Universal Input Power Factor Corrected 50W LED Driver Using KP118

FEATURES

- High PF and Low THD LED Driver Solution
- Quasi-Resonant (QR) Operation Mode with High Efficiency >89%
- High PF>0.95 Low THD<10%
- Fast Start-Up Speed <400ms
- Excellent Line and Load regulation <+-3%
- Built-in HV startup and IC Power supply circuit
- Leading Edge Blanking (LEB)
- LED Short and Open Protection
- Cycle-by-cycle Current Limiting
- Over Temperature Protection (OTP)

APPLICATIONS

- Commercial & Residential Lighting

INTRODUCTION

KP118 is a highly integrated LED controller with constant current (CC) control. The IC can achieve very high Power Factor, low THD 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 KP118-D01 is typically designed for the application of 36V~42V/1000mA with universal input (90-265Vac, 60/50Hz). Besides the multi-protection function, this demo also has very good efficiency, current regulation, Power Factor, THD and meet the EN55015 conducted and radiated EMI requirement.

DEMO BOARD SEPCIFICATION

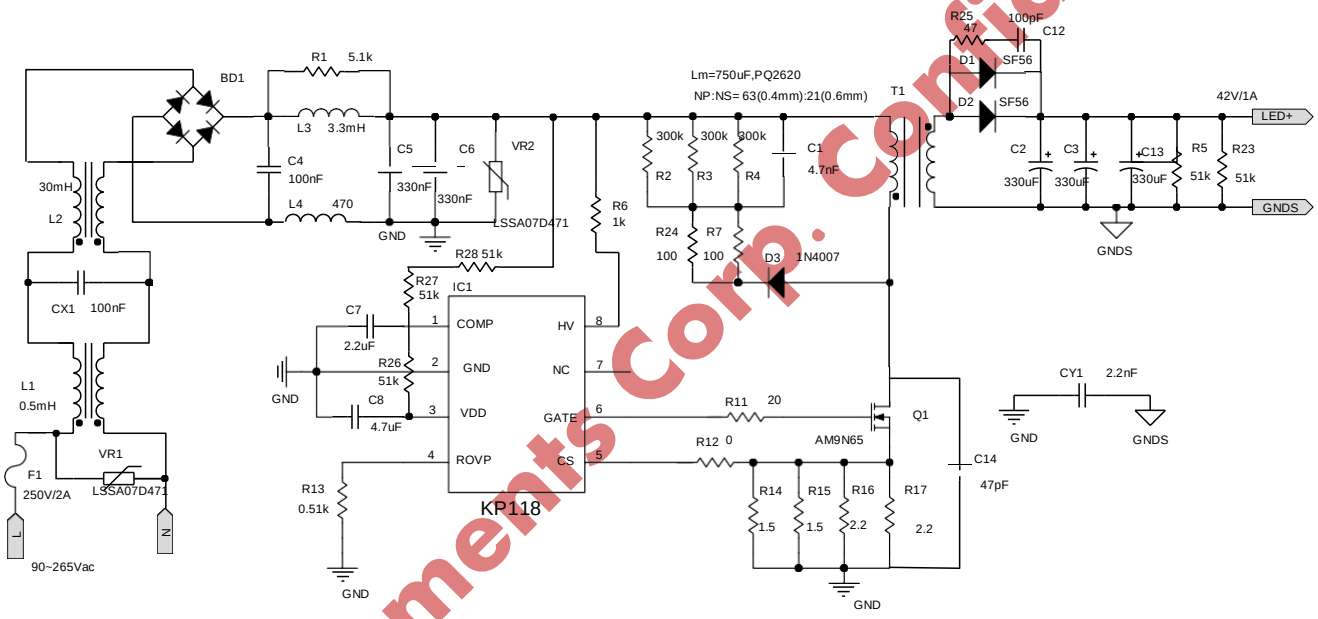
Description	Symbol	Min	Type	Max	Unit	Note
Input Voltage	Vin	90		265	Vac	50/60Hz
Output Voltage	Vout	36		42	Vdc	OVP voltage is 60V
Output Current	Iout		1000		mA	
Output Power	Pout		42		W	
Efficiency	η		89		%	Typical value tested at 230Vac/50Hz
Total Harmonic Distortion	THD			10	%	
Power Factor	PF	0.96				
Startup Time	Tst			350	ms	Tested at 90Vac/60Hz
Surge Test		1			kV	Typical Differential Surge value tested at 230Vac/50Hz

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

Demo Board of KP118SP_D01_REV1.1

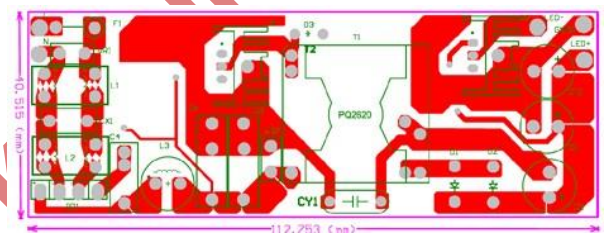
Board Size (in mm): L x W x H=113X41X24

Schematic

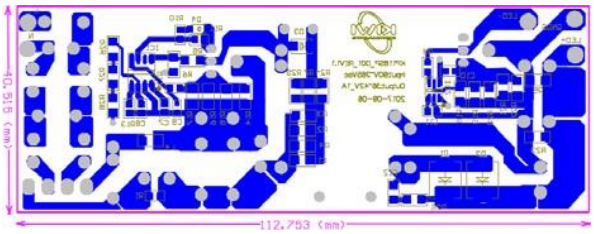


Printed Circuit Board Layout

Top Layer



Bottom Layer



Circuit Description

The demo board of KP118-D01 is designed with Flyback topology, which adopts QR operation mode to minimize the switching loss and lead to good EMI performance. 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, L1, L2, CX1, VR1, BD1, L3, L4, C4, C5, C6, VR2 and R1. F1 provides the inrush current limitation in the event of component failure or a short circuit. VR1, VR2 absorb transient energy to protect the circuit during surge. The L1, L2 and CX1 are EMI filter. The bridge diode BD1 rectifies the AC input to DC output. The value of C4, C5, C6 and L3 needs to be fine-tuned according to the EMI and THD requirement.

2. KP118 Operation

KP118 is a highly integrated LED controller with constant current (CC) control for isolated LED lighting applications. The IC utilizes Quasi-Resonant (QR) flyback topology with active PFC control for high PF, low THD, high efficiency and good EMI performance.

The VDD hold-up capacitor C8 is charged to 11V by an internal 11V regulator. When the internal power MOSFET is off, a current is drawn to the VDD capacitor from HV pin.

C7 is compensation capacitor. Larger capacitance can provide higher PF and lower THD which may make the system response slowly at the same time.

R14, R15, R16 and R17 are used as the sensing resistor. KP118 samples the peak inductor current in each switching cycle, which is then multiplied with the duty cycle information to be as the CC loop feedback, and the high accurate output current can be realized with a high accurate reference.

Q1 is MOSFET. When Q1 is on, the energy from the source is stored in transformer. When Q1 is off, the energy is transferred to the load.

D1 and D2 are rectifying diode. When MOSFET Q1 is off, D1 and D2 turn on.

3. Output Voltage Regulation

C2, C3 and C13 compose the output filtering circuit. R5 is the dummy resistor, and output capacitor is discharged after system is shut down.

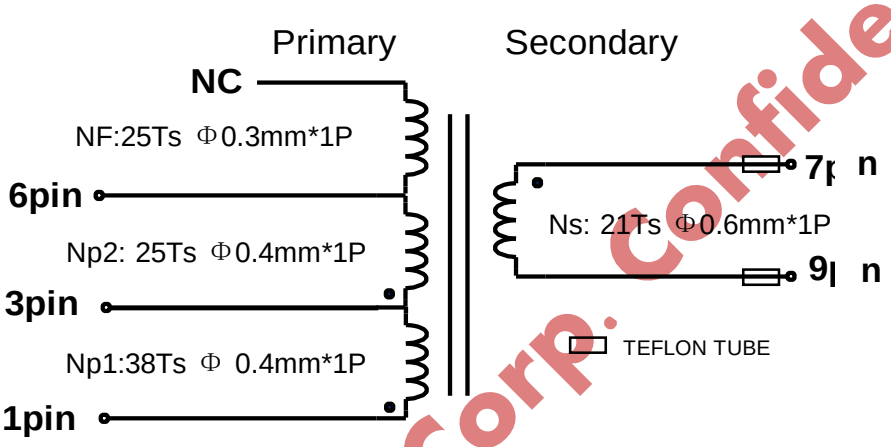
Bill of Material

No.	Designator	Value	Description	Package	Manufacturer	Part Number
1	BD1	1KV/2A	2.0A GLASS PASSIVATED BRIDGE RECTIFIER	TH	DIODES	KBP206G
2	C1	4.7nF	Ceramic Cap, 1kV X7R	1206	Murata	GRM31BR73A102KW01L
3	C2,C3,C13	330uF	Electrolytic Cap, 63V,12.5*20	TH	jianghai	ECR1JBK331M□□125020
4	C4	100nF	C21,400Vdc(200Vac),P=10mm,T=5.5mm	TH	STE	L22G104JJ1B0095095050E0Y
5	C5, C6	220nF	CL21,400Vdc(200Vac),P=10mm,T=7.5mm	TH	STE	L22G224JN1B0120120070E0Z
6	C7	2.2uF	Ceramic Cap, 25V X7R	0805	TDK	C2012X7R1E225K
7	C8	4.7uF	Ceramic Cap, 25V X7R	0805	TDK	C2012X7R1E475K
8	C12	100pF	Ceramic Cap, 1kV X7R	1206		
9	C14	47pF	Ceramic Cap, 1kV X7R	1206		
10	CX1	47nF	C21,400Vdc(200Vac),P=7.5mm,T=4.9mm	TH	Fala	C212G473K3AC000
11	CY1	4.7nF	CD/Y1 Y5V Cap,400VAC,P=10mm,T=5.5mm	TH	STE	Q12F1D472MN0B0S0
12	D1, D2	400V/5A	400V/5A Schottky Diode	DO-201AD	Lision Tech	SF56G
13	D3	1N4007	1.0 AMP SILICON RECTIFIERS	SMA	Any	1N4007
14	F1	250V/2A	Fuse 250V/2A	DIP	Any	
15	IC1	KP118	High Voltge High PF Isolated LED Driver	SO-8	KIWI Instrumental	KP118SP
16	L1	0.5mH	WE-Choke, IR=1.5A,Rdc=2*140mΩ,TYPE XS	CMB	Wurth Elektronik	744821240
17	L2	30mH			Wurth Elektronik	
18	L3,	2.2mH	WE-TI Inductor, Isat=0.40A,Rdc=2.40Ω,9*13	TH	Wurth Elektronik	7447452222
19	L4	470	470Ω±25%,4A @100MHz	1206	Murata	BLM31KN471SN1
20	Q1	AM9N65	N Mosfet, 650V/9A, Rdson=1.7ohm	TO-220	Analog Power	AM9N65
21	R1	5.1k	Film Resistor, 5%	0805	Yageo	RC0805JR-075K1L
22	R13	0.51k	Film Resistor, 5%	0805	Yageo	RC0805JR-07510RL
23	R2, R3, R4	300K	Film Resistor, 5%	1206	Yageo	RC1206JR-07300KL
24	R5, R23, R26, R27, R28	51K	Film Resistor, 5%	1206	Yageo	RC1206JR-0751KL
25	R6	1k	Film Resistor, 1%	1206	Yageo	RC1206FR-071KL
26	R7, R24	100	Film Resistor, 5%	0805	Yageo	RC0805JR-07100RL
27	R11	20	Film Resistor, 5%	0805	Yageo	RC0805JR-0720RL
28	R12	0	Film Resistor, 5%	0805	Yageo	RC0805JR-070RL
29	R14, R15	1.5	Film Resistor, 1%	1206	Yageo	RC1206FR-071R5L
30	R16, R17	2.2	Film Resistor, 1%	1206	Yageo	RC1206FR-072R2L

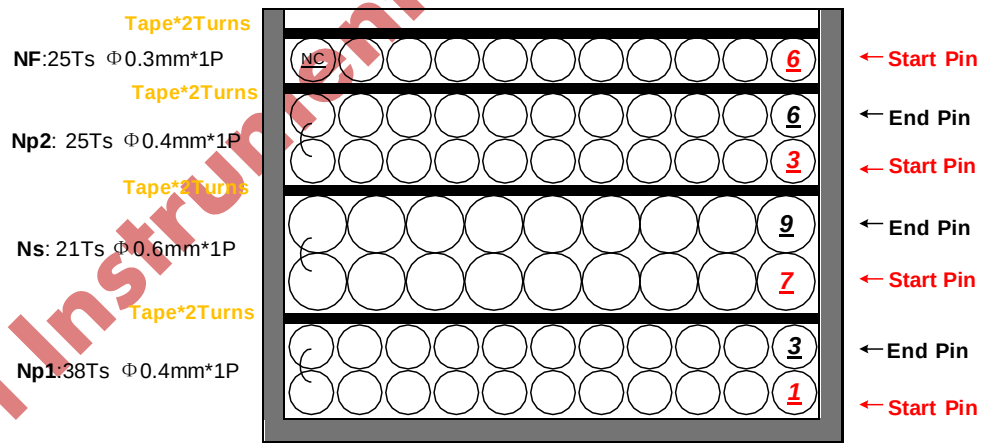
31	R25	47	Film Resistor, 5%	0805	Yageo	RC0805JR-07100RL
32	T1	0.75mH	PQ2620,Np:Ns=63(0.4mm):21(0.6mm)		Any	
33	VR1, VR2	7D471	VARISTOR,P=5.0mm,T=4.0mm	07D	Lision Tech	LSSA07D471K

Transformer Manufacture Guide

1. Electrical Diagram



2. Winding Diagram



3. Winding Order

Number	Winding	Layer	Start	End	Wire Size	Turns	Winding Method
1	Np1	Primary	1	3	0.4d*1P(2UEW)	38Ts	Dense
2	Ns	Secondary	7	9	0.6d*1P(TIW)	21Ts	Dense
3	Np2	Primary	3	6	0.4d*1P(2UEW)	25Ts	Spread
4	NF	Field	6	NC	0.3*1P(2UEW)	25Ts	Spread

4. Electrical Specification

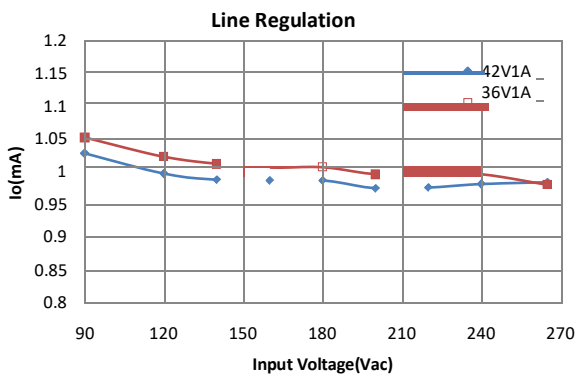
Items	Test Condition	Test Pin	Standard
Primary Inductance	measured at 40kHz, 1.0 VRMS	Pins 1 – 6; other windings open	0.759mH±5%
Primary Leakage Inductance	measured at 40kHz, 1.0 VRMS	Pins 1 – 6; other windings shorted	9.67uH±5%
Secondary Inductance	measured at 40kHz, 1.0 VRMS	Pins 7 – 9; other windings open	86.1uH±5%
Hi-POT HV Test	3500Vac/50Hz, One minute,	Primary to Secondary	3500Vac,5mA
	2500Vac/50Hz, One minute,	Secondary to Core	2500Vac,5mA
Insulation Resistance	500Vdc	All windings to core	1 GΩ min
	500Vdc	Between windings	1 GΩ min
DC Resistance	-	Pins 1-6	0.485Ω

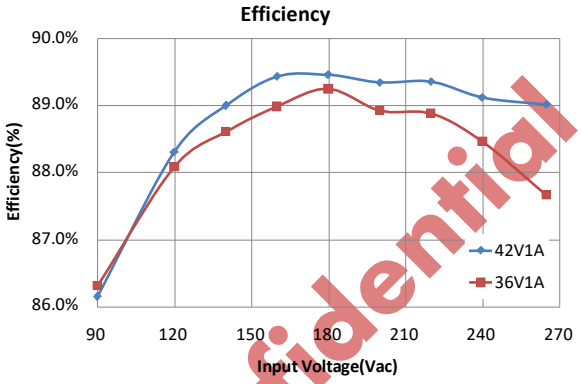
5. BOM

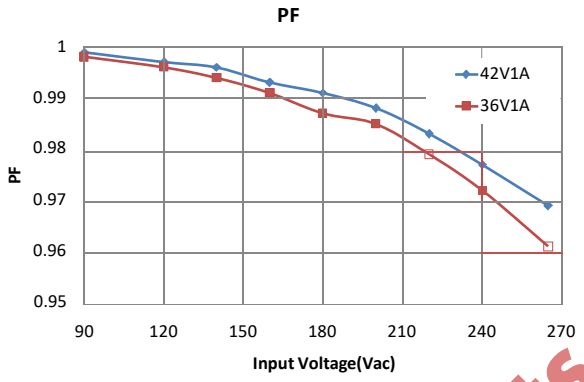
Items	Spec
Core	PQ2620， PC40 or equivalent
Bobbin	PQ2620, 6+6 vertical transformer bobbin
Wire	Φ0.3mm , 2UEW, Class B Φ0.4mm, 2UEW, Class B Φ0.6 mm ,TIW
Tape	3M 1350# Polyester Film

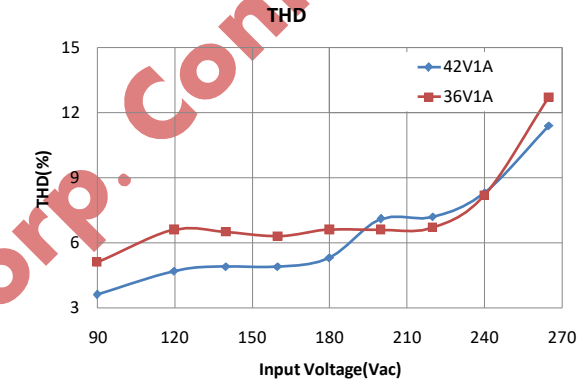
Test Result

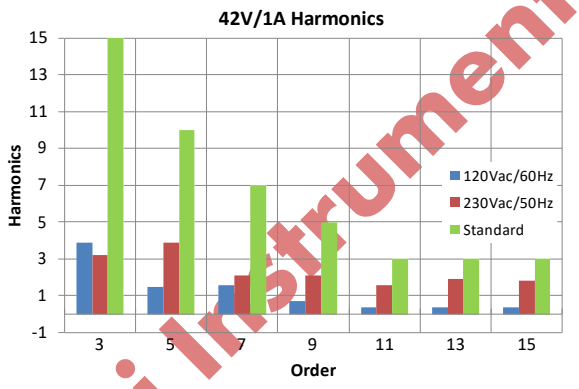
1. Test Data---Load/Line Regulation, Efficiency and THD

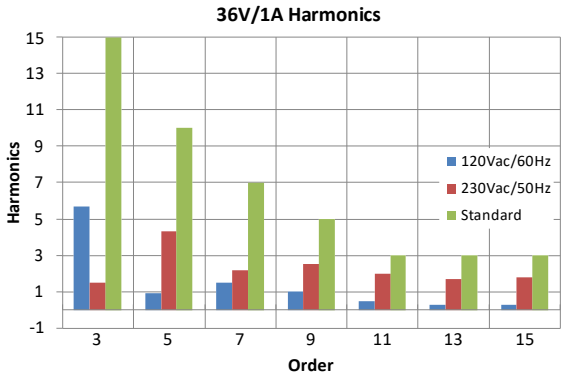


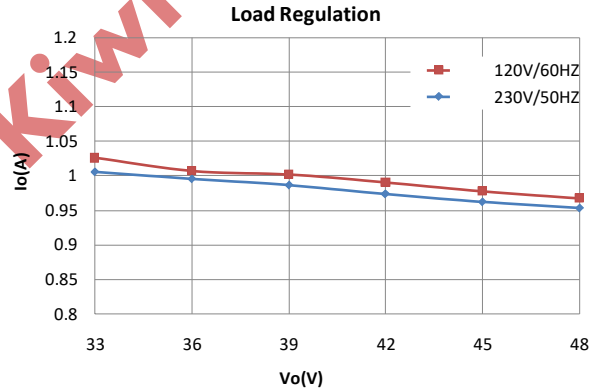








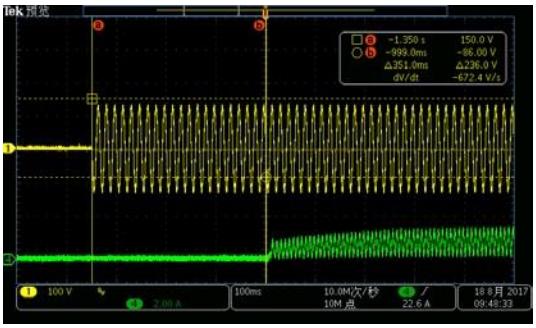




2. Operation Curves

1) Startup and Shutdown Test

Test Condition: 90Vac/50Hz Input, 42V1A Output

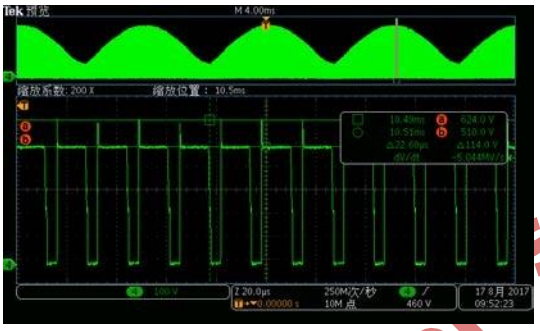


(CH1-VINAC, CH4-Io)

Comments: Startup Time=350ms and No Overshoot

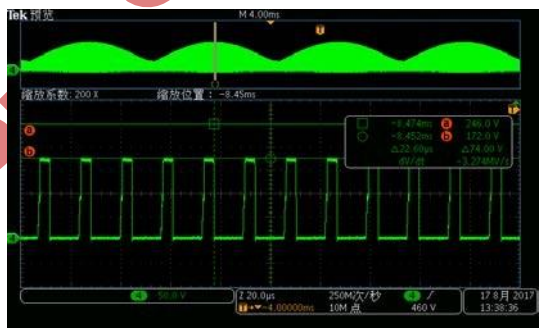
2) Device Maximum Rating Test

Test Condition: 265Vac/50Hz Input, 42V1A Output Steady State



(CH4-Vds)

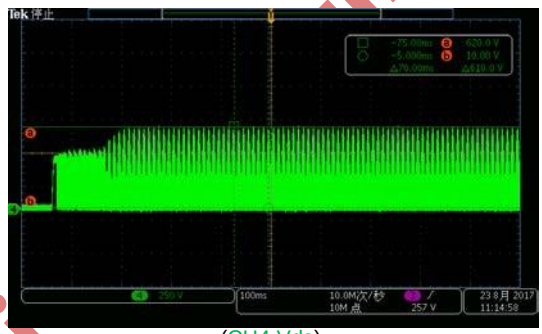
Comments: Vds_max=624V



(CH4-Vdiode)

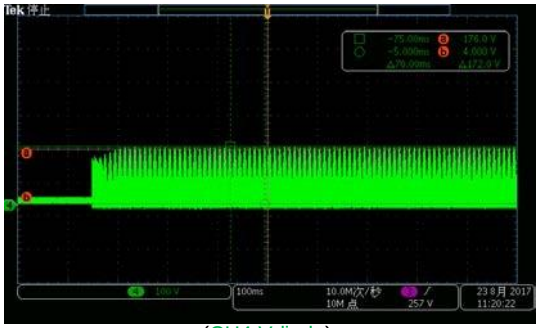
Comments: Vdiode_max=172V

Test Condition: 265Vac/50Hz Input, 42V1A Output Start Up



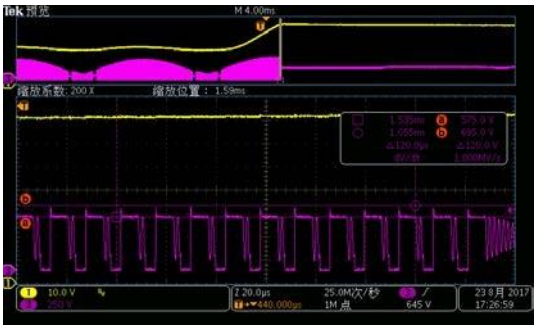
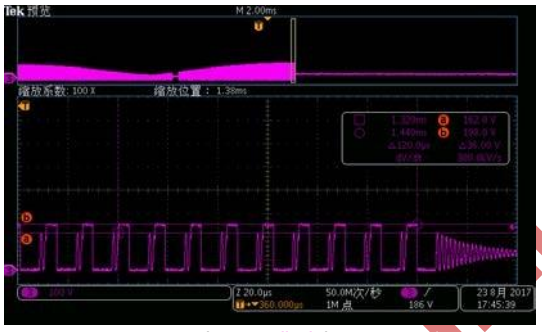
(CH4-Vds)

Comments: Vds_max=620V

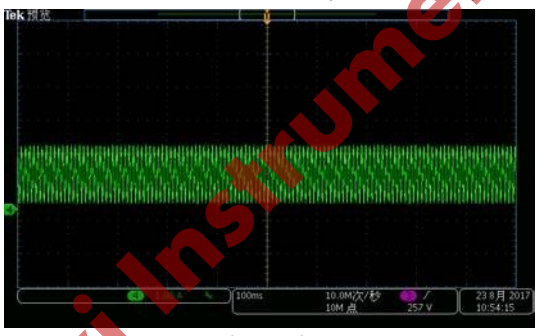
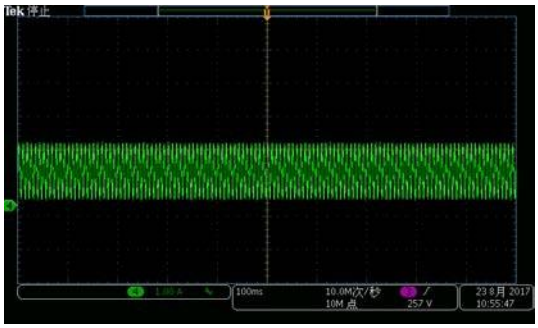


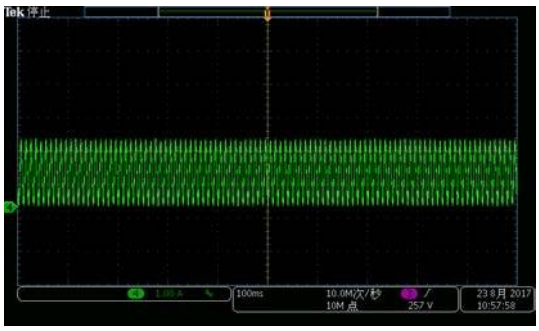
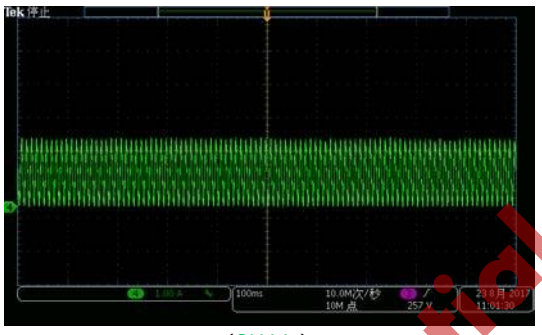
(CH4-Vdiode)

Comments: Vdiode_max=176V

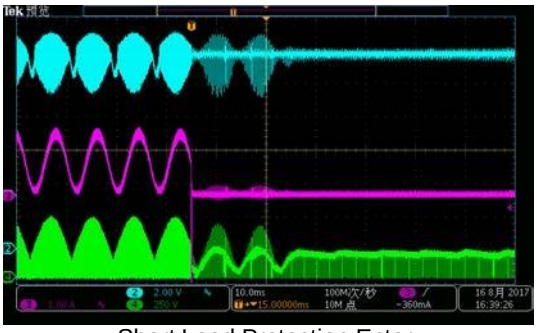
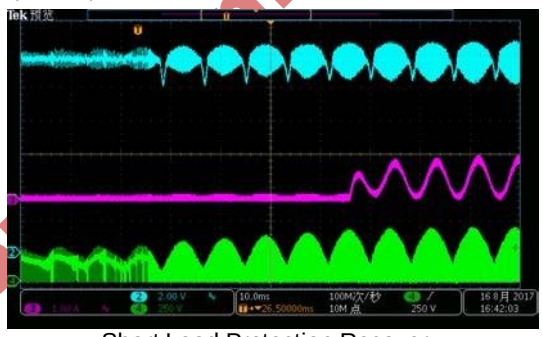
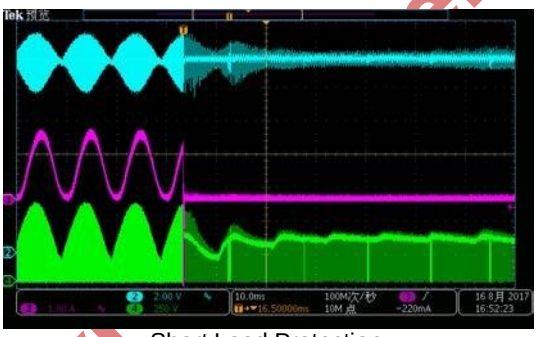
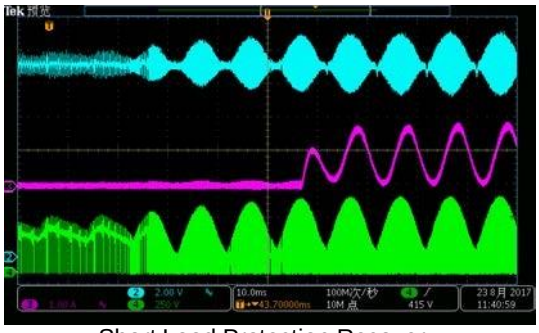
Test Condition: 265Vac/50Hz Input, 42V /1A Output_OVP	
 (CH3-Vds)	 (CH3-Vdiode)
Comments: Vds=695V	**Comments:** Vdiode_max =198V
Test Condition: 90Vac/60Hz Input, 42V/1A Output Steady State	
 (CH2-Vcs)	
Comments: ILp=2.693A, B=0.27T	

3) Output Ripple Test

Test Condition: 90Vac/60Hz Input, 42V1A Output	**Test Condition:** 120Vac/60Hz Input, 42V1A Output
 (CH4-Io)	 (CH4-Io)
Comments: Io_ripple_pp=1.78A	**Comments:** Io_ripple_pp=1.70A

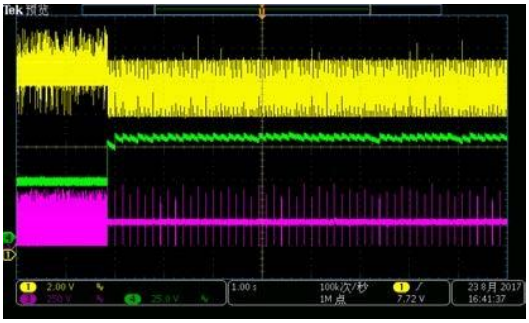
Test Condition: 230Vac/50Hz Input, 42V1A Output	**Test Condition:** 265Vac/50Hz Input, 42V1A Output
	
(CH4-Io)	(CH4-Io)
Comments: Io_ripple_pp=1.96A	**Comments:** Io_ripple_pp=1.98A

4) Over Load Protection Test

Test Condition: 120Vac/60Hz Input, Output short	
	
Short Load Protection Enter (CH2-VDD, CH3-IO,CH4-VDS)	Short Load Protection Recovery (CH2-VDD, CH3-IO,CH4-VDS)
Comments: OK	**Comments:** OK
Test Condition: 230Vac/50Hz Input, Output short	
	
Short Load Protection (CH2-VDD, CH3-IO,CH4-VDS)	Short Load Protection Recovery (CH2-VDD, CH3-IO,CH4-VDS)
Comments: OK	**Comments:** OK

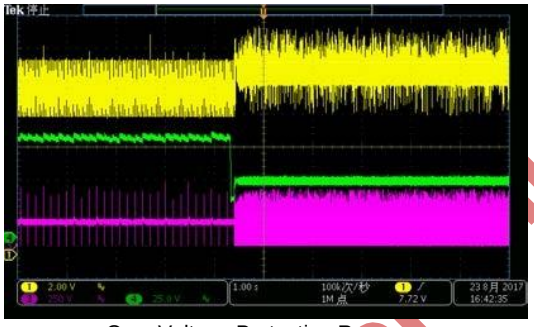
5) Over Voltage Protection Test

Test Condition: 120Vac/60Hz Input, Output Open Circuit



Over Voltage Protection
(CH1-VDD, CH3-VDS,CH4-VO)

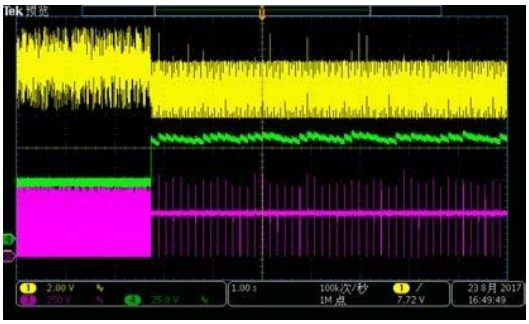
Comments: OVP=79.5V and it's OK



Over Voltage Protection Recovery
(CH1-VDD, CH3-VDS,CH4-VO)

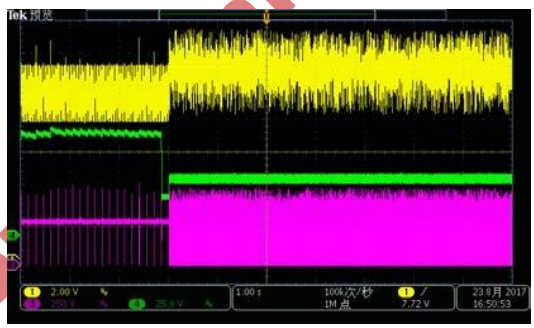
Comments: OVP=79.5V and it's OK

Test Condition: 230Vac/50Hz Input, Output Open Circuit



Over Voltage Protection
(CH1-VDD, CH3-VDS,CH4-VO)

Comments: OVP=81V and it's OK

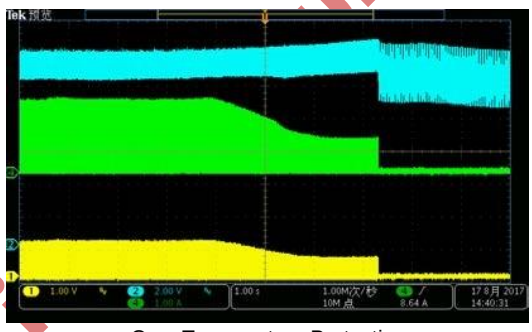


Over Voltage Protection Recovery
(CH1-VDD, CH3-VDS,CH4-VO)

Comments: OVP=81V and it's OK

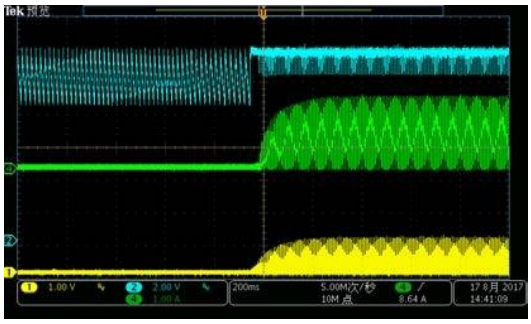
6) Over Temperature Protection Test

Test Condition: 120Vac/60Hz Input, 42V1A Output



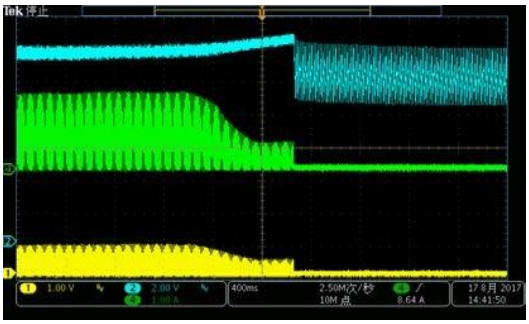
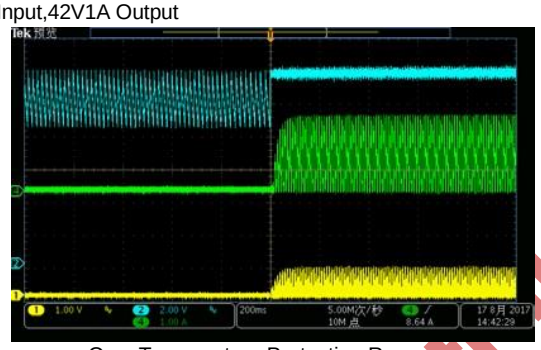
Over Temperature Protection
(CH1-VCS, CH2-VDD,CH4-IO)

Comments: OK



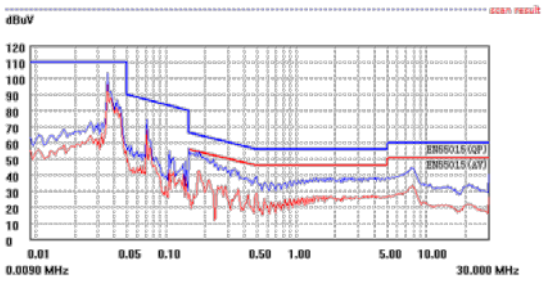
Over Temperature Protection Recovery
(CH1-VCS, CH2-VDD,CH4-IO)

Comments: OK

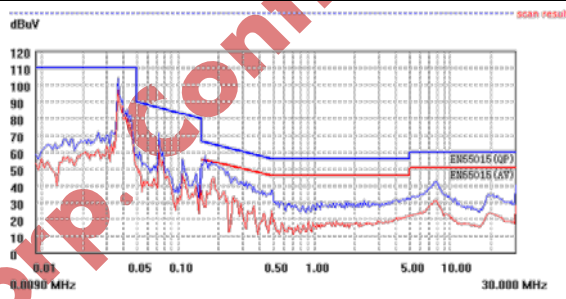
Test Condition: 230Vac/50Hz Input,42V1A Output	
 Over Temperature Protection (CH1-VCS, CH2-VDD,CH4-IO)	 Over Temperature Protection Recovery (CH1-VCS, CH2-VDD,CH4-IO)
Comments: OK	**Comments:** OK

3. EMC Test Result

Test Condition: Vin=110VAC/50Hz, Vout=42V, Io=1A

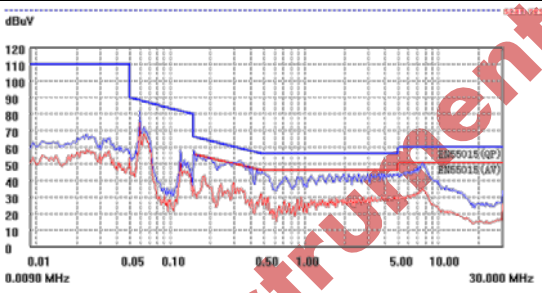


Conduction EMI---LINE

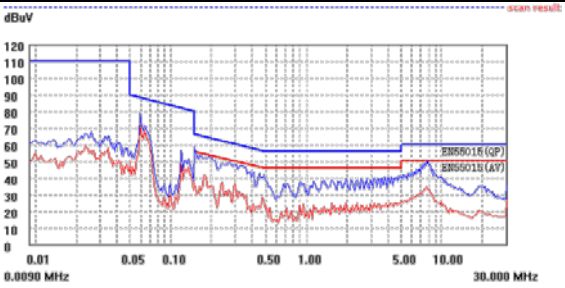


Conduction EMI---NEUTRAL

Test Condition: Vin=220VAC/50Hz, Vout=42V, Io=1A

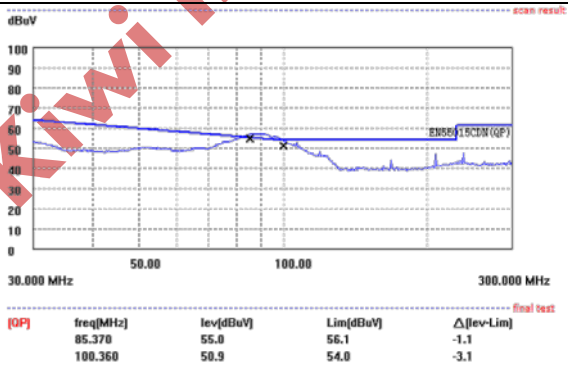


Conduction EMI---LINE



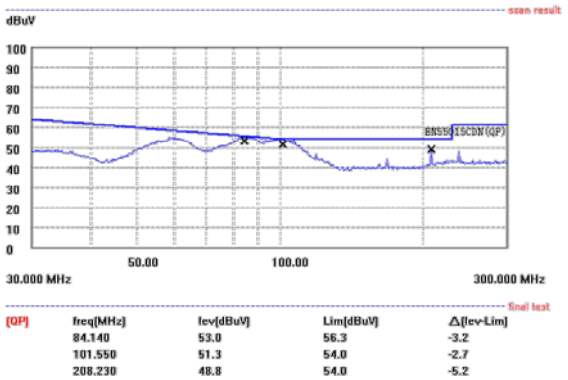
Conduction EMI---NEUTRAL

Test Condition: Vin=110VAC/50Hz, Vout=42V, Io=1A



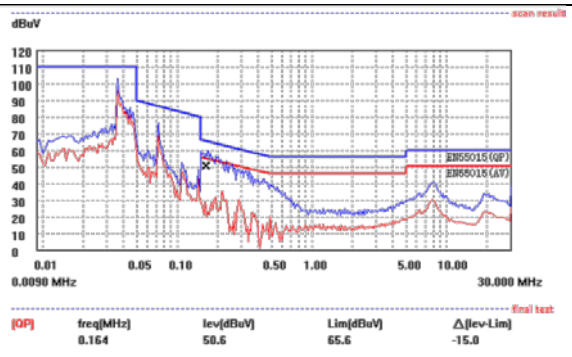
Radiation EMI---CDN

Test Condition: Vin=220VAC/50Hz, Vout=42V, Io=1A

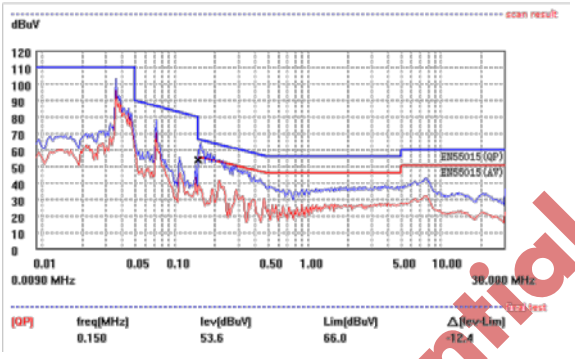


Radiation EMI---CDN

Test Condition: Vin=110VAC/50Hz, Vout=36V, Io=1A

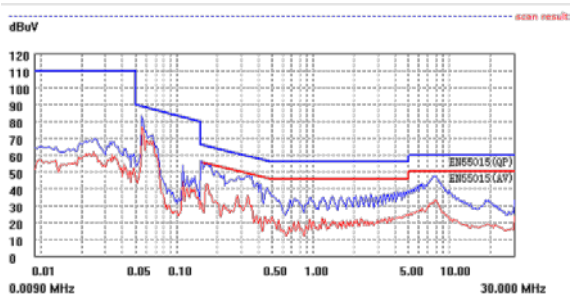


Conduction EMI---LINE

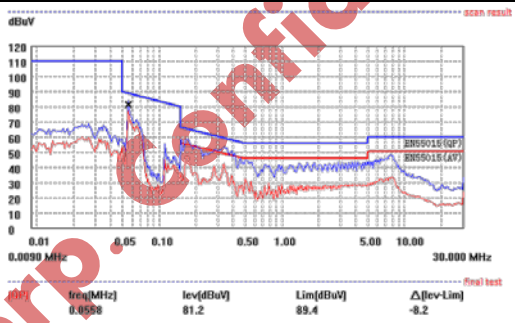


Conduction EMI---NEUTRAL

Test Condition: Vin=220VAC/50Hz, Vout=36V, Io=1A

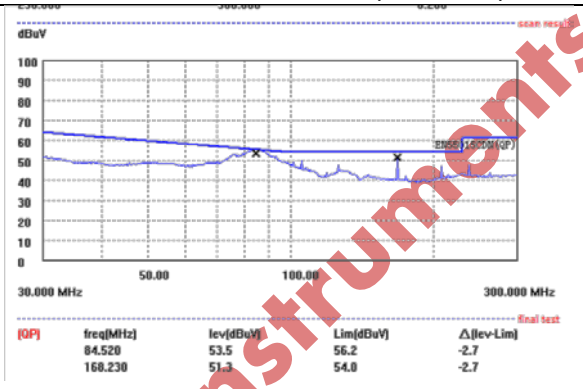


Conduction EMI---LINE



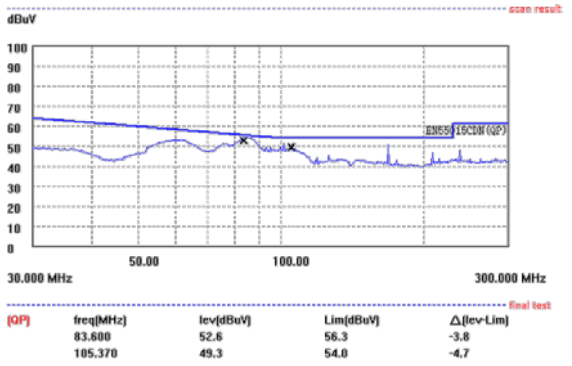
Conduction EMI---NEUTRAL

Test Condition: Vin=110VAC/50Hz, Vout=36V, Io=1A



Radiation EMI---CDN

Test Condition: Vin=220VAC/50Hz, Vout=36V, Io=1A

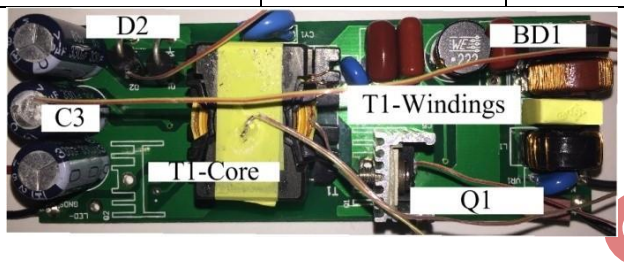


Radiation EMI---CDN

4. Thermal Test

Test Condition: 90Vac/60Hz, 265Vac/50Hz; 5V0.2A output; Ta=30ºC under natural convection

Component	90Vac		265Vac	
	T(ºC)	Trise(ºC)	T(ºC)	Trise(ºC)
Q1	114.2	84.2	65.8	35.8
BD1	93.5	63.5	54.4	24.4
D2	84.6	54.6	81.3	51.3
C3	50.5	20.5	44.7	14.7
T1-Core	70.7	40.7	69.9	39.9
T1-Windings	86.7	56.7	79.4	49.4
IC1	85.5	55.5	88.7	58.7



Test Setup Guide

1. Connect the “LED+” and “GNDS” terminal to the positive and negative end of the load.
2. Set the AC Power Source 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.

Revision History

DATE	REV	DESCRIPTION
2017/09/04	1.0	First Release
2017/11/13	1.1	Update PCB, SCH, BOM, EMI Test Result, Thermal Test Result and Winding Diagram

Contact Us:

US (Headquarter):

Add:2060 Walsh Ave, Suite 244, Santa Clara, CA, 95050
Tel:1-+86-18681585060 **Fax:**1-408-905-6912
E-mail: marketing@kiwiinst.com

Hangzhou (R&D Center):

Add: Room 1201, Building C, No.581 HuoJu Rd., Binjiang Dist., Hangzhou, P.R.C
Tel:(86) 571-8795-8612
Fax:(86) 571-8795-5363
E-mail: marketing@kiwiinst.com.cn

Shenzhen (Marketing/Field Support):

Add:B302-B303, University Creative Park, Xili Rd., Nanshan Dist., Shenzhen, P.R.C
Tel:(86)755-8204-2689
Fax:(86)755-8204-2192
E-mail: marketing@kiwiinst.com.cn

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