User Guide for

FEB-L042
Evaluation Board

Universal Input 10W LED Driver

Featured Fairchild Product:
FLS3247N

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

Fairchild Semiconductor.com

Table of Contents

This user guide supports the evaluation kit for the FLS3247N. It should be used in conjunction with the FLS3247N 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 describes the proposed solution for a universal line voltage LED ballast using the FLS3247N Primary-Side Regulator (PSR) single-stage controller. The input voltage range is $90V_{RMS}$ – $265V_{RMS}$ and there is one DC output with a constant current of 400mA at $25V_{MAX}$. This document contains a general description of the FLS3247N, the power supply specification, schematic, bill of materials, and typical operating characteristics.

1.1. General Description

The FLS3247N is an active Power Factor Correction (PFC) controller using single-stage flyback topology. Primary-Side Regulation (PSR) and single-stage topology minimize cost and reduce external components, such as input bulk capacitor and feedback circuitry. To improve power factor and Total Harmonic Distortion (THD), constant on-time control is utilized with an internal error amplifier and a low-bandwidth compensator. Precise constant-current control regulates accurate output current, independent of input voltage and output voltage. Operating frequency is proportionally changed by output voltage to guarantee Discontinuous Conduction Mode (DCM) operation with high efficiency and simple design. FLS3247N provides open-LED, short-LED, and over-temperature protections.

1.2. Features

- Cost-Effective Solution without Input Bulk Capacitor or Feedback Circuitry
- Power Factor Correction (PFC)
- Integrated Power MOSFET
- Accurate Constant-Current (CC) Control: Independent Online Voltage, Output Voltage, and Magnetizing Inductance Variation
- Linear Frequency Control for Better Efficiency and Simple Design
- Open-/Short-LED Protection
- Cycle-by-Cycle Current Limiting
- Over-Temperature Protection with Auto Restart
- Low Startup Current: 20µA
- Low Operating Current: 5mA
- V_{DD} Over-Voltage Protection
- V_{DD} Under-Voltage Lockout (UVLO)
- Application Voltage Range: $80V_{AC}$ ~ $308V_{AC}$

1.3. Internal Block Diagram

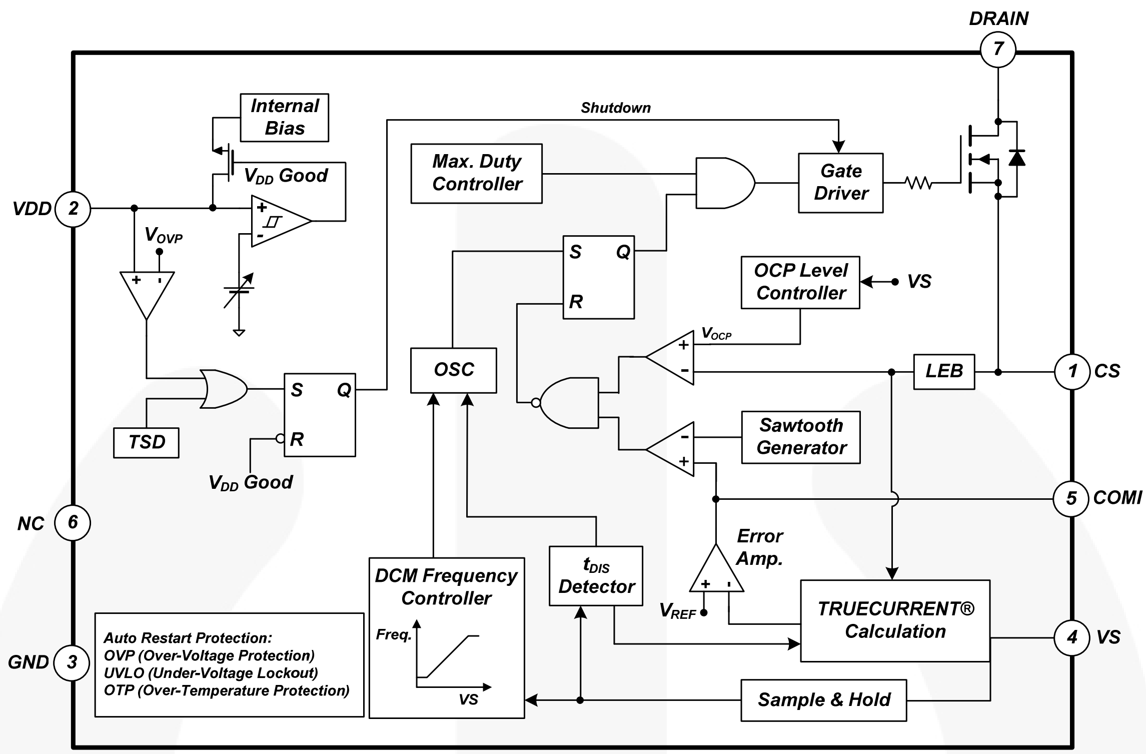

Figure 1. Internal Block Diagram of FLS3247N

2. General Specifications for Evaluation Board

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

Table 1. Evaluation Board Specifications for LED Lighting Lamp

Description		Symbol	Value	Comments
Input	Voltage	$V_{IN.MIN}$	90V	Minimum Input Voltage
		$V_{IN.MAX}$	265V	Maximum Input Voltage
		$V_{IN.NOMINAL}$	120V / 230V	Nominal Input Voltage
	Frequency	f_{IN}	60Hz / 50Hz	Line Frequency
Output	Voltage	$V_{OUT.MIN}$	11V	Minimum Output Voltage
		$V_{OUT.MAX}$	28V	Maximum Output Voltage
		$V_{OUT.NOMINAL}$	25V	Rated Output Voltage
	Current	$I_{OUT.NOMINAL}$	400mA	Rated Output Current
		CC Deviation	< ±2.85%	Line Input Voltage Change: 90~265V_{AC}
			< ±2.85%	Output Voltage Change: 11~28V
Efficiency		Eff_{90VAC}	84.27%	Efficiency at 90V_{AC} Line Voltage
		Eff_{120VAC}	86.29%	Efficiency at 120V_{AC} Line Input Voltage
		Eff_{140VAC}	86.74%	Efficiency at 140V_{AC} Line Input Voltage
		Eff_{180VAC}	86.83%	Efficiency at 180V_{AC} Line Input Voltage
		Eff_{230VAC}	86.16%	Efficiency at 230V_{AC} Line Input Voltage
		Eff_{265VAC}	85.41%	Efficiency at 265V_{AC} Line Input Voltage
PF/THD		PF/THD_{90VAC}	0.98 / 13.87%	PF/THD at 90V_{AC} Line Input Voltage
		PF/THD_{120VAC}	0.98 / 12.53%	PF/THD at 120V_{AC} Line Input Voltage
		PF/THD_{140VAC}	0.97 / 13.58%	PF/THD at 140V_{AC} Line Input Voltage
		PF/THD_{180VAC}	0.96 / 13.85%	PF/THD at 180V_{AC} Line Input Voltage
		PF/THD_{230VAC}	0.93 / 16.88%	PF/THD at 230V_{AC} Line Input Voltage
		PF/THD_{265VAC}	0.91 / 18.60%	PF/THD at 265V_{AC} Line Input Voltage
Temperature	FLS3217N	$T_{FLS3217N}$	57.4ºC	Main Controller Temperature
	Rectifier	$T_{Rectifier}$	57.8ºC	Secondary Diode Temperature

2.1. Photographs of Evaluation Board

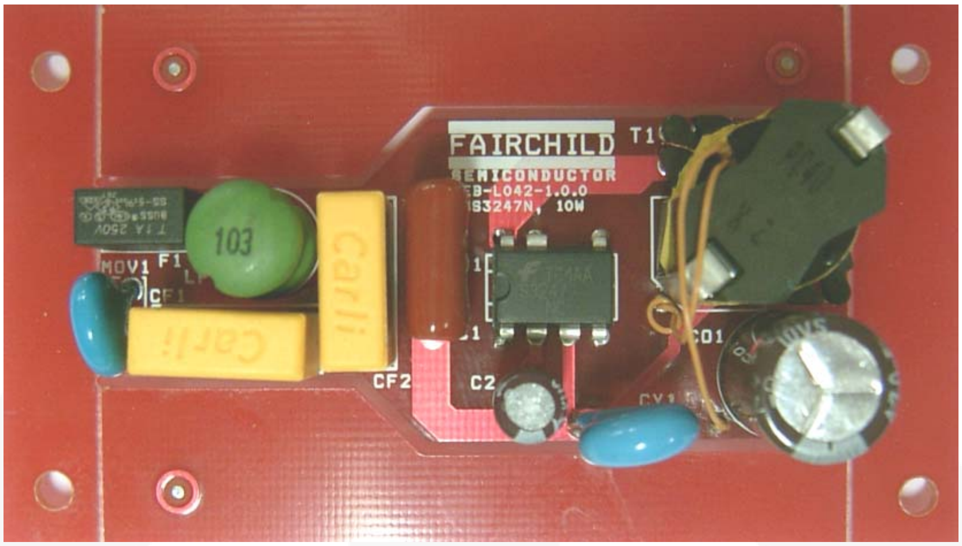

Figure 2. Top View Dimensions: 59mm (L) ×25.5mm (W) × 20.0mm (H)

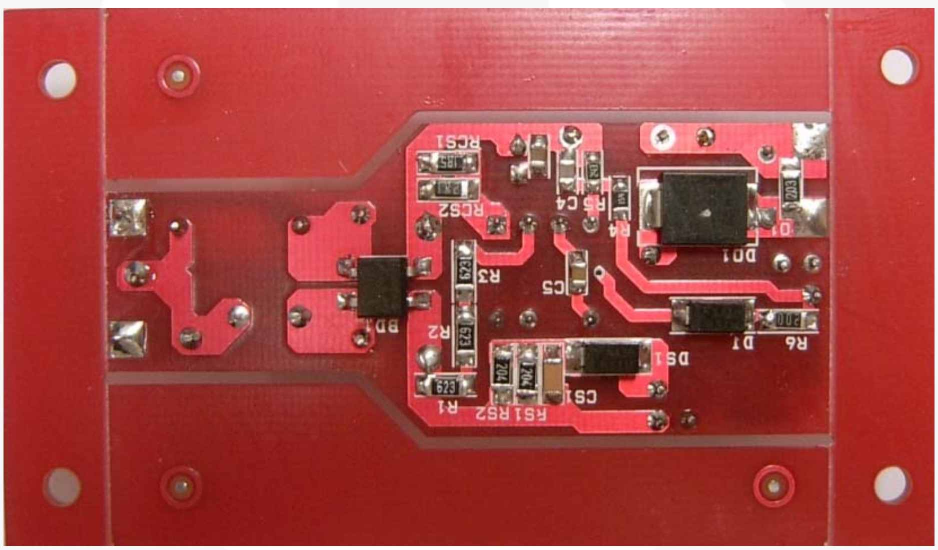

Figure 3. Bottom View Dimensions: 59mm (L) ×25.5mm (W) × 20.0mm (H)

2.2. Printed Circuit Board

Unit: mm

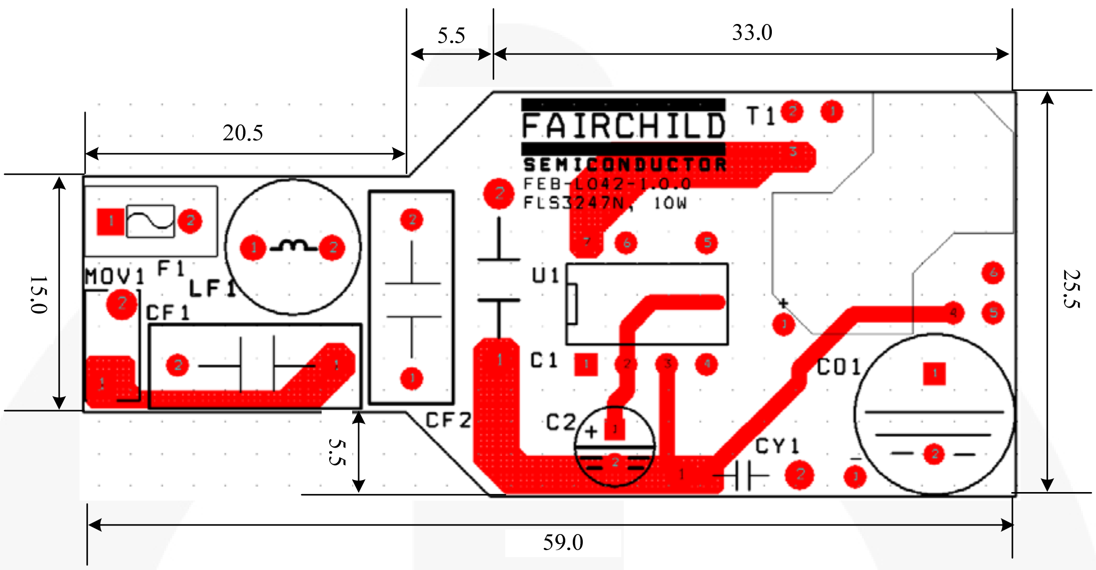

Figure 4. Top Side

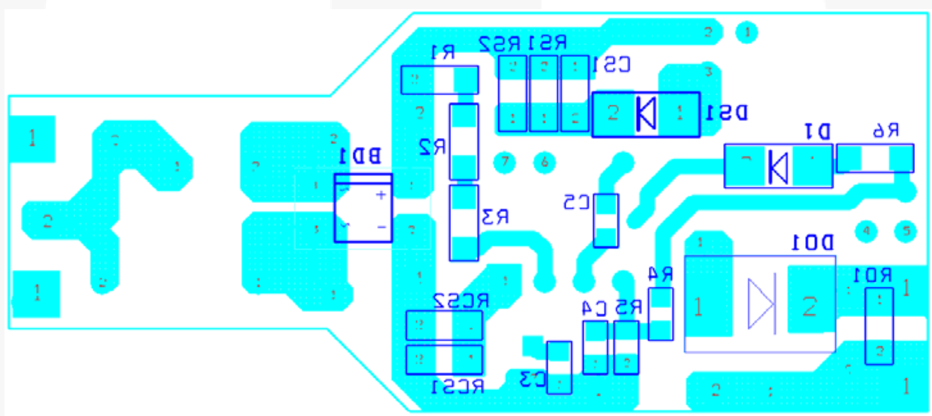

Figure 5. Bottom View

2.1. Schematic

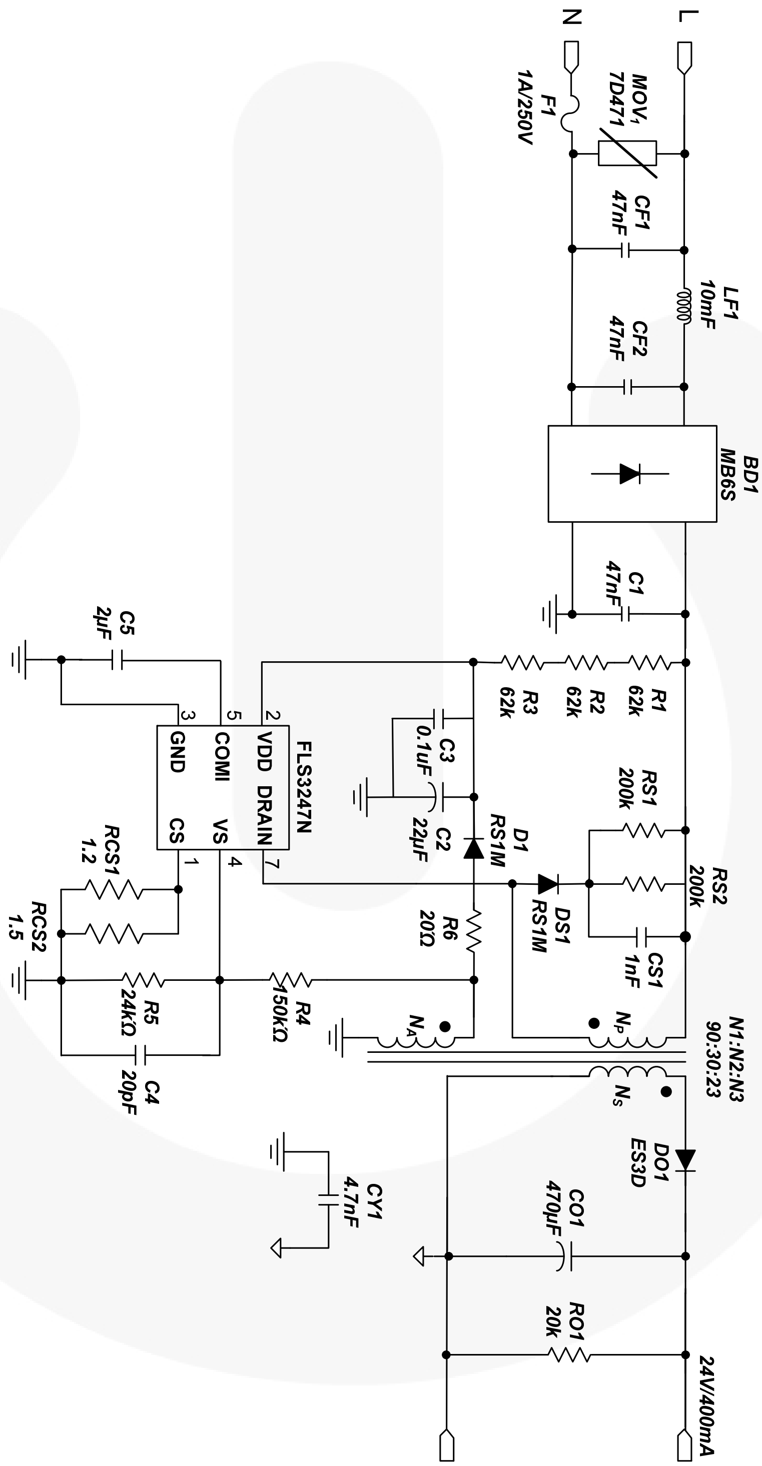

Figure 6. Evaluation Board Schematic

2.2. Bill of Materials

Item No.	Part Reference	Value	Qty.	Description	Manufacturer
1	BD1	MB6S	1	Bridge Diode	Fairchild Semiconducto
2	CF1, CF2	PX473K3IC2	2	47nF / 275V_{AC}, X-Capacitor	Carli
3	CS1	C1206C102KDRACTU	1	1nF / 1kV, SMD Capacitor 3216	Samwha
4	CY1	SCFZ2E472M10BW	1	4.7nF / 250V, Y-Capacitor	Samwha
5	CO1	KMG 470µF/ 35V	1	470µF / 35V, Electrolytic Capacitor	Samyoung
6	C1	MPE 630V473K	1	47nF / 630V, Film Capacitor	Sungho
7	C2	KMG 22µF / 35V	1	22µF / 35V, Electrolytic Capacitor	Samyoung
8	C3	C0805C104K3RACTU	1	0.1µF / 25V, SMD Capacitor 2012	Kemet
9	C4	C0805C200M3GACTU	1	20pF / 25V, SMD Capacitor 2012	Kemet
10	C5	C1206C205K3PACTU	1	2µF / 25V, SMD Capacitor 2012	Kemet
11	DS1, D1	RS1M	2	1A / 1000V, Diode	Fairchild Semiconductor
12	DO1	ES3D	1	3A / 200V, Fast Rectifier	Fairchild Semiconductor
13	F1	SS-5-1A	1	1A / 250V, Fuse	Bussmann
14	LF1	R06103KT00	1	10mH, 8Ø Filter Inductor	Bosung
15	MOV1	SVC 471D07	1	Varistor	Samwha
16	RS1, RS2	RC1206JR-07200KL	2	200kΩ, SMD Resistor 3216	Yageo
17	RCS1	RC1206JR-071R5L	1	1.2Ω, SMD Resistor 3216	Yageo
18	RCS2	RC1206JR-071R2L	1	1.5Ω, SMD Resistor 3216	Yageo
19	RO1	RC1206JR-0720KL	1	20kΩ, SMD Resistor 3216	Yageo
20	R1, R2, R3	RC1206JR-0762KL	3	62kΩ, SMD Resistor 3216	Yageo
21	R4	RC1206JR-07150KL	1	150kΩ, SMD Resistor 3216	Yageo
22	R5	RC1206JR-0724KL	1	24kΩ, SMD Resistor 3216	Yageo
23	R6	RC1206JR-0720RL	1	20Ω, SMD Resistor 3216	Yageo
24	T1	RM6	1	Transformer	TDK
25	U1	FLS3247N	1	Main Controller	Fairchild Semiconductor

2.3. Transformer Design

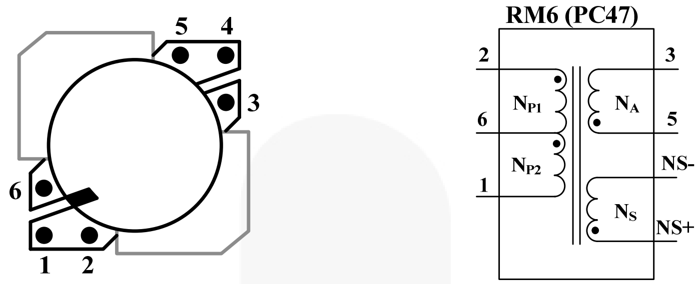

Figure 7. Transformer Bobbin Structure and Pin Configuration

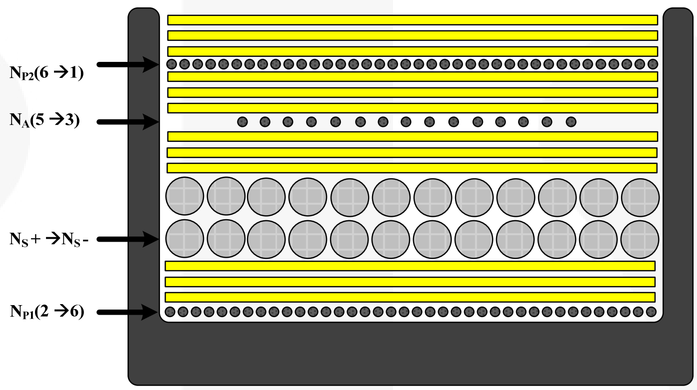

Figure 8. Transformer Winding Structure

Table 2. Winding Specifications

No	Winding	Pin (S → F)	Wire	Turns	Winding Method
1	N_{P1}	2 → 6	0.15φ	60Ts	Solenoid Winding
2	Insulation: Polyester Tape t = 0.025mm, 2-Layer				
3	N_S	NS + → NS-	0.25φ (TIW)	30 Ts	Solenoid Winding
4	Insulation: Polyester Tape t = 0.025mm, 2-Layer				
5	N_A	5 → 3	0.13φ	23 Ts	Solenoid Winding
6	Insulation: Polyester Tape t = 0.025mm, 2-Layer				
7	N_{P2}	6 → 1	0.15φ	30 Ts	Solenoid Winding
8	Insulation: Polyester Tape t = 0.025mm, 6-Layer				

Table 3. Electrical Characteristics.

	Pin	Specification	Remark
Inductance	2 – 1	1.1mH ±10%	60kHz, 1V
Leakage	2 – 1	14μH	60kHz, 1V Short All Output Pins

3. Performance of Evaluation Board

Table 4. Test Condition & Equipments

Ambient Temperature	**T_A = 25°C**
Test Equipment	AC Power Source: PCR500L by Kikusui Power Analyzer: PZ4000000 by Yokogawa Electronic Load: PLZ303WH by KIKUSUI Multi Meter: 2002 by KEITHLEY, 45 by FLUKE Oscilloscope: 104Xi by LeCroy Thermometer: Thermal CAM SC640 by FLIR SYSTEMS LED: EHP-AX08EL/GT01H-P03(3W) by Everlight

3.1. Startup

The startup time is 0.89s at V_{IN}=90V_{AC}. The results were measured using actual LED load. Startup time, C1 [V_{DD}], C2 [V_{IN}], C3 [V_{OUT}], C4 [I_{OUT}].

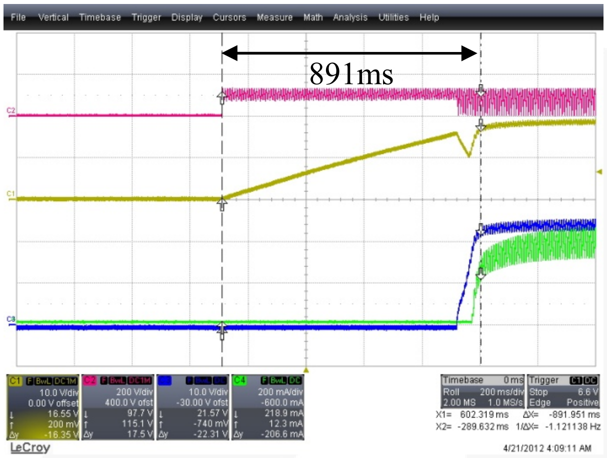

Figure 9. V_{IN}=90V_{AC} / 60Hz

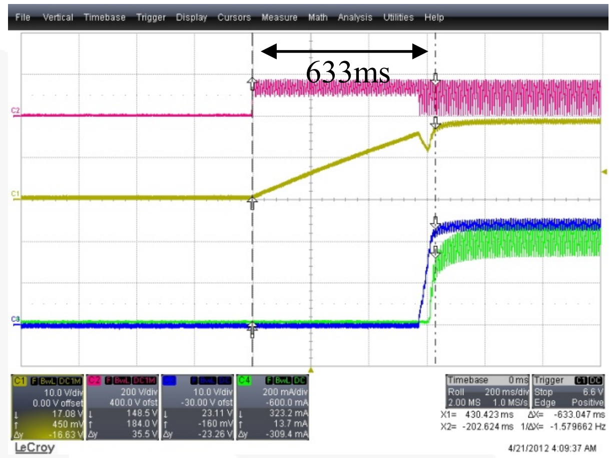

Figure 10. V_{IN}=120V_{AC} / 60Hz

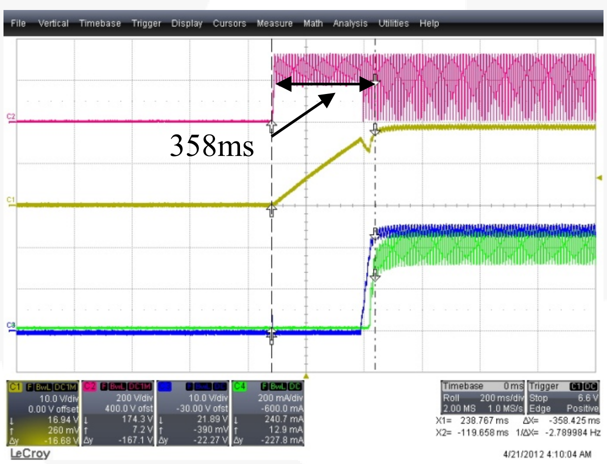

Figure 11. V_{IN}=230V_{AC} / 50Hz

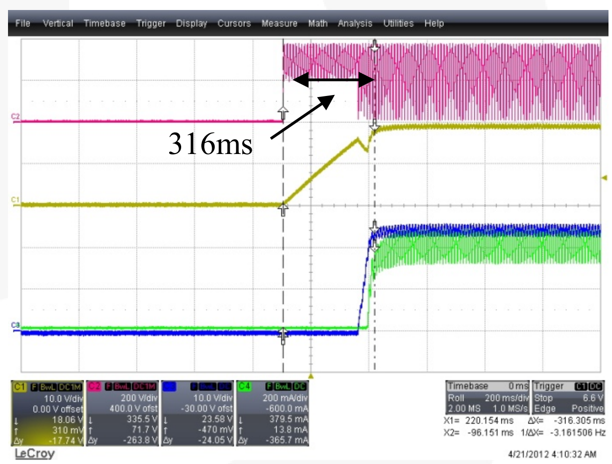

Figure 12. V_{IN}=265V_{AC} / 50Hz

3.2. Operation Waveforms

Output current ripple is under ±80mA with a rated output current of 400mA. The results were measured using actual LED load. Operation waveforms: V_{OUT}: [25V], I_{OUT}: [400mA], C1 [V_{CS}], C2 [V_{IN}], C3 [V_{OUT}], C4 [I_{OUT}].

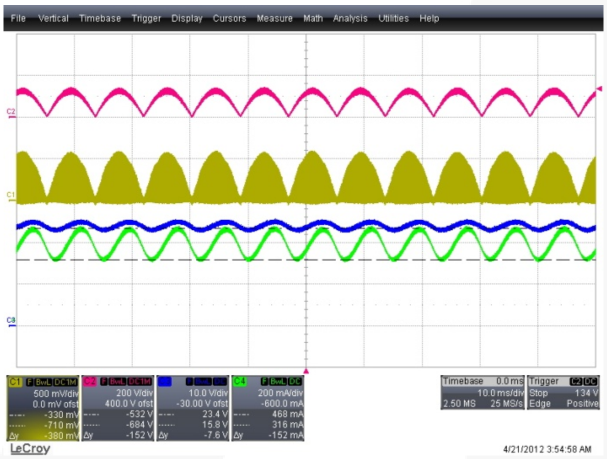

Figure 13. V_{IN}=90V_{AC} / 60Hz

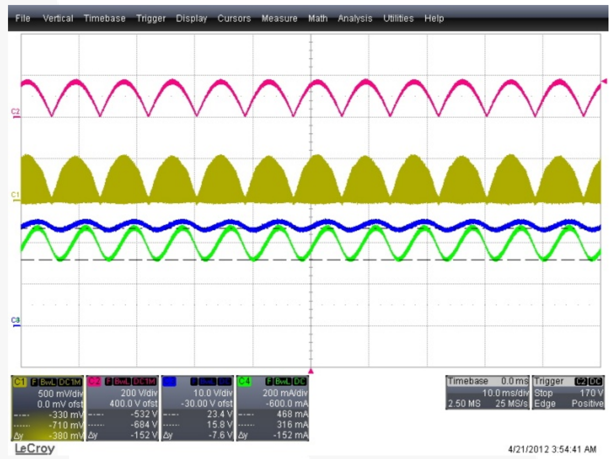

Figure 14. V_{IN}=120V_{AC} / 60Hz

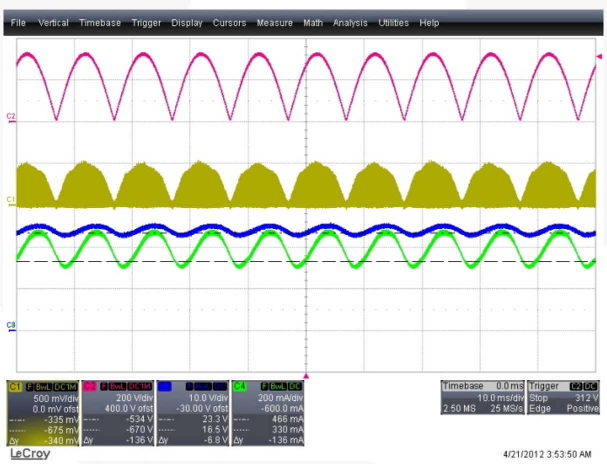

Figure 15. V_{IN}=230V_{AC} / 50Hz

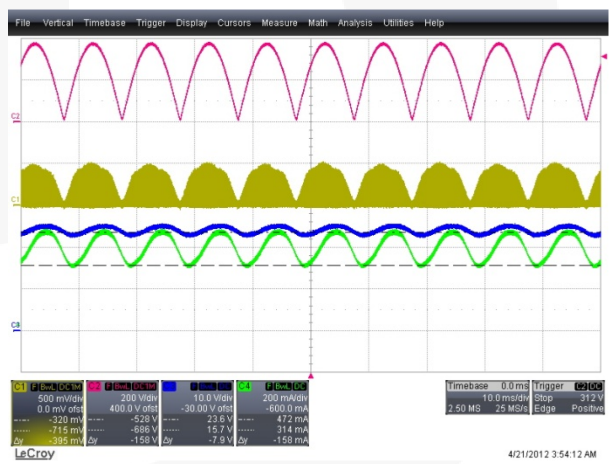

Figure 16. V_{IN}=265V_{AC} / 50Hz

3.3. Constant Current Regulation

Constant current deviation in the wide output voltage range from 11V to 28V is less than ±2.85% at each line input voltage. Line regulation 24V is less than ±2.85%. The results were measured by using E-load.

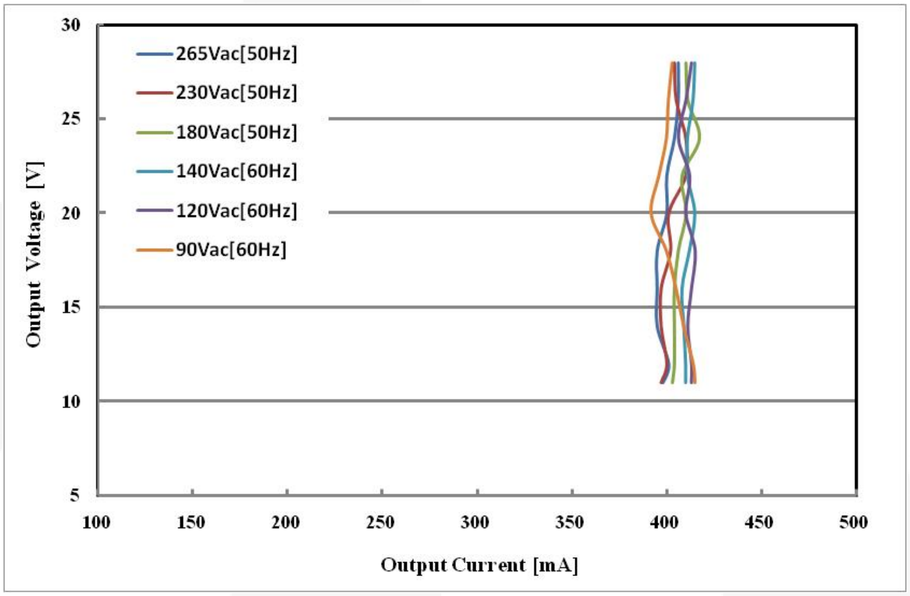

Figure 17. Constant Current Regulation – Measured by E-Load [CR Mode]

Table 5. Constant Current Regulation by Output Voltage Change (11~28V)

Input Voltage	Min. Current	Max. Current	Tolerance
$90V_{AC}$	392mA	415mA	±2.85%
$120V_{AC}$	406mA	415mA	±1.10%
$140V_{AC}$	408mA	415mA	±0.85%
$180V_{AC}$	403mA	417mA	±1.71%
$220V_{AC}$	397mA	410mA	±1.61%
$265V_{AC}$	395mA	410mA	±1.37%

Table 6. Constant Current Regulation by Line Voltage Change (90~265V_{AC})

Output Voltage	$90V_{AC}$ [60Hz]	$120V_{AC}$ [60Hz]	$140V_{AC}$ [60Hz]	$180V_{AC}$ [50Hz]	$220V_{AC}$ [50Hz]	$265V_{AC}$ [50Hz]	Tolerance
26V	401mA	410mA	414mA	411mA	405mA	406mA	±1.60%
24V	400mA	406mA	411mA	417mA	410mA	404mA	±2.08%
22V	396mA	412mA	411mA	408mA	410mA	400mA	±1.98%
20V	392mA	410mA	415mA	410mA	401mA	400mA	±2.85%

3.4. Short-LED Protections

In short-LED condition, the OCP level is reduced from 0.7V to 0.2V because FLS3247N lowers OCP level when V_S voltage is less than 0.4V during output diode conduction time. The results were measured using actual LED load. Short-LED condition: C1 [V_{DD}], C2 [V_{IN}], C3 [V_{OUT}], C4 [I_{OUT}].

Figure 18. V_{IN}=90V_{AC} / 60Hz

Figure 19. V_{IN}=120V_{AC} / 60Hz

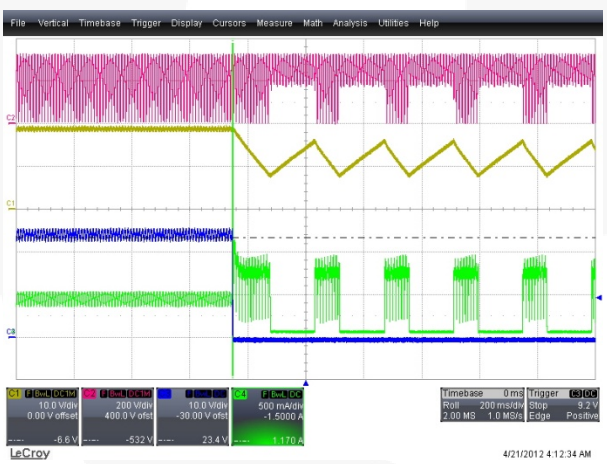

Figure 20. V_{IN}=230V_{AC} / 50Hz

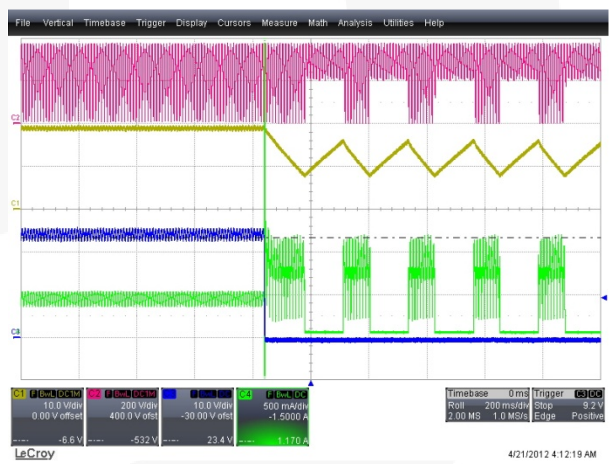

Figure 21. V_{IN}=265V_{AC} / 50Hz

3.5. Open-LED Protections

In open-LED condition, output voltage is limited around 30V by OVP in V_{DD}. Output over-voltage protection level can be controlled by the turns ratio of auxiliary and secondary windings. The results were measured using actual LED load. Open-LED condition: C1 [V_{DD}], C2 [V_{IN}], C3 [V_{OUT}], C4 [I_{OUT}].

Figure 22. V_{IN}=90V_{AC} / 60Hz

Figure 23. V_{IN}=120V_{AC} / 60Hz

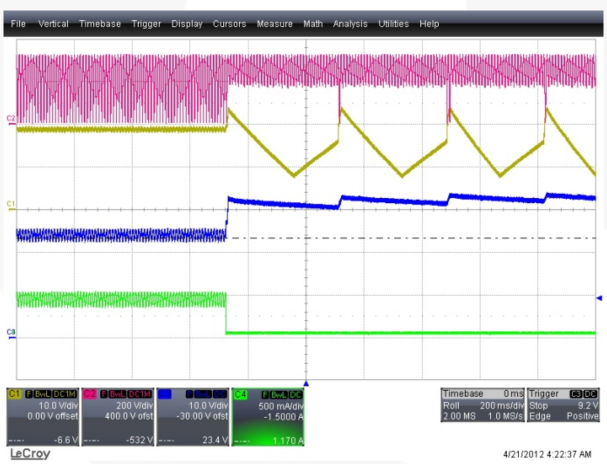

Figure 24. V_{IN}=230V_{AC} / 50Hz

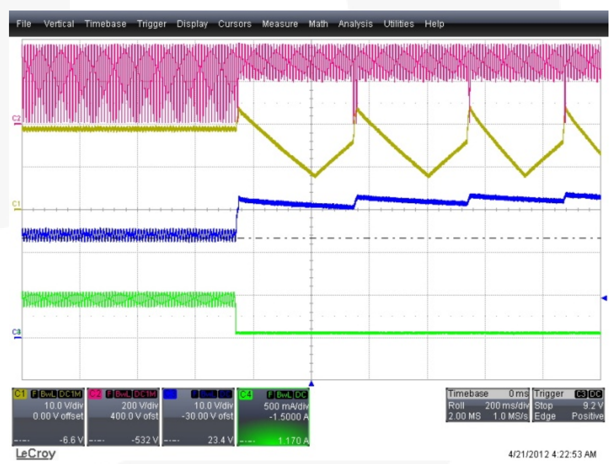

Figure 25. V_{IN}=265V_{AC} / 50Hz

3.6. System Efficiency

Power efficiency is 84.27% ~ 86.74% in 90 ~ 265V_{AC} input voltage range. The results were measured 30 minutes after startup using actual LED load.

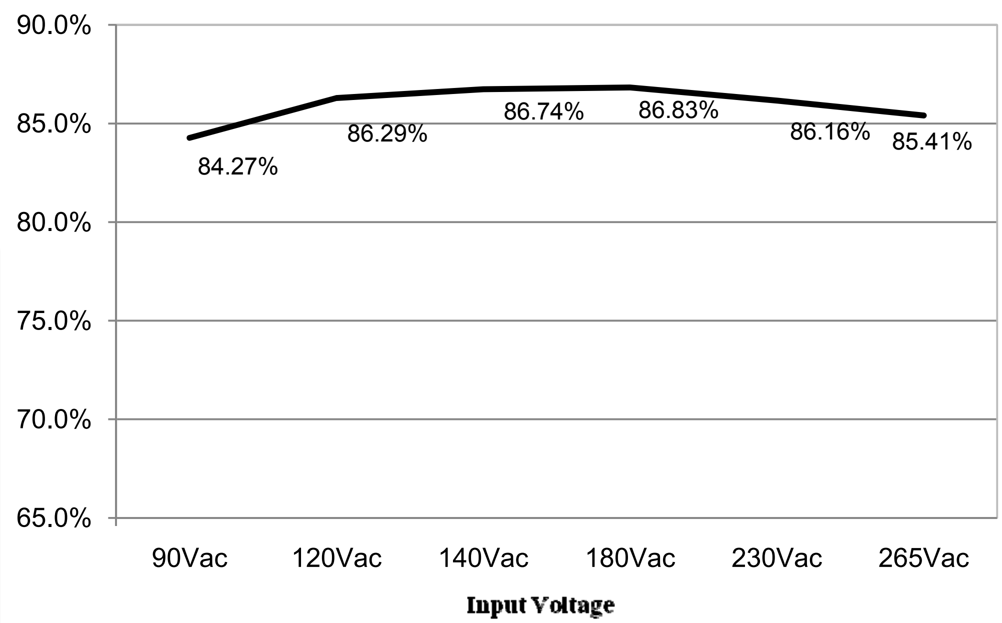

Figure 26. System Efficiency

Table 7. System Efficiency

Input Voltage	Input Power	Output Current	Output Voltage	Output Power	Efficiency
90V_{AC} / [60Hz]	11.80W	404mA	24.64V	9.94W	84.27%
120V_{AC} / [60Hz]	11.67W	408mA	24.67V	10.07W	86.29%
140V_{AC} / [60Hz]	11.84W	415mA	24.75V	10.27W	86.74%
180V_{AC} / [50Hz]	11.83W	415mA	24.74V	10.27W	86.83%
230V_{AC} / [50Hz]	11.62W	407mA	24.63V	10.01W	86.16%
265V_{AC} / [50Hz]	11.74W	407mA	24.63V	10.03W	85.41%

3.7. Power Factor and Total Harmonic Distortion

FLS3217N shows excellent power factor and total harmonic distortion performance. Power factor is very high with enough margin from 0.9. THD is less than the 20% of the specification. The results were measured 30 minutes after startup using actual LED load.

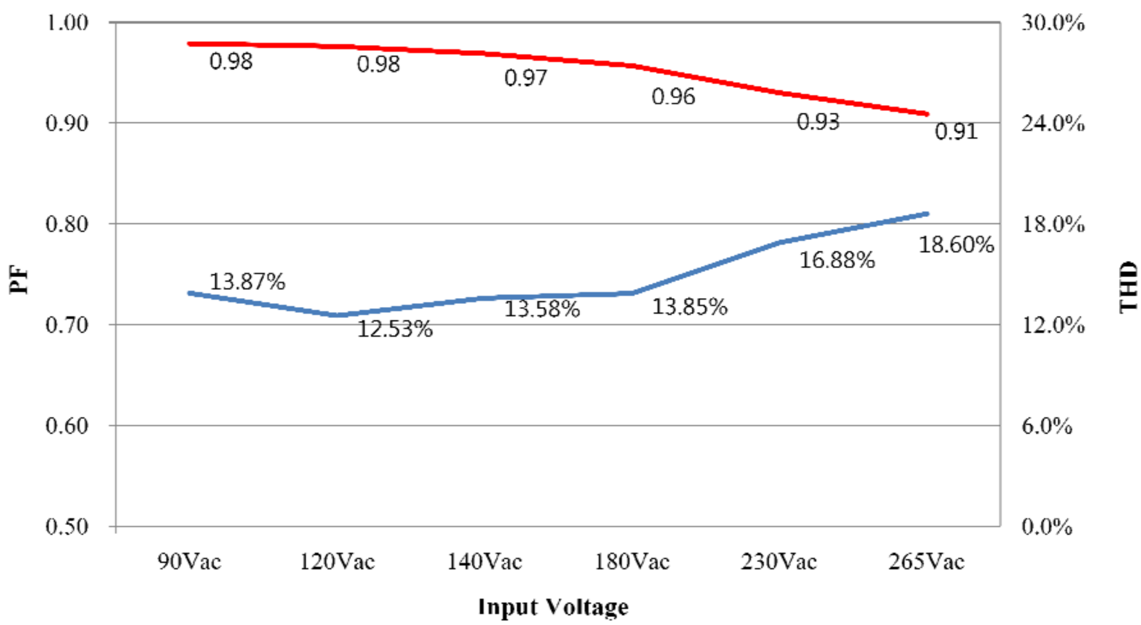

Figure 27. Power Factor and Total Harmonic Distortion

Table 8. Power Factor and Total Harmonic Distortion

Input Voltage	Output Current	Output Voltage	Power Factor	THD
90V_{AC} [60Hz]	404mA	24.64V	0.98	13.87%
120V_{AC} [60Hz]	408mA	24.67V	0.98	12.53%
140V_{AC} [60Hz]	415mA	24.75V	0.97	13.58%
180V_{AC} [50Hz]	415mA	24.74V	0.96	13.85%
230V_{AC} [50Hz]	407mA	24.63V	0.93	16.88%
265V_{AC} [50Hz]	407mA	24.63V	0.91	18.60%

3.8. Operating Temperature

Temperature of the all components on this board is less than 57.8ºC. The results were measured 60 minutes after startup using actual LED load.

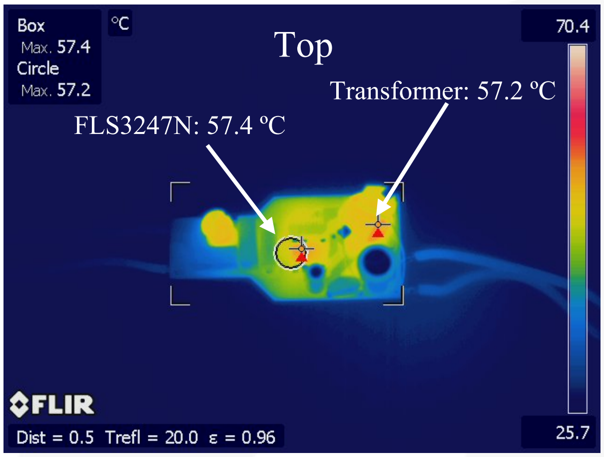

Figure 28. Board Temperature Top; V_{IN} [90V_{AC}], V_{OUT} [25V], I_{OUT} [400mA]

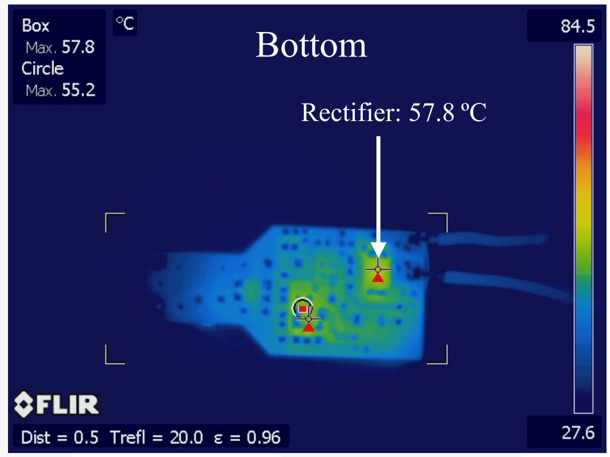

Figure 29. Board Temperature Bottom; V_{IN} [90V_{AC}], V_{OUT} [25V], I_{OUT} [400mA]

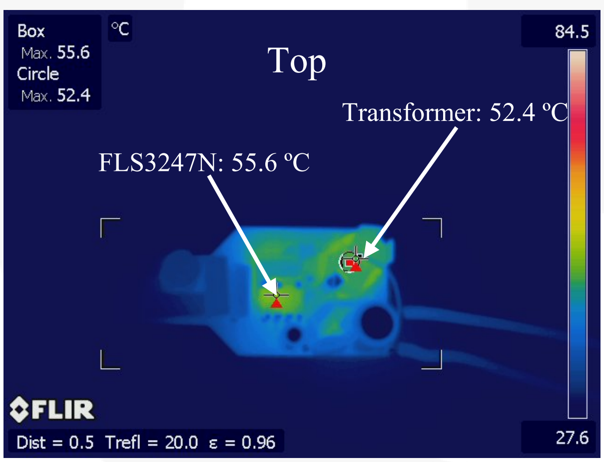

Figure 30. Board Temperature Top; V_{IN} [265V_{AC}], V_{OUT} [25V], I_{OUT} [400mA]

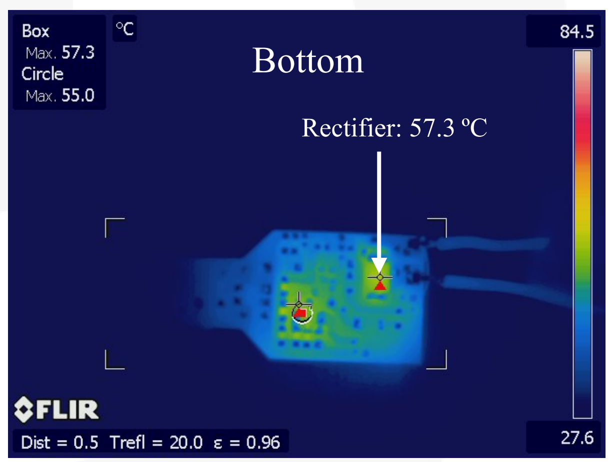

Figure 31. Board Temperature Bottom, V_{IN} [265V_{AC}], V_{OUT} [25V], I_{OUT} [400mA]

3.1. Electromagnetic Interference (EMI)

All measurement was conducted in observance of EN55022 criteria. The results were measured 30 minutes after startup using actual LED load.

Test Results

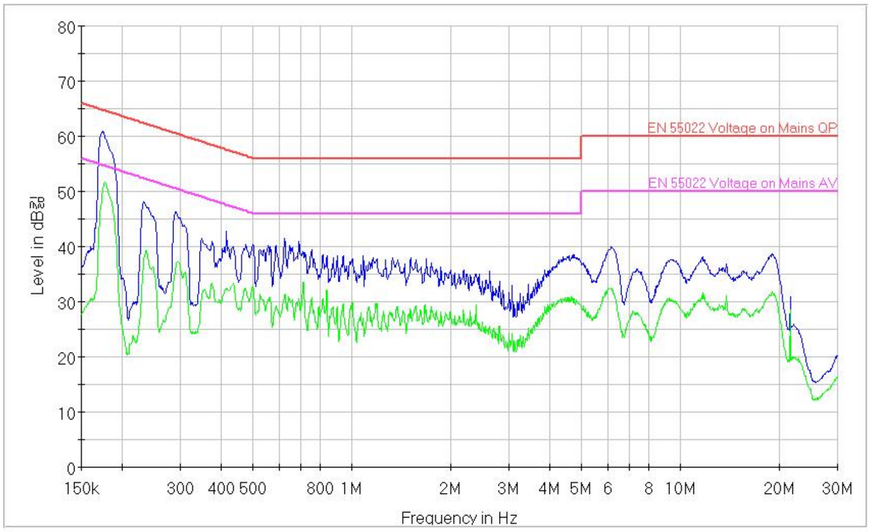

Figure 32. V_{IN}=110V_{AC}, V_{OUT} [25V], I_{OUT} [400mA]

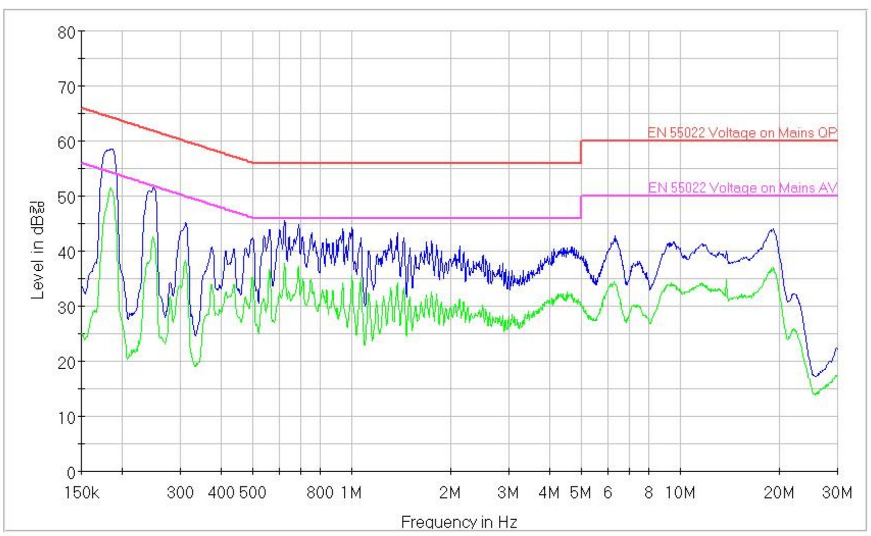

Figure 33. V_{IN}=220V_{AC}, V_{OUT} [25V], I_{OUT} [400mA]

4. Revision History

Rev.	Date	Description
1.0.0	June 2011	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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FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.