

LED Driver Design with IW3608 (Input 90~135Vac Output 80V, 110mA)

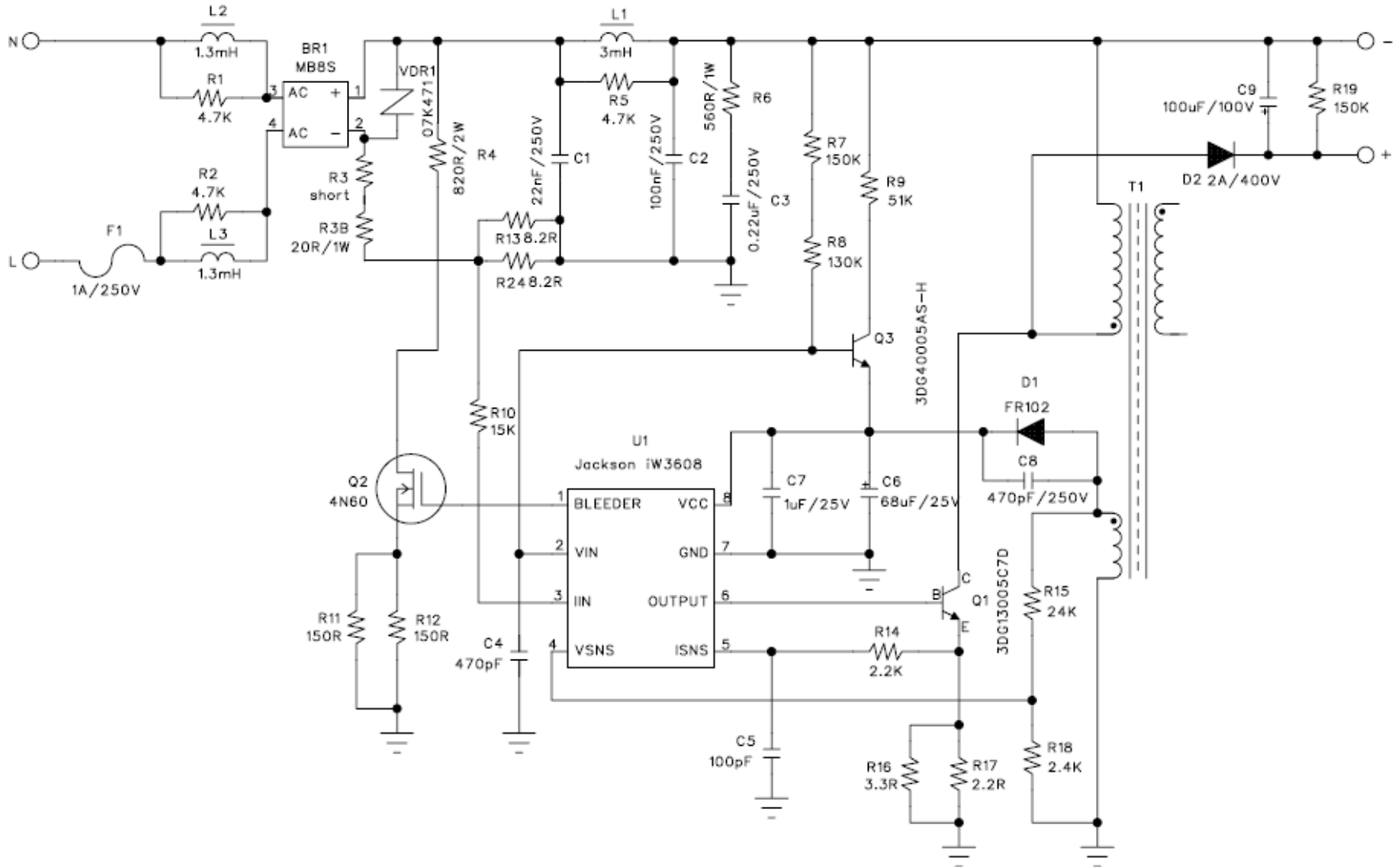
General Design Specification:

- 1.AC Input Range 90-135Vac
- 2.DC Output 80V, 110mA(Constant Current)
- 3.Non-isolated High efficiency

1. Specification

Description		Symbol	Min	Typ	Max	Units	Comment	
Input								
Voltage		V_{IN}	90	120	135	V _{AC}	2 Wire	
Frequency		f_{LINE}		60		Hz		
Open-load Input Power (264V _{AC})						W		
Output								
Const Voltage	Output Voltage	V_{OUT_CV}		80		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}		110		mA		
Total Output Power								
Continuous Output Power		P_{OUT}		9		W		
Over Current Protection		I_{OUT_MAX}				A	Auto-restart	
Efficiency		η	85			%	Measured at end of PCB@120V	
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	

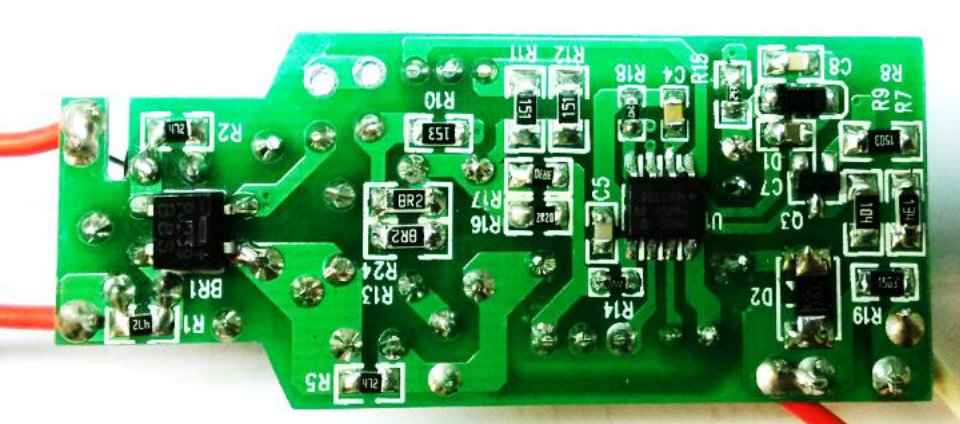
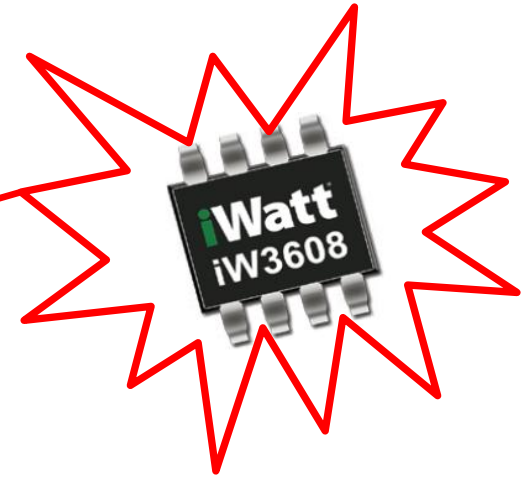
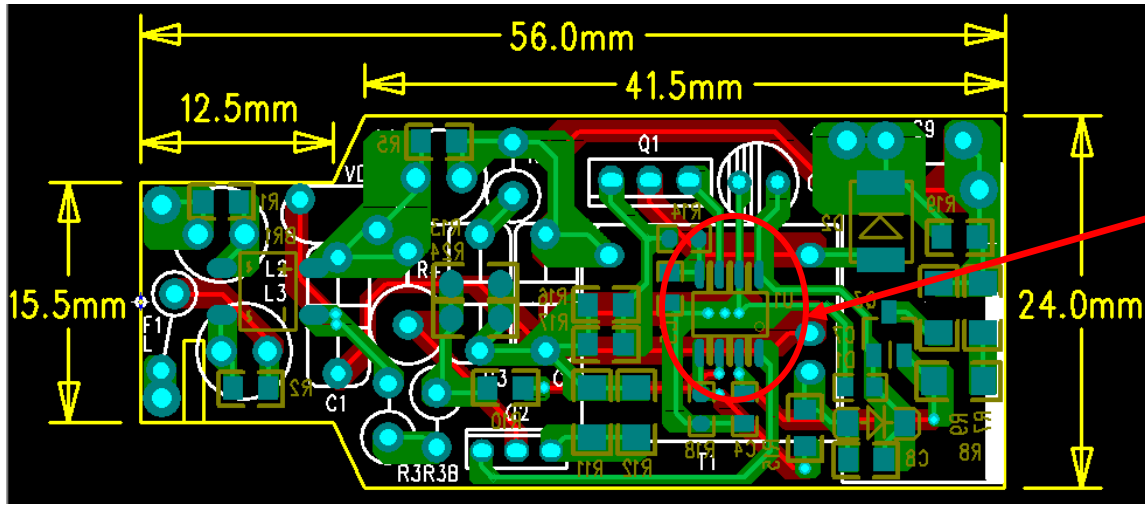
2. Schematics



3. Bill of Material

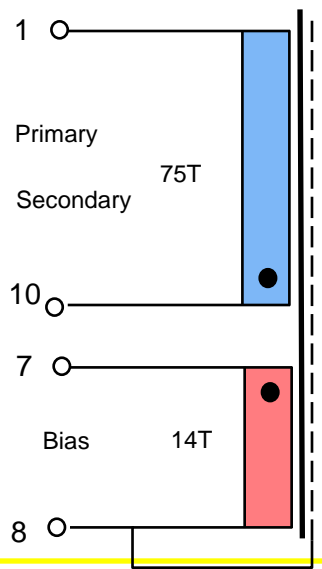
Qty	Ref.	Description			Size	Part Number	Manufacturer
1	U1				SO-8	IW3608-00	iWatt, Inc.
1	C1	0.022uF	250V	CL21	PIN=7.5MM	AF223J2E079L250D9R	Carli
1	C2	0.1	250V	CL21	PIN=7.5MM	AF104J2E079L230D9R	Carli
1	C3	0.22uF	250V	CL21	PIN=7.5MM	AF224J2E079L250D9R	Carli
1	C5	100pF	50V		SMD-0805	C2012COGX7R1H101KT	TDK Corp.
1	C4	470pF	50V		SMD-0805	C2012COGX7R1H471KT	TDK Corp.
1	C8	470pF	250V		SMD-0805	C2012COGX7R2E471KT	TDK Corp.
1	C9	100UF	100V	E-CAP,105°C	8X16MM	100LK100M	Yongming
1	C6	68UF	25V	E-CAP,105°C	5X11MM	25LK68M	Yongming
1	C7	1UF	25V		SMD-0805	C2012COGX7R1E105KT	TDK Corp.
1	BR1	1A	1000V	B10S		B10S	PANJIT Semiconductor
1	D1	1A	200V	FR102	SMD	SREGC10DH/FR102	ZOWEI
1	D2	2A	400V	UGC20GH		UGC20GH	ZOWEI
1	Q2	4A	600V	mosfet	TO-251	FTD04N60BG	ARK
1	Q1	4A	700V	BJT	TO-126	3DG13005C7D	huajing
1	Q3					3DG40005AS-H	huajing
1	R14	2.2KΩ	+/-5%		SMD-0805	RC0805JR-072K2L	YAGEO
1	R9	51KΩ	+/-5%		SMD-0805	RC0805JR-0751KL	YAGEO
1	R19	150KΩ	+/-5%		SMD-0805	RC0805JR-07150KL	YAGEO
1	R7	150KΩ	+/-5%		SMD-1206	RC1206JR-07150KL	YAGEO
1	R8	130KΩ	+/-5%		SMD-1206	RC1206JR-07130KL	YAGEO
2	R11,R12	150Ω	+/-5%		SMD-1206	RC1206JR-07150RL	YAGEO
1	R13	8.2Ω	+/-5%		SMD-1206	RC1206JR-078R2L	YAGEO
1	R24	8.2Ω	+/-5%		SMD-1206	RC1206JR-078R2L	YAGEO
1	R10	15KΩ	+/-5%		SMD-1206	RC1206JR-0715KL	YAGEO
3	R1,R2,R3	4.7KΩ	+/-1%		SMD-0805	RC0805FR-074K7L	YAGEO
1	R3B	20Ω	+/-1%	MOF	1W		
1	R6	560Ω	+/-1%	MOF	1W		
1	R4	820Ω	+/-1%	MOF	2W		
1	R18	2.4KΩ	+/-1%		SMD-0805	RC0805FR-072K4L	YAGEO
1	R15	24KΩ	+/-1%		SMD-0805	RC0805FR-0724KL	YAGEO
1	R16	3.3Ω	+/-1%		SMD-0805	RC0805FR-073R3L	YAGEO
1	R17	2.2Ω	+/-1%		SMD-0805	RC0805FR-072R2L	YAGEO
1	MOV	07D471				07D471	TKS
1	F1	10R	1WS		1WS	KNP1WST-52-J-10R	SHUNCHI
2	L1,L2,L3	1.3MH			6X8MM		
1	L3	3MH			6X8MM		

4. PCB Layout



5. Transformer Design

SCHEMATIC



- Note:
- Dot (●) denote electrical start.
 - Electrical start could be different to Mechanical/Winding start.

ELECTRICAL SPECIFICATIONS:

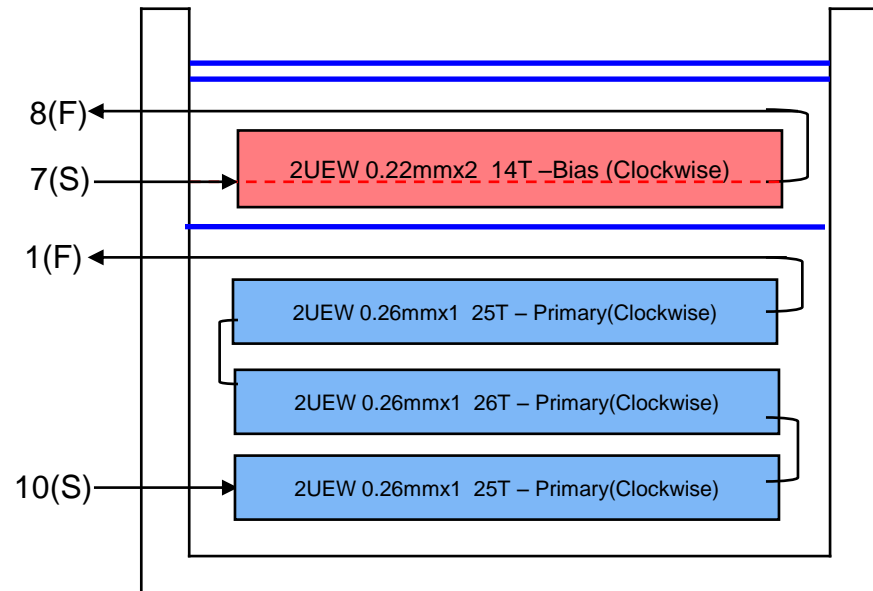
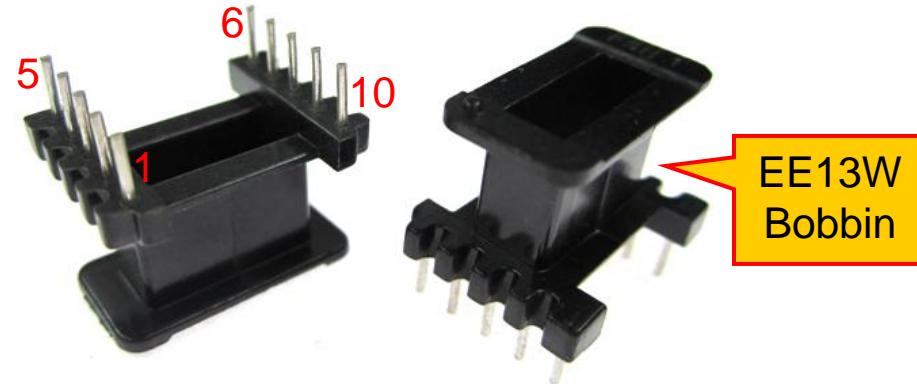
1. Primary Inductance (L_p) = 1mH @10KHz
2. Primary Leakage Inductance (L_k) <= 100uH @10KHz
3. Electrical Strength = 3KV, 50/60Hz, 1Min

MATERIALS:

1. Core : EE13W(Ferrite Material TDK PC40 or equivalent)
2. Bobbin :EE13W Horizontal. Primary=5, Secondary=5
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires
5. Layer Insulation Tape :3M1298 or equivalent.

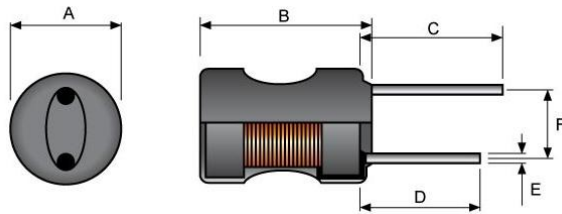
FINISHED :

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



6. PFC Inductor Design

Differential Mode Inductor_L1



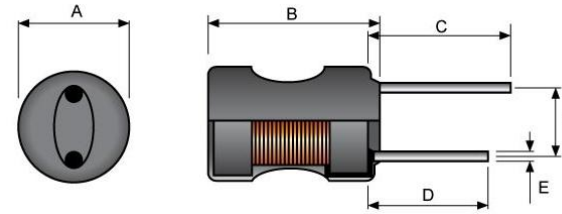
Ferrite core size : AxB 6x8mm

Wire gauge: 0.15mm, 220Turns

Inductance @10kHz, 1V: 1.3mH +/-10%

DCR: 8 OHM +/-20%

Differential Mode Inductor_L3&L2



Ferrite core size : AxB 6x8mm

Wire gauge: 0.13mm, 320Turns

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

DCR: 8 OHM +/-20%

7.Constant Current and Efficiency

#of LEDs	Vin (V)	Pin (W)	Vout (V)	Iout (mA)	efficiency	PF	THD
25LEDS	90	10.83	81.59	108.0	83.59%	0.993	6.45
	100	10.82	82.18	110.0	83.59%	0.993	10.76
	110	10.61	81.47	110.0	84.46%	0.993	8.78
	120	10.46	80.90	110.0	85.08%	0.993	8.23
	130	10.39	80.81	110.0	85.55%	0.993	7.82
	135	10.31	80.35	111.0	86.52%	0.993	7.46

8. Efficiency with dimmer

Dimmer : SELV-300P-WH Trialing edge

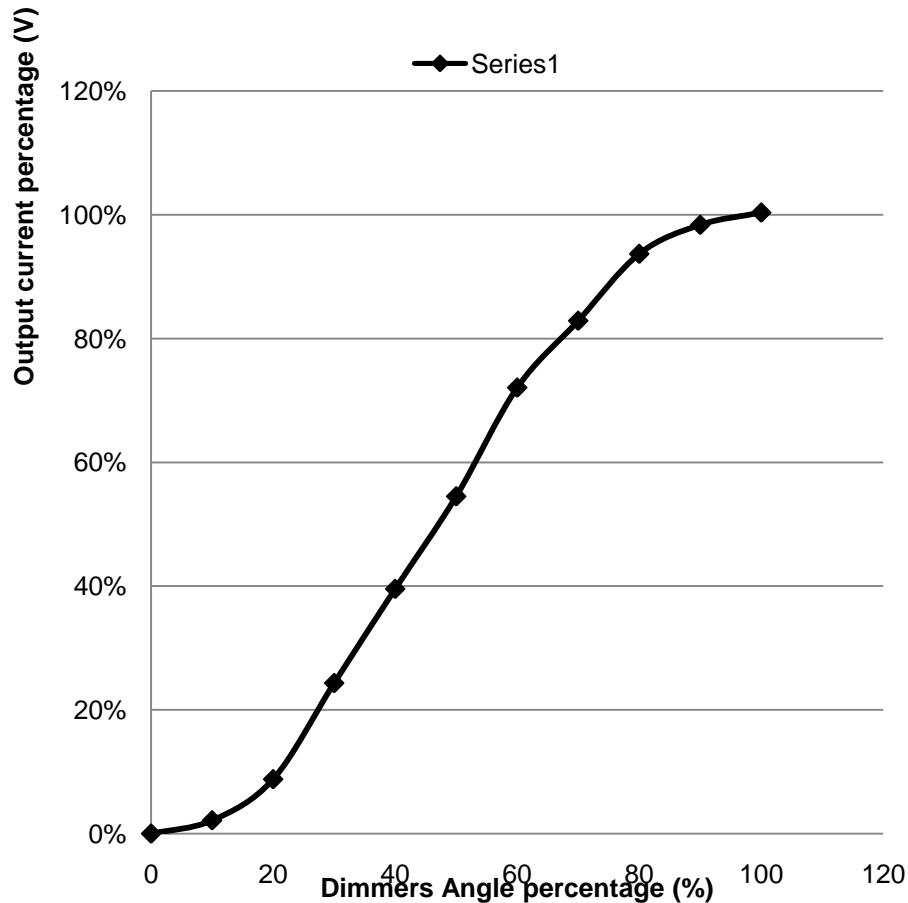
#of LEDs	Vin	Pin	Vout	Iout	efficiency
	(V)	(W)	(V)	(mA)	
25LEDS 120Vac	Max.	11.510	80.34	111.5	77.83%
	Mid.	6.510	78.76	55.5	67.15%
	Min.	1.700	70.22	0.05	0.21%

Dimmer : DIVA DV-600PR Leading edge

#of LEDs	Vin	Pin	Vout	Iout	efficiency
	(V)	(W)	(V)	(mA)	
25LEDS 120Vac	Max.	11.630	80.16	111.3	76.71%
	Mid.	6.840	78.62	55.8	64.14%
	Min.	1.453	70.46	0.07	0.34%

9. Dimmers Angle Percentage(%) Trialing edge

Dimmer : SELV-300P-WH Trialing edge

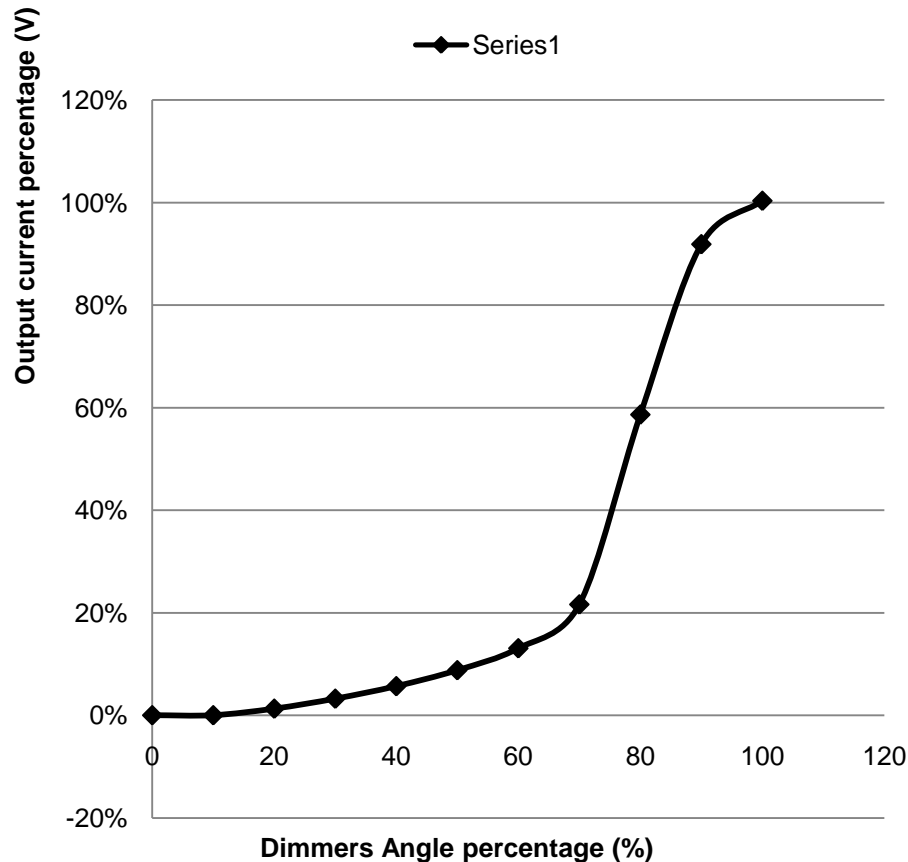


Dimmer Scale	Vin phase	Vin phase Duty	Iout	Dimming Level
0	2.12	25.4%	0.0	0%
10	3.08	37.0%	2.4	2%
20	3.64	43.7%	9.8	9%
30	4.08	49.0%	27.0	24%
40	4.4	52.8%	43.9	40%
50	4.8	57.6%	60.5	55%
60	5.08	61.0%	80.0	72%
70	5.2	62.4%	92.0	83%
80	5.8	69.6%	104.0	94%
90	6.12	73.4%	109.2	98%
100	6.84	82.1%	111.4	100%

10.Dimmers Angle Percentage(%) Leading edge

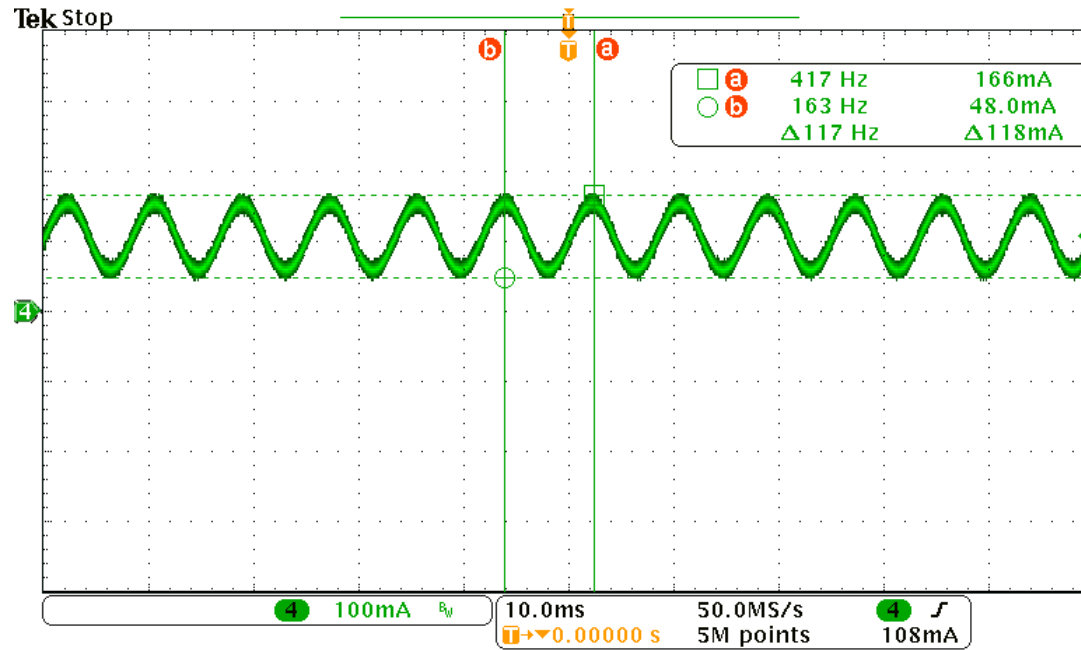
Dimmer : DIVA DV-600PR

Leading edge



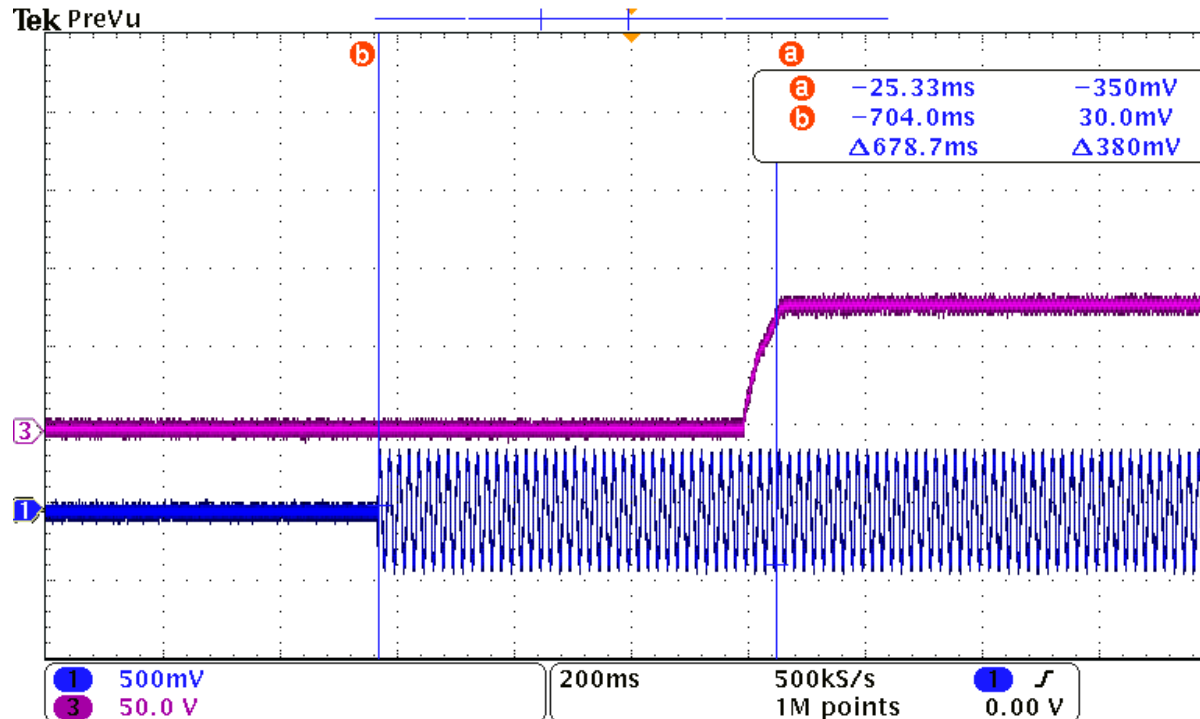
Dimmer Scale	Vin phase	Vin Duty	Iout	Dimming Level
0	0	0.0%	0.0	0%
10	1.98	23.8%	0.0	0%
20	2.26	27.1%	1.4	1%
30	2.52	30.3%	3.6	3%
40	3.04	36.5%	6.3	6%
50	3.4	40.8%	9.8	9%
60	3.8	45.6%	14.5	13%
70	4.4	52.8%	24.0	22%
80	5	60.0%	65.1	59%
90	5.64	67.7%	102.0	92%
100	6.6	79.2%	111.4	100%

11. Output ripple current



Input: 120Vac Output: 80Vdc 110mA
Output cap: 100uF PF>0.99
Peak_peak : **118mA**

12. Start up and turn on delay time

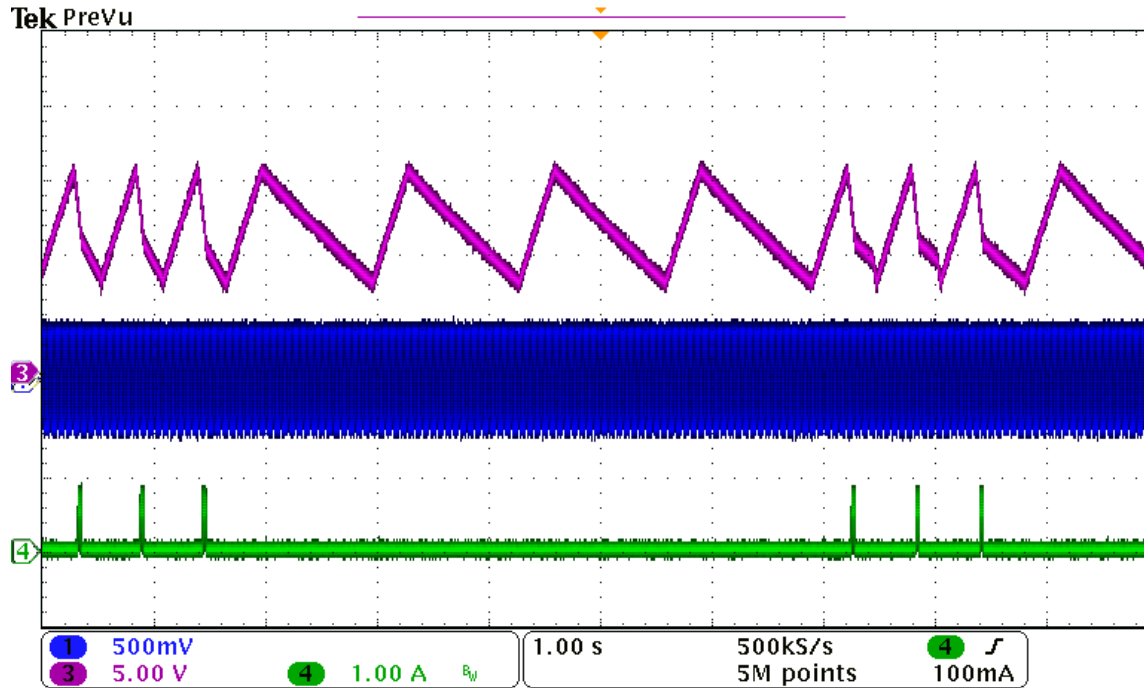


120V_{AC}, Full Load

V_{cc} ASU resistor 51k V_{cc} cap 68uF

T_{ST_DELAY} = 678.7mS

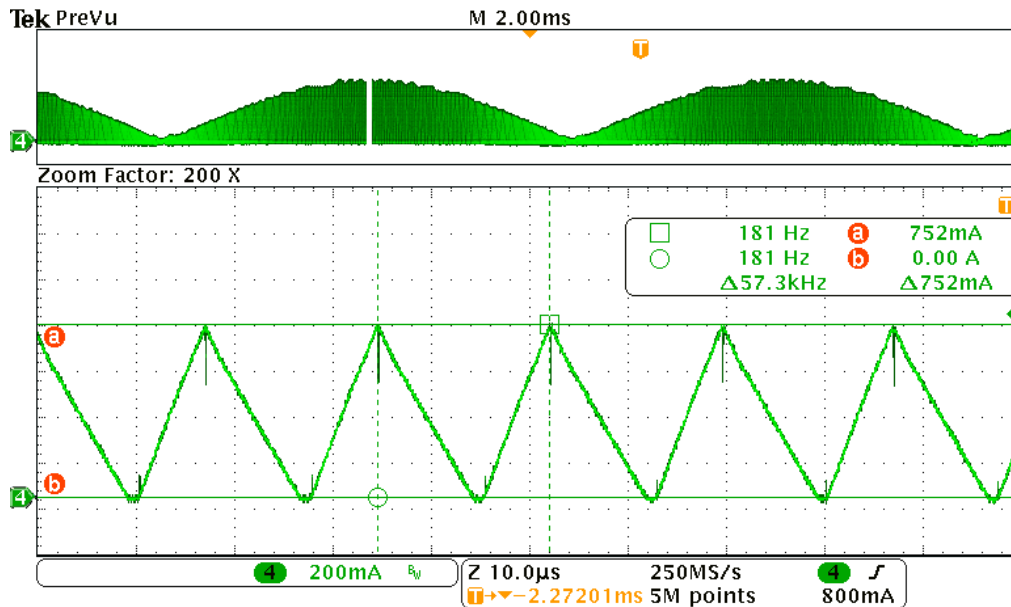
13. Output short circuit test



Vin 120V, output Short circuit
Pin = 0.4 W

14. Transformer Flux Density

($N_p=75T_s$, $L_m=1mH$, $A_e=34mm$ EE13W)



I_p is monitored at 90Vac and 110mA load

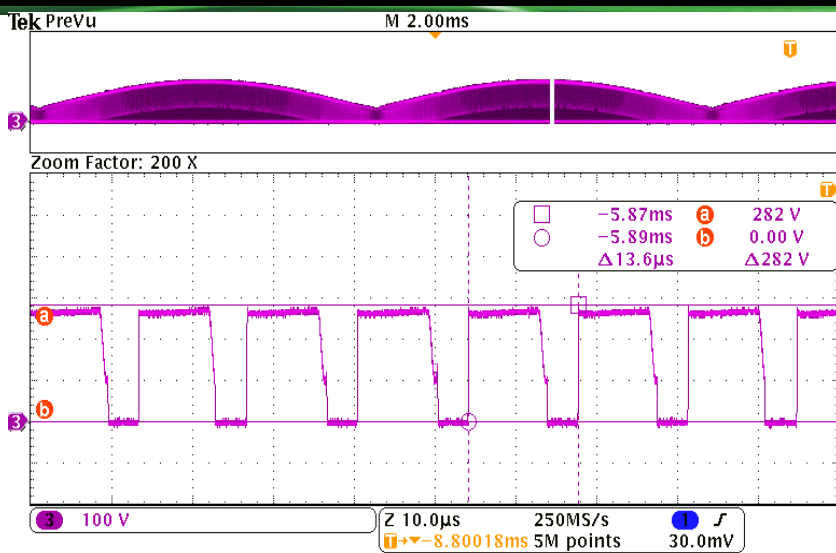
$I_p = 752mA$

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

$$= (752 * 1) / (75 * 34)$$

$$= 0.2949 \text{ Tesla}$$

15. V_{CE} Waveform



Test Condition:

V_{IN}=135V_{AC}, I_{OUT_CV}=110mA

Result:

V_{CE_MAX}=282V

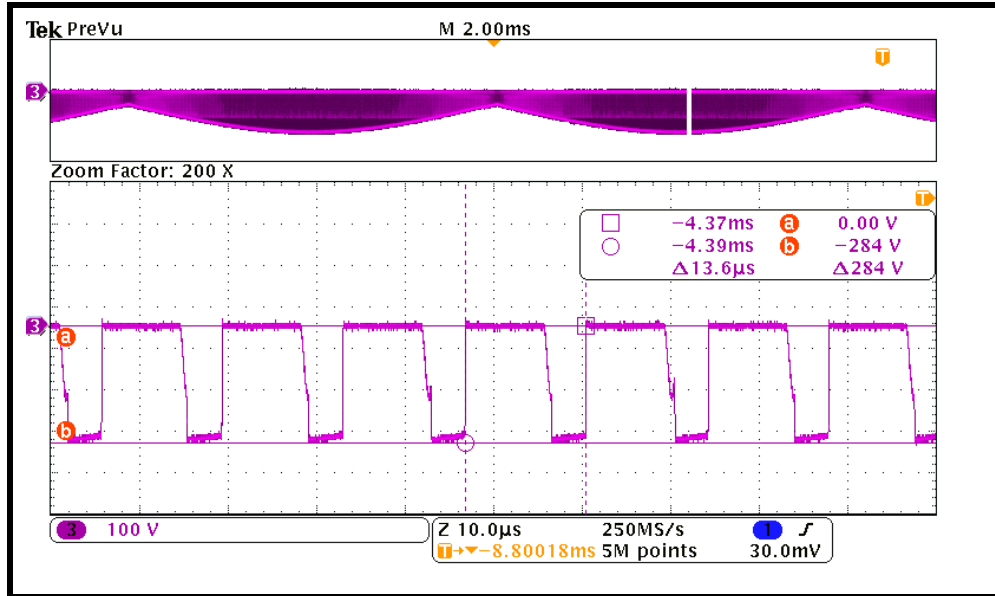
Appendix – Simple Specification for used Transistor(E13005)

NPN Silicon Transistor

Absolute Maximum Ratings T_C=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V _{CB0}	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:

$V_{IN}=135VAC$, $I_{out}=110mA$

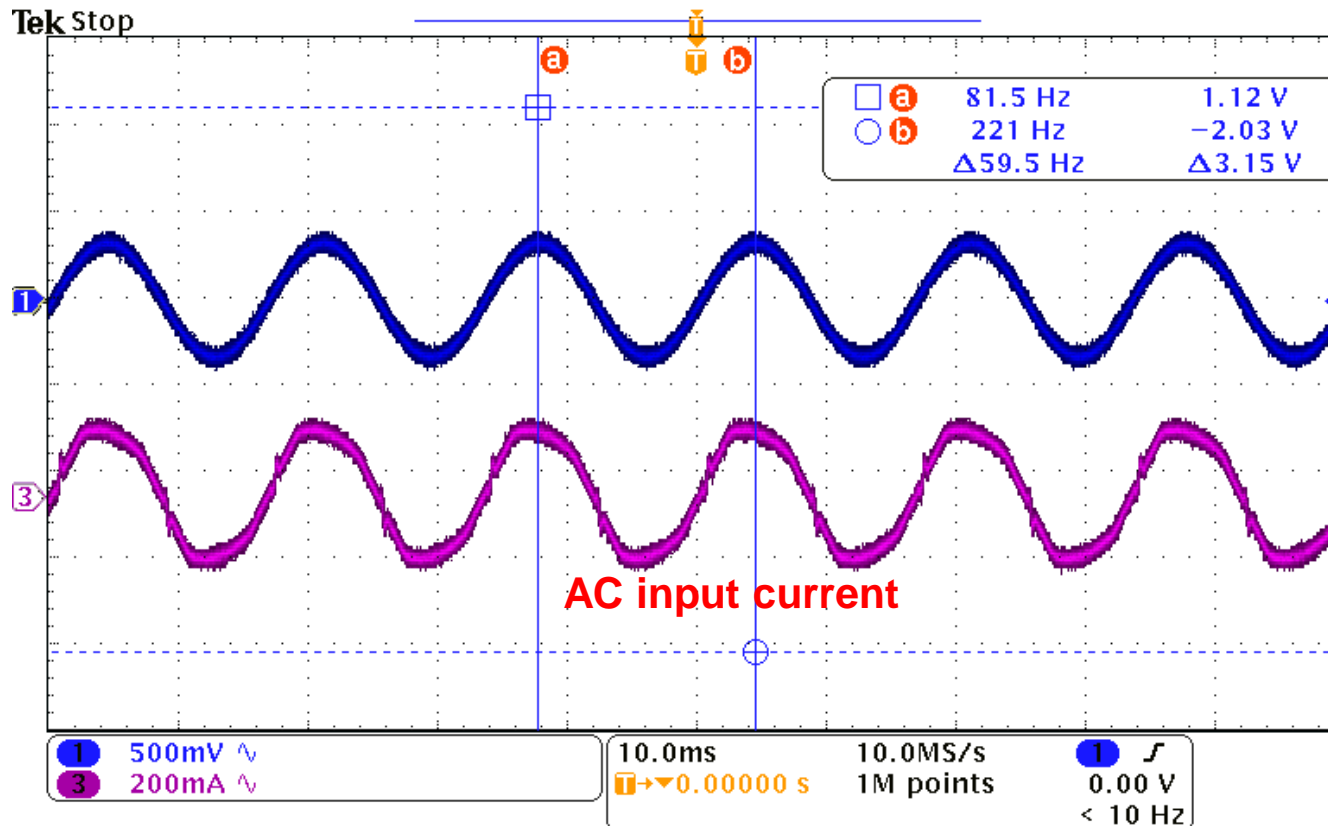
Result:

$V_R (pk-pk)=284V$

Output rectifier diode: UGC20GH (2A/400V)

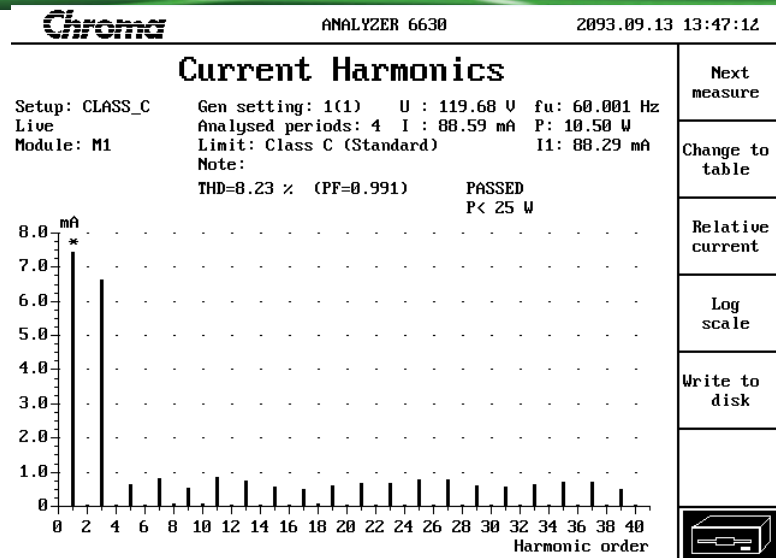
ITEM	Symbol	Conditions	UGC20				Unit
			DH	GH	JH	KH	
Repetitive peak reverse voltage	VRRM		200	400	600	800	V
Average forward current	IF(AV)		2.0				A
Peak forward surge current	IFSM	8.3ms single half sine-wave	50				A
Reverse recovery time	Trr	IF = 0.5A, IR = 1.0A, Irr = 0.25A	35				nS
Operating junction and storage temperature Range	Tj, TSTG		-65 to +175				°C

17. AC input waveform



Vin 120Vac, Output: 80V、110mA
PF:0.99

18. Harmonic and THD_IEC61000-3-2

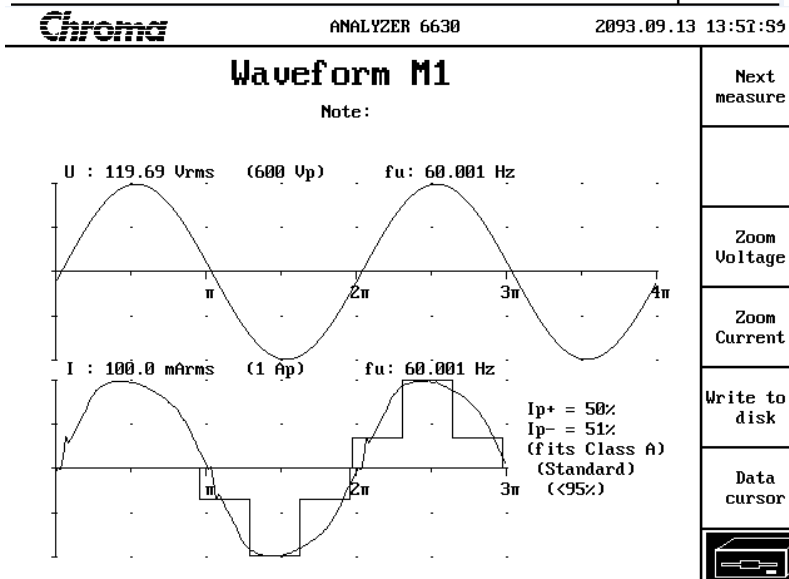


Harmonics current @120Vac

Meet IEC61000-3-2 requirement

Ac current waveform @120Vac

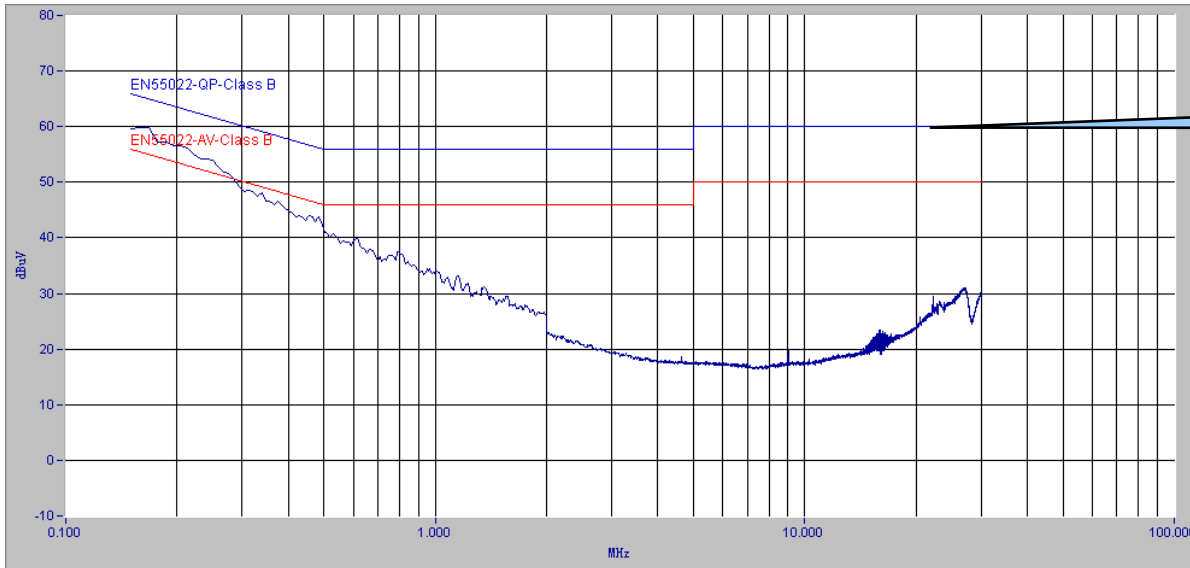
PF=0.991



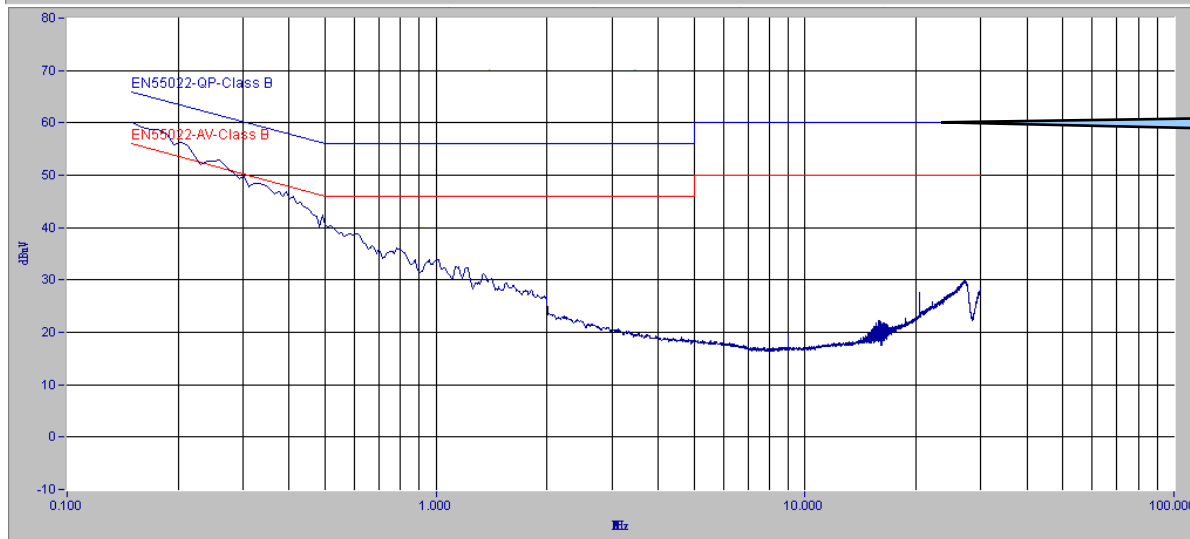
Output: 80V110mA

THD: 8.23%

19. Conducted EMI (Full Load)

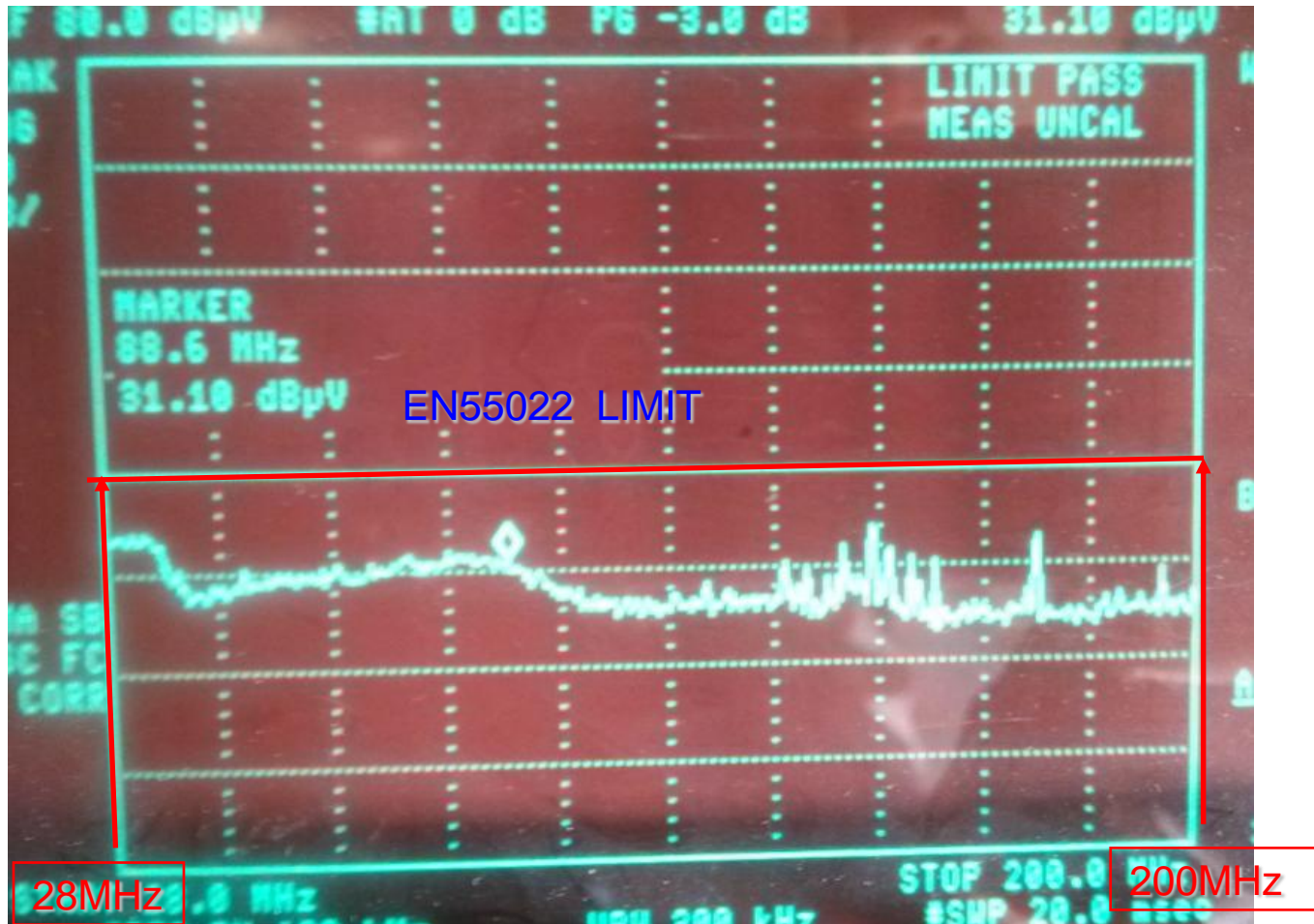


Input=120VAC
L line PK scan



Input=120VAC
N line PK scan

20. Radiated IEM (for reference) 120Vac



Note: 1, $V_{in}=120V_{ac}$

2, Output is floating, with LED load

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)

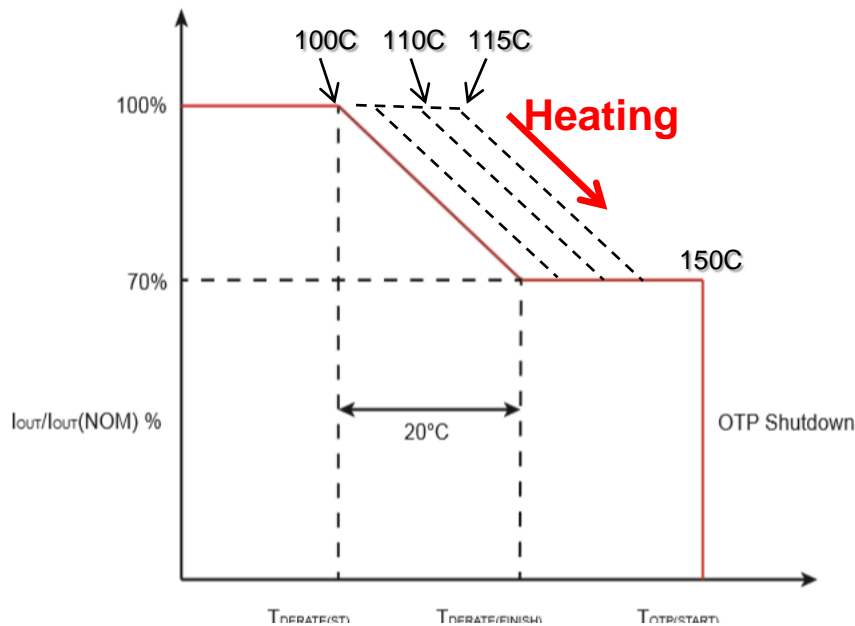


Figure 9.6 : Temperature DeRating and OTP

V_{SENSE} CFG Option Number	V_{SENSE} Pin Resistors (R8//R9 in Fig. 11.1)		Temperature Derating Starting Point $T_{derate_st}(^\circ\text{C})$ (Fig. 9.6)
	Typical Value(k Ω)	Tolerance	
0	0.72	$\leq 5\%$	100
1	1.38	$\leq 5\%$	105
2	2.30	$\leq 5\%$	110
3	3.60	$\leq 5\%$	115

Table 9.1 V_{SENSE} Pin Configuration Resistor Values