User Guide for

FEBL008 Evaluation Board

Universal LED Driver using the FL6961 CRM PFC Controller and FL6300A QR PWM Controller

Featured Fairchild Products:

FL6961, FL6300A

Direct questions or comments about this evaluation board to: "Worldwide Direct Support"

Fairchild Semiconductor.com

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This user guide supports the evaluation kit for the FL6961 & FL6300A. It should be used in conjunction with the FL6961 & FL6300A datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at www.fairchildsemi.com.

1. Introduction

This document describes the proposed solution for a universal LED ballast using the FL6961 CRM PFC controller and the FL6300A QR PWM controller. The input voltage range is $90V_{RMS}$ – $277V_{RMS}$ and there is one DC output with a constant current of 2.9A at $24V_{MAX}$. This document contains A general description of FL6961 & FL6300A, the power supply specification, schematic, a bill of materials, and the typical operating characteristics.

1.1. General Description of FL6961

The FL6961 is an active Power Factor Correction (PFC) controller for boost PFC applications that operate in Critical Conduction Mode (CRM). It uses a voltage mode PWM that compares an internal ramp signal with the error amplifier output to generate the MOSFET turn-off signal. Because the voltage-mode CRM PFC controller does not need rectified AC line voltage information, it saves the power loss of the input voltage-sensing network required by the current-mode CRM PFC controller.

1.2. Features of FL6961

- Boundary Mode PFC Controller
- Low Input Current THD
- Controlled On-Time PWM
- Zero-Current Detection (ZCD)
- Cycle-by-Cycle Current Limiting
- Leading-Edge Blanking Instead of RC Filtering
- Low Startup Current: 10µA (Typical)
- Low Operating Current: 4.5mA (Typical)
- Feedback Open-Loop Protection
- Programmable Maximum On-Time (MOT)
- Output Over-Voltage Clamping Protection
- Clamped Gate Output Voltage: 16.5V

2. Block Diagram

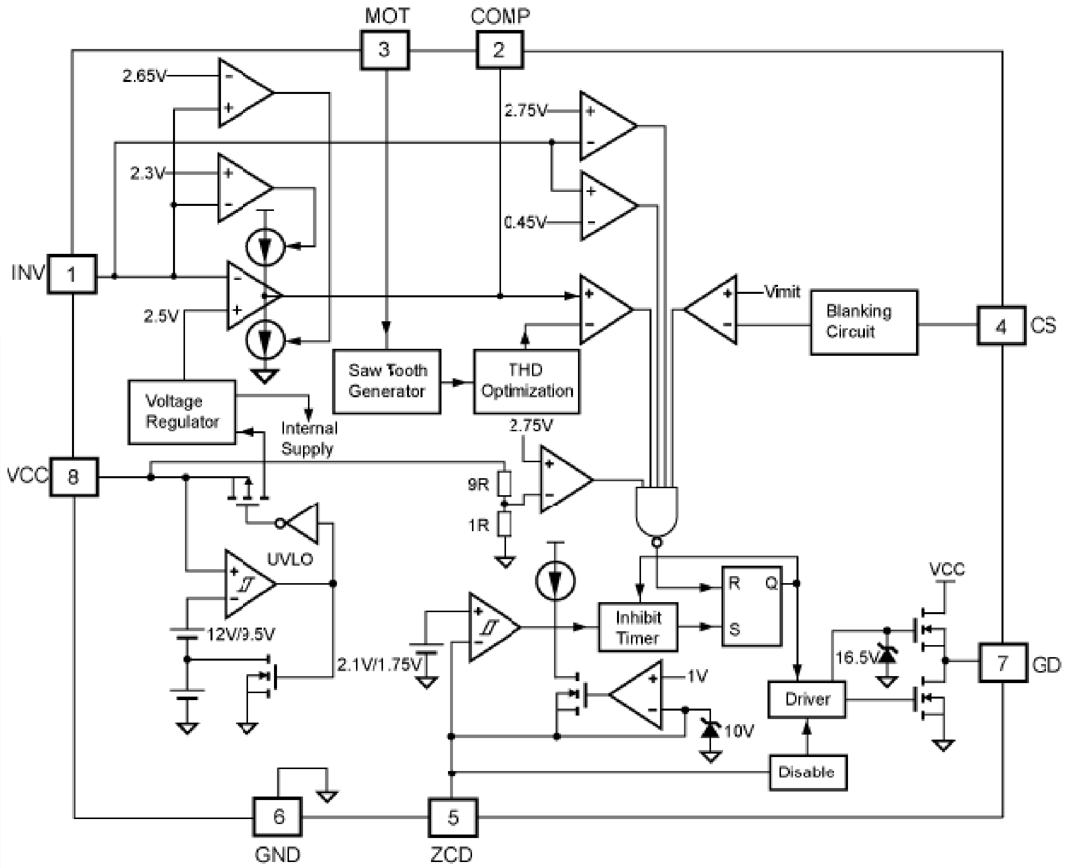

Figure 1. FL6961 Block Diagram

2.1. General Description of FL6300A

The FL6300A is a highly integrated quasi-resonant PWM controller with several features to enhance the performance of flyback converters. A built-in HV startup circuit can provide more startup current to reduce the startup time of the controller and reduce power consumption. An internal valley voltage detector ensures the power system operates at quasi-resonant operation in wide range line voltage and any load conditions and reduces switching loss to minimize switching voltage on the drain of the power MOSFET.

2.2. Features of FL6300A

- Internal High-Voltage Startup
- Quasi-Resonant Operation
- Cycle-by-Cycle Current Limiting
- Peak Current Mode Control
- Leading-Edge Blanking
- Internal Minimum t_{OFF}
- Internal 2ms Soft-Start
- Over-Power Compensation
- Gate Output Maximum Voltage
- Auto-Recovery Short-Circuit Protection (FB Pin)
- Auto-Recovery Open-Loop Protection (FB Pin)
- VDD Pin & Output Voltage (DET Pin) Latch OVP

2.3. Block Diagram

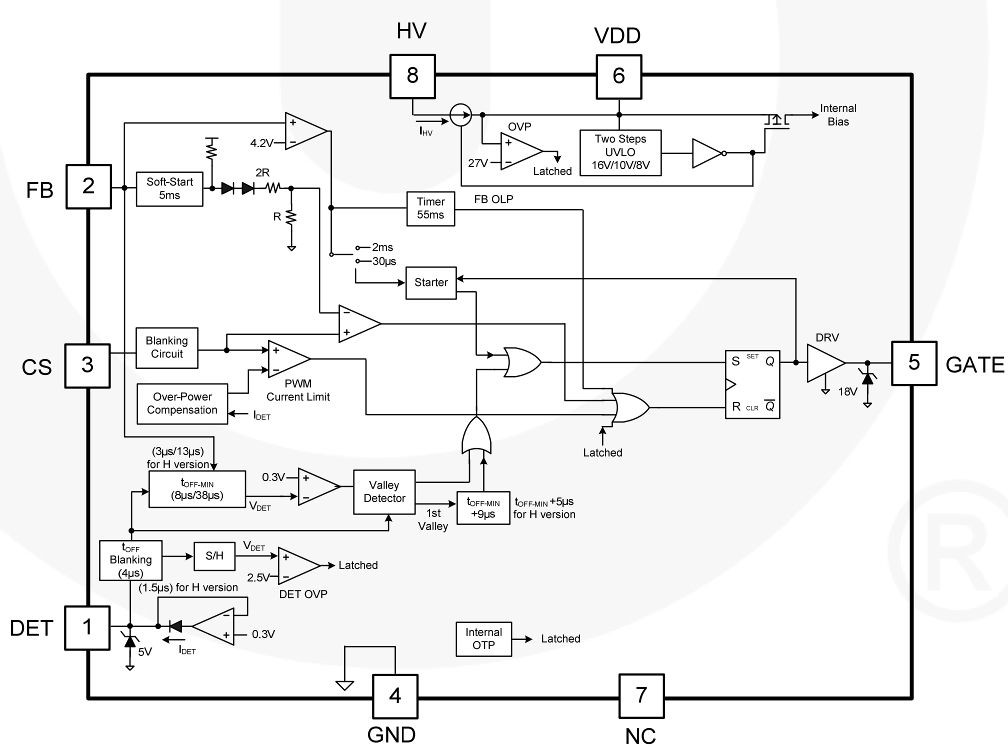

Figure 2. FL6300A Block Diagram

3. Evaluation Board Specifications

All data of the evaluation board was measured with the board enclosed in a case and external temperature of around 25°C.

Table 1. Summary of Features for LED Lighting Bulb

Main Controller	FL6961 & FL6300A
Input Voltage Range	$90V_{AC}$~$277V_{AC}$
Input Voltage Frequency	47Hz~63Hz
Rated Output Power	70W
Rated Output Voltage	24V
Rated Output Current	2.9A
Application	LED Lighting

4. Photographs

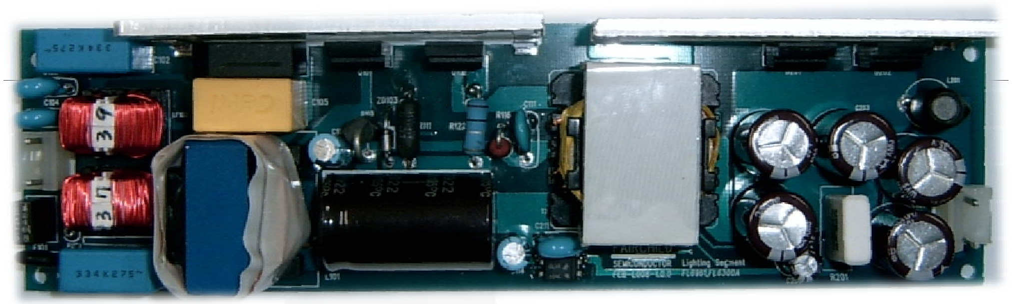

Figure 3. Photograph (183mm (W) x 55mm (H)) Top View

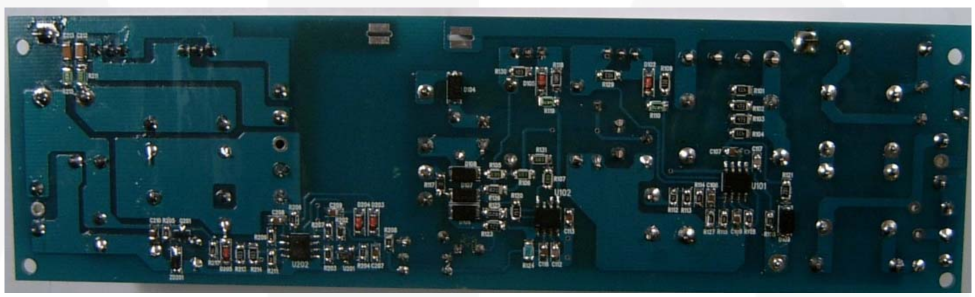

Figure 4. Photograph (183mm (W) x 55mm (H)) Bottom View

5. Printed Circuit Board

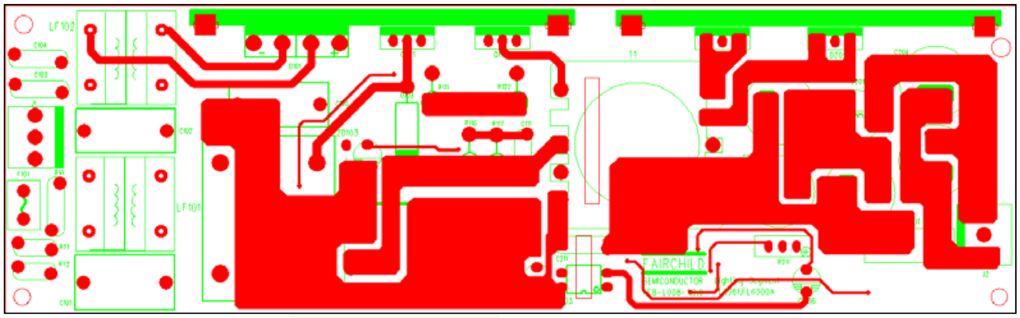

Figure 5. Printed PCB, Top Side

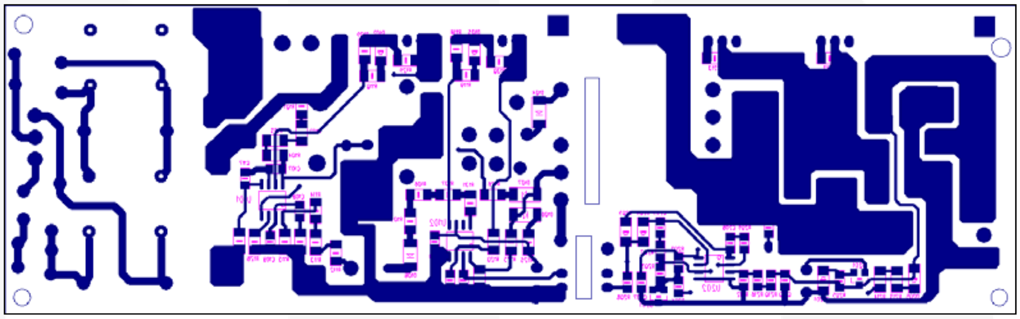

Figure 6. Printed PCB, Bottom Side

6. Schematic

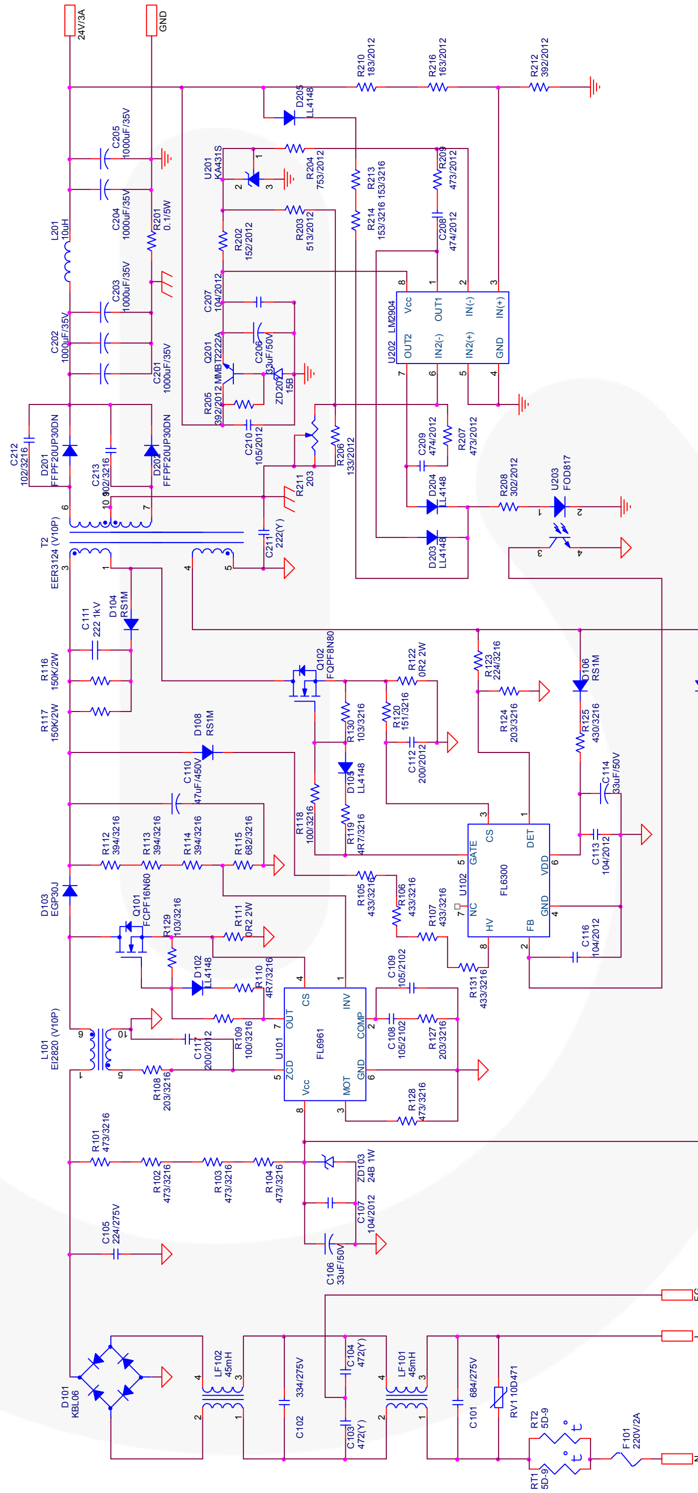

Figure 7. Evaluation Board Schematic

7. Bill of Materials

Table 2. Bill of Materials of Evaluation Board

Item No.	Part Reference	Value	Qty	Description (Manufacturer)
1	U101	FL6961	1	CRM PFC Controller (Fairchild Semiconductor)
2	U102	FL6300A	1	QR PWM Controller Fairchild Semiconductor)
3	Q101	FCPF20N60	1	600V/20A MOSFET (Fairchild Semiconductor)
4	Q102	FQPF8N80	1	800V/8A MOSFET (Fairchild Semiconductor)
5	D201, D202	FFPF20UP30DN	2	Ultra-Fast Recovery Power Rectifier (Fairchild Semiconductor)
6	D103	EGP30J	1	600V/3A Ultra-Fast Recovery Diode (Fairchild Semiconductor)
7	D104, D106, D107, D108	RS1M	4	1000V/1A Ultra-Fast Recovery Diode (Fairchild Semiconductor)
8	D101	KBL06	1	Bridge Diode (Fairchild Semiconductor)
9	Q201	MMBT2222A	1	General-Purpose Transistor (Fairchild Semiconductor)
10	U202	LM2904	1	Dual OP Amp (Fairchild Semiconductor)
11	U203	FOD817	1	Opto-Coupler (Fairchild Semiconductor)
12	U201	KA431S	1	Shunt Regulator (Fairchild Semiconductor)
13	ZD103	24B 1W	1	Zener Diode (Fairchild Semiconductor)
14	ZD201	15B	1	Zener Diode (Fairchild Semiconductor)
15	D102, D105, D203, D204, D205	LL4148	5	General-Purpose Diode (Fairchild Semiconductor)
16	C101	684/275V	1	X – Capacitor
17	C102	334/275V	1	X – Capacitor
18	C105	224/275V	1	X – Capacitor
19	C103,C104	472 (Y)	2	Y – Capacitor
20	C211	222 (Y)	1	Y – Capacitor
21	C106, C114, C206	33µF/50V	3	Electrolytic Capacitor, 105°C
22	C107, C113, C116, C207	104/2012	4	SMD Capacitor 2012
23	C108, C109, C210	105/2102	3	SMD Capacitor 2012
24	C110	68µF/450V	1	Electrolytic Capacitor, 105°C
25	C111	222/1kV	1	Ceramic-Capacitor
26	C112, C117	200/2012	2	SMD Capacitor 2012
27	C201, C202, C203, C204, C205	1000µF/35V	5	Electrolytic Capacitor, 105°C
28	C208, C209	474/2012	2	SMD Capacitor 2012
29	C212, C213	102/3216	2	SMD Capacitor 3216
30	F101	250V/2A	1	Fuse
31	L101	EI2820	1	PFC Inductor (V10P), 450µH, 1kHz, 1V
32	L201	10µH	1	Stick Inductor
33	LF101, LF102	45mH	2	Line Filter
34	R101, R102, R103, R104	104/3216	4	SMD Resistor 3216
35	R128	393/3216	1	SMD Resistor 3216
36	R105, R106, R107, R131	433/3216	4	SMD Resistor 3216

Bill of Materials (Continued)

37	R108, R124, R127	203/3216	3	SMD Resistor 3216
38	R109, R118	100/3216	2	SMD Resistor 3216
39	R110, R119	4R7/3216	2	SMD Resistor 3216
40	R111, R122	0R2/2W	2	Metal Film Resistor 2W
41	R112, R113, R114	394/3216	3	SMD Resistor 3216
42	R115	682/3216	1	SMD Resistor 3216
43	R213, R214	153/3216	2	SMD Resistor 3216
44	R116, R117	150K/2W	2	Metal Film Resistor 2W
45	R120	151/3216	1	SMD Resistor 3216
46	R123	224/3216	1	SMD Resistor 3216
47	R125, R126	430/3216	2	SMD Resistor 3216
48	R129, R130	103/3216	2	SMD Resistor 3216
49	R201	0.1/5W	1	MPR Resistor 5W
50	R202	152/2012	1	SMD Resistor 2012
51	R203	513/2012	1	SMD Resistor 2012
52	R204	753/2012	1	SMD Resistor 2012
53	R205	392/2012	1	SMD Resistor 2012
54	R206	133/2012	1	SMD Resistor 2012
55	R207, R209	473/2012	2	SMD Resistor 2012
56	R208	302/2012	1	SMD Resistor 2012
57	R212	432/2012	1	SMD Resistor 2012
58	R210	153/2012	1	SMD Resistor 2012
59	R216	223/2012	1	SMD Resistor 2012
60	R211	20k	1	Variable Resister 20k
61	RT1, RT2	5D-9	2	NTC
62	T2	EER3124	1	QR Transformer (V10P), 500µH, 1kHz, 1V
63	RV1	10D471	1	VARISTOR

8. Transformer and Inductor Specifications

- Core: EER3124
- Bobbin: 10 pins

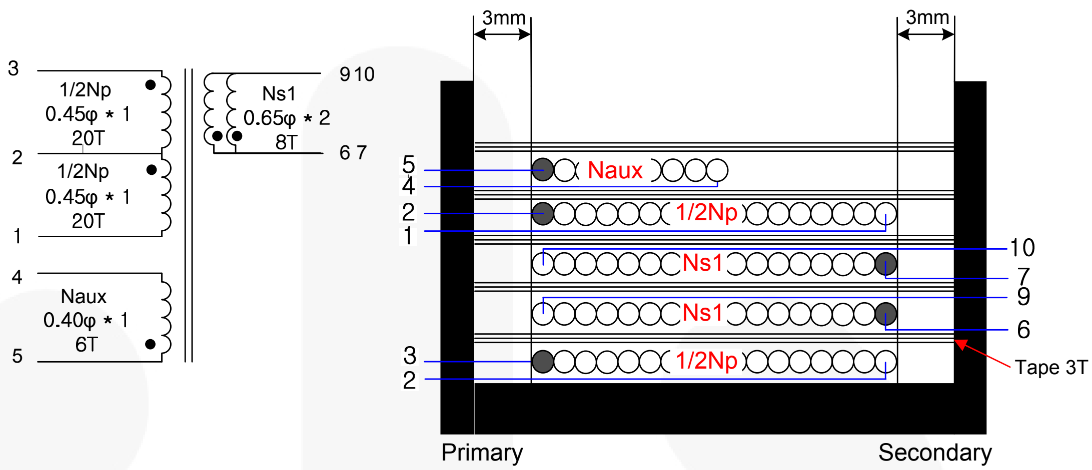

Figure 8. Transformer Specifications & Construction (EER3124)

Table 3. Winding Specifications

No.	Winding	Pin (S → F)	Wire	Turns	Winding Method
1	1/2Np	3 → 2	0.10φ×20	20 Ts	Solenoid Winding
	Insulation: Polyester Tape t = 0.025mm, 3-Layer				
2	Ns1	6 → 9	0.10φ×50	8 Ts	Solenoid Winding
	Insulation: Polyester Tape t = 0.025mm, 1-Layer				
3	Ns2	7 → 10	0.10φ×50	8 Ts	Solenoid Winding
	Insulation: Polyester Tape t = 0.025mm, 3-Layer				
4	1/2Np	2 → 1	0.10φ×20	20 Ts	Solenoid Winding
	Insulation: Polyester Tape t = 0.025mm, 2-Layer				
6	Naux	5 → 4	0.40φ×1	6 Ts	Solenoid Winding
	Insulation: Polyester Tape t = 0.025mm, 3-Layer				

Table 4. Electrical Characteristics

	Pin	Specification	Remark
Inductance	1 – 3	500μH ±7%	1kHz, 1V
Leakage	1 – 3	14μH Maximum	Short All Output Pins

- Core : EI2820
- Bobbin : 10 pin

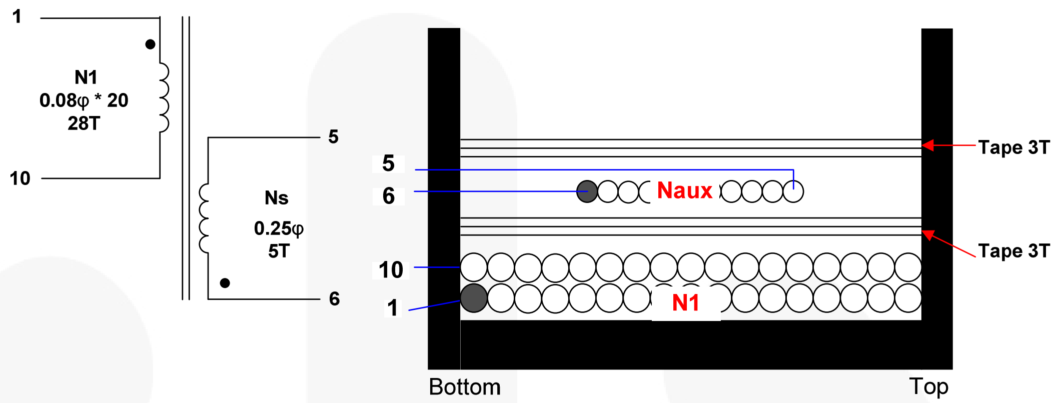

Figure 9. Inductor Specifications & Construction (EI2824)

Table 5. Winding Specifications

No	Winding	Pin (S→F)	Wire	Turns	Winding Method
1	N1	1 → 10	0.12φ×25	44 Ts	Solenoid Winding
	Insulation: Polyester Tape t = 0.025mm, 3-Layer				
2	Ns1	7 → 5	0.1φ×12	6 Ts	Space Winding
	Insulation: Polyester Tape t = 0.025mm, 3-Layer				

Table 6. Electrical Characteristics

	Pin	Specification	Remark
Inductance	1 – 10	450μH	1kHz, 1V
Leakage	1 – 10	10μH Maximum	Short All Output Pins

9. Performance of Evaluation Board

Table 7. Test Conditions & Items

Ambient Temperature	**T_A = 25°C**
Test Equipment	AC Power Source: PCR500L by Kikusui Power Analyzer: PM3000 by Voltech Electronic Load: PLZ303WH by KIKUSUI Multi Meter: 2002 by KEITHLEY, 45 by FLUKE Oscilloscope: 104Xi by LeCroy Two-Line V-Network: ENV216 by ROHDE & SCHWARZ Thermometer: Thermal CAM SC640 by FLIR SYSTEMS
Test Items	9.1 Electrical Performances 9.2 Power Factor 9.3 Constant Current & Constant Voltage (CC/CV) 9.4 THD Performance 9.5. Temperature Checking Results 9.6. Startup Time 9.7. Operation Waveforms 9.8 Short-Circuit Protection 9.9. Stress of the MOSFET & Rectifier 9.10. EMI Results

9.1. Electrical Performances

Figure 10 shows at least 84% system efficiency with universal input condition at the rated output load.

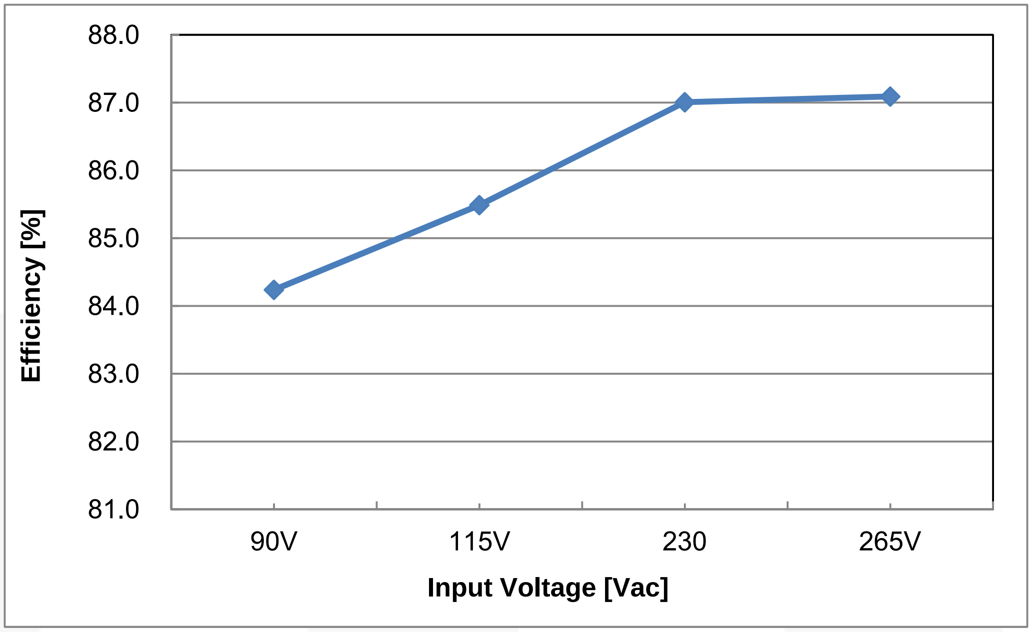

Figure 10. System Efficiency

Input Voltage	**90V$_{AC}$**	**115V$_{AC}$**	**230V$_{AC}$**	**277V$_{AC}$**
Efficiency	83.02%	84.77%	87.23%	87.33%

9.2. Power Factor

Figure 11 shows consistent results over 90% PF results with universal input condition at the rated output power.

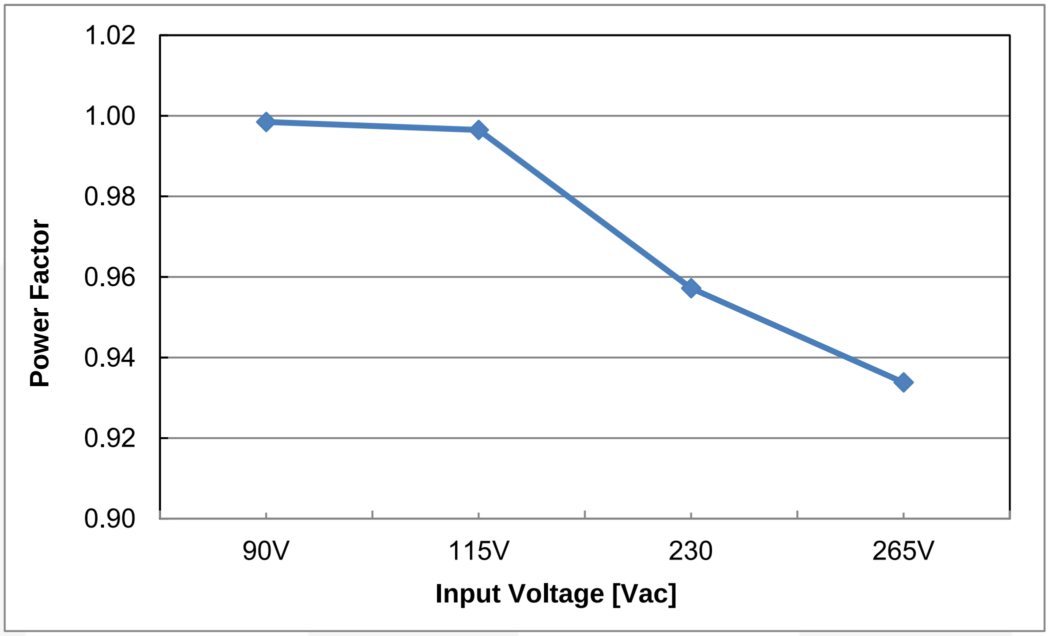

Figure 11. Power Factor

Input Voltage	$90V_{AC}$	$115V_{AC}$	$230V_{AC}$	$277V_{AC}$
PF	99.60%	99.50%	95.40%	91.30%

9.3. Constant Current & Constant Voltage (CC/CV)

Figure 12 shows the typical CC/CV performance on the board, showing very stable CC performance at $90V_{AC}$ ~ $277V_{AC}$ input conditions.

Input Voltage	Min. Current	Max. Current	Tolerance	Remark
$90V_{AC}$ / 60Hz	2.968	2.976	0.27%	< 10%
$115V_{AC}$ / 60Hz	2.967	2.975	0.27%	
$230V_{AC}$ / 60Hz	2.977	2.984	0.23%	
$277V_{AC}$ / 60Hz	2.970	2.977	0.24%	
Total	2.968	2.984	0.54%	

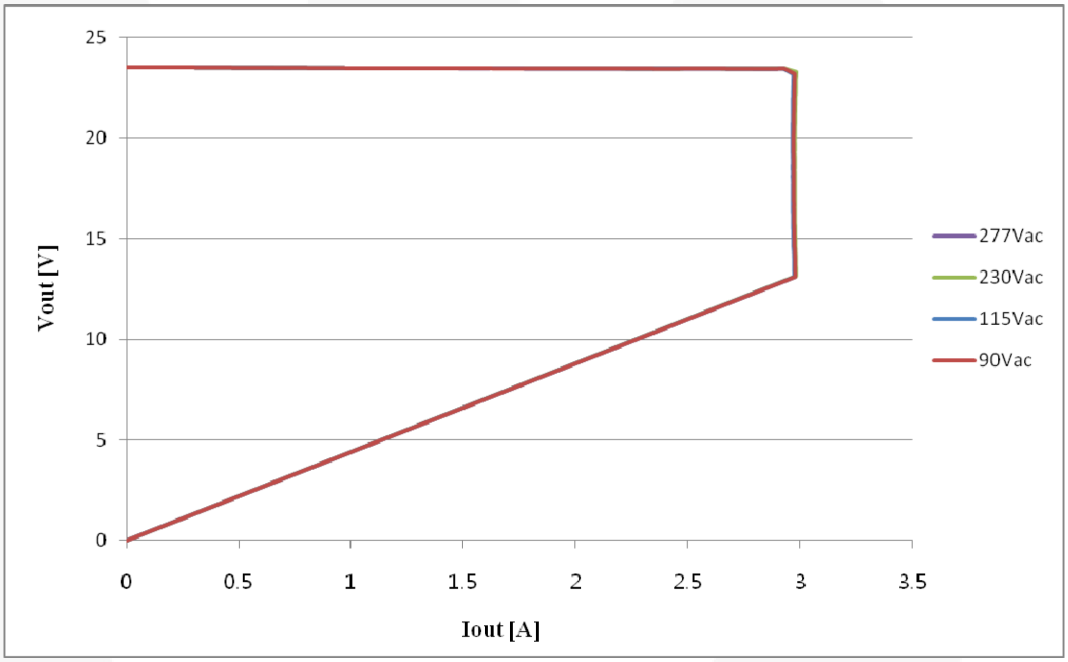

Figure 12. CC/CV Performance

Table 8. CC and CV Measured Data

$90V_{AC}$		$115V_{AC}$		$230V_{AC}$		$277V_{AC}$	
V_{OUT}	I_{OUT}	V_{OUT}	I_{OUT}	V_{OUT}	I_{OUT}	V_{OUT}	I_{OUT}
23.52	0	23.52	0	23.51	0	23.52	0
23.52	0.291	23.52	0.291	23.51	0.291	23.51	0.440
23.51	0.440	23.51	0.440	23.50	0.440	23.51	0.440
23.50	0.582	23.50	0.582	23.49	0.582	23.50	0.582
23.50	0.731	23.50	0.731	23.49	0.731	23.50	0.731
23.49	0.879	23.49	0.879	23.48	0.879	23.49	0.879
23.48	1.022	23.48	1.022	23.47	1.021	23.48	1.022
23.48	1.170	23.48	1.170	23.47	1.170	23.48	1.170
23.47	1.312	23.48	1.312	23.47	1.312	23.47	1.466
23.47	1.466	23.47	1.466	23.46	1.466	23.46	1.615
23.47	1.615	23.47	1.615	23.46	1.615	23.47	1.757
23.46	1.757	23.47	1.757	23.46	1.757	23.46	1.906
23.46	1.906	23.46	1.906	23.46	1.905	23.46	1.906
23.46	2.054	23.46	2.054	23.46	2.053	23.46	2.054
23.46	2.190	23.46	2.190	23.46	2.190	23.46	2.190
23.46	2.344	23.46	2.344	23.45	2.343	23.46	2.344
23.45	2.789	23.45	2.789	23.45	2.789	23.46	2.927
23.46	2.926	23.46	2.926	23.47	2.927	23.46	2.926
23.46	2.926	23.46	2.926	23.47	2.927	23.22	2.975
23.20	2.973	23.18	2.971	23.29	2.984	23.21	2.975
22.27	2.971	22.26	2.969	22.35	2.982	22.28	2.973
21.69	2.970	21.68	2.968	21.77	2.980	21.10	2.972
20.80	2.969	20.79	2.967	20.87	2.979	20.52	2.971
20.50	2.969	20.49	2.967	20.57	2.978	20.22	2.970
19.89	2.968	19.87	2.967	19.94	2.978	19.90	2.970
19.57	2.968	19.56	2.967	19.63	2.978	19.32	2.970
19.31	2.968	19.30	2.967	19.37	2.978	19.32	2.970
18.70	2.969	18.69	2.968	18.76	2.978	18.71	2.971
18.42	2.969	18.41	2.967	18.48	2.978	18.44	2.971
18.13	2.969	18.12	2.968	18.18	2.978	18.14	2.971
17.53	2.969	17.53	2.968	17.59	2.978	17.54	2.971
17.53	2.969	17.53	2.968	17.59	2.978	17.22	2.971
17.21	2.969	17.21	2.968	17.26	2.978	17.22	2.971
17.21	2.969	17.21	2.968	17.26	2.978	16.94	2.971
16.93	2.969	16.92	2.968	19.98	2.978	16.94	2.971
16.34	2.970	16.33	2.968	16.39	2.978	16.05	2.972
16.04	2.970	16.03	2.969	16.08	2.978	16.05	2.972
16.04	2.970	16.03	2.969	16.08	2.978	15.78	2.972
15.77	2.970	15.77	2.969	15.81	2.978	15.78	2.972
15.47	2.971	15.47	2.970	15.51	2.979	15.17	2.973
15.16	2.971	15.16	2.970	15.20	2.979	15.17	2.973
14.87	2.972	14.86	2.971	14.90	2.980	14.59	2.974
14.58	2.972	14.58	2.971	14.62	2.980	14.59	2.974
14.29	2.974	14.29	2.973	14.33	2.981	14.02	2.976
14.01	2.975	14.01	2.974	14.05	2.982	14.02	2.976
13.69	2.975	13.69	2.974	13.72	2.982	13.41	2.977
13.40	2.975	13.40	2.974	13.43	2.983	13.41	2.977
13.11	2.976	13.10	2.975	13.14	2.983	13.11	2.977

9.4. THD Performance

Figure 13 and Figure 14 show the test results of FL6961 and FL6300A evaluation board. All the results meet the international regulations.

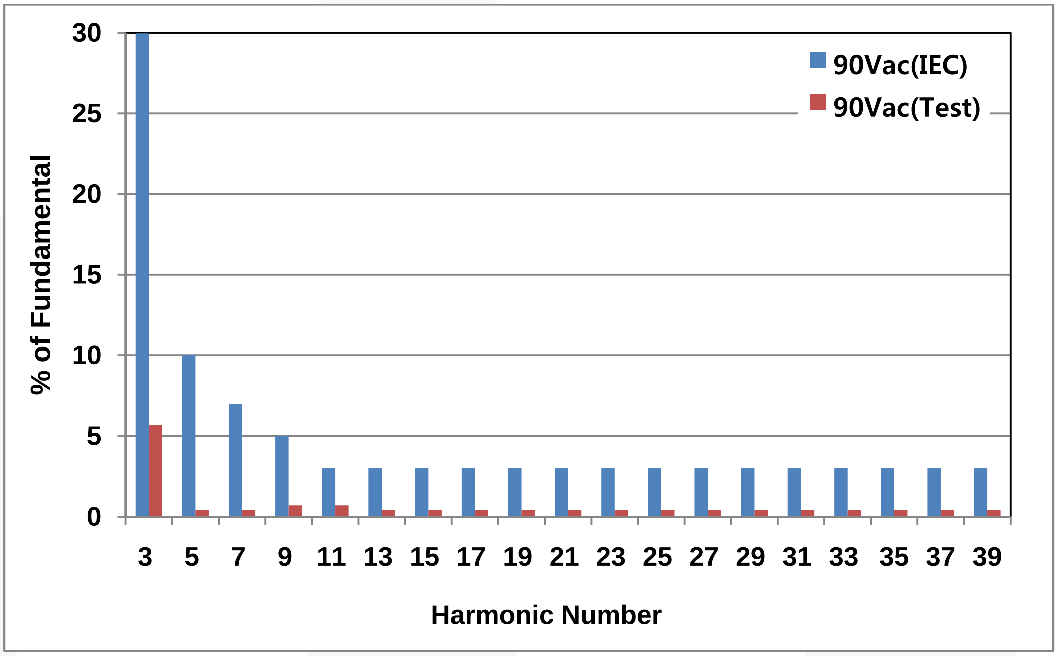

Figure 13. THD Performance Results at $90V_{AC}$

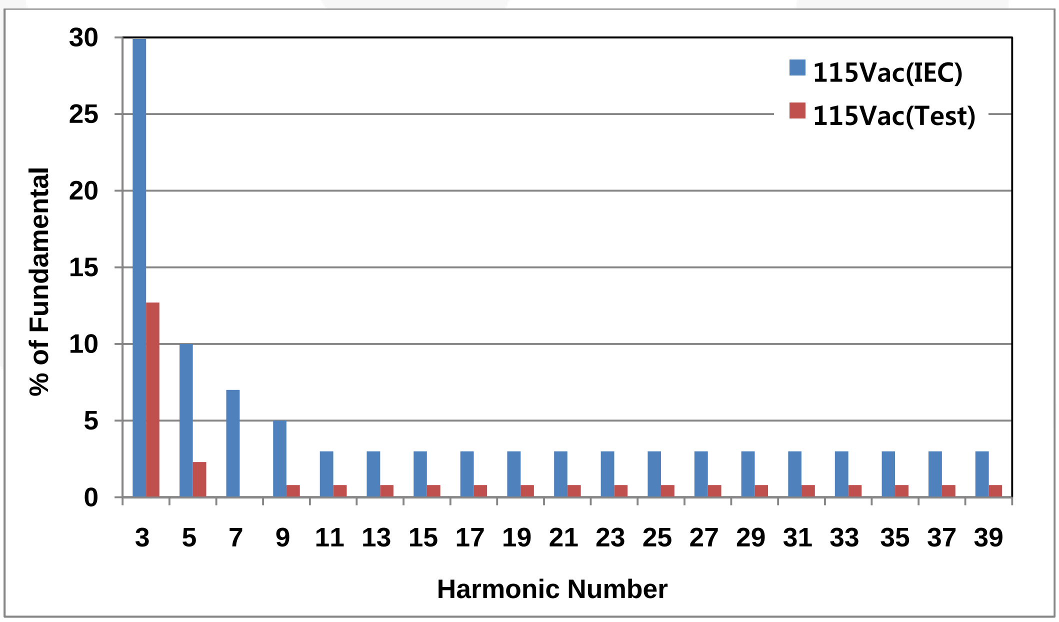

Figure 14. THD Performance Results at $115\ V_{AC}$

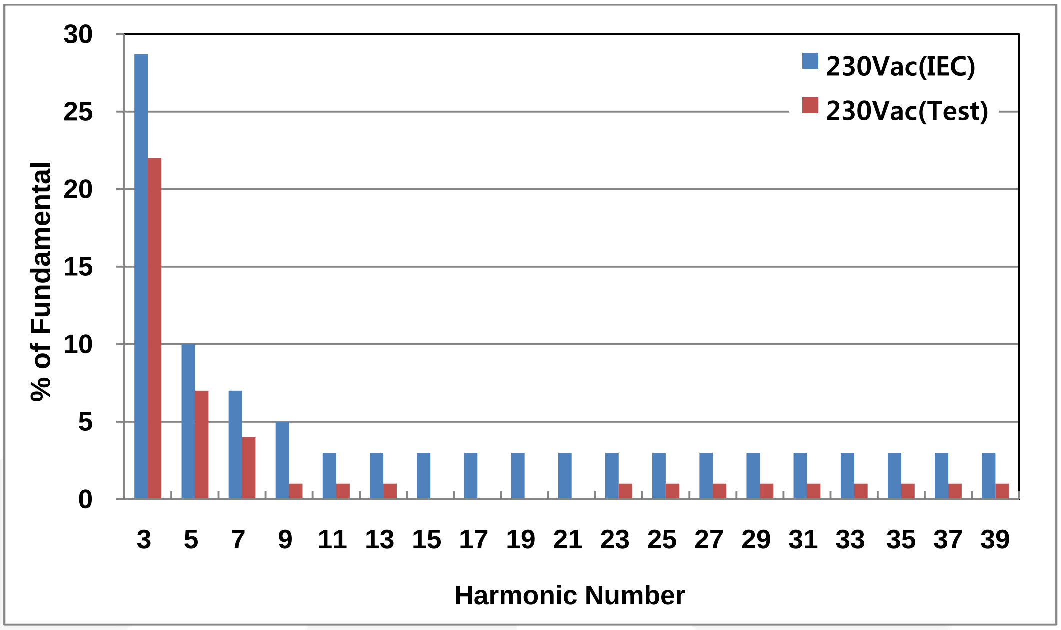

Figure 15. THD Performance Results at 230 V_{AC}

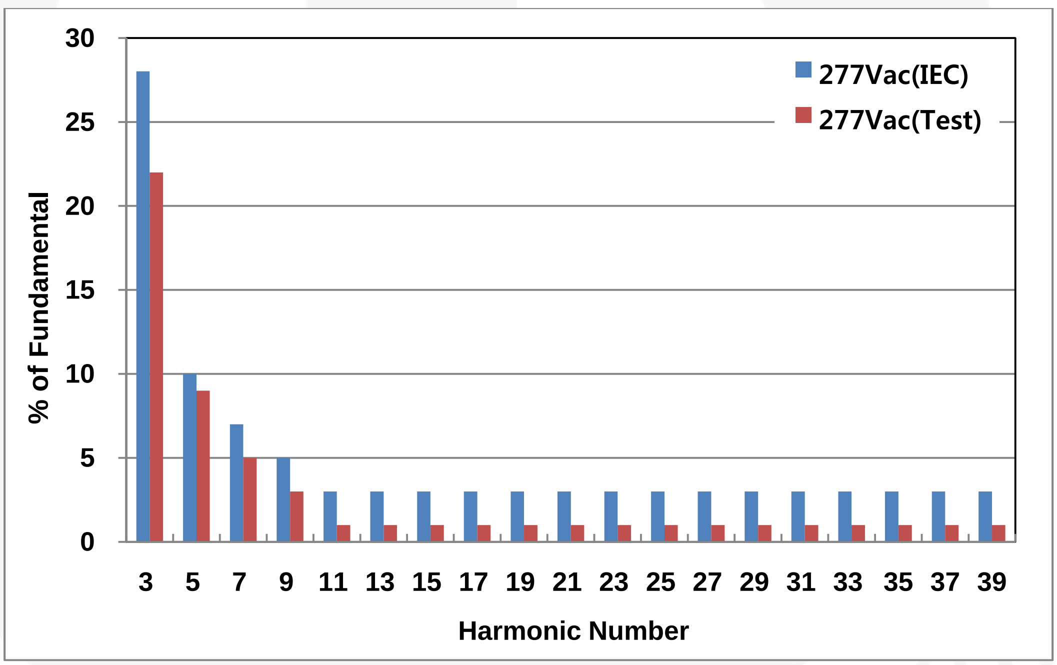

Figure 16. THD Performance Results at 277 V_{AC}

9.5. Temperature Checking Results

Figure 17 - Figure 20 show the temperature-checking results on the board in minimum and maximum input voltage condition.

	$90V_{AC}$ / 60Hz	$277V_{AC}$ / 60Hz	Remark
Bridge Diode	66.3°C	55.7°C	Top-Side Circle
FET(PFC)	63.5°C	56.8°C	Top-Side Line
FET(QR)	65.2°C	56.8°C	Top-Side Box
Rectifier	64.9°C	65.6°C	Top-Side Spot

Temperature Results

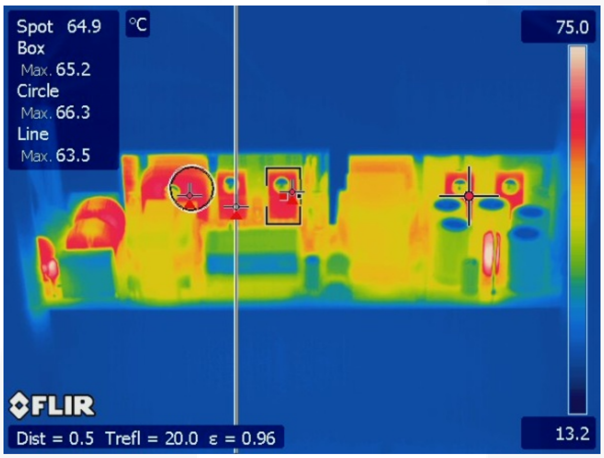

Figure 17. $90V_{AC}$ / 60Hz; Top Side

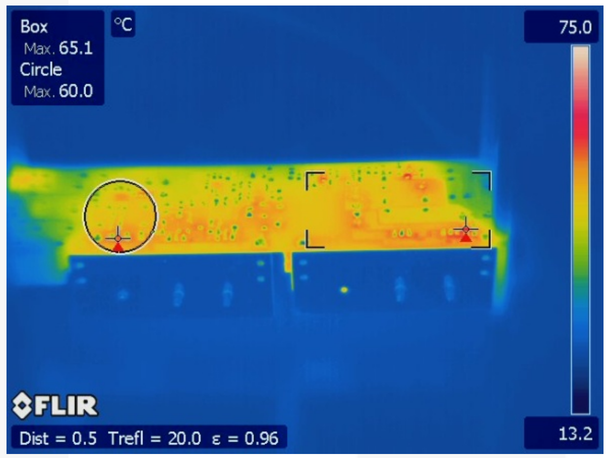

Figure 18. $90V_{AC}$ / 60Hz; Bottom Side

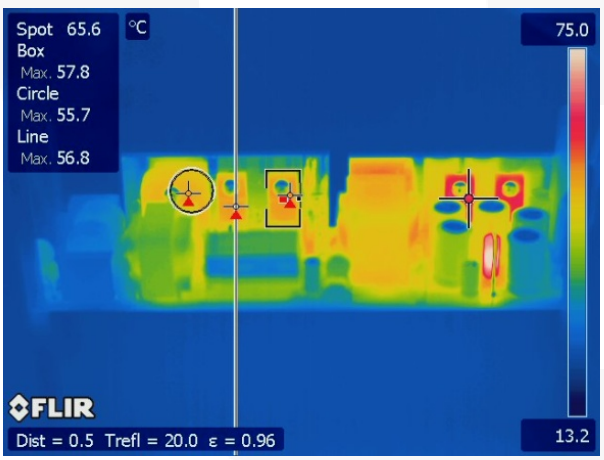

Figure 19. $277V_{AC}$ / 60Hz; Top Side

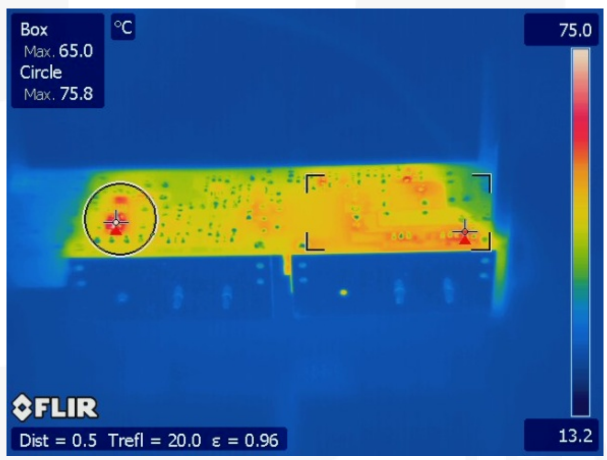

Figure 20. $277V_{AC}$ / 60Hz; Bottom Side

9.6. Startup Time

Figure 21 and Figure 22 show the typical startup performance on the board. A longer startup time to release the UVLO function can be achieved on the IC at $90V_{AC}$ condition rather than $277V_{AC}$ condition. This time normally depends on the starting resistor and capacitor on the board.

Input Voltage	Turn On Time	Remark
$90V_{AC}$ / 60Hz	0.872s	< 1s
$277V_{AC}$ / 60Hz	0.271s	

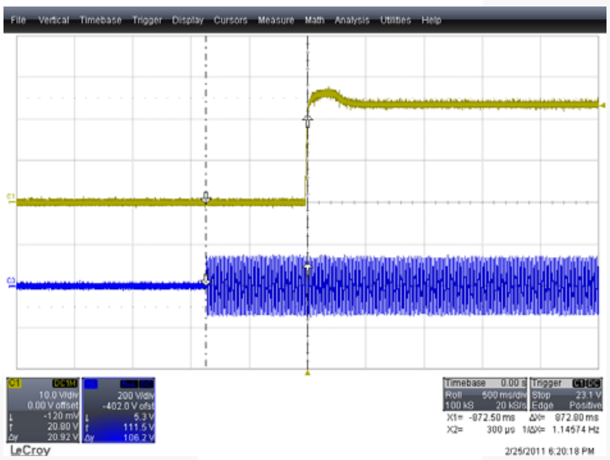

Figure 21. $90V_{AC}$ / 60Hz, CH1 (Yellow): V_{OUT}, CH3 (Blue): V_{IN}

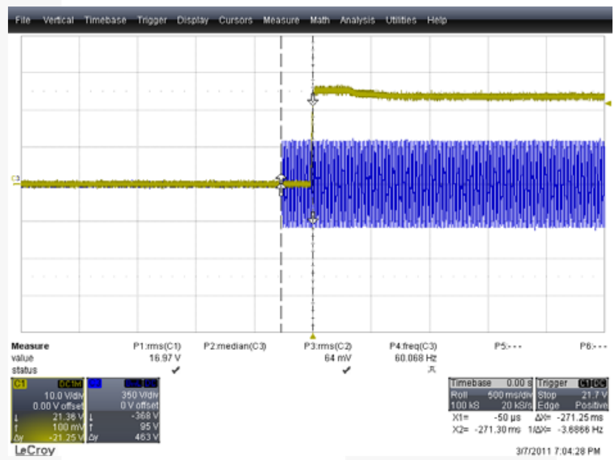

Figure 22. $277V_{AC}$ / 60Hz, CH1 (Yellow): V_{OUT}, CH3 (Blue): V_{IN}

Figure 23 through Figure 26 show the typical startup performance of PFC circuit on the board.

Input Voltage	Turn-On Time	Remark
$90V_{AC}$ / 60Hz	0.584s	< 1s
$115V_{AC}$ / 60Hz	0.535s	
$230V_{AC}$ / 60Hz	0.320s	
$277V_{AC}$ / 60Hz	0.242s	

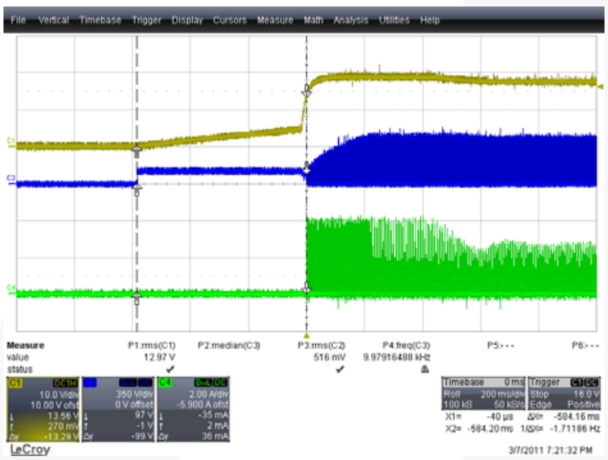

Figure 23. $90V_{AC}$ / 60Hz, CH2 (Red): $V_{CC(PFC)}$, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

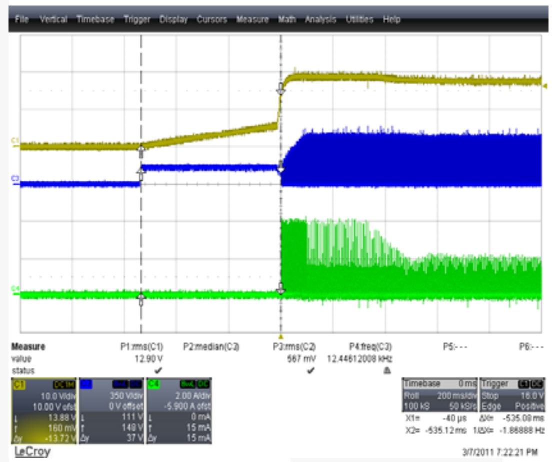

Figure 24. $115V_{AC}$ / 60Hz, CH2 (Red): $V_{CC(PFC)}$, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

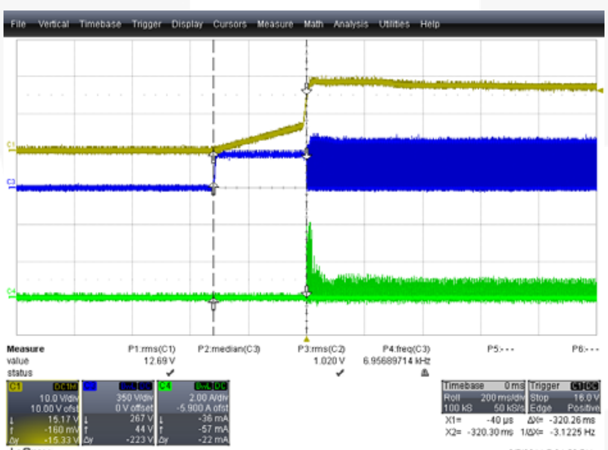

Figure 25. $30V_{AC}$ / 60Hz, CH2 (Red): $V_{CC(PFC)}$, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

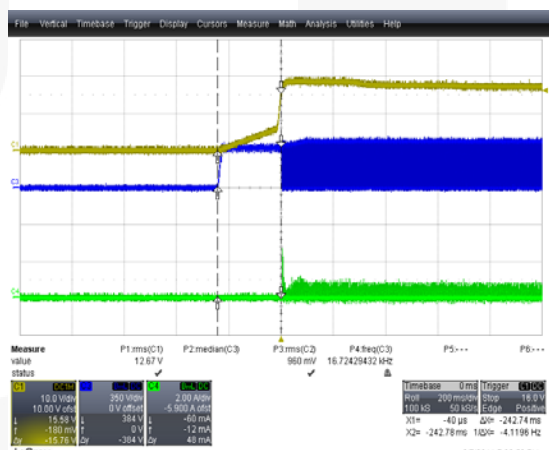

Figure 26. $277V_{AC}$ / 60Hz, CH2 (Red): $V_{CC(PFC)}$, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

Figure 27 - Figure 30 show the typical startup performance of the QR flyback circuit on the board.

Input Voltage	Turn On Time	Remark
$90V_{AC}$ / 60Hz	0.878s	< 1s
$115V_{AC}$ / 60Hz	0.677s	
$230V_{AC}$ / 60Hz	0.351s	
$277V_{AC}$ / 60Hz	0.320s	

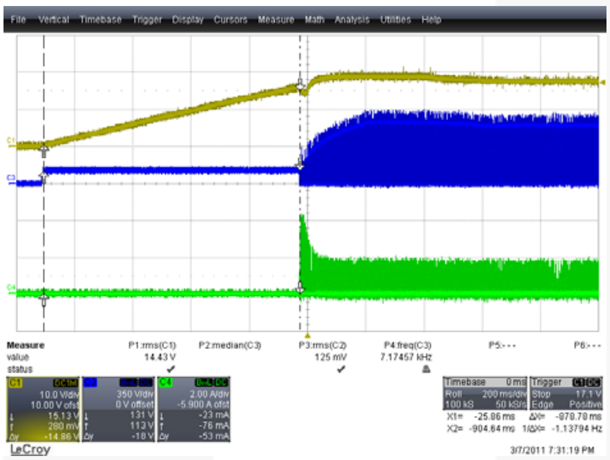

Figure 27. $90V_{AC}$ / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green):, $I_{DS(QR)}$

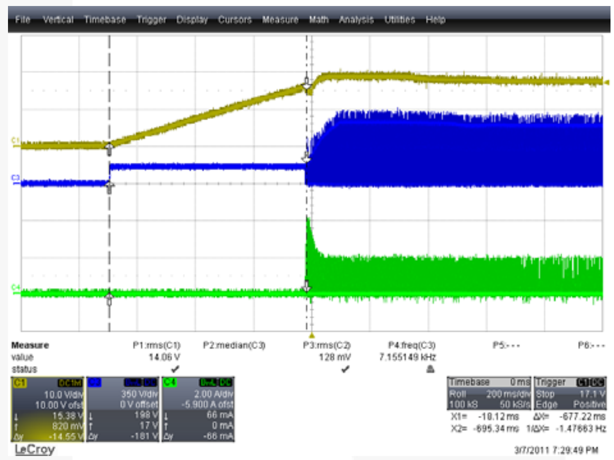

Figure 28. $115V_{AC}$ / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

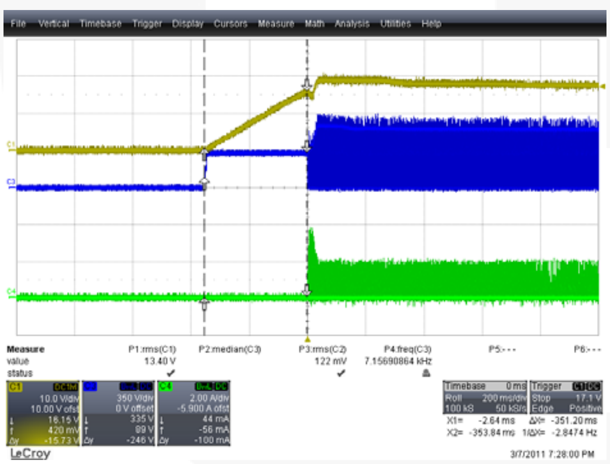

Figure 29. $230V_{AC}$ / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

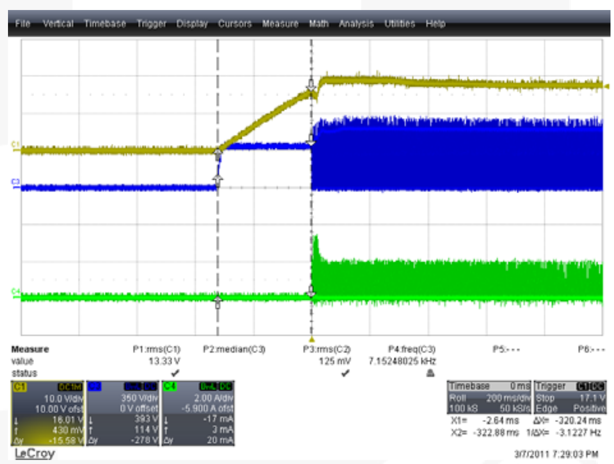

Figure 30. $277V_{AC}$ / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

9.7. Operation Waveforms

Normal Operation

Figure 31 through Figure 34 show the input current waveforms on the board at different input voltage conditions.

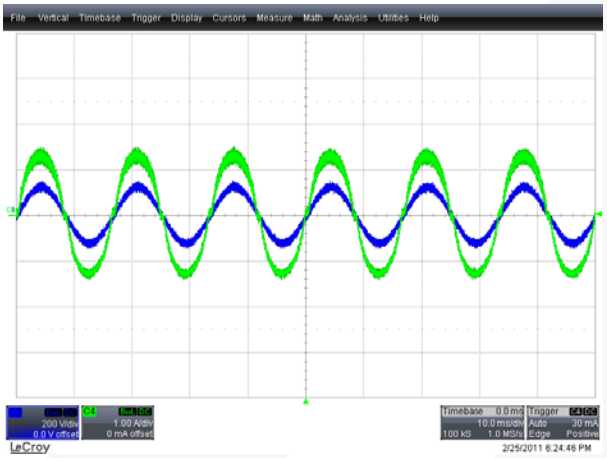

Figure 31. 90V_{AC} / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

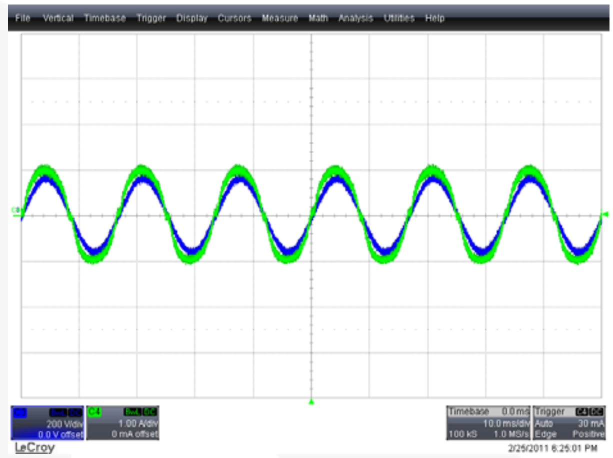

Figure 32. 115V_{AC} / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

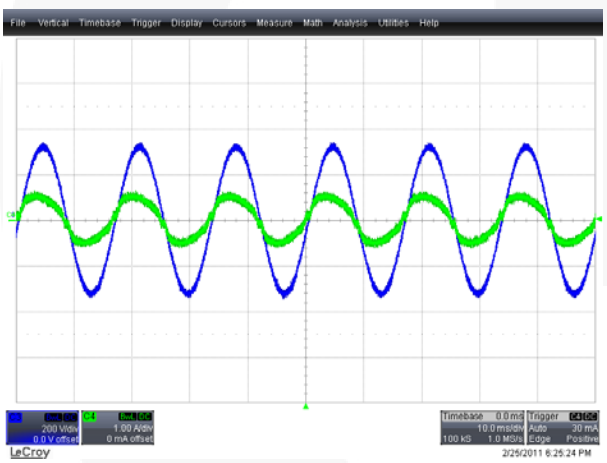

Figure 33. 230V_{AC} / 60Hz, CH3 (Blue): V_{IN}, CH4 (Green): I_{IN}

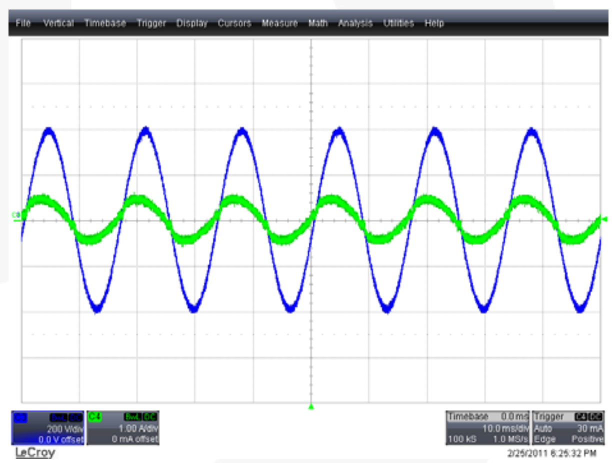

Figure 34. 277V_{AC} / 60Hz, CH3 (Blue): V_{IN} CH4 (Green): I_{IN}

Figure 35 through Figure 38 show the V_{DS} and I_{DS} waveform of the FET(PFC) on the board at different input voltage conditions.

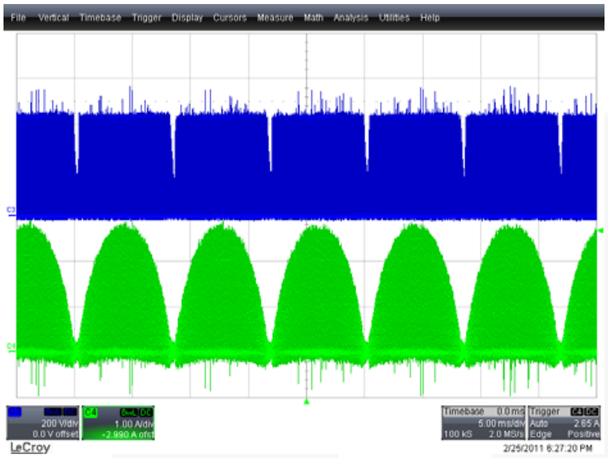

Figure 35. 90V_{AC} / 60Hz, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

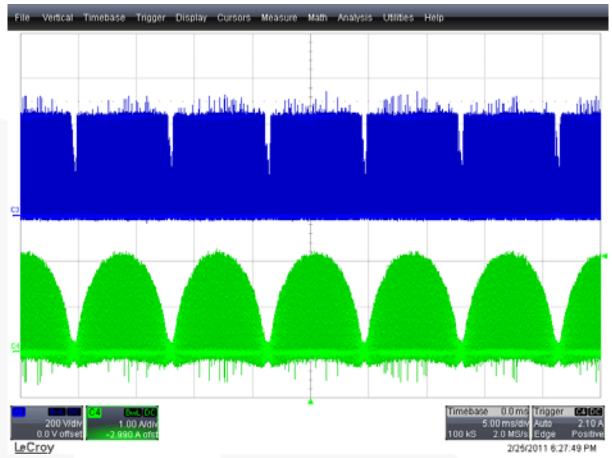

Figure 36. 115V_{AC} / 60Hz, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

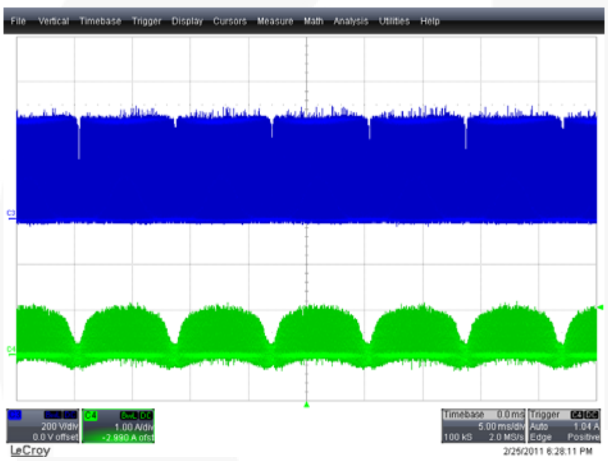

Figure 37. 230V_{AC} / 60Hz, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

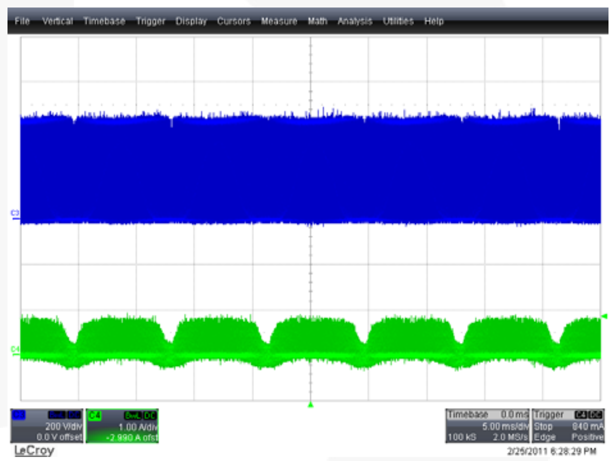

Figure 38. 277V_{AC} / 60Hz, CH3 (Blue): $V_{DS(PFC)}$, CH4 (Green): $I_{DS(PFC)}$

Normal Operation of MOSFET (QR)

Figure 39 and Figure 40 show the V_{DS} and I_{DS} waveforms of the MOSFET (QR) at different input voltage conditions.

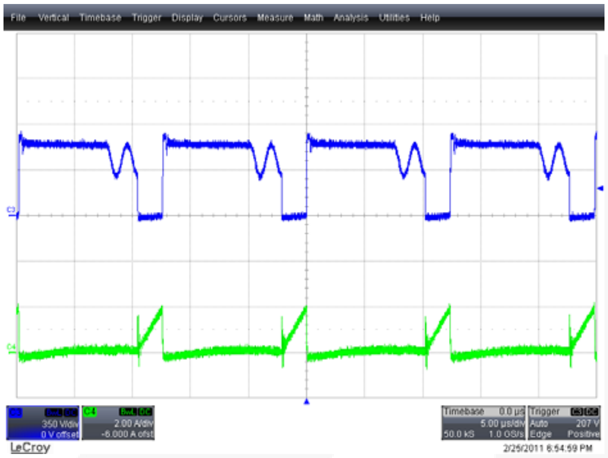

Figure 39. 90V_{AC} / 60Hz, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

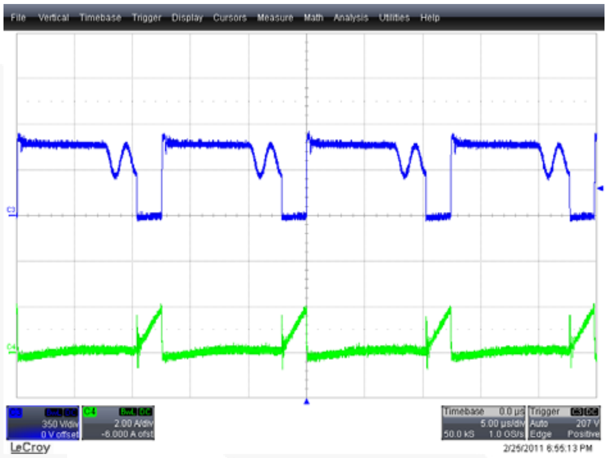

Figure 40. 277V_{AC} / 60Hz, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

Normal Operation of Rectifier

Figure 41 and Figure 42 show the V_{AK} and I_{AK} waveforms of the rectifier at different input voltage conditions.

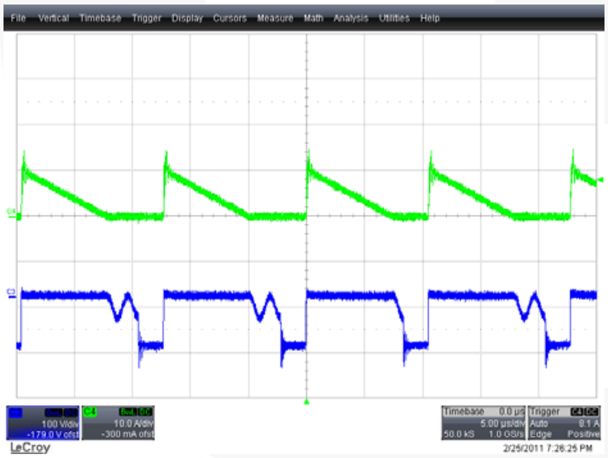

Figure 41. 90V_{AC} / 60Hz, CH3 (Blue): $V_{AK(Rectifier)}$, CH4 (Green): $I_{AC(Rectifier)}$

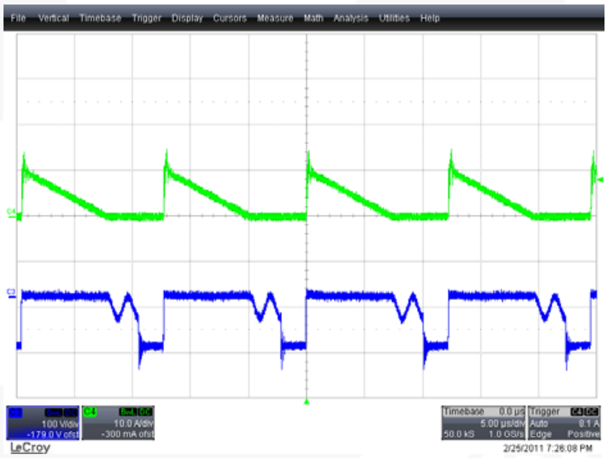

Figure 42. 277V_{AC} / 60Hz, CH3 (Blue): $V_{AK(Rectifier)}$, CH4 (Green): $I_{AC(Rectifier)}$

9.8. Short-Circuit Protection

Output-Short Protection

Figure 43 and Figure 44 show the V_{DS} and I_{DS} waveforms of the MOSFET (QR) at short-load condition. The IC repeats ON and OFF functions in this mode.

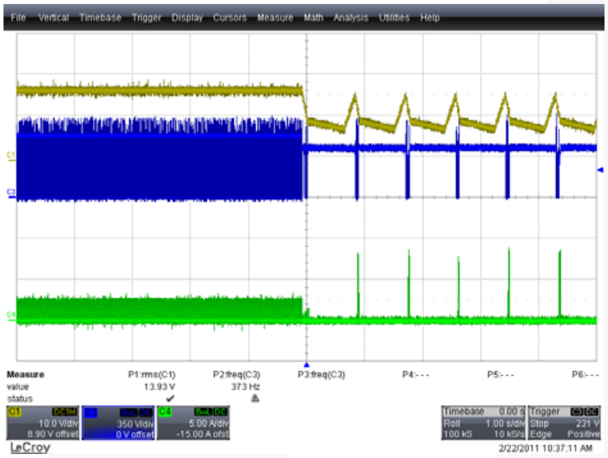

Figure 43. 90V_{AC} / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

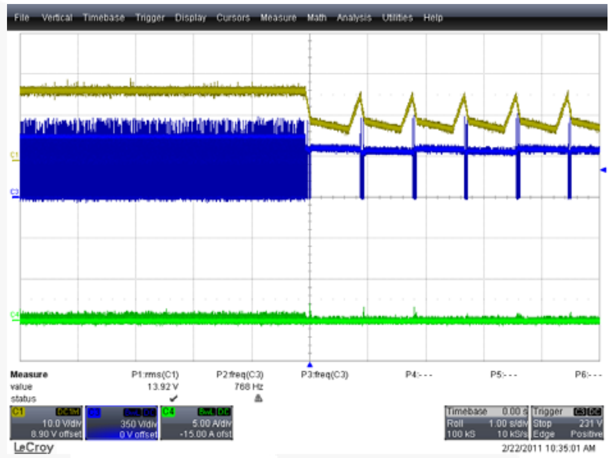

Figure 44. 277V_{AC} / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

Auto-Recovery Protection

Figure 45 and Figure 46 show the V_{DS} and I_{DS} waveforms of the MOSFET (QR) when short circuits at output load were removed.

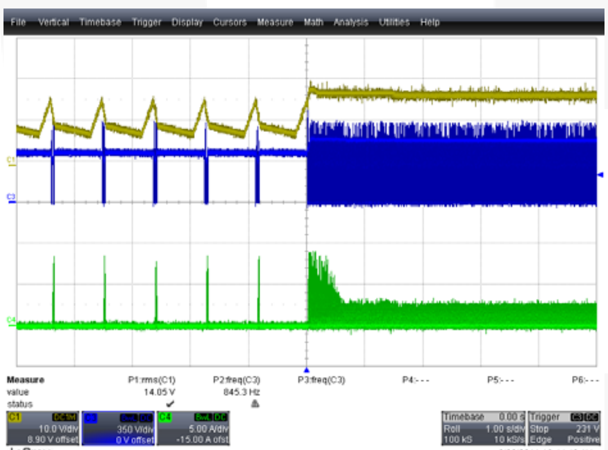

Figure 45. 90V_{AC} / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

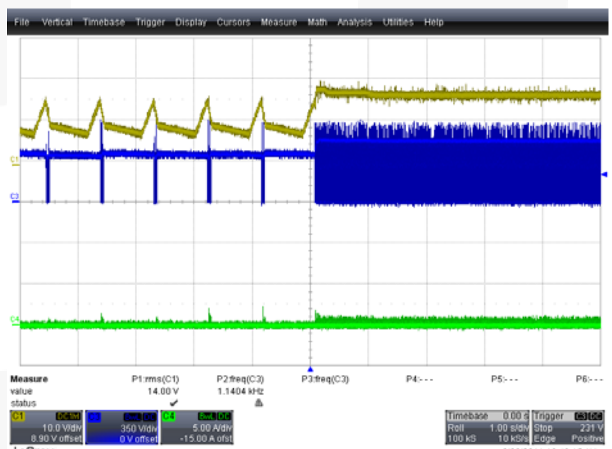

Figure 46. 277V_{AC} / 60Hz, CH1 (Yellow): $V_{CC(QR)}$, CH3 (Blue): $V_{DS(QR)}$, CH4 (Green): $I_{DS(QR)}$

9.9. Stress of the MOSFET & Rectifier

MOSFET Voltage Stress of PFC

Figure 47 through Figure 50 shows the voltage stress on the MOSFET of the PFC at startup time with rated load condition.

	90V_{AC} / 60Hz	**115V_{AC} / 60Hz**	**230V_{AC} / 60Hz**	**277V_{AC} / 60Hz**	**Remark**
MOSFET (V_{DS}) PFC	522V	511V	500V	476V	600V / 16A
MOSFET (I_{DS}) PFC	4.64A	4.10A	4.00A	1.20A	
MOSFET (V_{DS}) QR	686V	700V	686V	668V	800V / 8A
MOSFET (I_{DS}) QR	4.30A	4.18A	3.70A	3.62A	
Rectifier (V_{AK})	166V	164V	160V	162V	200V / 40A
Rectifier (I_{AK})	23.7A	26.4A	23.6A	23.7 A	

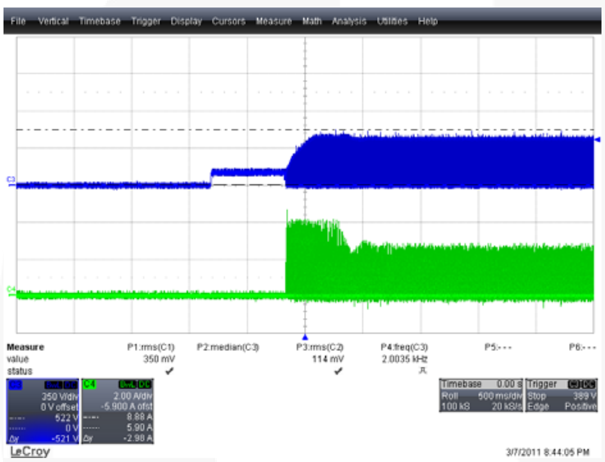

Figure 47. 90V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

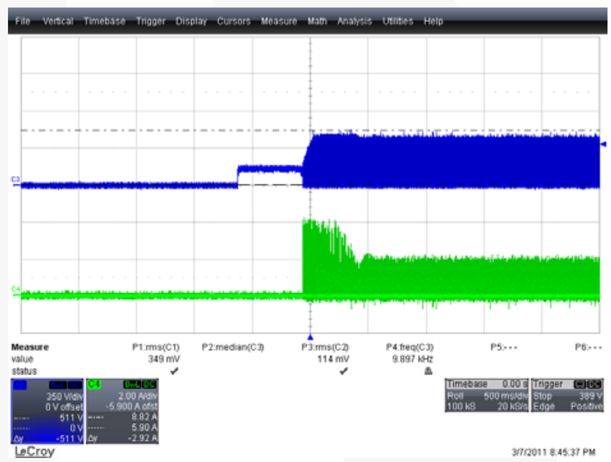

Figure 48. 115V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

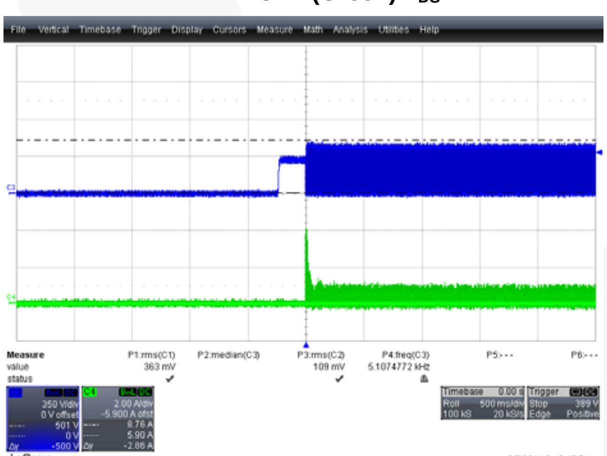

Figure 49. 230V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

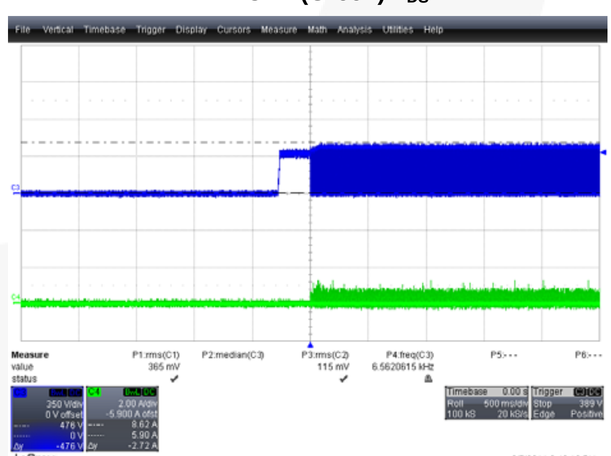

Figure 50. 277V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

Figure 51 through Figure 54 show the current stress on the MOSFET of PFC at startup time with the rated load condition.

Figure 51. 90V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

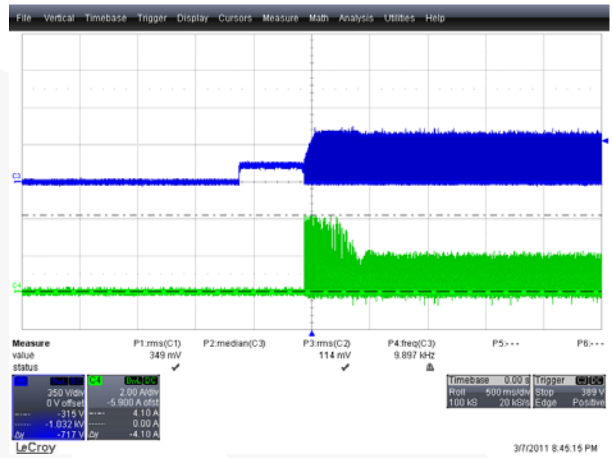

Figure 52. 115V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

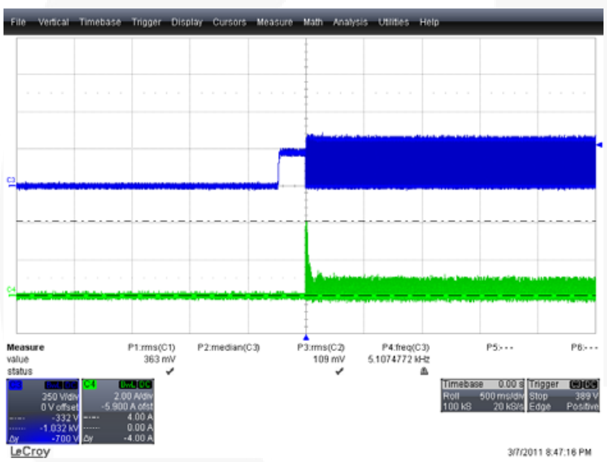

Figure 53. 230V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

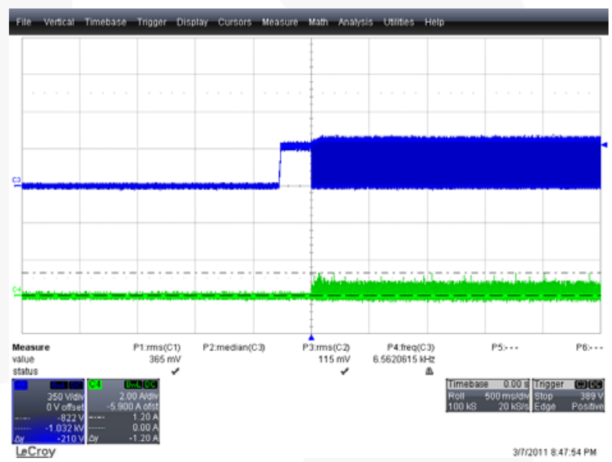

Figure 54. 277V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

MOSFET Voltage Stress of QR Flyback

Figure 55 through Figure 58 shows the voltage stress on the MOSFET of the QR flyback circuit at startup time with the rated load condition.

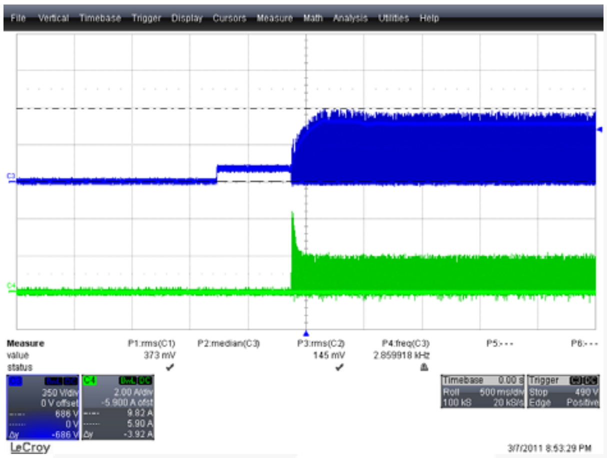

Figure 55. 90V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

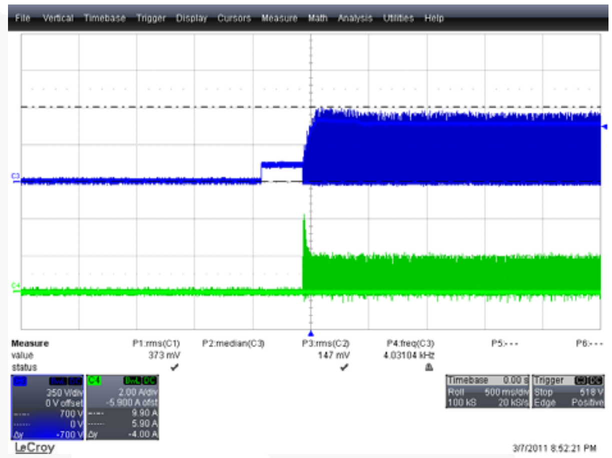

Figure 56. 115V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

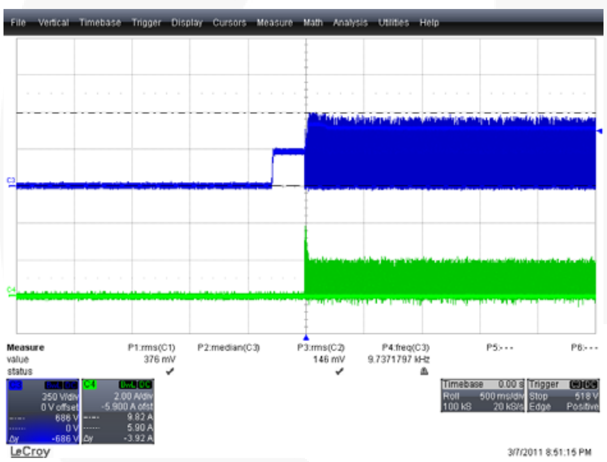

Figure 57. 230V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

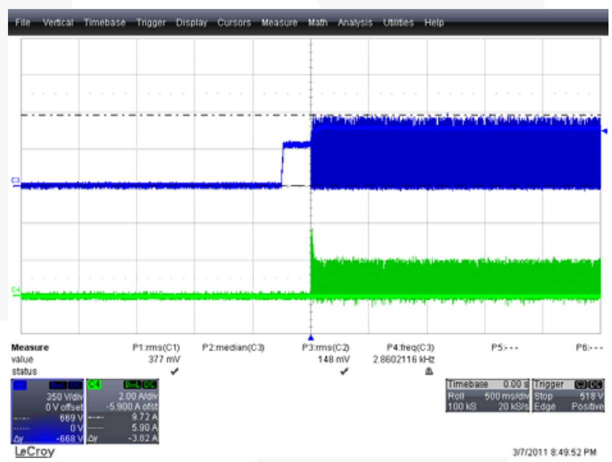

Figure 58. 277V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

Figure 59 through Figure 62 show the current stress on the MOSFET of the QR fyback circuit at startup time with rated load condition.

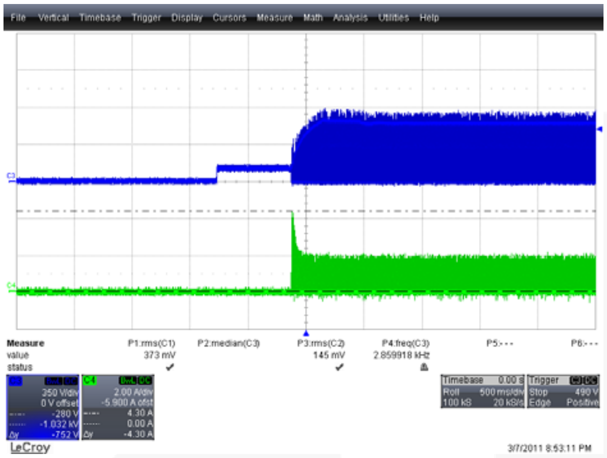

Figure 59. 90V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

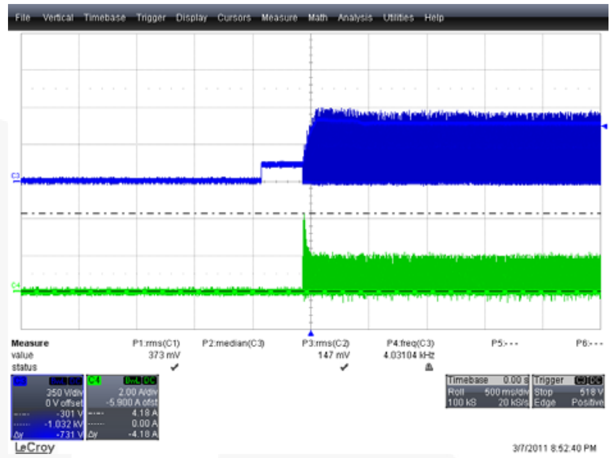

Figure 60. 115V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

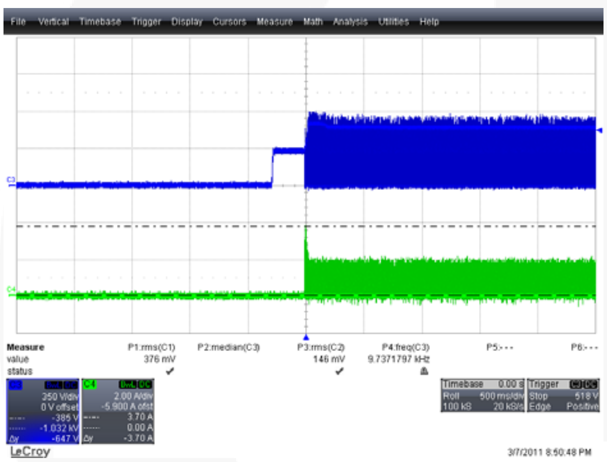

Figure 61. 230V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

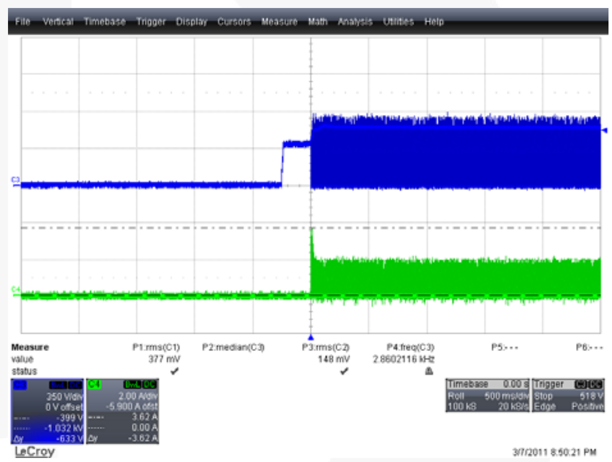

Figure 62. 277V_{AC} / 60Hz, CH3 (Blue): V_{DS}, CH4 (Green): I_{DS}

Rectifier Voltage Stress

Figure 63 through Figure 66 show the voltage stress on the output rectifier at startup time with the rated load condition.

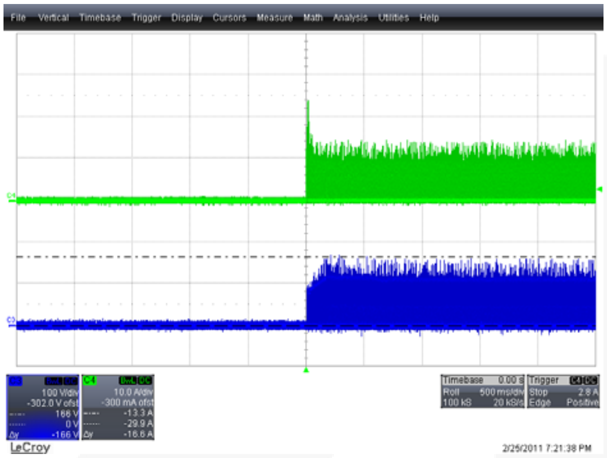

Figure 63. 90V_{AC} / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

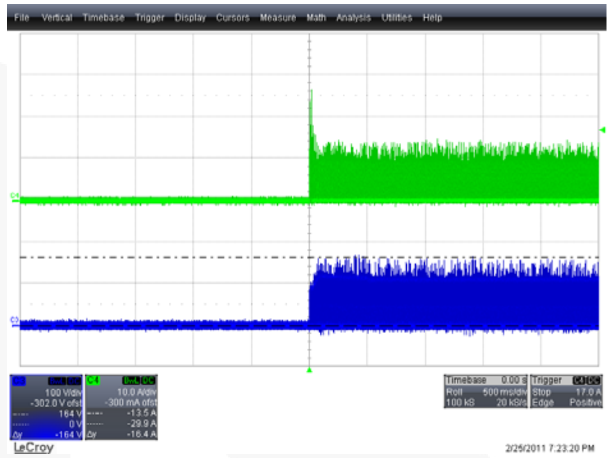

Figure 64. 115V_{AC} / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

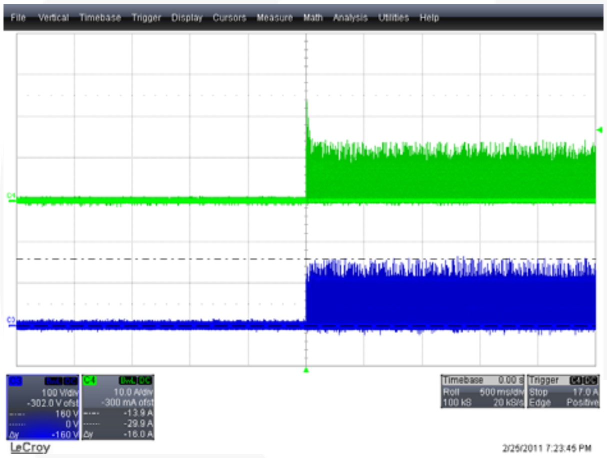

Figure 65. 230V_{AC} / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

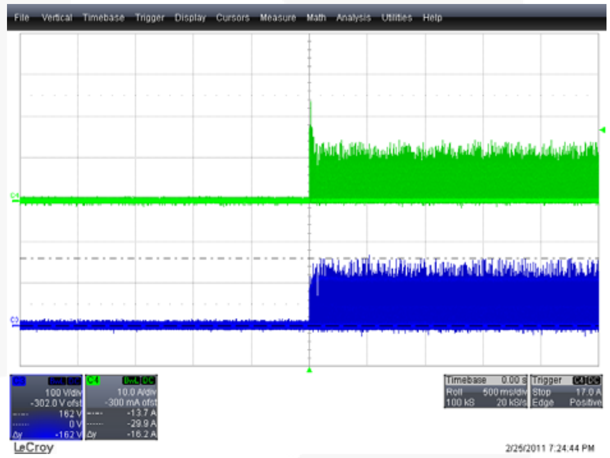

Figure 66. 277V_{AC} / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

Rectifier Current Stress

Figure 67 through Figure 70 show the current stress on the output rectifier at startup time under the rated load condition.

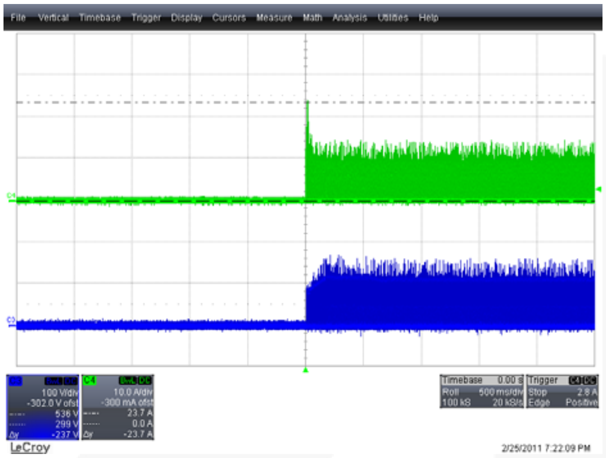

Figure 67. $90V_{AC}$ / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

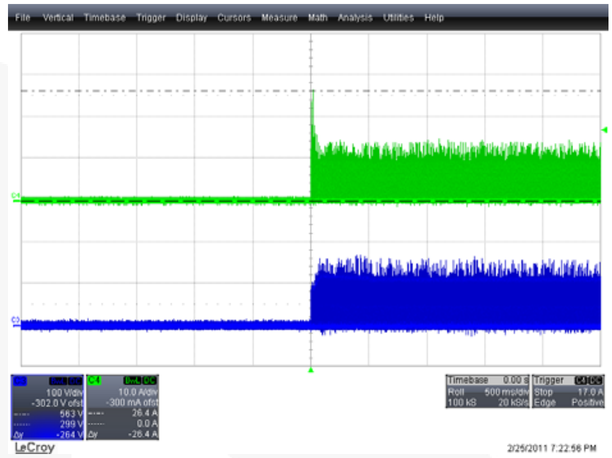

Figure 68. $115V_{AC}$ / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

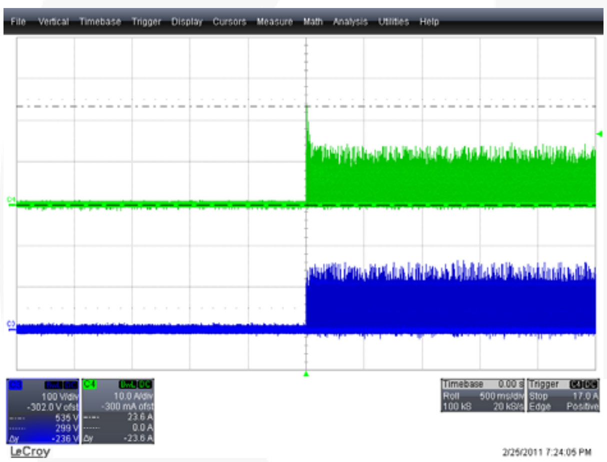

Figure 69. $230V_{AC}$ / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

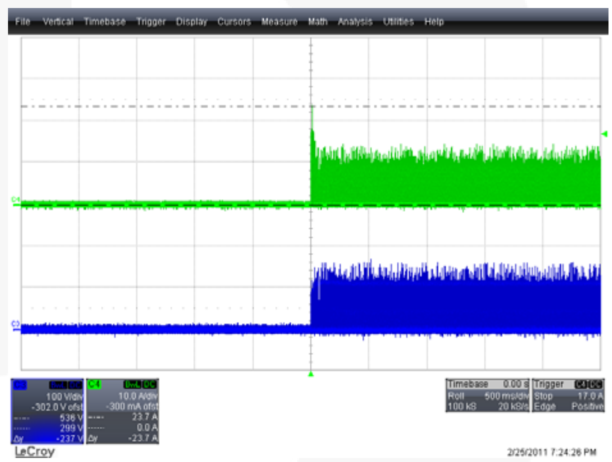

Figure 70. $277V_{AC}$ / 60Hz, CH3 (Blue): V_{AK}, CH4 (Green): I_{AK}

9.10. EMI Results

All measurements were conducted in observance of CISPR22 criteria.

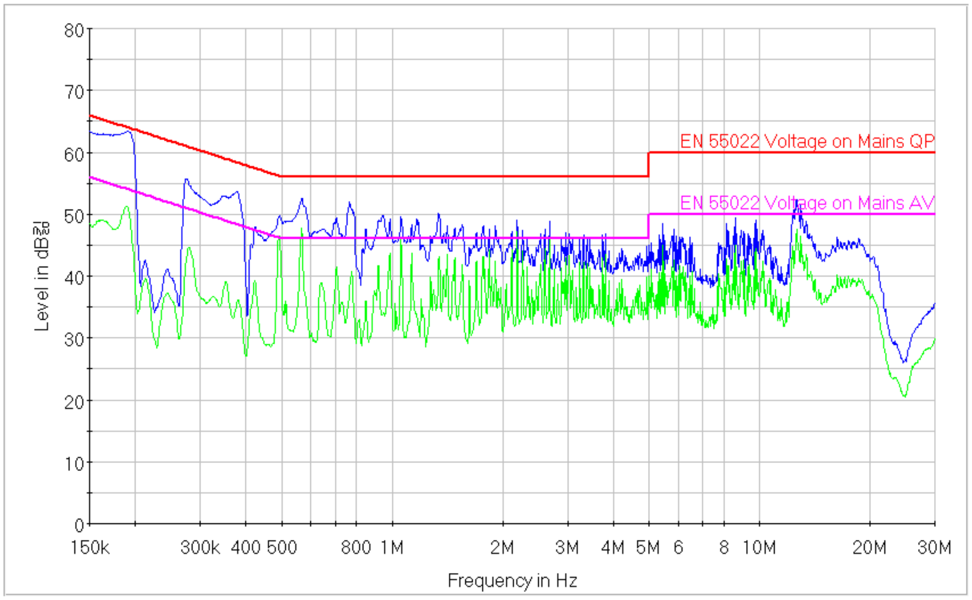

Figure 71. EMI Results
(Conducted Emission-Line at 220V_{AC}, Full-Load (24V/29.A))

10. Revision History

Rev.	Date	Description
1.0.0	May 2012	Initial Release

WARNING AND DISCLAIMER

Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Users' Guide. Contact an authorized Fairchild representative with any questions.

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