. UCC28880EVM-616 Board Jumpers

DESIGNATOR	DESCRIPTION	NOTE
JP1	Selecting feedback resistor values to select between 5-V and 13-V output: • When the jumper is inserted, the output is 5 V. • When left open, the output is 13 V.	Output is measured from pin 2 to pin 1 of P2.

Table 4. UCC28880EVM-616 Test Points

DESIGNATOR	DESCRIPTION
TP1	Buck switch node
TP2	High voltage rectified DC
TP3	GND
TP4	GND
TP5	VOUT

Table 5. UCC28880EVM616 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 (5 V/13 V) (pin1)	Positive output node.
	Gnd (pin2)	Negative output node (one diode drop above the input N).

The UCC28880EVM-616 is configured as a non-isolated AC-to-DC high-side buck converter with direct feedback. The output voltage OUT is referenced to the GND node, which is referenced to the negative high voltage node N. The potential difference between these nodes is equivalent to the voltage drop in diode D2. The output voltage is positive with respect to the GND node. The output voltage at OUT can be selected to be either ~5 V (typical) or ~13 V (typical) with the jumper JP1. See Table 3 for jumper settings to select between the two output voltage levels.

AC input voltage can be fed to the AC input nodes L and N in connector P1. When connecting AC input to P1 it does not matter which way line and neutral are connected to the P1 nodes. When connecting DC input to P1, please verify that polarity is correct, L is the positive node and N the negative node.

The feedback path, consisting of resistors R2 and R3, diode D5 and capacitor C4, sets the output voltage to ~13 V by default when the jumper JP1 is open. The diode D5 is identical to D4, and their voltage drops compensate each other. The feedback is sampling the output voltage level to capacitor C4 during the off state of the integrated HV FET of the UCC28880 and the output voltage is set by the resistors R2 and R3 following the equation:

$$V_{OUT} = \frac{R2 + R3}{R2} \times V_{FB} \quad (1)$$

where V_{OUT} is the output voltage and V_{FB} = 1.0 V is the voltage level at the feedback pin. The current through the external feedback path is set by the total resistance between OUT and GND nodes (resistors R2 through R3):

$$I_{FB} = \frac{V_{OUT}}{R2 + R3} \quad (2)$$

where I_{FB} is the current through the feedback and set to ~100 µA on this board.

When the jumper JP1 is closed, the resistor R4 is connected in parallel with resistor R3, and the output is set to ~5 V. To change either the output voltage or the feedback path current, use the equations above.

There is a pre-loaded resistor (R5), which sets a pre-load of ~1 mA at the output when 13 V is selected. With 5 V output, the preload is ~400 µA. A load of up to 100 mA can be applied to the output.

The design of UCC28880EVM-616 is optimized for 13-V output setting. For 5-V setting, there is additional room for optimization when factors such as audible noise, output voltage ripple, stand-by power etc are considered. The value of the bootstrap capacitor (C4), the impedance of the feedback divider network (R4, R3, R2), and output capacitor (C5) are especially critical. The RC time constant of the bootstrap capacitor and feedback resistor divider network influences voltage on the FB pin, which in turn, influences the burst pattern of switching pulses in the device. By adjusting these components the frequency of the burst pattern can be manipulated higher or lower. This is an effective way to address audible noise emanating from the magnetics and capacitors in the system. A higher RC time constant reduces the frequency of occurrence of burst pulses, which increases the output voltage ripple unless the value of output capacitor is also increased alongside. A lower-time constant increases the frequency of the burst pattern, but a smaller resistor divider impedance increases the stand-by power consumption. These trade-offs have to be considered when designing the power supply.

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-616. Start by applying a low DC voltage (~15 V to 20 V) into the AC input (P1). When connected correctly the output voltage is regulated to ~13 V (positive with respect to GND). Once correct output level is obtained, increase the input voltage to the desired level.

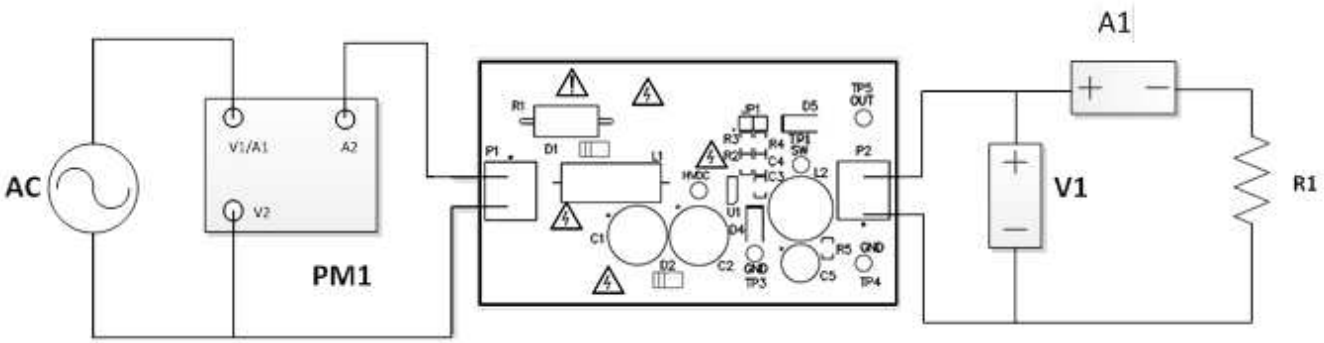

Figure 2. UCC28880EVM-616 Test Setup

8 Test Equipment

AC Input Source: The input source is 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 results in a small current error. This is very significant when measuring no-load power)

Load: The UCC28880EVM-616 is capable of delivering 100 mA of output current. 50 Ω, at 1 W is the minimum value of load resistance for the 5-V output and 130 Ω at 5 W is the minimum value of load resistance for the 13-V output. Alternatively an electronic load may be used.

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

Power Meter: The power analyzer (PM1) is capable of measuring low-input current, typically less than 100 µA, 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 Yokogawa WT210 Digital Power Meter.

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

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.

9 Performance Data and Typical Characteristic Curves

9.1 Typical Efficiency and Load Regulation

Table 6. Efficiency and Regulation at 115 V_{AC} for 13-V Output

V_O	I_O	P_{IN}	EFFICIENCY
13.19	0	27	0.0
12.7	9	174	65.7
12.66	19	291	82.7
12.63	29	442	82.9
12.61	40	632	79.8
12.6	51	794	80.9
12.59	59	922	80.6
12.58	70	1091	80.7
12.57	79	1221	81.3
12.56	89	1390	80.4
12.57	100	1554	80.9

Table 7. Efficiency and Regulation at 115 V_{AC} for 13-V Output

V_O	I_O	P_{IN}	EFFICIENCY
13.23	0	38	0.0
12.71	9	184	62.2
12.67	19	294	81.9
12.63	30	492	77.0
12.61	41	648	79.8
12.6	51	815	78.8
12.59	61	986	77.9
12.58	69	1116	77.8
12.57	80	1284	78.3
12.57	91	1448	79.0
12.59	100	1523	82.7

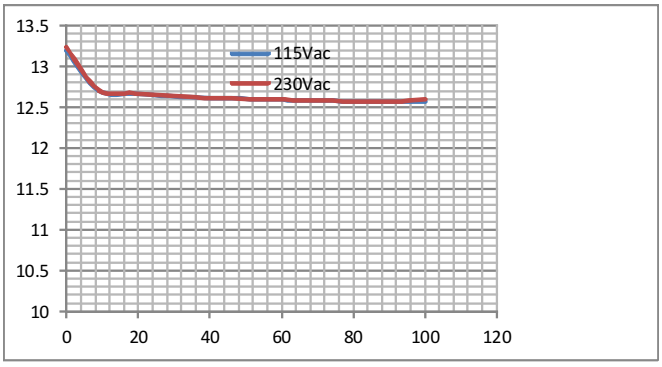

Figure 3. Regulation for 13-V Output

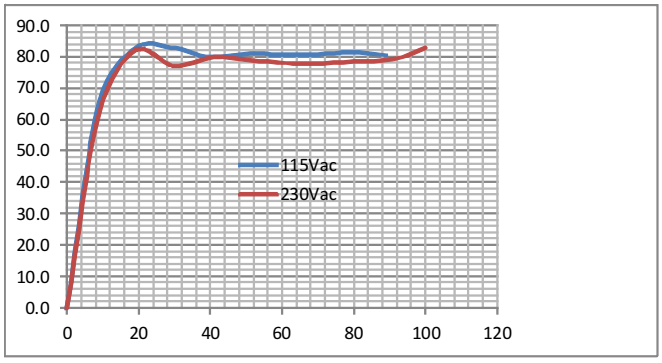

Figure 4. Efficiency for 13-V Output

Table 8. Efficiency and Regulation at 115 V_{AC} for 5-V Output

V_O	I_O	P_{IN}	EFFICIENCY
6.18	0	14	0.0
4.51	10	71	63.5
4.43	19	134	62.8
4.4	29	197	64.8
4.38	39	261	65.4
4.36	49	332	64.3
4.35	59	405	63.4
4.34	70	481	63.2
4.33	81	555	63.2
4.32	89	613	62.7
4.31	100	689	62.6

Table 9. Efficiency and Regulation at 230 V_{AC} for 5-V Output

V_O	I_O	P_{IN}	EFFICIENCY
6.26	0	24	0.0
4.51	10	81	55.7
4.44	19	140	60.3
4.4	29	214	59.6
4.38	39	275	62.1
4.37	49	344	62.2
4.36	60	418	62.6
4.35	70	492	61.9
4.34	78	549	61.7
4.34	89	625	61.8
4.33	100	703	61.6

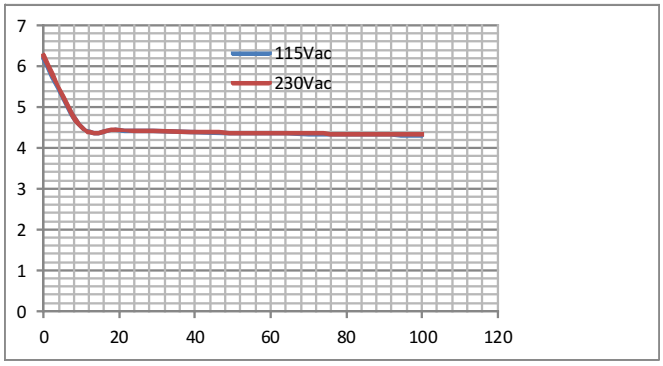

Figure 5. Regulation for 5-V output

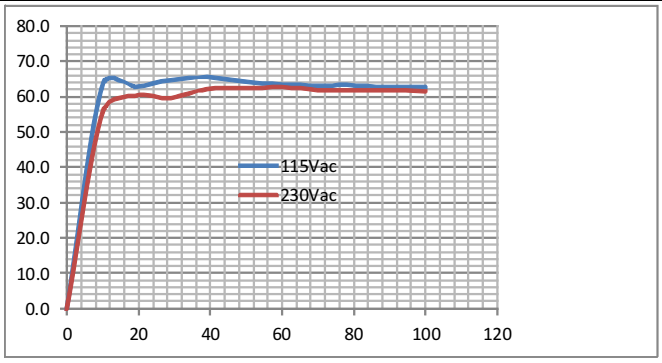

Figure 6. Efficiency for 5-V output

9.2 Output Ripple

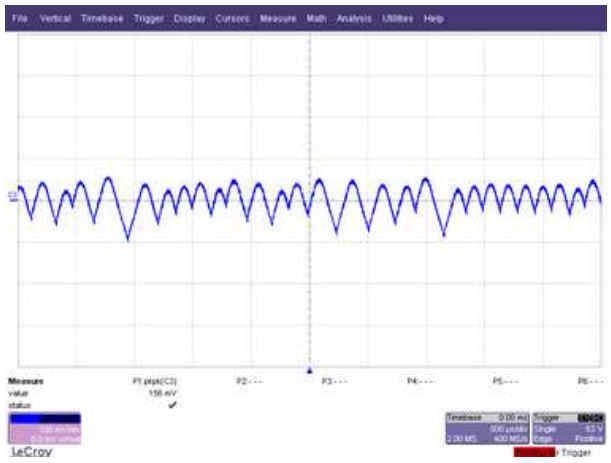

Figure 7. Output Ripple for 5-V Output

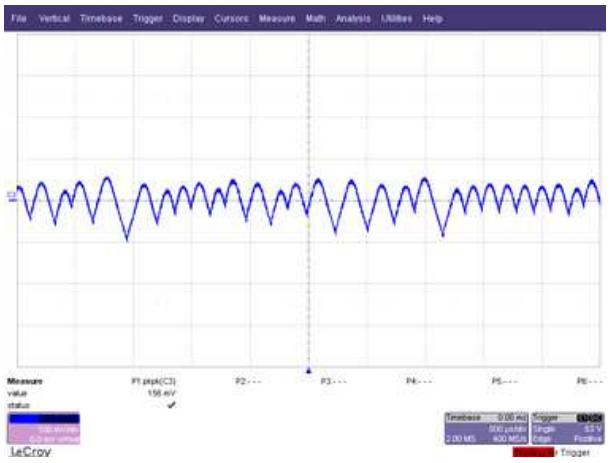

Figure 8. Output Ripple for 13-V Output

9.3 Switching Waveforms

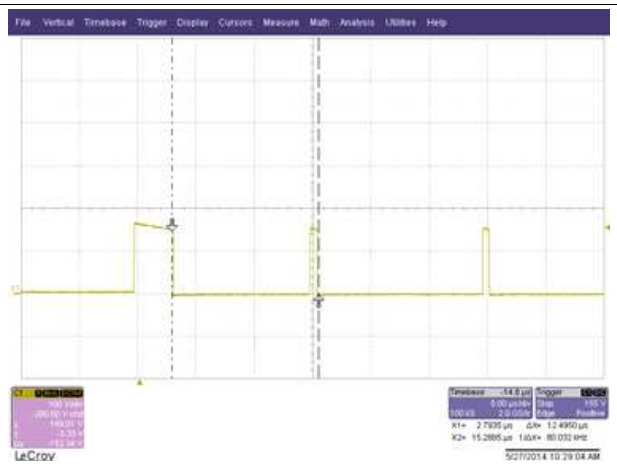

Figure 9. VD4 at 115 V_{AC} In, 4.27 V_{OUT}, 75 Ω

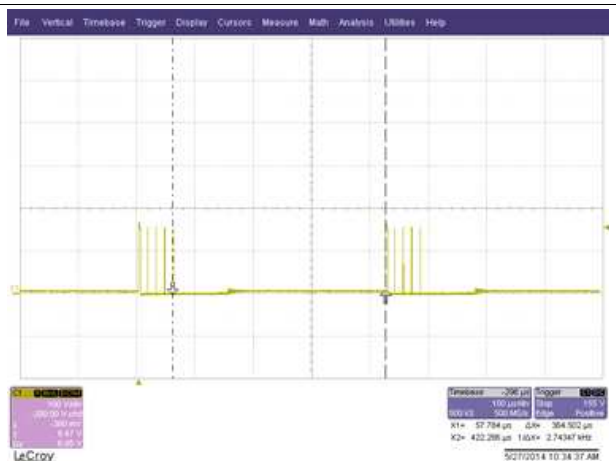

Figure 10. VD4 at 115 V_{AC} In, 4.27 V_{OUT}, 75 Ω

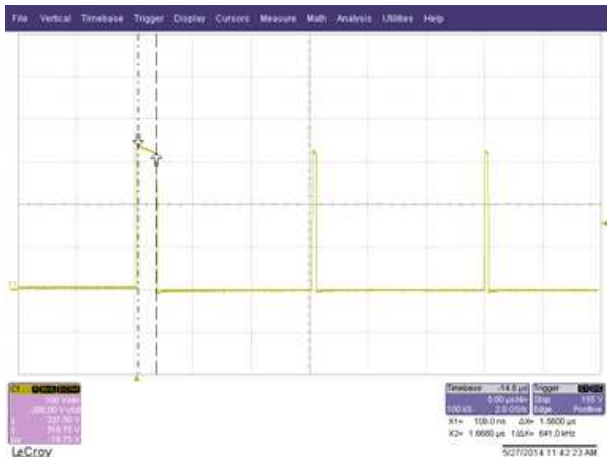

Figure 11. VD4 at 230 V_{AC} In, 4.27 V_{OUT}, 75 Ω

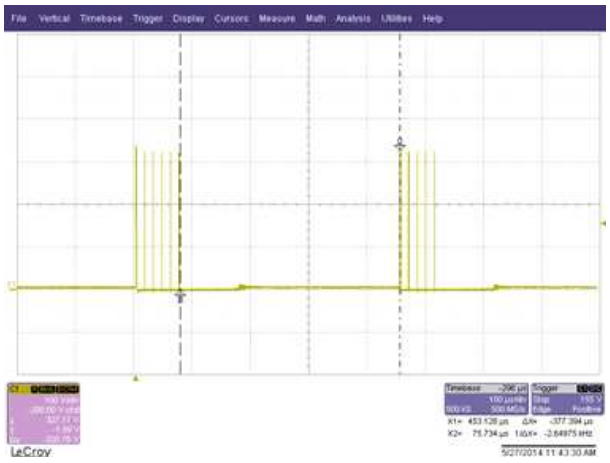

Figure 12. VD4 at 230 V_{AC} In, 4.27 V_{OUT}, 75 Ω

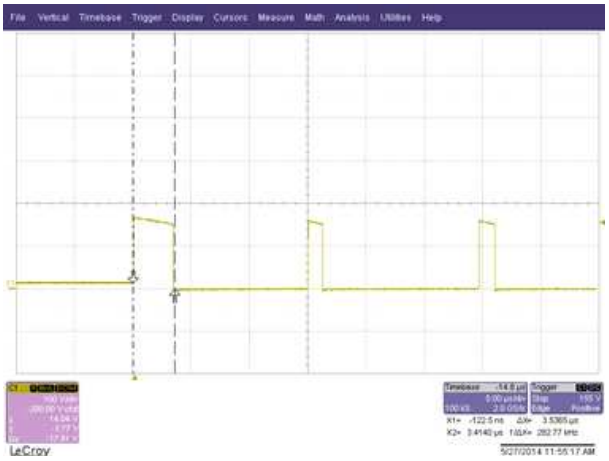

Figure 13. VD4 at 115 V_{AC} In, 12.55 V_{OUT}, 100 mA

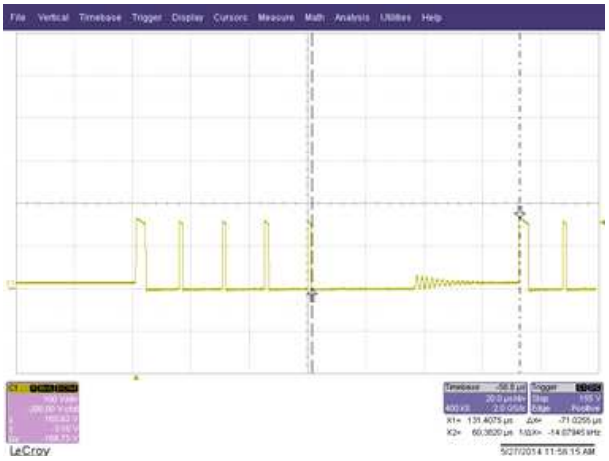

Figure 14. VD4 at 115 V_{AC} In, 12.55 V_{OUT}, 100 mA

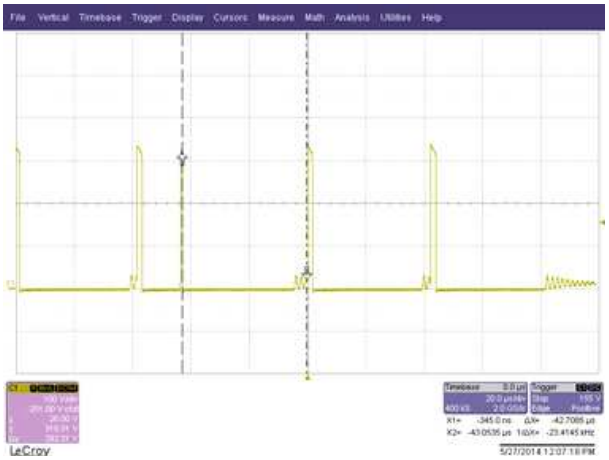

Figure 15. VD4 at 230 V_{AC} In, 12.55 V_{OUT}, 100 mA

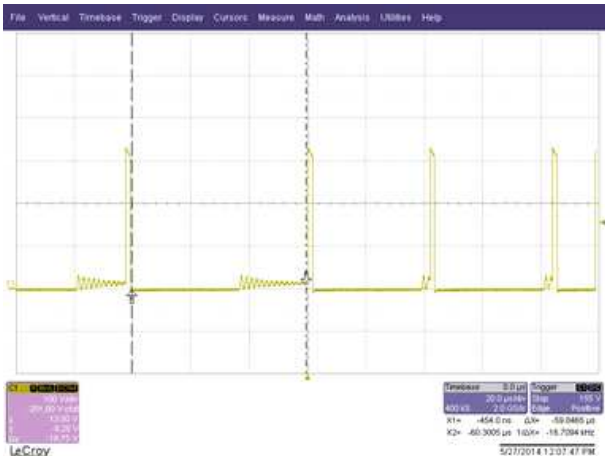

Figure 16. VD4 at 230 V_{AC} In, 12.60 V_{OUT}, 100 mA

10 EVM Assembly Drawing and PCB Layout

Figure 17 and Figure 18 show the design of the UCC2880EVM-616 printed circuit board.

Figure 17. UCC28880EVM-616 Assembly (top view)

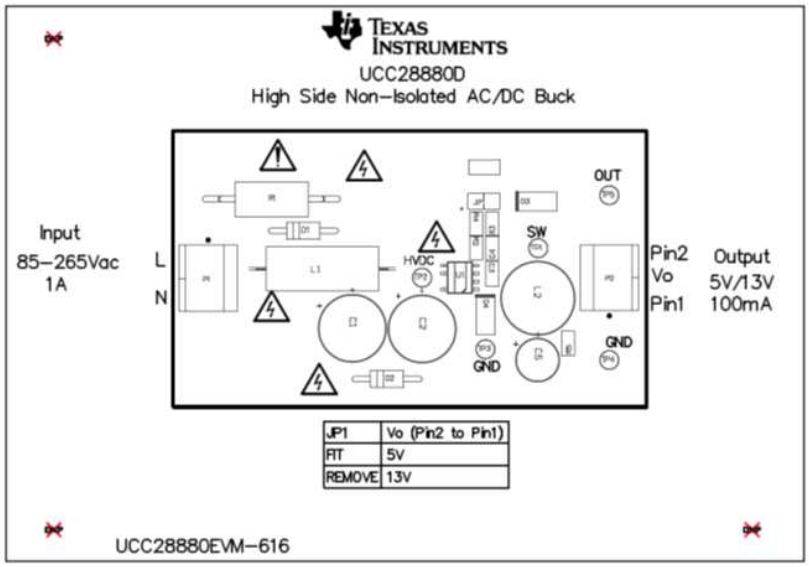

Figure 18. UCC28880EVM-616 Layout (top layer)

11 List of Materials

Table 10. UCC28880EVM-616 List of Materials

QTY	DES	DESCRIPTION	MANUFACTURER	PART NUMBER
1	PCB	Printed Circuit Board	Any	PWR616
2	C1, C2	Capacitor, aluminum, 4.7 µF, 450 V, ±20%, TH	Kemet	ESH475M450AH2AA
1	C3	Capacitor, ceramic, 0.1 µF, 50 V, ±10%, X7R, 0805	Kemet	C0805C104K5RACTU
1	C4	Capacitor, ceramic, 1 µF, 50 V, ±10%, X7R, 0805	MuRata	GRM21BR71H105KA 12L
1	C5	Capacitor, aluminum, 100 µF, 25 V, ±20%, 0.13 Ω, TH	Panasonic	EEU-FM1E101
2	D1, D2	Diode, P-N, 1000 V, 1 A, TH	Fairchild Semiconductor	1N4007
2	D3, D4	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	JP1	Header, TH, 100 millimeter, 2 x 1, gold plated, 230 millimeter above insulator	Samtec	TSW-102-07-G-S
1	L1	Inductor, wirewound, ferrite, 1mH, 0.2A, 2.3 Ω, TH	Bourns	5800-102-RC
1	L2	Inductor, wirewound, 2.2mH, 0.33A, 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	R1	Resistor, 8.2 Ω, 5%, 3 W, fusible, TH	Bourns	PWR4522AS8R20JA
1	R2	Resistor, 10.0 kΩ, 1%, 0.125 W, 0805	Panasonic	ERJ-6ENF1002V
1	R3	Resistor, 121 kΩ, 1%, 0.125 W, 0805	Panasonic	ERJ-6ENF1213V
1	R4	Resistor, 57.6 kΩ, 1%, 0.125 W, 0805	Panasonic	ERJ-6ENF5762V
1	R5	Resistor, 12.1 kΩ, 1%, 0.125 W, 0805	Panasonic	ERJ-6ENF1212V
1	SH-JP1	Shunt, 100 millimeter, flash gold, black	Sullins Connector Solutions	SPC02SYAN
2	TP1, TP2	Test point, miniature, red, TH	Keystone	5000
2	TP3, TP4	Test point, miniature, black, TH	Keystone	5001
1	TP5	Test point, miniature, white, TH	Keystone	5002
1	U1	Low Quiescent Current Switcher Device for AC-to-DC Power Supplies, D0007A	Texas Instruments	UCC28880D

Revision History

Changes from Original (July 2014) to A Revision **Page**

- Added an updated UCC28880EVM-616 description..... 2
- Added Preset Output Voltage of ~13 V feature description..... 3
- Added UCC28880EVM-616 circuit description. 8

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

ADDITIONAL TERMS AND CONDITIONS, WARNINGS, RESTRICTIONS, AND DISCLAIMERS FOR EVALUATION MODULES

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3. User agrees that EVMs shall not be used as, or incorporated into, all or any part of a finished product.
4. User agrees and acknowledges that certain EVMs may not be designed or manufactured by TI.
5. User must read the user's guide and all other documentation accompanying EVMs, including without limitation any warning or restriction notices, prior to handling and/or using EVMs. Such notices contain important safety information related to, for example, temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.
6. User assumes all responsibility, obligation, and any corresponding liability for proper and safe handling and use of EVMs.
7. Should any EVM not meet the specifications indicated in the user's guide or other documentation accompanying such EVM, the EVM may be returned to TI within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY TI TO USER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. TI SHALL NOT BE LIABLE TO USER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES RELATED TO THE HANDLING OR USE OF ANY EVM.
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9. User assumes sole responsibility to determine whether EVMs may be subject to any applicable federal, state, or local laws and regulatory requirements (including but not limited to U.S. Food and Drug Administration regulations, if applicable) related to its handling and use of EVMs and, if applicable, compliance in all respects with such laws and regulations.
10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user's use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

Certain Instructions. User shall operate EVMs within TI's recommended specifications and environmental considerations per the user's guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, user should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the applicable EVM user's guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using EVMs' schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of, or in connection with, any handling and/or use of EVMs. User's indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user's product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

RADIO FREQUENCY REGULATORY COMPLIANCE INFORMATION FOR EVALUATION MODULES

Texas Instruments Incorporated (TI) evaluation boards, kits, and/or modules (EVMs) and/or accompanying hardware that is marketed, sold, or loaned to users may or may not be subject to radio frequency regulations in specific countries.

General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

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.

U.S. Federal Communications Commission Compliance

For EVMs Annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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.

http://www.tij.co.jp

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In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

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