Using the UCC28911EVM-718

User's Guide

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Using the UCC28911EVM-718 7.5W Universal Off-Line Flyback Converter with Primary-Side Regulation

1 Introduction

The UCC28911EVM-718 evaluation module is an offline flyback power supply that provides isolated output voltage and current regulation without the use of an optocoupler. The input accepts a voltage range of 85 V_{AC} to 265 V_{AC}, 47 Hz to 64 Hz.

2 Description

The evaluation module uses the UCC28911 CV/CC PWM HV Switcher. This device integrates a 700-V power MOSFET and controller that processes operating information from an auxiliary flyback winding and from the power MOSFET to provide precise output voltage and current control. Control algorithms in the UCC28911 allow operating efficiencies to meet or exceed applicable standards. Discontinuous Conduction Mode (DCM) with valley switching is used to reduce switching losses. A combination of switching frequency and peak-primary current amplitude modulation is used to keep conversion efficiency high across the full load and input voltage range. Figure 1 below details the output V-I characteristic.

Low-system parts count and built-in advanced protection features result in a cost-effective solution that meets stringent world-wide energy efficiency requirements.

This user's guide provides the schematic, component list, assembly drawing, art work, and test set up necessary to evaluate the UCC28911 in a typical off-line converter application.

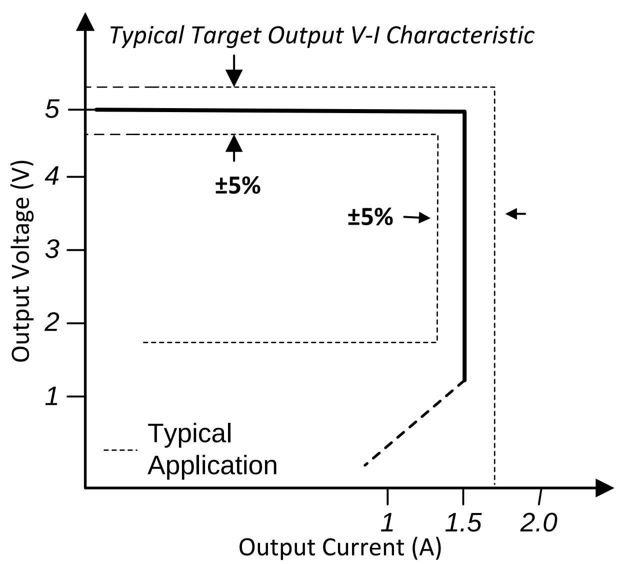

Figure 1. Output Voltage as a Function of Output Load

2.1 Applications

The UCC28911 is suited for use in isolated off-line systems requiring high efficiency and advanced fault protection features including:

- USB Compliant Adapters for Cell Phones, Tablets and Cameras
- 7-W to 10-W AC-to-DC Power Supplies

2.2 Features

The UCC28911EVM-718 features include:

- Isolated 7.5-W, 5-V Output
- Universal Off-Line Input Voltage Range
- Meets USB Specification 1.1
- Multiple Operating Modes and Valley Switching (for optimum efficiency over entire operating range)
- Primary-Side Control Eliminates Need for Optocoupler
- Output Over-Voltage Protection
- Input Under-Voltage Protection
- Primary Over-Current protection
- Thermal Shutdown
- Controlled Start Up and Restart After Fault Protection

CAUTION

High voltage levels are present on the evaluation module when energized. Proper precautions must be taken when working with the EVM. The large bulk capacitors, C1 and C2, and the output capacitors, C7 and C8, 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. UCC28911EVM-718 Electrical Performance Specifications

PARAMETER		TEST CONDITIONS	Min	NOM	MAX	UNITS
Input Characteristics						
V_{IN}	Input voltage		85	115/230	265	V
f_{LINE}	Frequency		47	50/60	64	Hz
P_{NL}	No-load power	V_{IN} = V_{NOM} I_{OUT} = 0 A		15	20	mW
$V_{IN(uvlo)}$	Brownout voltage	I_{OUT} = I_{NOM}		70		V
V_{INOV}	Brownout recovery voltage			80		V
I_{IN}	Input current	V_{IN} = V_{MIN} I_{OUT} = $I_{OUT(max)}$		0.3		A
Output Characteristics						
V_{OUT}	Output voltage	V_{IN} = V_{MIN} to V_{MAX} I_{OUT} = 0 to I_{NOM}	4.75	5	5.25	V
$I_{OUT(max)}$	Maximum output current	V_{IN} = V_{MIN} to V_{MAX}	1.425	1.5	1.575	A
$I_{OUT(min)}$	Minimum output current	V_{IN} = V_{MIN} to V_{MAX}		0		A
ΔV_{OUT}	Output voltage ripple	V_{IN} = V_{MIN} to V_{MAX} I_{OUT} = 0 to I_{NOM}		150		mV
P_{OUT}	Output power	V_{IN} = V_{MIN} to V_{MAX}		7.5		W
System Characteristics						
η	Average efficiency	V_{IN} = V_{NOM} I_{OUT} = 25%, 50%,,75%,,100% of I_{OUT}		75%		
Mechanical						
W	Dimensions	Width		3.5		in
L		Length		5		in
H		Component Height		1		in

4 Schematic

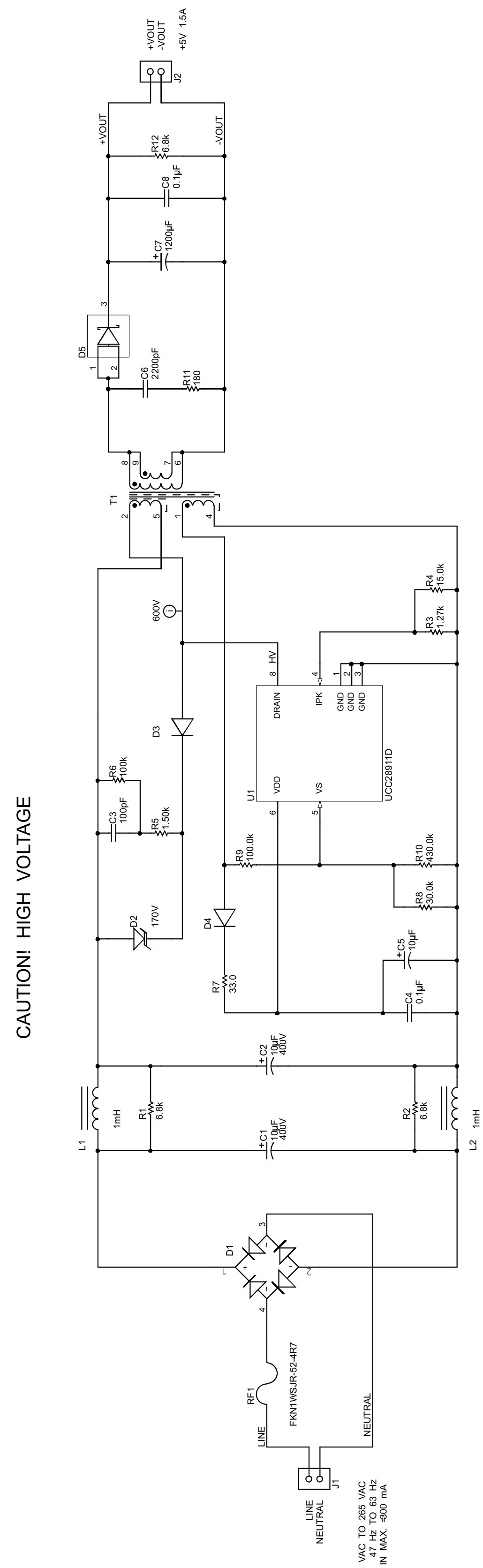

Figure 2. UCC28911EVM-718 Schematic

5 Circuit Description

A brief description of the circuit elements follows:

- Diode Bridge D1, input capacitors C1 and C2, transformer T1, UCC28911 switcher U1, Schottky rectifier D5 and capacitor C7 form the power stage of the converter.

NOTE: The UCC28911 U1 is also part of the power stage since the high-voltage MOSFET is internal to U1.

- Capacitor C8 filters the high-frequency noise directly across the electrolytic output capacitor.
- The input EMI filter is made up of C1 and C2 and differential mode inductors, L2 and L3.
- R1, R2 serve the dual function of dampening input filter oscillations and prevent a large voltage being developed across L2 and L3 in the event of an ESD pulse.
- Input-current protection is provided by fusible resistor, RF1.
- Resistors R5 and R6, capacitor C3, and diodes D2 and D3 make up the primary-side voltage clamp. The clamp prevents the drain voltage on U1 from exceeding its maximum rating. A secondary function of the clamp is to alleviate the EMI currents associated with the turnoff voltage of U1.
- Operating bias to the controller is provided by the auxiliary winding on T1, diode D4, resistor R7 and bulk capacitor C5.
- Capacitor C4 is a decoupling capacitor which should always be good quality low ESR/ESL type capacitors placed as close to the device pins as possible and returned directly to the device ground reference.
- Secondary-side snubber C6 and R11are used to reduce the effects switching noise of D5.
- Resistor R9 programs the start-up voltage threshold.
- Resistors R8 and R10 program the output voltage set point.
- Resistors R3 and R4 program the maximum output current.
- Resistor R12 is used to adjust the no-load output voltage.

6 EVM Test Set Up

Figure 3 shows the equipment set up when measuring the input power consumption during no load. 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 should be used. Figure 4 shows the basic test set up recommended to evaluate the UCC28911EVM-718 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.

6.1 Test Equipment

See Figure 3 and Figure 4 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 15 W and connected as shown in Figure 3 and Figure 4. For accurate efficiency calculations, a power meter 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.

NOTE: Connecting the voltage terminals directly to the EVM results in a small current error. This is very significant when measuring no load power.

Load: For the output load, a programmable electronic load set to constant current mode and capable of sinking 0 to 1.5 A_{DC} at 10 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 and Figure 4. 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 (PM1) shall be 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. To measure the intermittent bursts of current and power drawn from the line during no-load operation, the WT210 should be set to integrate.

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.

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.

6.2 Recommended Test Set Up for Operation Without a Load

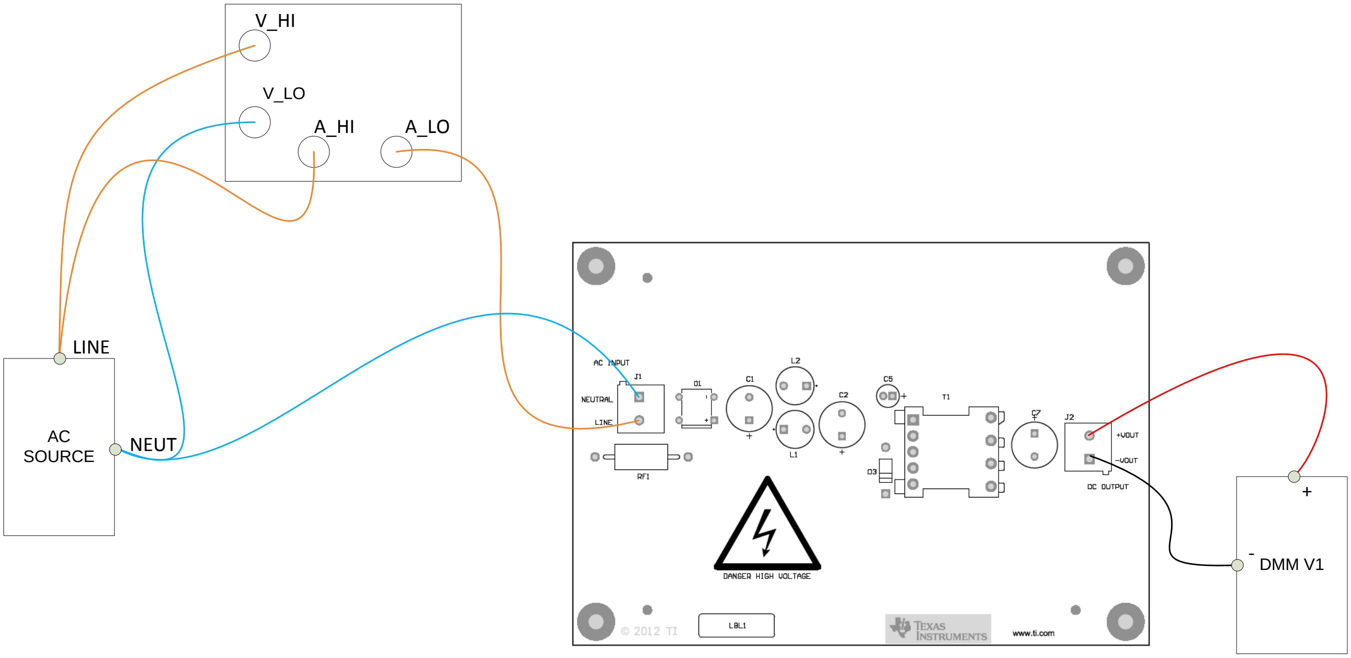

Figure 3. UCC28911EVM-718 Recommended Test Set Up without a Load

6.3 Recommended Test Set Up for Operation With a Load

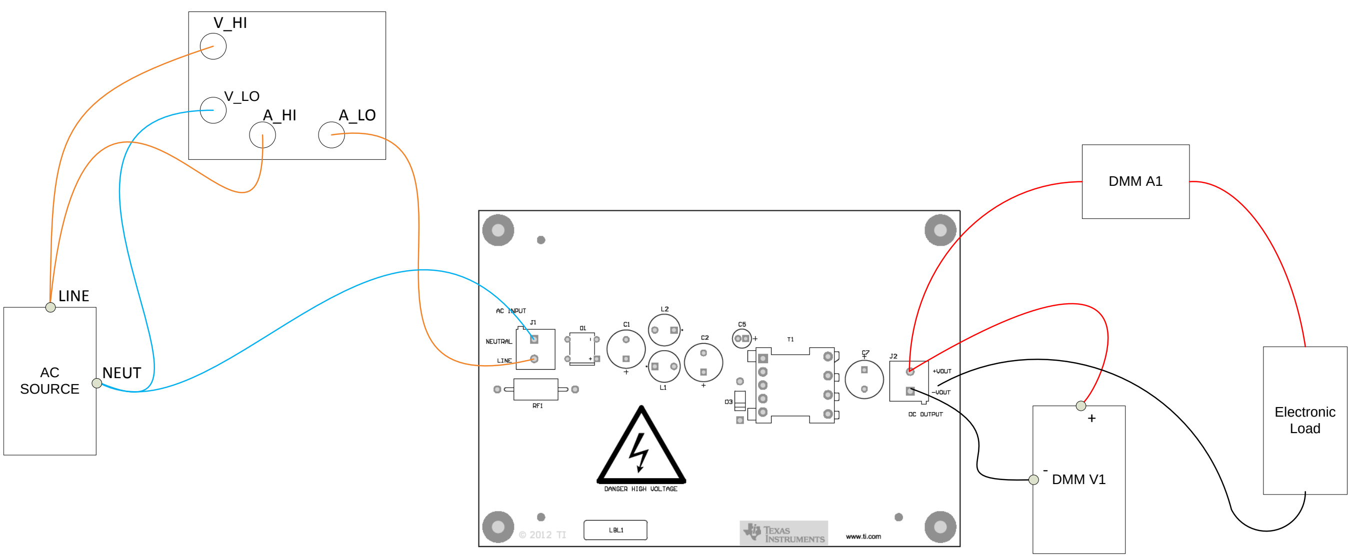

Figure 4. UCC28911EVM-718 Recommended Test Set Up With a Load

7 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.

7.1 Applying Power to the EVM

1. Set up the EVM as shown in Section 6 of this user's guide.
   (a) If no-load input power measurements are to be made, set the power analyzer to long averaging or integrating power measurement mode.
   (b) For operation with a load, as shown in Figure 4, set the electronic load to constant resistance mode.
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.

7.2 No-Load Power Consumption

1. Use the test set up shown in Figure 3.
   (a) Set the power analyzer to integrating average power mode.
   (b) Set the current measurement scale to 0.25 A.
   (c) Set the voltage range to 300 V.
   (d) Set the measurement mode to RMS.
2. Apply power to the EVM per Section 7.1.
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.

7.3 Output Voltage Regulation and Efficiency

1. For load regulation:
   (a) Use the test set up shown in Figure 4.
   (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 7.1.
   (d) Vary the load current from 0 A up to 1.5 A, as measured on DMM A1.
   (e) Observe that the output voltage on DMM V1 remains between 4.75 V and 5.25 V from no load up to 1.5 A and thereafter the current remains between 1.425 A and 1.575 A until the output voltage drops to 2 V or lower. See Figure 1 for details.
2. For line regulation:
   (a) Set the load to sink 1.5 A.
   (b) Vary the AC source from 85 V_{AC} to 265 V_{AC}.
   (c) Observe that the output voltage on DMM V1 remains between 4.75 V and 5.25 V.
3. Make sure the input power is off and the bulk capacitor and output capacitors are completely discharged before handling the EVM.

7.4 Output Voltage Ripple

1. For output ripple measurements, solder a 0.1-µF, 50-V ceramic capacitor and 4.7-µF, 35-V tantalum capacitor on a BNC adapter as shown in Figure 5 below. Connect the red test lead to the V_{OUT} output and the black test lead to the $–V_{OUT}$ on the EVM.
2. Connect the other end of the BNC cable to the oscilloscope and monitor the output ripple on the oscilloscope.
3. Apply power to the EVM per Section 7.1.

Figure 5. Typical Example of Tip Measurement Technique

7.5 Equipment Shutdown

1. Ensure the load is at maximum; this quickly discharges the output capacitors.
2. Turn off the AC source.
3. Make sure the bulk capacitors, C1, C2 and output capacitor, C7 are completely discharged before handling the EVM.

8 Performance Data and Typical Characteristic Curves

Figure 6 through Figure 14 present typical performance curves for the UCC28911EVM-718.

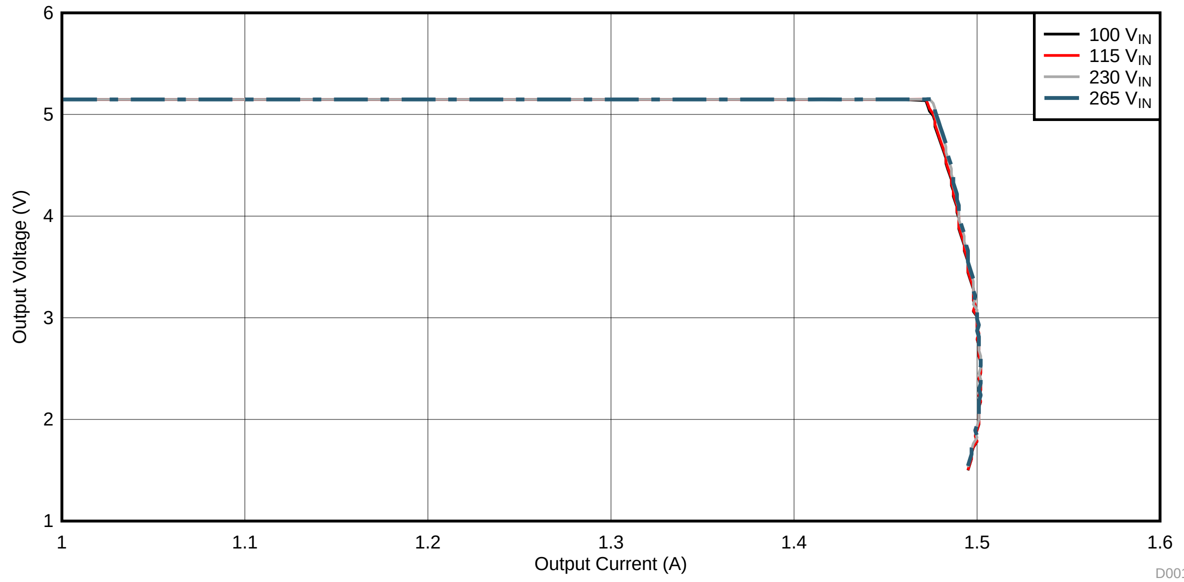

Figure 6. Typical V-I Characteristic

Table 2. Average and 10% Load Efficiency

V_{IN} (V)	f (Hz)	P_{IN} (W)	I_{OUT} (A)	V_{OUT} (V)	P_{OUT} (W)	Eff (%)	Avg Eff (%)
115	60	10.27	1.497	5.131	7.68	74.79	75.48
		7.654	1.122	5.123	5.75	75.10	
		5.047	0.747	5.118	3.82	75.75	
		2.495	0.372	5.115	1.90	76.26	
		1.042	0.148	5.119	0.76	72.71	
230	50	10.02	1.493	5.148	7.69	76.71	76.32
		7.476	1.119	5.133	5.74	76.83	
		4.964	0.744	5.122	3.81	76.77	
		2.527	0.370	5.120	1.89	74.97	
		1.052	0.145	5.117	0.74	70.53	

Table 3. No-Load Power Consumption

V_{IN} (V)	f (Hz)	P_{IN} (mW)	V_{OUT} (V)
115	60	11.4	5.21
230	50	13.5	5.21

Table 4. Typical V-I Test Data

100 V_{AC}		115 V_{AC}		230 V_{AC}		265 V_{AC}	
I_{OUT} (A)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} (V)
1.387	5.147	1.387	5.148	1.387	5.148	1.387	5.148
1.401	5.147	1.401	5.148	1.401	5.149	1.401	5.148
1.415	5.147	1.416	5.148	1.416	5.149	1.416	5.149
1.429	5.147	1.43	5.149	1.431	5.149	1.43	5.148
1.444	5.147	1.445	5.149	1.445	5.149	1.445	5.149
1.46	5.147	1.46	5.149	1.461	5.149	1.461	5.149
1.472	5.136	1.476	5.15	1.476	5.149	1.476	5.149
1.473	5.086	1.48	5.108	1.492	5.15	1.492	5.15
1.474	5.033	1.481	5.058	1.508	5.15	1.508	5.15
1.476	4.987	1.482	5.004	1.513	5.11	1.525	5.15
1.477	4.933	1.483	4.952	1.514	5.057	1.524	5.089
1.477	4.88	1.484	4.902	1.515	5.004	1.525	5.037
1.478	4.829	1.485	4.85	1.516	4.951	1.526	4.983
1.479	4.777	1.485	4.796	1.517	4.899	1.527	4.93
1.48	4.726	1.486	4.743	1.518	4.843	1.527	4.874
1.481	4.673	1.487	4.691	1.519	4.791	1.528	4.821
1.482	4.621	1.488	4.64	1.519	4.736	1.529	4.766
1.483	4.568	1.489	4.585	1.52	4.681	1.53	4.712
1.483	4.516	1.49	4.532	1.521	4.629	1.531	4.659
1.484	4.461	1.49	4.479	1.521	4.574	1.531	4.603
1.485	4.409	1.491	4.426	1.522	4.519	1.532	4.547
1.486	4.357	1.491	4.373	1.523	4.465	1.533	4.494
1.486	4.302	1.492	4.32	1.523	4.41	1.533	4.438
1.487	4.25	1.493	4.267	1.524	4.355	1.534	4.384
1.487	4.195	1.494	4.214	1.524	4.3	1.534	4.328
1.488	4.143	1.494	4.158	1.525	4.244	1.535	4.273
1.489	4.091	1.495	4.106	1.525	4.189	1.536	4.217
1.489	4.036	1.495	4.051	1.526	4.136	1.536	4.162
1.49	3.982	1.496	3.999	1.526	4.08	1.537	4.106
1.49	3.928	1.497	3.944	1.527	4.022	1.537	4.051
1.49	3.874	1.497	3.89	1.527	3.969	1.537	3.993
1.491	3.82	1.497	3.835	1.528	3.914	1.538	3.939
1.492	3.767	1.497	3.781	1.528	3.859	1.539	3.884
1.493	3.713	1.499	3.727	1.529	3.803	1.539	3.827
1.493	3.659	1.499	3.672	1.53	3.747	1.54	3.771
1.494	3.605	1.499	3.618	1.53	3.692	1.541	3.718
1.495	3.551	1.5	3.563	1.531	3.636	1.541	3.661
1.495	3.497	1.501	3.51	1.531	3.581	1.542	3.606
1.495	3.443	1.502	3.455	1.532	3.525	1.542	3.549
1.496	3.388	1.502	3.401	1.532	3.469	1.543	3.493
1.497	3.334	1.502	3.347	1.533	3.413	1.543	3.436
1.498	3.281	1.503	3.292	1.533	3.358	1.543	3.381
1.498	3.225	1.503	3.237	1.534	3.302	1.544	3.325
1.498	3.171	1.504	3.181	1.534	3.246	1.544	3.267
1.499	3.117	1.504	3.127	1.534	3.188	1.546	3.213
1.498	3.062	1.504	3.072	1.535	3.133	1.546	3.157
1.5	3.011	1.505	3.016	1.535	3.077	1.546	3.1

Table 4. Typical V-I Test Data (continued)

100 V_{AC}		115 V_{AC}		230 V_{AC}		265 V_{AC}	
I_{OUT} (A)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} (V)	I_{OUT} (A)	V_{OUT} (V)
1.5	2.951	1.505	2.961	1.535	3.021	1.547	3.042
1.5	2.896	1.505	2.906	1.536	2.964	1.547	2.986
1.501	2.841	1.505	2.85	1.536	2.907	1.546	2.929
1.5	2.786	1.505	2.794	1.536	2.851	1.547	2.873
1.501	2.729	1.506	2.74	1.536	2.794	1.548	2.815
1.501	2.675	1.505	2.683	1.536	2.738	1.548	2.758
1.501	2.621	1.506	2.626	1.537	2.682	1.547	2.7
1.502	2.565	1.506	2.572	1.536	2.624	1.547	2.642
1.502	2.509	1.506	2.516	1.537	2.568	1.547	2.585
1.502	2.453	1.506	2.46	1.537	2.51	1.547	2.527
1.501	2.397	1.506	2.405	1.537	2.453	1.547	2.47
1.502	2.341	1.506	2.349	1.537	2.396	1.547	2.412
1.502	2.286	1.506	2.292	1.537	2.339	1.547	2.355
1.501	2.23	1.506	2.237	1.536	2.281	1.547	2.296
1.502	2.174	1.505	2.181	1.536	2.224	1.546	2.239
1.501	2.119	1.505	2.124	1.536	2.167	1.546	2.181
1.501	2.062	1.505	2.067	1.535	2.11	1.546	2.124
1.501	2.006	1.505	2.011	1.535	2.052	1.545	2.066
1.501	1.949	1.504	1.956	1.535	1.994	1.546	2.008
1.5	1.894	1.504	1.898	1.534	1.936	1.545	1.95
1.499	1.838	1.503	1.841	1.533	1.879	1.544	1.892
1.5	1.782	1.503	1.786	1.533	1.821	1.544	1.834
1.498	1.725	1.502	1.73	1.532	1.764	1.543	1.776
1.497	1.668	1.501	1.673	1.531	1.705	1.542	1.718
1.497	1.612	1.501	1.616	1.531	1.648	1.541	1.659
1.496	1.555	1.5	1.559	1.53	1.591	1.54	1.601
1.495	1.499	1.498	1.503	1.528	1.532	1.539	1.543

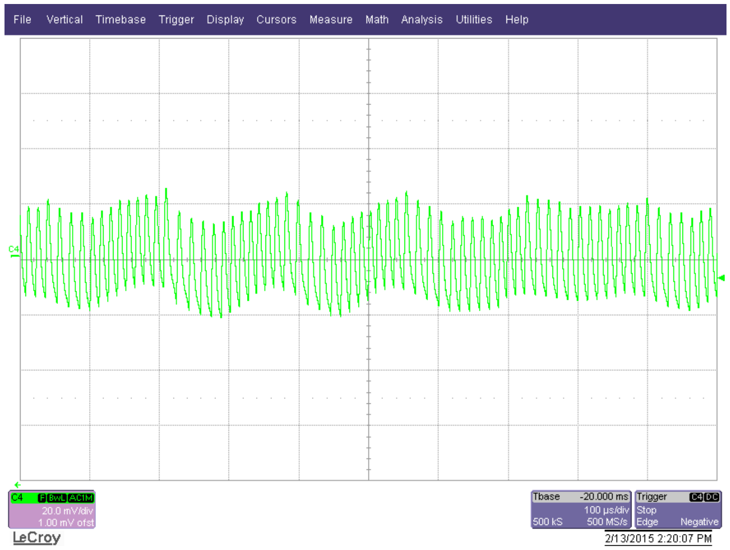

Figure 7. Ripple with 5 V, 1.5 A Out, 115 V_{AC} in 20 mV/div 100 µs/div

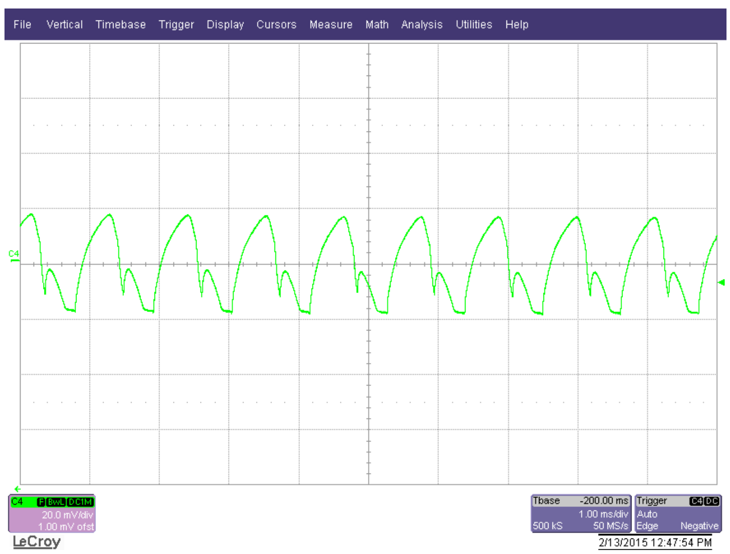

Figure 8. Ripple with 5 V, 1 A Out, 115 V_{AC} in 20 mV/div 100 µs/div

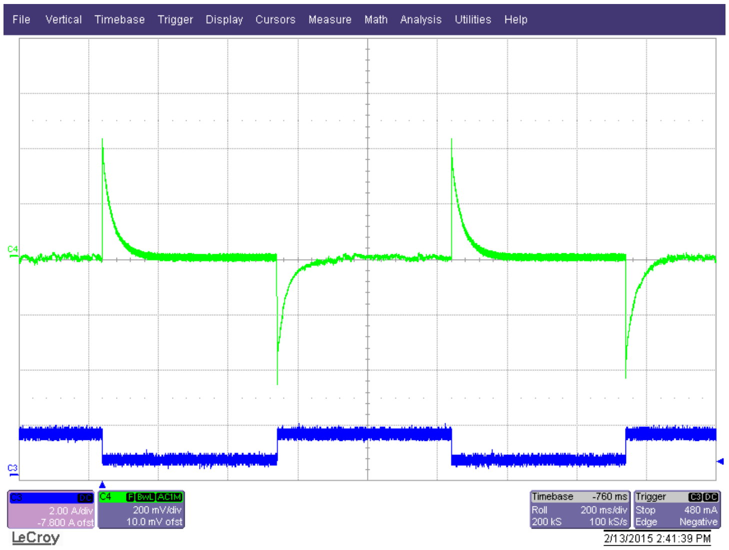

Figure 9. Step Load 1.5 A to 0.5 A, C4 200 mV/div, C3 2 A/div 200 ms/div

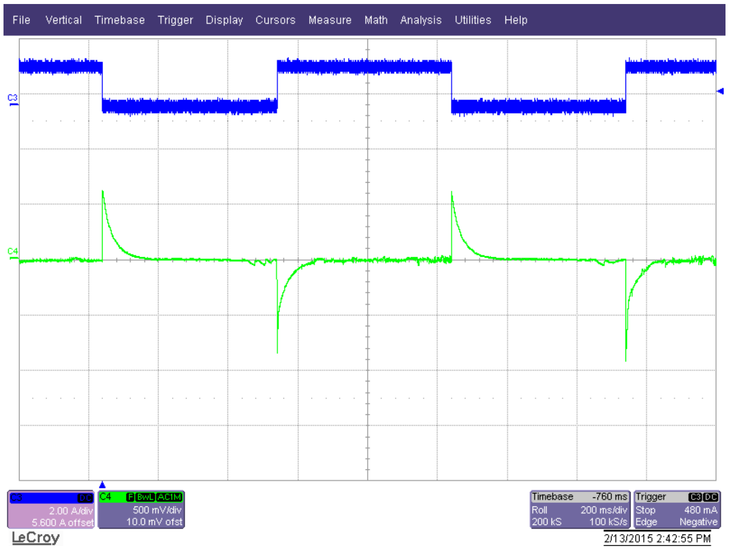

Figure 10. Step Load 1.5 A to 0 A, C4 500 mV/div, C3 2 A/div 200 ms/div

Figure 11. Output Voltage Start 115 V_{AC}, 1.5-A load, 1 V/div 50 mS/div

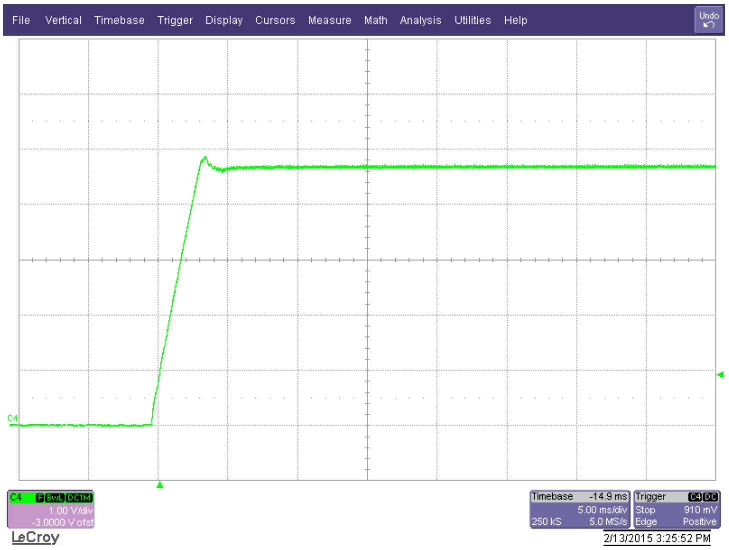

Figure 12. Output Voltage Start, 230 V_{AC}, 1.5-A load, 1 V/div 50 ms/div

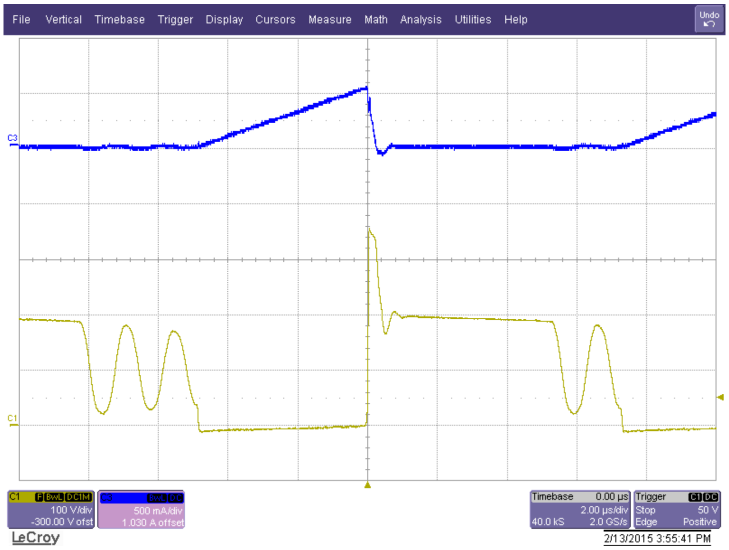

Figure 13. Primary-Side Switching Waveforms 85 V_{AC} (1.5-A Load Drain Voltage, CH 1 100 V/div and Current, CH3 0.5 A/div 2 µs/div)

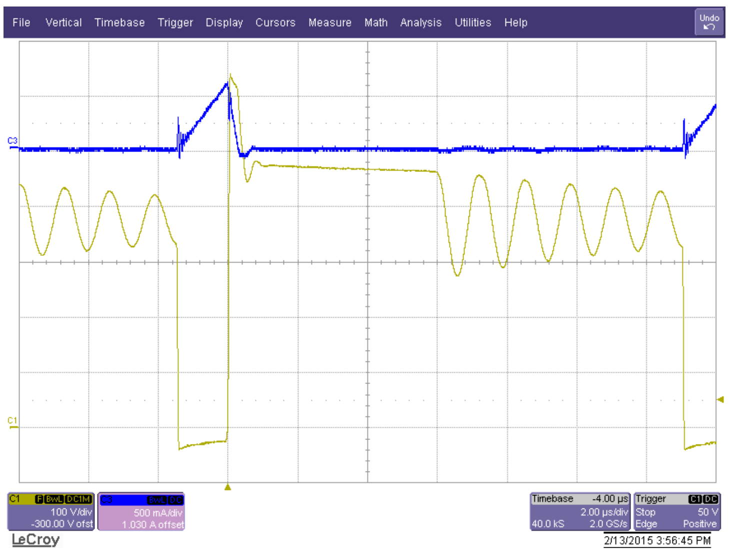

Figure 14. Primary-Side Switching Waveforms 265 V_{AC} (1.5-A Load Drain Voltage, CH 1 100 /div and Current,CH4 0.5 A/div 2 µs/div)

9 EVM Assembly Drawing and Layout

The following figures show the design of the UCC28911EVM-718 printed circuit board.

Figure 15. UCC28911EVM-718 (top view)

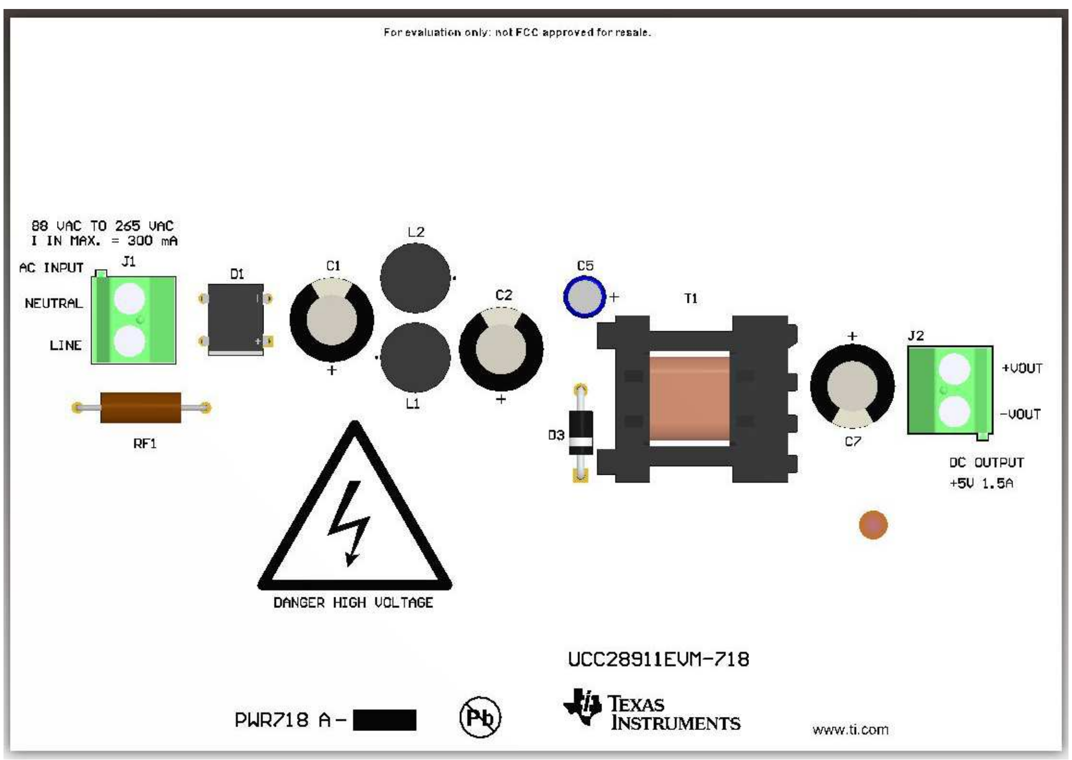

Figure 16. PCB (top)

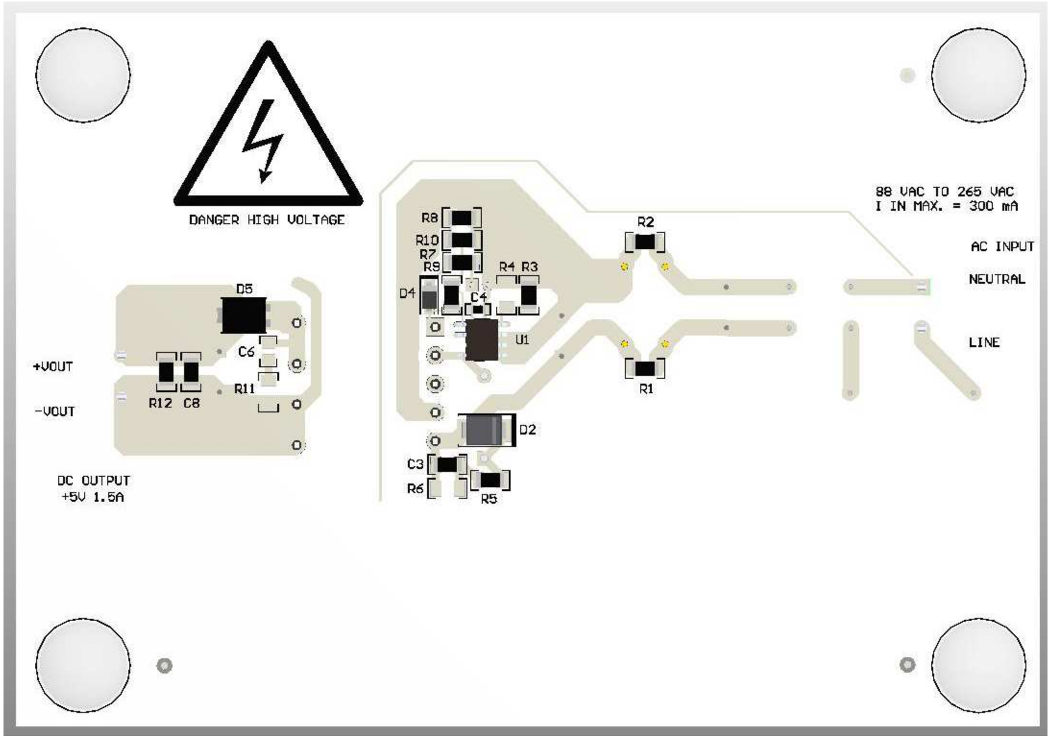

Figure 17. PCB (bottom)

10 List of Materials

10.1 Flyback Transformer

10.1.1 Material List

- EE16/8/5 ferrite core pair.
- EE16/8/5 9-pin through hole, horizontal bobbin.
- 0.18-mm OD enamel copper wire.
- 0.35-mm Furukawa TEX-E triple insulated copper wire or equivalent.
- 10.6-mm wide mylar tape.

10.1.2 Winding Table

Table 5. Winding Table

WINDING	START	FINISH	WIRE	WINDING DIRECTION	TURNS	COMMENTS
WDG 1	2		0.18-mm OD	CW	50	WDG 1 is full single layer. Finish of WDG1 is lead out towards pin 2 and becomes start of WDG2.
			Tape	CW	2	
WDG 2		5	0.18-mm OD	CW	49	WDG 1 is full single layer. Finish of WDG1 is lead out towards pin 2 and becomes start of WDG2.
			10.6-mm tape	CW	2	
WDG 3	4	x	0.18-mm OD	CW	25	WDG 3 wound bifilar. single layer
			10.6-mm tape	CW	2	
WDG 4	x	4	0.18-mm OD	CW	25	WDG 4 wound bifilar, single layer
			10.6-mm tape	CW	2	
WDG 5	1	4	0.18-mm OD	CW	21	WDG 5 wound bifilar. single layer
			10.6-mm tape	CW	2	
WDG 6	3	NC	0.18-mm OD	CW	28	WDG 6 wound bifilar, single layer
			10.6-mm tape	CW	2	
WDG 7	6	8	0.35-mm TEX	CCW	6	WDG 7 wound bifilar
			10.6-mm tape	CCW	2	
WDG 8	7	9	0.35-mm TEX	CCW	6	WDG 8 wound bifilar
			10.6-mm tape	CCW	2	

10.1.3 Transformer Cross Section

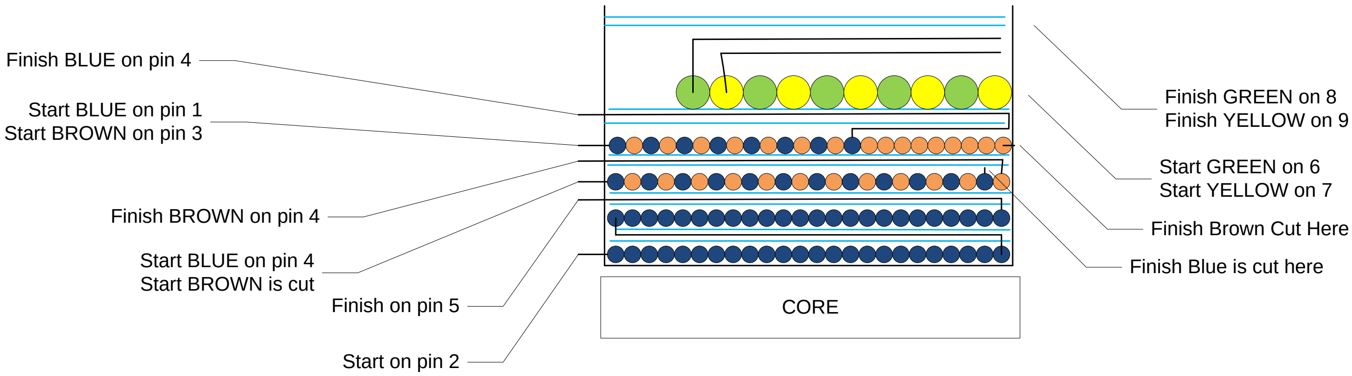

Figure 18. Transformer Cross Section

10.1.4 Electrical Specifications

Table 6. Electrical Specifications

PARAMETER	PINS	TEST CONDITIONS	VALUE
DC resistance	1 to 4		0.685 Ω, 10%
DC resistance	2 to 5		2.680 Ω, 10%
DC resistance	6 to 9	Tie 6 to 7 and 8 to 9	0.021 Ω, 20%
Inductance	2 to 5	10 kHz,100 mV	825 µH, 10%
Dielectric	1 to 9	4500 V_{AC}, 1 s	No breakdown
Dielectric	1 to 5	625 V_{AC}, 1 s	No breakdown
Turns ratio	(2 to 5) and (1 to 4)		4.71:1, 1%
Turns ratio	(2 to 5) and (9 to 6)	Tie 6 to 7 and 8 to 9	16.5:1, 1%

10.1.5 Part View

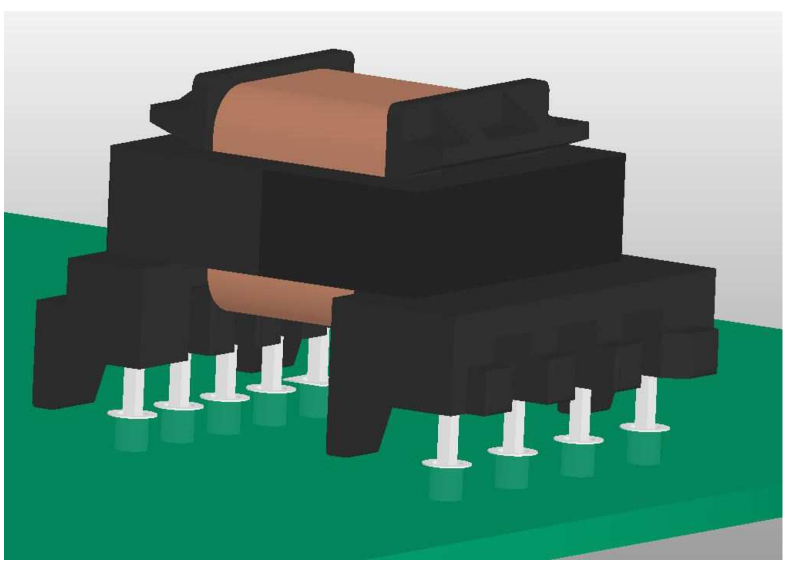

Figure 19. Part View

11 Detailed List of Materials

Table 7. UCC28911EVM-718 List of Materials

QTY	DES	DESCRIPTION	MANUFACTURER	PART NUMBER
2	C1, C2	Capacitor, aluminum, 10 µF, 400 V, ±20%, 2.864788 Ω, TH	Panasonic	EEUED2G100
1	C3	Capacitor, ceramic, 100 pF, 500 V, ±5%, C0G/NP0, 1206	Kemet	C1206C101JCGACTU
1	C4	Capacitor, ceramic, 0.1 µF, 25 V, ±10%, X5R, 0603	AVX	06033D104KAT2A
1	C5	Capacitor, aluminum, 10 µF, 35 V, ±20%, TH	Nichicon	UVR1V100MDD1TA
0	C6	Capacitor, ceramic, 2200 pF, 50 V, ±10%, X7R, 0805	AVX	08055C222KAT2A
1	C7	Capacitor, aluminum, 1200 µF, 10 V, ±20%, TH	Panasonic	EEUFM1A122
1	C8	Capacitor, ceramic, 0.1 µF, 50 V, ±5%, X7R, 1206	AVX	12065C104JAT2A
1	D1	Diode, switching-bridge, 600 V, 1 A, TH	Diodes Inc.	DF06M
1	D2	Diode, TVS, Uni, 170 V, 600 W, SMB	ST Microelectronics	SMBJ170A-TR
1	D3	Diode, switching, 600 V, 1 A, TH	Vishay-Semiconductor	1N4937-E3
1	D4	Diode, switching, 200 V, 0.2 A, SOD-123	Diodes Inc.	BAV21W-7-F
1	D5	Diode, Schottky, 40 V, 10 A, PowerDI5	Diodes Inc.	PDS1040L-13
4	H109, H110, H111, H112	Bumpon, hemisphere, 0.44 X 0.20, clear	3M	SJ-5303 (CLEAR)
2	J1, J2	Conn term block, 2 position, 5.08 mm, TH	Phoenix Contact	1715721
2	L1, L2	Inductor, shielded drum core, metal composite, 1 mH, 0.5 A, 1.7 Ω, TH	Wurth Elektronik	768772102
3	R1, R2, R12	Resistor, 6.8 kΩ, 5%, 0.25 W, 1206	Vishay-Dale	CRCW12066K80JNEA
1	R3	Resistor, 1.27 kΩ, 1%, 0.25 W, 1206	Vishay-Dale	CRCW12061K27FKEA
1	R5	Resistor, 1.50 kΩ, 1%, 0.25 W, 1206	Vishay-Dale	CRCW12061K50FKEA
1	R7	Resistor, 33.0 Ω, 1%, 0.25 W, 1206	Panasonic	ERJ-8ENF33R0V
1	R8	Resistor, 30.0 kΩ, 1%, 0.25 W, 1206	Panasonic	ERJ-8ENF3002V
1	R9	Resistor, 100.0 kΩ, 1%, 0.25 W, 1206	Vishay-Dale	CRCW1206100KFKEA
1	R10	Resistor, 430.0 kΩ, 1%, 0.25 W, 1206	Yageo America	RC1206FR-07430KL
1	RF1	Resistor, 4.7 Ω, 5%, 1 W, fusible, TH	Yageo America	FKN1WSJR-52-4R7
0	R4	Resistor, 15.0 kΩ, 1%, 0.25 W, 1206	Vishay-Dale	CRCW120615K0FKEA
0	R6	Resistor, 100 kΩ, 5%, 0.25 W, 1206	Vishay-Dale	CRCW1206100KJNEA
0	R11	Resistor, 180 Ω, 5%, 0.25 W, 1206	Vishay-Dale	CRCW1206180RJNEA
1	T1	Transformer, 825 µH	Wurth Elektronik eiSos	750315369
1	U1	High-Voltage Flyback Switcher with Primary-Side Regulation and Constant-Current Control, D0007A	Texas Instruments	UCC28911D
1	PCB	Printed Circuit Board	Any	PWR718

12 References

1. Datasheet, *UCC28910, UCC28911 High-Voltage Flyback Switcher with Constant-Current Control,* Texas Instruments Literature Number, SLUS769.

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      3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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

      FCC Interference Statement for Class A EVM devices

      NOTE: 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 his own expense.

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- *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.*

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3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-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.

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.

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.

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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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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