

LED Driver Design with IW3608 (Input 180~264Vac Output 30V/350mA)

General Design Specification:

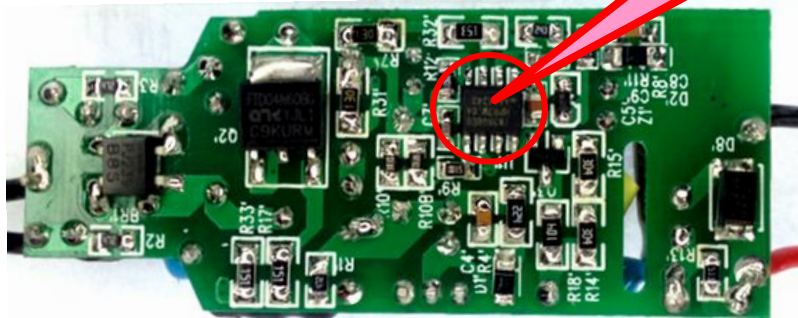
- 1.AC Input Range 180-264Vac
- 2.DC Output 30V/350mA(Constant Current)
- 3.Isolated High efficiency



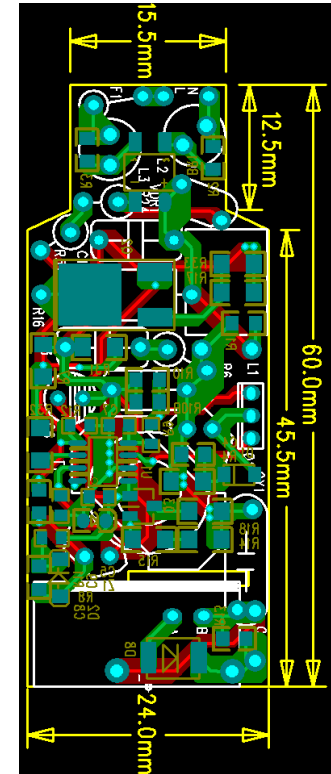
1. Specification

Description		Symbol	Min	Typ	Max	Units	Comment	
Input								
Voltage		V_{IN}	180	230	264	V _{AC}	2 Wire	
Frequency		f_{LINE}		50		Hz		
Open-load Input Power (264V _{AC})						W		
Output								
Const Voltage	Output Voltage	V_{OUT_CV}		30		V	Measured at the PCB connector	
	Output Current	I_{OUT_CV}				A		
Const Current	Output Voltage	V_{OUT_CV}				V	Min Vout is depend on Vcc	
	Output Current	I_{OUT_CV}		350		mA		
Total Output Power								
Continuous Output Power		P_{OUT}		10		W		
Over Current Protection		I_{OUT_MAX}				A	Auto-restart	
Efficiency		η	83			%	Measured at end of PCB@230V	
Power Fact		PF	0.9				Harmonic meet IEC61000-3-2	
Turn on Delay Time						Sec		
Conducted EMI			Meets EN55015B					
Hi-pot test						KV		
Operation temperature		T_{opr}		40		° C	Free convection, sea level	

2. PCB Layout



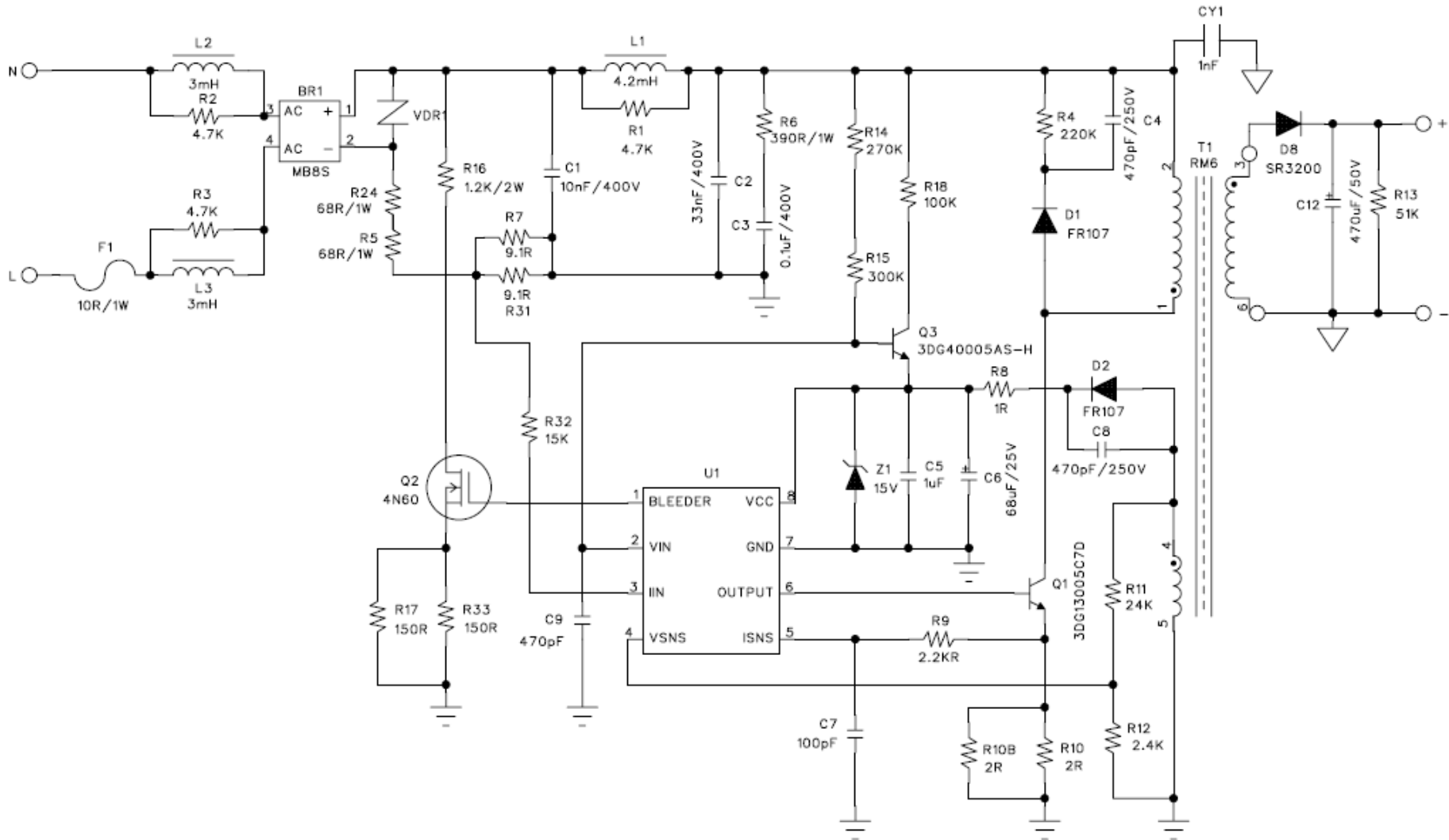
IW3608



3. BOM

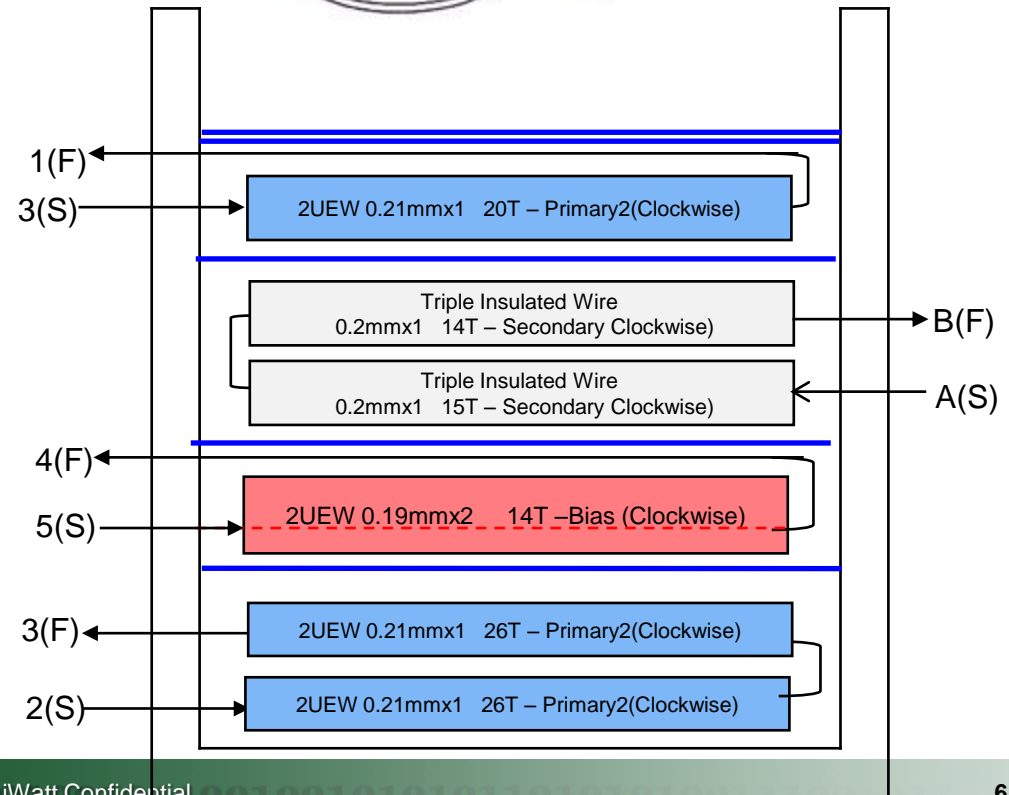
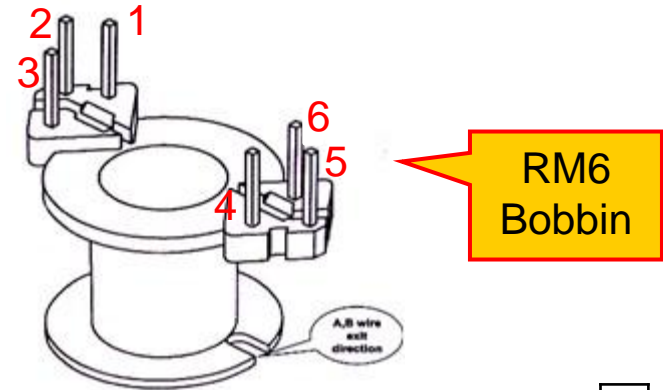
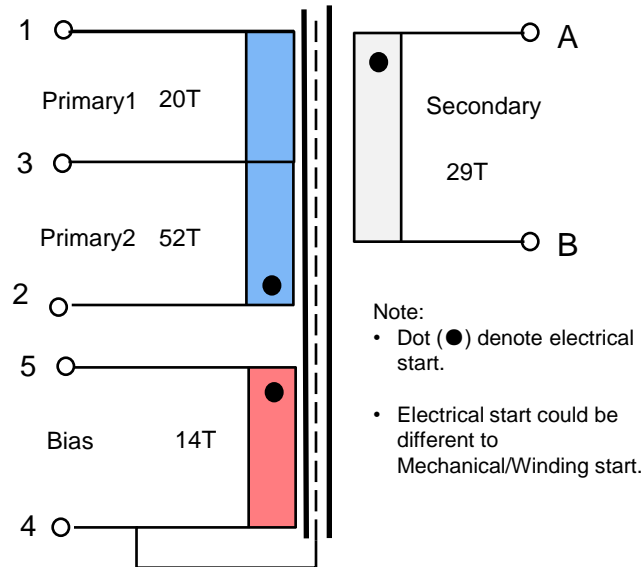
Qty	Ref.	Description			Size	Part Number	Manufacturer
1	U1				SO-8	IV3608-00	iWatt, Inc.
1	C1	0.01uF	400V	CL21	PIN=7.5MM	AF103J2E079L230D9R	Carli
1	C2	0.033uF	400V	CL21	PIN=7.5MM	AF333J2E079L250D9R	Carli
1	C3	0.1uF	400V	CL21	PIN=7.5MM	AF104J2E079L230D9R	Carli
1	C7	100pF	50V		SMD-0805	C2012COGX7R1H101KT	TDK Corp.
1	C9	470pF	50V		SMD-0805	C2012COGX7R1H471KT	TDK Corp.
1	C4	470pF	250V		SMD-0805	C2012COGX7R2E471KT	TDK Corp.
1	C8	470pF	250V		SMD-0805	C2012COGX7R2E221KT	TDK Corp.
1	C12	470UF	50V	E-CAP,105°C	8X16MM	50LK470M	Yongming
1	C6	68UF	25V	E-CAP,105°C	5X11MM	25LK68M	Yongming
1	C5	1UF	25V		SMD-0805		TDK Corp.
1	BR1	1A	1000V	B10S		B10S	PANJIT Semiconductor
2	D1,D2	1A	1000V	FR107	SMD	SREGC10MH/FR107	ZOWEI
1	D8	3A	200V	SB320		SB320	PANJIT Semiconductor
1	Q2	4A	600V	mosfet	TO-252	FTD04N60BG	ARK
1	Q1	4A	700V	mosfet	TO-126	3DG13005C7D	huajing
1	Q3					3DG40005AS-H	huajing
1	R4	220KΩ	+/-5%		SMD-1206	RC1206JR-07220KL	YAGEO
1	R9	2.2KΩ	+/-5%		SMD-0805	RC0805JR-072K2L	YAGEO
1	R18	100KΩ	+/-5%		SMD-0805	RC0805JR-07100KL	YAGEO
1	R14	270KΩ	+/-5%		SMD-1206	RC1206JR-07270KL	YAGEO
1	R15	300KΩ	+/-5%		SMD-1206	RC1206JR-07300KL	YAGEO
2	R17,R33	150Ω	+/-5%		SMD-1206	RC1206JR-07150RL	YAGEO
2	R7,R31	9.1Ω	+/-5%		SMD-1206	RC1206JR-079R1L	YAGEO
1	R32	15KΩ	+/-5%		SMD-1206	RC1206JR-0715KL	YAGEO
1	R8	1Ω	+/-5%		SMD-0805	RC0805JR-071RL	YAGEO
3	R1,R2,R3	4.7KΩ	+/-1%		SMD-0805	RC0805FR-074K7L	YAGEO
2	R5,R24	68Ω	+/-1%		1W		MOF
1	R6	390Ω	+/-1%		1W		MOF
1	R16	1.2KΩ	+/-1%		2W		MOF
1	R12	2.4KΩ	+/-1%		SMD-0805	RC0805FR-072K4L	YAGEO
1	R11	24KΩ	+/-1%		SMD-0805	RC0805FR-0724KL	YAGEO
2	R10,R10B	2Ω	+/-1%		SMD-0805	RC0805FR-072RL	YAGEO
1	Z1	15V			SOD-23		
1	CY1	1000PF	400V				
1	MOV	07D471					
1	F1	10R	1WS		1WS		SHUNCHI
2	L1,L2	3MH			6X8MM		
1	L3	4.2MH			8X10MM		
1	T1	Transformer			RM6		

4. Schematics



5. Transformer Design

SCHEMATIC



ELECTRICAL SPECIFICATIONS:

1. Primary Inductance (L_p) = 0.82mH @10KHz
2. Primary Leakage Inductance (L_k) <= 100uH @10KHz
3. Electrical Strength = 3KV, 50/60Hz, 1Min

MATERIALS:

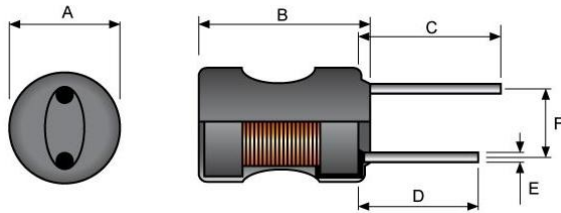
1. Core : RM6(Ferrite Material TDK PC40 or equivalent)
2. Bobbin :RM6Horizontal. Primary=3, Secondary=3
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires
5. Layer Insulation Tape :3M1298 or equivalent.

FINISHED :

1. Cut remained of Pin after wires termination
2. Varnish the complete assembly

6. PFC Inductor Design

Differential Mode Inductor_L3&L2



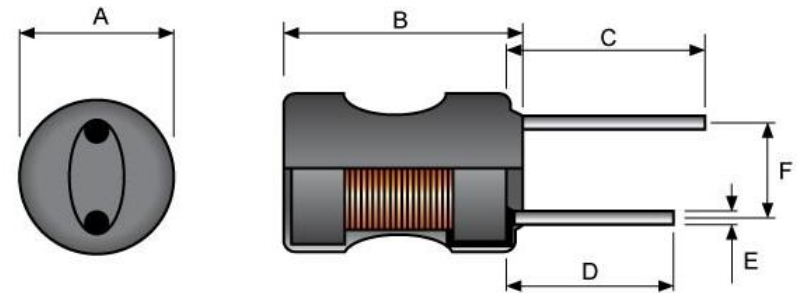
Ferrite core size : AxB 6x8mm

Wire gauge: 0.13mm, 320Turns

Inductance @10kHz, 1V: 3mH +/-10%

DCR: 8 OHM +/-20%

Differential Mode Inductor_L1



Ferrite core size : AxB 8x10mm

Wire gauge: 0.16mm, 360Turns

Inductance @10kHz, 1V: 4.2mH +/-10%

DCR: 10 OHM +/-20%

7.Constant Current and Efficiency

#of LEDs	Vin	Pin	Vout	Iout	efficiency	PF
	(V)	(W)	(V)	(mA)		
9LEDS	180	12.00	29.62	332.8	82.15%	0.986
	190	12.63	29.71	352.5	82.92%	0.984
	200	12.62	29.68	352.5	82.90%	0.983
	210	12.61	29.67	351.5	82.70%	0.981
	220	12.52	29.66	351.4	83.25%	0.980
	230	12.46	29.65	350.2	83.33%	0.978
	240	12.43	29.63	349.8	83.38%	0.975
	250	12.39	29.62	349.4	83.53%	0.971
	264	12.42	29.62	348.6	83.14%	0.966

8. Efficiency with dimmer

Dimmer : HEM 500VA/L Leading edge

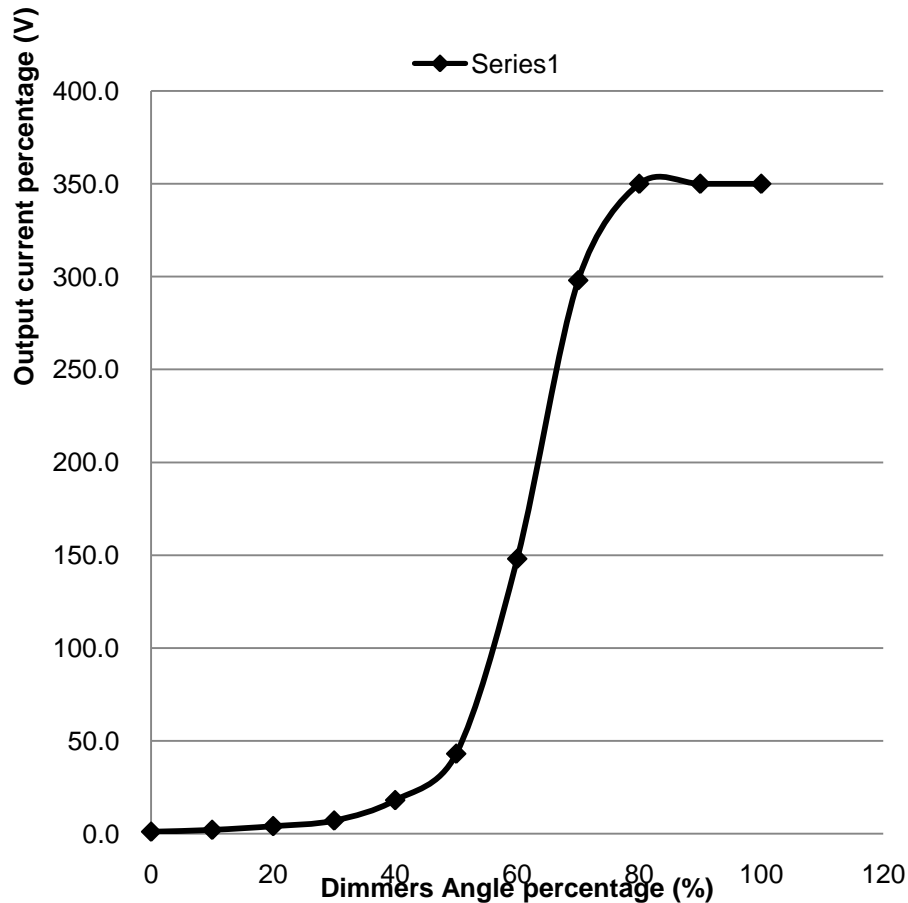
#of LEDs	Vin	Pin	Vout	Iout	efficiency
	(V)	(W)	(V)	(mA)	
9LEDS 230Vac	Max.	13.780	29.19	353.0	74.78%
	Mid.	8.250	28.01	174.0	59.08%
	Min.	1.830	25.37	1.00	1.39%

Dimmer : Cipsal 32E45OUDM Trialing edge

#of LEDs	Vin	Pin	Vout	Iout	efficiency
	(V)	(W)	(V)	(mA)	
9LEDS 230Vac	Max.	13.630	29.17	351.0	75.11%
	Mid.	7.485	27.99	170.0	63.57%
	Min.	1.580	25.35	1.00	1.60%

9. Dimmers Angle Percentage(%) Trialing edge

Dimmer : Cipsal 32E45OUDM Trialing edge

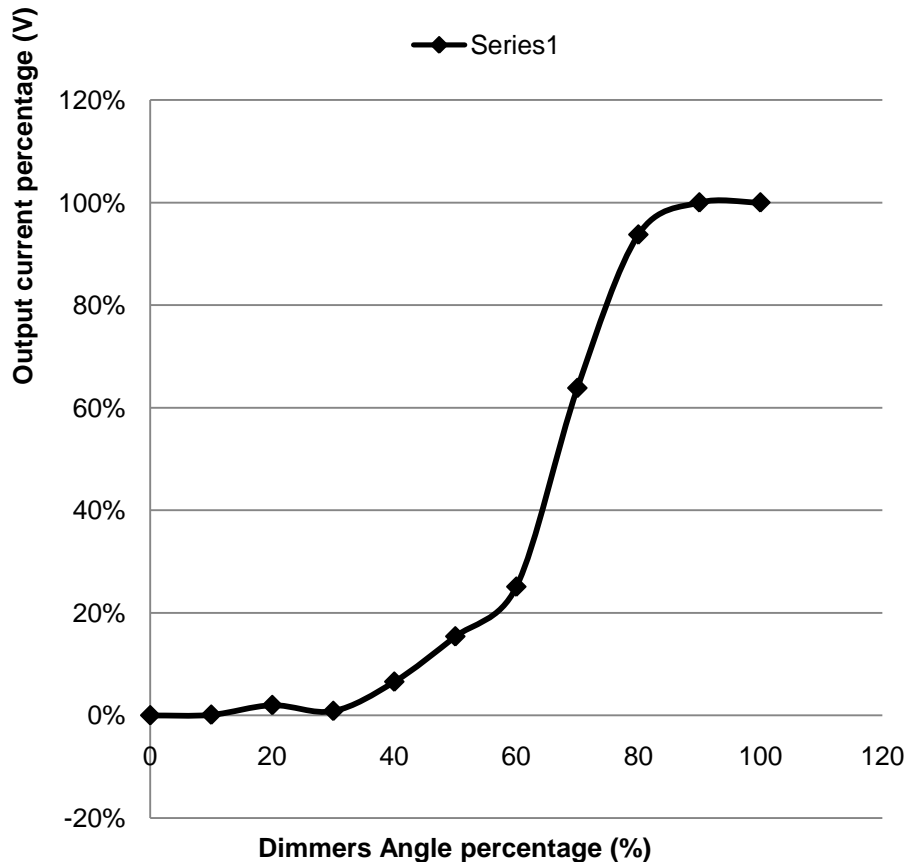


Dimmer Scale	Vin phase	Vin Duty	Iout	Dimming Level
0	2.48	24.8%	1.0	0%
10	2.64	26.4%	2.0	1%
20	3.08	30.8%	4.0	1%
30	4.08	40.8%	7.0	2%
40	4.12	41.2%	18.0	5%
50	4.88	48.8%	43.0	12%
60	5.72	57.2%	148.0	42%
70	6.8	68.0%	298.0	85%
80	7.68	76.8%	350.0	100%
90	7.72	77.2%	350.0	100%
100	7.76	77.6%	350.0	100%

10.Dimmers Angle Percentage(%) Leading edge

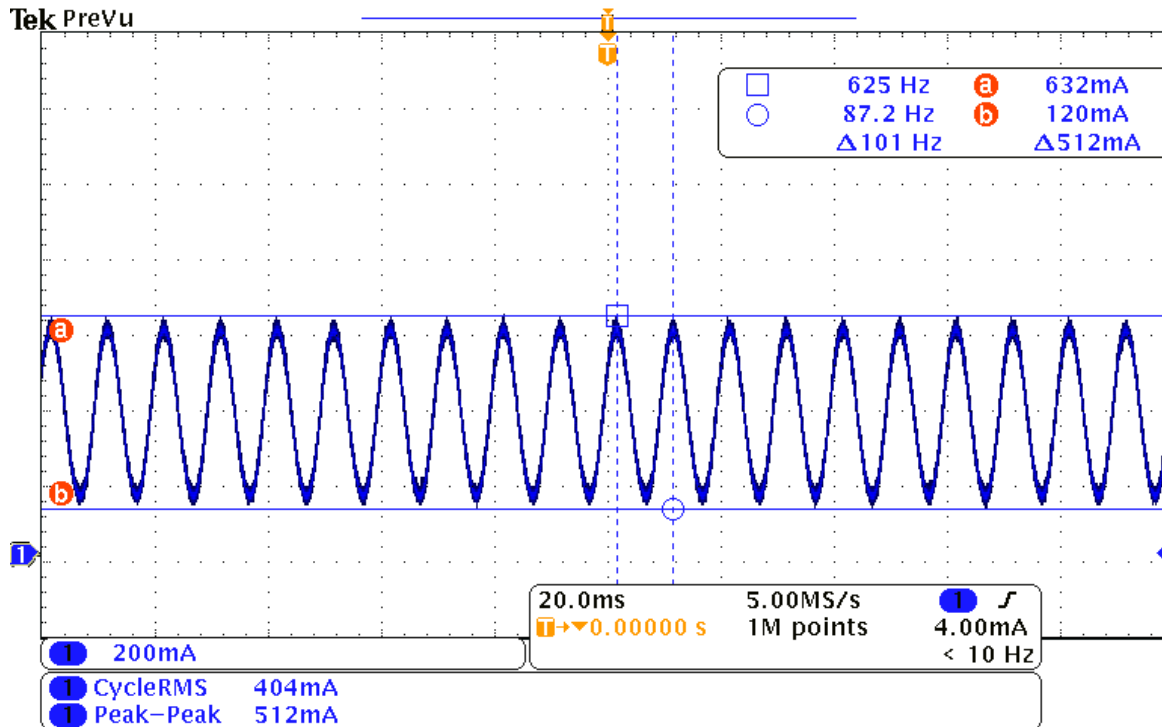
Dimmer : HEM 500VA/L

Leading edge



0	0	0.0%	0.0	0%
10	1.98	19.8%	0.4	0%
20	2.08	20.8%	7.0	2%
30	2.4	24.0%	3.0	1%
40	3.5	35.0%	23.0	7%
50	4.64	46.4%	54.0	15%
60	5.2	52.0%	88.0	25%
70	6.52	65.2%	224.0	64%
80	7.04	70.4%	329.0	94%
90	8.64	86.4%	351.0	100%
100	8.84	88.4%	351.0	100%

11. Output ripple current



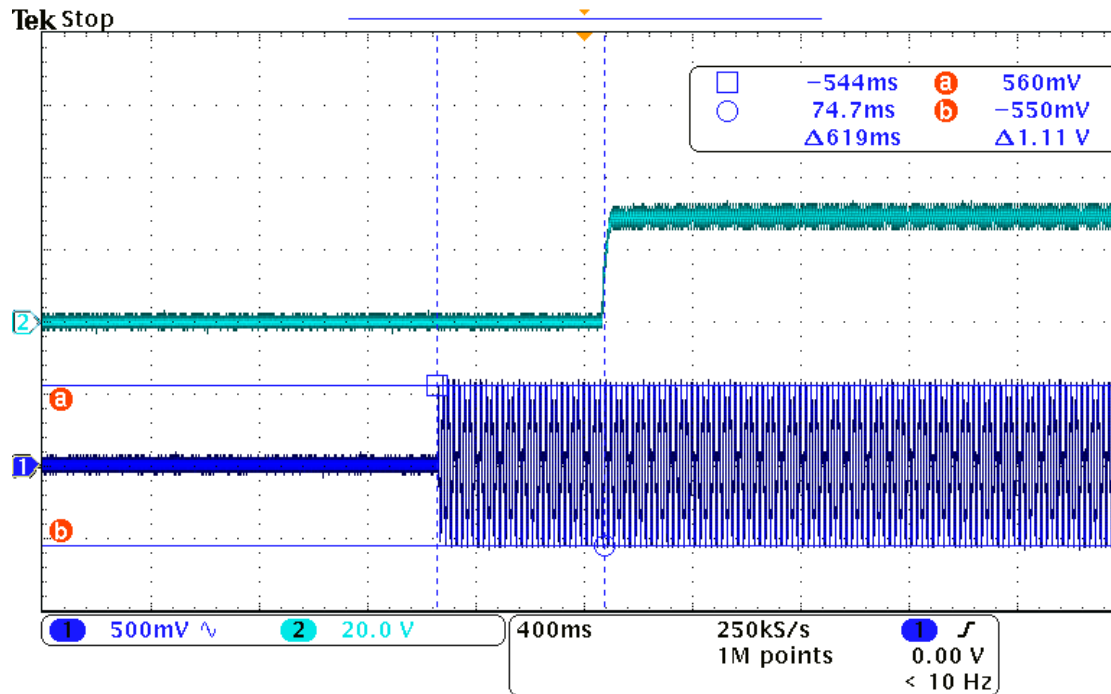
Input: 230Vac

Output: 30Vdc 350mA

Output cap: 470uF PF>0.98

Peak_peak : **512mA**

12. Start up and turn on delay time

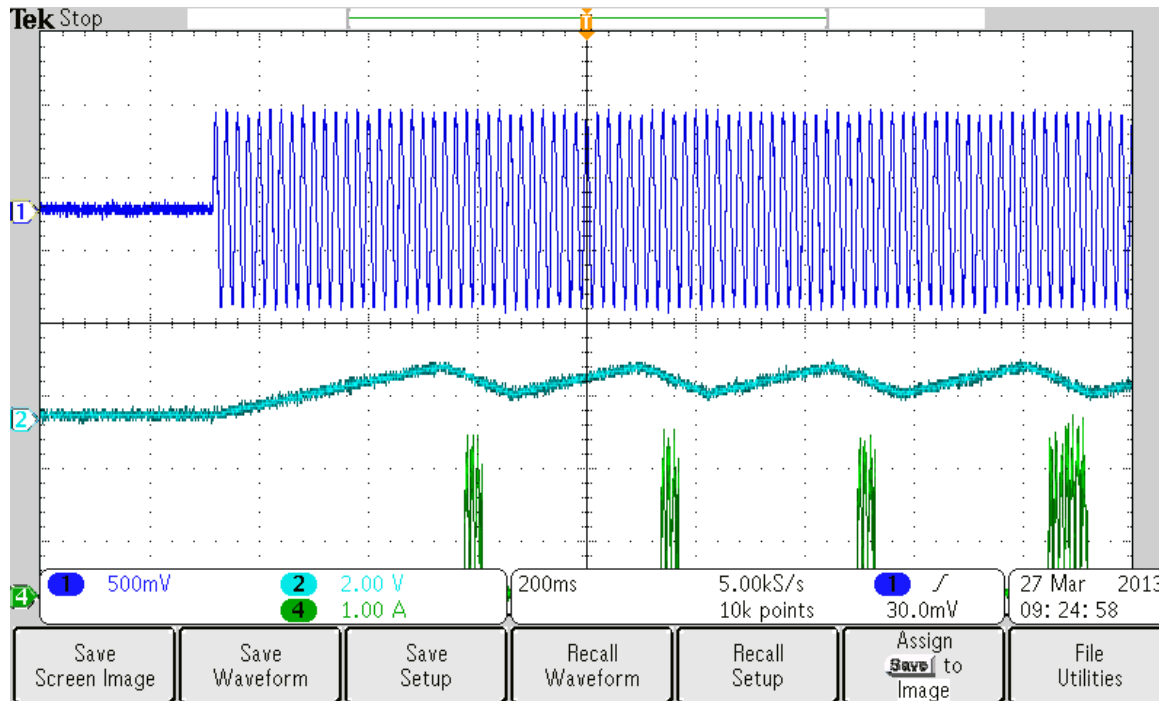


180V_{AC}, Full Load

V_{cc} resistor 100k V_{cc} cap 68uF

T_{ST_DELAY} = 619mS

13. Output short circuit test

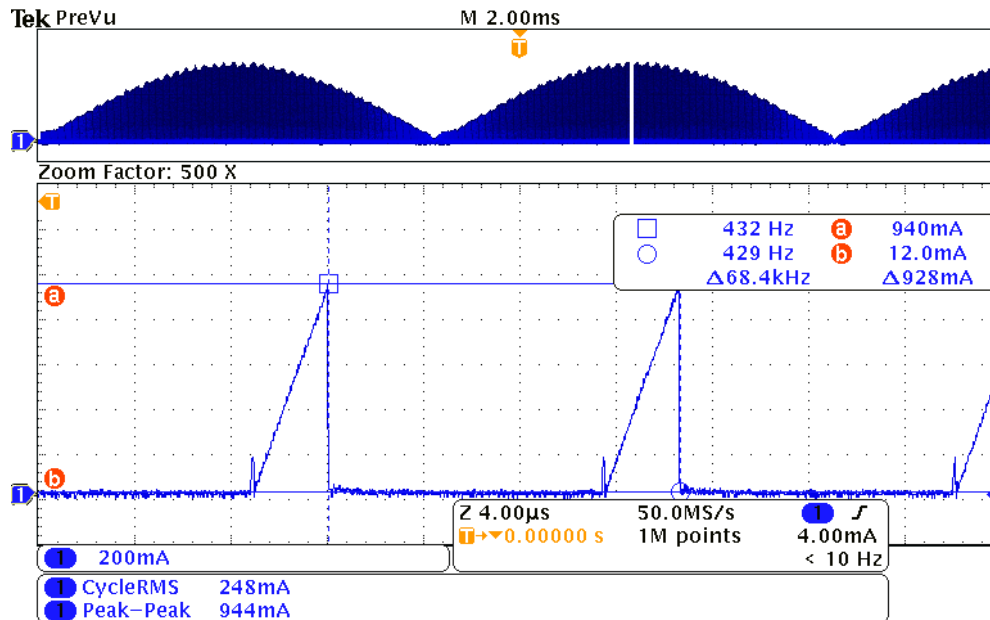


CH1:AC input
Ch2:VCC
CH3:Iout

**Vin 230V, output Short circuit
Pin =1.2W**

14. Transformer Flux Density

($N_p=72T_s$, $L_m=0.82mH$, $A_e=36.6mm$ RM6)



I_p is monitored at 180Vac and 350mA load

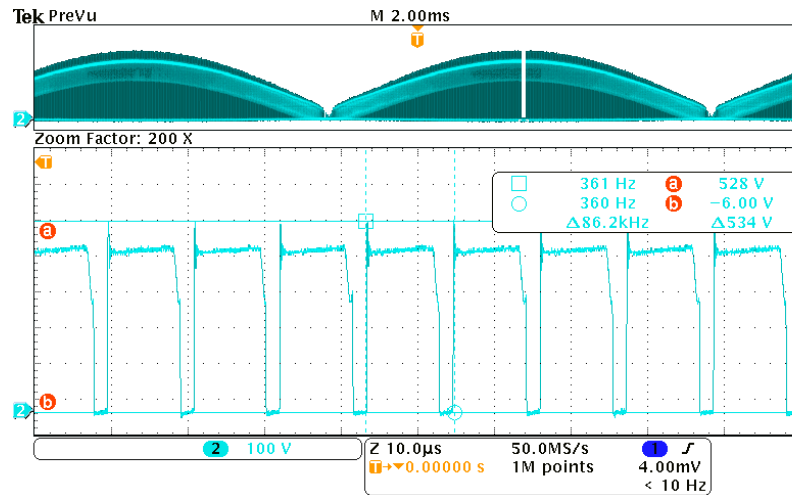
$I_p=0.928A$

$$B_{MAX} = I_p * L_m / (N_p * A_e)$$

$$= (928 * 0.82) / (72 * 36.6)$$

$$= 0.288 \text{ Tesla}$$

15. V_{CE} Waveform



Test Condition:

V_{IN}=264V_{AC}, I_{OUT_CV}=350mA

Result:

V_{CE_MAX}=534V

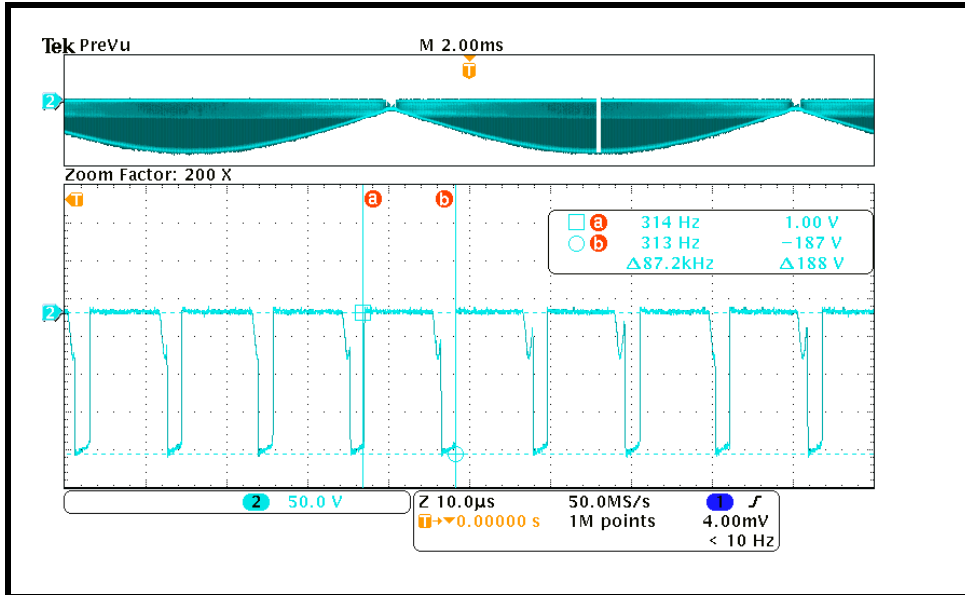
Appendix – Simple Specification for used Transistor(E13005)

NPN Silicon Transistor

Absolute Maximum Ratings T_C=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V _{CBO}	Collector-Base Voltage	: MJE13004	600
		: MJE13005	700
V _{CEO}	Collector-Emitter Voltage	: MJE13004	300
		: MJE13005	400
V _{EBO}	Emitter-Base Voltage	9	V
I _C	Collector Current (DC)	4	A
I _{CP}	Collector Current (Pulse)	8	A
I _B	Base Current	2	A
P _C	Collector Dissipation (T _C =25°C)	75	W
T _J	Junction Temperature	150	°C
T _{STG}	Storage Temperature	- 65 ~ 150	°C

16. Output rectifier waveform



Test Condition:

$V_{IN}=264VAC$, $I_{out}=350mA$

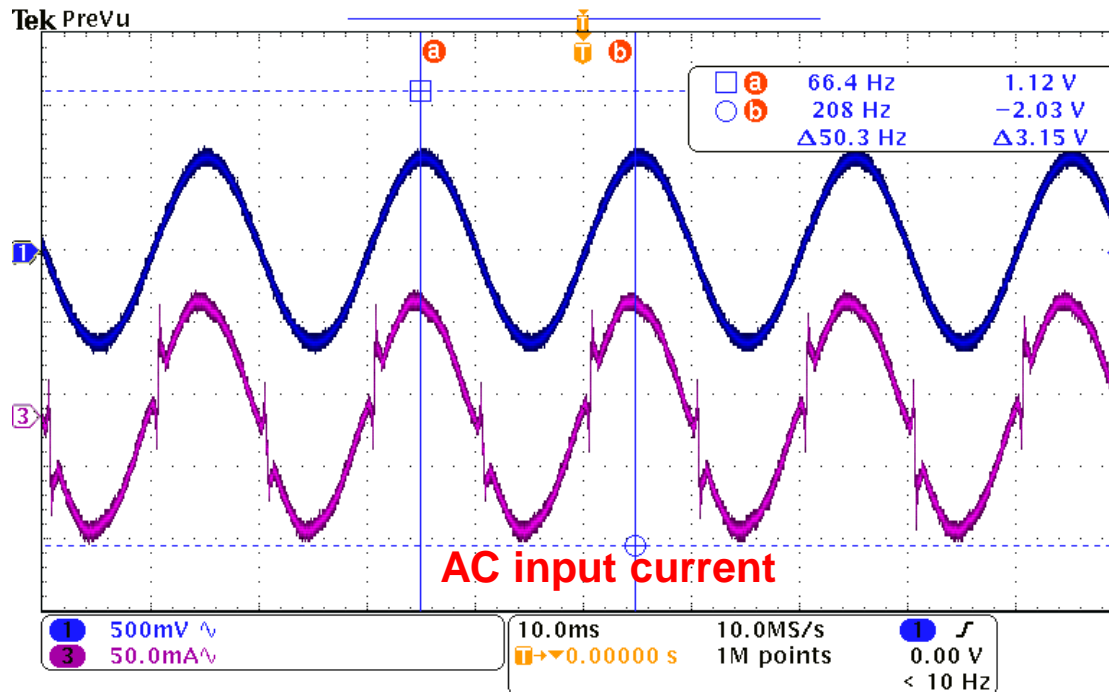
Result:

$V_R (pk-pk)=188V$

Output rectifier diode: SR3200 (3A, 200V)

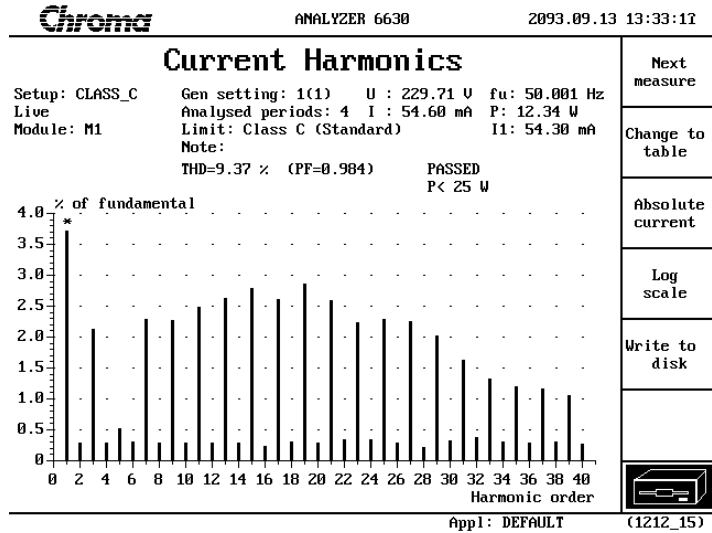
PARAMETER	SYMBOL	BX34	BX34A	BX35	BX36	BX38	BX39	BX310	BX315	BX320	UNITS
Maximum Recurrent Peak Reverse Voltage	V_{RRM}	40	45	50	60	80	90	100	150	200	V
Maximum RMS Voltage	V_{RMS}	28	31.5	35	42	56	63	70	105	140	V
Maximum DC Blocking Voltage	V_{DC}	40	45	50	60	80	90	100	150	200	V
Maximum Average Forward Current (See figure1)	$I_{F(AV)}$	3.0									A
Peak Forward Surge Current :8.3ms single half sine-wave superimposed on rated load(JEDEC method)	I_{FSM}	80									A
Maximum Forward Voltage at 3.0A (Note 1)	V_F	0.70		0.74		0.80		0.90			V
Maximum DC Reverse Current $T_J=25^{\circ}C$ at Rated DC Blocking Voltage $T_J=100^{\circ}C$	I_R	0.05 20									mA
Typical Thermal Resistance (Note 2)	$R_{\theta JL}$ $R_{\theta JA}$	20 75									$^{\circ}C / W$
Operating Junction and Storage Temperature Range	T_J, T_{STG}	-55 to +150			-65 to +175						$^{\circ}C$

17. AC input waveform



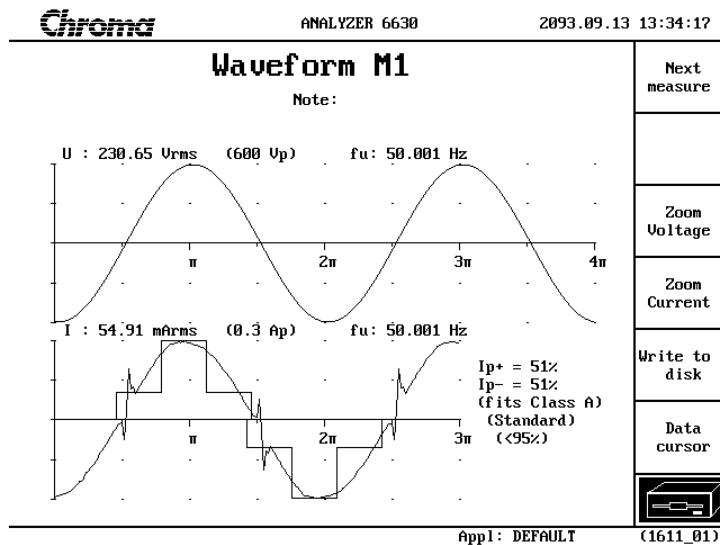
Vin 230Vac, Output: 30V、350mA
 PF:0.98
 Peak_peak : **180mA**

18. Harmonic and THD_IEC61000-3-2



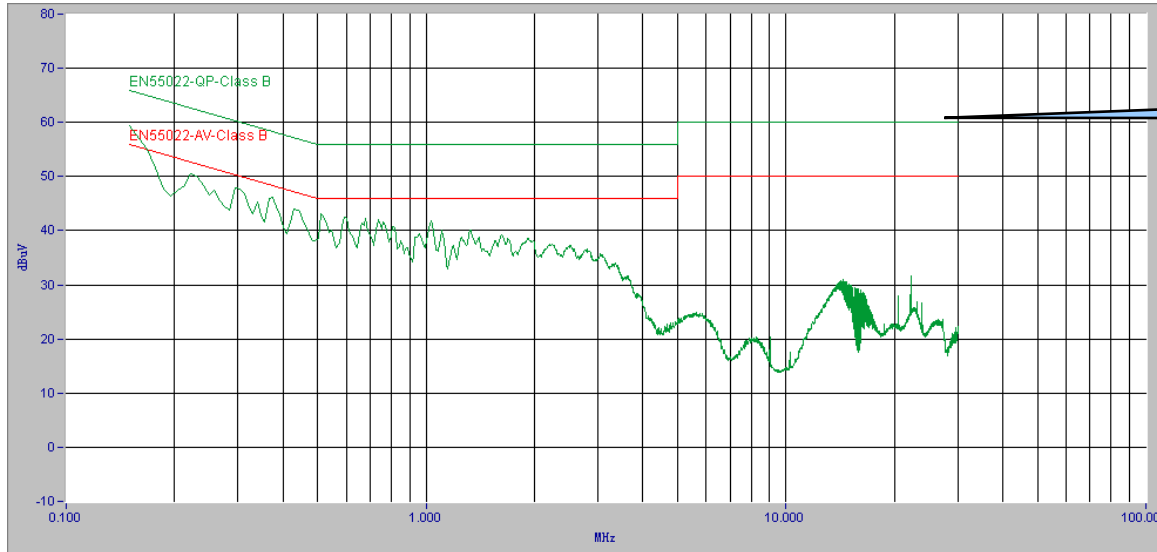
Harmonics current @230Vac
 Meet IEC61000-3-2 requirement

Ac current waveform @230Vac
 PF=0.984

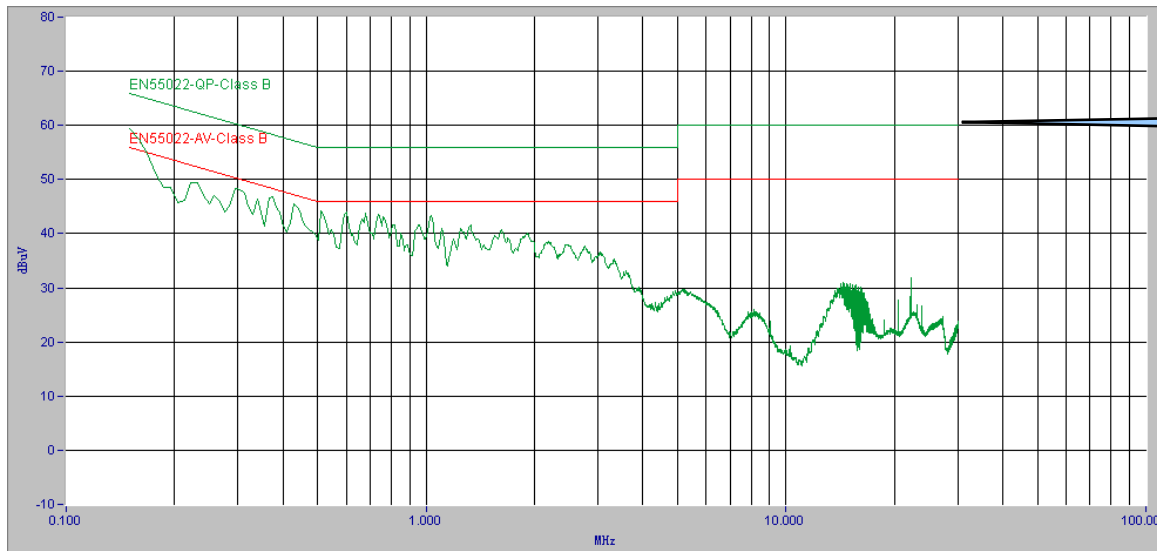


Output: 30V350mA
 THD: 9.37%

19. Conducted EMI (Full Load)

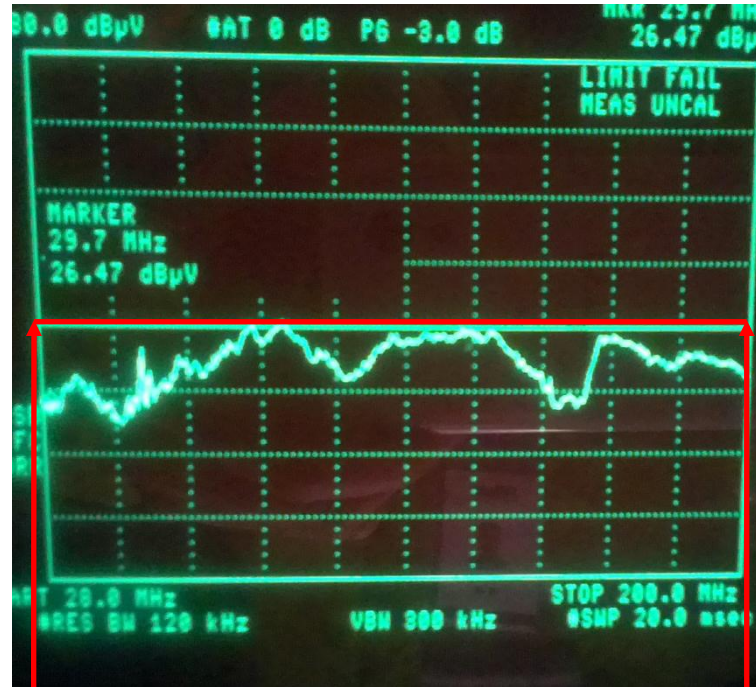


Input=230VAC
L line PK scan



Input=230VAC
N line PK scan

20. Radiation _ Similar test at 230vac input



28MHz

200MHz

Test condition: 230Vac 9LED 30V350mA

21. Over temperature protection

Configuration and thermal de-rating selection on Vsesne pin (equal resistance):

- Internal current source to detect Vsense pin resistor
- Sense IC junction temperature
- If Vsense high side resistor is 24k, low side is 2.4k, equals 2.18k, it means OTP is configured at 110 °C)

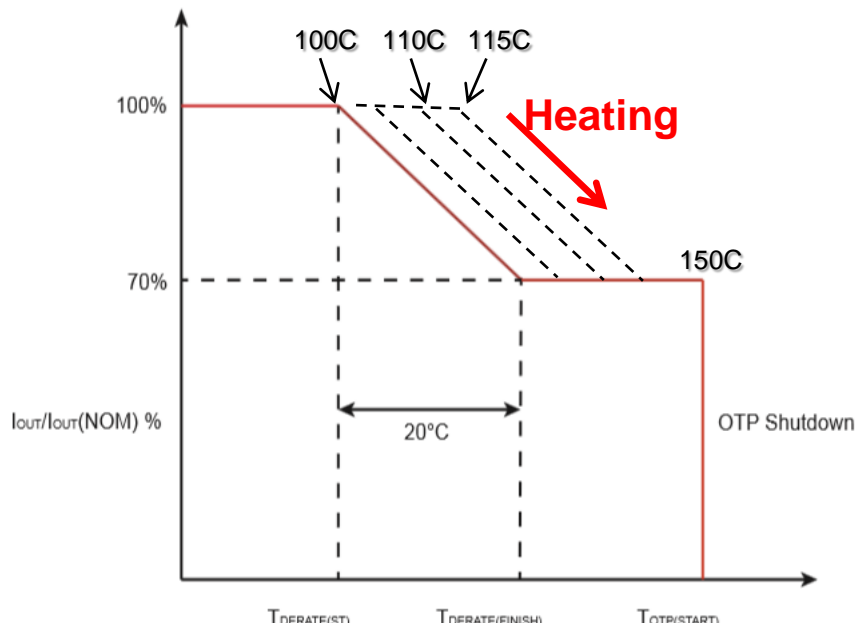


Figure 9.6 : Temperature DeRating and OTP

V _{SENSE} CFG Option Number	V _{SENSE} Pin Resistors (R8//R9 in Fig. 11.1)		Temperature Derating Starting Point T _{derate_st} (°C) (Fig. 9.6)
	Typical Value(kΩ)	Tolerance	
0	0.72	≤ 5%	100
1	1.38	≤ 5%	105
2	2.30	≤ 5%	110
3	3.60	≤ 5%	115

Table 9.1 V_{SENSE} Pin Configuration Resistor Values