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# RT7302 Evaluate Report for T8 Internal Power (Flyback)

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*ACDC BU / SLM Division  
Mar. 2016*

<http://www.richtek.com/LED>

**RICHTEK**  
your power partner.

# RT7302 Brief introduction

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RT7302 is an active power factor correction controller specifically designed for using as a constant current LED driver.

Supporting:

Isolation: PSR mode

Non-isolation: Buck-Boost mode

**Applications**    **➔**    **AC/DC LED lighting driver**



**PAR Lamp**



**E27 Bulb**



**T5/T8 Tube**

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# RT7302 Features

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## Primary-Side Regulation PWM Controller and High PF LED Driver

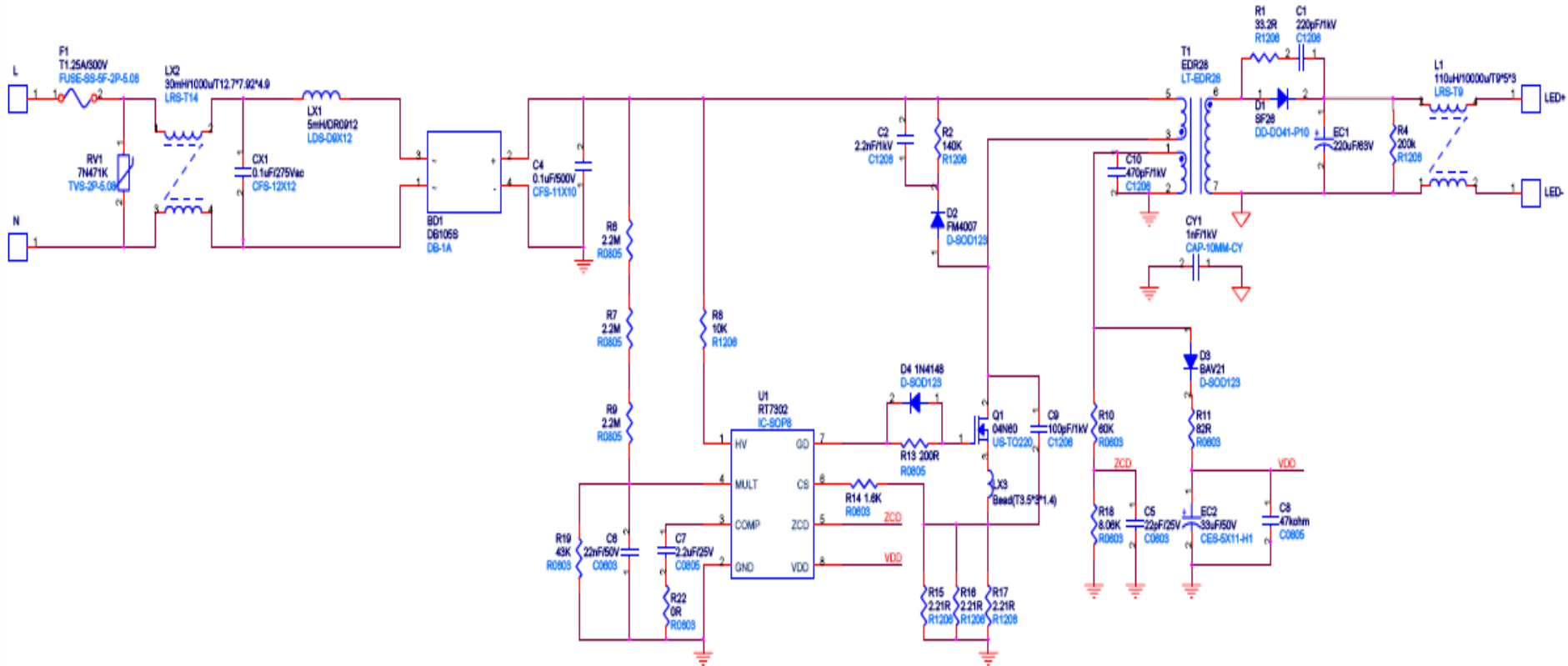
- Primary Side Regulation(PSR)
- Power Factor Correction(PFC)
- Compatible with TRIAC Dimmer
- Built-in HV start-up Device
- Critical conduction mode(CRM)
- Max/Min switch frequency clamping
- Max/Min on time limitation

# RT7302 Advantage

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- Universal input voltage. (90Vac~264Vac)
- Good LED current regulation.
- No shunt regulator and photo to achieve the 2<sup>nd</sup> regulation.
- Protection:
  - a. Open-circuit protection
  - b. Short-circuit protection
  - c. Output diode short-circuit protection
  - d. Vdd under/over voltage protection
  - e. Over temperature protection
  - f. Cycle-by-cycle current limitation
  - g. Excellent PF and THD.

# Circuit



# Electrical Performance

Frequency	Vac [V]	Pin [watt]	Vout [V]	Iout [mA]	Pout [Watt]	Eff. [%]	PF Value	THD
60Hz	90	21.54	45.75	405	18.53	86.02%	0.9960	6.37
60Hz	100	21.24	45.78	405	18.54	87.29%	0.9960	6.68
60Hz	110	21.03	45.80	404	18.50	87.98%	0.9954	7.03
60Hz	120	20.87	45.83	403	18.47	88.50%	0.9950	7.24
60Hz	132	20.73	45.86	402	18.44	88.93%	0.9944	7.53
50Hz	180	20.60	46.00	401	18.45	89.54%	0.9908	7.51
50Hz	200	20.60	46.07	400	18.43	89.46%	0.9886	7.02
50Hz	220	20.64	46.15	400	18.46	89.44%	0.9851	6.73
50Hz	230	20.69	46.23	400	18.49	89.38%	0.9832	6.82
50Hz	240	20.75	46.31	400	18.52	89.27%	0.9811	6.99
50Hz	264	20.90	46.44	400	18.58	88.88%	0.9738	7.86

current regulation = 1.23%

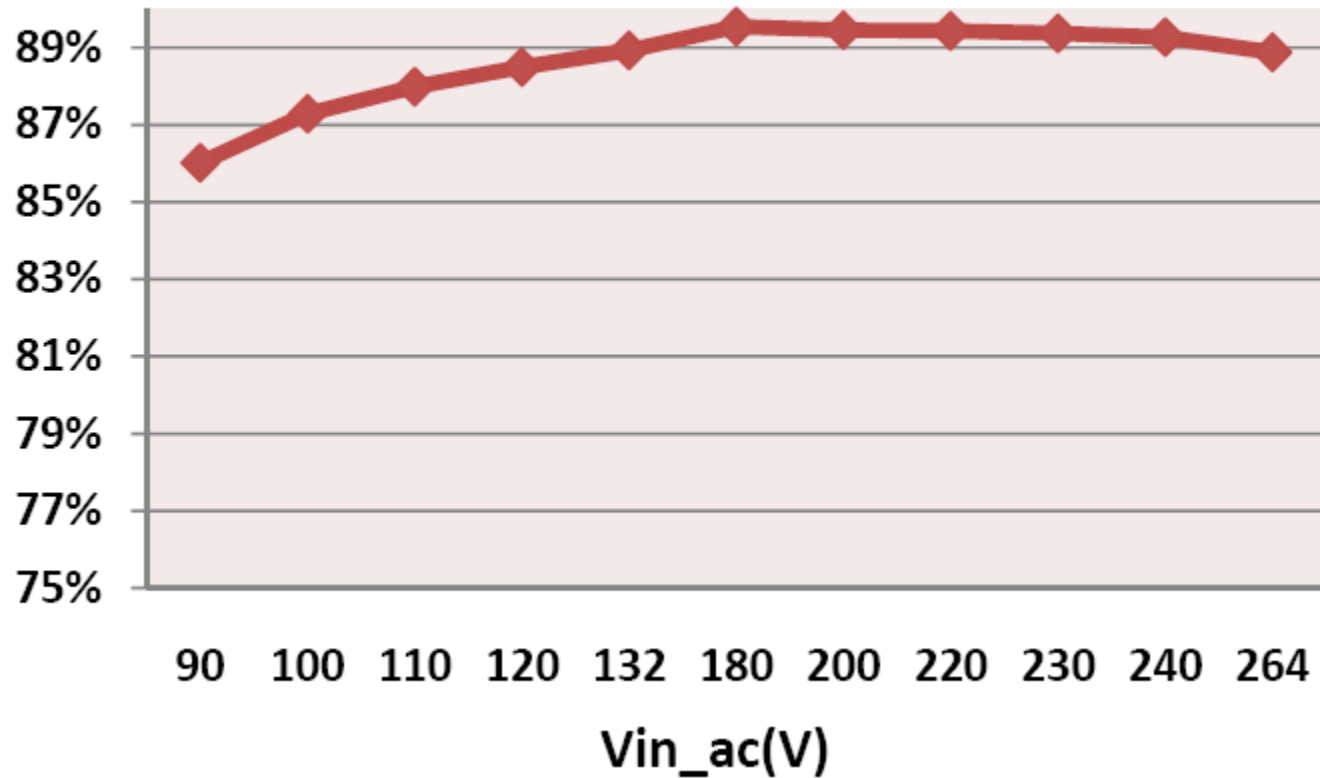
△ Efficiency = 3.52%

Maximum PFC = 0.996

Minimum PFC = 0.974

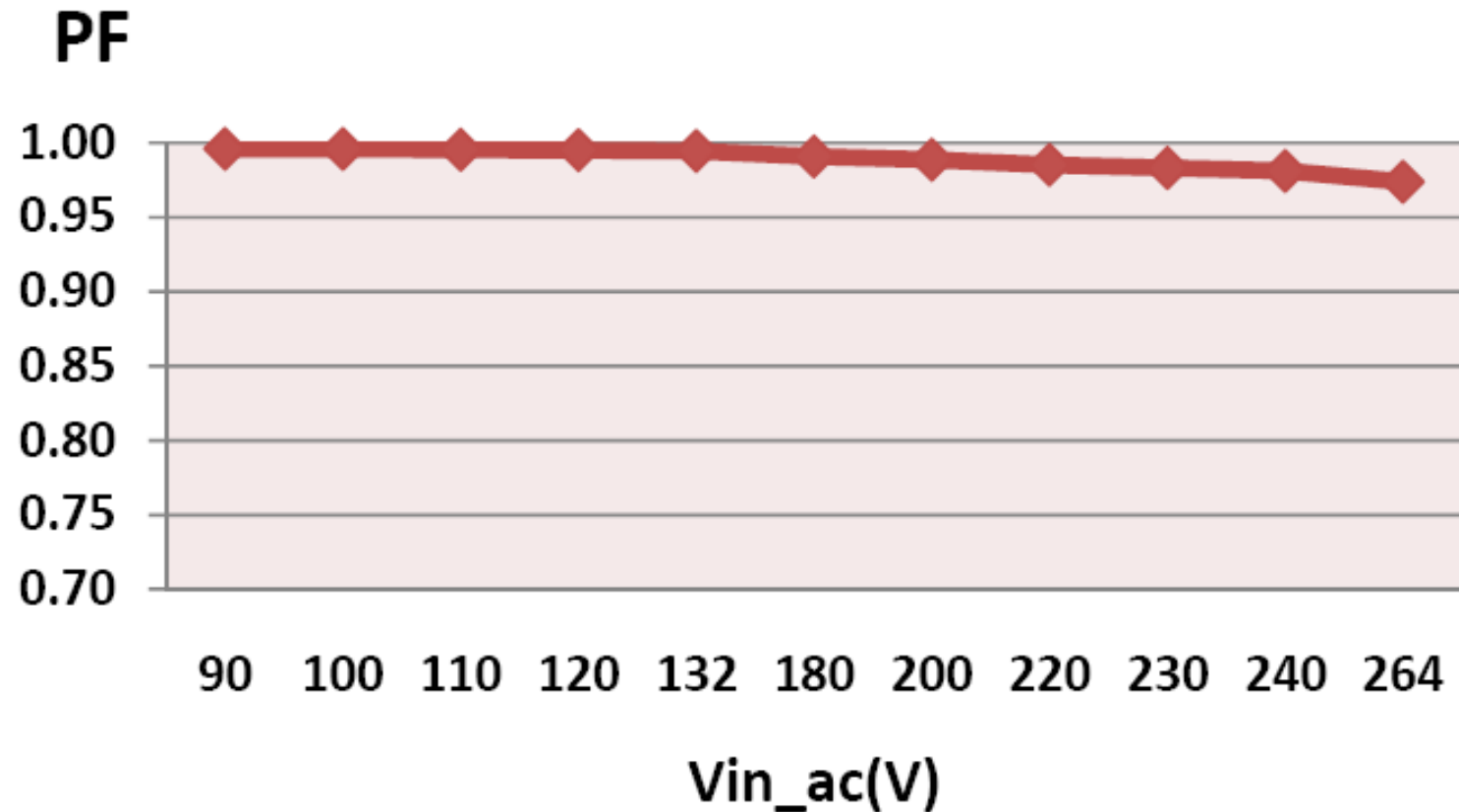
# Efficiency

## Efficiency



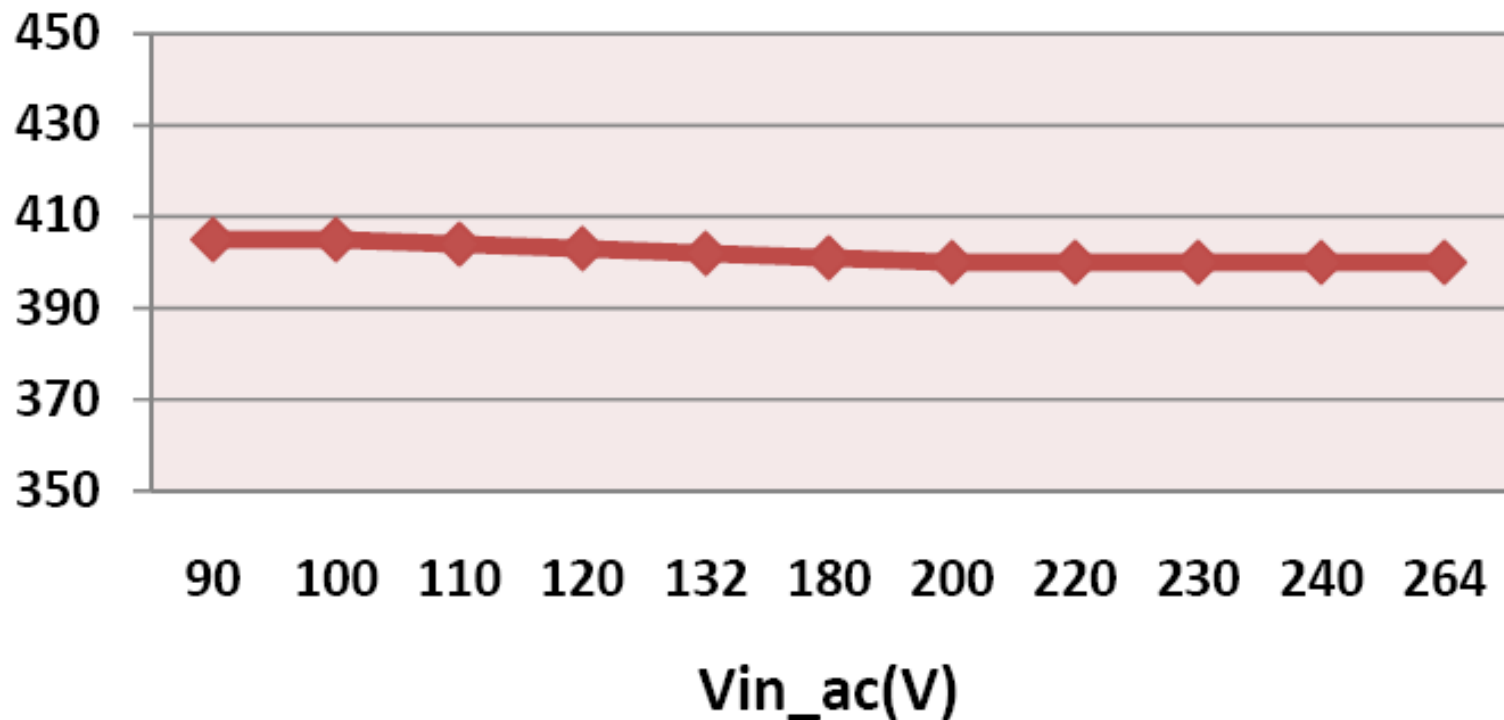


# Power Factor



# Current regulation

$I_{out}(mA)$

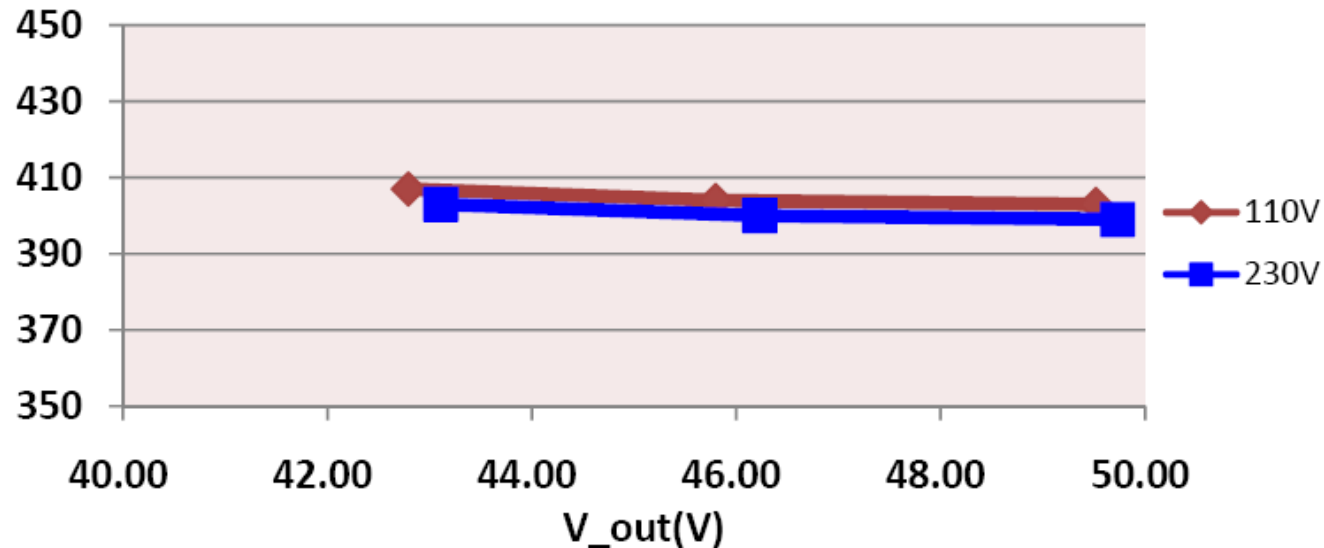


Limit in 1.23%

# Load regulation

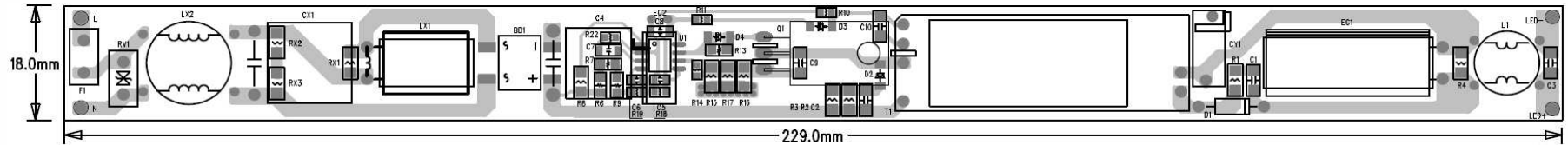
Frequency	Vac [V]	Vout [V]	Iout [mA]	Load regulation
60Hz	110	42.79	407	0.98%
60Hz	110	45.80	404	
60Hz	110	49.52	403	
50Hz	230	43.11	403	0.99%
50Hz	230	46.23	400	
50Hz	230	49.73	399	

I<sub>out</sub>(mA)

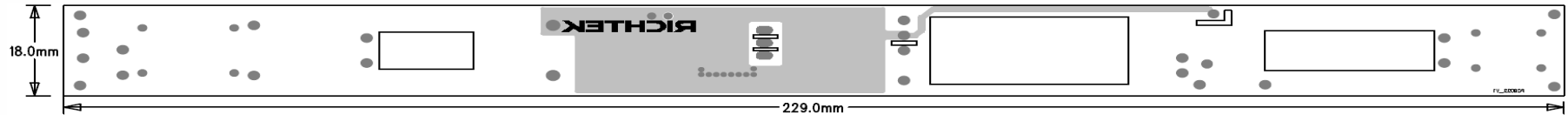


# PCB layout

## Top Trace



## Bottom Trace



# Demo board photo



Length	Width	Height
229mm	18mm	10mm

**PCB No : PCB022\_V1**

# BOM

Item	Location	Value	Type
1	F1	T1.25A/300V	SS-5F-2P
2	RV1	7N471K	TVS-2P
3	LX2	30mH	LRS-T14
4	CX1	0.1uF	CFS-12X12
5	LX1	5mH	LDS-D9X12
6	BD1	1A/600V	DB-1A
7	C4	0.1uF/500V	CFS-11X10
8	R6,R7,R9	2.2Mohm	0805
9	R19	43kohm	0603
10	C6	22nF/50V	0603
11	C7	2.2uF/25V	0805
12	R22	0ohm	0603

# BOM

Item	Location	Value	Type
13	R8	10kohm	1206
14	R2	140kohm	1206
15	D2	FM4007	SOD123
16	C2	2.2nF/1kV	1206
17	R13	200R	0805
18	D4	1N4148	SOD-123
19	Q1	4A/600V	TO-220
20	C9	100p/1kV	1206
21	LX3	T3.5*3*1.4	---
22	R15,R16,R17	2.21ohm	1206
23	R14	2kohm	0603
24	C10	470p/1kV	1206

# BOM

Item	Location	Value	Type
25	CY1	1000pF/250Vac	CAP-10mm
26	R10	60kohm	0603
27	R18	8.06kohm	0603
28	C5	22pF	0603
29	D3	BAV21	SOD-123
30	R11	82R	0603
31	EC2	33uF/50V	CES-5X11
32	T1	EDR28	EDR28
33	U1	RT7302	SOP-8
34	D1	SF26	DO-15
35	R1	33.2R	1206
36	C1	220p/1kV	1206



# BOM

Item	Location	Value	Type
37	EC1	220uF/63V	CES-10X25
38	L1	110uF	LR-T9
39	R4	200kohm	1206
40	C8	47.5kohm	1206

Total : 44 pcs

# Transformer

## Transformer Specification

CORE SIZE: **EDR-28**

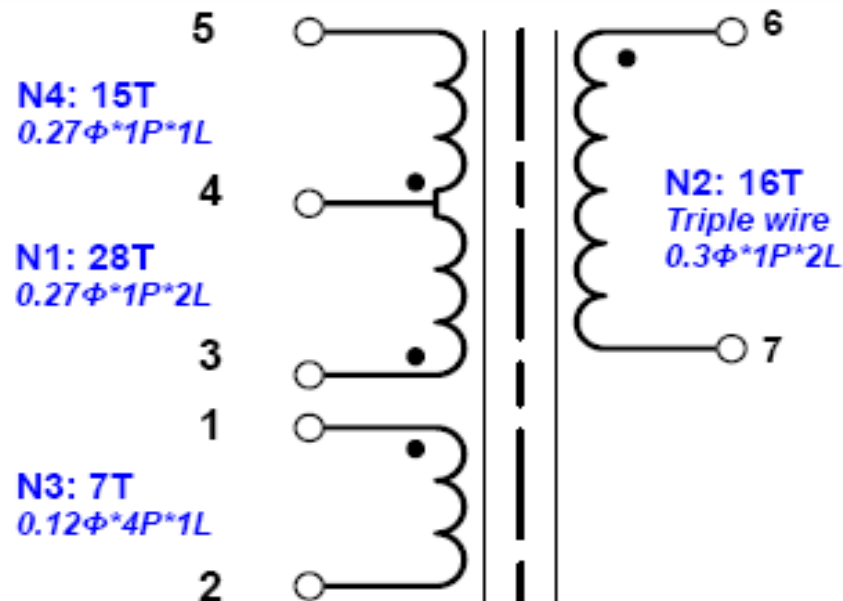
Material: **PC40**

Bobbin/PINs: **Horizontal / 7 pins**

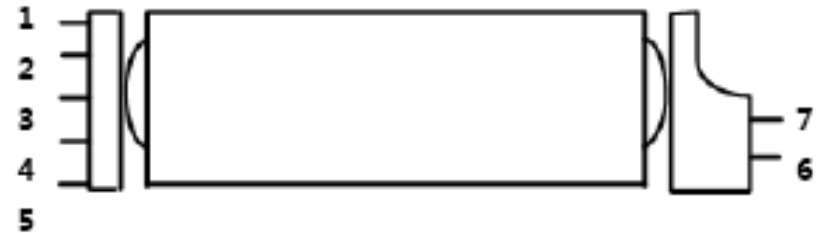
Primary inductor (+-5%) **920uH**

Leakage inductor **30uH**

Electrical :



top view



WINDING TABLE: (繞線結構)

Winding No. (組別)	PIN (腳位)	Wire & Wire & Copper (線徑 x 股數 x 層數)	Turns (圈數)	Winding Tape (繞線方式)	Tape Layer (膠帶層次)
<i>Bobbin</i>					
N1	3 → 4	0.27 x 1P x 2L	28Ts	密繞	2L
N2	6 → 7	Triple wire 0.3 x 1P x 2L	16Ts	密繞	2L
N3	1 → 2	0.12 x 4P x 1L	7Ts	密繞	1L
N4	4 → 5	0.27 x 1P x 1L	15Ts	密繞	1L
<i>Core - EDR28</i>				920uH	

# Power Component Stress Voltage

**Test condition: 90Vac input / 60V,300mA output**

Stead state			
Location	Max rating (V)	Measure	De-rating
Q1	600	304	50.67%
D1	400	110	27.50%

Transient State			
Location	Max rating (V)	Measure	De-rating
Q1	600	304	50.67%
D1	400	110	27.50%

# Power Component Stress Voltage

**Test condition: 264Vac input / 60V,300mA output**

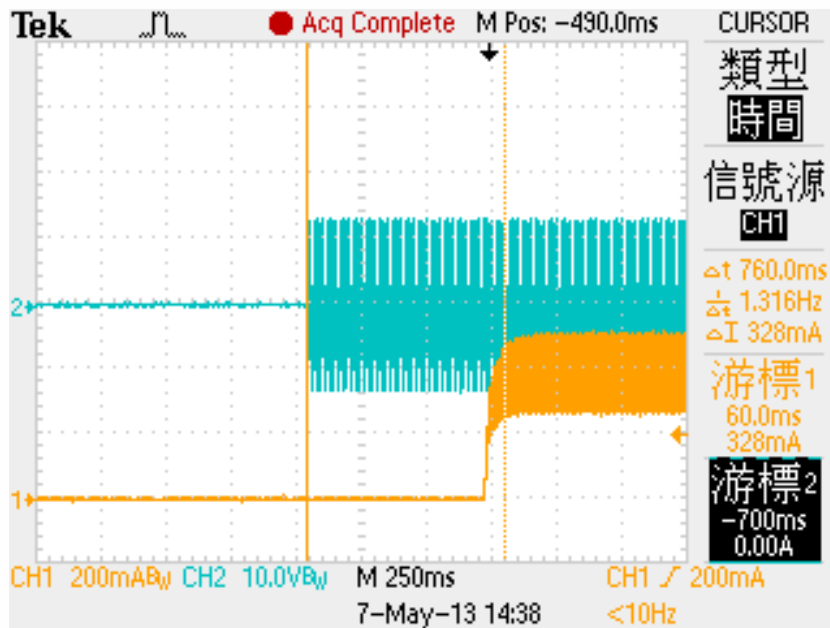
Stead state			
Location	Max rating (V)	Measure	De-rating
Q1	600	568	94.67%
D1	400	227	56.75%

Transient State			
Location	Max rating (V)	Measure	De-rating
Q1	600	572	95.33%
D1	400	230	57.50%

**Suggestion:** If change the Q1 from 600V to 650V. The de-rating decrease to 87.38%(Stead state) and 88%(Transient state) .

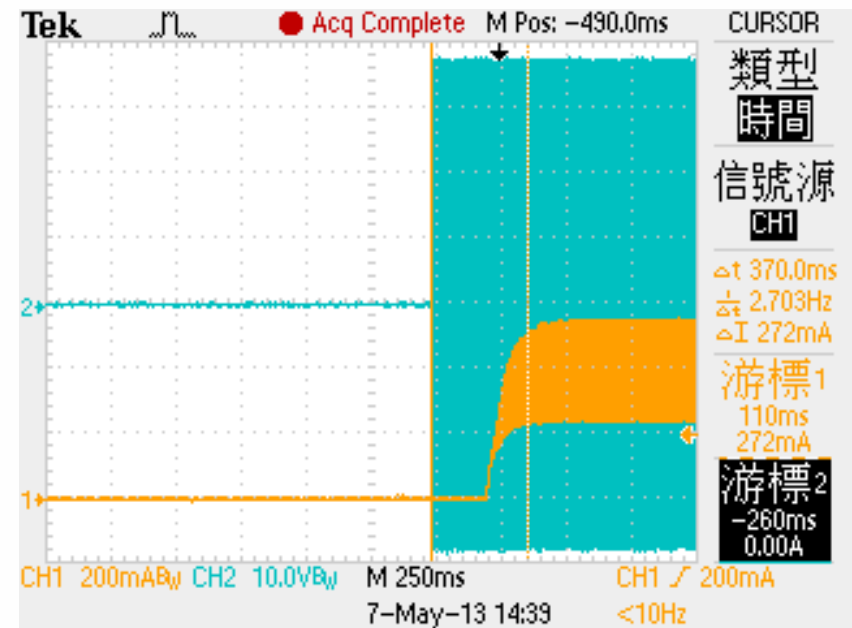
# Start up waveform

$V_{ac\_in} = 90V$



$T_{start\ up} = 760ms$

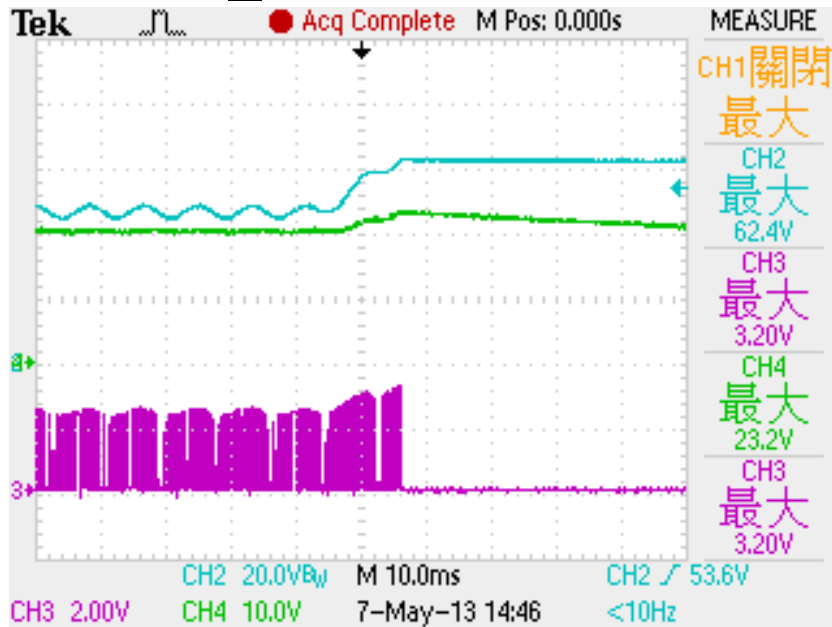
$V_{ac\_in} = 264V$



$T_{start\ up} = 370ms$

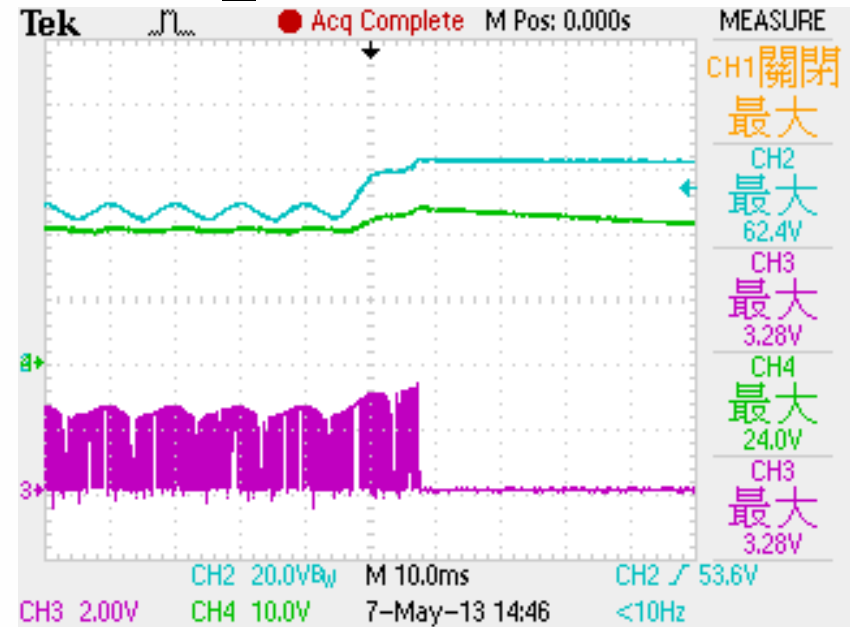
# LED open protection

$V_{ac\_in} = 90V$



Ch2:Vout ; Ch3:Vzcd ; Ch4:Vdd

$V_{ac\_in} = 264V$

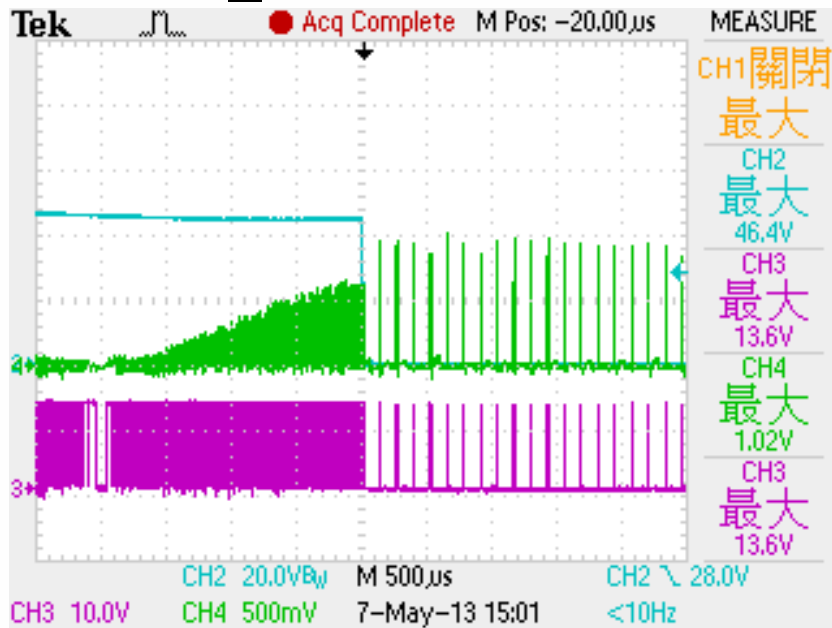


Ch2:Vout ; Ch3:Vzcd ; Ch4:Vdd

When LED open , the output keeps rising and causing the  $V_{ZCD}$  rising accordingly. If  $V_{zcd}$  trigger the protected level(2.9V~3.3V), the IC latch down. IC will be auto-restarted when the output is recovered.

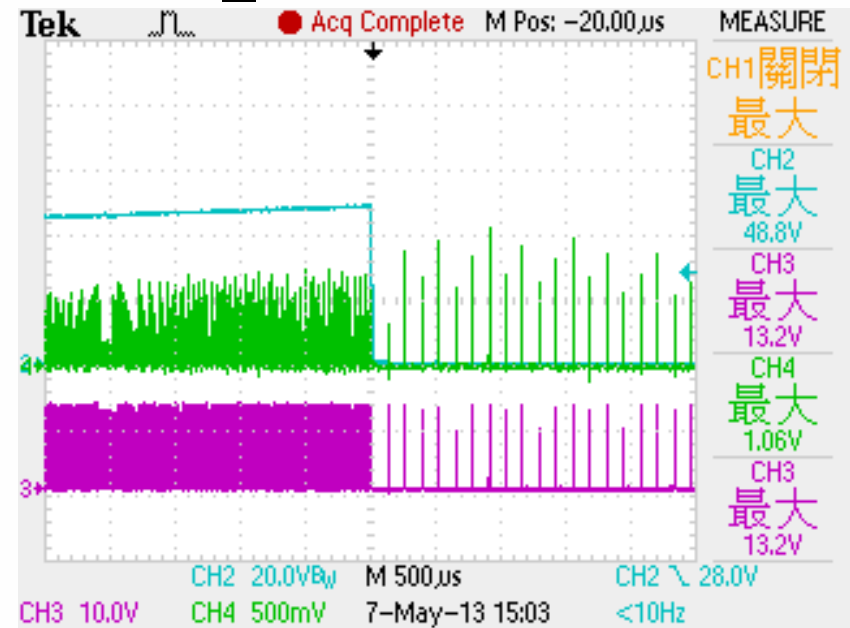
# LED Short protection

$V_{ac\_in} = 90V$



Ch2:Vout ; Ch3:Vgate ; Ch4:Vcs

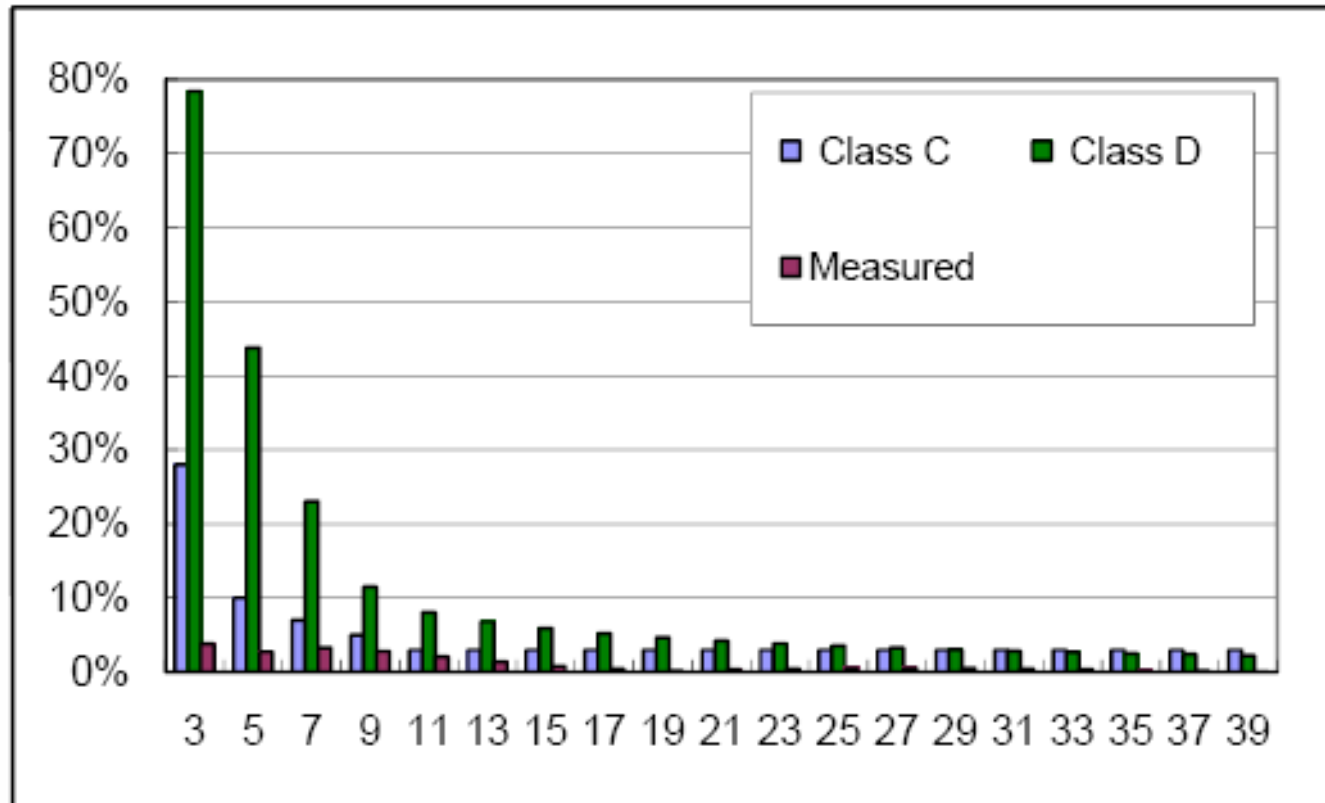
$V_{ac\_in} = 264V$



Ch2:Vout ; Ch3:Vgate ; Ch4:Vcs

**When LED short , the output level is 0V and the Vcs will rise to trigger the protected function. IC will be auto-restarted when the output is recovered.**

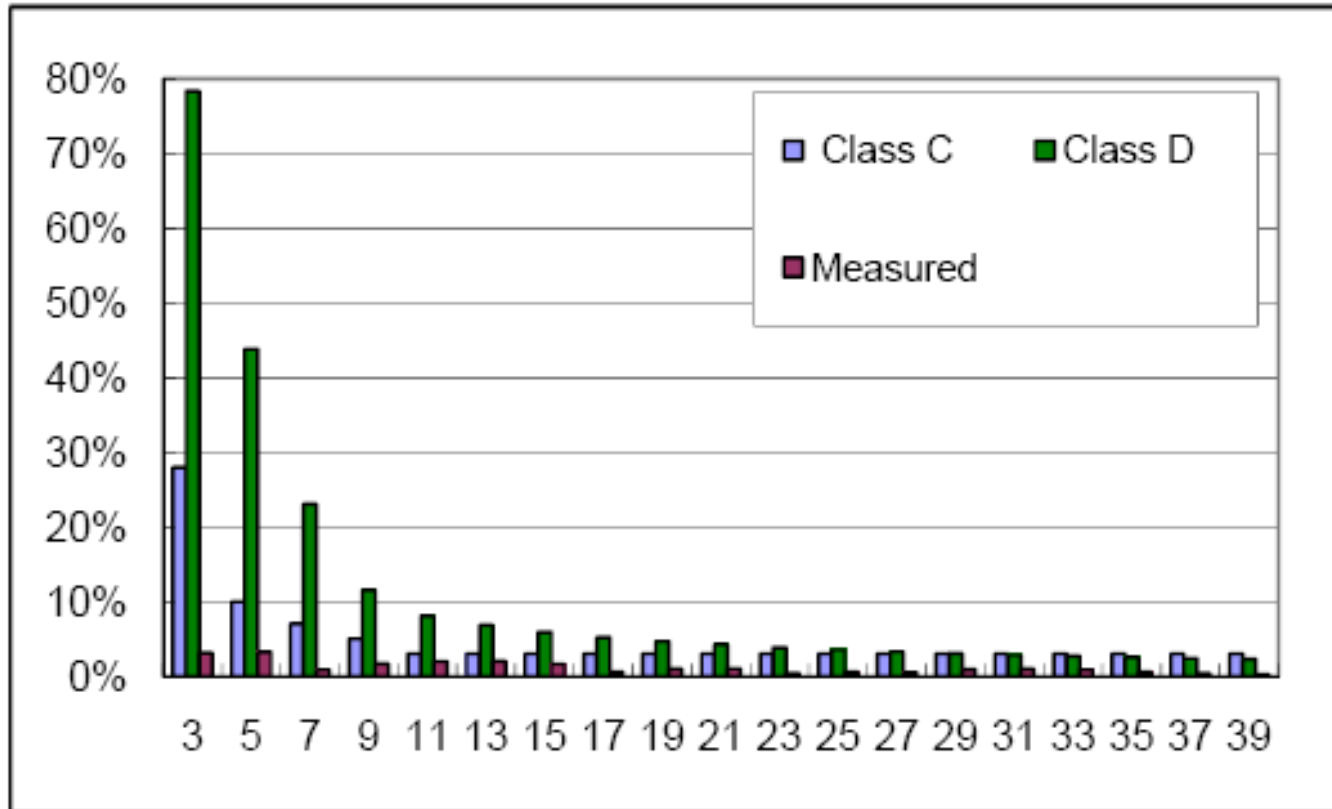
# Harmonic(IEC61000-3-2)



**110V input**  
**Class C : Pass**  
**Class D : Pass**



# Harmonic(IEC61000-3-2)



**230V input**  
**Class C : Pass**  
**Class D : Pass**

# Conduction-EMI



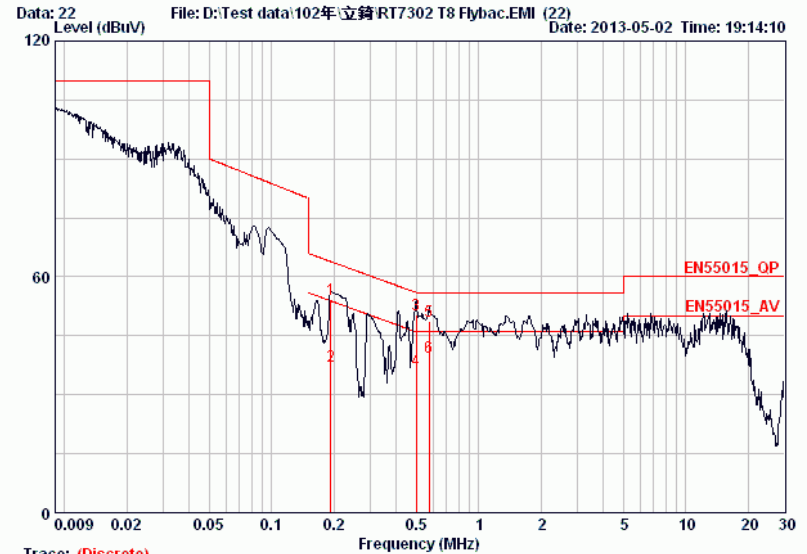
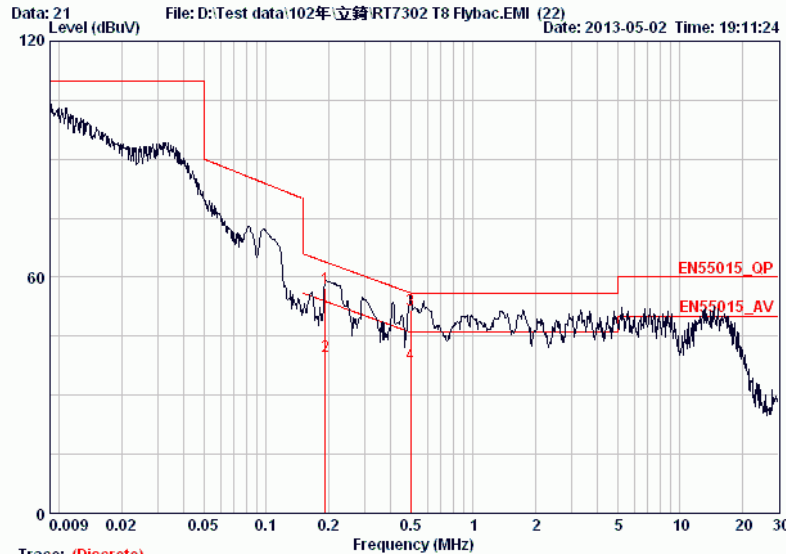
## 230V-L → Pass

No.8 Lane 724, Bo Ai Street  
Hsin Chu Hsien 302, Taiwan  
TEL:03-656-9065  
FAX:03-656-9085



## 230V-N → Pass

No.8 Lane 724, Bo Ai Street  
Hsin Chu Hsien 302, Taiwan  
TEL:03-656-9065  
FAX:03-656-9085



Trace: (Discrete)  
Condition : EN55015\_QP LISN 20120622 LINE  
Engineer : Hank  
Eut : RT7302 flyback 45V/400mA  
Power : 230V  
Mode :  
Memo : LISN LINE  
Memo-1 : original  
Memo-2 :  
Memo-3 :  
Memo-4 :  
Memo-5 :  
Memo-6 :

Trace: (Discrete)  
Condition : EN55015\_QP LISN 20120622 NEUTRAL  
Engineer : Hank  
Eut : RT7302 flyback 45V/400mA  
Power : 230V  
Mode :  
Memo : LISN NEUTRAL  
Memo-1 : original  
Memo-2 :  
Memo-3 :  
Memo-4 :  
Memo-5 :  
Memo-6 :

	Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Pol/Phase	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	dB		
1 @	0.19315	57.16	-6.74	63.90	56.96	0.15	0.05	LINE	QP
2 @	0.19315	39.82	-14.08	53.90	39.62	0.15	0.05	LINE	AVERAGE
3 @	0.49896	51.77	-4.25	56.02	51.56	0.15	0.05	LINE	QP
4 @	0.49896	37.80	-8.22	46.02	37.59	0.15	0.05	LINE	AVERAGE

	Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Pol/Phase	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	dB		
1 @	0.19315	54.36	-9.54	63.90	54.23	0.08	0.05	NEUTRAL	QP
2 @	0.19315	37.23	-16.67	53.90	37.10	0.08	0.05	NEUTRAL	AVERAGE
3 @	0.49896	50.21	-5.81	56.02	50.07	0.08	0.05	NEUTRAL	QP
4 @	0.49896	36.16	-9.86	46.02	36.02	0.08	0.05	NEUTRAL	AVERAGE
5 @	0.57740	48.57	-7.43	56.00	48.43	0.08	0.06	NEUTRAL	QP
6 @	0.57740	39.52	-6.48	46.00	39.38	0.08	0.06	NEUTRAL	AVERAGE