User Guide for

FEBFSL3276ALR_IO01U25A Evaluation Board

Integrated Controller FSL3276ALRN 0.25 W Auxiliary Power Supply

Featured Fairchild Product:

FSL3276ALRN

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"Worldwide Direct Support"

[Fairchild Semiconductor.com]

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This user guide supports the evaluation kit for the FSL3276ALRN. It should be used in conjunction with the FSL3276ALRN datasheet as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at www.fairchildsemi.com.

1. Introduction

This document is an engineering report describing measured performance of the FSL3276ALRN evaluation board.

1.1. General Description

The FSL3276ALRN is ideal to be configured as a non-isolated high voltage buck switch for low power applications. Its peak current is adjustable down to 70 mA which enables optimum inductor size selection. The modulation control is designed to reduce standby power to 25 mW at 230 V_{AC} input. Though the Pulse Width Modulator (PWM) and SenseFET are ideally integrated for high-performance offline buck, it can also be configured as a buck-boost or non-isolated flyback with minimal external components. This device integrates a high-voltage power regulator that enables operation without an auxiliary bias winding. An internal transconductance amplifier reduces external components for the feedback compensation circuit.

The integrated PWM controller includes: 10 V regulator for no external bias circuit, Under-Voltage Lockout (UVLO), Leading-Edge Blanking (LEB), an optimized gate turn-on / turn-off driver, EMI attenuator, Thermal Shutdown (TSD), temperature-compensated precision current sources for loop compensation, and fault-protection circuitry. Protections include: Overload Protection (OLP), Over-Voltage Protection (OVP), Open Feedback Loop Protection (OFLP), and Abnormal Over-Current Protection (AOCP). FSL3276ALRN offers good soft-start performance during startup.

The internal high-voltage startup switch and the Burst-Mode operation with very low operating current reduce the power loss in Standby Mode. As the result, it is possible to reach power loss of 120 mW below (including dummy load: 1 kΩ) without external bias when input voltage is 145 V_{AC}.

1.2. Features

- Built-in Avalanche-Rugged SenseFET: 650 V
- Fixed Operating Frequency: 50 kHz
- No-Load Power Consumption: <25 mW at 230 V_{AC} with External Bias; <120 mW at 230 V_{AC} without External Bias
- No Need for Auxiliary Bias Winding
- Frequency Modulation for Attenuating EMI
- Pulse-by-Pulse Current Limiting
- Ultra-Low Operating Current: 250 µA
- Built-in Soft-Start and Startup Circuit
- Adjustable Peak Current Limit
- Built-in Transconductance (Error) Amplifier
- Various Protections: Overload Protection (OLP), Over-Voltage Protection (OVP), Open Feedback Loop Protection (OFLP), AOCP (Abnormal Over-Current Protection), Thermal Shutdown (TSD)
- Fixed 650 ms Restart Time for Safe Auto-Restart Mode of All Protections

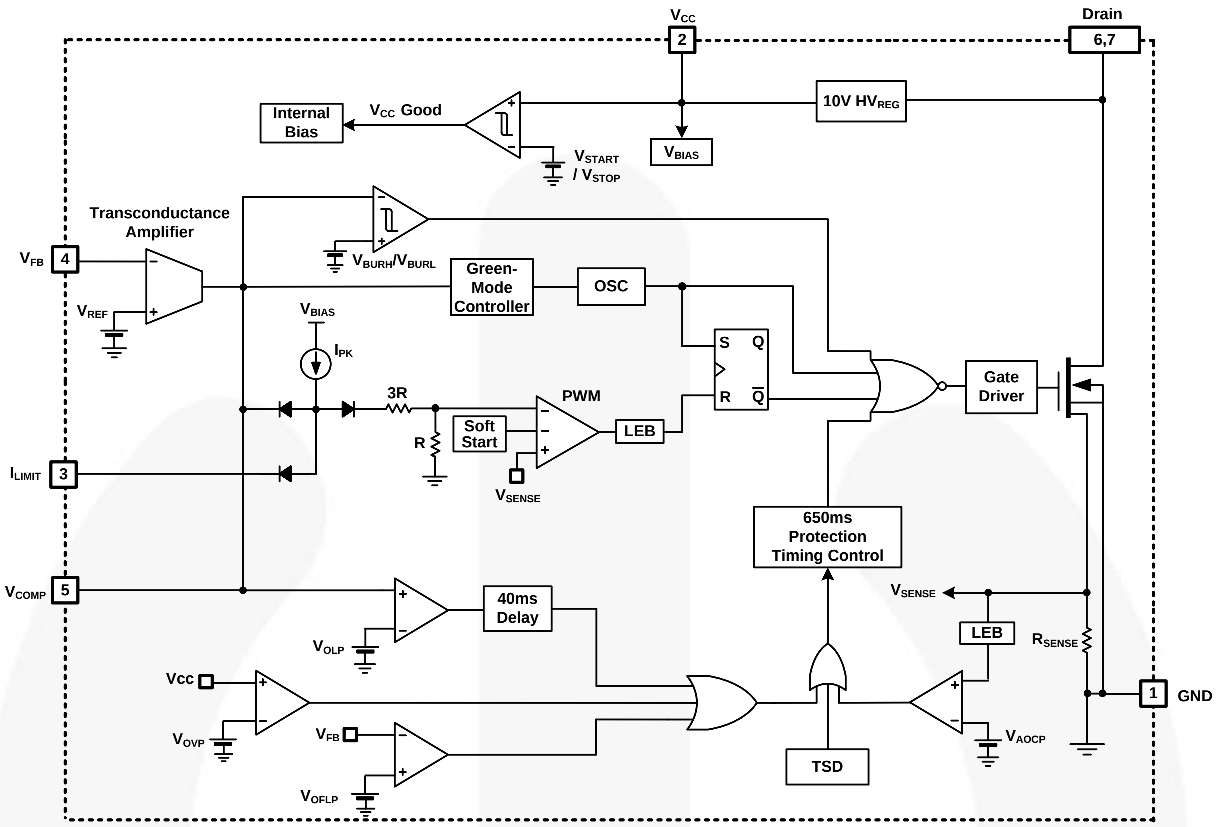

Figure 1. Internal Block Diagram

2. Specifications

Table 1. Evaluation Board Specifications

Fairchild Device	FSL3276ALRN
Input Voltage Range	85 ~ 145 V_{AC}
Frequency	60 Hz
Maximum Output Power	0.25 W
Output Full-Load Condition	5 V / 50 mA

3. Photographs

Figure 2. Top View (Dimension 18 x 18 [mm^2])

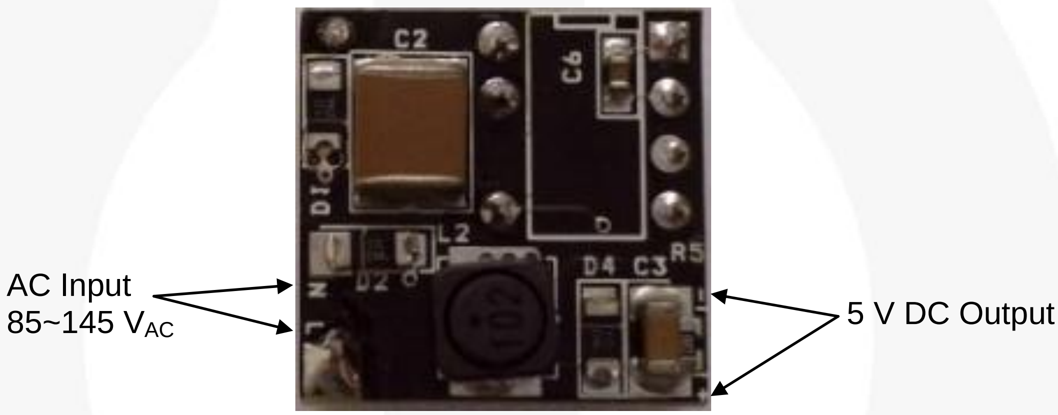

Figure 3. Bottom View (Dimension 18 x 18 [mm^2])

4. PCB Layout

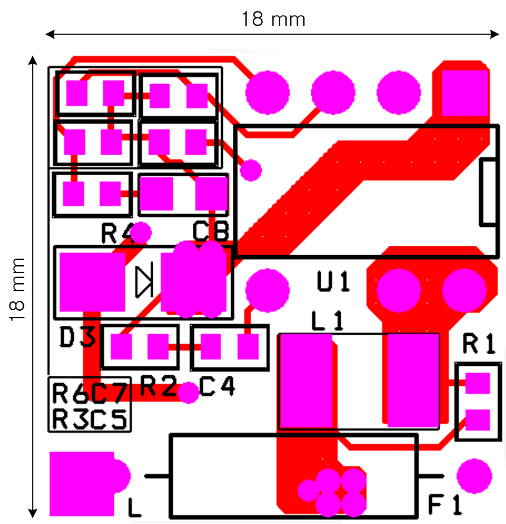

Figure 4. Top Overlay

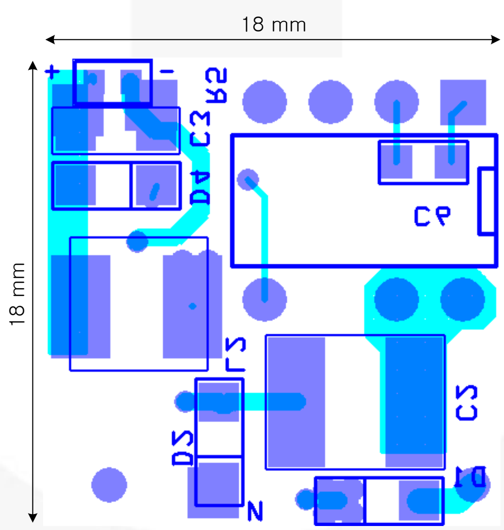

Figure 5. Bottom Overlay

5. Test Conditions

Evaluation Board #	FEBFSL3276ALRN
Test Date	JANUARY 8, 2016
Test Equipment	AC Source: 6800 Series Electronic Load: Fujitsu EML-05B & Actual Resistor Load Oscilloscope: LeCroy 104Xi-A Power Meter: Yokogawa PZ4000
Test Items	1. Startup Performance 2. Normal Operation 3. Voltage Stress of Drain and Freewheeling Diode 4. Output Ripple and Noise 5. Step Load Response 6. Output Line & Load Regulation 7. Temperature Measurement 8. Efficiency Test Result 9. Standby Power Consumption 10. Conducted EMI Measurement

6. Performance of Evaluation Board

6.1. Startup Performance

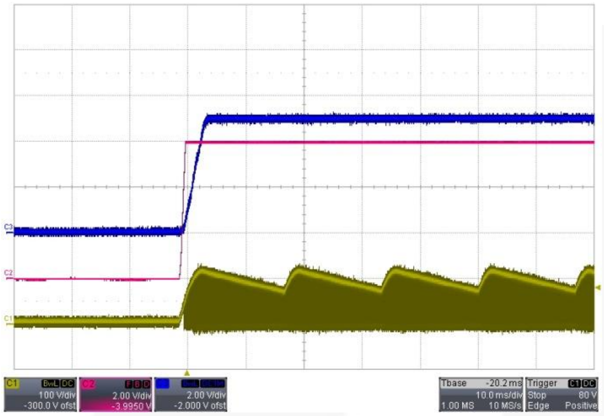

Figure 6. 85 V_{AC}, Full-Load Condition (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), Time: 10 ms/div)

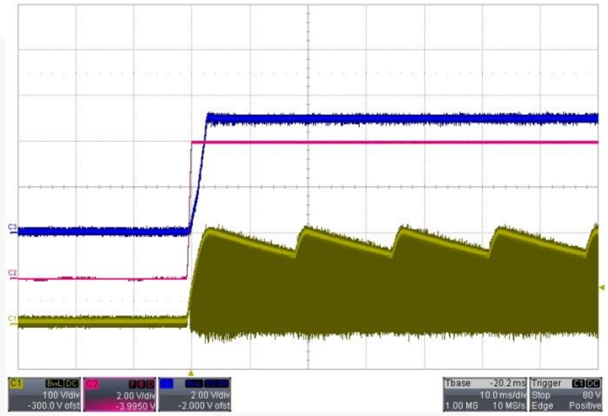

Figure 7. 145 V_{AC}, Full-Load Condition (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), Time: 10 ms/div)

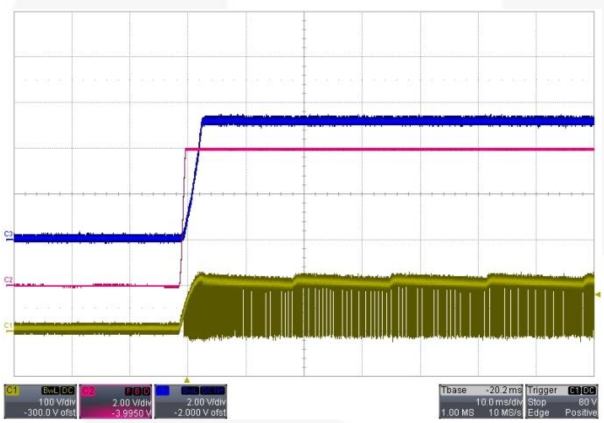

Figure 8. 85 V_{AC}, No-Load Condition (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), Time: 10 ms/div)

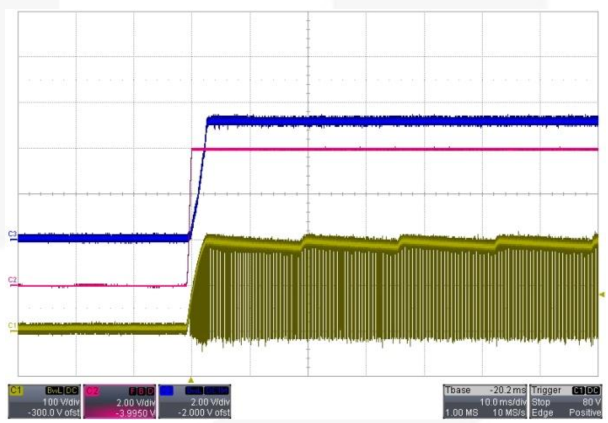

Figure 9. 145 V_{AC}, No-Load Condition (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), Time: 10 ms/div)

6.2. Normal Operation

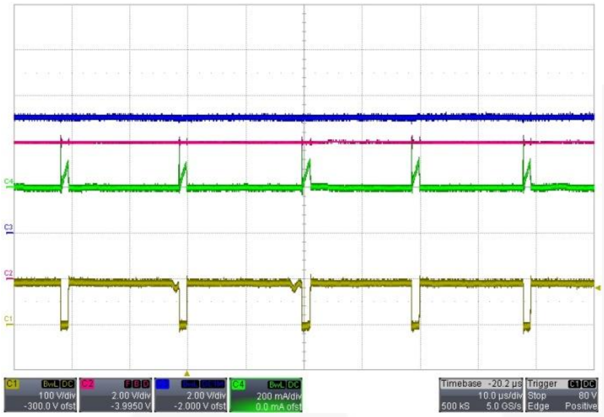

Figure 10. Full-Load Condition, 85 V_{AC}, (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), CH4: I_{DS} (200 mA/div), Time: 10 µs/div)

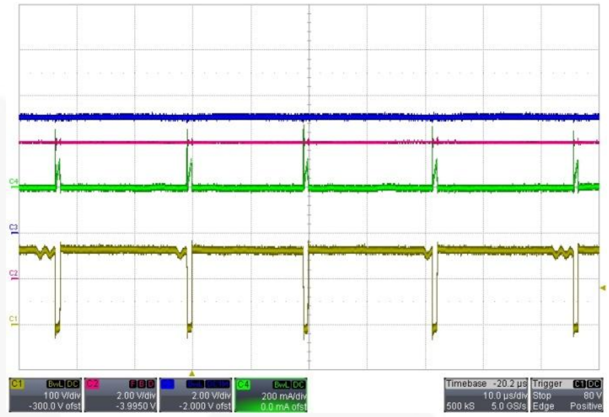

Figure 11. Full-Load Condition, 145 V_{AC}, (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), CH4: I_{DS} (200 mA/div), Time: 10 µs/div)

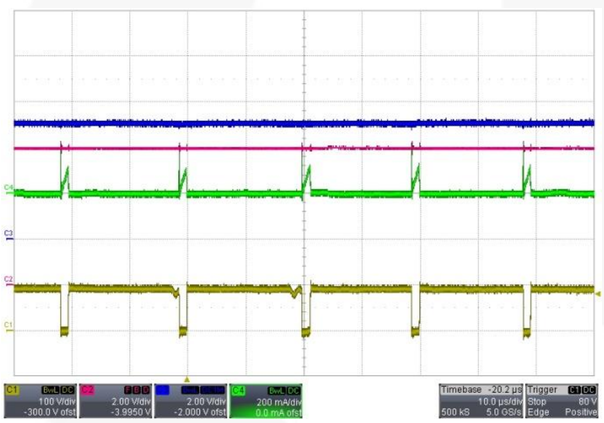

Figure 12. No-Load Condition, 85 V_{AC}, (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), CH4: I_{DS} (200 mA/div), Time: 10 µs/div)

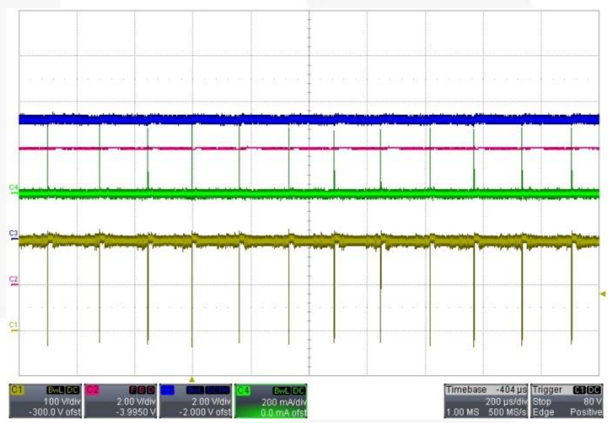

Figure 13. No-Load Condition, 145 V_{AC}, (CH1: V_{DS} (100 V/div), CH2: V_{CC} (2 V/div), CH3: 5 V_{OUT} (2 V/div), CH4: I_{DS} (200 mA/div), Time: 200 µs/div)

6.3. Voltage Stress of Drain and Freewheeling Diode

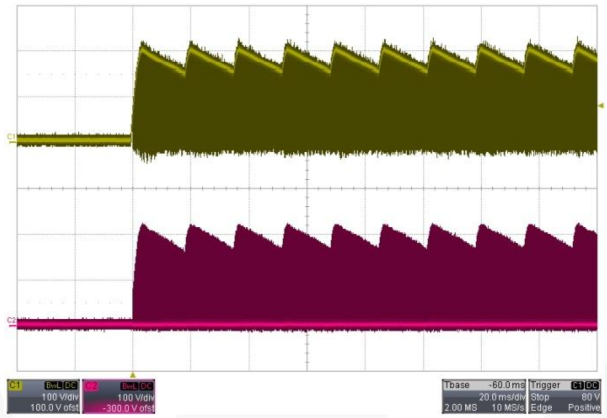

Figure 14. V_{DS}=213 V, V_{DIODE}=226 V, Startup Condition, Full-Load Condition, **145 V_{AC}, (CH1: V_{DS} (100 V/div), CH2: V_{DIODE} (100 V/div), Time: 20 ms/div)**

6.4. Output Ripple and Noise

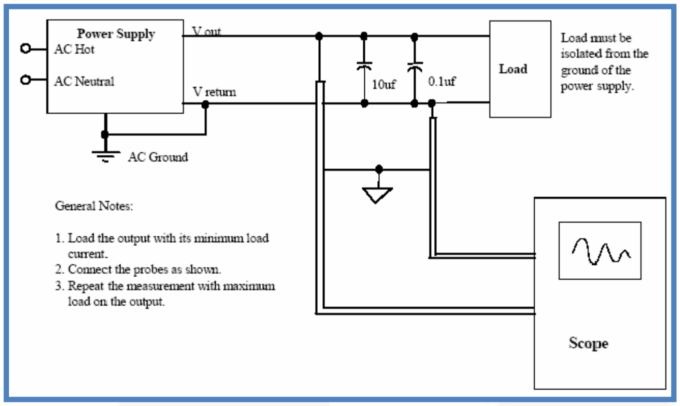

Figure 15. Recommended Test Setup

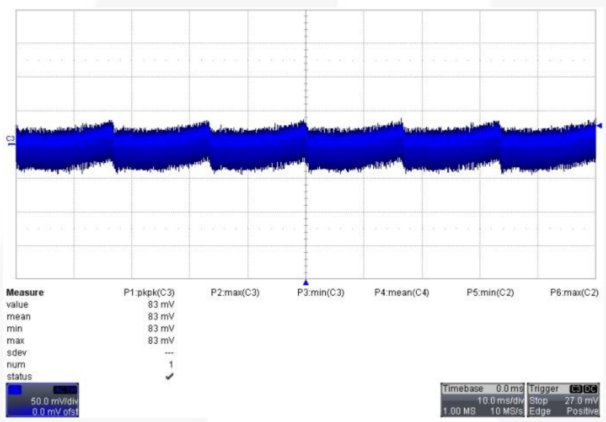

Figure 16. 5 V_{OUT_RIPPLE} = 83 mV, Output Voltage Ripple with 85 V_{AC} and Full-Load Condition, CH3: 5 V_{OUT} (50 mV/div), Time: 10 ms/div

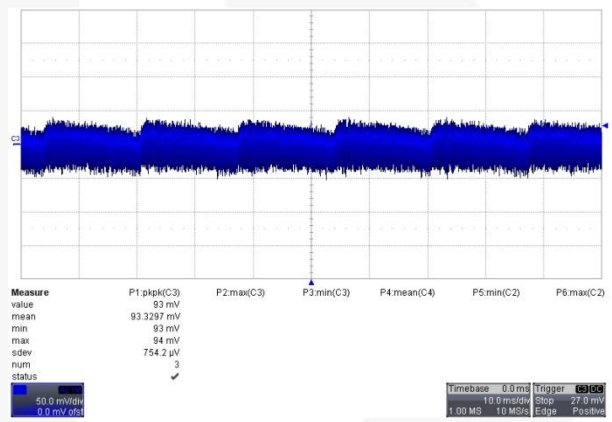

Figure 17. 5 V_{OUT_RIPPLE} = 94 mV, Output Voltage Ripple with 145 V_{AC} and Full-Load Condition, CH3: 5 V_{OUT} (50 mV/div), Time: 10 ms/div

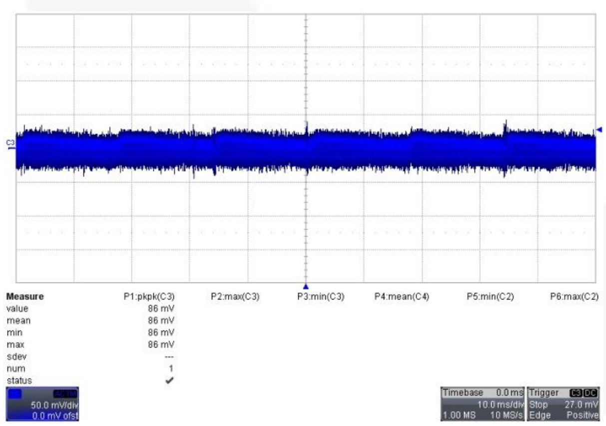

Figure 18. 5 V_{OUT_RIPPLE} = 86 mV, Output Voltage Ripple with 85 V_{AC} and Half-Load Condition, CH3: 5 V_{OUT} (50 mV/div), Time: 10 ms/div

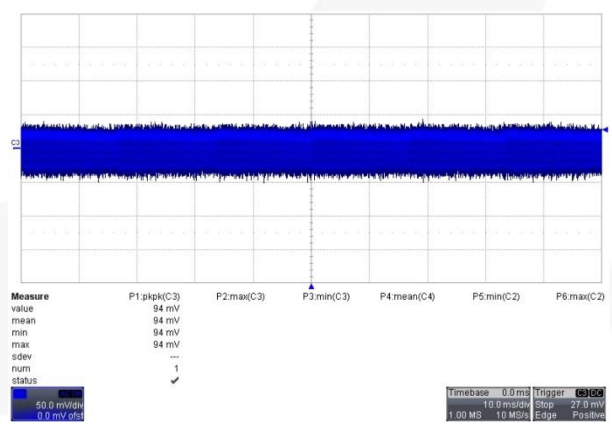

Figure 19. 5 V_{OUT_RIPPLE} = 94 mV, Output Voltage Ripple with 145 V_{AC} and Half-Load Condition, CH3: 5 V_{OUT} (50 mV/div), Time: 10 ms/div

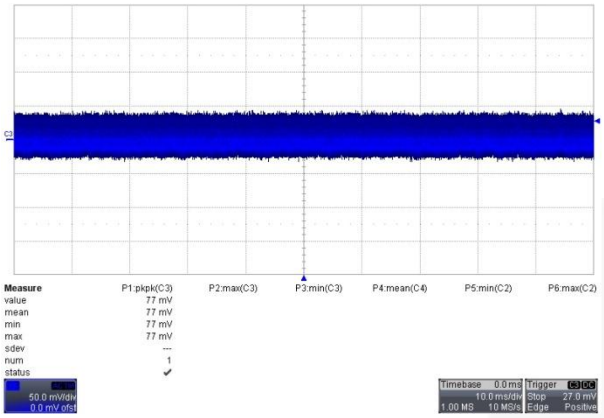

Figure 20. 5 V_{OUT_RIPPLE} = 77 mV, Output Voltage Ripple with 85 V_{AC} and No-Load Condition, CH3: 5 V_{OUT} (50 mV/div), Time: 10 ms/div

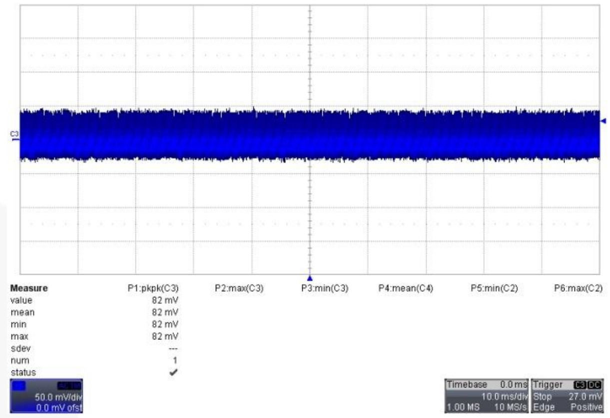

Figure 21. 5 V_{OUT_RIPPLE} = 82 mV, Output Voltage Ripple with 145 V_{AC} and No-Load Condition, CH3: 5 V_{OUT} (50 mV/div), Time: 10 ms/div

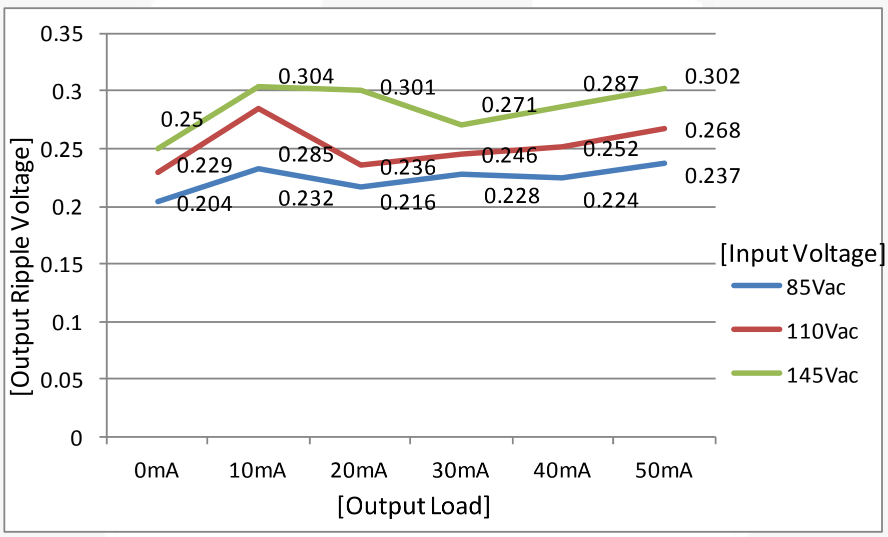

Figure 22. 5 V Output Ripple according to the Input Voltage variation

6.5. Step Load Response

Test Slew Rate (250 mA/μs)

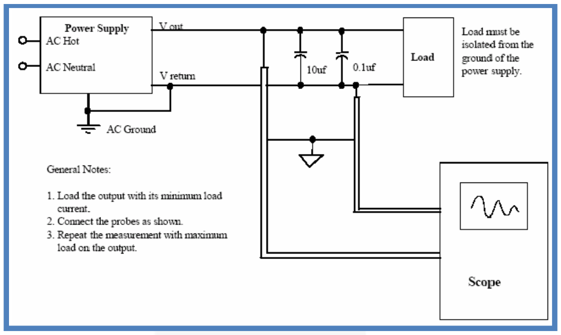

Figure 23. Recommended Test Setup

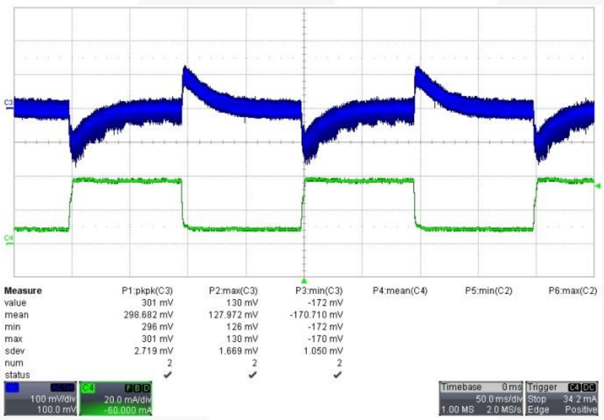

Figure 24. Overshoot = 130 mV, Undershoot = 172 mV, 5 V Output Step Load with 85 V_{AC}, 80% Load ↔ 20% Load (CH3: 5 V_{OUT} (100 mV/div), CH4: I_{OUT} (20 mA/div)Time: 50 ms/div)

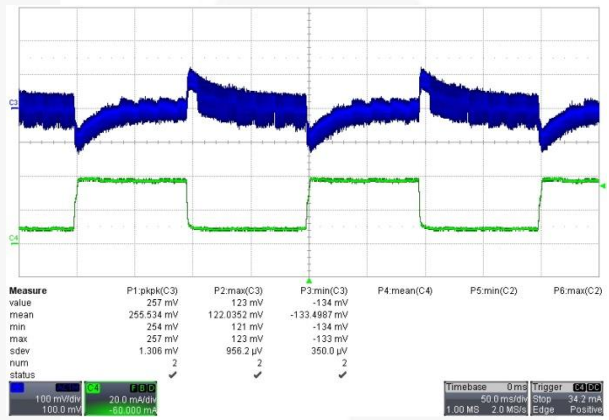

Figure 25. Overshoot = 123 mV, Undershoot = 134 mV, 5 V Output Step Load with 110 V_{AC}, 80% Load ↔ 20% Load (CH3: 5 V_{OUT} (100 mV/div), CH4: I_{OUT} (20 mA/div) Time: 50 ms/div)

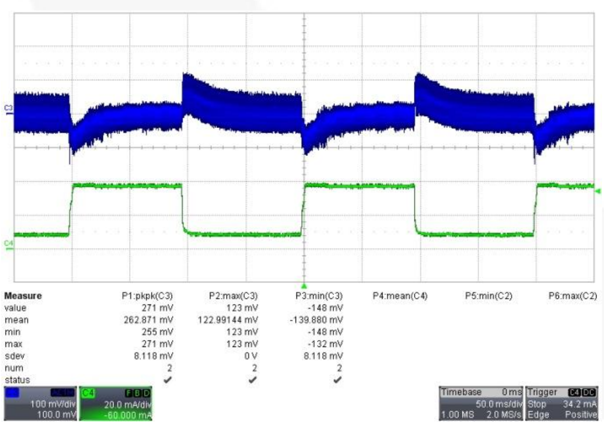

Figure 26. Overshoot = 123 mV, Undershoot = 148 mV, 5 V Output Step Load with 145 V_{AC}, 80% Load ↔ 20% Load (CH3: 5 V_{OUT} (100 mV/div), CH4: I_{OUT} (20 mA/div) Time: 50 ms/div)

6.6. Output Line & Load Regulation

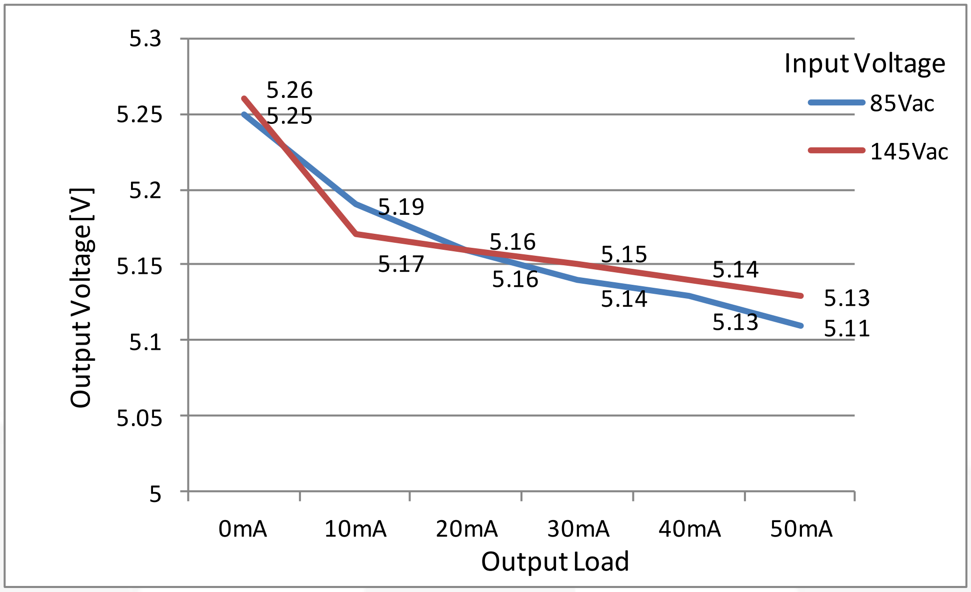

Figure 27. 5 V Output & Load Regulation

6.7. Temperature Measurement

Table 2. Temperature Test Result

Input Voltage		**85 V$_{AC}$**	**110 V$_{AC}$**	**145 V$_{AC}$**
Temperature	**IC (FSL3276ALRN)**	< 30°C		
	Freewheeling Diode (ES1J)			
	Inductor (PKS0807-681K-TF)			
Room Temperature		25°C		

6.8. Efficiency Test Result

- Test Method:
  - Test after 10 minutes aging.
  - Test from heavy load to light-load.

Table 3. Efficiency Test Result

Input Condition	Load Variation, Full Load: 5 V, 50 mA			
	100%	75%	50%	25%
85 V_{AC}	53.53%	50.72%	44.21%	33.65%
110 V_{AC}	51.40%	48.00%	41.47%	30.39%
145 V_{AC}	47.69%	43.88%	37.65%	28.33%

6.9. Standby Power Consumption

V_{IN} Condition	85 V_{AC}	110 V_{AC}	145 V_{AC}
With 1 kΩ Dummy Load	84 mW	98 mW	116 mW

6.10. Conducted EMI Measurement

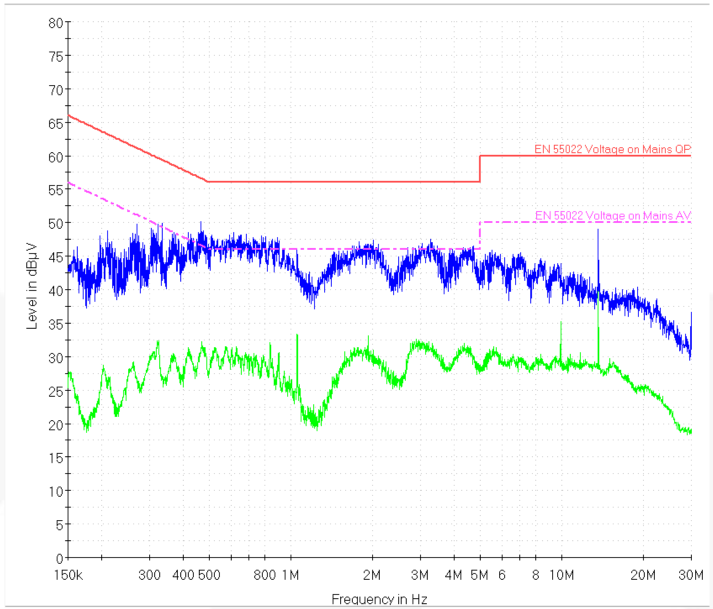

Figure 28. 110 V_{AC} <L> & 5 V / 50 mA

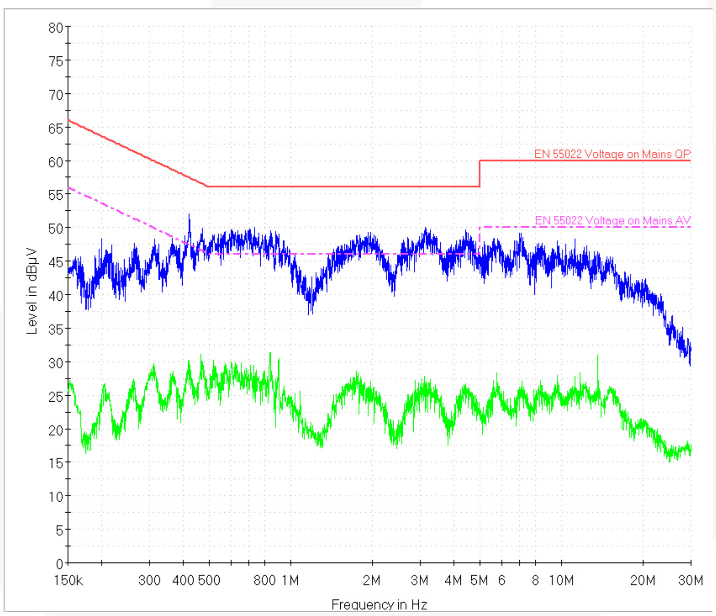

Figure 29. 110 V_{AC} <N> & 5 V / 50 mA

7. Schematic

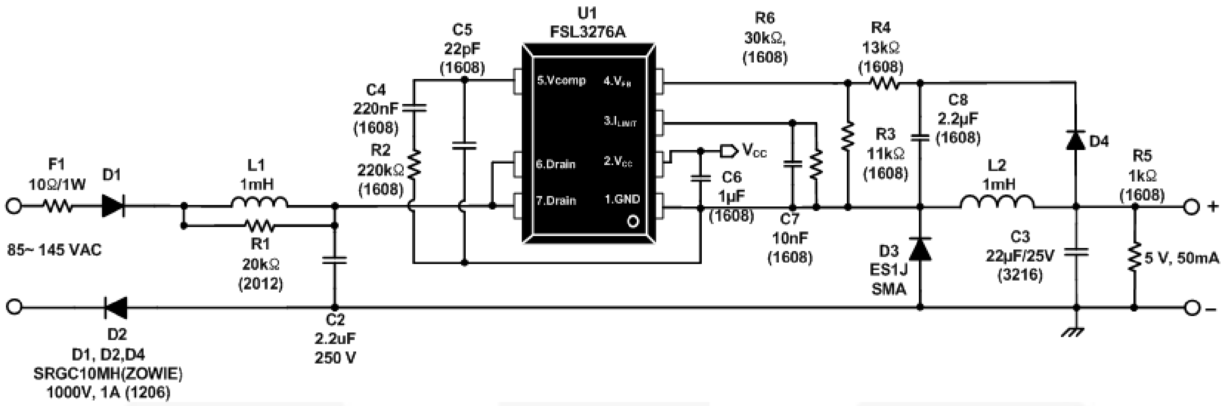

Figure 30. Schematic and Bill of Materials

8. Bill of Materials

Component	Qty.	Part No.	Manufacturer	Reference
Chip Resistor 0805 1 kΩ ±5%	1			R2
Chip Resistor 0805 3.3 kΩ ±5%	1			R7
Chip Resistor 0805 11.5 kΩ ±1%	1			R4
Chip Resistor 0805 13 kΩ ±1%	1			R3
Chip Resistor 0805 180 kΩ ±5%	1			R5
0805 MLCC X7R ±10% 47P (47 pF) 50 V	1			C9
0805 MLCC X7R ±10% 103P (10 nF) 50 V	1			C7
0805 MLCC X7R ±10% 104P (100 nF) 50 V	2			C5, C6
0805 MLCC X7R ±10% 224P (220 nF) 50 V	1			C8
0805 MLCC X7R ±10% 225P (2.2 μF) 50 V	1			C4
Ceramic Capacitor 2.2 μF 250 V	1	C5750X7T2E225M250KE	TDK	C2
1206 MLCC ±10% 226P 22 μF 25 V	1			C3
Fixed Inductor 1 mH ±10%	1	EC36-102K	SYNTON	L1
Inductor DR8X7 1 mH	1	PKS0807-102K-TF	3L Electronic	L2
General Diode 1 A / 600 V SMA	2	S1J	Fairchild Semiconductor	D1, D2
Fast Recovery Diode 1 A / 600 V SMA	1	RS1J	Fairchild Semiconductor	D4
Super Fast Diode 1 A / 600 V SMA	1	ES1J	Fairchild Semiconductor	D3
IC SMPS Power Switch	1	FSL3276ALRN	Fairchild Semiconductor	U1
Wire Wound Resistor 1 W 10R ±5%	1			RF

9. Revision History

Rev.	Date	Description
1.0	March 21,2016	Initial Release