DEMO BOARD TEST REPORT

Universal Input Power Factor Corrected 24W LED Driver with PWM Dimming Using KP114

FEATURES

- Low Cost PSR Buck LED Driver Solution
- Active Power Factor Correction Technique
- Universal Input Range with High PF>0.9
- Quasi-Resonant (QR) Operation Mode with Up to 91% Efficiency
- Fast Start-Up Speed <600ms
- Good Line and Load regulation <+-3%
- Flicker-Free Operation with PWM Dimmers
- Valley Switching Technique for Good EMI
- LED Short and Open Protection
- Current Sense Resistor Short and Open Protection
- Over Voltage Protection (OVP) on VDD
- Cycle-by-cycle Current Limiting
- Line Voltage Absent Protection
- Over Temperature Protection (OTP)
- Internal Soft Start

INTRODUCTION

KP114 is an off-line Primary Side Regulation (PSR) LED controller with PWM Dimming function, which can achieve very high Power Factor and accurate output current regulation. At the same time, the adopted QR operation Mode minimized the switching loss and lead to good EMI performance.

The Demo Board of KP114-D002 is typically designed for the application of 72V/300mA with universal input (90-265Vac, 60/50Hz). Besides the multi-protection function, this demo also has very good efficiency, current regulation, Power Factor and meet the EN55015 conducted and radiated EMI requirement.

APPLICATIONS

- **Dimmable Lights**
- **Commercial & Residential Lighting**

DEMO BOARD SEPCIFICATION

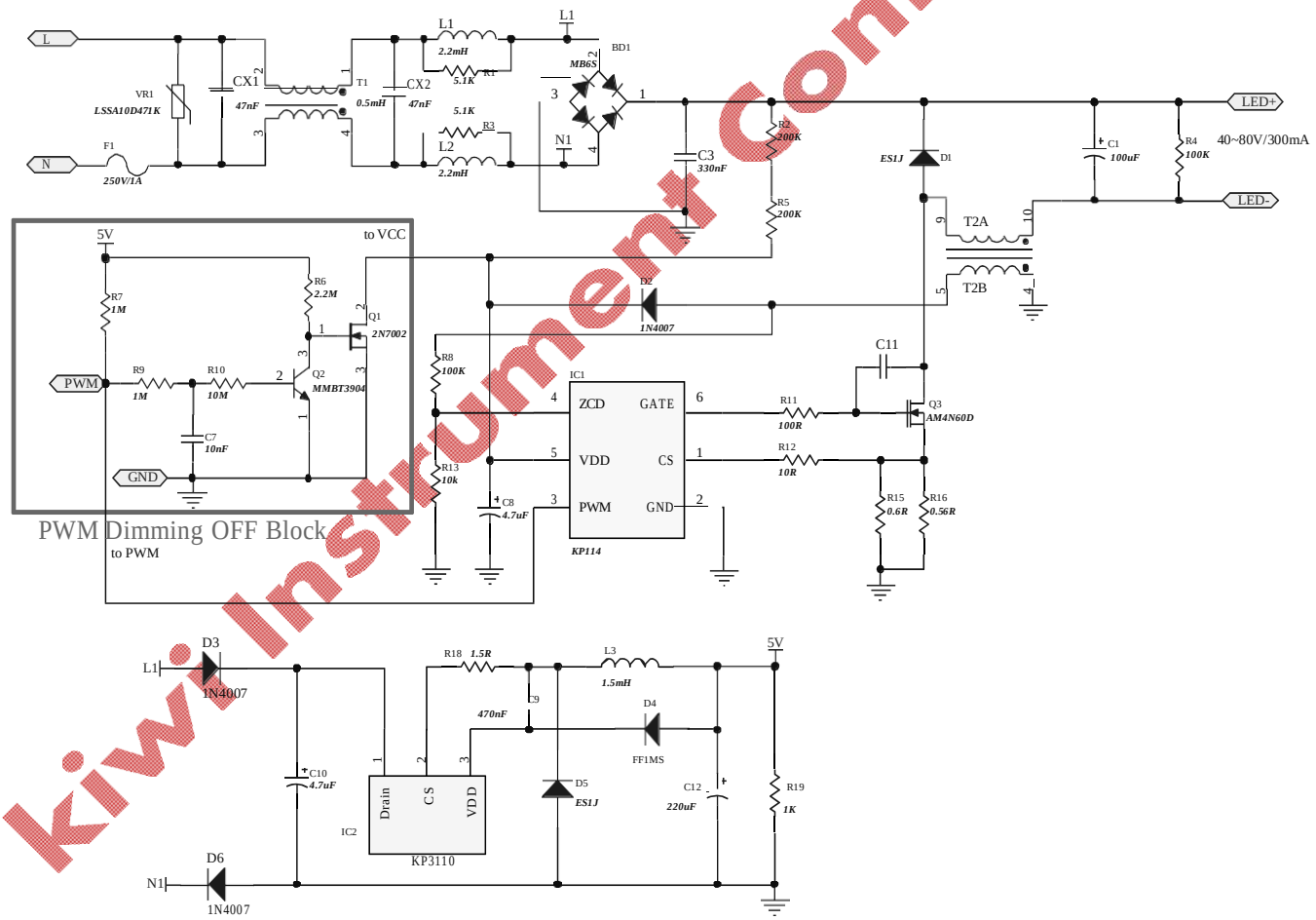
Description	Symbol	Min	Type	Max	Unit	Note
Input Voltage	Vin	90		265	Vac	
Output Voltage	Vout	40		80	Vdc	
Output Current	Iout		300		mA	No Dimming and PWM Dimming Duty Cycle>99%
Output Power	Pout			24	W	
Efficiency	η		90	91	%	Typical value tested at 120Vac/60Hz
Standby Power Consumption	Pst		120		mW	Typical value tested at 230Vac/50Hz
Startup Time	Tst			600	ms	Tested at 90Vac/60Hz
Power Factor	PF	0.92				
Total Harmonics Distortion	THD				%	

The table above shows the minimum acceptable performance of the design. Actual performance is listed in the results section.

Demo Board of KP114-D002

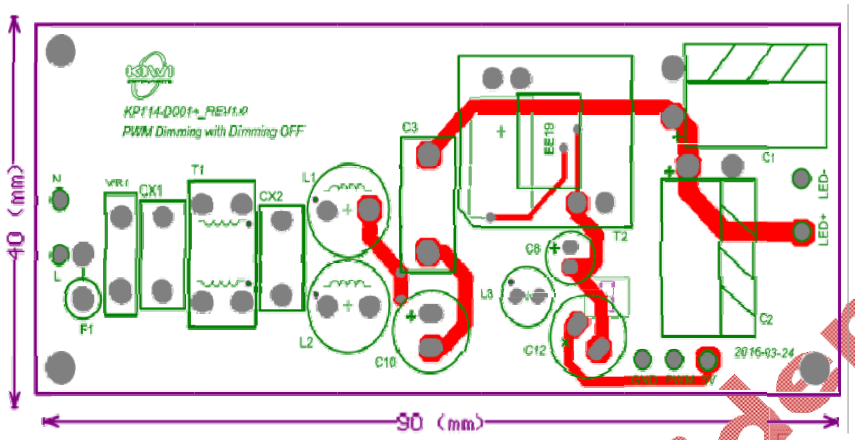
Board Size(in mm): L x W x H=90X40X26

Schematic

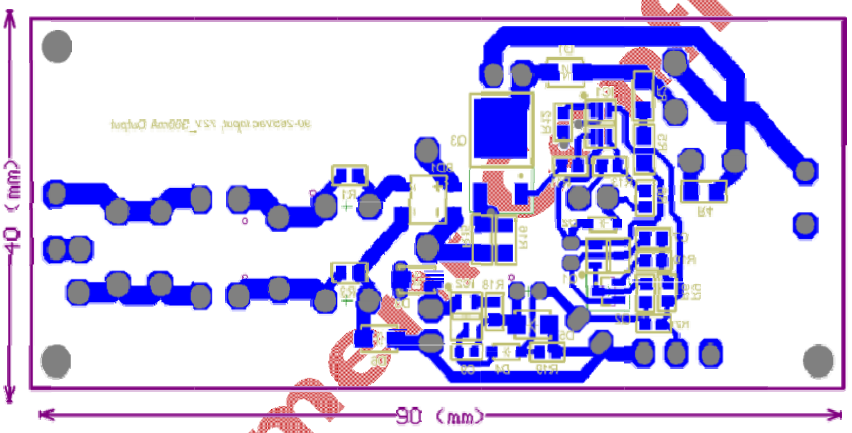


Printed Circuit Board Layout

Top Layer



Bottom Layer



Circuit Description

The demo board of KP114-D002 is designed with the single stage Low Side Buck topology, which uses the primary side regulation technology to simply the circuit and save cost of BOM. With Dimming-Off Circuit added, the demo can achieve LED Current Dimming OFF when PWM Dimming duty is lower than a given value. Additionally the demo board can achieve good performance for high efficiency, high power factor and accurate output current.

1. Input Rectification and EMI filtering

The circuit input stage is composed by the components of F1, CX1, CX2, T2, L1, L2, C1, R1 and R3. F1 provides the inrush current limitation in the event of component failure or a short circuit. CX1, CX2, T2, L1, L2, R1 and R3 together provide the differential and common mode EMI filtering. The bridge diode of BD1 rectifies the AC input to DC output which is followed by a high frequency noise filter capacitor C3. The value of C3 needs to be fine-tuned according to the EMI and PF requirement.

2. KP114 Operation

KP114 is an off-line Primary Side Regulation (PSR) LED controller with PWM Dimming function, which operates in the QR Mode to achieve high efficiency and good EMI performance. Due to the constant on time control function, high PF result can be maintained. When PWM pulse dimming signal is applied, the output current can be automatically changed.

C8 is the DC voltage power supply for the IC, which is charged from the rectified voltage through R2 and R5 during the startup period and charged by the auxiliary winding from D2 after the output voltage is ready. When the voltage of C8 is higher than the internal OVP threshold, the IC stops switching immediately and enters quiescent operation mode.

R8 and R13 are used to detect zero current cross point for QR operation mode. When the falling edge of the ZCD Pin voltage signal is found, the GATE is turned on with some internal dely. In each switching cycle, the high voltage level of ZCD Pin is monitored and then is used to configure the OCP level on CS Pin. When LED is shorted, the output and high voltage level of ZCD Pin become nearly zero, which makes the OCP level to the minimum value.

R11 and C11 compose the GATE driver circuit which is used to slow down the MOSFET turn on and off speed for good radiated EMI performance. There's a tradeoff between the EMI margin, efficiency and LED current regulation. R15 and R16 are used as the sensing resistor. The averaged voltage on CS pin is regulated by the IC which helps to achieve accurate output current.

3. Output Current Regulation

T2, Q3, D1, C5 and C1 compose the typical Low Side Buck converter. R4 is the dummy resistor, and output capacitor is discharged after system is shut down.

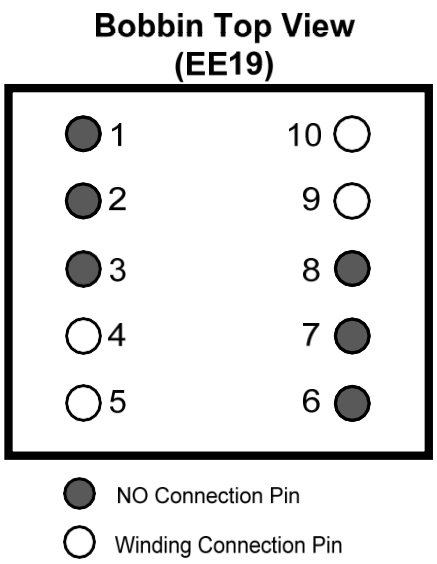
Bill of Material

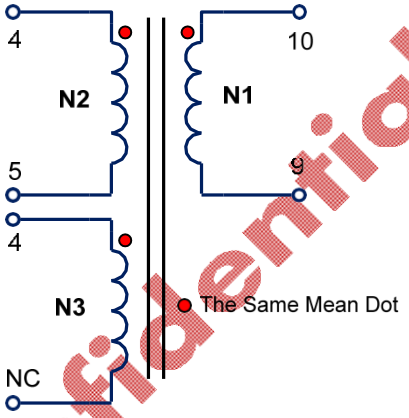
Number	Designator	Value	Description	Package	Manufacturer	Part Number
1	BD1	600V/0.5A	SINGLE PHASE SILICON BRIDGE,600V/0.5A	SMD	Any	MB6S
2	C1	100uF	Electrolytic Cap, 100V,12.5*20	TH	jianghai	ECR2ABK101M□□12502 0
3	C2	100uF	Electrolytic Cap, 100V,12.5*20	TH	jianghai	ECR2ABK101M□□12502 0
4	C3	330nF	C21,400Vdc,P=10mm,T=6.2mm	TH	Fala	334J 400V
5	C7	10nF	Ceramic Cap, 50V X7R	1206	Murata	GRM31CR73A103KW03 L
6	C8	4.7uF	Electrolytic Cap, 50V,5*11.5	TH	jianghai	ECR1HBK4R7M□□05001 1
7	C9	470nF	Ceramic Cap, 50V NPO	0603	Murata	GRM188R71H102KA01D
8	C10	4.7uF	Electrolytic Cap, 450V,10*16	TH	jianghai	ECR2WBK4R7M□□1000 16
9	C11	10pF	Ceramic Cap, 1kV X7R	1206	Murata	GRM31A5C3A100JW01 D
10	C12	220uF	Electrolytic Cap, 50V,8*11.5	TH	jianghai	ECR1HBK101M□□08001 1
11	CX1	47nF	MKP62,275Vac~X2,P=7.5mm,T=5m m	TH	Fala	C42P2473K3SC000
12	CX2	47nF	MKP62,275Vac~X2,P=7.5mm,T=5m m	TH	Fala	C42P2473K3SC000
13	D1	600V/1A	1.0 AMP Surface Mount Super Fast Recovery Rectifiers	SMA	Lision Tech	ES1J
14	D2	100V/0.3A	SILICON RECTIFIERS,100V/0.3A	SOD123	Any	1N4007
15	D3	100V/0.3A	SILICON RECTIFIERS,100V/0.3A	SOD123	Any	1N4007
16	D4	1KV/1A	Fast Recovery Rectifiers	SOD123	YEA SHIN	FF1MS
17	D5	600V/1A	1.0 AMP Surface Mount Super Fast Recovery Rectifiers	SMA	Lision Tech	ES1J
18	D6	100V/0.3A	SILICON RECTIFIERS,100V/0.3A	SOD123	Any	1N4007
19	F1	250V/1A	Fuse 250V/1A	TH	Any	
20	IC1	KP114	PWM Dimmable Primary Side Regulation PWM Controller With PFC	SOT-23-6	Kiwi Instruments	KP114
21	IC2	KP3110	High Performance Low Cost Off-line PWM Power Switch	TO-92	Kiwi Instruments	KP3110
22	L1	2.2mH	WE-TI Inductor,Isat=0.40A,Rdc=2.40Ω,9*1 3	TH	Wurth Elektronik	7447452222
23	L2	2.2mH	WE-TI Inductor,Isat=0.40A,Rdc=2.40Ω,9*1 3	TH	Wurth Elektronik	7447452222
24	L3	1.5mH	WE-TI Inductor,Isat=0.80A,Rdc=1.00Ω,10* 14	TH	Wurth Elektronik	7447480102
25	Q1	2N7002	N Mosfet, 60V/0.16A, Rdson=1.5ohm	SOT23	Any	2N7002
26	Q2	MMBT3904	SMALL SIGNAL NPN TRANSISTOR	SOT23	Any	MMBT3904
27	Q3	AM4N60D	N Mosfet, 600V/4A, Rdson=2.0ohm	TO-252	Analog Power	AM4N60D
28	R1	5.1K	Film Resistor, 5%	1206	Yageo	RC1206JR-075K1L
29	R2	240K	Film Resistor, 5%	1206	Yageo	RC1206JR-07240KL
30	R3	5.1K	Film Resistor, 5%	1206	Yageo	RC1206JR-075K1L

31	R4	100K	Film Resistor, 5%	1206	Yageo	RC1206JR-07100KL
32	R5	240K	Film Resistor, 5%	1206	Yageo	RC1206JR-07240KL
33	R6	2.2M	Film Resistor, 5%	1206	Yageo	RC1206JR-071ML
34	R7	1M	Film Resistor, 5%	1206	Yageo	RC1206JR-071ML
35	R8	82K	Film Resistor, 5%	0805	Yageo	RC0805JR-0782KL
36	R9	1M	Film Resistor, 5%	1206	Yageo	RC1206JR-071ML
37	R10	10M	Film Resistor, 5%	1206	Yageo	RC1206JR-071ML
38	R11	100R	Film Resistor, 5%	0805	Yageo	RC0805JR-07100RL
39	R12	10R	Film Resistor, 5%	0805	Yageo	RC0805JR-0710RL
40	R13	10k	Film Resistor, 5%	0805	Yageo	RC0805JR-0710KL
41	R15	0.6R	Film Resistor, 1%	1206	Yageo	RC1206FR-07R60L
42	R16	0.56R	Film Resistor, 1%	1206	Yageo	RL1206FR-070R56L
43	R18	1.5R	Film Resistor, 1%	1206	Yageo	RL1206FR-070R56L
44	R19	1K	Film Resistor, 5%	0805	Yageo	RC0805JR-071K5L
45	T1	0.5mH	WE-CMBNC Common Mode Power Line Choke,TYPE XS	XS	Wurth Elektronik	7448013501
46	T2	Lp=439uH	Self Widing,Np=123T,Naux=44T	EE19		
47	VR1	470V@0.1mA	VARISTOR,P=7.5mm,T=3.6mm	7D	Lision Tech	LSSA7D471K

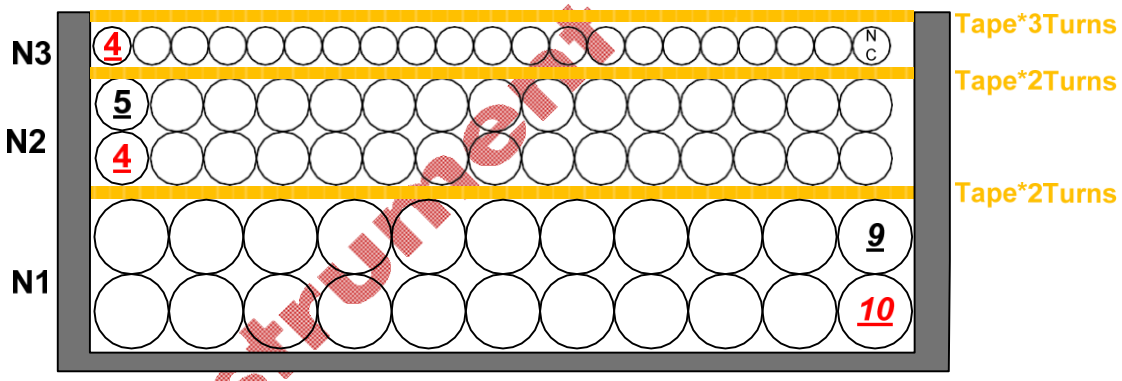
Transformer Manufacture Guide

1. Electrical Diagram





2. Winding Diagram



3. Winding Order

Winding Number	Layer	Start	End	Wire Size	Turns
N1	Primary	10	9	0.3d*1P	123Ts
N2	Auxiliary	4	5	0.2d*1P	44Ts
N3	Shielding	4	NC	0.1d*1P	

4. Electrical Specification

Primary Inductance	➢ **Value:** 439uH±5% ➢ **Test condition:** Pins 10 - 9,all other windings open, measured at 40kHz, 1.0 VRMS

Test Result

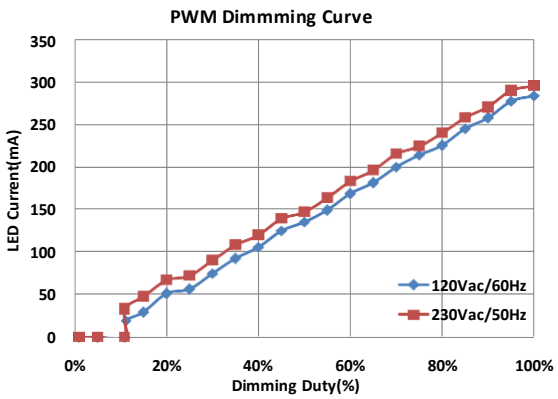
1. Efficiency, PF and LED Current Line Regulation

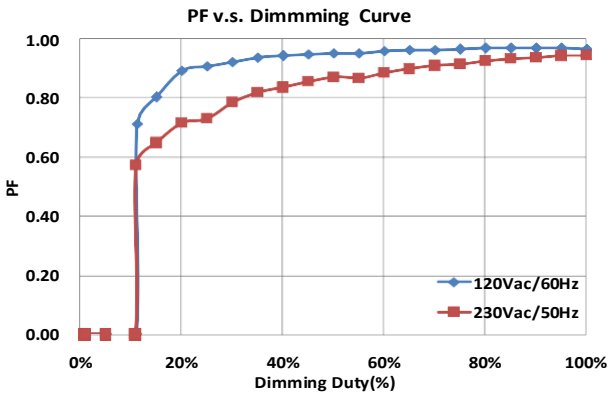
f (Hz)	Vin (VAC)	Pin (W)	Vout (V)	Iout (mA)	Pout (W)	Efficiency (%)	PF
60	90	22.76	71.8	285	20.46	89.91%	0.923
	100	22.40	71.8	282	20.25	90.39%	0.943
	110	22.30	71.8	282	20.25	90.80%	0.956
	120	22.31	71.8	282	20.25	90.76%	0.965
	130	22.37	71.8	283	20.32	90.83%	0.97
	140	22.53	71.8	284	20.39	90.51%	0.971
50	190	23.35	71.8	292	20.97	89.79%	0.969
	200	23.51	71.8	293	21.04	89.48%	0.965
	210	23.64	71.8	293	21.04	88.99%	0.957
	220	23.74	71.8	293	21.04	88.62%	0.948
	230	23.95	71.8	294	21.11	88.14%	0.947
	240	24.18	71.8	296	21.25	87.89%	0.942
	250	24.45	71.8	298	21.40	87.51%	0.936
	260	24.70	71.8	300	21.54	87.21%	0.929
	265	24.85	71.8	301	21.61	86.97%	0.924

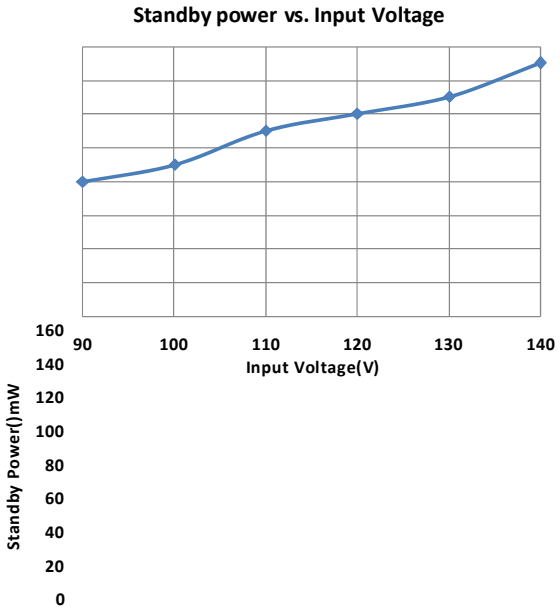
2. LED Current Load Regulation

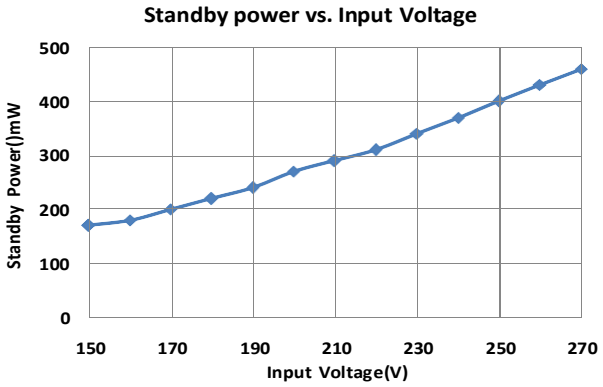
	Vout (V)	39.9	44.1	48.1	52.1	56.2	60.2	64.2	68.2	72.2	76.2	80.2
120Vac /60Hz	Iout (mA)	273	275	276	276	278	279	280	281	282	283	284
230Vac /50Hz	Iout (mA)	290	292	292	293	294	294	294	294	295	296	298

3. PWM Dimming Performance Test (PWM Dimming Signal: 1kHz, PWM_H=5V, PWM_L=0V)



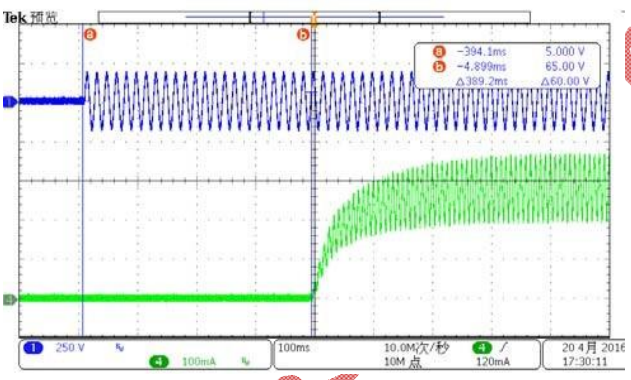




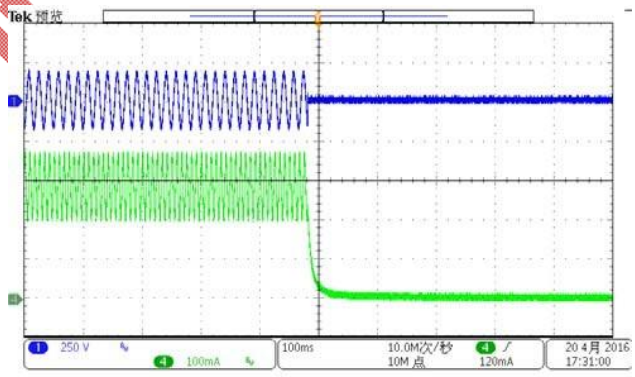


4. EMC Test Result (未测)

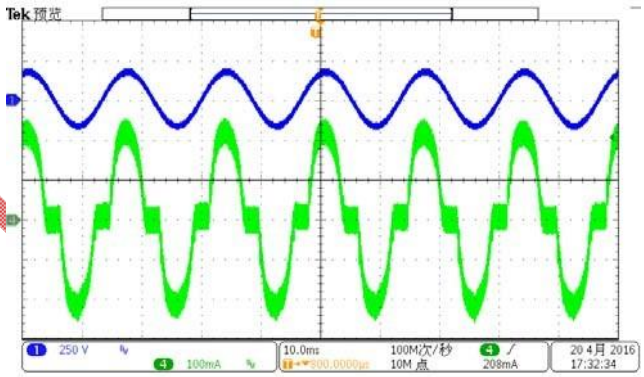
5. Operation Curves (Test Condition: Vin=120VAC/60Hz, Vout=72V, Io=300mA)



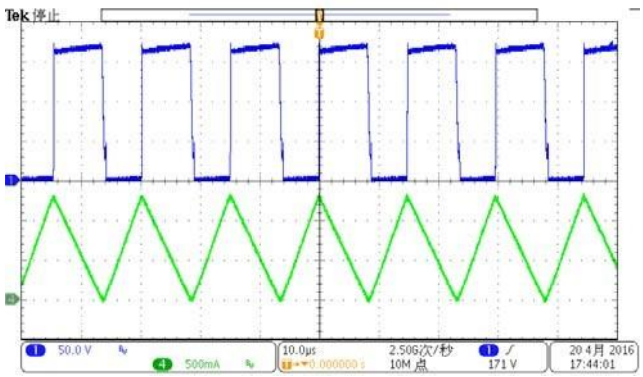
System Startup Time
(CH1-VINAC, CH4-LED Current)



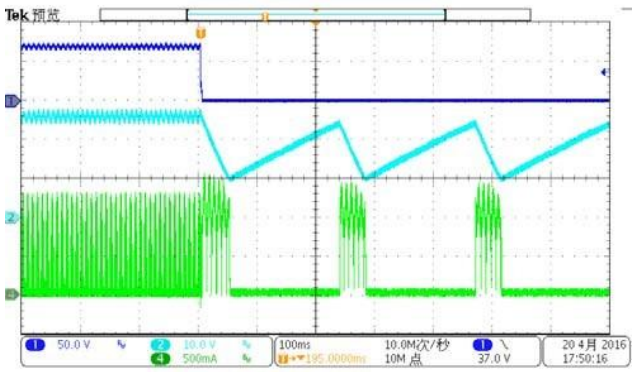
System Shut Down
(CH1-VINAC, CH4-LED Current)



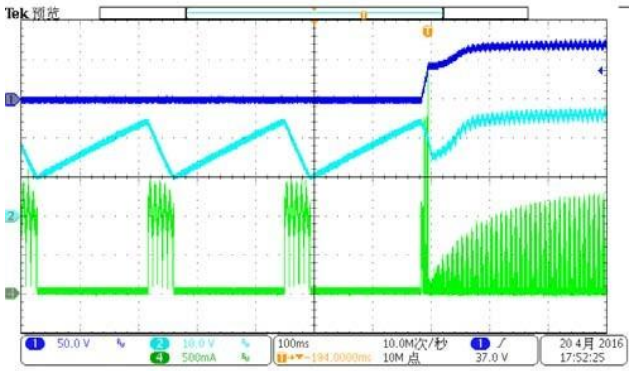
System Steady State
(CH1-VINAC, CH4-AC Current)



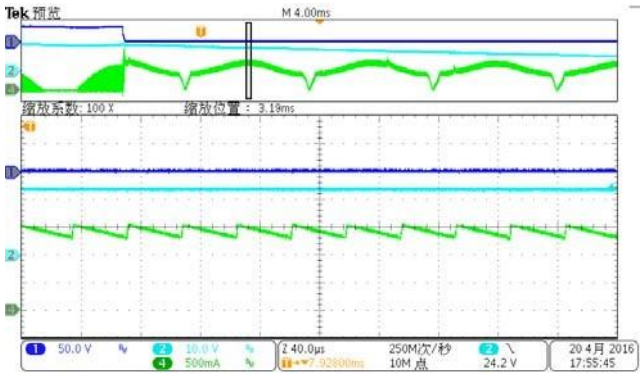
System Steady State
(CH1-V_MOS, CH2-V_Diode, CH4-Primary Current)



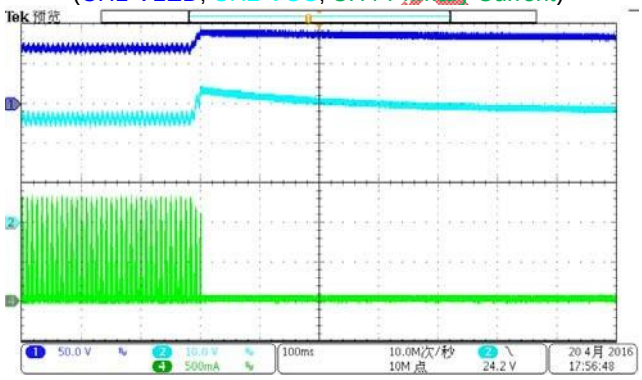
LED Short Fault Happen
(CH1-VLED, CH2-VCC, CH4-Primary Current)



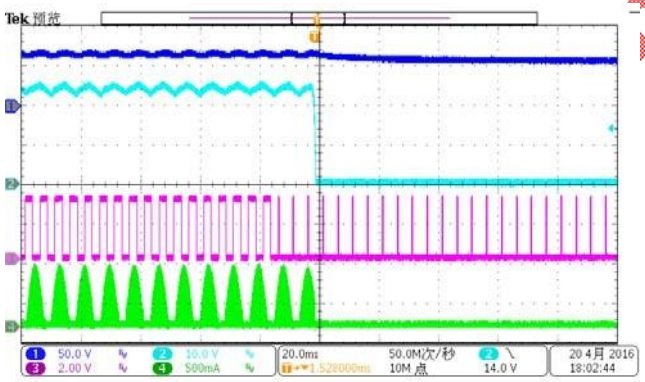
LED Short Fault Recovery
(CH1-VLED, CH2-VCC, CH4-Primary Current)



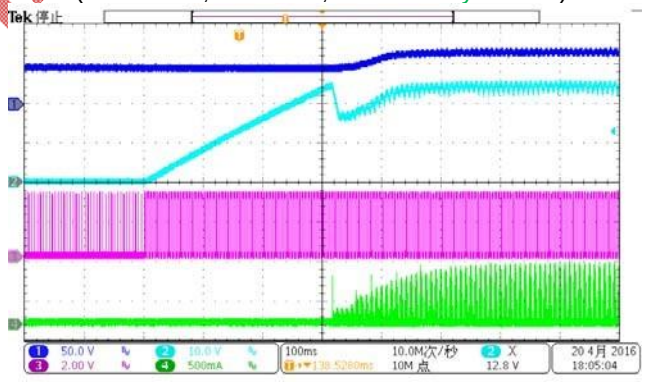
LED Short Fault Steady State
(CH1-VLED, CH2-VCC, CH4-Primary Current)



LED Open Fault Happen
(CH1-VLED, CH2-VCC, CH4-Primary Current)

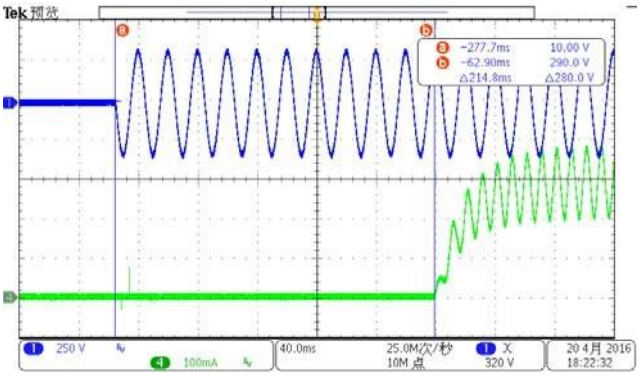


LED Dimming OFF (50%->5%)
(CH1-VLED, CH2-VCC, CH3-PWM Dimming,CH4-Primary Current)

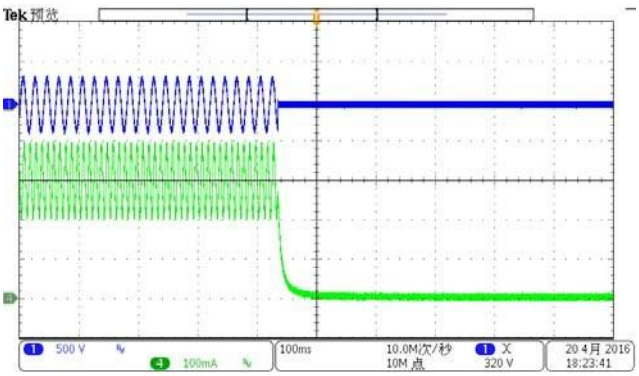


LED Dimming ON (5%->50%)
(CH1-VLED, CH2-VCC, CH3-PWM Dimming,CH4-Primary Current)

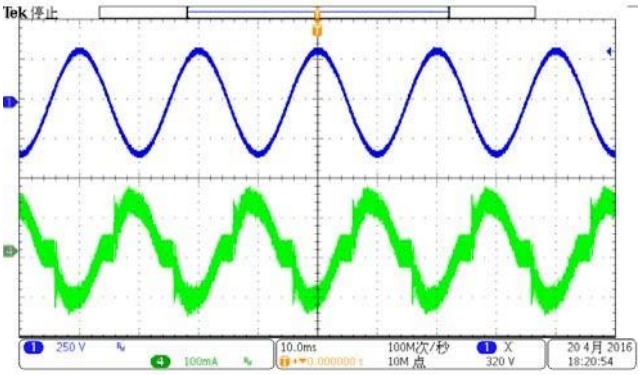
6. Operation Curves (Test Condition: Vin=230VAC/50Hz, Vout=72V, Io=300mA)



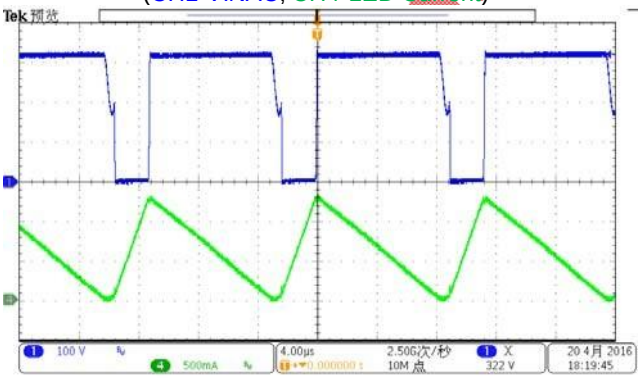
System Startup Time
(CH1-VINAC, CH4-LED Current)



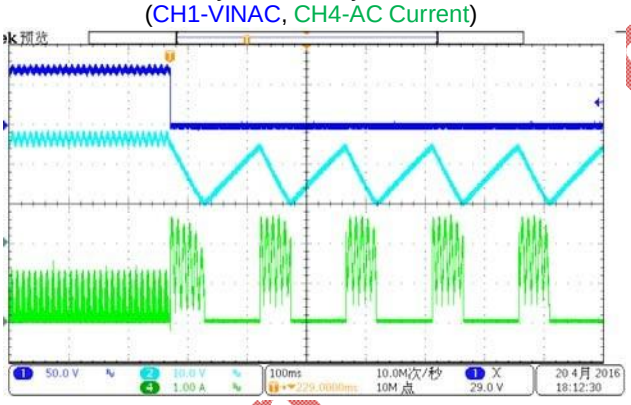
System Shut Down
(CH1-VINAC, CH4-LED Current)



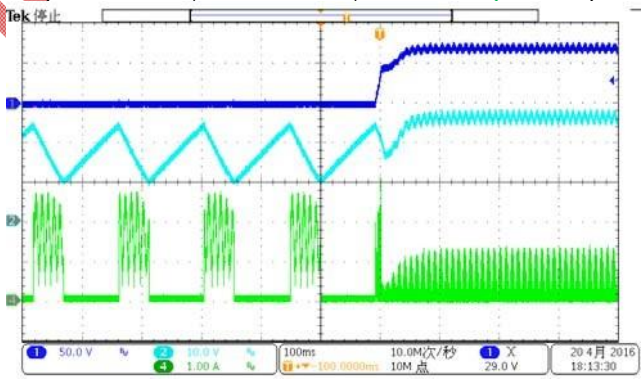
System Steady State
(CH1-VINAC, CH4-AC Current)



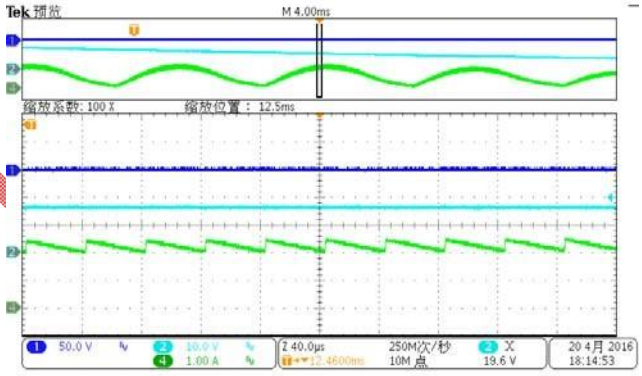
System Steady State
(CH1-V MOS, CH2-V Diode, CH4-Primary Current)



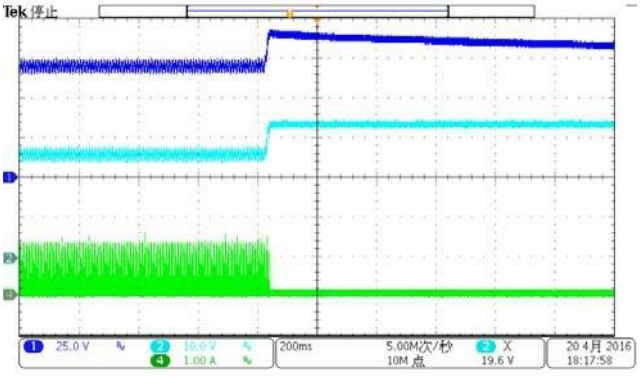
LED Short Fault Happen
(CH1-VLED, CH2-VCC, CH4-Primary Current)



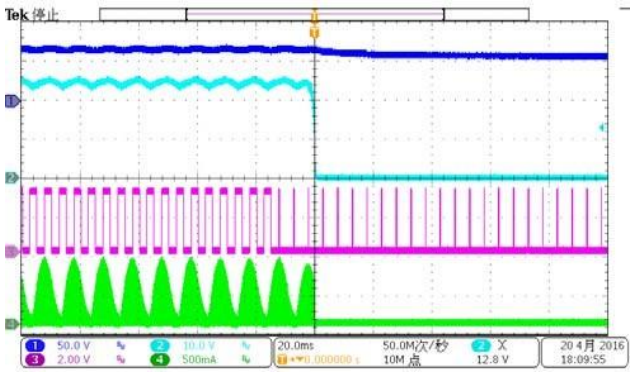
LED Short Fault Recovery
(CH1-VLED, CH2-VCC, CH4-Primary Current)



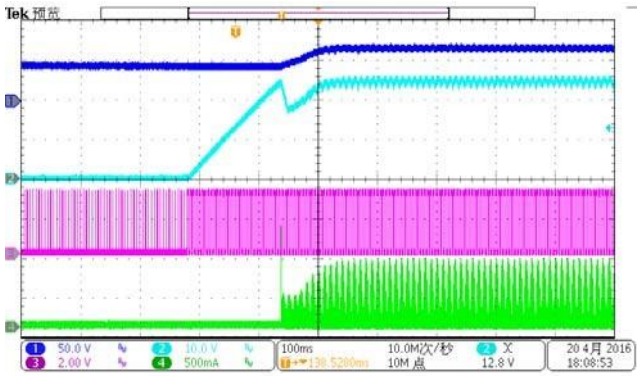
LED Short Fault Steady State
(CH1-VLED, CH2-VCC, CH4-Primary Current)



LED Open Fault Happen
(CH1-VLED, CH2-VCC, CH4-Primary Current)



LED Dimming OFF (50%->5%)
(CH1-VLED, CH2-VCC, CH3-PWM Dimming,CH4-Primary Current)



LED Dimming ON (5%->50%)
(CH1-VLED, CH2-VCC, CH3-PWM Dimming,CH4-Primary Current)

Test Setup Guide

1. Connect the “LED+” terminal to the anode of LED string and the “LED-” terminal to the cathode of LED string.
2. Set the AC Power Source to between 90VAC and 265VAC.
3. Connect the AC Power Source terminal to the “L” and “N” terminals on the Demo Board
4. Turn on the AC Power Source to make system startup; and Turn off the AC Power Source to make system shutdown.
5. For PWM dimming case:
   a) Pre-define the external PWM Dimming Signal to satisfy following condition:
      - Dimming Frequency: 100Hz<PWM<20kHZ
      - Dimming Voltage: 2V<PWM_H<5V; PWM_L<0.5V
   b) Connect the positive terminal of the PWM Dimming signal to the “PWM+” terminal on the Demo Board, and connect the GND terminal of the PWM Dimming signal to the “GND” terminal on the Demo Board.
   c) Repeat the step of 1-4 to enable PWM dimming function.

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