

EBC940 Dimmable LED Driver With iW3616-00

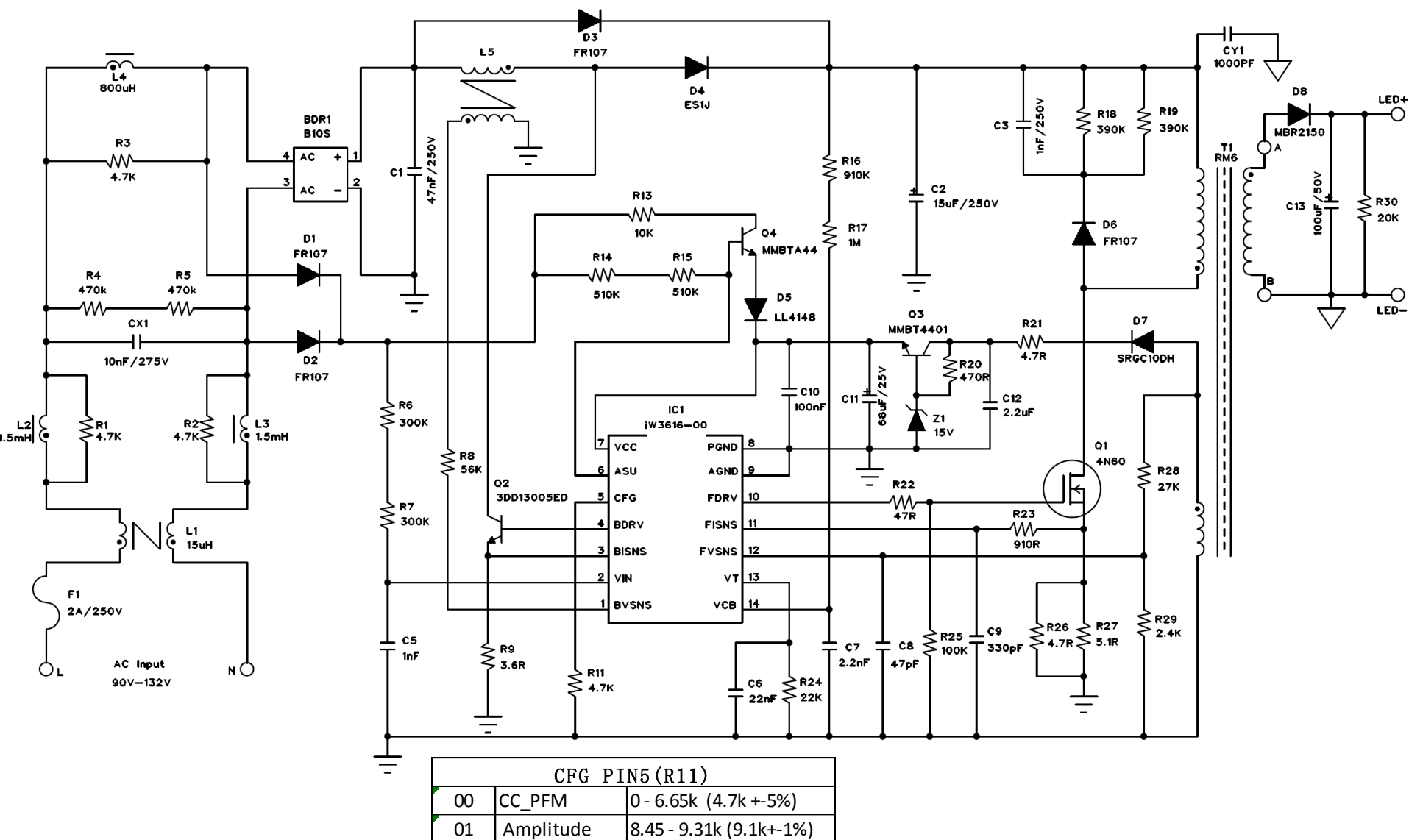
General Design Specification:

1. AC Input Range 90-132Vac, Isolated ac-dc offline, 9LEDS, Output 350mA
2. Intelligent wall dimmer detections(Leading-edge dimmer , Trailing-edge dimmer , No-dimmer)
3. Multiple dimming control scheme
4. Wide dimming range from 1% up to 100%
5. No visible flicker
6. Resonant control to achieve high efficiency
7. High Power Factor, 0.9 without dimmer
8. Temperature degrade control to adjust the LED
9. Primary-only Sensing eliminates opto-isolator feedback and simplifies design

1. Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	V_{IN}	90		132	V _{AC}	2 Wire
Frequency	f_{LINE}	47	50/60	63	Hz	
Output						
Output Voltage	V_{OUT}		30		V	Measured at the end of PCB
Output Current	I_{OUT}		0.35		A	
Output Ripple Current	I_{RIPPLE}		30		mA _{P-P}	Set oscilloscope at 20MHz bandwidth.
Total Output Power						
Continuous Output Power	P_{OUT}		10.5		W	
Performance Factor	PF		0.98			$V_{IN} = 115VAC$
Active Mode Efficiency (EPA2.0 Requirement)	η		82		%	Measured at end of PCB, $V_{IN} = 115VAC$ ($T_{AMB} = 25^{\circ}C$).
Environmental						
THD	THD			15	%	$V_{IN} = 115VAC$
Conducted EMI		Meets CISPR22B / EN55022B				
Safety		Designed to meet IEC950, UL1950 Class II				
Ambient Temperature	T_{AMB}	0		40	° C	Free convection, sea level

2. Schematic



3. Circuit Board Photograph

AC
Input

DC
output
To LED

Primary

Secondary

24mm

60mm

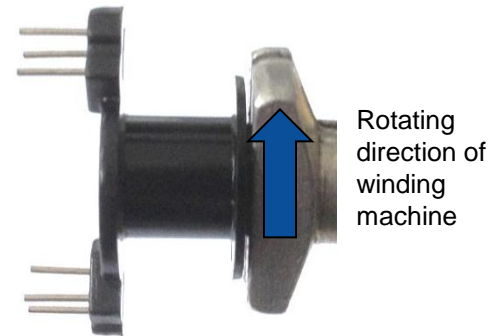
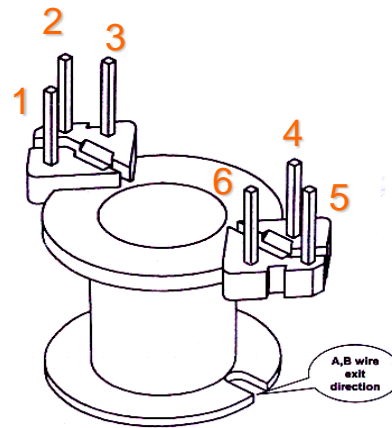
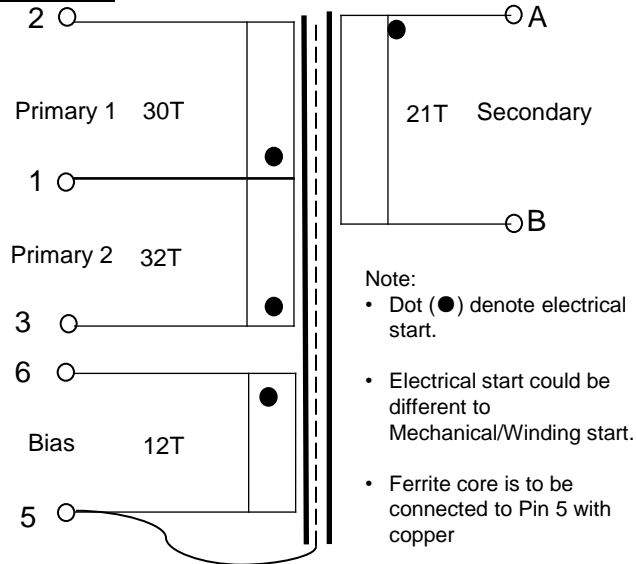
iW3616-00

4.BOM

Item	Reference	Description	Qty	Item	Reference	Description	Qty
1	IC1	iW3616-00, Digital PWM Controller,Dimmable, SO-14	1	29	R16	910K Ω , $\pm 1\%$, SMD-1206	1
2	CX1	10nF,275V, X2,P=7.5mm	1	30	R17	1M Ω $\pm 1\%$, SMD-1206	1
3	C1	47nF,250V,CBB21,P=7.5mm	1	31	R23	910 Ω $\pm 1\%$, SMD-0603	1
4	C2	15uF,250V, E-CAP	1	32	R29	2.4K Ω $\pm 1\%$, SMD-0603	1
5	C11	68uF,25V, E-CAP	1	33	R28	27K Ω $\pm 1\%$, SMD-0603	1
6	C13	100uF,50V,E-CAP	1	34	R26	4.7 Ω $\pm 1\%$, SMD-0805	1
7	C7	2.2nF, 25V, X7R, SMD-0603	1	35	R27	5.1 Ω $\pm 1\%$, SMD-0805	1
8	C5	1nF, 25V, X7R, SMD-0603	1	36	R13	MOF,10K Ω ,1W	1
9	C8	47pF, 25V, X7R, SMD-0603	1	37	F1	FUSE,T2A250V	1
10	C9	330pF,25V, X7R, SMD-0603	1	38	BDR1	B10S,0.5A,1000V,MDI	1
11	C6	22nF,25V, X7R, SMD-0603	1	39	D7	SRGC10DH,1A,200V, 1206-S	1
12	C10	100nF,25V, X7R, SMD-0603	1	40	D1,D2,D3,D6	SRGC10MH(FR107),1A,1000V, 1206-S	4
13	C3	1nF,250V,SMD-0805	1	41	D4	ES1J,1A,600V,SMA	1
14	C12	2.2uF,25V, X7R, SMD-1206	1	42	D8	MBR2150,2A,150V,DO-15	1
15	R11	4.7K Ω $\pm 5\%$, SMD-0603	1	43	D5	LL4148,0.15A,100V,LL-34	1
16	R21	4.7 Ω $\pm 5\%$, SMD-0603	1	44	Z1	Zener,MM3Z15,15V SOD-323	1
17	R22	47 Ω $\pm 5\%$, SMD-0603	1	45	Q1	4N60,4A,600V,TO-251	1
18	R20	470 Ω $\pm 5\%$, SMD-0603	1	46	Q4	MMBTA44, NPN,0.3A,500V, SOT-23	1
19	R25	100K Ω $\pm 5\%$, SMD-0603	1	47	Q3	MMBT4401,NPN,SOT-23	1
20	R24	22K Ω $\pm 5\%$, SMD-0603	1	48	Q2	3DD13005ED,NPN,4A 700V,T0-126S	1
21	R8	56K Ω $\pm 5\%$, SMD-0805	1	49	L2,L3	Drum choke, I-shaped,8X10mm, 1.5mH	2
22	R1,R2,R3	4.7K Ω $\pm 5\%$, SMD-0805	3	50	L4	Drum choke, I-shaped,8X10mm, 800uH	1
23	R30	20K Ω $\pm 5\%$, SMD-1206	1	51	L1	Common Mode Inductor T8*3*3 15uH	1
24	R14,R15	510K Ω $\pm 5\%$, SMD-1206	2	52	L5	EE10, L=2.2mH	1
25	R18,R19	390K Ω $\pm 5\%$, SMD-1206	2	53	CY1	Y2,1000pF,250V	1
26	R9	3.6 Ω , $\pm 5\%$, SMD-1206	1	54	T1	Transformer RM6 L=1.2mH	1
27	R4,R5	470K Ω $\pm 5\%$, SMD-1206	2	55	PCB	Tw o-layout,24mm*60mm	1
28	R6,R7	300K Ω , $\pm 1\%$, SMD-1206	2	56			

5. Transformer Design

SCHEMATIC



ELECTRICAL SPECIFICATIONS:

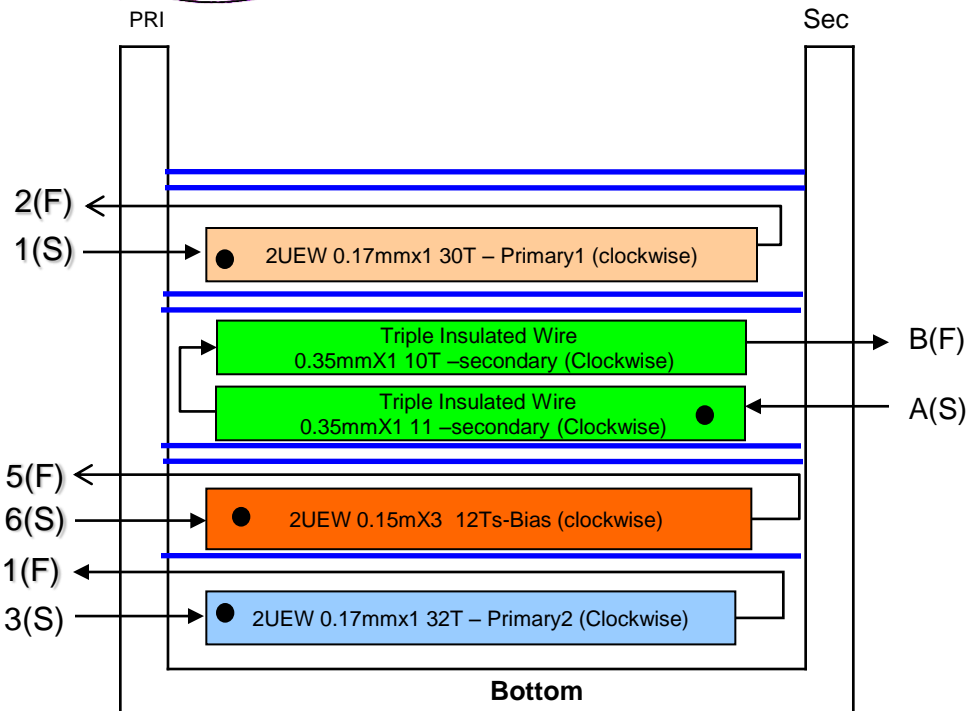
1. Primary Inductance (L_p) = 1.2mH @10KHz
2. Primary Leakage Inductance (L_k) <= 20uH @60KHz
3. Electrical Strength = 3KV, 50/60Hz, 1Min

MATERIALS:

1. Core : RM6 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : RM6 Vertical 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.

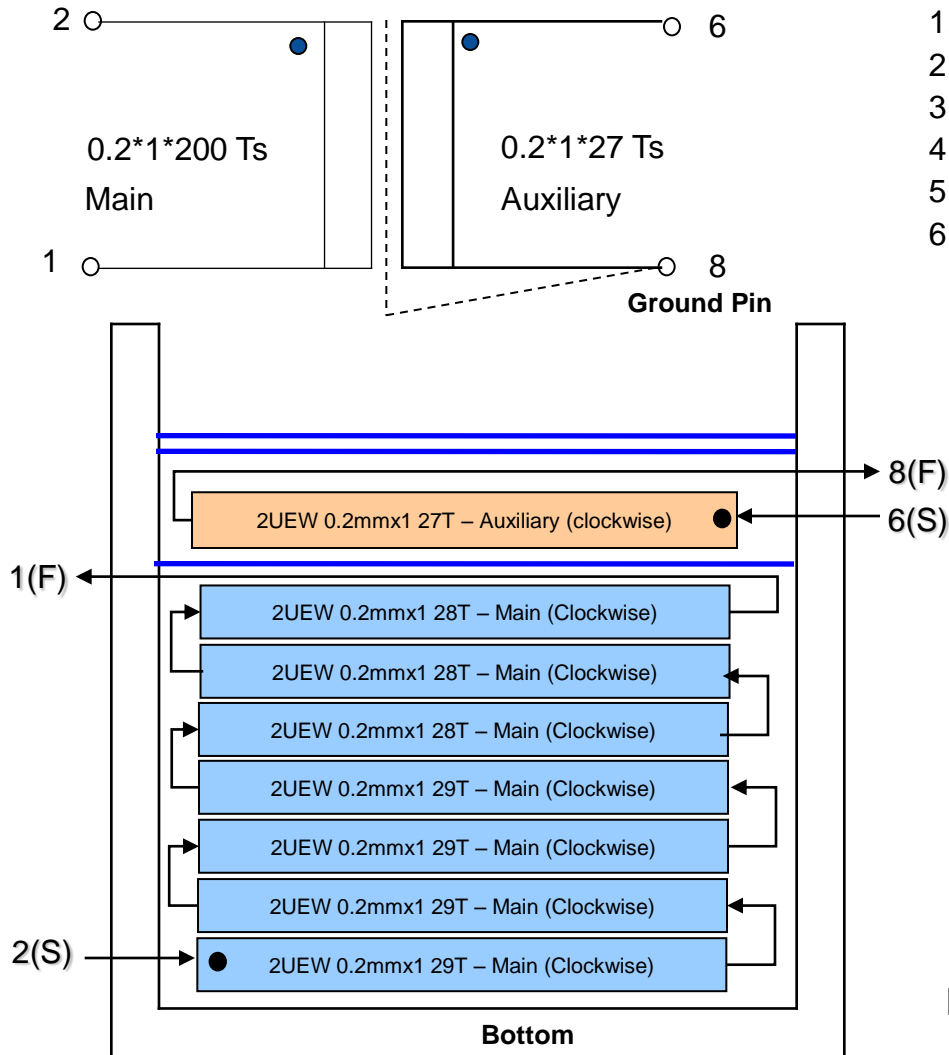
FINISHED :

1. Cut remained of Pin1,4 after wires termination
2. Core is connected to PRI-GND Pin5.
3. Varnish the complete assembly



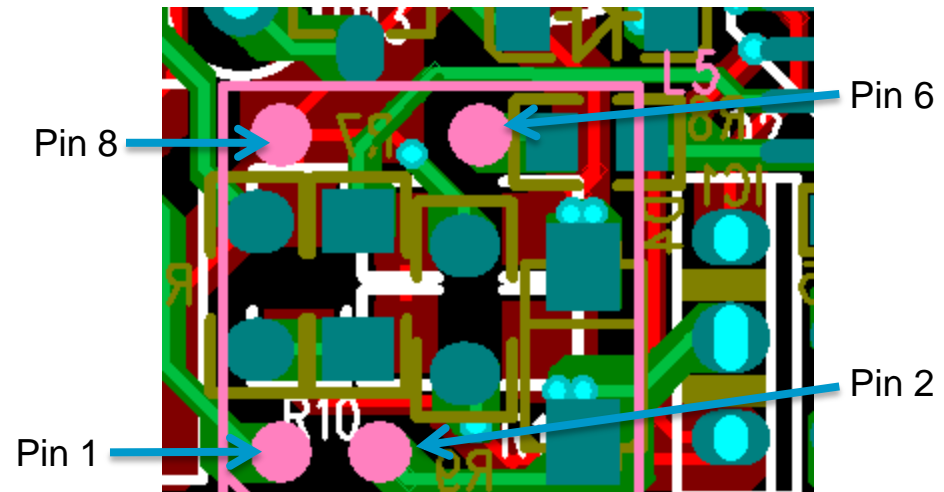
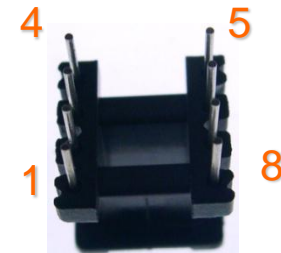
6. PFC Boost Inductor

SCHEMATIC



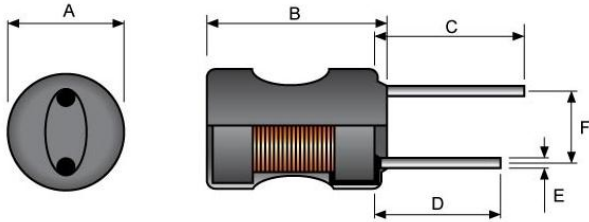
ELECTRICAL SPECIFICATIONS:

1. Inductance (L_{p2-1}) = 2.2mH @10KHz
2. Core : EE10 (Ferrite Material TDK PC40 or equivalent)
3. Bobbin : EE10 Vertical
4. Ferrite core is connected to Pin 8 after assembling
5. Cut Pin 3,4,5,7 after wires termination
6. Varnish the complete assembly



7. EMI choke

Inductor L2 L3



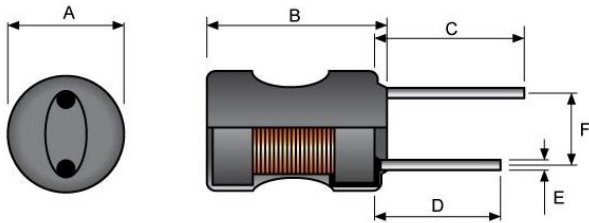
Ferrite core size : AxB 8x10mm

Wire gauge: 0.2mm, 215Turns

Inductance @10kHz, 1V: 1.5mH +/-20%

ICR: 2.3 OHM +/-20%

Inductor L4



Ferrite core size : AxB 8x10mm

Wire gauge: 0.25mm, 157Turns

Inductance @10kHz, 1V: 800uH +/-20%

ICR: 1.1 OHM +/-20%

Common Mode Inductor L1



Core size:T8*3*3

Wire gauge: 0.35mm*2(Insulation& 2-UEW wire)

Turns:8T

Inductance @10kHz, 1V: 15uH +/-20%

ICR: 0.3 OHM +/-20%

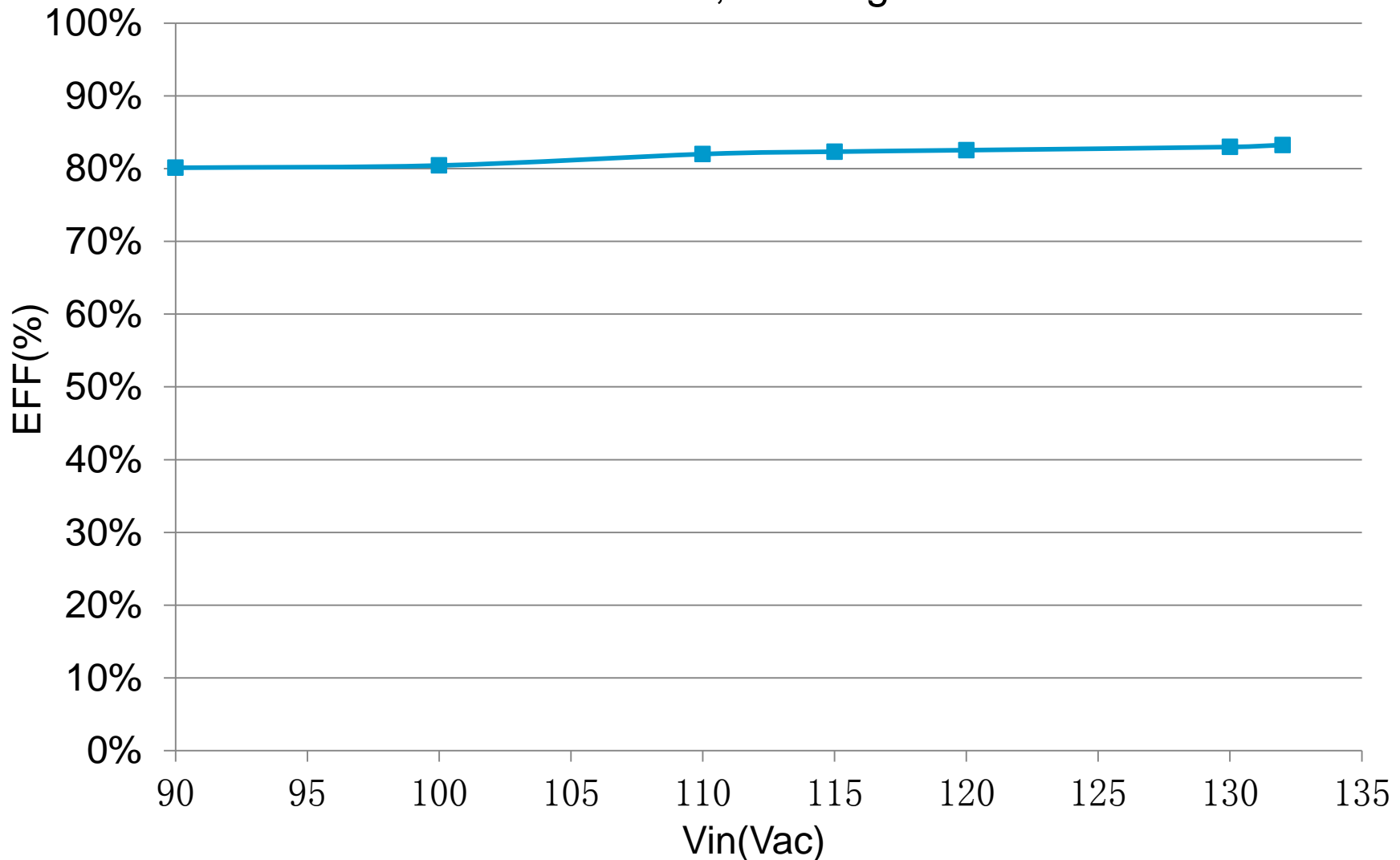
8. Regulation, Ripple and Efficiency Measurement

$V_{IN}=90V_{ac} \sim 132V_{ac}/60Hz$; Loading with 9LEDS 350mA

Vin	Pin	Vout	Iout	Ripple(PK)	efficiency	PF	Vbulk
(V)	(W)	(V)	(mA)	(mA)			(V)
90	13.31	30.38	351	25.2	80.12%	0.987	142
100	13.25	30.36	351	24.4	80.43%	0.991	170
110	13.04	30.36	352	24.0	82.00%	0.996	187
115	13.01	30.35	353	22.8	82.33%	0.997	191
120	12.98	30.34	353	22.8	82.54%	0.998	198
130	12.93	30.34	354	22.8	82.97%	0.998	203
132	12.90	30.33	354	22.8	83.25%	0.998	208

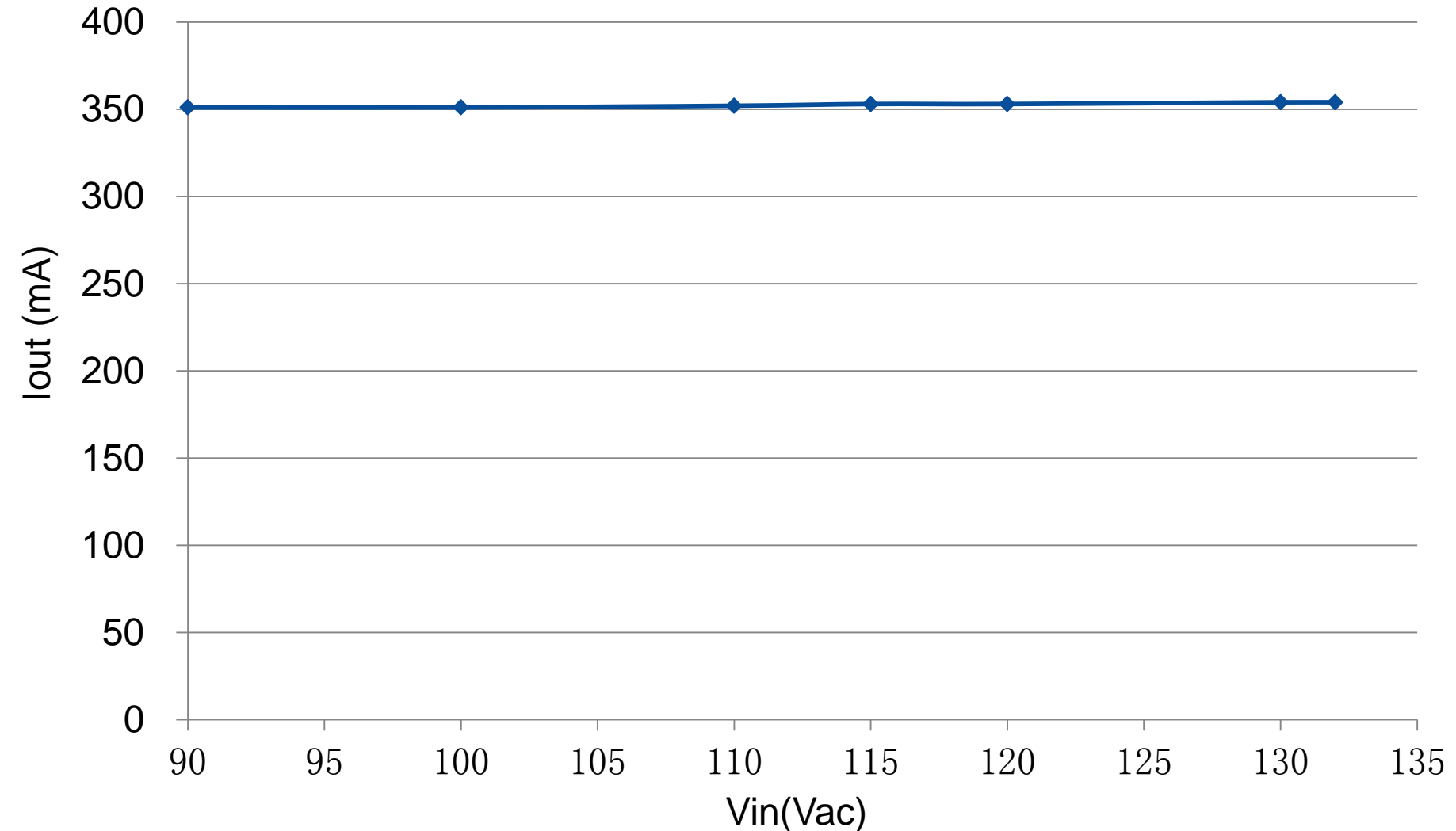
9. Variable Input Vs. Efficiency Measurement

$V_{IN}=90V_{ac} \sim 132V_{ac}/60Hz$; Loading with 9LEDS 350mA



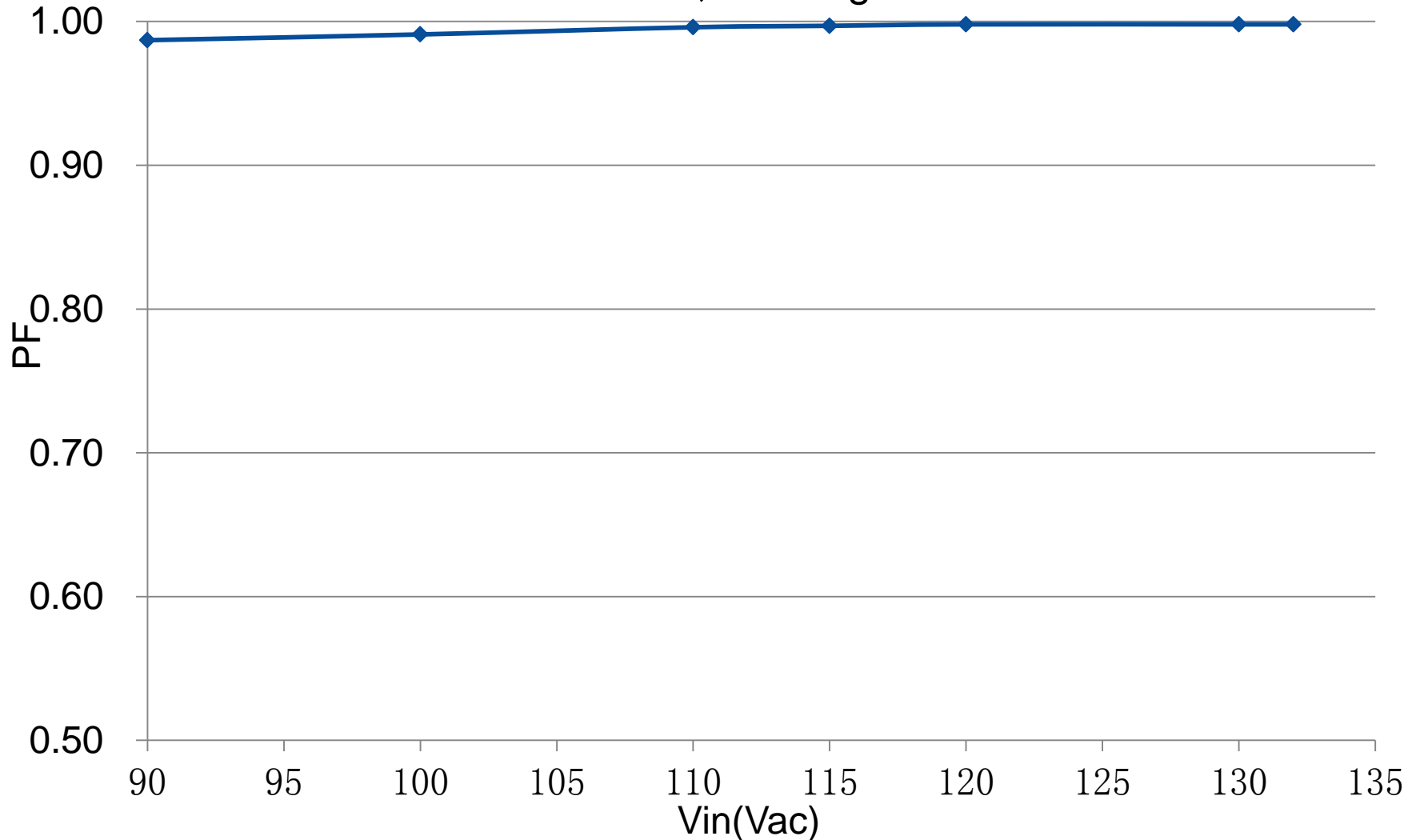
10. Variable Input Vs. Iout Measurement

$V_{IN}=90V_{ac} \sim 132V_{ac}/60Hz$; Loading with 9LEDS 350mA



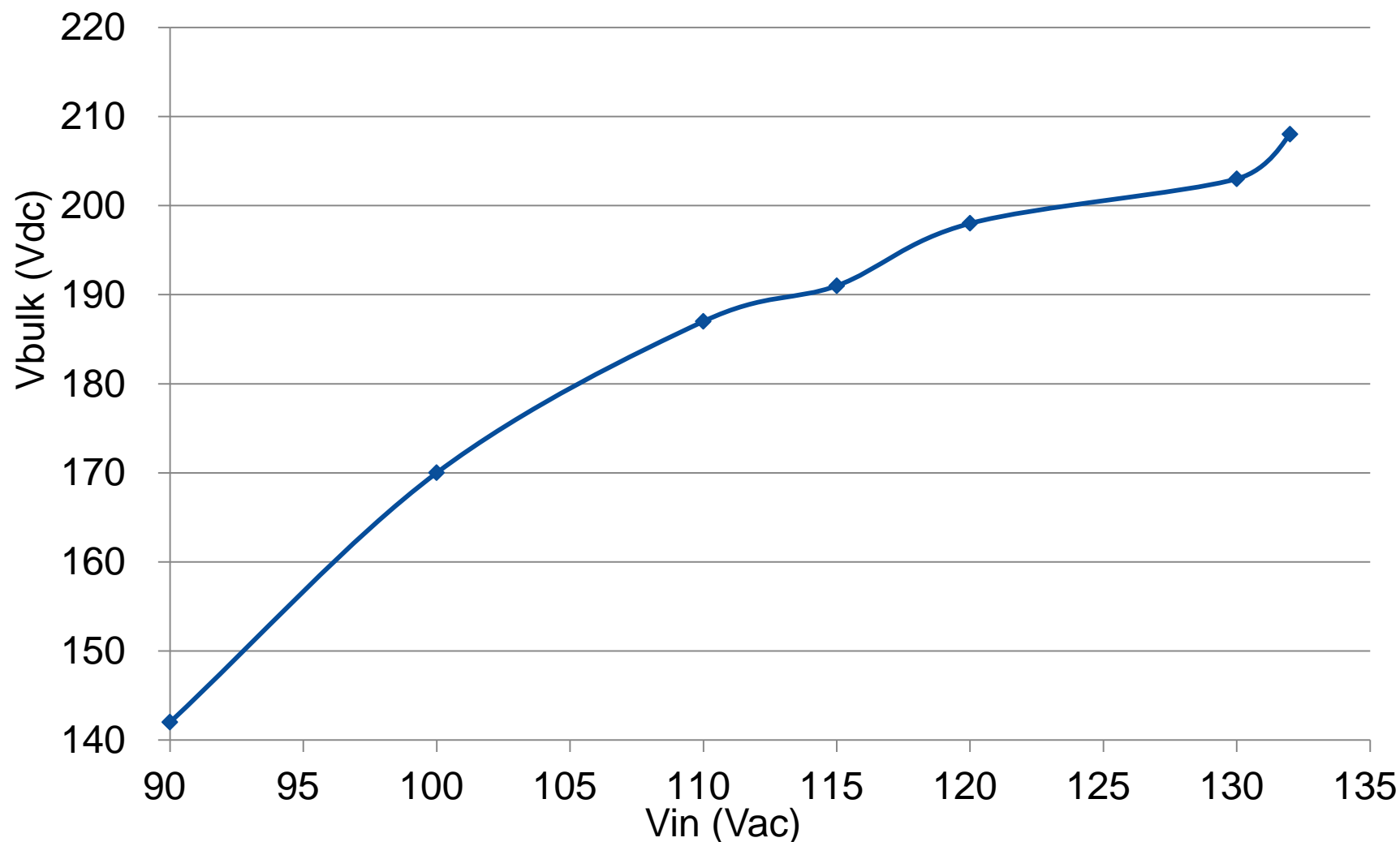
11. Variable Input Vs. PF Measurement

$V_{IN}=90V_{ac} \sim 132V_{ac}/60Hz$; Loading with 9LEDS 350mA



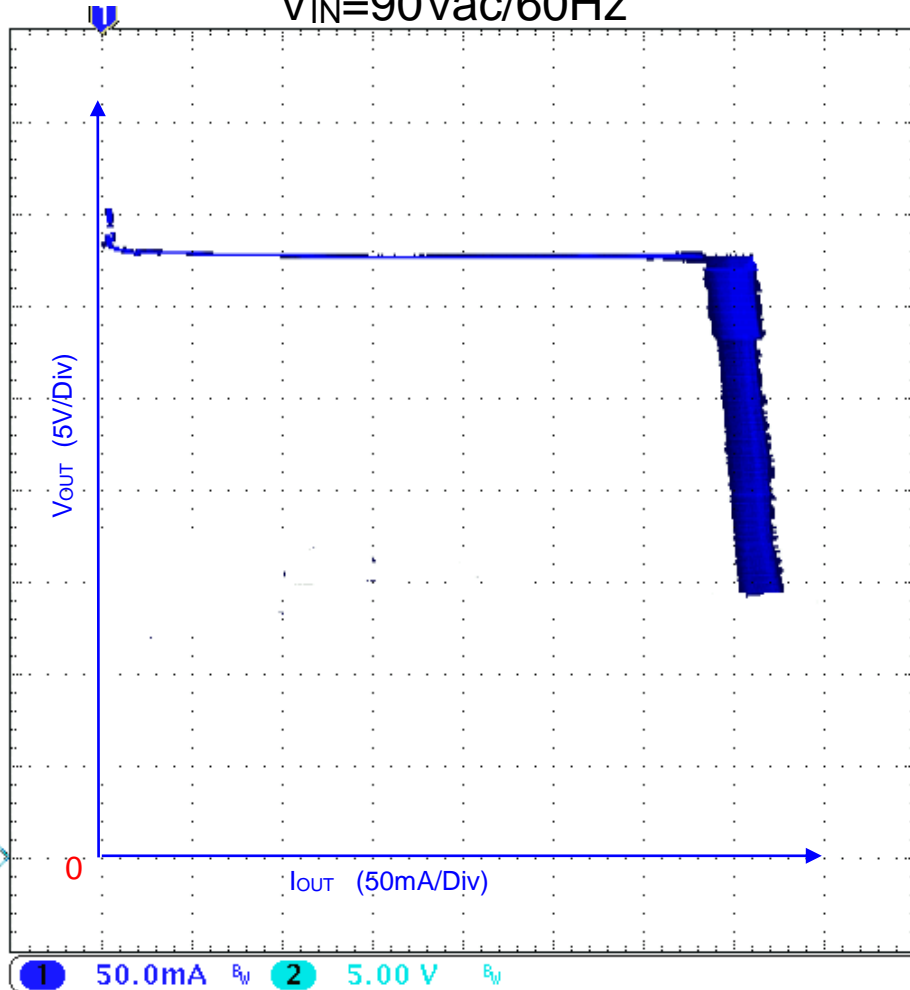
12. Variable Input Vs. Vbulk Measurement

$V_{IN}=90V_{ac} \sim 132V_{ac}/60Hz$; Loading with 9LEDS 350mA

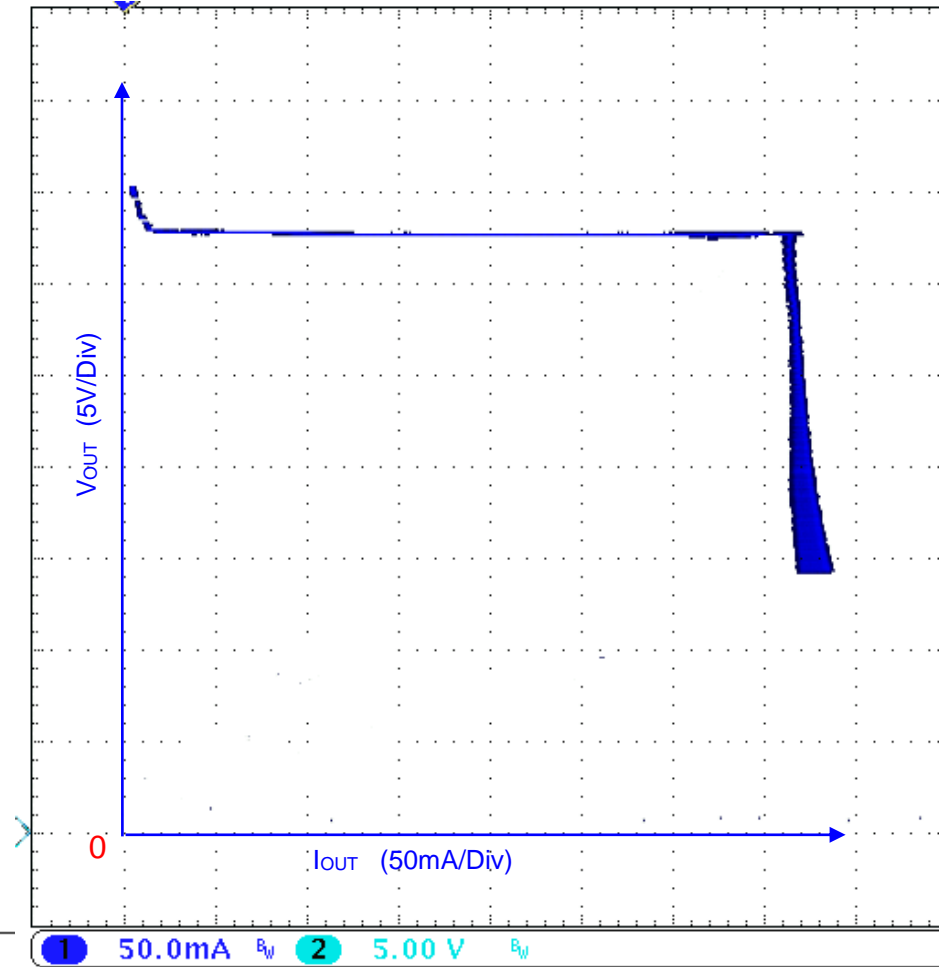


13. Output VI Characteristics(CV Mode)

$V_{IN}=90V_{ac}/60Hz$



$V_{IN}=132V_{ac}/60Hz$



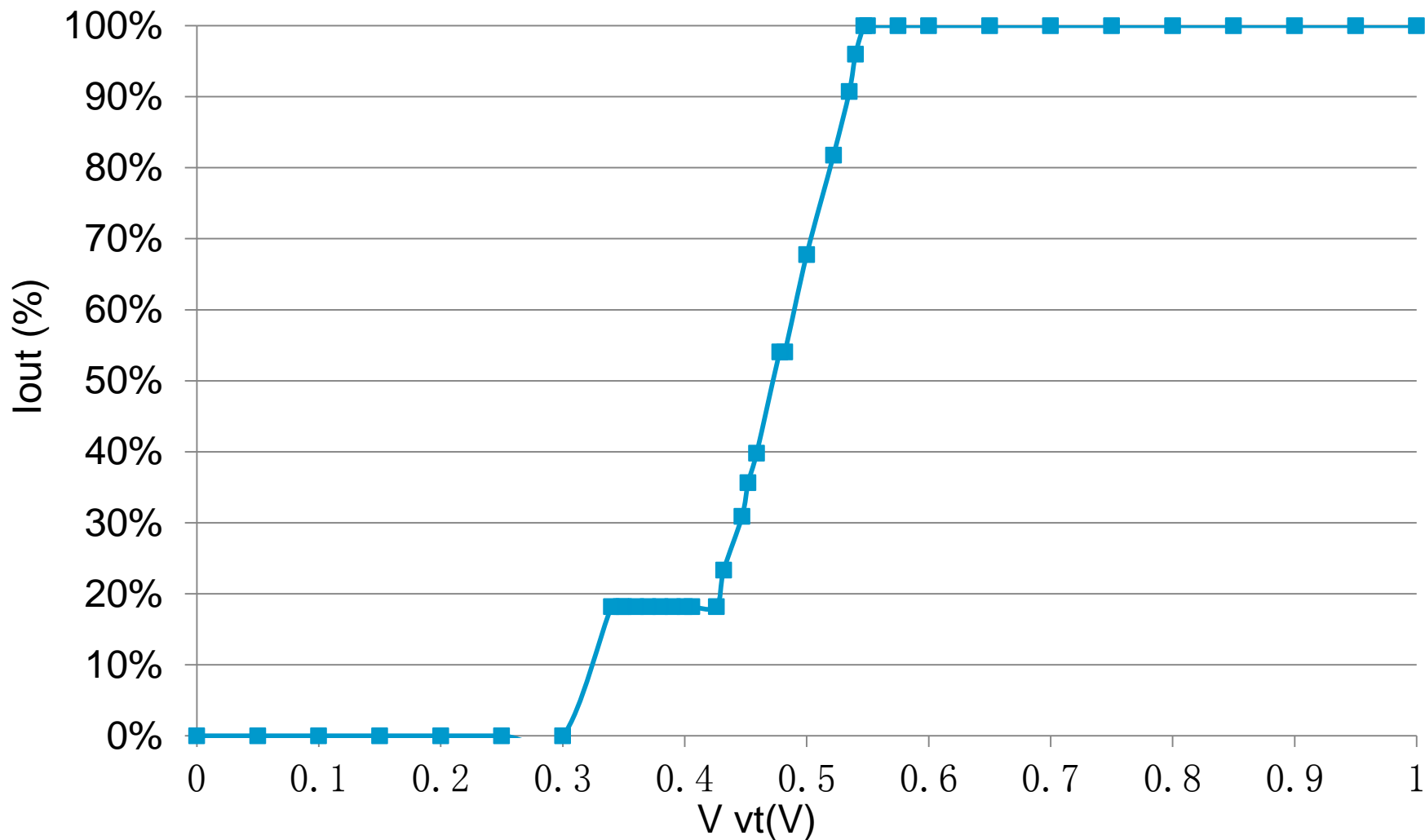
*** Note: Output voltage is monitored at end of PCB**

14. Dimming range with dimmer

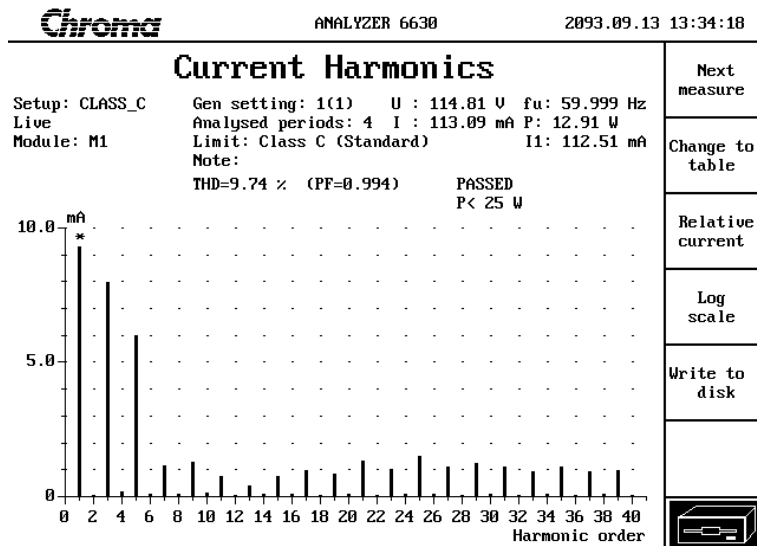
Leading edge dimmer test _OH391I_9 LEDs								
Vin	DIM Level	Pin	LED Voltage	LED current	Pout	Eff	Angle percentage	VCC
(V)		(W)	(V)	(mA)	(W)	(%)	(%)	(V)
90	Max.	13.98	30.58	366.5	11.21	80.2%	75.3	14.69
		6.39	28.87	174.5	5.04	78.8%	58.6	14.54
	Min.	0.45	24.80	1.38	0.03	7.6%	19.7	8.47
115	Max.	13.42	30.52	365.2	11.15	83.1%	89.8	14.71
		6.53	28.85	174.7	5.04	77.2%	54.3	14.57
	Min.	0.48	24.79	1.37	0.03	7.1%	19.2	8.45
132	Max.	13.16	30.49	365.7	11.15	84.7%	91.2	14.75
		6.55	28.83	174.6	5.03	76.9%	53.8	14.59
	Min.	0.51	24.77	1.37	0.03	6.7%	19.7	8.44
Leading edge dimmer test _TG-600P_9 LEDs								
Vin	DIM Level	Pin	LED Voltage	LED current	Pout	Eff	Angle percentage	VCC
(V)		(W)	(V)	(mA)	(W)	(%)	(%)	(V)
90	Max.	12.03	30.15	322.1	9.71	80.7%	65.3	14.72
		6.31	28.72	165.5	4.75	75.3%	51.4	14.58
	Min.	0.66	24.81	1.5	0.04	5.6%	16.8	8.47
115	Max.	13.70	30.49	369.3	11.26	82.2%	71.5	14.77
		6.79	28.81	177.5	5.11	75.3%	56.7	14.63
	Min.	0.83	24.77	1.47	0.04	4.4%	15.8	8.41
132	Max.	13.52	30.43	369.7	11.25	83.2%	75.9	14.82
		6.90	28.77	176.9	5.09	73.8%	57.1	14.64
	Min.	1.01	24.81	1.62	0.04	4.0%	19.7	8.50

15. VT Pin voltage and output presence

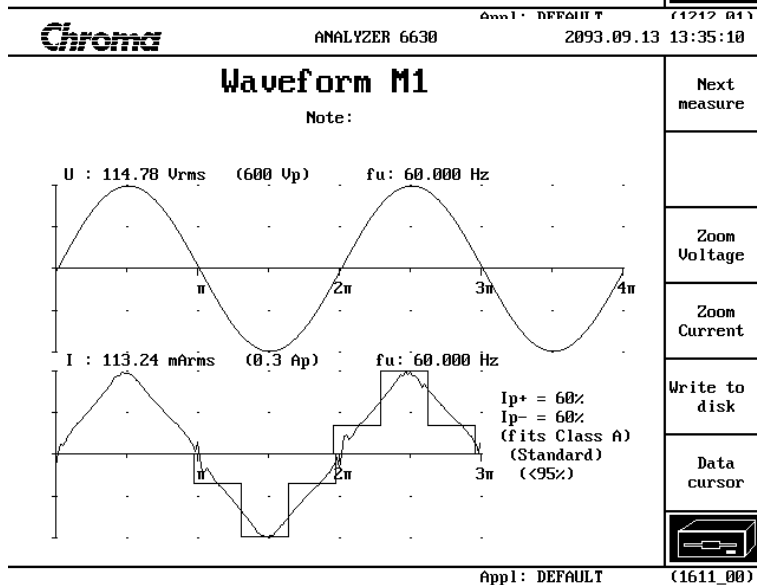
$V_{IN}=120V_{ac}/60Hz$; Possible for OTP with NTC



16. Harmonic and current waveform

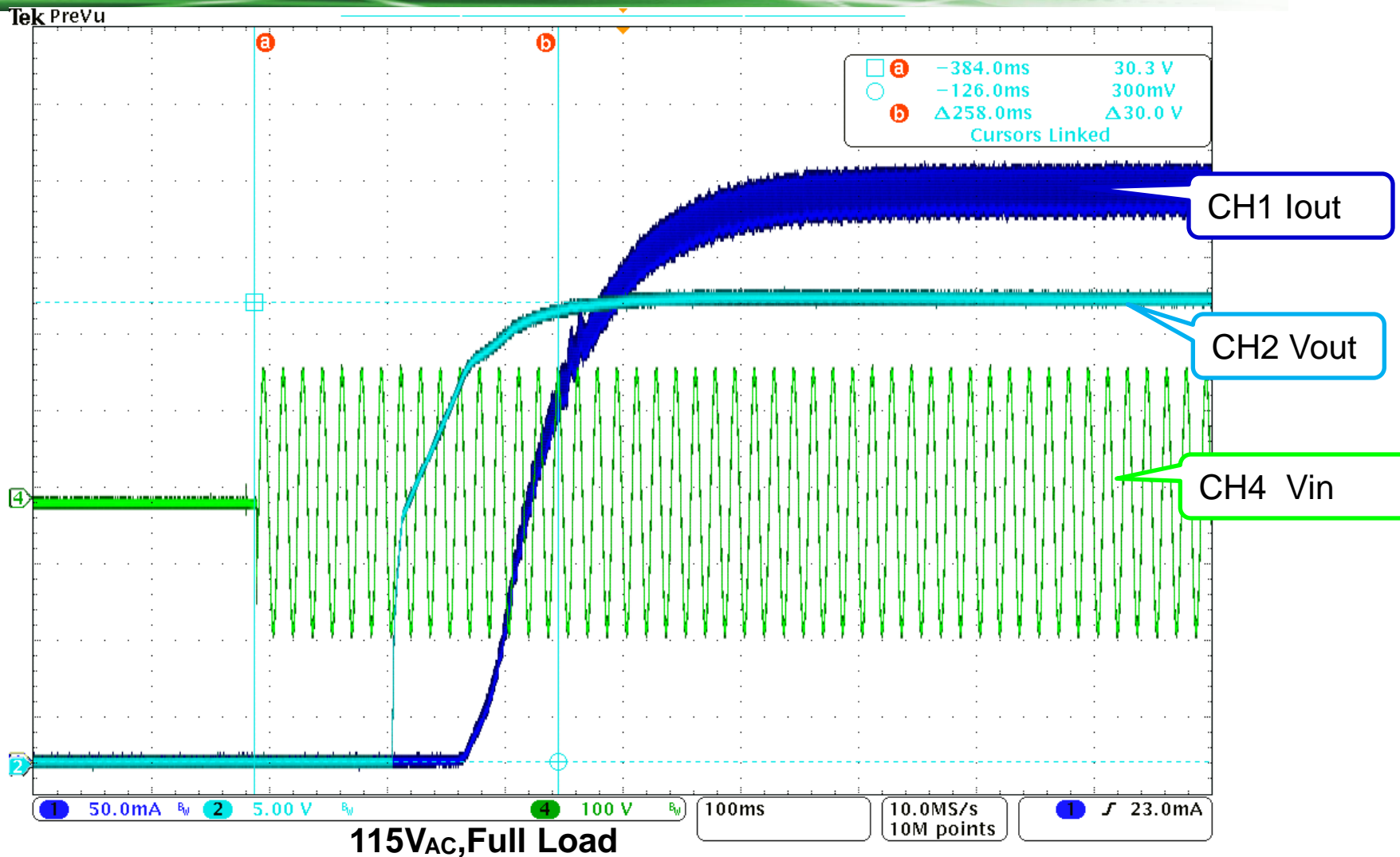


Harmonics current @115Vac THD=9.74%



AC current waveform @115Vac PF=0.994

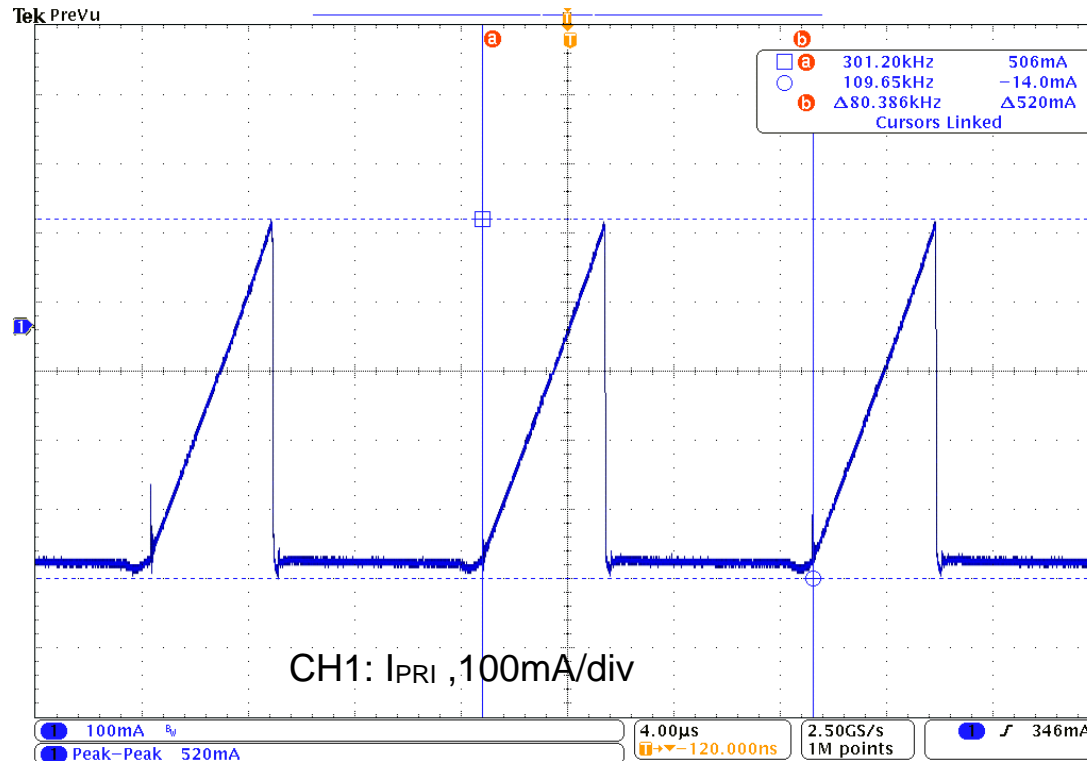
17. Turn-on Delay Time



$T_{ST_DELAY} = 258\text{ms}$

18. Transformer Flux Density

($N_p=62T_s$, $L_m=1.2mH$, $A_e=36.6mm^2$ -RM6)



I_{PRI} is monitored at 90Vac and 0.351A load

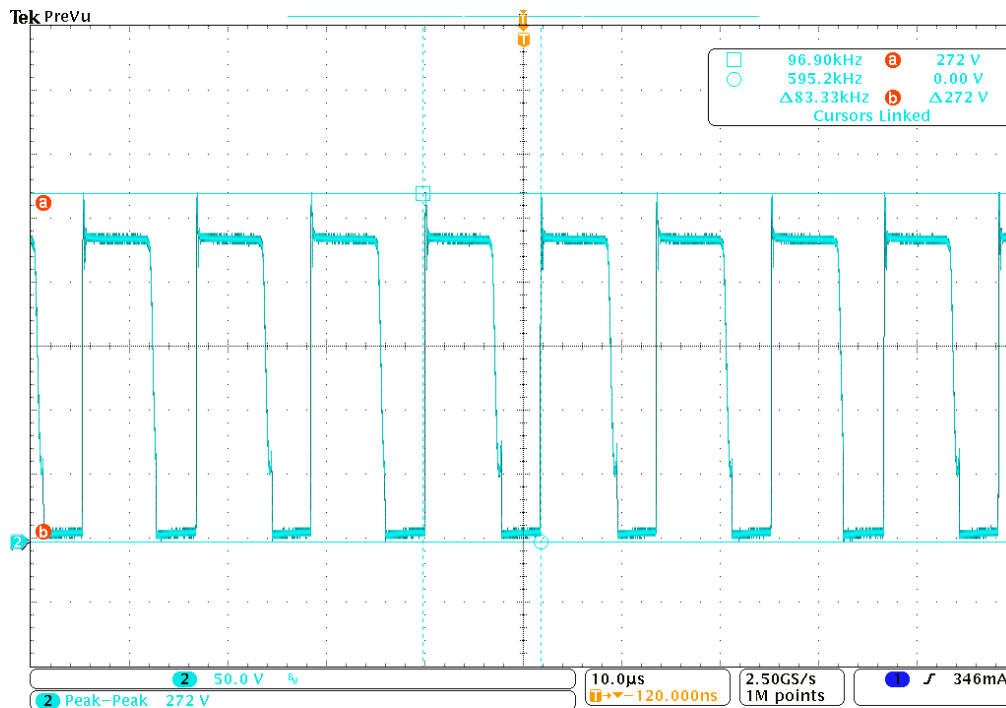
$$I_{PRI}=520mA$$

$$B_{MAX} = I_{PRI} * L_{PRI} / (N_p * A_e)$$

$$=(520*1.2)/(62*36.6)$$

$$=0.275Tesla$$

19. Q1 MOSFET V_{DS} Waveform



Test Condition:

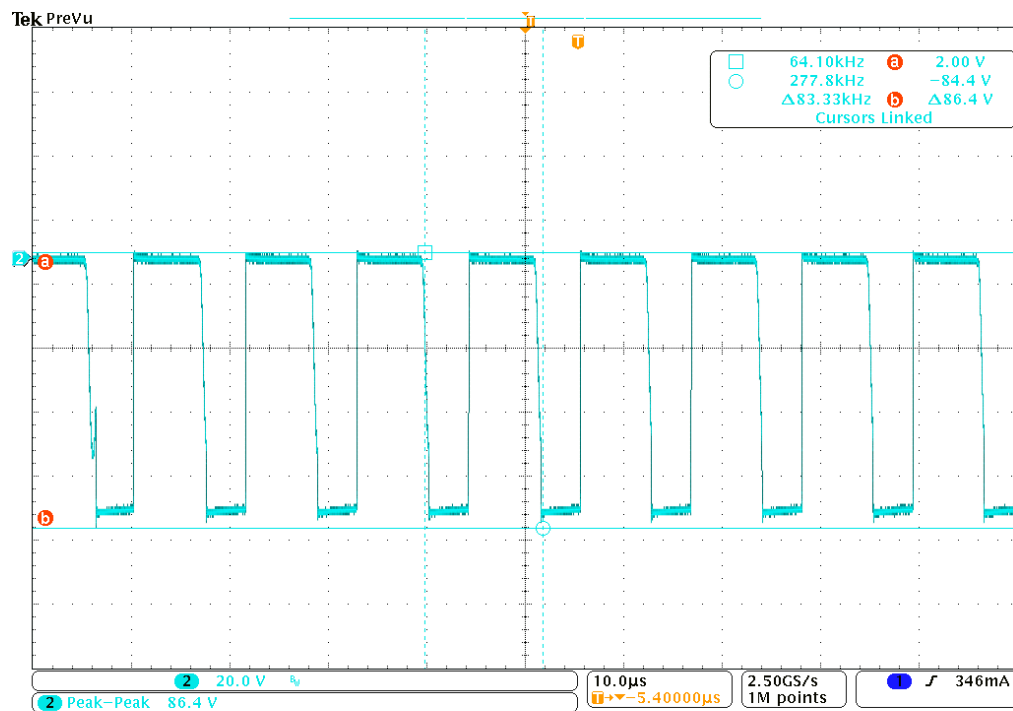
$V_{IN}=132V_{ac}$, $V_{OUT}=30V$

Result:

$V_{DS_MAX}=272V$

Remark: Mosfet Spec__4A 600V

20. Output Diode Waveform



Test Condition:

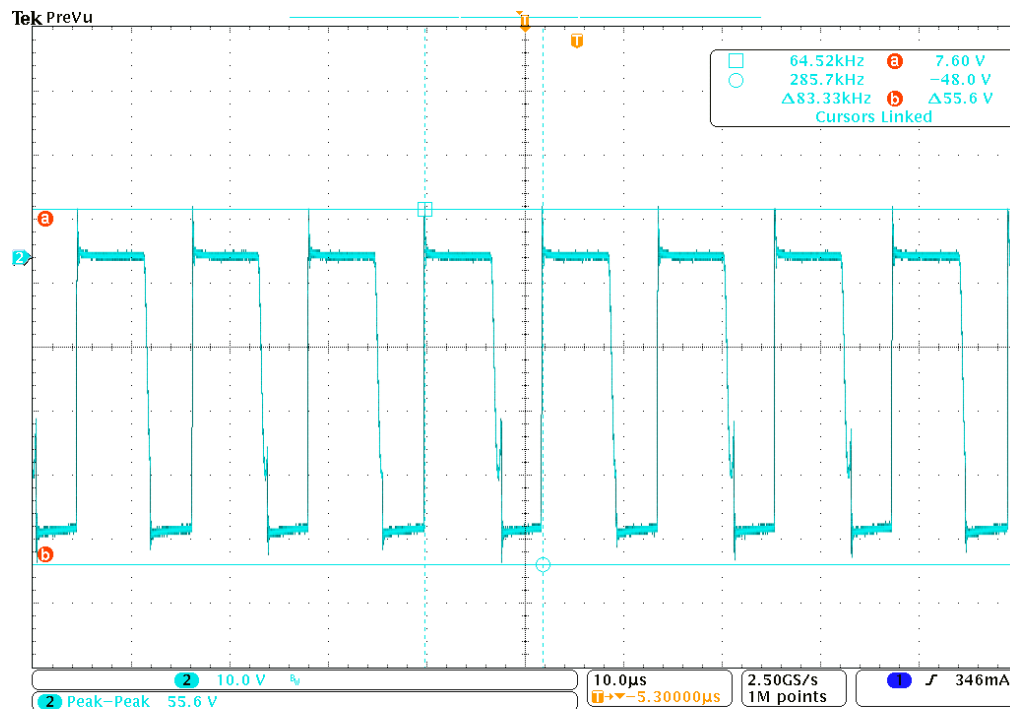
$V_{IN}=132V_{ac}$, $V_{OUT}=30V$

Result:

$V_{RRM_MAX}=86.4V$

Remark: Diode Spec__2A 150V

21. Vcc Diode waveform



Test Condition:

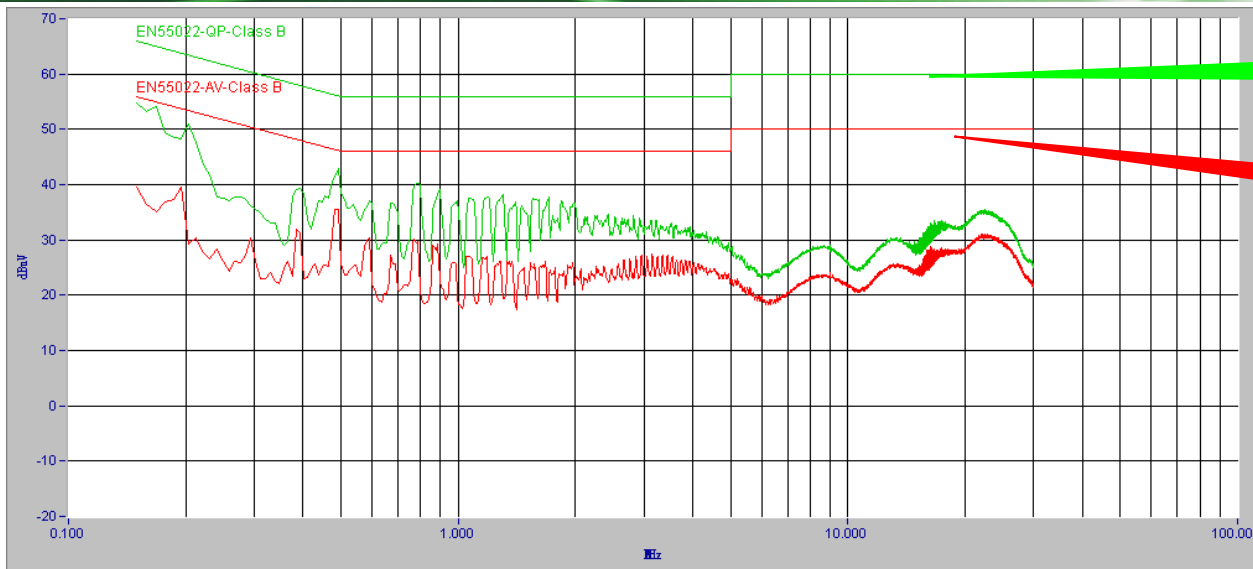
$V_{IN}=132V_{ac}$, $V_{OUT}=30V$

Result:

$V_{RRM_MAX}=55.6V$

Remark: Diode Spec__1A 200V

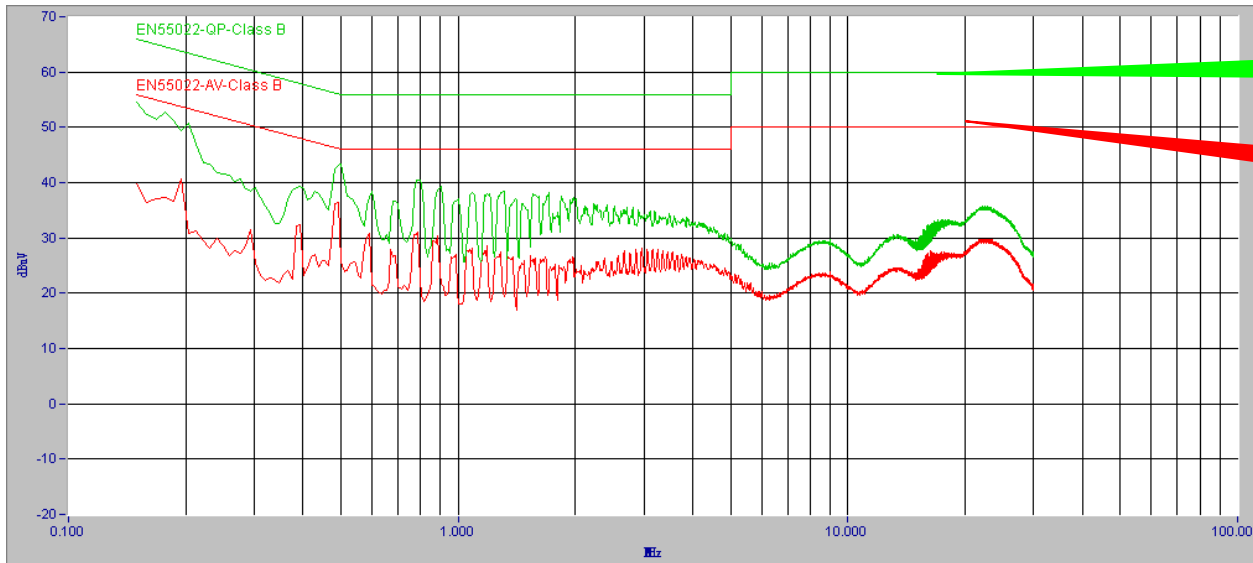
22. Conducted EMI (Full Load)



QP Scan
QP Limit line

AV Scan
AV Limit line

Input=115VAC
L line QP&AV scan

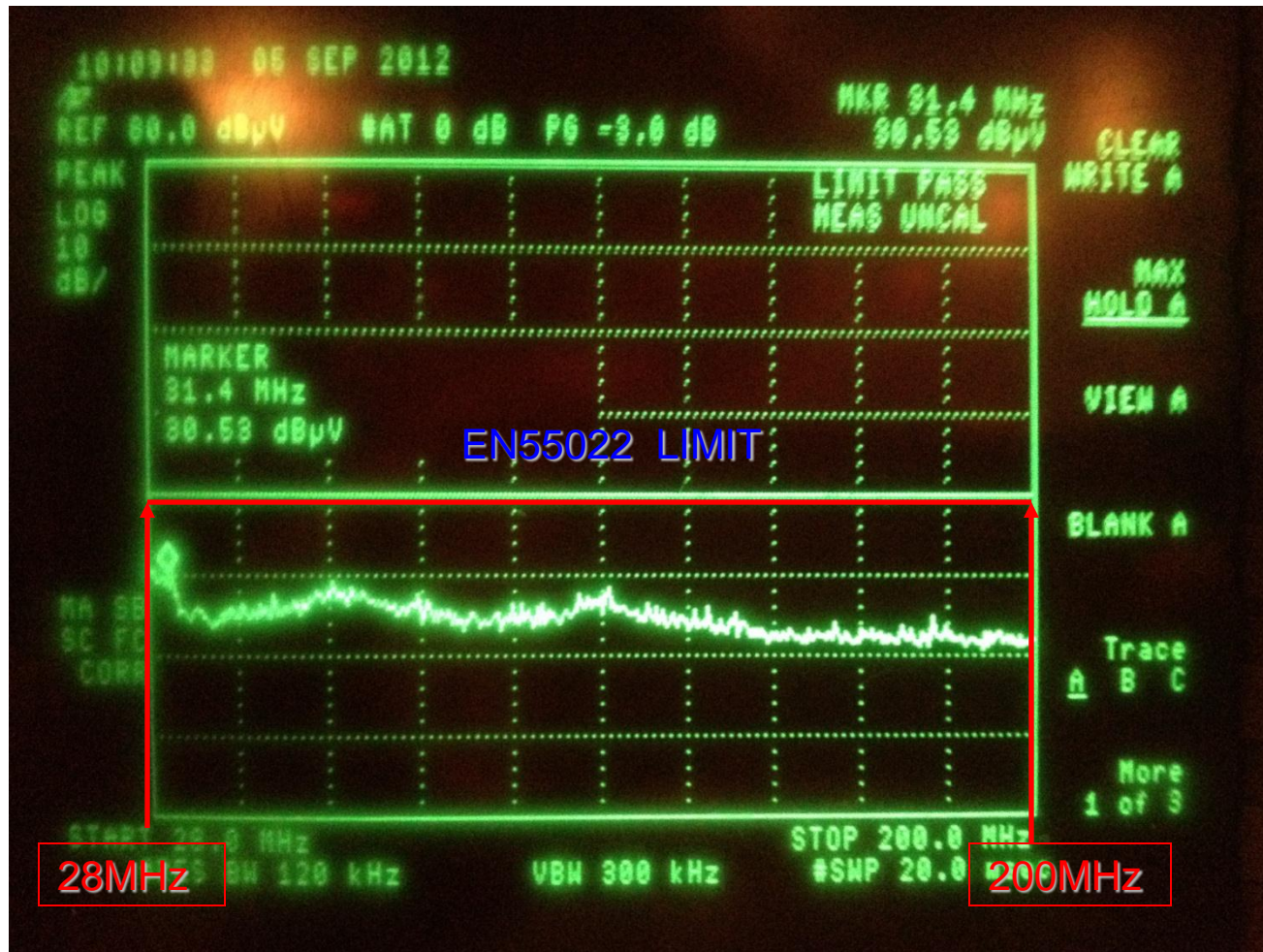


QP Scan
QP Limit line

AV Scan
AV Limit line

Input=115VAC
N line QP&AV scan

23. Radiated EMI (for reference)



Note: 1, $V_{in}=115V_{ac}$

2, Output is floating