20W LED Lump Module Design with FT822

应用FT822设计的20瓦LED灯模块

(Preliminary Release)

初次发行

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1 INTRODUCTION

This document presents performance characteristics of a Low THD Fly-back LED lump module designed with FT822. The module features:

- Low THD and High Power Factor Correction
- high precision for output current in universal input voltage
- OVP，OSCP，OTP

This document contains sessions on power supply specification, schematic/PCB Gerber/BOM, and transformer design and performance data.

2 MODULE SPECIFICATION

2.1 Input Specification

Input Voltage Range	100Vac to 240Vac
Input Frequency	47Hz to 63Hz
Input Current	1A max @ 100Vac/50Hz with full load

Table 1

2.2 Output Specification

Output Voltage	+32V
Output Current	500mA
Precision of Output Voltage	±10%
Precision of Output Current	±3%
Ripple of Output Voltage	1Vpk-pk Max
Ripple of Output Current	200mA

Table 2

2.3 Performance Specification

Total Output Power	16W Typical
Standby Power	<1W @ 240Vac/47Hz, no load
Efficiency	>82 % @ 90Vac/50Hz with full load
Turn on Delay Time	≤2s. @ 90Vac/50Hz with full load
Power Factor Correction	>0.9 with full load
EMI	Compliance to EN55015 (class B)

Table 3

2.4 Protection Features

Short Circuit Protection	Input power less than 2W
Over Voltage Protection	Output voltage is less than 50V max

Table 4

2.5 Environmental Specification

Operating Temperature	-20℃ to +40℃
Operating Humidity	20 % to 90 % R. H.
Storage Temperature	-40℃ to 85℃
Storage Humidity	0 % to + 90 % R. H.

Table 5

3 MODULE INFORMATION

3.1 Schematic

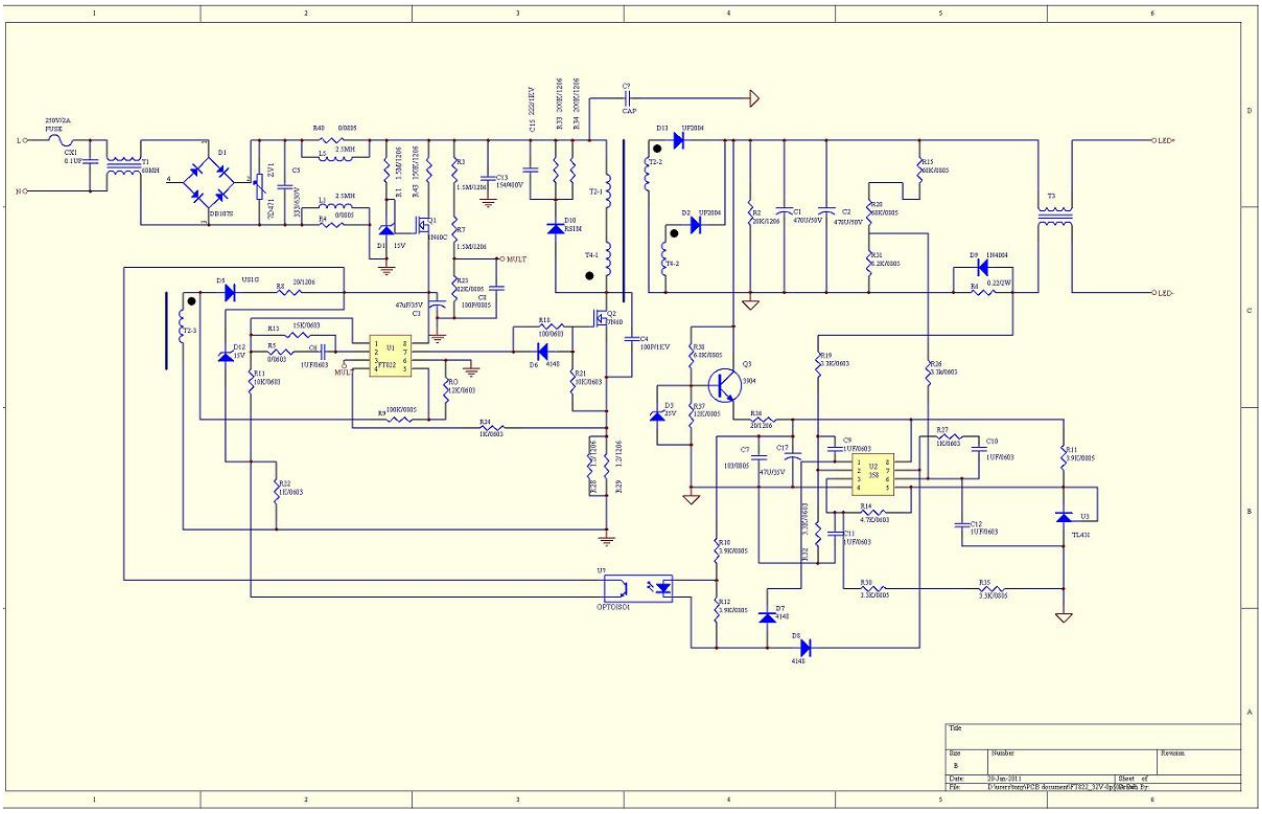


Figure 1: Schematic

3.2 PCB Gerber

Figure 2: Top View

Figure 3: Bottom view

3.3 Bill of Materials

序号	物料名称	描述	规格型号	单位	用量	工位
1	电路板	PCB	LFT-301B-REV1.0	PC	1	PCB
2	交流保险丝	3.6*11 带引线	T2A L 250VAC 带引线	PC	1	FUSE
3	共模电感	60mH	EE10	PC	1	T1
4	共模电感	450uH	T6.5*3*3.2	PC	1	T3
5	X 电容	13*12*6	0.1uF/275VAC	PC	1	CX1
6	差模电感	工字电感	2.5mH	PC	2	L1,L5
7	压敏电阻	7D471K	7D471K	PC	1	ZV1
8	整流二极管	1A700V	DB107 DIP4	PC	1	D1
9	CBB 电容	333/630V±10%	333/630V±10%	PC	1	C5
10	CBB 电容	154/400V±10%	154/400V±10%	PC	1	C13
11	场效应管	1N60DB	1A600V TO-92	PC	1	Q1
12	场效应管	SVD7N60F	7A600V TO-220F	PC	1	Q2
13	电解电容	47uF/35V 11*5	47uF/35V/-40C-105C 11*5	PC	2	C3,C17
14	电解电容	470uF/50V 10*20	470uF/50V/-40C--105C 10*20	PC	2	C1,C2
15	陶瓷电容	222/2KV±10% D=5	2.2nF/2KV±10% D=5	PC	1	C15
16	陶瓷电容	101/1KV±10% D=5	100pF/1KV±10% D=5	PC	1	C4
17	安规电容	Y1-cap	2.2nF/250VAC F=10mm	PC	1	CY1
18	金属氧化膜电阻	金属氧化膜电阻	0.22/2W/1%/小体积	PC	1	R6
19	快速整流管	1A/400V	US1G SOD124	PC	1	D5
20	快恢复二极管	1A/1000V	RS1M SOD124	PC	1	D10
21	快速整流管	2A400V	UF2004 DO-15	PC	2	D2,D13
22	肖特基二极管	1A40V	M4 1N4004	PC	1	D9
23	高频变压器	ER20	G301B1 V3.3A	PC	1	T4
24	高频变压器	ER20	G301B2 V3.3A	PC	1	T2
25	光电耦合管	B1023 817C	B1023 817C	PC	1	U4
26	贴片 IC	运放 IC	UTC358 SOP-8	PC	1	U2
27	贴片 IC	基准 IC	TL431 SOT-3	PC	1	U3
28	贴片 IC	控制 IC	FT822 SOP-8	PC	1	U1
29	贴片稳压管	Zener	15V SOD323	PC	2	D1,D12
30	贴片稳压管	Zener	25V SOD323	PC	1	D3
31	贴片二极管	diode	4148 SOD322	PC	3	D6,D7,D8
32	贴片三极管	diode	2N3906 SOT-23	PC	1	Q3

33	贴片电容	0805-101	100pF/50V/0805	PC	1	C8
34	贴片电容	0603-105	1uF/50V/0603	PC	5	C6,C9,C10,C11,C12
35	贴片电容	0805-103	10nF/50V/0805	PC	1	C7
36	贴片电阻	1206-155	1.5M±5%-1206	PC	3	R1,R3,R7
37	贴片电阻	1206-154	150K±5%-1206	PC	1	R43
38	贴片电阻	1206-200	20±5%-1206	PC	2	R8,R36
39	贴片电阻	1206-203	20K±5%-1206	PC	1	R2
40	贴片电阻	1206-204	200K±5%-1206	PC	2	R34,R33
41	贴片电阻	1206-1R2	1R2±5%-1206	PC	2	R29,R28
42	贴片电阻	0805-000	0±5%-0805	PC	1	R40
43	贴片电阻	0805-472	4K7±5%-0805	PC	1	R4
44	贴片电阻	0603-153	15K±5%-0603	PC	1	R13
45	贴片电阻	0603-000	0±5%-0603	PC	2	R5,R25
46	贴片电阻	0603-103	10K±5%-0603	PC	2	R1,R21
47	贴片电阻	0603-102	1K±5%-0603	PC	3	R22,R24,R27
48	贴片电阻	0603-332	3K3±5%-0603	PC	3	R26,R19,R32
49	贴片电阻	0805-332	3K3±5%-0805	PC	2	R30,R35
50	贴片电阻	0805-123	12K±5%-0805	PC	1	R37
51	贴片电阻	0805-682	6K8±5%-0805	PC	1	R38
52	贴片电阻	0805-392	3K9±5%-0805	PC	2	R10,R11
53	贴片电阻	0805-822	8K2±5%-0805	PC	1	R31
54	贴片电阻	0805-104	100K±5%-0805	PC	1	R9
55	贴片电阻	0805-683	68K±5%-0805	PC	2	R15,R20

Table 6

3.4 Transformer Design

1) Transformer Specification

1) Bobbin: ER20

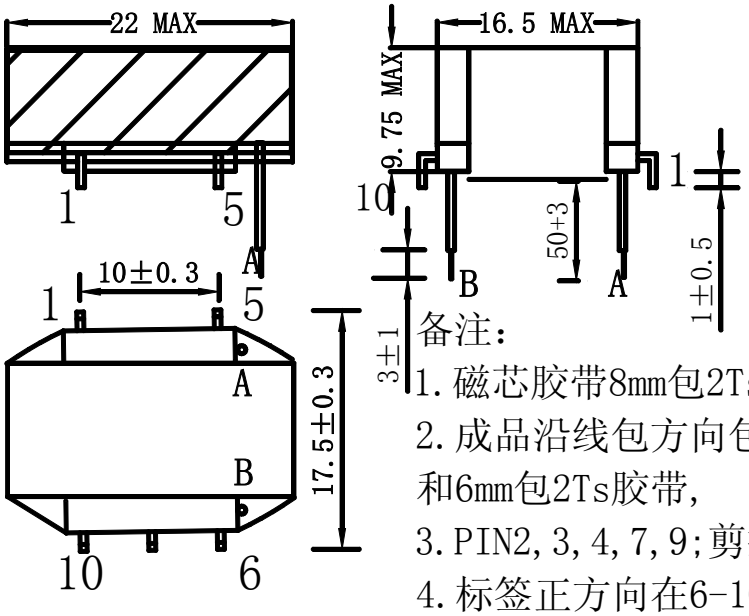
2) Core Material: PC40 (TDG).

3) L(1-5) = 250uH±50uH (1KHz,1V,25℃)

4) HI-POT: (60Hz/5mA/3SecT).

Pri. to Sec. 3000 Vac.

2) Electrical diagram



备注：

1. 磁芯胶带8mm包2Ts；
2. 成品沿线包方向包0.025mmx3 1.1圈铜箔和6mm包2Ts胶带,
3. PIN2,3,4,7,9;剪掉；
4. 标签正方向在6-10脚，底部；
5. A脚为套蓝色套管，B脚套黑色的 ，套管外露不少于47mm

Figure 4: Electrical Diagram

3) Transformer Build Diagram

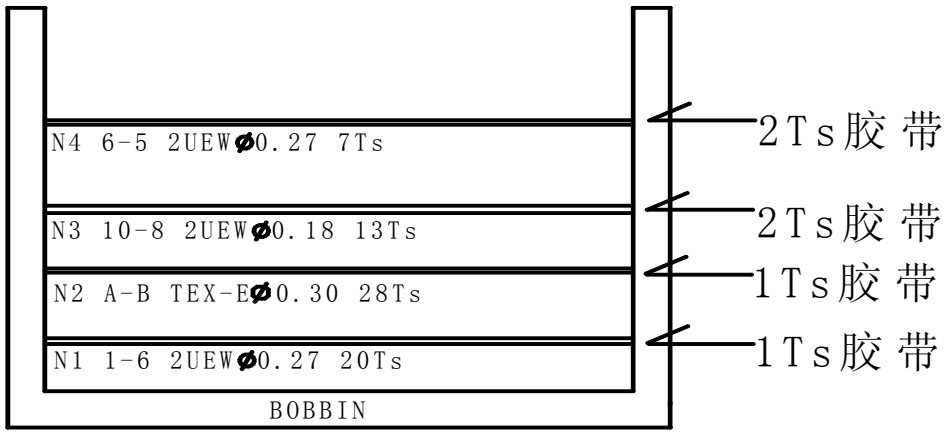


Figure 5: Transformer Build Diagram

4 PERFORMANCE EVALUATION

Performance Highlights:

The efficiency over 100Vac ~240Vac is >82%

The standby power is < 0.3W at 240Vac/50Hz with no load

Characterization Results Summary

Test Item	Specification	Test result
1. Input Characteristics		
Input Voltage	100~240V	100~240V
Input Current	<1A	<0.2A
Standby power	<1W	<0.9W
Efficiency (average)	>82%	>82%
2. Output Characteristics		
Output Voltage Range	32V±10%	31.7V
Output Current Range	500mA±3%	509mA
Output Voltage Ripple	2V	<1.2V
Output Current Ripple	200mA	<168mA
3. Time Sequence		
Turn on delay time	<2s	<1.7s
Hold up time		
Power Factor Correction	>0.9 with full load	>0.94
4. Protection		
Over Voltage protection	<50V	<48V
Short Circuit protection	Pin<2W	<1W

Table 7

4.1 Input Characteristics

1) Input Normal Characteristics

The module was tested at different input voltages (from 90Vac to 264Vac) and different load conditions (full load and no load). Efficiency and standby power were measured and listed in table 10 and table 11.

Input	Irms (A)	Pin (W)	Vo(V)	Io (A)	PF	η	Spe.	Test Result
100V/50Hz	0.193	19.2	31.45	0.508	0.986	83.21%	>82%	pass
150V/50Hz	0.128	18.9	31.40	0.509	0.985	84.56%		
180V/50Hz	0.106	18.9	31.32	0.509	0.983	84.34%		
220V/50Hz	0.089	19.1	31.28	0.509	0.974	83.35%		
240V/50Hz	0.082	19.2	31.26	0.509	0.968	82.87%		

Table 8: Input characteristics at full load

2) Standby Power

Input Voltage	Vo(V)	Input Power (W)	Specification	Test Result
100V/50Hz	<48	0.22	<1W	pass
150V/50Hz	<48	0.35		
180V/50Hz	<48	0.50		
220V/50Hz	<48	0.70		
240V/50Hz	<48	0.84		

Table 9: Standby power at no load

4.2 Output Characteristics

1) Precision of Output Current

Input Voltage	100V	150V	220V	240V	Precision
Current(A)	0.509	0.509	0.509	0.509	±1%

Table 10: Precision of Output Current

2) Ripple

Input Voltage	100V	150V	220V	240V
Ripple of Output Voltage	1.02V	1.06V	1.07V	1.07V

Table11: Ripple of Output Voltage

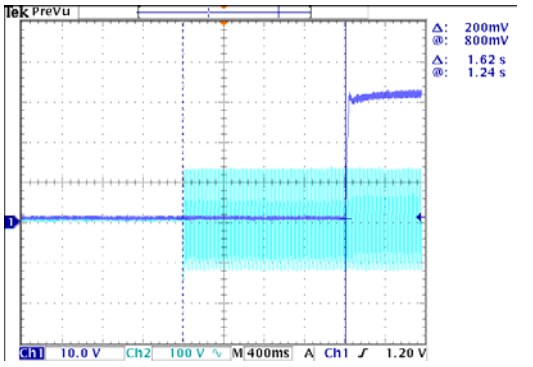
Input Voltage	100V	150V	220V	240V
Ripple of Output Current	0.168A	0.136A	0.160A	0.162A

Table12: Ripple of Output Current

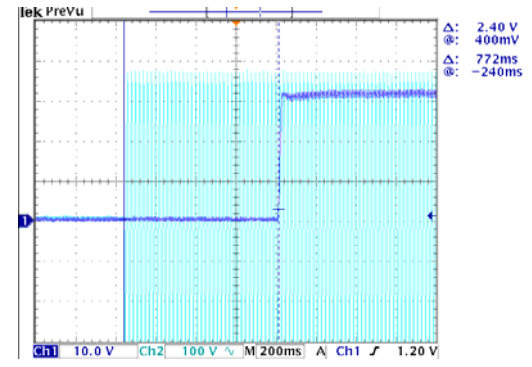
3) Time Sequence

a) Start Up & Turn On Delay Test

The unit shall be able to start up into a resistive load up to the rated current. Use a digital oscilloscope to capture the output voltage waveform against the input voltage waveform to find the time from application of AC power to output reach 90% of final value as well as the turn on overshoot / undershoot voltage



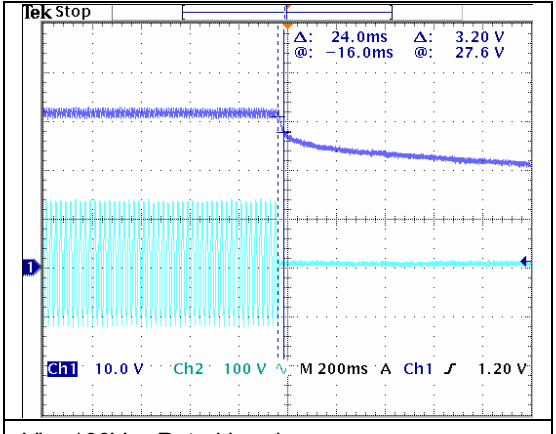
Vin=100 Vac, Rated Load
Vos=0mV, Tdelay=1620mS



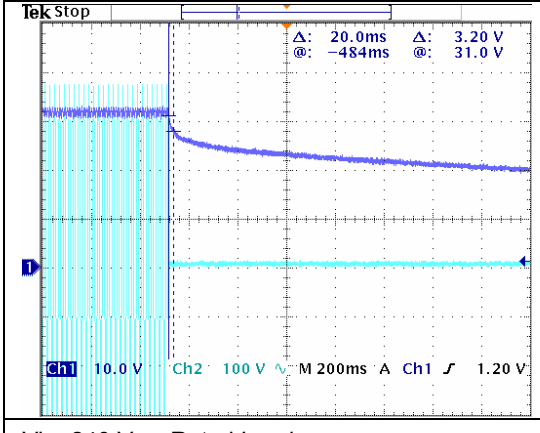
Vin=240 Vac, Rated Load
Vos=0mV, Tdelay=772mS

b) Shut Down & Hold Up Time Test

Connect the unit to a missing cycle tester so that the turn off instant can be captured. Set the AC ON-time to maximum and the OFF-time to 1sec or greater. Use a digital oscilloscope to capture the output voltage waveform against the input voltage waveform when the AC power changes from on to off in order to find the time from the zero crossing point of AC power off to output voltage drop out of regulation limit.



Vin=100Vac,Rated Load
Vos=0mV, Thold=24mS

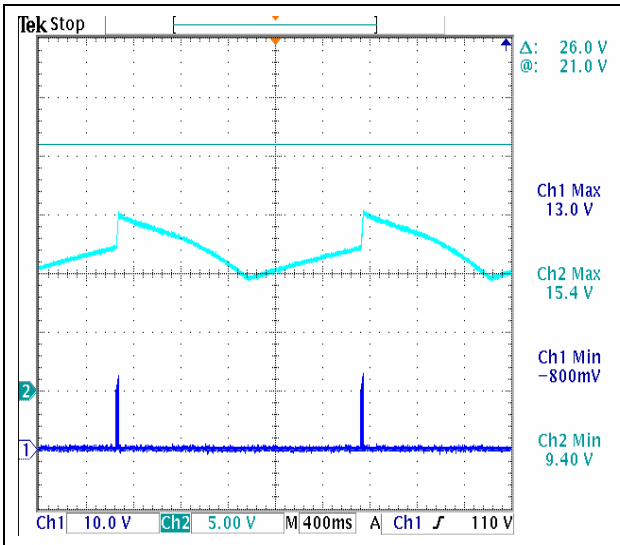


Vin=240 Vac, Rated Load
Vos=0mV, Thold=20mS

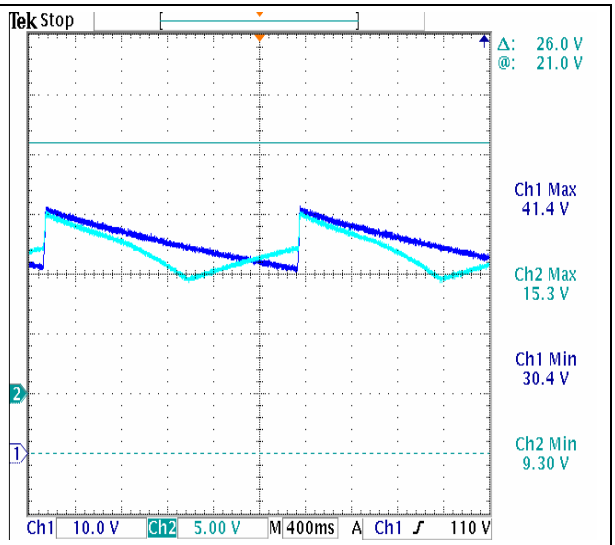
4.3 Protection

1) Over Voltage Protection

The system is latched protected during open loop condition or over voltage condition and recovered when re-starting Vcc.



Input Voltage: 100V
CH1:Vgs CH2:VCC



Input Voltage:100V
CH1:Vout CH2:VCC

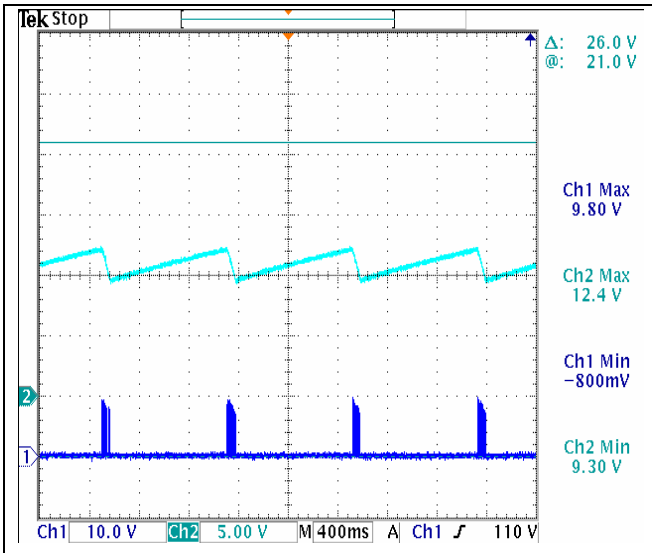
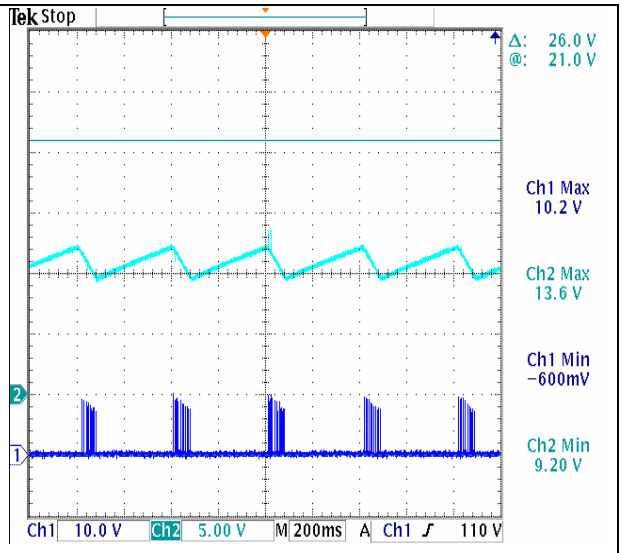
2) Short Circuit Protection

The system is protected during output short circuit condition and recovered when re-starting Vcc.

Vin	Initial Condition				During Short		After Removed		
(Vac)	Iout (A)	Vout (Vdc)	Iin (A)	Pin (W)	Iout (A)	Pin (W)	Vout (Vdc)	Iin (A)	Pin (W)
100	**Rated**	31.44	0.194	19.16	0	0.05*	31.44	0.194	19.16
240	**Rated**	31.42	0.069	19.23	0	0.825*	31.42	0.069	19.23

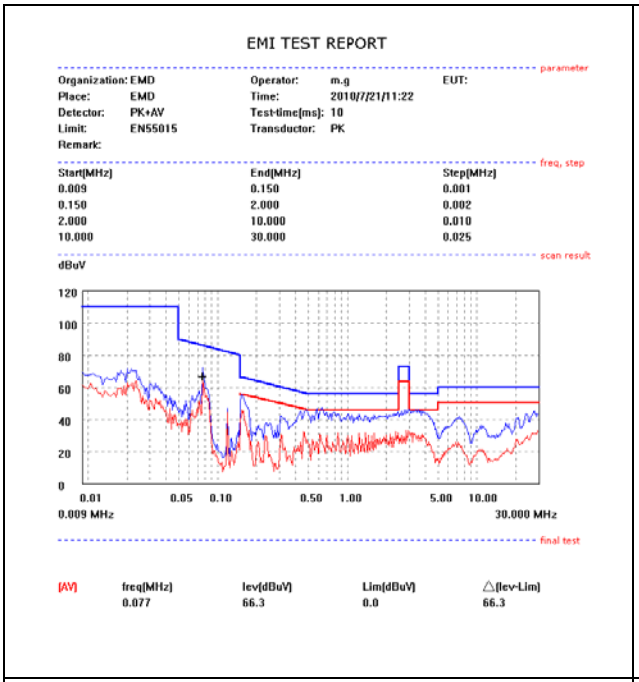
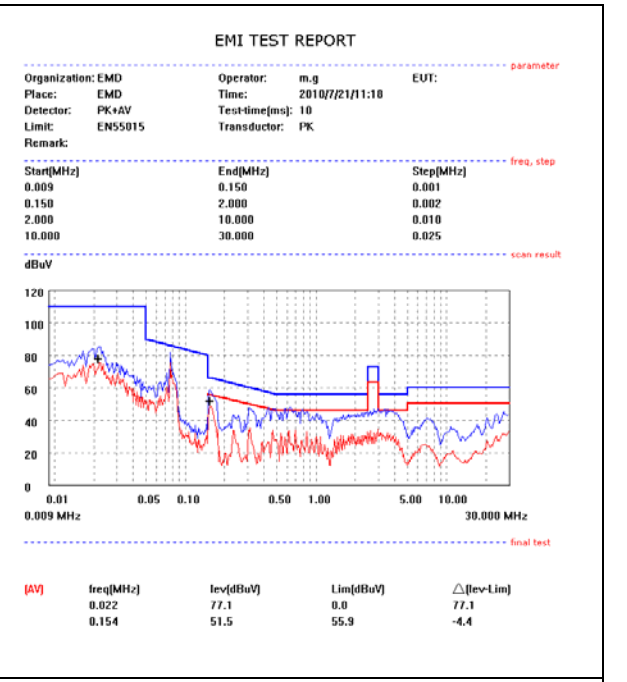
Table 13

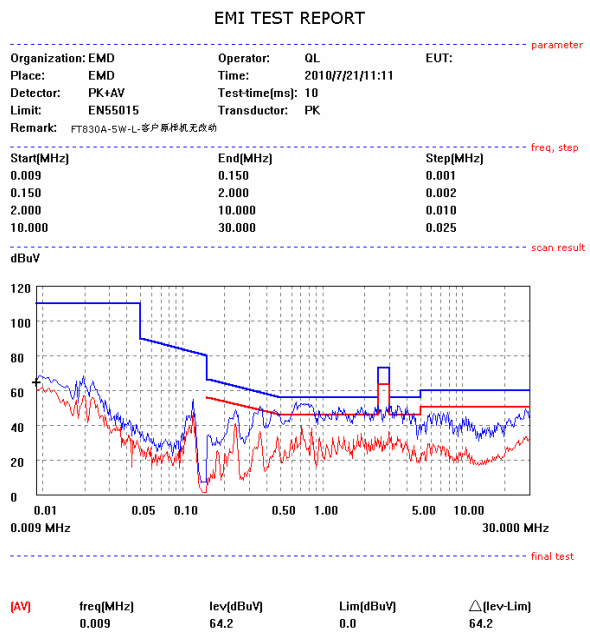
Note:* means average power

	
Input Voltage: 100V CH1:Vgs CH2:VCC	Input Voltage:240V CH1:Vgs CH2:VCC

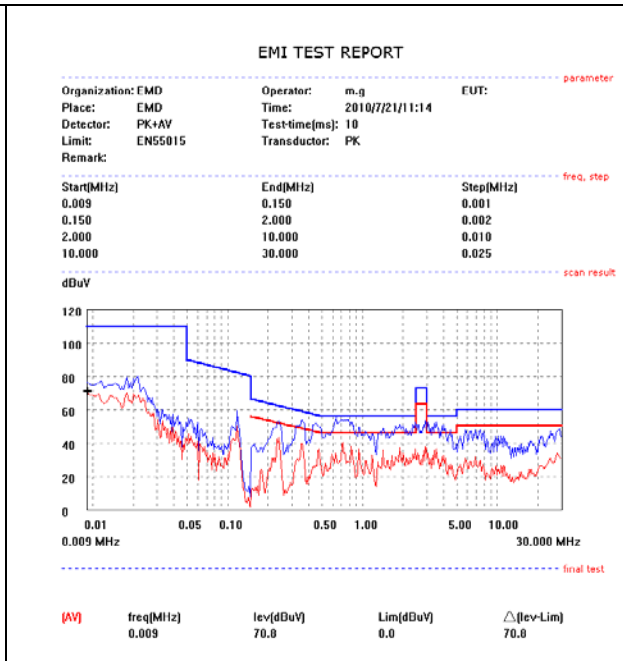
4.4 EMI Test

The Power supply passed EN55015 Class B EMI requirement with more than 4dB margin.

	
Input Voltage: 100V-L	Input Voltage: 100V-N



Input Voltage: 230V-L

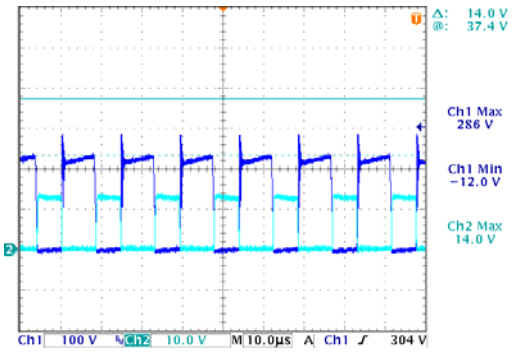


Input Voltage: 230V-N

5 SYSTEM OTHER IMPORTANT WAVEFORM

5.1 MOSFET VDS Waveform at startup

Q2

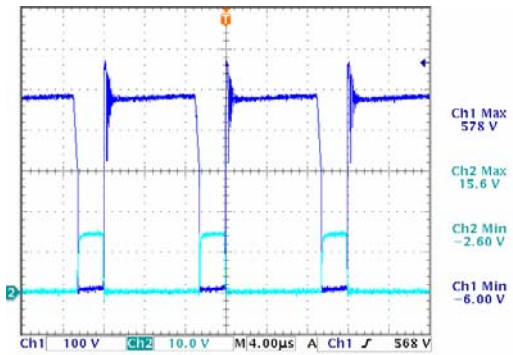


Vin=100Vac, Rated Load

CH1 : Vp-ds=286V (< spec. *1)

CH4 : Vp-gs=14.9V (< spec. *1)

Q2

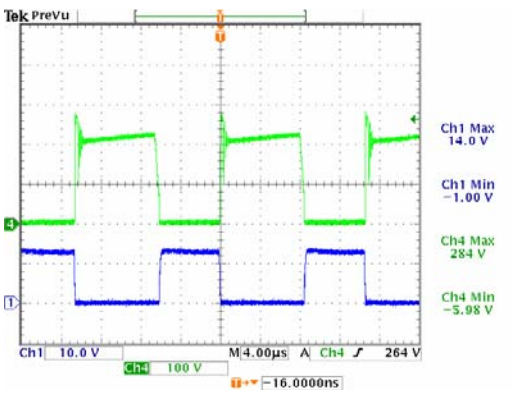
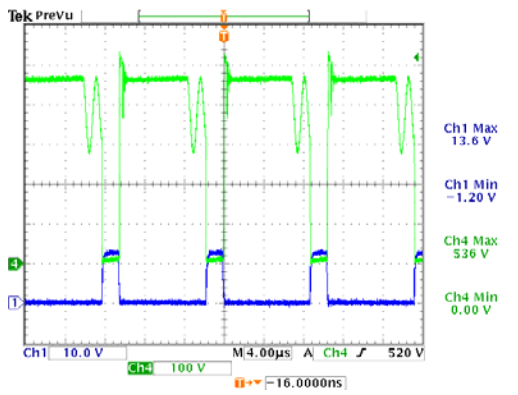


Vin=240Vac, Rated Load

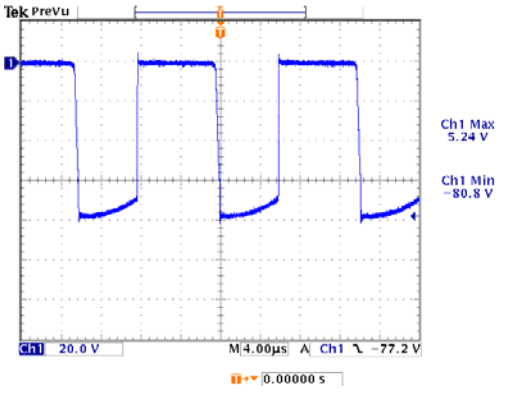
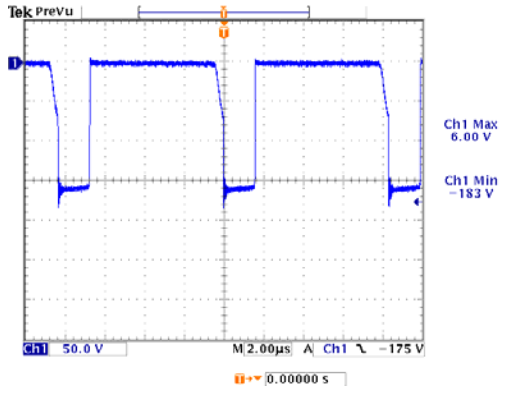
CH1 : Vp-ds=578V (< spec. *1)

CH4 : Vp-gs=15V (< spec. *1)

5.2 MOSFET VDS Waveform at rated load

Q2	Q2
	
Vin=100Vac, Rated Load CH1 : Vp-ds=284V (< spec. *0.9) CH4 : Vp-gs=14V (< spec. *0.9)	Vin=240Vac, Rated Load CH1 : Vp-ds=536V (< spec. *0.9) CH4 : Vp-gs=13.6V (< spec. *0.9)

5.3 Output Rectifier Diode VAK Waveftom at Fall Load

D13	D13
	
Vin=100Vac, Rated Load CH1 : Vp =80.8V (< spec. *0.9)	Vin=240Vac, Rated Load CH 1: Vp =183V (< spec. *0.9)