Fairchild Reference Design RD-570

The following reference design supports inclusion of FL7921R in design of LED illumination. It should be used in conjunction with the FL7921R datasheet and technical support team. Please visit Fairchild's website at www.fairchildsemi.com.

Application	Fairchild Device	Input Voltage Range	Rated Output Power	Output Voltage (Rated Current)	Topology
Smart Lamp	FL7921R	90-305 V_{AC}	100 W	50 V (2A)	CRM Boost PFC+ QR Flyback

Key Features

- Integrated PFC and Flyback Controller
- Critical-Mode PFC Controller
- Zero-Current Detection for PFC Stage
- Quasi-Resonant Operation for PWM Stage
- Internal Minimum tOFF 8 µs for QR PWM Stage
- Internal 10 ms Soft-Start for PWM
- High / Low Line Over-Power Compensation
- Auto Recovery Over-Current Protection
- Auto Recovery Open-Loop Protection
- Auto Recovery Over-Temperature Protection
- Adjustable Over-Temperature with external NTC through the RT pin
- Auto Recovery VDD Pin and Output Voltage OVP

1. Schematics

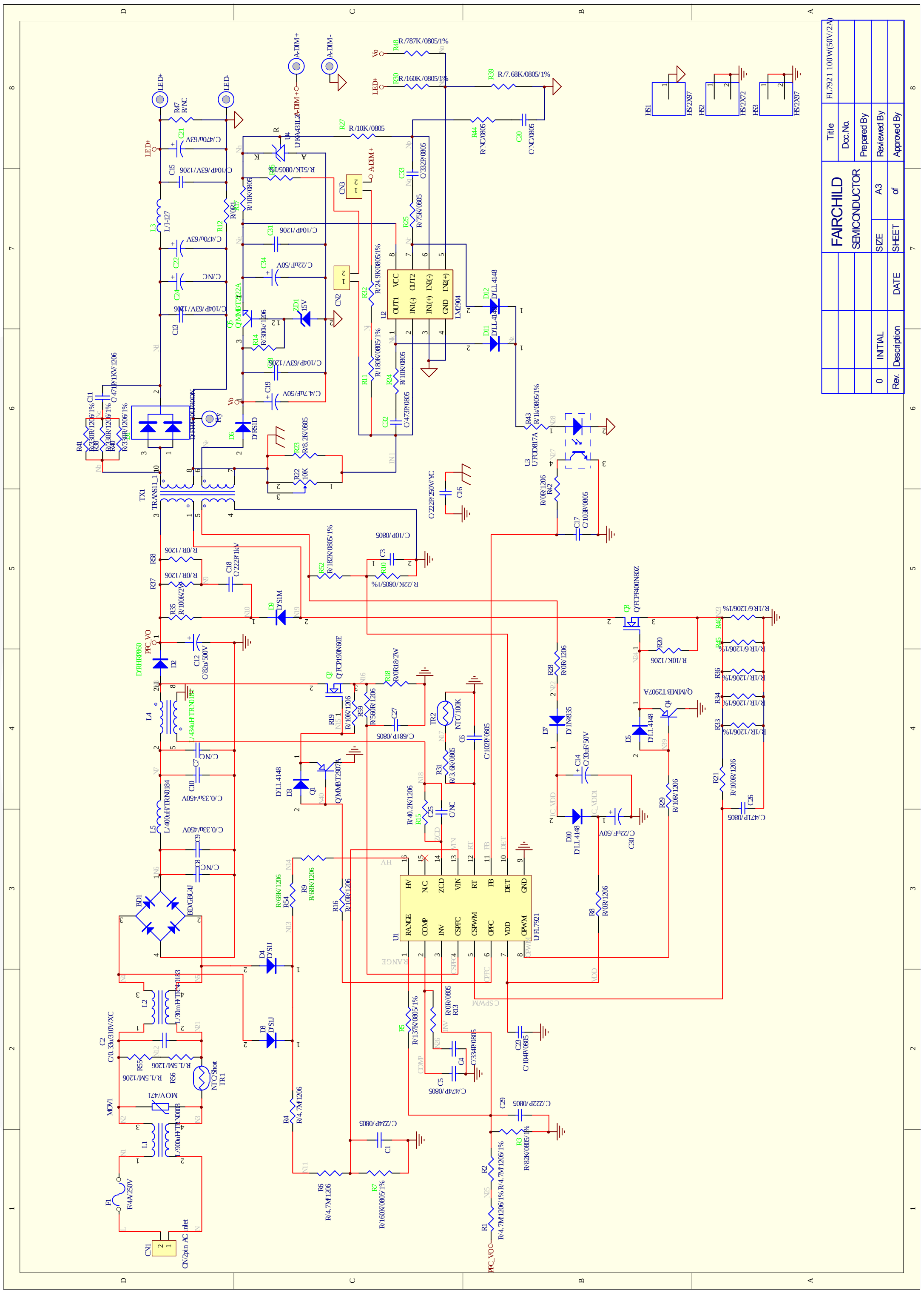

Figure 1. Schematic

2. Transformer

2.1. Flyback Transformer

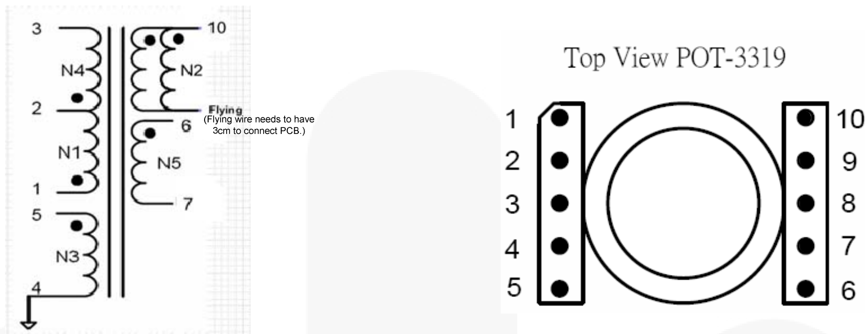

Figure 2. Transformer Specifications & Construction

2.2. Winding Specification

	Pin (S → F)	Wire	Turns	Winding Method
N1	1 → 2	0.32 φ×1	24	Solenoid Winding
Insulation: Polyester Tape t = 0.025 mm, 2-Layer E1 Shield: 0.025 mm × 7 mm, 0.9 turns, one end should be connected to pin 4 Insulation: Polyester Tape t = 0.025 mm, 2-Layer				
N2	10 → Flying	0.4 φ×1 (Triple insulation wire)	16	Solenoid Winding
Insulation: Polyester Tape t = 0.025 mm, 1-Layer				
N2	10 → Flying	0.4 φ×1 (Triple insulation wire)	16	Solenoid Winding
Insulation: Polyester Tape t = 0.025 mm, 2-Layer E1 Shield: 0.025 mm × 7 mm, 0.9 turns, one end should be connected to pin 4 Insulation: Polyester Tape t = 0.025 mm, 2-Layer				
N4	2 → 3	0.32 φ×1	24	Solenoid Winding
Insulation: Polyester Tape t = 0.025 mm, 2-Layer				
N3	5 → 4	0.3 φ×1	6	Solenoid Winding (To wind distribution evenly across the full winding width.)
Insulation: Polyester Tape t = 0.025 mm, 2-Layer				
N5	6 → 7	0.3 φ×1 (Triple insulation wire)	8	Solenoid Winding (To wind distribution evenly across the full winding width.)
Insulation: Polyester Tape t = 0.025 mm, 3-Layer				

Core: POT3319

Bobbin: POT3319 (10 Pins)

2.3. Electrical Characteristics

	Pin	Specification	Remark
Primary-Side Inductance	1 – 3	887 μH ± 5%	100 kHz, 1 V
Primary-Side leakage Inductance	1 – 3	8 μH ± 5%	Short One of the Secondary Windings

2.4. Boost Inductor

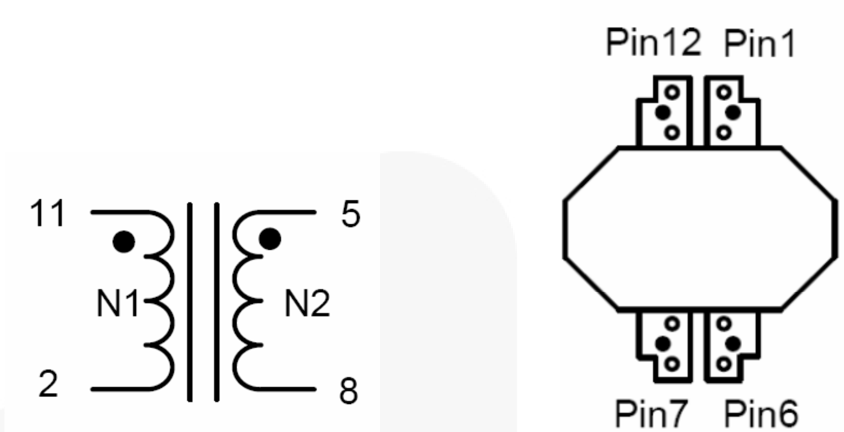

Figure 3. Transformer Specifications & Construction

2.5. Winding Specification

No	Pin (S - F)	Wire	Turns	Winding Method
N_1	11→2	0.1 Φ ×35	45 Ts	Solenoid Winding
Insulation: Mylar® Tape t = 0.03 mm, 2-Layer				
N2	5→8	0.35 Φ×1	6 Ts	Solenoid Winding (To wind distribution evenly across the full winding width.)
Insulation: Mylar® Tape t = 0.03 mm, 2-Layer Core RM-10 1.2T Closed loop shielding to PIN8 Insulation: Mylar® Tape t = 0.03 mm, 2-Layer				

Core: RM10

Bobbin: RM10 (12 Pins, only keep useful 4 pins)

2.6. Electrical Characteristics

	Pin	Specification	Remark
Primary-Side Inductance	2 – 11	434 μH ± 5%	100 kHz, 1 V

3. Bill of Materials

Table 1. BOM for Reference Design

Item No.	Reference No.	Part Number	Qty.	Description	Manufacturer
1	R13	RP0805T 0000	1	0 Ω ±5%, 0805 SMD Resistor	Taiwan Resistor
2	R39	RP0805T 7681	1	7.68 kΩ ±-1%, 0805 SMD Resistor	Taiwan Resistor
3	R31	RP0805T 3601	1	3.6 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
4	R43	RP0805T 1001	1	1 kΩ ±5%, 0805 SMD Resistor	Taiwan Resistor
5	R23	RP0805T 8201	1	8.2 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
6	R17, R24, R27	RP0805T 1002	3	10 kΩ ±5%, 0805 SMD Resistor	Taiwan Resistor
7	R10	RP0805T 2202	1	22 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
8	R32	RP0805T 2492	1	24.9 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
9	R26	RP0805T 5102	1	51 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
10	R25	RP0805T 7502	1	75 kΩ ±5%, 0805 SMD Resistor	Taiwan Resistor
11	R3	RP0805T 8202	1	82 Ω ±1%, 0805 SMD Resistor	Taiwan Resistor
12	R5	RP0805T 1373	1	137 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
13	R7, R30	RP0805T 1603	2	160 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
14	R11	RP0805T 1803	1	180 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
15	R48	RP0805T 7873	1	787 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
16	R52	RP0805T 1823	1	182 kΩ ±1%, 0805 SMD Resistor	Taiwan Resistor
17	R8, R28, R37, R42, R58	RP1206T 0000	5	0 Ω ±5%, 1206 SMD Resistor	Taiwan Resistor
18	R45, R46	RP1206T 1R6	2	1.6 Ω ±5%, 1206 SMD Resistor	Taiwan Resistor
19	R33, R34, R36	RP1206T 1R	3	1 Ω ±5%, 1206 SMD Resistor	Taiwan Resistor
20	R16, R29	RP1206T 10R	2	10 Ω ±5%, 1206 SMD Resistor	Taiwan Resistor
21	R38, R40, R41	RP1206T 3300	3	330 Ω ±5%, 1206 SMD Resistor	Taiwan Resistor
22	R21	RP1206T 1000	1	100 Ω ±5%, 1206 SMD Resistor	Taiwan Resistor
23	R59	RP1206T 5600	1	560 Ω ±1%, 1206 SMD Resistor	Taiwan Resistor
24	R19, R20	RP1206T 1002	2	10 kΩ ±5%, 1206 SMD Resistor	Taiwan Resistor
25	R14	RP1206T 3003	1	300 kΩ ±5%, 1206 SMD Resistor	Taiwan Resistor
26	R15	RP1206T 4022	1	40.2 kΩ ±5%, 1206 SMD Resistor	Taiwan Resistor
27	R9, R54	RP1206T 6802	2	68 kΩ ±5%, 1206 SMD Resistor	Taiwan Resistor
28	R55, R56	RP1206T 1504	2	1.5 MΩ ±1%, 1206 SMD Resistor	Taiwan Resistor
29	R1, R2, R4, R6	RP1206T 4704	4	4.7 MΩ ±5%, 1206 SMD Resistor	Taiwan Resistor
30	C3	MLCC100K050B	1	10 pF / 50 V ±10% X7R	Taiwan Resistor

Bill of Materials (Continued)

Item No.	Reference No.	Part Number	Qty.	Description	Manufacturer
31	C6	MLCC102K050B	1	1 nF / 50 V ±10% X7R	Taiwan Resistor
32	C17	MLCC103K050B	1	10 nF / 50 V ±10% X7R	Taiwan Resistor
33	C23	MLCC104K050B	1	100 nF / 50 V ±10% X7R	Taiwan Resistor
34	C29	MLCC222K050B	1	2.2 nF / 50 V ±10% X7R	Taiwan Resistor
35	C1	MLCC224K050B	1	220 nF / 50 V ±10% X7R	Taiwan Resistor
36	C33	MLCC332K050B	1	3.3 nF / 50 V ±10% X7R	Taiwan Resistor
37	C4	MLCC334K050B	1	330 nF / 50 V ±10% X7R	Taiwan Resistor
38	C26	MLCC471K050B	1	470 pF / 50 V ±10% X7R	Taiwan Resistor
39	C27	MLCC681K050B	1	680 pF / 50 V ±10% X7R	Taiwan Resistor
40	C32	MLCC473K050B	1	47 nF / 50 V ±10% X7R	Taiwan Resistor
41	C5	MLCC474K050B	1	470 nF / 50 V ±10% X7R	Taiwan Resistor
42	C15, C28, C13	MLCC104K100B	3	100 nF / 100 V ±10% X7R	Taiwan Resistor
43	C31	MLCC104K050B	1	100 nF / 50 V ±10% X7R	Taiwan Resistor
44	C11	MLCC471K102B	1	470 pF / 1 kV ±10% X7R	Taiwan Resistor
45	C18	MLCC222K102B	1	2.2 nF /1 kV ±10% X7R	Taiwan Resistor
46	R22		1	1/4"TOP 10 kΩ, Variable Resistor	Taiwan Resistor
47	R12	MPR 5W 0Ω1J	1	0Ω1 5 W	Tzai Yuan
48	R18	CR-200 0Ω18J	1	2 W, 0.18 Ω ±5%, DIP Resistor	Taiwan Resistor
49	R35	CR-200 R1003	1	2 W, 100 kΩ ±5%, DIP Resistor	Taiwan Resistor
50	MOV1	MOV471KD10SBNL	1	10 ψ 470 V	UNIT-TEEK
51	TR2	TTC105104KSY	1	5 ψ 100 kΩ	Thinking
52	C2	PX334K2WD32	1	330 nF / 310 V, X2 Capacitor	Kenjet
53	C9, C10	MTF334	2	0.33 µF / 450 V ±10%, MTF Capacitor	Kenjet
54	C16	E2GA222MYASA	1	2.2 nF / 250 V ±20%, Y1 Capacitor	WYX
55	C19	LHK 4.7 µF/ 50 V	1	4.7 µF / 50 V 105°C 5*11 mm, Electrolytic Capacitor	JACKCON
56	C22, C21	L-ESR 470 µF/ 63 V	2	470 µF / 63 V 105°C 13*21 mm L-, Electrolytic Capacitor	JACKCON
57	C30, C34	LHK 22 µF/ 50 V	2	22 µF / 50 V 105°C 5*11 mm, Electrolytic Capacitor	JACKCON
58	C12	RD 82 µF/ 500 V	1	82 µF / 500 V 105°C 18*45 mm RD, Electrolytic Capacitor	SAMXON
59	C14	LHK 33 µF/ 50 V	1	33 µF / 50 V 105°C 5*11 mm LHK, Electrolytic Capacitor	JACKCON
60	TX1	I-129	1	POT33 887 µH SUMIDA PS13-150, Transformer	SUMIDA
61	L4	I-130	1	RM-10, 434 µH PS15-146, Inductor	勝輝

Bill of Materials (Continued)

Item No.	Reference No.	Part Number	Qty.	Description	Manufacturer
62	L2	TRN0183	1	T18X10X10 L=30 mH	勝輝
63	L5	TRN0184	1	T6026 L=400 µH	勝輝
64	L1	TRN0003	1	L1=L2=900 µH	勝輝
65	L3	WURTH 7447452100	1	WURTH 7447452100 10 µH	WURTH
66	ZD1	MMSZ5245B	1	15 V,0.5 W SOD-123, Zener	Fairchild
67	BD1	GBU4J	1	VRRM=600 V; IF @100°C=4 A, Bridge Rectifier	Fairchild
68	D7	1N4935	1	1 A / 200 V	Fairchild
69	D1	FFPF20UP30DNTU	1	20 A, 300 V	Fairchild
70	D3, D5, D10, D11, D12	LL4148	5	200 mA / 100 V	Fairchild
71	D2	RHRP860	1	8 A / 400 V	Fairchild
72	D6	RS1D (代FR103)	1	1 A / 200 V	Fairchild
73	D4, D8	S1J	2	1 A / 600 V	Fairchild
74	D9	S1M	1	1 A / 1000 V	Fairchild
75	Q2	FCP190N60E	1	600 V, 20.6 A, 190 mΩ	Fairchild
76	Q3	FCPF400N80Z	1	800 V, 11 A, 400 mΩ	Fairchild
77	Q5	MMBT2222A	1	NPN General Purpose Amplifier	Fairchild
78	Q1, Q4	MMBT2907A	2	PNP General Purpose Amplifier	Fairchild
79	U2	LM2904MX	1	SOP-8	Fairchild
80	U1	IC Controller FL7921RMX	1	SOP-16 IC	Fairchild
81	U3	FOD817A	1	Current Transfer Ratio :80–160%	Fairchild
82	U4	KA431LZTA	1	Adjustable/2.5 V, 0.5%	Fairchild
83	CN1	INLET 2P 90°	1	R-201SN90(B06)	RICH BAY
84	CN2,CN3	PIN HDR 2*2P 2.54 mm 180°	1	2.54 mm 180°	MOST WELL
85	CN2	JUMPER	1	6 mm CLOSE	T&A
86	F1	FUSE GLASS 250V4A SLOWELY	1	3.6*10 36ES	SLEEK
87	HS1	HEAT SINK MCH0090	1	61-10176-1Z	HTC
88	HS2	HEAT SINK MCH0666	1	47.5 x 20 x 3 mm	LONG TENG FENG
89	HS3	HEAT SINK MCH0667	1	70 x 20 x 3 mm	LONG TENG FENG
90	LED+, LED-	SG004-05 Pin ψ2.2*18.2 mm OEM-10	2		KANG YANG
91	A-DIM+, A-DIM-	TEST PIN	2		KANG YANG
92	PCB	PCB PLM0338V2	1		SK

4. Performance

4.1. System Efficiency and No Load Power Consumption

System Efficiency

Figure 4 and Table 2 are the system efficiency curve and the data measured over whole line voltages at two output voltage conditions [47 V / 27 V] that LEDs can be connected with the maximum and minimum numbers.

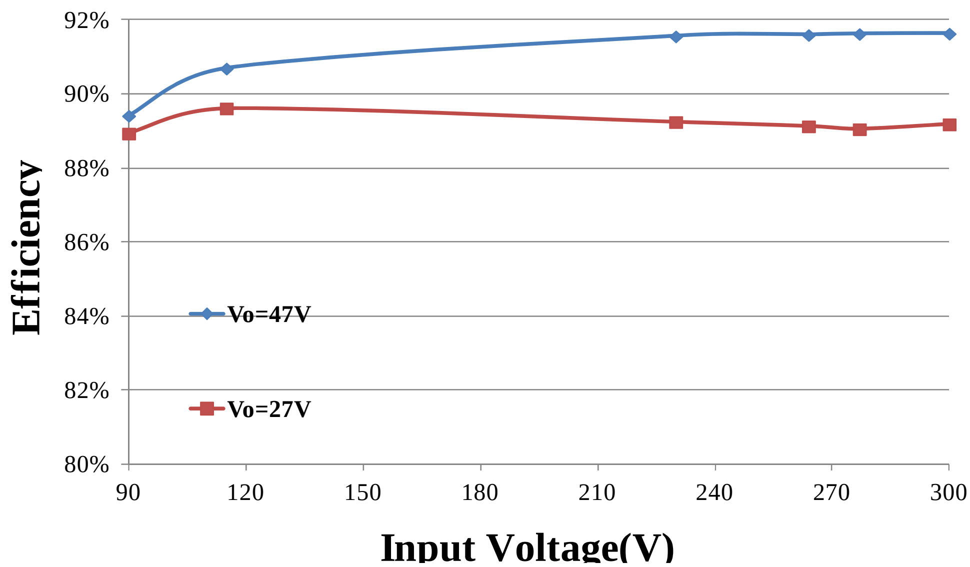

Figure 4. System Efficiency

Table 2. Test Results

Output Voltage	Input Voltage					
	90 V_{AC} 60 Hz	115 V_{AC} 60 Hz	230 V_{AC} 50 Hz	264 V_{AC} 50 Hz	277 V_{AC} 50 Hz	300 V_{AC} 50 Hz
47 V	89.41%	90.69%	91.56%	91.59%	91.62%	91.63%
27 V	88.93%	89.61%	89.24%	89.12%	89.05%	89.18%

No Load Power Consumption

Table 3 shows the results of the system power consumptions measured over whole line inputs at no load condition. The power loss shows less than 0.5 W whole line inputs.

Table 3. Test Result

Input Voltage	Input Power (mW)	Output Voltage (V)
90 V_{AC} / 60 Hz	320	50.28
115 V_{AC} / 60 Hz	292	50.28
230 V_{AC} / 50 Hz	322	50.33
264 V_{AC} / 50 Hz	322	50.33
277 V_{AC} / 50 Hz	322	50.33
300 V_{AC} / 50 Hz	325	50.33

4.2. Power Factor (PF) and Total Harmonic Distortion (THD)

Figure 5 and Table 4 show PF and THD performance measured over whole line voltages at two output voltage conditions [47 V / 27 V] that LEDs can be connected with the maximum and minimum numbers. PF can beyond 0.9 and THD can be less than 30% in whole input lines although min LED numbers are connected.

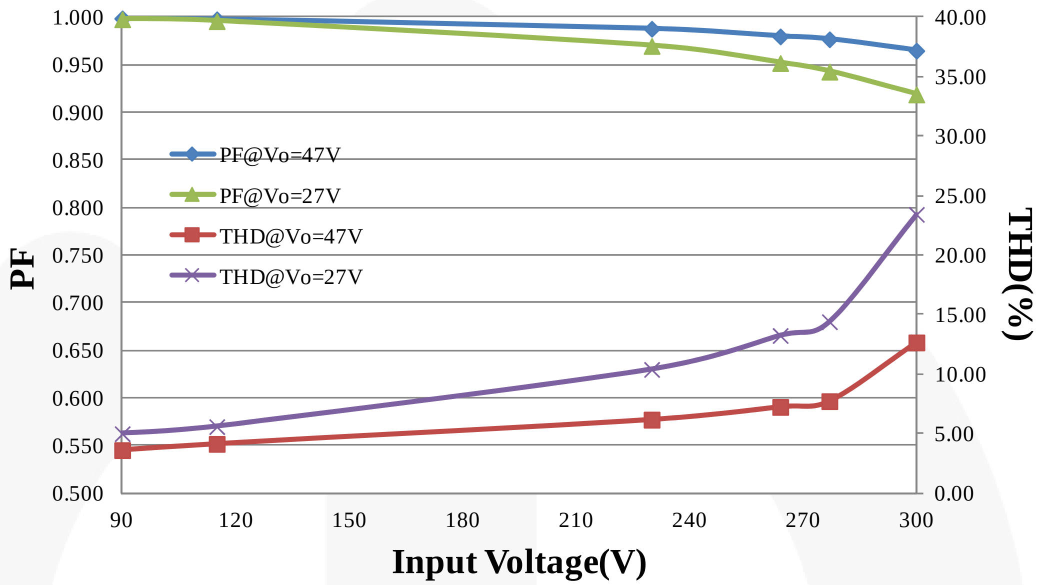

Figure 5. PF and THD

Table 4. Test Results

Input Voltage		**Output Voltage** V_O=47 V	**Output Voltage** V_O=27 V
90 V_{AC} / 60 Hz	PF	0.999	0.998
	THD (%)	3.63	5.01
115 V_{AC} / 60 Hz	PF	0.998	0.996
	THD (%)	4.15	5.60
230 V_{AC} / 50 Hz	PF	0.988	0.970
	THD (%)	6.19	10.41
264 V_{AC} / 50 Hz	PF	0.980	0.952
	THD (%)	7.26	13.26
277 V_{AC} / 50 Hz	PF	0.977	0.944
	THD (%)	7.74	14.42
300 V_{AC} / 50 Hz	PF	0.965	0.919
	THD (%)	12.68	23.44

4.3. Harmonics Performance Analysis

Figure 6 through Figure 9 show results measured per current harmonic order in each line voltage (90 V_{AC} and 277 V_{AC}) and two output voltage conditions (47 V / 27 V) that LEDs can be connected with the maximum and minimum numbers.

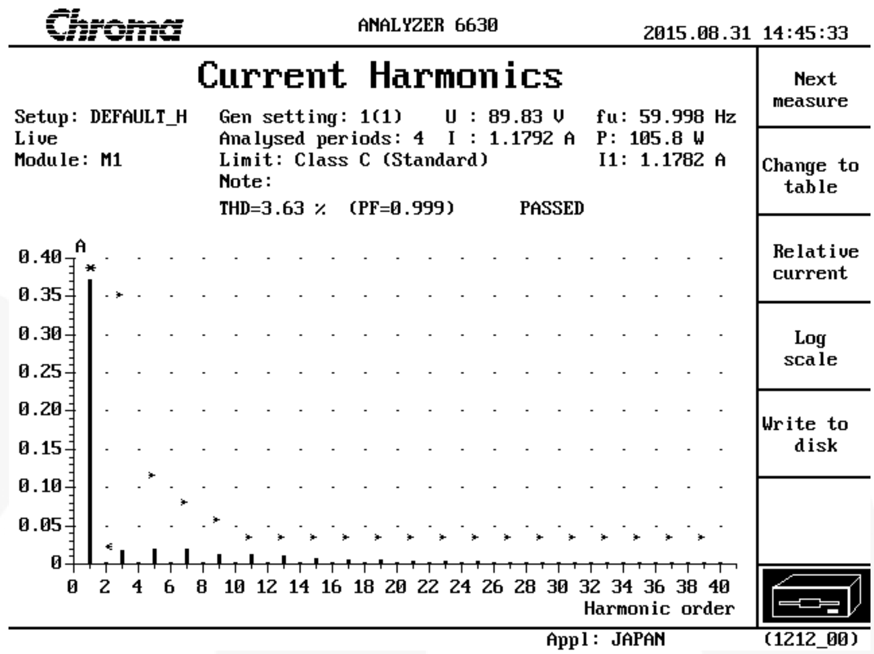

Figure 6. Harmonic Performance Results at 90 V_{AC} and V_O=47 V

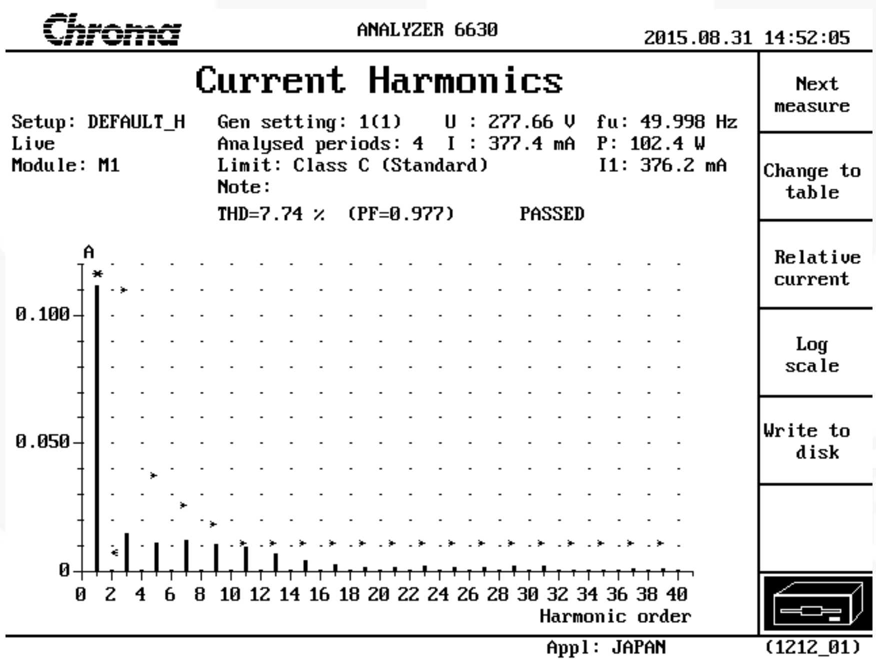

Figure 7. Harmonic Performance Results at 277 V_{AC} and V_O=47 V

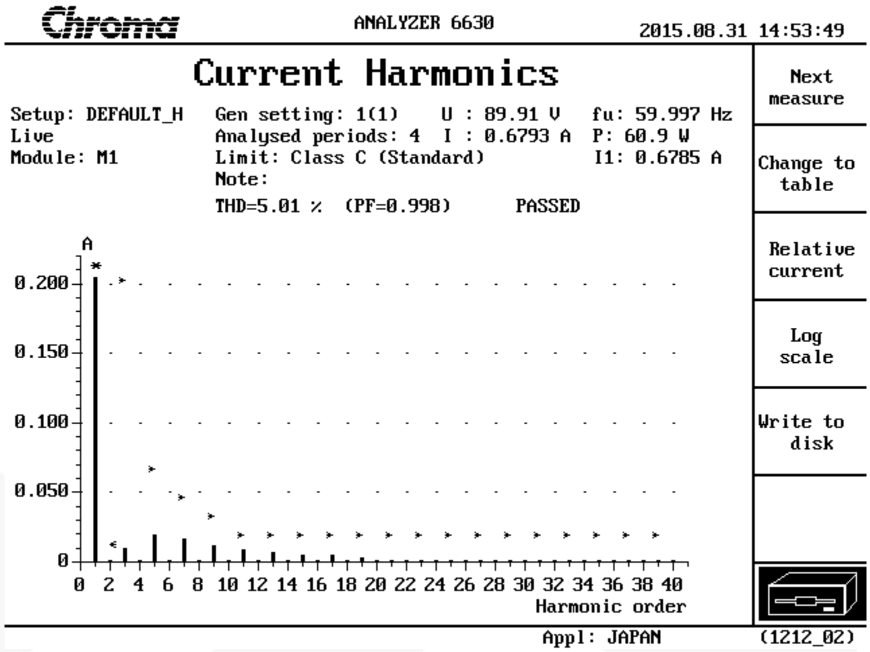

Figure 8. Harmonic Performance Results at 90 V_{AC} and V_O=27 V

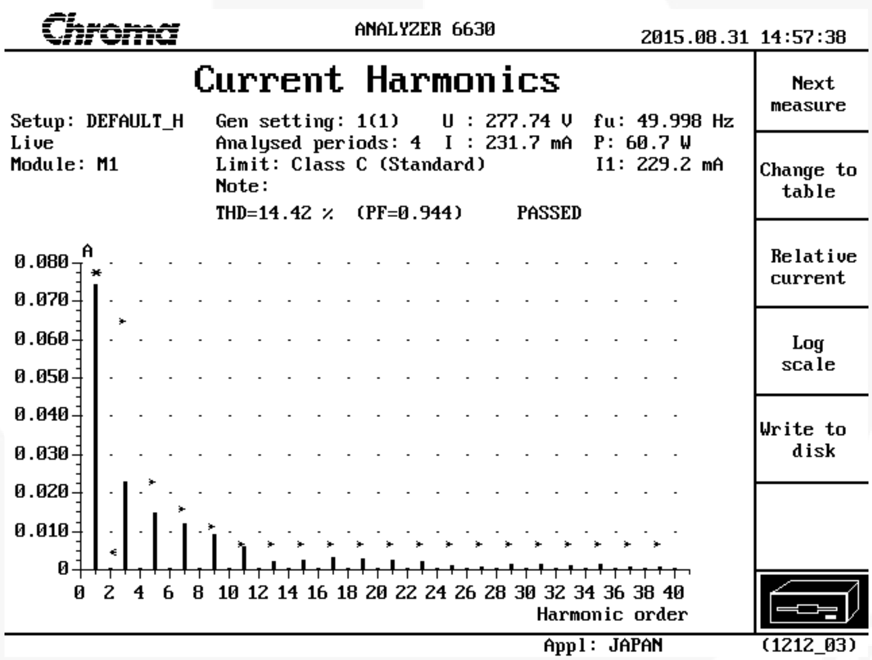

Figure 9. Harmonic Performance Results at 277 V_{AC} and V_O=27 V

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

CC and CV tolerance over whole input line voltages and wide output voltage ranges are less ±1% and ±3% as shown respectively in Table 5 and Table 6. Figure 10 shows the typical CC / CV graph with very stable performance and it was measured using electronic load with CR mode at each line voltage from 90 V_{AC} to 300 V_{AC}.

Table 5. CC Test Results

Input Voltage	Min. Current (mA)	Max. Current (mA)	Tolerance	Remark
90 V_{AC} / 60 Hz	2003.44	2008.13	±0.12%	< ±1%
115 V_{AC} / 60 Hz	2004.38	2007.19	±0.07%	
230 V_{AC} / 50 Hz	2003.44	2007.19	±0.09%	
277 V_{AC} / 50 Hz	2003.44	2007.19	±0.09%	
300 V_{AC} / 50 Hz	2003.44	2007.19	±0.09%	
Total	2003.44	2008.13	±0.12%	

Table 6. CV Test Results

Input Voltage	Min. Voltage (V)	Max. Voltage (V)	Tolerance	Remark
90 V_{AC} / 60 Hz	48.27	50.12	±1.88%	< ±3%
115 V_{AC} / 60 Hz	48.27	50.35	±2.11%	
230 V_{AC} / 50 Hz	47.86	50.39	±2.58%	
277 V_{AC} / 50 Hz	48.49	50.36	±1.89%	
300 V_{AC} / 50 Hz	48.50	50.40	±1.92%	
Total	47.86	50.40	±2.58%	

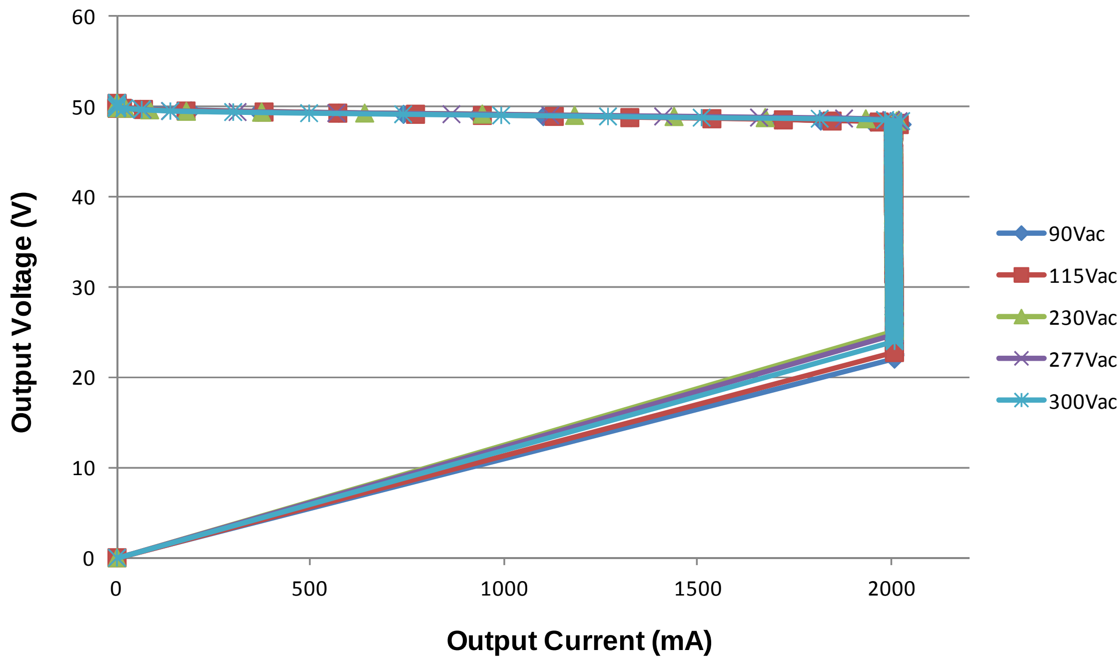

Figure 10. CC / CV Performance

4.5. Analog Dimming

Figure 11 and Table 7 show dimming curve and output current measured according to 0 to 10 V applied. In demo board, analog dimming function can be implemented simply by adjusting reference voltage in current regulation feedback circuits so that analog dimming signal coming from 0 to 10 V dimmer can be connected directly in secondary side as shown in Figure 12. The output current can be adjusted within the range of 0%~100% at rated input line voltage and output voltage.

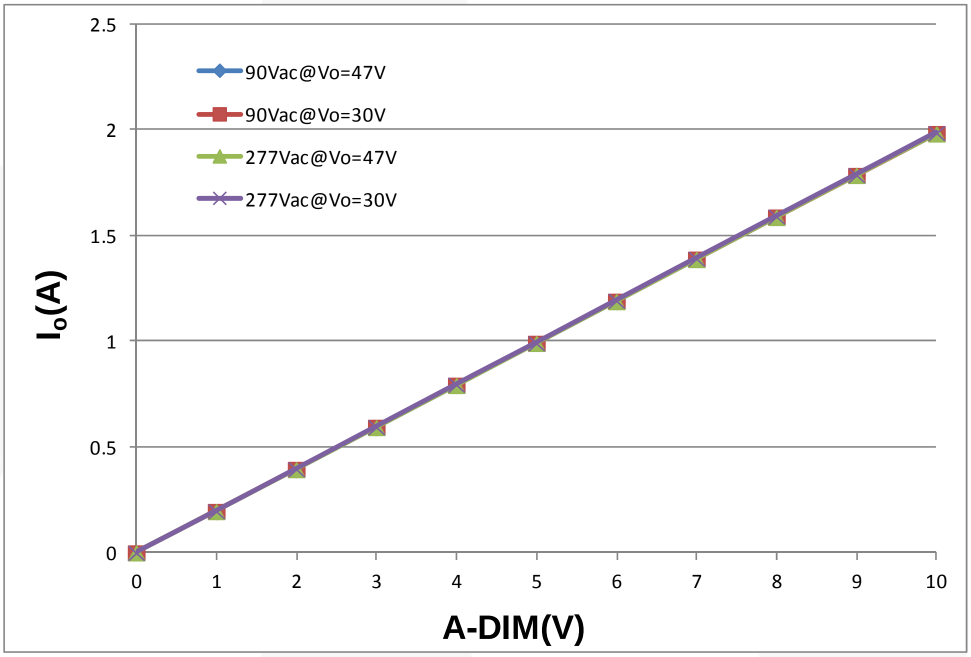

Figure 11. Analog Dimming Curve

Table 7. Output Current according to A-DIM

	V_{IN} (V_{AC})	V_{OUT} (V)	A-DIM (V)										
			0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Output Current (A)	**90**	**47**	0.000	0.195	0.393	0.592	0.791	0.990	1.188	1.387	1.586	1.785	1.981
		30	0.000	0.196	0.395	0.594	0.793	0.991	1.190	1.389	1.588	1.785	1.983
	277	**47**	0.000	0.195	0.393	0.592	0.791	0.990	1.188	1.387	1.586	1.785	1.981
		30	0.000	0.196	0.395	0.594	0.795	0.991	1.192	1.391	1.590	1.786	1.985

External Circuit for Analog Dimming

Output current can be changed by adjusting the reference voltage level of op-amp. On demo board, jumper should be moved from CN2 to CN3 and 0 to 10 V signal should be connected to A-DIM+. The output current formula show as below:

$$I_o = \frac{R_{cc2} \times V_{DIM+}}{R_{cc1} \times R_{cc.sen}} \quad (1)$$

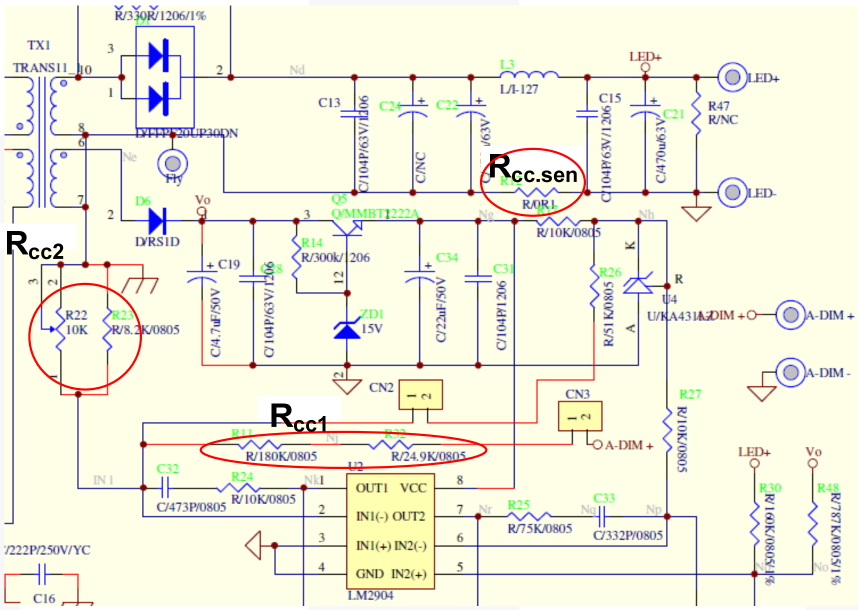

Figure 12. Analog Dimming Circuit

4.6. Startup Behavior of PFC and PWM

Startup Time

Figure 13 and Figure 14 show the overall startup performance at full load condition. The output load current starts flowing after about 883 ms at 90 V_{AC} input and 322 ms at 277 V_{AC} input when the AC input power switch turns on.

Table 8. Test Results

Input Voltage	Turn On Time	Remark
90 V_{AC} / 60 Hz	0.883 s	< 1 s
277 V_{AC} / 50 Hz	0.322 s	

Waveforms: CH1: V_{IN}(200 V / div), CH2: V_{DD}(5 V / div), CH3: $V_{O(PWM)}$ (10 V / div), CH4: I_O(500 mA / div), Time Scale: (500 ms / div)

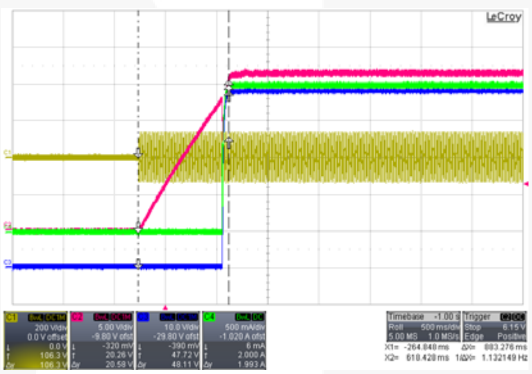

Figure 13. 90 V_{AC} / 60 Hz

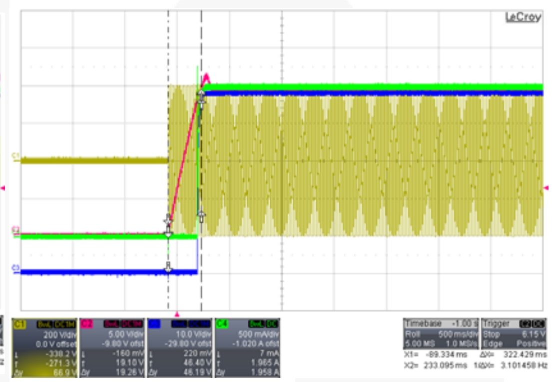

Figure 14. 277 V_{AC} / 50 Hz

PFC Behavior

Figure 15 to Figure 18 show startup performance of boost converter (PFC) on the board. Output voltage can be changed as two levels depending on input lines. In this board, output voltage is set as 290 V at 90 V_{AC} and 445 V at 277 V_{AC} respectively.

Waveforms: CH1: V_{DD}(5 V / div), CH2: V_{COMP}(1 V / div), CH3: $V_{GS(PFC)}$ (10 V / div), CH4: $V_{O\text{-}PFC}$ (100 V / div), Time Scale: (500 ms / div)

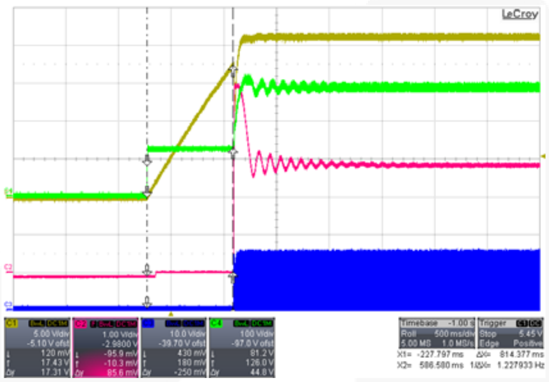

Figure 15. 90 V_{AC} / 60 Hz

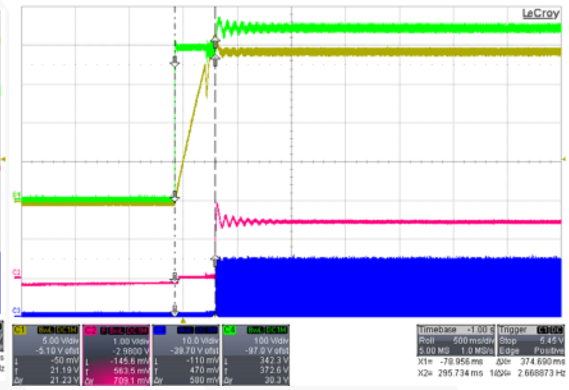

Figure 16. 277 V_{AC} / 50 Hz

Waveforms: CH1: $V_{O(PWM)}$(10 V / div), CH2: $V_{GS(PWM)}$ (10 V / div), CH3: $V_{GS(PFC)}$ (10 V / div), CH4: $V_{O(PFC)}$ (100 V / div) Time Scale: (500 ms / div)

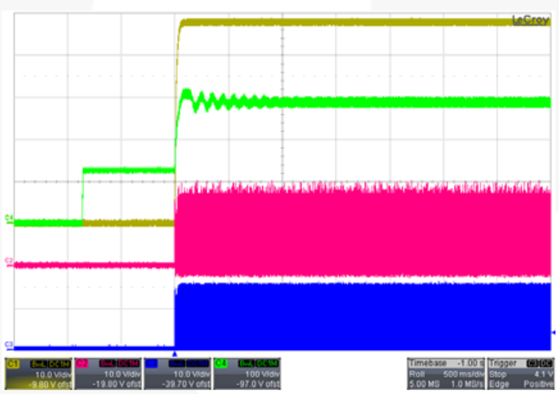

Figure 17. 90 V_{AC} / 60 Hz

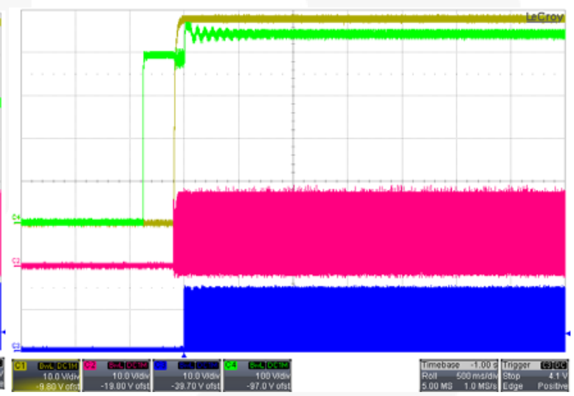

Figure 18. 277 V_{AC} / 50 Hz

PWM Behavior

Figure 19 through Figure 22 show startup performance of the flyback converter (QR PWM) on the board.

Waveforms: CH1: V_{DD}(5 V / div), CH2: V_{FB}(1 V / div), CH3: $V_{GS(PWM)}$ (10 V / div), CH4: $I_{O\text{-}PWM}$(500 mA / div), Time Scale: (500 ms / div)

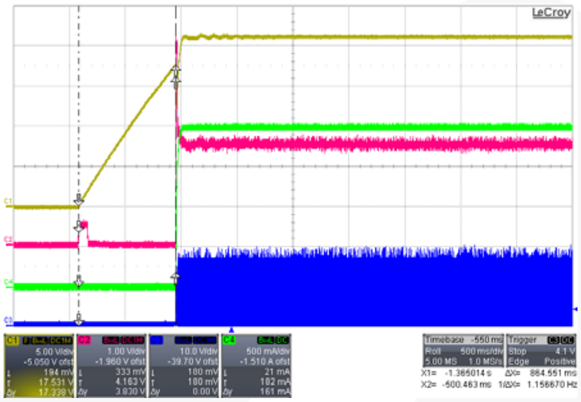

Figure 19. 90 V_{AC} / 60 Hz

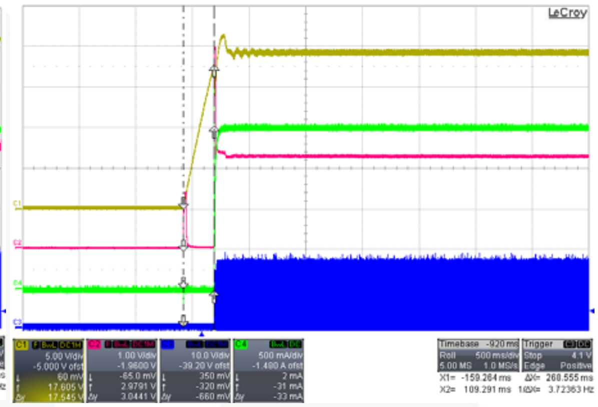

Figure 20. 277 V_{AC} / 50 Hz

Waveforms: CH1: $V_{O(PFC)}$ (100 V / div), CH2: V_{FB}(1 V / div), CH3: $V_{GS(PWM)}$ (10 V / div), CH4: $I_{O\text{-}PWM}$ (500 mA / div) Time Scale: (500 ms / div)

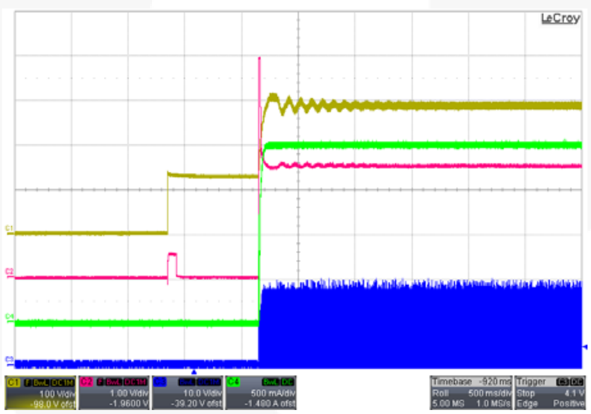

Figure 21. 90 V_{AC} / 60 Hz

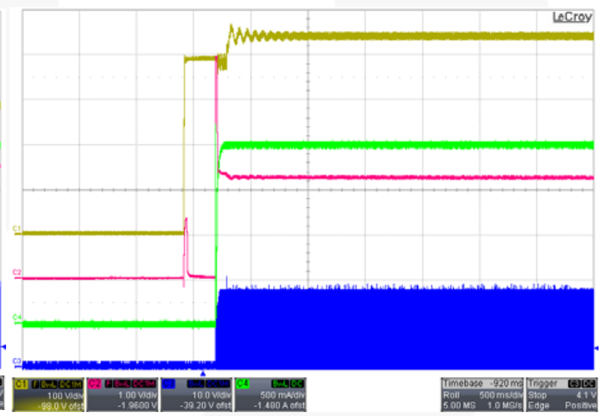

Figure 22. 277 V_{AC} / 50 Hz

4.7. Operation Waveforms

Normal Operation

Figure 23 through Figure 26 shows the AC input voltage and current waveforms respectively for each input line (90 V_{AC} ~ 277 V_{AC}) at rated output load condition.

Waveforms: CH1: V_{IN} (200 V / div), CH4: I_{IN} (1 A / div), Time Scale: (10 ms / div)

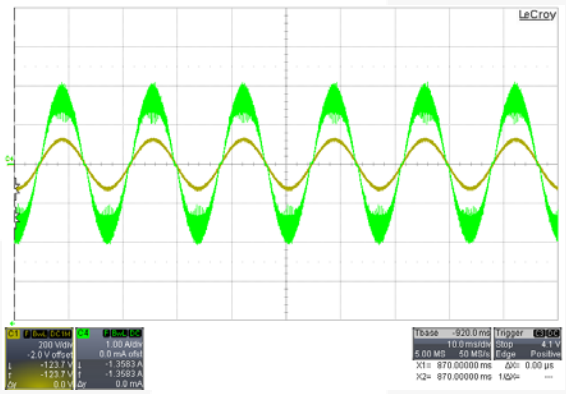

Figure 23. 90 V_{AC} / 60 Hz

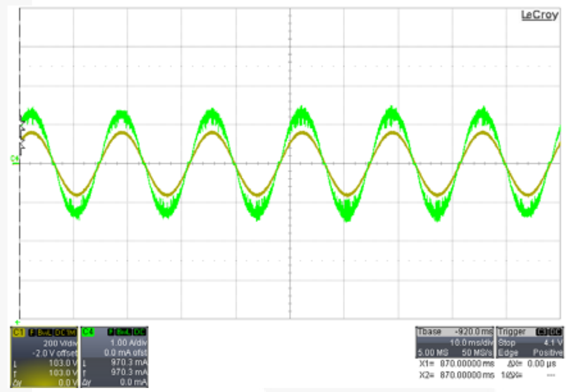

Figure 24. 115 V_{AC} / 60 Hz

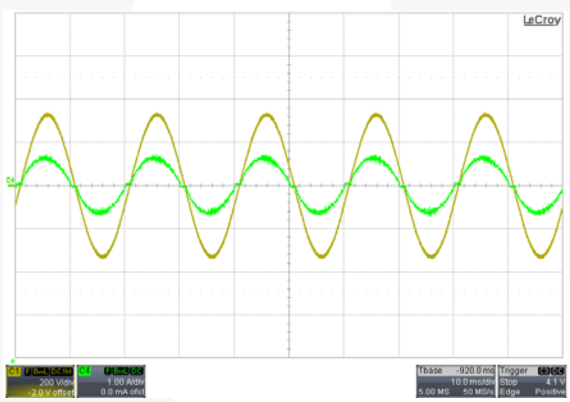

Figure 25. 230 V_{AC} / 50 Hz

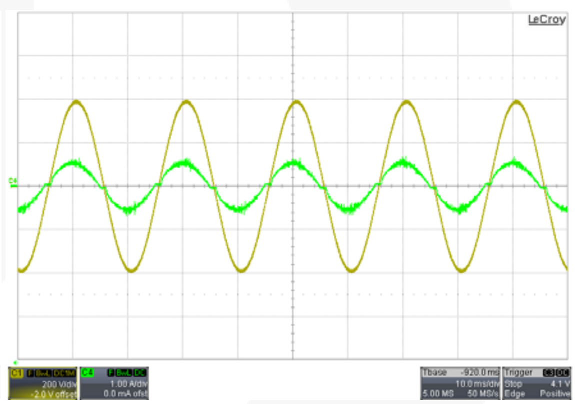

Figure 26. 277 V_{AC} / 50 Hz

Normal Operation of MOSFET (PFC)

Figure 27 through Figure 30 shows key waveforms of the PFC stage operated normally at rated output load condition.

Waveforms: CH1: $V_{CS\text{-}PFC}$(200 mV / div), CH2: V_{COMP} (1 V / div), CH3: $V_{DS\text{-}PFC}$ (200 V / div), CH4: $V_{O\text{-}PFC}$ (100 V / div), Time Scale: (5 ms / div)

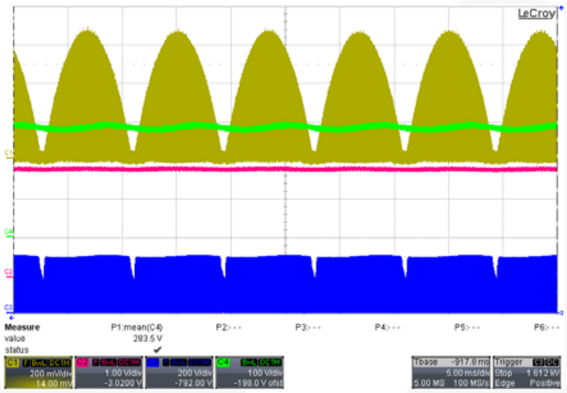

Figure 27. 90 V_{AC} / 60 Hz

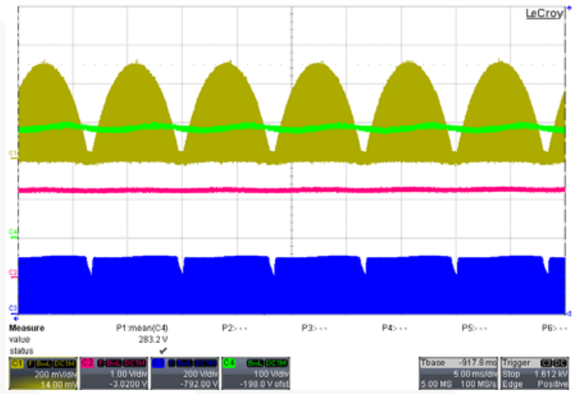

Figure 28. 115 V_{AC} / 60 Hz

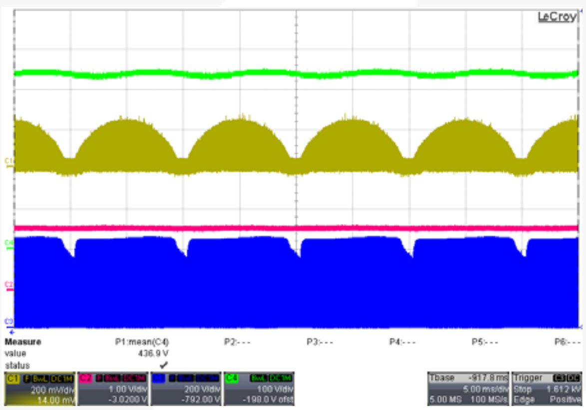

Figure 29. 230 V_{AC} / 50 Hz

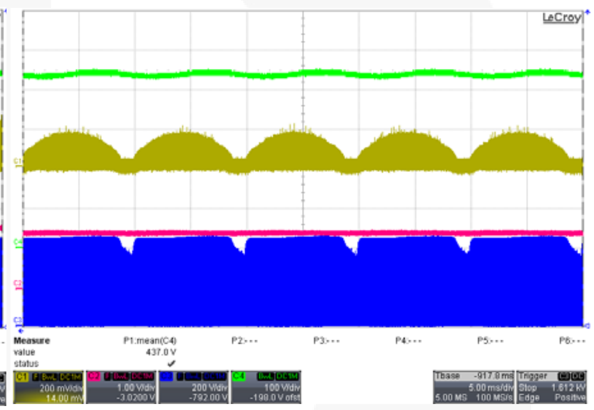

Figure 30. 277 V_{AC} / 50 Hz

Normal Operation of MOSFET and Rectifier (QR PWM)

Figure 31 through Figure 34 shows key waveforms of the Flyback stage operated normally at rated output load condition.

Waveforms: CH1: $V_{CS\text{-}PWM}$ (200 mV / div), CH2: V_{FB} (1 V / div), CH3: $V_{DS\text{-}PWM}$ (200 V / div), CH4: $I_{O\text{-}PWM}$ (500 mA / div), Time Scale: (10 µs / div)

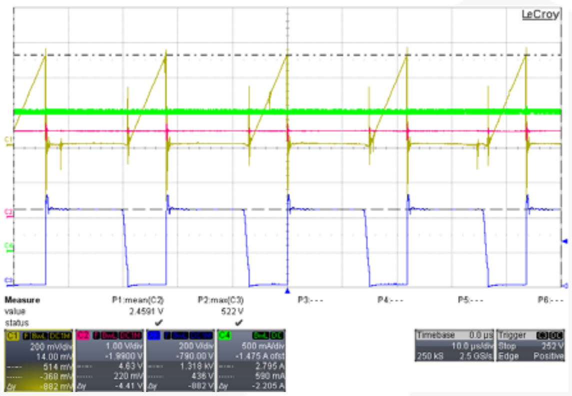

Figure 31. 90 V_{AC} / 60 Hz

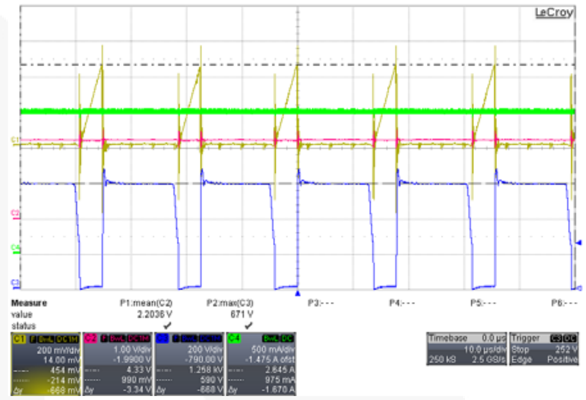

Figure 32. 277 V_{AC} / 50 Hz

Waveforms: CH1: $V_{AK\text{-}PWM}$ (50 V / div), CH2: V_{FB} (1 V / div), CH3: $V_{DS\text{-}PWM}$ (200 V / div), CH4: $I_{O\text{-}PWM}$ (500 mA / div), Time Scale: (10 µs / div)

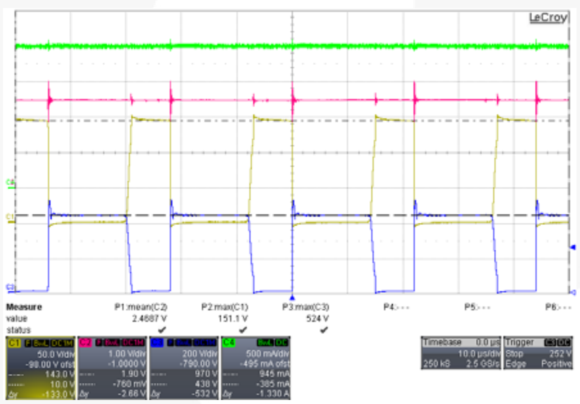

Figure 33. 90 V_{AC} / 60 Hz

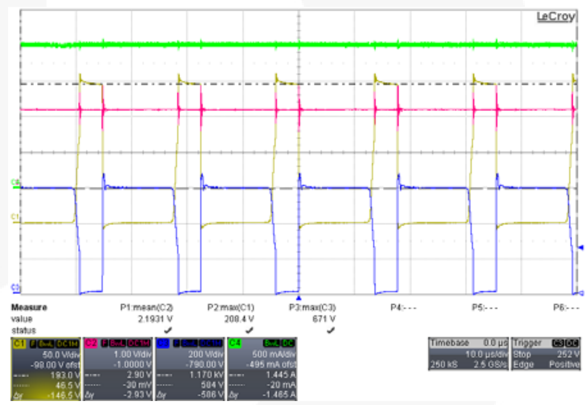

Figure 34. 277 V_{AC} / 50 Hz

4.8. Short-Circuit Protection

Output-Short Protection

Figure 35 and Figure 36 show waveforms related when LED is shorted.

Waveforms: CH1: V_{DD} (5 V / div), CH2: V_{FB} (1 V / div), CH3: $V_{DS\text{-}PWM}$ (200 V / div), CH4: $I_{O\text{-}PWM}$ (500 mA / div), Time Scale: (1 s / div)

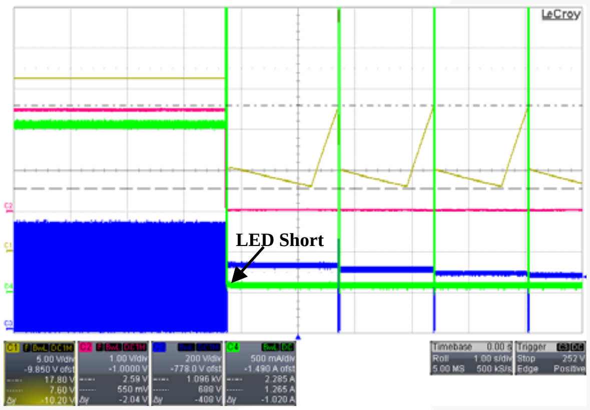

Figure 35. 90 V_{AC} / 60 Hz

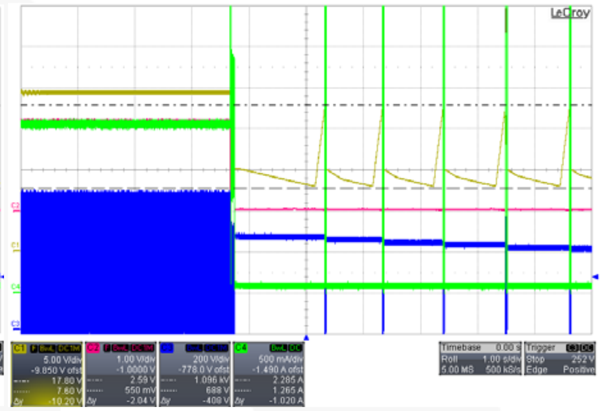

Figure 36. 277 V_{AC} / 50 Hz

Auto-Recovery Protection

Figure 37 and Figure 38 show waveforms related when LED is recovered from short condition. IC operates in hiccup mode during output short then system can be recovered normally once the output short is removed.

Waveforms: CH1: V_{DD}(5 V / div), CH2: V_{FB} (1 V / div), CH3: $V_{DS\text{-}PWM}$ (200 V / div), CH4: $I_{O\text{-}PWM}$ (500 mA / div), Time Scale: (1 s / div)

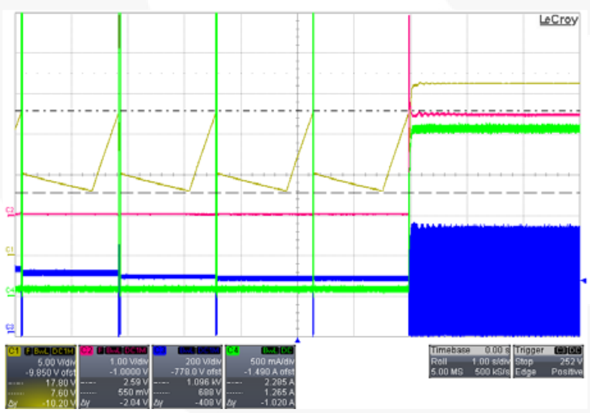

Figure 37. 90 V_{AC} / 60 Hz

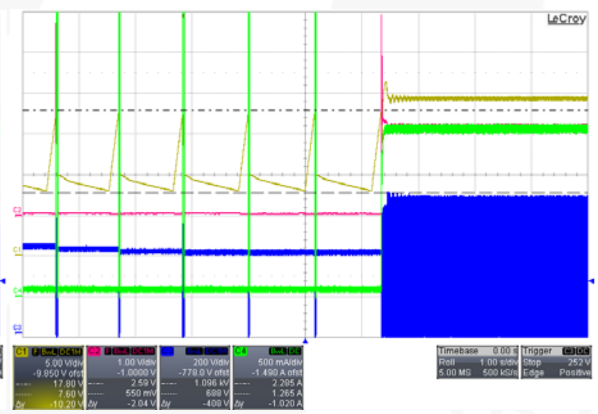

Figure 38. 277 V_{AC} / 50 Hz

4.9. Over-Temperature Protection (External Detection)

RT<0.8 V

Figure 39 and Figure 40 show waveforms that over-temperature protection is triggered when RT voltage is less than 0.8 V.

Waveforms: CH1: $V_{GS\text{-}PFC}$ (10 V / div), CH2: V_{RT} (500 mV / div), CH3: V_{DD} (5 V / div), CH4: $V_{GS\text{-}PWM}$ (10 V / div), Time Scale: (500 ms / div)

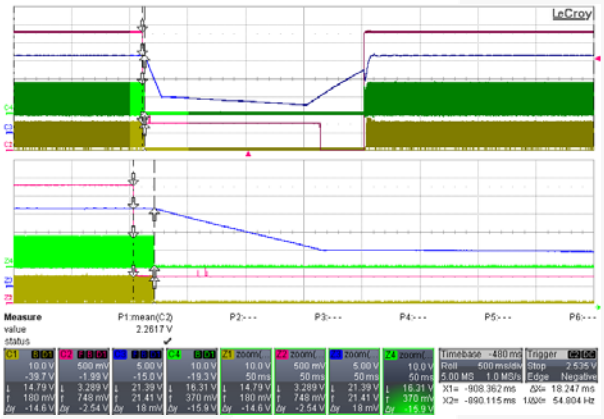

Figure 39. 90 V_{AC} / 60 Hz

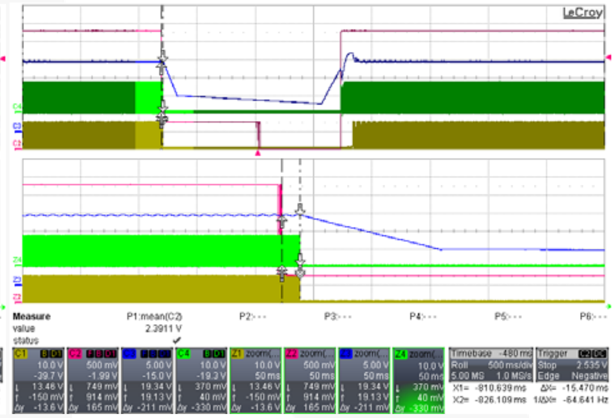

Figure 40. 277 V_{AC} / 50 Hz

RT<0.5 V

The IC operates at hiccup mode during system happens over-temperature phenomenon. Figure 41 and Figure 42 show related waveforms when system recovers from over-temperature protection. IC operate hiccup mode during OTP and system can restart once system is recovered to normal conditions.

Waveforms: CH1: $V_{GS\text{-}PFC}$ (10 V / div), CH2: V_{RT} (500 mV / div), CH3: V_{DD} (5 V / div), CH4: $V_{GS\text{-}PWM}$ (10 V / div), Time Scale: (500 ms / div)

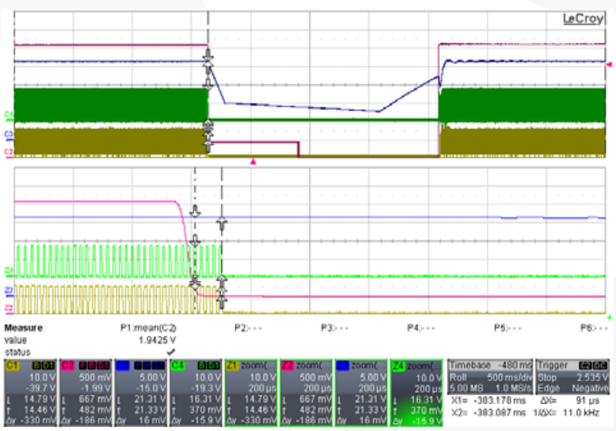

Figure 41. 90 V_{AC} / 60 Hz

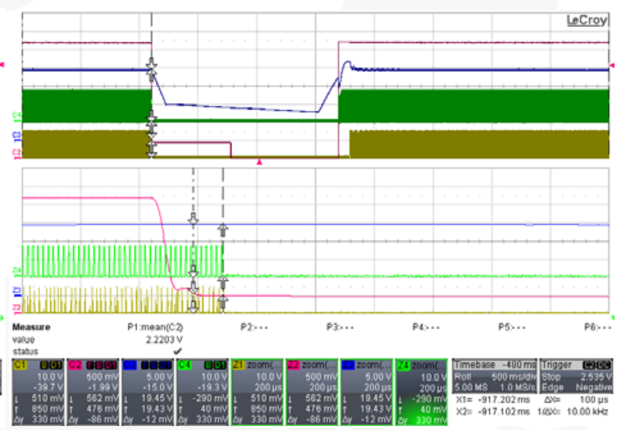

Figure 42. 277 V_{AC} / 50 Hz

4.10. EMI

Test Conditions

- Frequency Subrange: 150 kHz – 30 MHz, Probe: 2-Line-LISN ESH3-Z5
- Signal Path: Receiver-2-Line-LISN ESH3-Z5, Detectors: Peak; Average
- Load is Resistance(24 Ω)

Test Results:

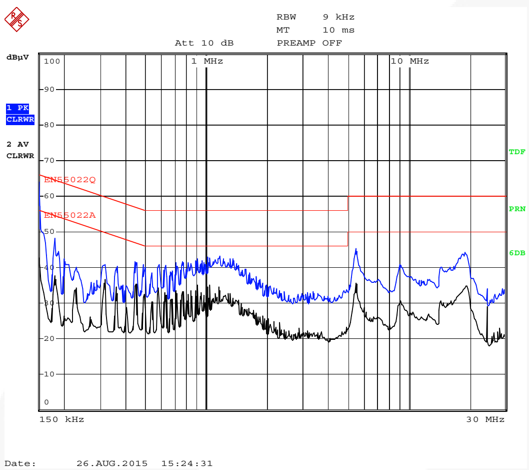

Figure 43. 115 V_{AC} / 60 Hz, L

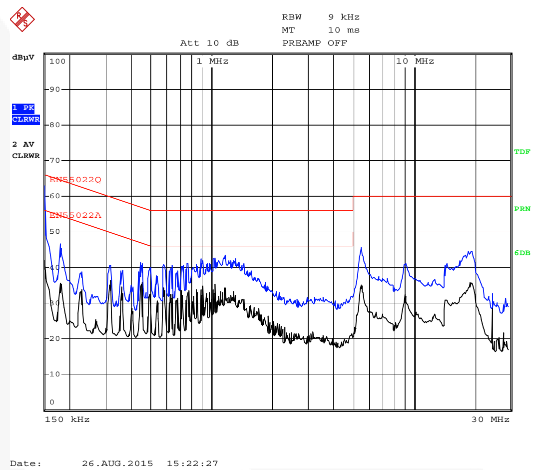

Figure 44. 115 V_{AC} / 60 Hz, N

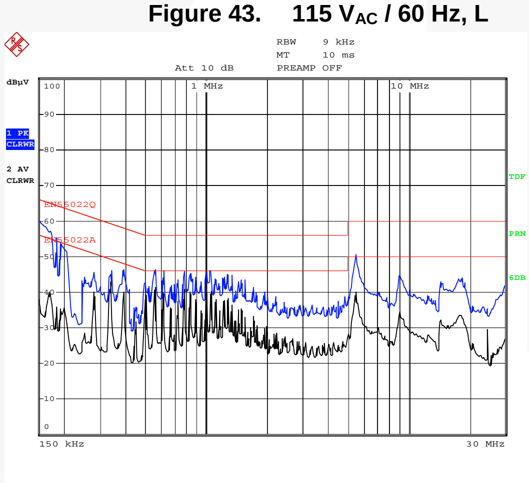

Figure 45. 230 V_{AC} / 50 Hz, L

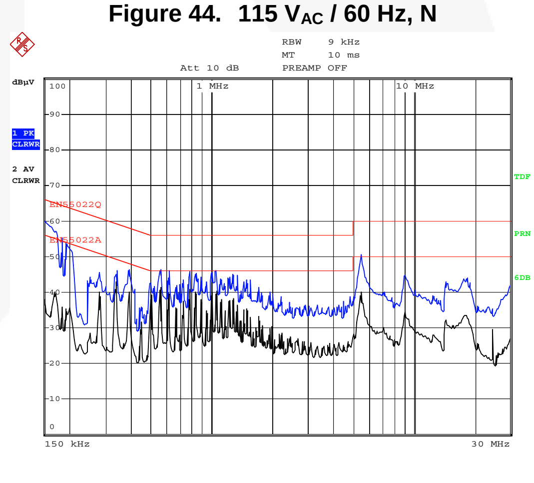

Figure 46. 230 V_{AC} / 50 Hz, N

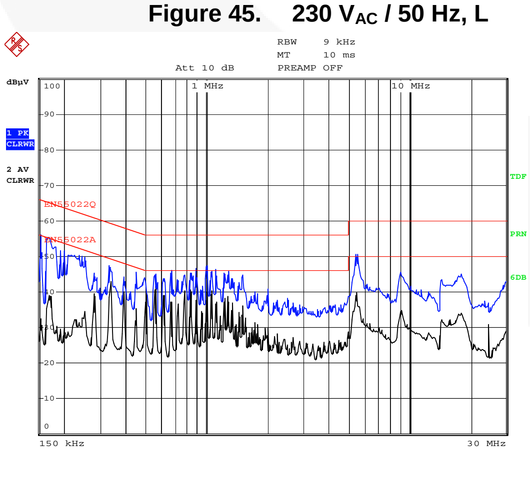

Figure 47. 277 V_{AC} / 50 Hz, L

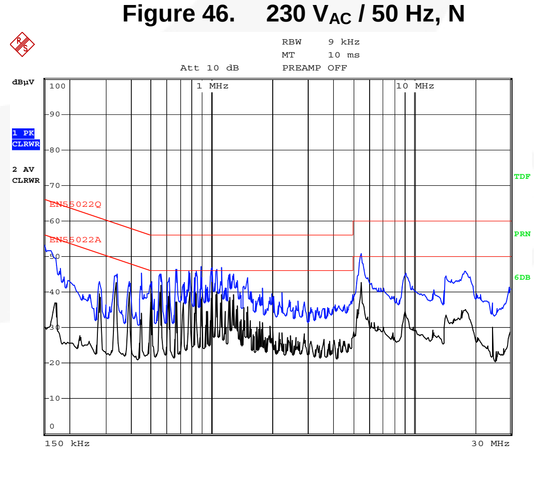

Figure 48. 277 V_{AC} / 50 Hz, N

5. Related Resources

FL7921R Product Information

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