AL1665+AL5822: 42V/1A
0-10V Dimmable Design for External LED Drivers

General Description

This demonstration board utilizes the AL1665 Flyback LED driver-controller and AL5822 LED current ripple suppressor providing a cost effective solution for high brightness LED applications. This user-friendly evaluation board provides users with quick connection to their different types of LEDs string. The demonstration board can also support 0-10V dimming mode. It works at 0-10V dimming mode when a 0-10V analog signal is connected to 0-10V input.

A bill of materials is included that describes the parts used on this demonstration board. A schematic have also been included along with measured performance characteristics. These materials can be used as a reference design for your products improving your product's time to market.

Key Features

- Universal input: 90~305Vac
- 0-10V dimmable
- Deep dimming to <5% depth
- Wide output voltage range: 20V to 42V
- Single-Stage topology: Flyback
- Accurate constant current(CC) regulation
- PF>0.96 at 120~277Vac input voltage at full load
- THD<10% at 120Vac and 230Vac with full load
- Peak efficiency >89% at 230Vac input, 42V/1A output
- LED open protection
- LED short protection
- Secondary diode short protection
- Primary winding short protection
- Secondary winding short protection
- Built-in over temperature protection
- Low output current ripple with external LED current suppressor(AL5822)

Applications

- 0-10V LED Driver

Evaluation Board

Figure 1: Top View

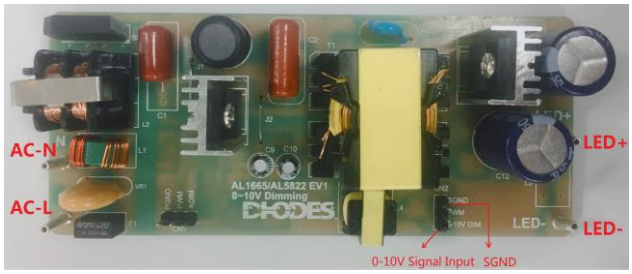
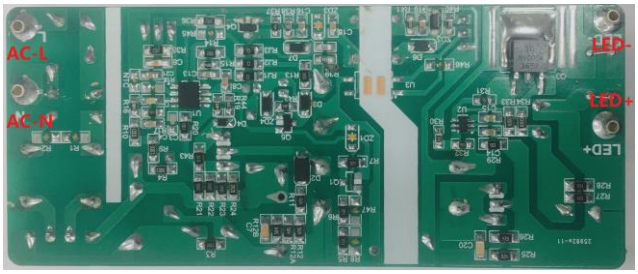


Figure 2: Bottom View



Connection Instructions:

AC+ Input: AC-L
AC- Input: AC-N
DC LED+ Output: LED+
DC LED- Output: LED-
0-10V Signal Input: 0-10V Input
SGND: Secondary side GND

Evaluation Board Specifications

The table below represents the minimum acceptable performance of Design

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Input voltage range	V_{IN}	90		305	Vac	
Line frequency range	f_{LINE}	47		63	Hz	
Power factor		0.96				Full load@120~277Vac
THD				10	%	Full load@120~277Vac
Output						
Output current	Io		1000		mA	
Maximum power				42	W	
Output voltage	Vo	20		42	V	
Output voltage(LED open)			58		V	
Line regulation				±2%	%	
Load regulation				±2%	%	
Current ripple				5%	%	Peak-to-peak
Startup time(AC to 90% Io)				500	ms	Full load @120~277Vac
Efficiency						
Active mode efficiency		88			%	Full load @120~277Vac
Standby						
Input power				500	mW	LED open @120~277Vac
EMI Conduction Test						
EMI Conduction Test	Pass EN55022 with 8dB margin @120Vac, 6dB margin @230Vac					

Board Layouts

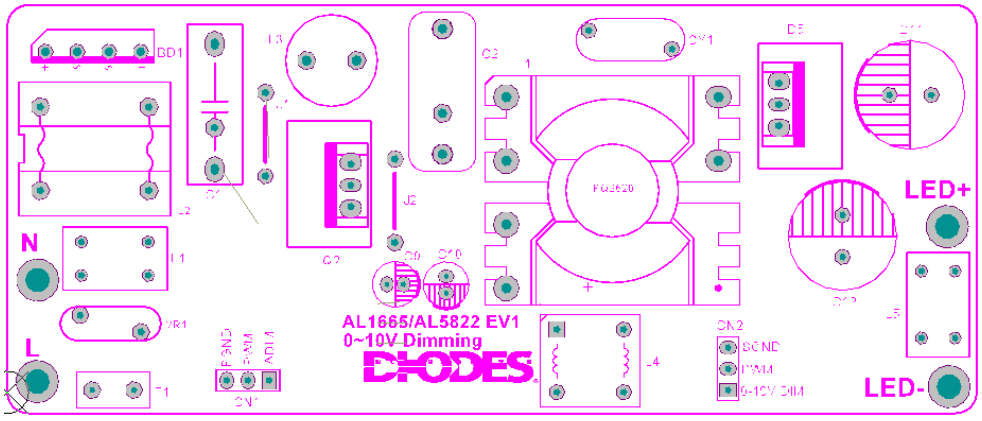


Figure 3: PCB Layout Top View

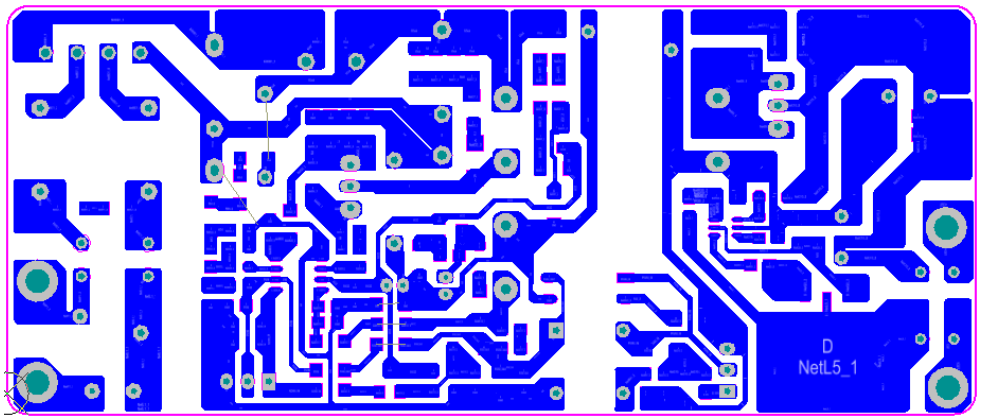


Figure 4: PCB Layout Bottom View

Quick Start Guide

1. Preset the isolated AC source to 120Vac/230Vac.
2. Ensure that the AC source is switched OFF or disconnected.
3. Connect the anode wire of the LED string to the LED+ of the evaluation board.
4. Connect the cathode wire of the LED string to the LED- terminal of the evaluation board.
5. Connect two AC line wires to the AC-L and AC-N terminals on the evaluation board.
6. Connect your 0-10V analog signal wire to the 0-10V input terminal if you wanna make the evaluation board work at 0-10V dimming mode.
7. Ensure that the area around the board is clear and safe, and preferably that the board and LEDs are enclosed in a transparent safety cover.
8. Turn on the main switch. LED string should light up.
   DO NOT TOUCH THE BOARD, LEDs OR BARE WIRING.

Caution: This AL1665+AL5822 evaluation board is a non-isolated design. All terminals carry high voltage during operation!

Schematic

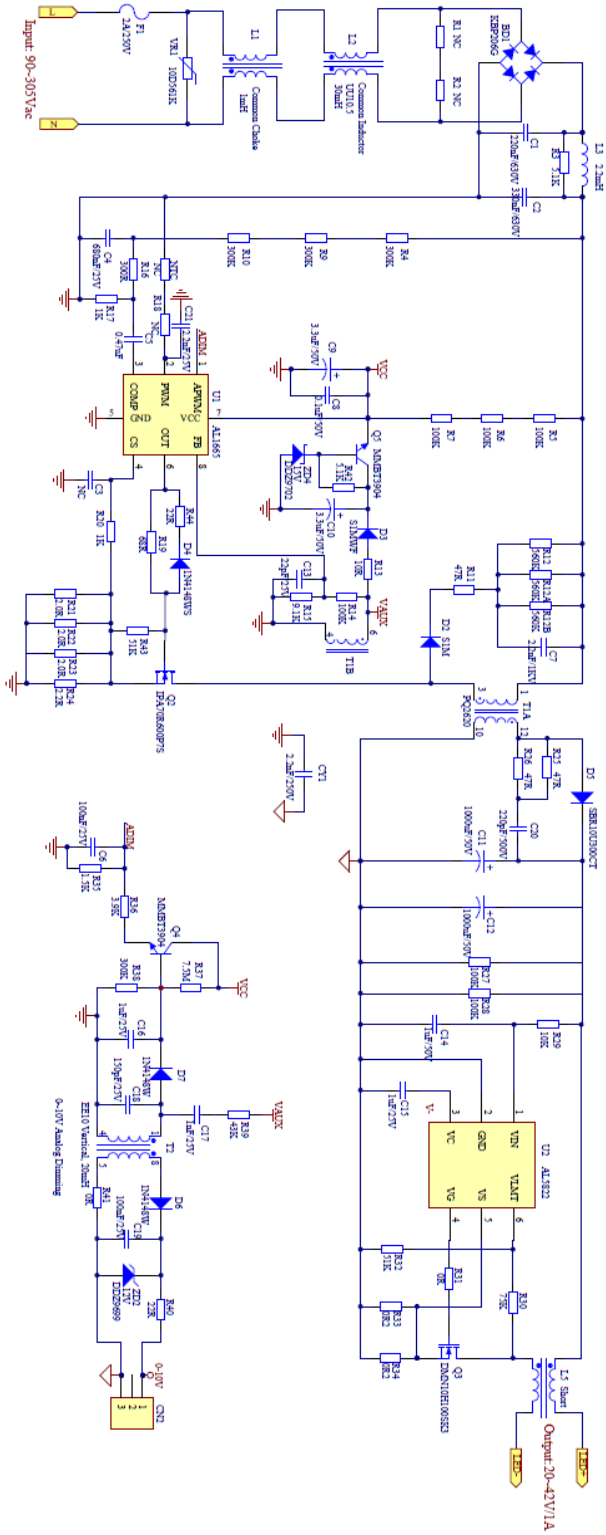


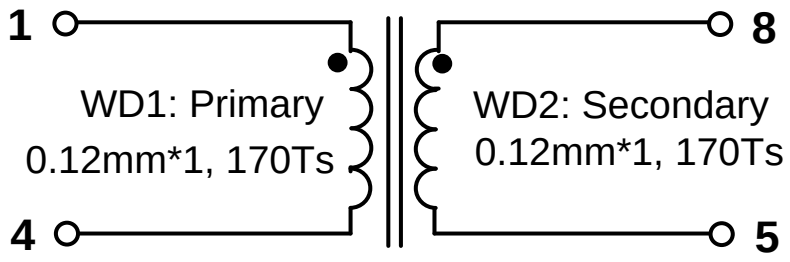
Figure 5: Schematic Circuit

Transformer Design

① Isolated DIM Inductor Design

Bobbin and Core

EE10 Vertical Pin 4+4



Transformer Parameters

1. Primary Inductance (Pin1-Pin4)：Lp=20mH, ±5%@1kHz
2. Primary Winding Turns (Pin1-Pin4): N_P=170Ts
3. Secondary Inductance (Pin8-Pin5)： Ls=20mH, ±5%@1kHz
4. Secondary Winding Turns (Pin8-Pin5): N_S=170Ts
5. Varnish the complete assembly

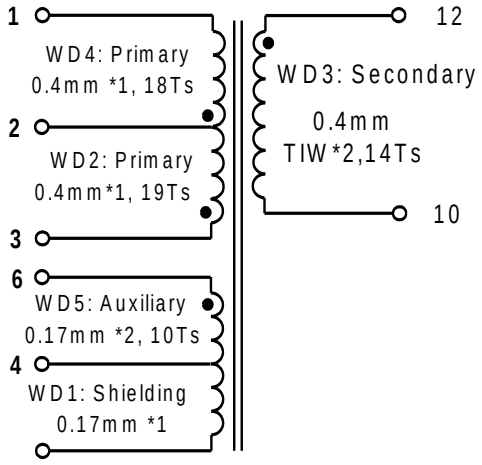
Transformer Winding Construction Diagram

Item	Winding name	Description
1	Wd1 Primary	Start at Pin 1, Wind 150 turns of Φ0.12mm wire and finish on Pin4
2	Insulation	2 Layer of insulation tape
3	Wd2 Secondary	Start at Pin 8, Wind 19 turns of Φ0.12mm wire and finish on Pin 5
4	Insulation	2 Layer of insulation tape

② Main Transformer Design

Bobbin and Core

PQ2620 (Pin 6+6)



Transformer Parameters

1. Primary Inductance (Pin3-Pin1)：L_P=450uH, ±5%@1kHz
2. Primary Leakage Inductance (Short other Windings, test the inductance of Pin3-Pin1): L_K<50uH, ±5%@1kHz
3. Primary Winding Turns (Pin3-Pin1): N_P=37Ts
4. Auxiliary Winding Turns (Pin6-Pin4): N_{AUX}=10Ts
5. Secondary Winding Turns (Pin12-Pin10): N_S=14Ts

Transformer Winding Construction Diagram

Item	Winding name	Description
1	Wd1 shielding	Start at Pin 4, Wind a full layer of Φ0.17mm*1 wire and dangle the end
2	Insulation	2 Layer of insulation tape
3	Wd2 Primary	Start at Pin 3, Wind 19 turns of Φ0.4mm*1 wire and finish on Pin 2
4	Insulation	2 Layer of insulation tape
5	Wd3 Secondary	Start at Pin 12, Wind 14 turns of Φ0.4mm*2 insulated wire and finish on Pin 10
6	Insulation	2 Layers of insulation tape
7	Wd4 Primary	Start at Pin 2, Wind 18 turns of Φ0.4mm*1 wire and finish on Pin 1
8	Insulation	2 Layer of insulation tape
9	Wd5 Auxiliary	Start at Pin 6, Wind 10 turns of Φ0.17mm*2 wire and finish on Pin 4
10	Insulation	2 Layers of insulation tape

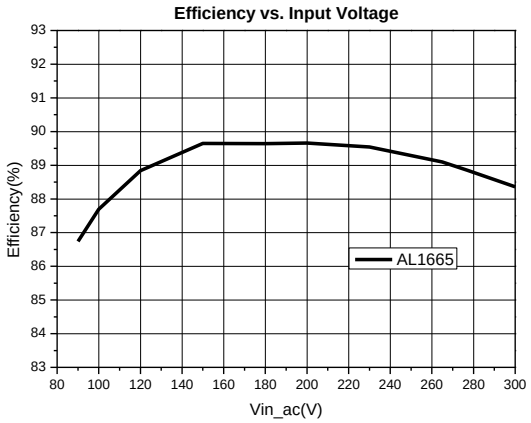
Bill of Material

No.	Item	Description	Manufactor	Package	QTY
1	C1	Film Cap, 220nF/630V, CL21,Pitch=10mm	Faratronic	DIP	1
2	C2	Film Cap, 330nF/630V, CL21,Pitch=15mm	Faratronic	DIP	1
3	C3	NC	Yageo	0805	0
4	C4	Ceramic Cap, 680nF/25V,X7R	Yageo	0805	1
5	C5	Ceramic Cap, 470nF/25V,X7R	Yageo	0805	1
6	C6	Ceramic Cap, 100nF/25V,X7R	Yageo	0805	1
7	C7	Ceramic Cap, 2.2nF/1KV,X7R	Yageo	1206	1
8	C8	Ceramic Cap, 0.1uF/50V,X7R	Yageo	0805	1
9	C9,C10	E-Cap, 105℃,3.3uF/50V, 5*7mm	Aishi	DIP	2
10	C11,C12	E-Cap, 105℃,1000uF/50V,13*20mm	Aishi	DIP	2
11	C13	Ceramic Cap, 22pF/25V,X7R	Yageo	0805	1
12	C14	Ceramic Cap, 1uF/50V,X7R	Yageo	0805	1
13	C15	Ceramic Cap, 1uF/25V,X7R	Yageo	0805	1
14	C16	Ceramic Cap, 1uF/25V,X7R	Yageo	0805	1
15	C17	Ceramic Cap, 1nF/25V,X7R	Yageo	0805	1
16	C18	Ceramic Cap, 150pF/25V,X7R	Yageo	0805	1
17	C19	Ceramic Cap, 100nF/25V,X7R	Yageo	0805	1
18	C20	Ceramic Cap, 220pF/500V,X7R	Yageo	1206	1
19	C21	Ceramic Cap, 2.2nF/25V,X7R	Yageo	0805	1
20	CY1	Y-Cap, 2.2nF/250VAC, 10mm		DIP	1
21	BD1	Rectifier Bridge,KBP206G, 600V/2A	Diodes Inc	DIP	1
22	D2	Rectifier Diode, S1M,1A/1KV	Diodes Inc	SMA	1
23	D3	Rectifier Diode, S1MWF, 1A/1KV	Diodes Inc	SOD-123	1
24	D4	Switching Diode, 1N4148WS,100V/0.3A	Diodes Inc	SOD-323	1
25	D5	Super Barrier Rectifier,SBR10U300CT, 300V/10A	Diodes Inc	TO-220	1
26	D6, D7	Switching Diode, 1N4148W,100V/0.3A	Diodes Inc	SOD-123	2
27	ZD2	Zener Diode, DDZ9699, 12V Zener	Diodes Inc	SOD-123	1
28	ZD4	Zener Diode, DDZ9702, 15V Zener	Diodes Inc	SOD-123	1
29	VR1	Varistor, 10D561K	Thinking	DIP	1
30	F1	Fuse, 2A/250V	Bussmann	DIP	1
31	R1, R2	NC		1206	0
32	R3	SMD Resistor, 5.1K, 5%, 1/4W	Yageo	1206	1
33	R4, R9, R10	SMD Resistor, 300K, 5%, 1/4W	Yageo	1206	3
34	R5, R6, R7	SMD Resistor, 100K, 5%, 1/4W	Yageo	1206	3
35	R11	SMD Resistor, 47R, 5%, 1/4W	Yageo	1206	1
36	R12, R12A, R12B	SMD Resistor, 560K, 5%, 1/4W	Yageo	1206	3
37	R13	SMD Resistor,10R, 5%, 1/4W	Yageo	1206	1
38	R14	SMD Resistor, 100K, 1%, 1/4W	Yageo	1206	1

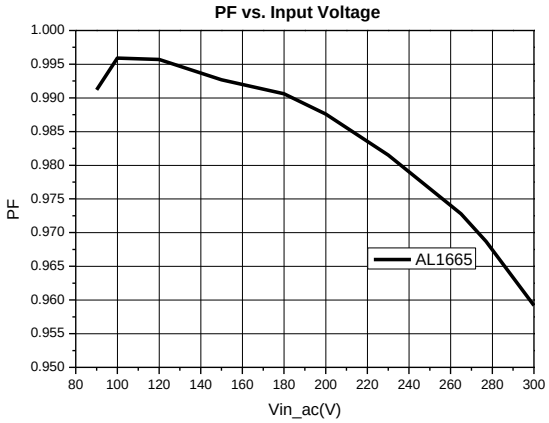
No.	Item	Description	Manufactor	Package	QTY
39	R15	SMD Resistor, 9.1K, 1%, 1/8W	Yageo	0805	1
40	R16	SMD Resistor, 300R, 5%, 1/4W	Yageo	0805	1
41	R17	SMD Resistor, 1K, 5%, 1/8W	Yageo	0805	1
42	R18	NC	Yageo	1206	0
43	R19	SMD Resistor, 68R, 5%, 1/8W	Yageo	0805	1
44	R20	SMD Resistor, 1K, 5%, 1/4W,	Yageo	1206	1
45	R21, R22, R23	SMD Resistor, 2.0R, 1%, 1/4W	Yageo	1206	3
46	R24	SMD Resistor, 2.2R, 1%, 1/4W	Yageo	1206	1
47	R25, R26	SMD Resistor, 47R, 5%, 1/4W	Yageo	1206	2
48	R27, R28	SMD Resistor, 100K, 5%, 1/4W	Yageo	1206	2
49	R29	SMD Resistor, 10K, 5%, 1/4W	Yageo	1206	1
50	R30, R32	SMD Resistor, 300K, 5%, 1/8W	Yageo	0805	2
51	R31	SMD Resistor, 0R, 5%, 1/8W	Yageo	0805	1
52	R33, R34	SMD Resistor, 0.2R, 5%, 1/4W	Yageo	1206	2
53	R35	SMD Resistor, 1.5K, 5%, 1/4W	Yageo	1206	1
54	R36	SMD Resistor, 3.9K, 5%, 1/4W	Yageo	1206	1
55	R37	SMD Resistor, 7.5M, 5%, 1/8W	Yageo	0805	1
56	R38	SMD Resistor, 300K, 5%, 1/8W	Yageo	0805	1
57	R39	SMD Resistor, 36K, 5%, 1/8W	Yageo	0805	1
58	R40	SMD Resistor, 22R, 5%, 1/8W	Yageo	0805	1
59	R41	SMD Resistor, 0R, 5%, 1/8W	Yageo	0805	1
60	R43	SMD Resistor, 51K, 5%, 1/4W	Yageo	1206	1
61	R44	SMD Resistor, 22R, 5%, 1/8W	Yageo	0805	1
62	NTC	NC			0
63	RJ1, RJ2, RJ3	SMD Resistor, 0R, 5%, 1/4W	Yageo	1206	3
64	L1	Common Choke, 1mH		DIP	1
65	L2	Common Inductor, UU10.5, 30mH		DIP	1
66	L3	Drum Inductor, 2.2mH, 11*13mm	Gaoya Coil	DIP	1
67	L4	DIM Inductor, EE10, Vertical, 20mH		DIP	1
68	L5	Common Choke, Short			0
69	T1	Flyback Transformer, PQ2620, 6+6Pin, 0.45mH		DIP	1
70	Q2	N-Mos, IPA70R600P7S, 700V, Rdson=0.6ohm	Infineon	TO-220	1
71	Q3	N-Mos, DMN10H100SK3-13, 100V	Diodes Inc	TO252	1
72	Q4, Q5	NPN-BJT, MMBT3904, 40V/0.2A	Diodes Inc	SOT-23	2
73	U1	AL1665, High performance dimmable LED controller	Diodes Inc	SOIC-8	1
74	U2	AL5822, 100/120Hz LED current ripple suppressor	Diodes Inc	SOT23-6	1
75	PCB	FR4 Single layer, 116*48mm			
Total					**87**

Functional Performance

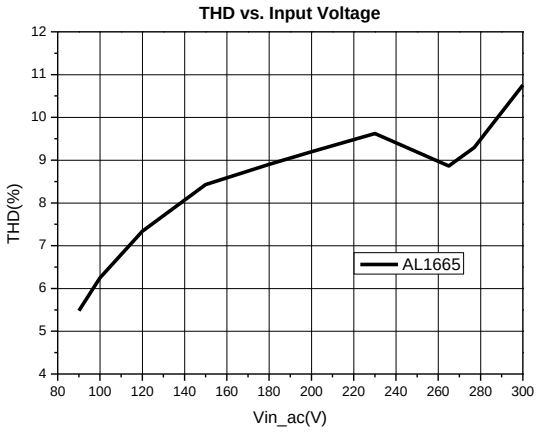
Efficiency vs. Input Voltage



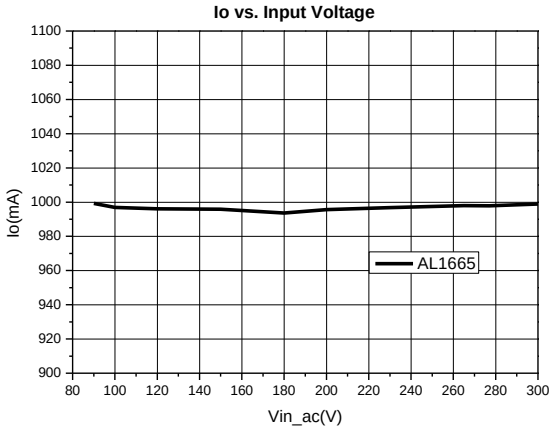
PF vs. Input Voltage



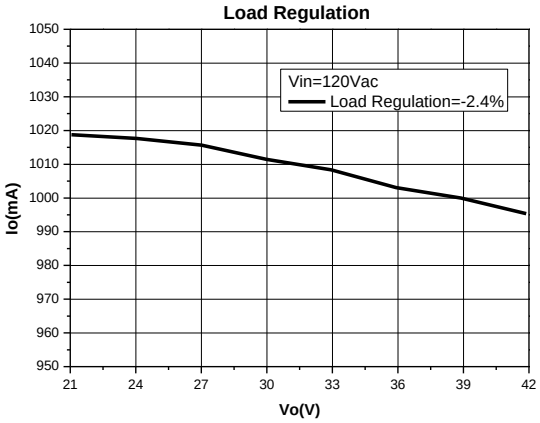
THD vs. Input Voltage



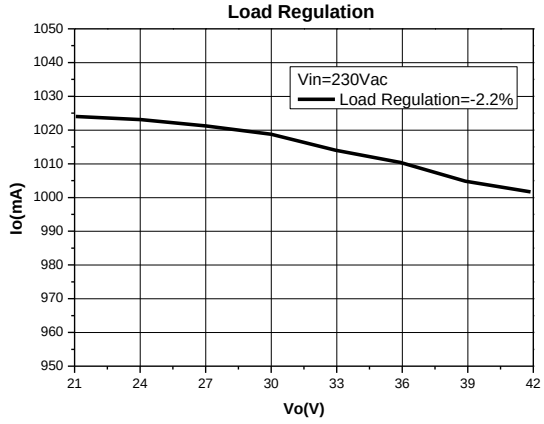
Output Current vs. Input Voltage



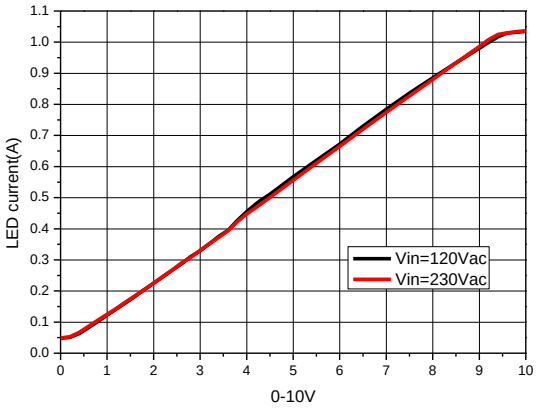
Output Current vs. Output Voltage @Vin=120Vac



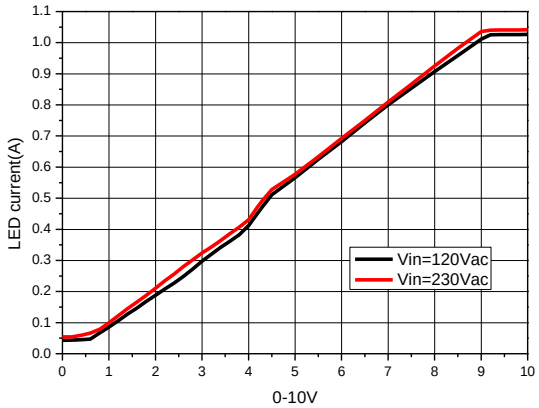
Output Current vs. Output Voltage @Vin=230Vac



0-10V Dimming Curve @Uo=42V



0-10V Dimming Curve @Uo=20V



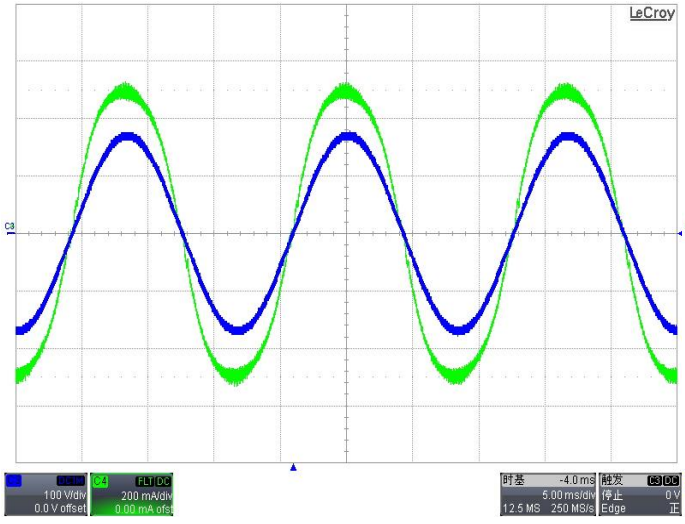
Functional Waveform

Waveforms:

Input Voltage & Input Current

Vin=120Vac/60Hz

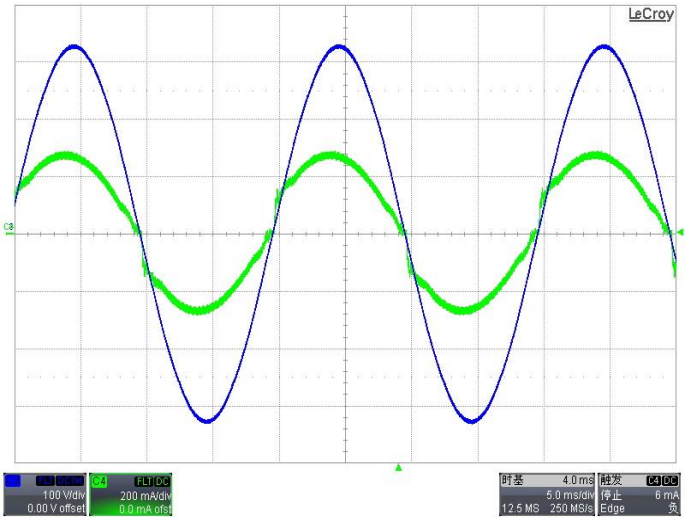
Vin **Iin**



Input Voltage & Input Current

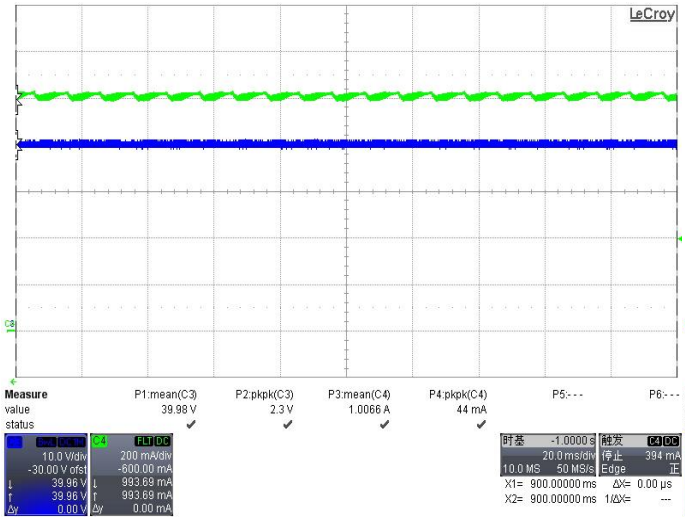
Vin=230Vac/50Hz

Vin **Iin**



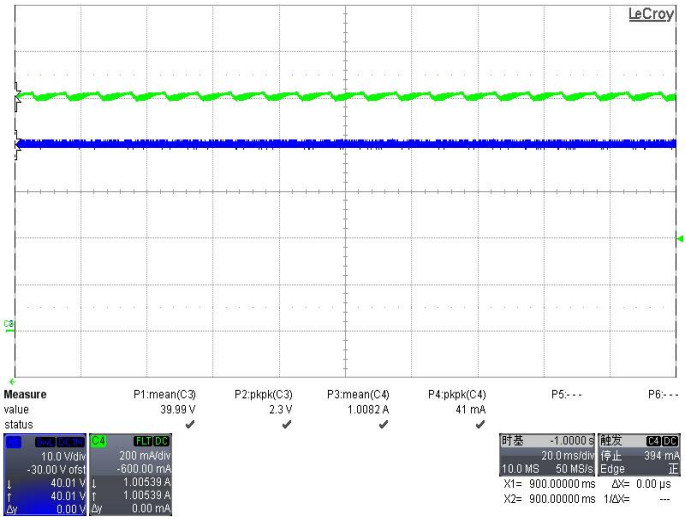
Output Voltage & Output Current
Vin=120Vac/60Hz, Current Ripple: 44mA

V_O Io



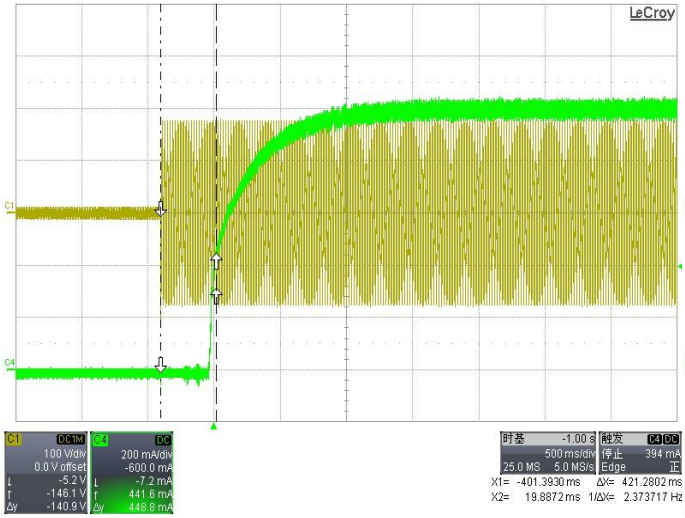
Output Voltage & Output Current
Vin=230Vac/50Hz, Current Ripple: 41mA

V_O Io



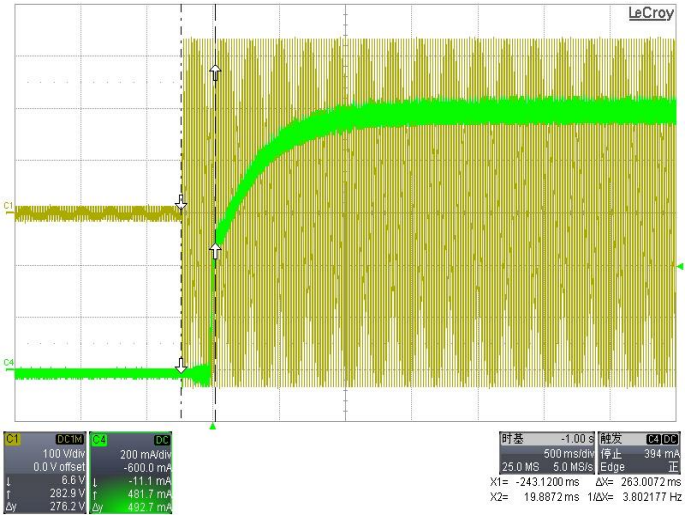
Startup time
Vin=120Vac/60Hz (Start time=421ms)

V_{in} Io



Startup time
Vin=230Vac/50Hz (Start time=263ms)

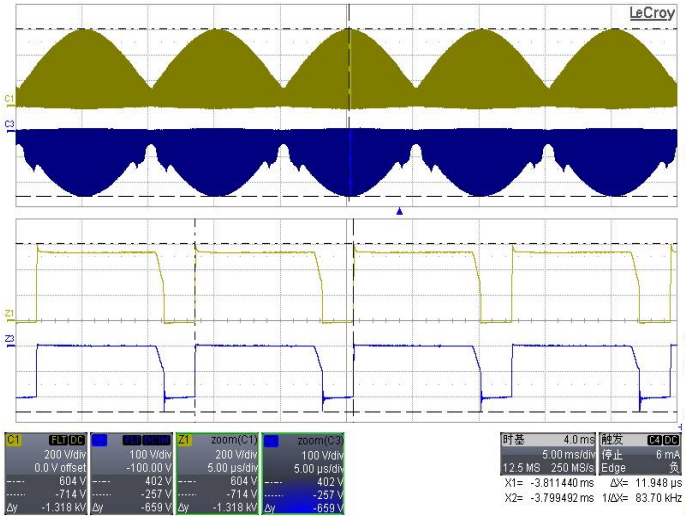
V_{in} Io



V_{Drian} and V_{D5}, Vin=300Vac/50Hz

V_{DS_MAX}=604V, V_{D5_MAX}=257V

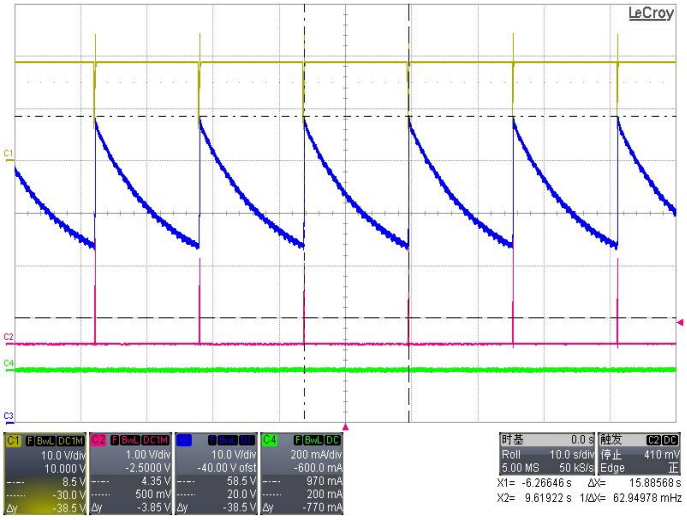
V_{Drain} V_{D5}



LED open protection

Vin=230Vac/50Hz, V_{OVP}=58.5V

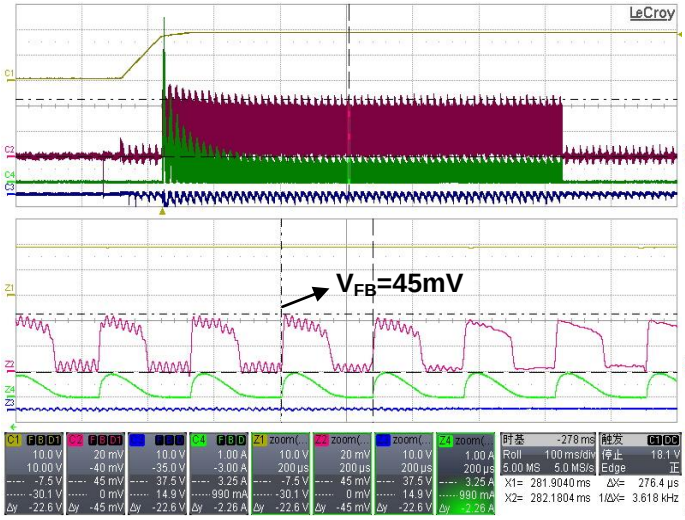
V_{CC} V_{FB} V_O Io



LED short protection

Vin=230Vac/50Hz

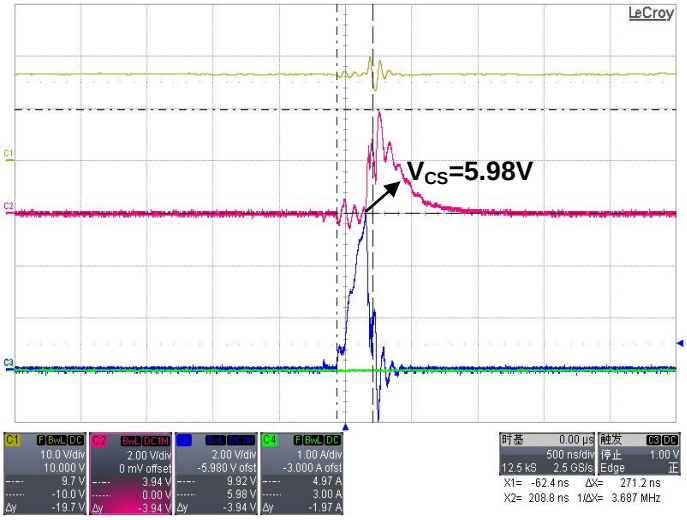
V_{CC} V_{FB} V_O Io



Secondary diode short protection

Vin=230Vac/50Hz

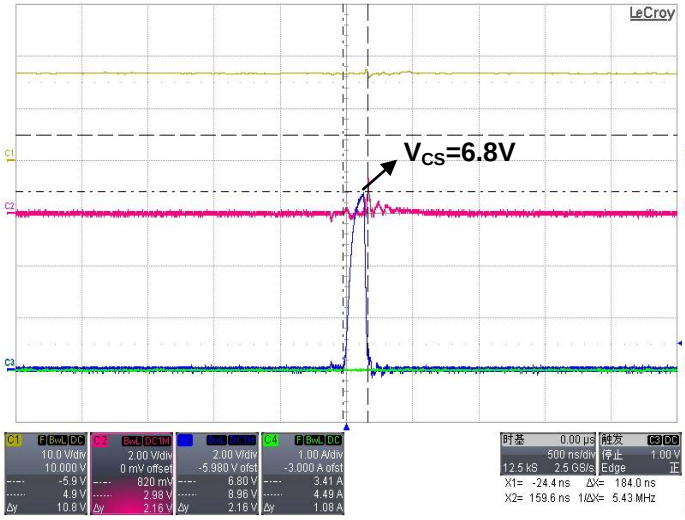
V_{CC} V_{FB} V_{CS} Io



Primary winding short protection

Vin=230Vac/50Hz

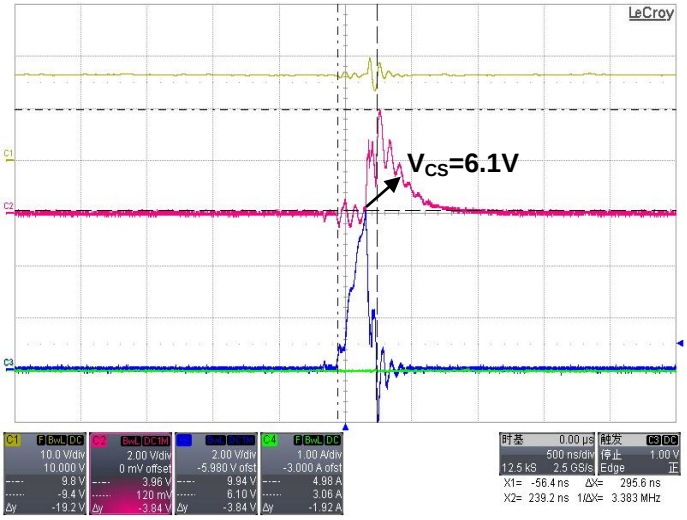
V_{CC} V_{FB} V_{CS} Io



Secondary winding short protection

Vin=230Vac/50Hz

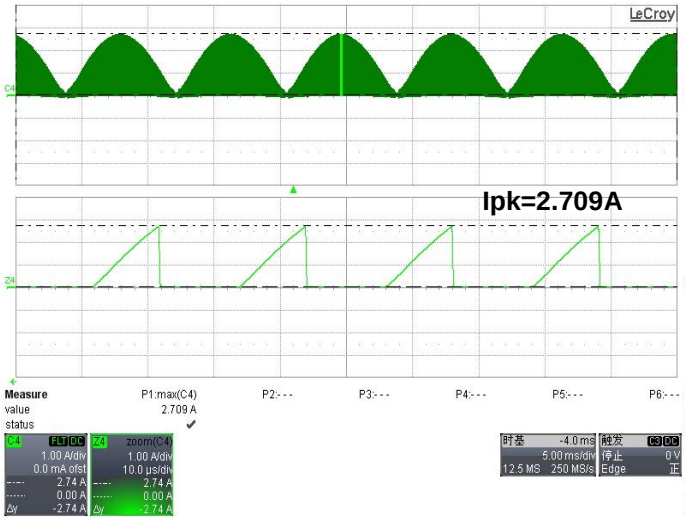
V_{CC} V_{FB} V_{CS} Io



Peak primary-side current

Vin=90Vac/60Hz

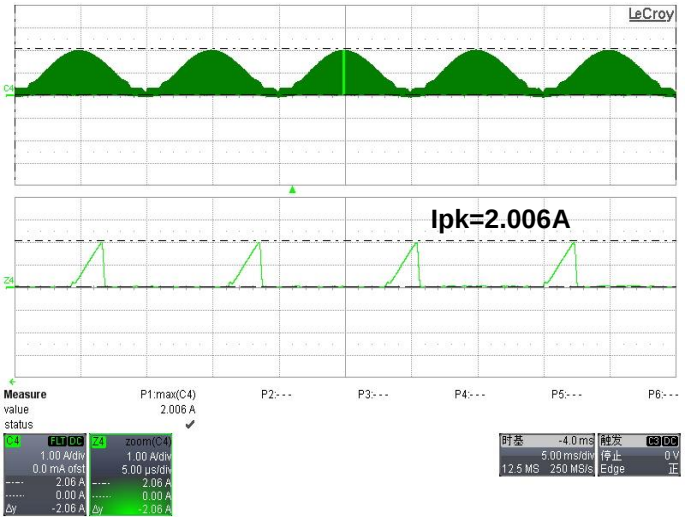
V_{CC} V_{FB} V_{CS} Io



Peak primary-side current

Vin=300Vac/50Hz

V_{CC} V_{FB} V_{CS} Io



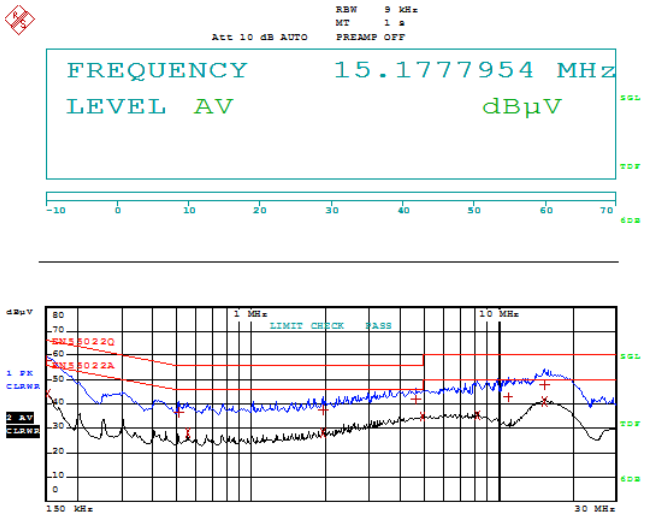
$$B_{MAX} = \frac{L_P \bullet I_{PK}}{N_P \bullet A_e} = \frac{0.45*10^{-3}*2.709}{37*119*10^{-6}} = 0.277(T)$$

$$B_{MAX} = \frac{L_P \bullet I_{PK}}{N_P \bullet A_e} = \frac{0.45*10^{-3}*2.006}{37*119*10^{-6}} = 0.205(T)$$

EMI Conduction Test

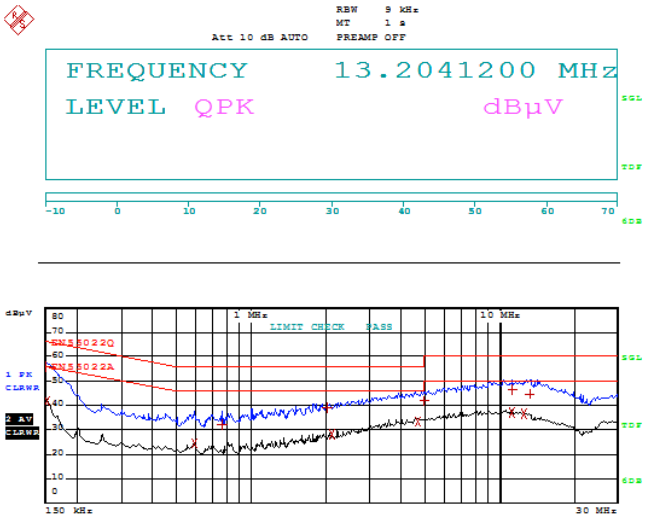
Line Terminal

Vin=120Vac/60Hz LIMIT CHECK PASS



Neutral Terminal

Vin=120Vac/60Hz LIMIT CHECK PASS



Line Terminal

Vin=120Vac/60Hz Margin>8dB

EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	150 kHz	57.83	-8.16
2	Average	151.5 kHz	44.12	-11.79
1	Quasi Peak	510.05878768 kHz	36.84	-19.15
2	Average	552.320578504 kHz	28.20	-17.79
1	Quasi Peak	1.95436508353 MHz	37.48	-18.51
2	Average	1.95436508353 MHz	28.44	-17.55
1	Quasi Peak	4.59879277394 MHz	41.85	-14.14
2	Average	4.88171119798 MHz	34.75	-11.25
2	Average	8.18999279463 MHz	35.13	-14.86
1	Quasi Peak	10.8213634985 MHz	42.97	-17.02
1	Quasi Peak	15.177795402 MHz	47.98	-12.01
2	Average	15.177795402 MHz	40.71	-9.28

Neutral Terminal

Vin=120Vac/60Hz Margin>8dB

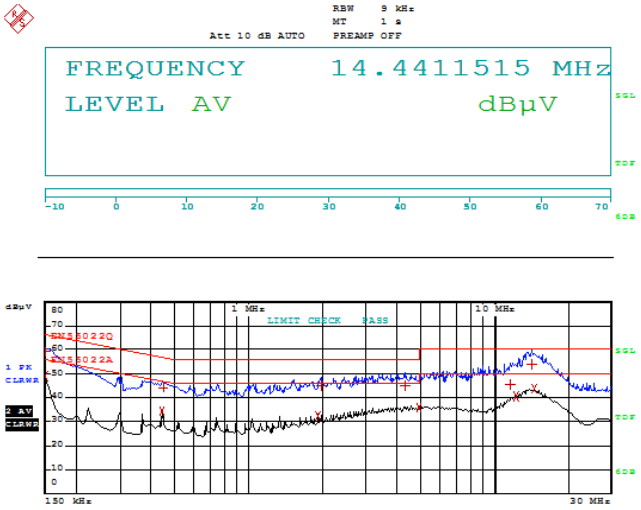
EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	150 kHz	57.83	-8.16
2	Average	151.5 kHz	44.12	-11.79
1	Quasi Peak	510.05878768 kHz	36.84	-19.15
2	Average	552.320578504 kHz	28.20	-17.79
1	Quasi Peak	1.95436508353 MHz	37.48	-18.51
2	Average	1.95436508353 MHz	28.44	-17.55
1	Quasi Peak	4.59879277394 MHz	41.85	-14.14
2	Average	4.88171119798 MHz	34.75	-11.25
2	Average	8.18999279463 MHz	35.13	-14.86
1	Quasi Peak	10.8213634985 MHz	42.97	-17.02
1	Quasi Peak	15.177795402 MHz	47.98	-12.01
2	Average	15.177795402 MHz	40.71	-9.28

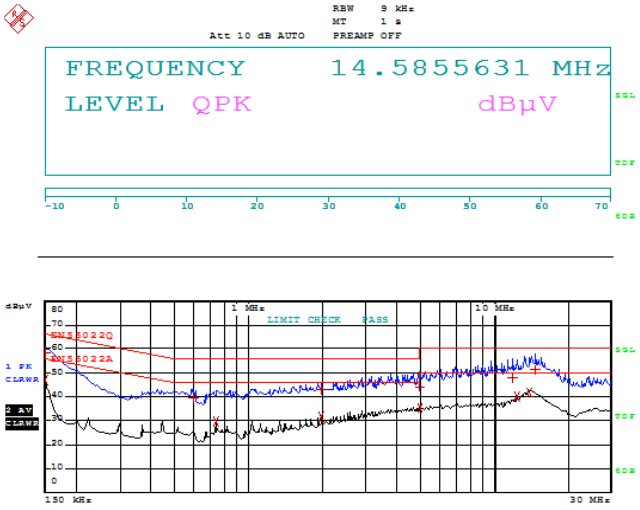
Line Terminal

Vin=230Vac/50Hz LIMIT CHECK PASS



Neutral Terminal

Vin=230Vac/50Hz LIMIT CHECK PASS



Line Terminal

Vin=230Vac/50Hz Margin>6dB

EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	150 kHz	59.10	-6.89
2	Average	150 kHz	49.01	-6.98
2	Average	443.732257589 kHz	34.37	-12.61
1	Quasi Peak	448.169580165 kHz	44.34	-12.56
2	Average	1.91585637048 MHz	32.47	-13.53
1	Quasi Peak	1.97390873436 MHz	45.29	-10.70
1	Quasi Peak	4.33227082061 MHz	45.37	-10.62
2	Average	4.88171119798 MHz	35.72	-10.27
1	Quasi Peak	11.6019663647 MHz	45.38	-14.61
2	Average	12.1937832503 MHz	40.27	-9.72
1	Quasi Peak	14.1566038021 MHz	53.86	-6.13
2	Average	14.4411515385 MHz	43.97	-6.02

Neutral Terminal

Vin=230Vac/50Hz Margin>7dB

EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	150 kHz	58.47	-7.52
2	Average	150 kHz	46.78	-9.21
1	Quasi Peak	592.16241791 kHz	39.51	-16.48
2	Average	737.073853121 kHz	29.77	-16.22
1	Quasi Peak	1.97390873436 MHz	42.78	-13.21
2	Average	1.99364782171 MHz	31.59	-14.40
1	Quasi Peak	4.93052830996 MHz	44.22	-11.77
2	Average	4.93052830996 MHz	35.46	-10.53
1	Quasi Peak	11.8351658887 MHz	48.15	-11.85
2	Average	12.3157210828 MHz	39.97	-10.02
2	Average	13.8776627802 MHz	41.98	-8.01
1	Quasi Peak	14.5855630539 MHz	51.11	-8.88

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