

# Zero Ripple Current and Hi-PF LED Driver With iW3623

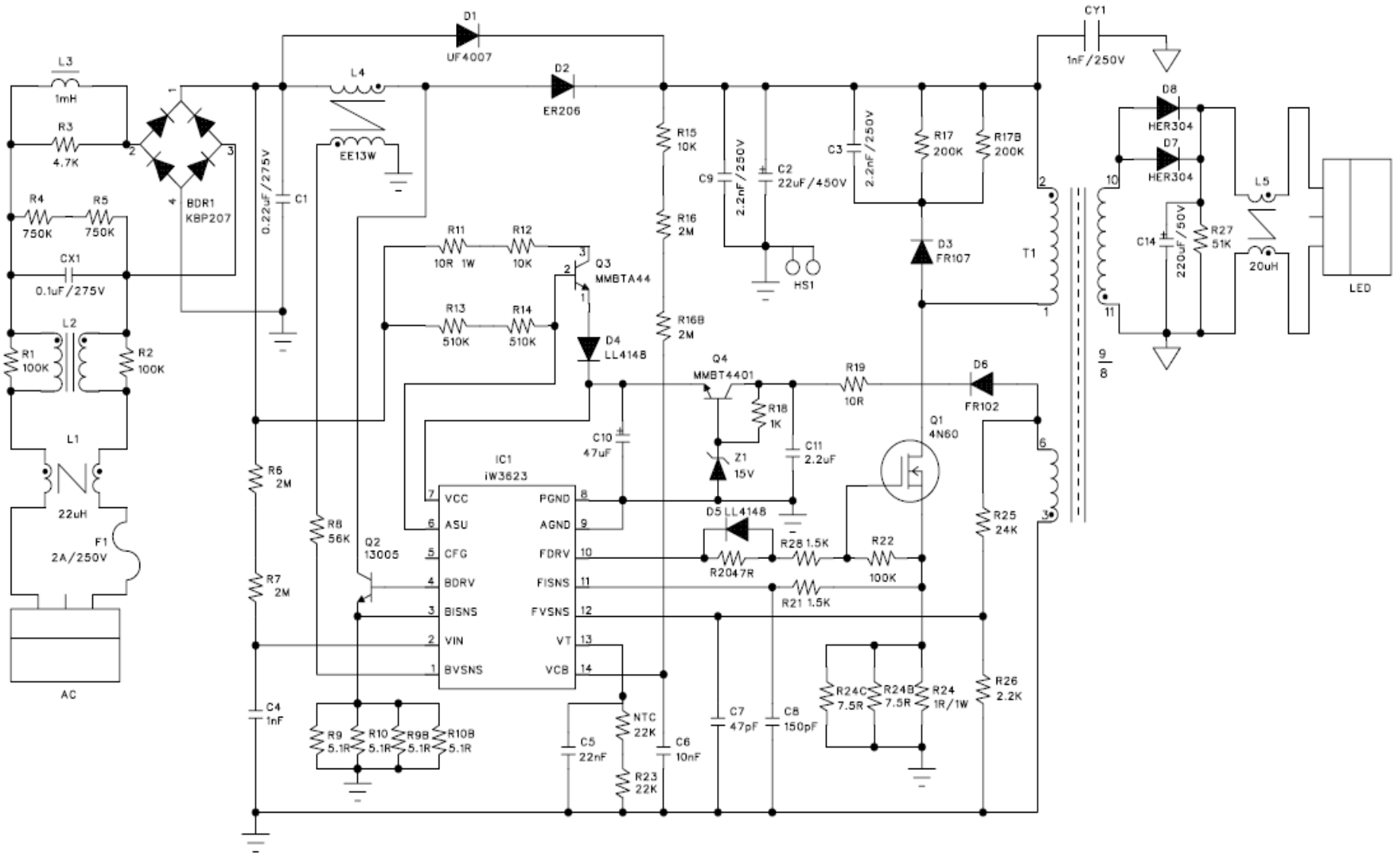
## General Design Specification:

1. AC Input Range 90-264Vac, Isolated ac-dc offline, 12LEDS, Output 700mA
2. For Isolated Applications
3. High Efficiency, High power Factor and Least Parts Solution
4. Temperature degrade control to adjust the LED.
5. Primary-only Sensing eliminates opto-isolator feedback and simplifies design

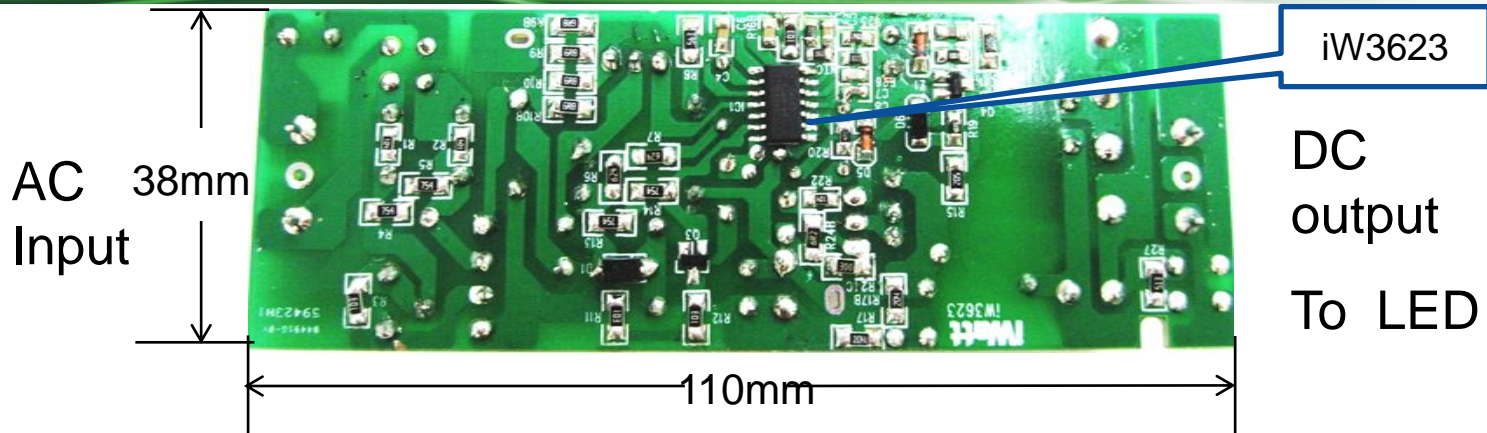
# 1. Specification

Description	Symbol	Min	Typ	Max	Units	Comment
Input						
Voltage	$V_{IN}$	90		264	V <sub>AC</sub>	2 Wire
Frequency	$f_{LINE}$	47	50/60	63	Hz	
Output						
Output Voltage	$V_{OUT}$		40		V	Measured at the end of PCB
Output Current	$I_{OUT}$		0.7		A	
Output Ripple Current	$I_{RIPPLE}$		35		mA <sub>P-P</sub>	Set oscilloscope at 20MHz bandwidth.
Total Output Power						
Continuous Output Power	$P_{OUT}$		28		W	
Performance Factor	$PF$	0.9			A	
Active Mode Efficiency	$\eta$		86		%	Measured at end of PCB, $V_{IN} = 230V_{AC}$ ( $T_{AMB} = 25^{\circ}C$ ).
Environmental						
THD	THD			15	%	
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



Primary

Secondary



# 4.BOM\_\_\_IW3623 40V700mA

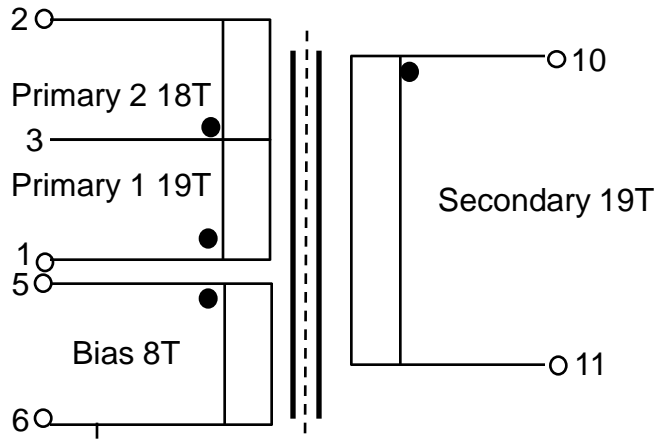
	Circuit code	Description	Manufacture
1	IC1	iW3623 SO-14	
2	CX1	100nF,275V, X2,P=10.5mm	Carli
3	C1	22nF,450V,CBB21,P=10.5mm	Carli
4	C2	33uF,450V, E-CAP	Yongming
5	C10	47uF,25V, E-CAP	Yongming
6	C14	220uF,50V,E-CAP	Yongming
7	C3	2.2NF/250VP=5mm	STE
8	C7	47pF, 25V, X7R, SMD-0805	TDK/HEC
9	C4	1nF, 25V, X7R, SMD-0805	TDK/HEC
10	C5	22nF,25v, X7R SMD-0805	TDK/HEC
11	C6	10nF,25V, X7R, SMD-0805	TDK/HEC
11	C8	150pF,25V, X7R, SMD-0805	TDK/HEC
12	C11	2.2uF,25V, X7R, SMD-0805	TDK/HEC
14	R19	10Ω ±5%, SMD-0805	YAGEO
15	R20	47Ω ±5%, SMD-0805	YAGEO
16	R18	1KΩ ±5%, SMD-0805	YAGEO
17	R22	100KΩ±1%, SMD-0805	YAGEO
18	R1, R2	100KΩ±5%, SMD-0805	YAGEO
19	R22, NTC	22KΩ ±5%, SMD-0805	YAGEO
20	R4,R5	750KΩ ±5%, SMD-1206	YAGEO
21	R3	4.7KΩ ±5%, SMD-1206	YAGEO
28	R24B	7.5Ω ±1%, SMD-1206	YAGEO
28	R24C	5.6Ω ±1%, SMD-1206	YAGEO
22	R8	56KΩ±5%, SMD-1206	YAGEO
23	R13,R14	510KΩ±5%, SMD-1206	YAGEO
24	R16 ,R16B	2MΩ±1%, SMD-1206	YAGEO
25	R6	2MΩ±1%, SMD-1206	YAGEO
26	R7	2MΩ,±1%, SMD-1206	YAGEO
27	R25	24KΩ ±1%, SMD-0805	YAGEO

# 4.BOM\_\_IW3623 40V700mA

	Circuit code	Discription	Manufacture
28	R26	2.2K $\Omega$ $\pm$ 1 %, SMD-0805	YAGEO
29	R27	30K $\Omega$ $\pm$ 1 %, SMD-0805	YAGEO
30	R9,R9B,R10,R10B	5.1 $\Omega$ $\pm$ 1 %, SMD-1206	YAGEO
31	R11, R12, R15	10K $\Omega$ $\pm$ 1 %, SMD-1206	YAGEO
32	R24	1 $\Omega$ $\pm$ 5 %, MOF 1W	
33	R21	1.5K $\Omega$ $\pm$ 5 %, MOF 1/8W	
26	R17, R17B	200K $\Omega$ , $\pm$ 1 %, SMD-1206	YAGEO
	JUMP3, 4	Jumper $\phi$ 0.6mm P=6.1mm	
34	F1	T3.15A250V	HONGDA
35	BDR1	KBP307G,3A,1000V,KBP	PANJIT
36	D6	RS1D,1A,200V,SMA	PANJIT
	D3	FR107, DO-15	
37	D1	RS1M,1A,1000V,SMA	PANJIT
38	D2	ER206,1A,600V,DO-15	PANJIT
39	D7, D8	ER304/HER304,5A,300V,DO-201AD	PANJIT
40	D5	LL4148,0.15A,100V,LL-34	
40	D4	LL4148,0.15A,100V, 插件	
41	Z1	Zener, ZMM15B,15V, LL-34	
42	Q1	4N60.4A,600V,TO-220F	ARK
43	Q4	MMBT4401,NPN,SOT-23	NXP/ON
44	Q3	MMBTA44, NPN, 0.3A,500V, SOT-23	NXP/ON
45	Q2	3DD13005ED,NPN,4A 700V,T0-220HF	huajing
46	L3	Drum choke, l-shaped 10X12mm, 1mH	XIN YUAN YANG
	L2	UU9.5	
48	L1	Common Mode Inductor T8*4*3 15uH	XIN YUAN YANG
49	L5	Common Mode Inductor T10*4*6 330uH	XIN YUAN YANG
50	L4	EF16	XIN YUAN YANG
51	T1	Transformer PQ2016 L=0.85mH(Vcc=11Ts)	XIN YUAN YANG
52	CY1	Y1,1000pF,400V	STE

# 5. Transformer Design

## SCHEMATIC



## ELECTRICAL SPECIFICATIONS:

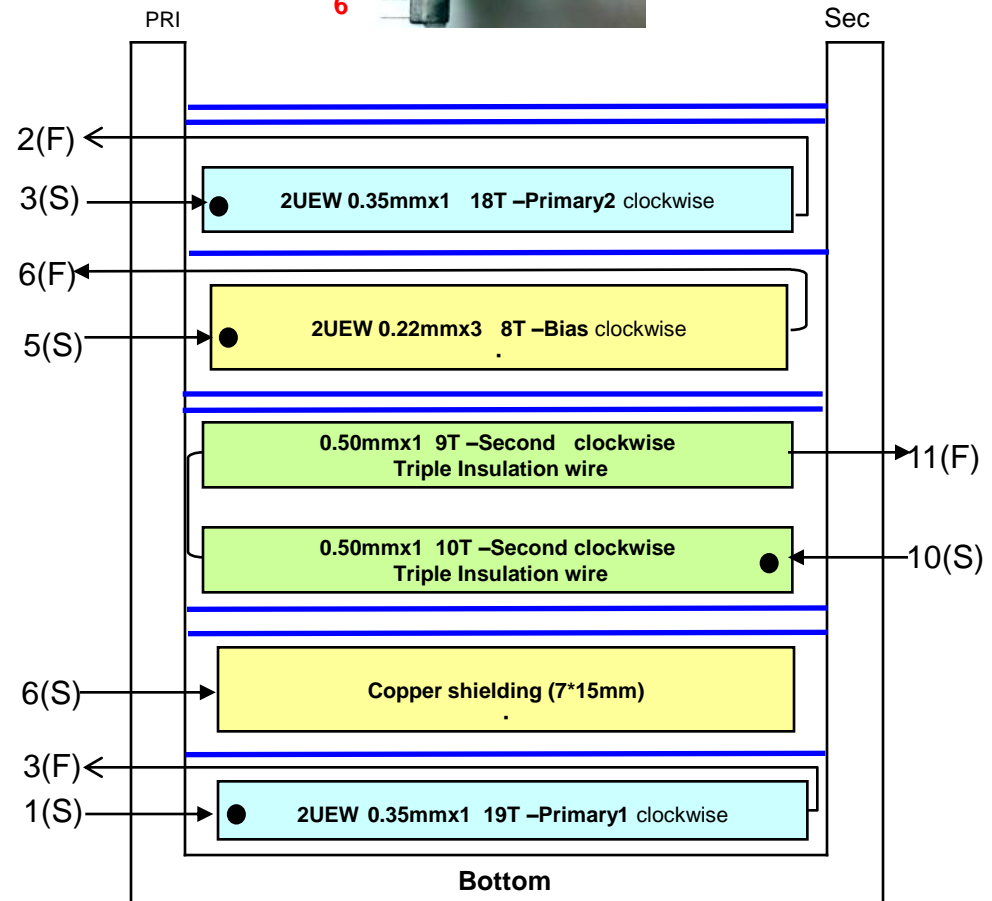
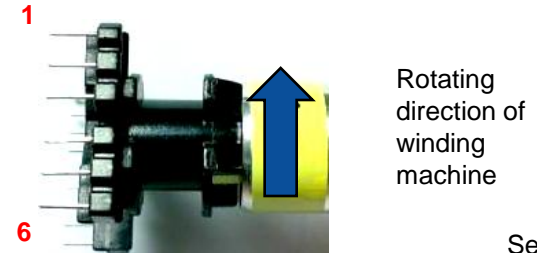
1. Primary Inductance ( $L_p$ ) = 0.5mH @10KHz
2. Primary Leakage Inductance ( $L_k$ ) ≤ 40uH@10KHz

## MATERIALS:

1. Core : PQ2016 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : PQ2016 Vertical Primary=6, Secondary=8
3. Magnet Wires (Pri) : Type 2-UEW
4. Magnet Wire (Sec) : Triple Insulated Wires
5. Layer Insulation Tape : 3M1298 or equivalent.

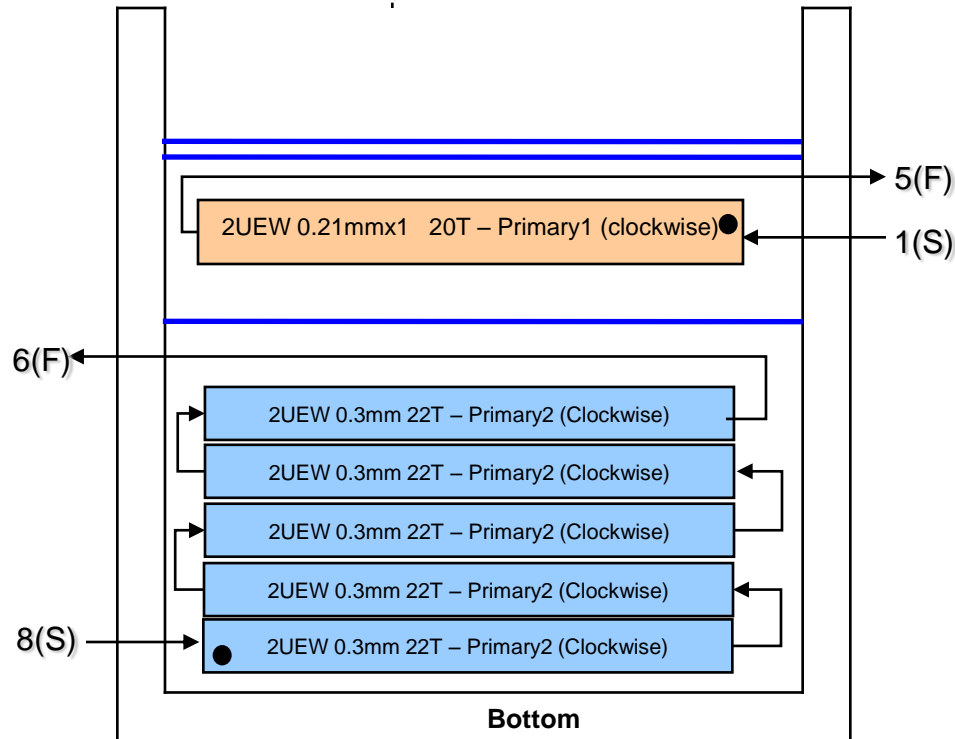
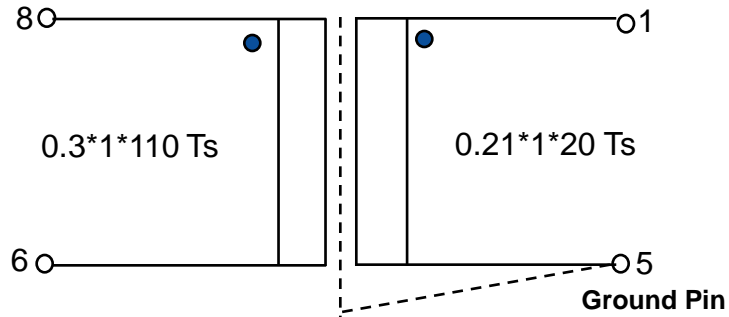
## FINISHED :

1. Core is connected to PRI-GND pin6.
2. Varnish the complete assembly



# 6. PFC Inductor

## SCHEMATIC



## ELECTRICAL SPECIFICATIONS:

1. Inductance (Lp6-10) = 0.8mH @10KHz
2. Core : EE13 W (Ferrite Material TDK PC40 or equivalent)
3. Bobbin : EE13W, Horizontal
4. Ferrite core is connected to Pin 5 after assembling
5. Varnish the complete assembly



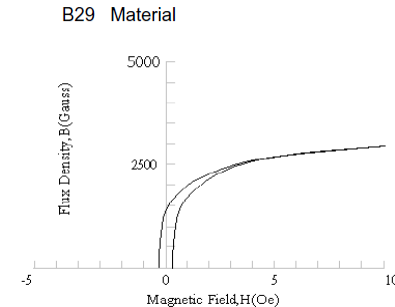


# 7. Common Mode Inductor L1

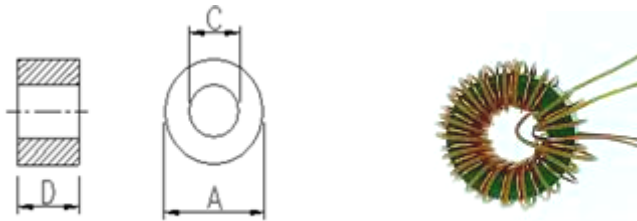
## Properties of B&F Ferrite - Nickel Zinc (Ni-Zn)

Material	$\mu_i$	Bms(Gs)	Hc(Oe)	Br(Gs)	Tc(°C)	$\rho$ ( $\Omega$ -cm)	Frequency (MHz)	$\alpha$ ur x $10^{-6}/^{\circ}\text{C}$
B29	800	2900	0.30	1420	150	$1 \times 10^7$	0.1~0.7	25~45

## Saturation Flux Density (Ni-Zn)



## EMI Toroidal Core ( T Type )



Dimensions 尺寸 ( mm )

Core Size	Conf.	A	D	C	Fig
T 8.0x4.0x3.0		8.0±0.3	4.0±0.3	3.0±0.2	1,2,3

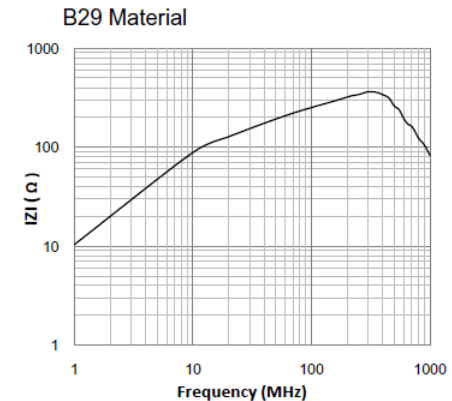
Ferrite core : Ni -Zn T8\*4\*3

Wire gauge: 0.3mm, 8Turns (Triple Insulated Wire)

Inductance @10kHz, 1V: 25uH +/-10%

DCR: 0.12 OHM +/-20%

## Impedance Vs Frequency Curve (Ni-Zn)



**B.F.**

**Contacts Information**

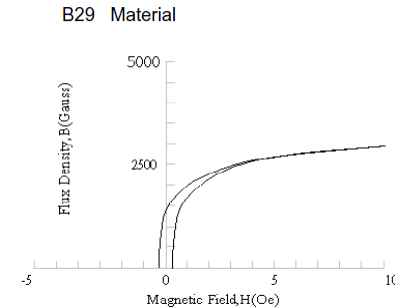
Company Name : Bead & Ferrite Electronics (HK) Ltd.  
 Telephone No. : ( 852 ) 2601 0833  
 Fax No. : ( 852 ) 2693 6202  
 Email Address : [bf@bnf.com.hk](mailto:bf@bnf.com.hk)  
 Home Page : [www.bnf.com.hk](http://www.bnf.com.hk)  
 Address : RM. 16-17, 15/F., Block C, Goldfield Ind. Centre,  
 No.1 Sui Wo Road, Fo Tan, N.T. Hong Kong

# 8. Common Mode Choke L5

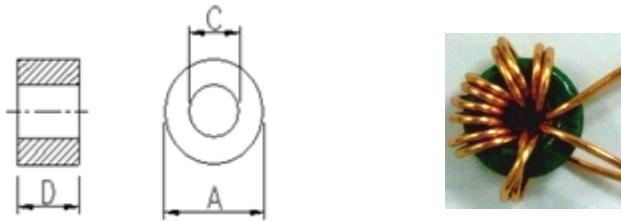
## Properties of B&F Ferrite - Nickel Zinc (Ni-Zn)

Material	$\mu_i$	Bms(Gs)	Hc(Oe)	Br(Gs)	Tc(°C)	$\rho (\Omega \cdot \text{cm})$	Frequency (MHz)	$\alpha \text{ ur } \times 10^{-6} / ^\circ\text{C}$
B29	800	2900	0.30	1420	150	$1 \cdot 10^{-7}$	0.1~0.7	25~45

## Saturation Flux Density (Ni-Zn)



## EMI Toroidal Core ( T Type )



Dimensions 尺寸 ( mm )

Core Size	Conf.	A	D	C	Fig
T 8.0x4.0x3.0		8.0±0.3	4.0±0.3	3.0±0.2	1,2,3

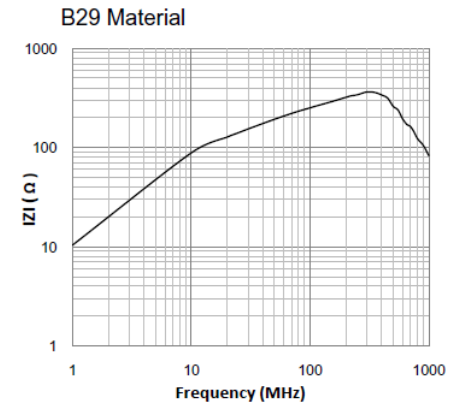
Ferrite core : Ni -Zn T8\*4\*3

Wire gauge: 0.45mm, 6Turns

Inductance @10kHz, 1V: 17uH +/-10%

DCR: 0.1 OHM +/-20%

## Impedance Vs Frequency Curve (Ni-Zn)



**B.F.**

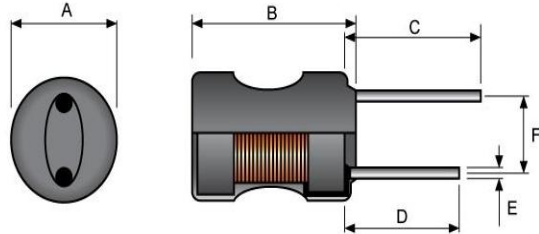
### Contacts Information

Company Name : Bead & Ferrite Electronics (HK) Ltd.  
 Telephone No. : ( 852 ) 2601 0833  
 Fax No. : ( 852 ) 2693 6202  
 Email Address : [bf@bnf.com.hk](mailto:bf@bnf.com.hk)  
 Home Page : [www.bnf.com.hk](http://www.bnf.com.hk)  
 Address : RM. 16-17, 15/F., Block C, Goldfield Ind. Centre,  
 No.1 Sui Wo Road, Fo Tan, N.T. Hong Kong

# 9. Inductor

## 1. Differential Mode Inductor L4

SCHEMATIC



Ferrite core size : A x B 10x12mm

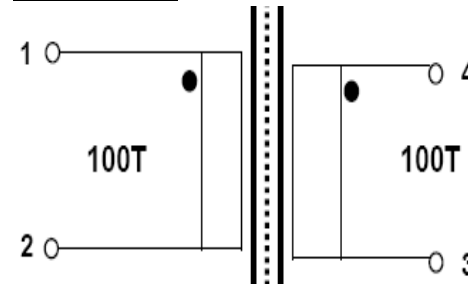
Wire gauge: 0.23mm, 185 Turns

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

DCR: 1.4 OHM +/-20%

## 2. Common Choke L2 for EMI

SCHEMATIC



Ferrite core : UU9.5 Material 10k

Wire gauge: 0.25mm, 100Turns

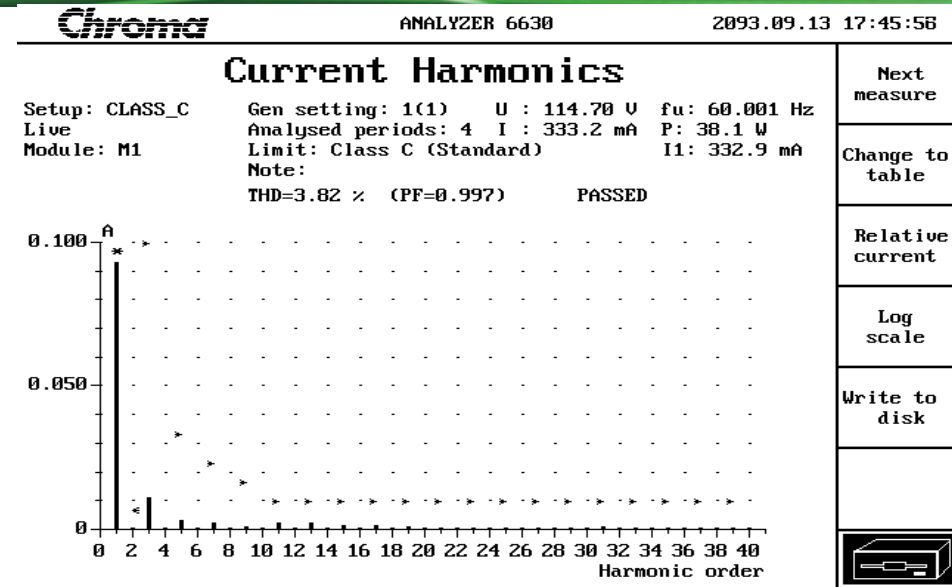
Inductance @10kHz, 1V: 25mH +/-20%

DCR: 1.2OHM +/-20%

# 10. Regulation, Ripple and Efficiency Measurement

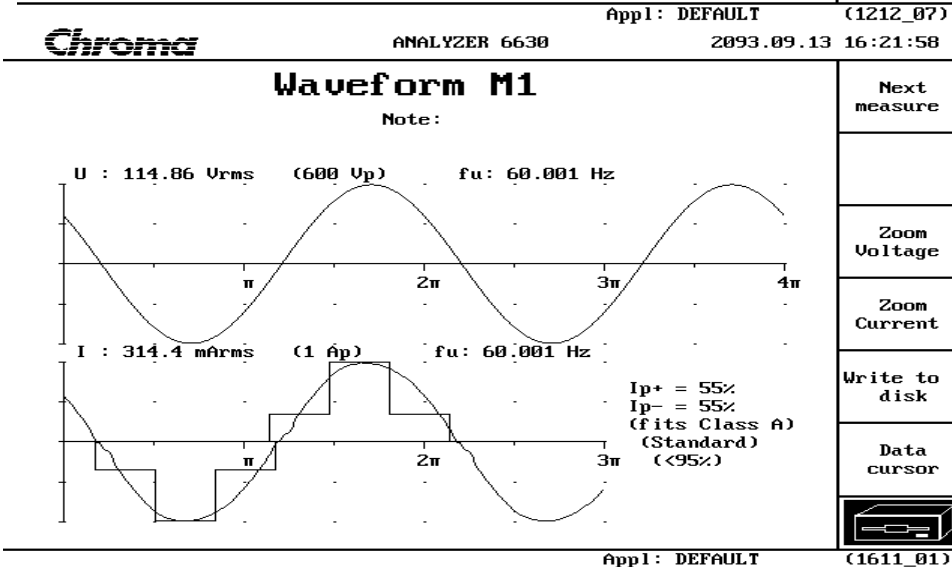
Vin	Pin	Vout	Iout	Ripple(PK)	efficiency	PF	Vbulk	THD
(V)	(W)	(V)	(mA)	(mA)			(V)	(%)
90	32.90	40.26	686.00	35.00	83.94%	0.987	202.0	12.80
100	32.19	40.26	683.00	35.00	85.42%	0.994	207.0	2.710
110	31.65	40.26	682.00	35.00	86.75%	0.998	213.0	2.910
115	31.49	40.26	682.00	35.00	87.19%	0.997	218.0	3.080
120	31.38	40.26	682.00	35.00	87.49%	0.997	223.0	3.190
130	31.23	40.26	682.00	33.00	87.91%	0.996	228.0	4.100
140	31.14	40.26	680.00	33.00	87.91%	0.995	232.0	3.800
150	31.08	40.26	680.00	33.00	88.08%	0.993	245.0	3.770
160	30.99	40.26	680.00	33.00	88.33%	0.993	257.0	4.190
170	30.90	40.26	680.00	33.00	88.59%	0.992	269.0	4.260
180	30.94	40.26	678.00	31.00	88.22%	0.990	282.0	5.150
190	30.96	40.26	678.00	31.00	88.16%	0.990	294.0	5.400
200	31.00	40.26	679.00	31.00	88.18%	0.985	306.0	5.340
210	31.19	40.26	682.00	31.00	88.03%	0.983	331.0	5.800
220	31.20	40.26	684.00	31.00	88.26%	0.981	345.0	5.660
230	31.18	40.26	685.00	31.00	88.44%	0.977	357.0	5.680
240	31.32	40.26	686.00	31.00	88.17%	0.974	369.0	6.030

# 11. Harmonic and current waveform



Harmonics current @115Vac

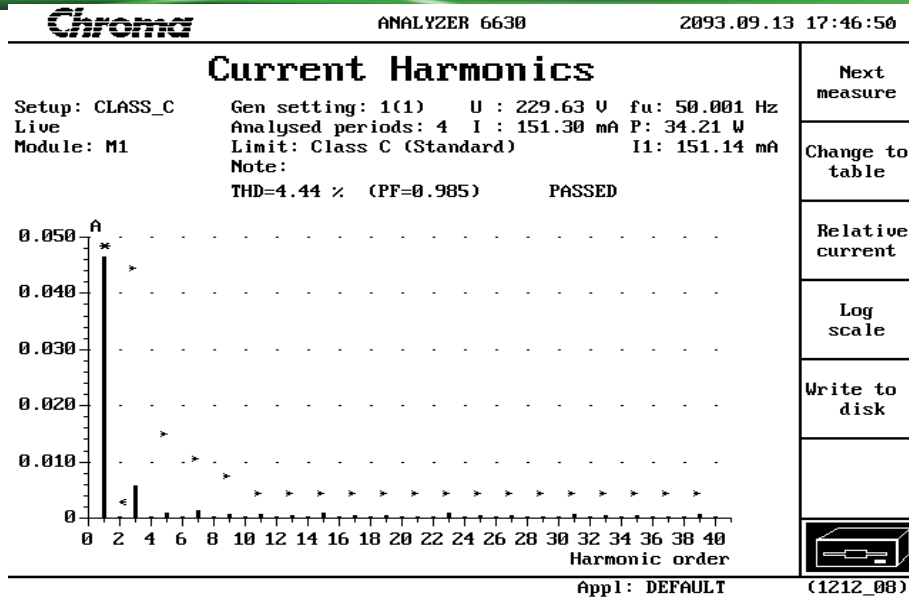
THD=3.82%



AC current waveform @115Vac

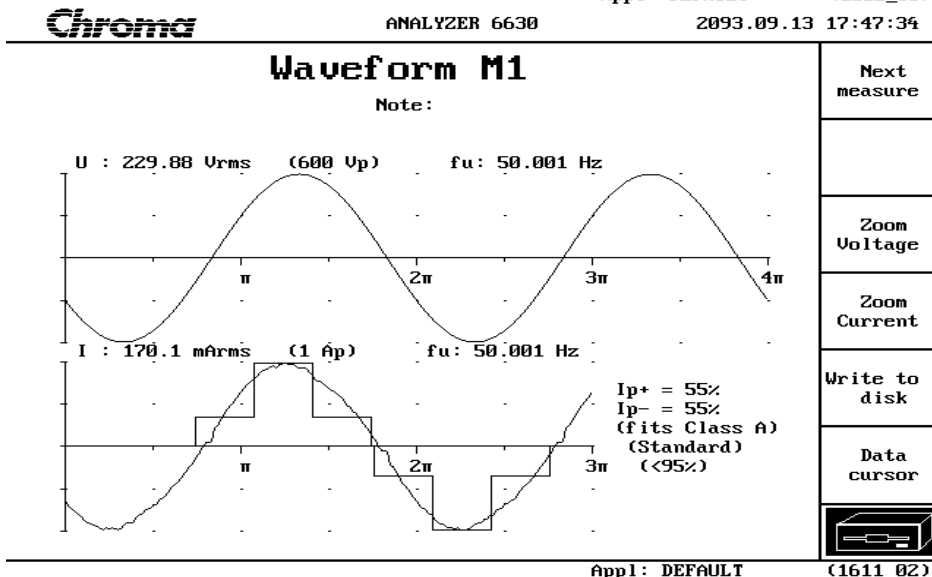
PF=0.997

# 12. Harmonic and current waveform



- Next measure
- Change to table
- Relative current
- Log scale
- Write to disk

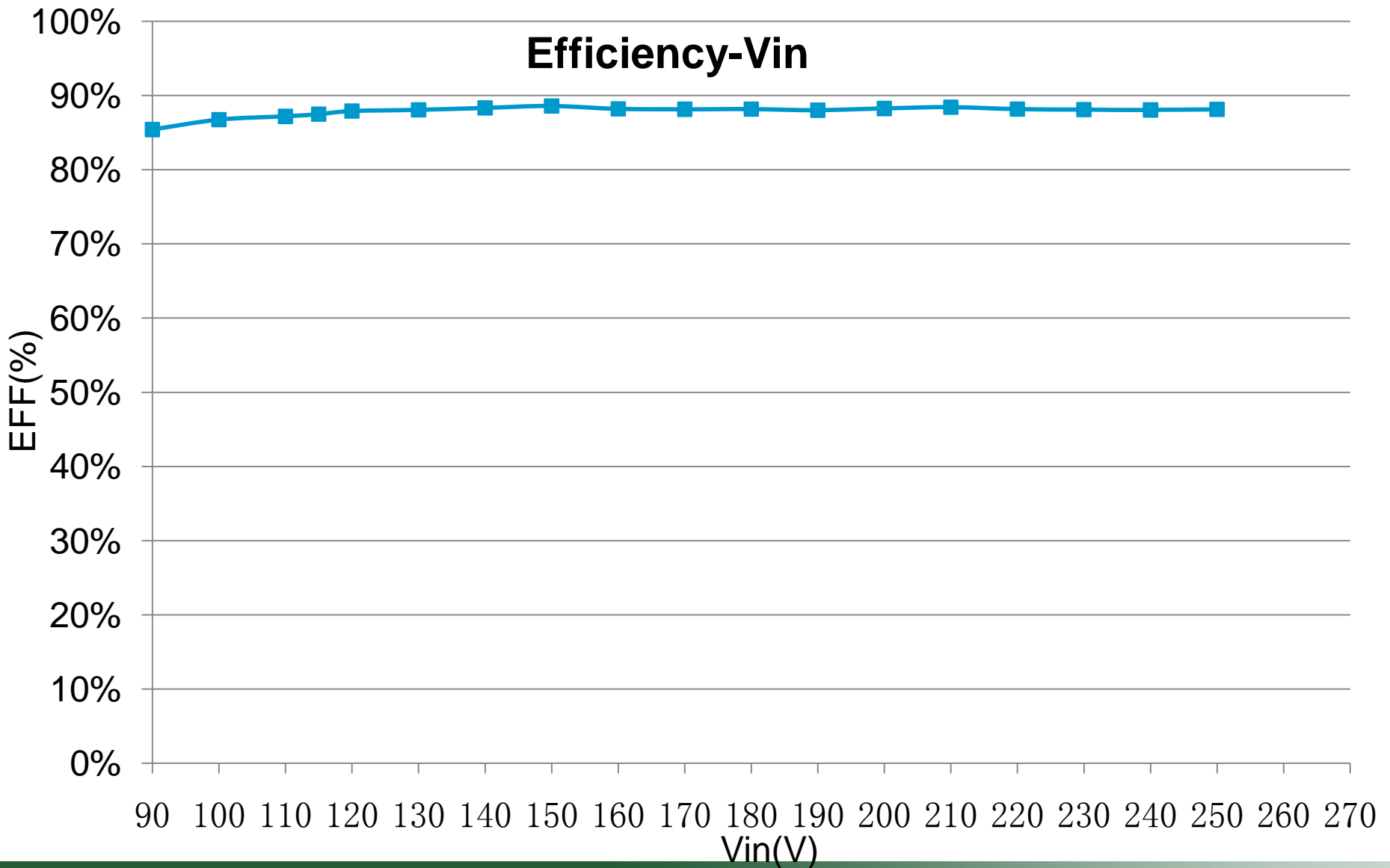
Harmonics current @230Vac  
THD=4.44%



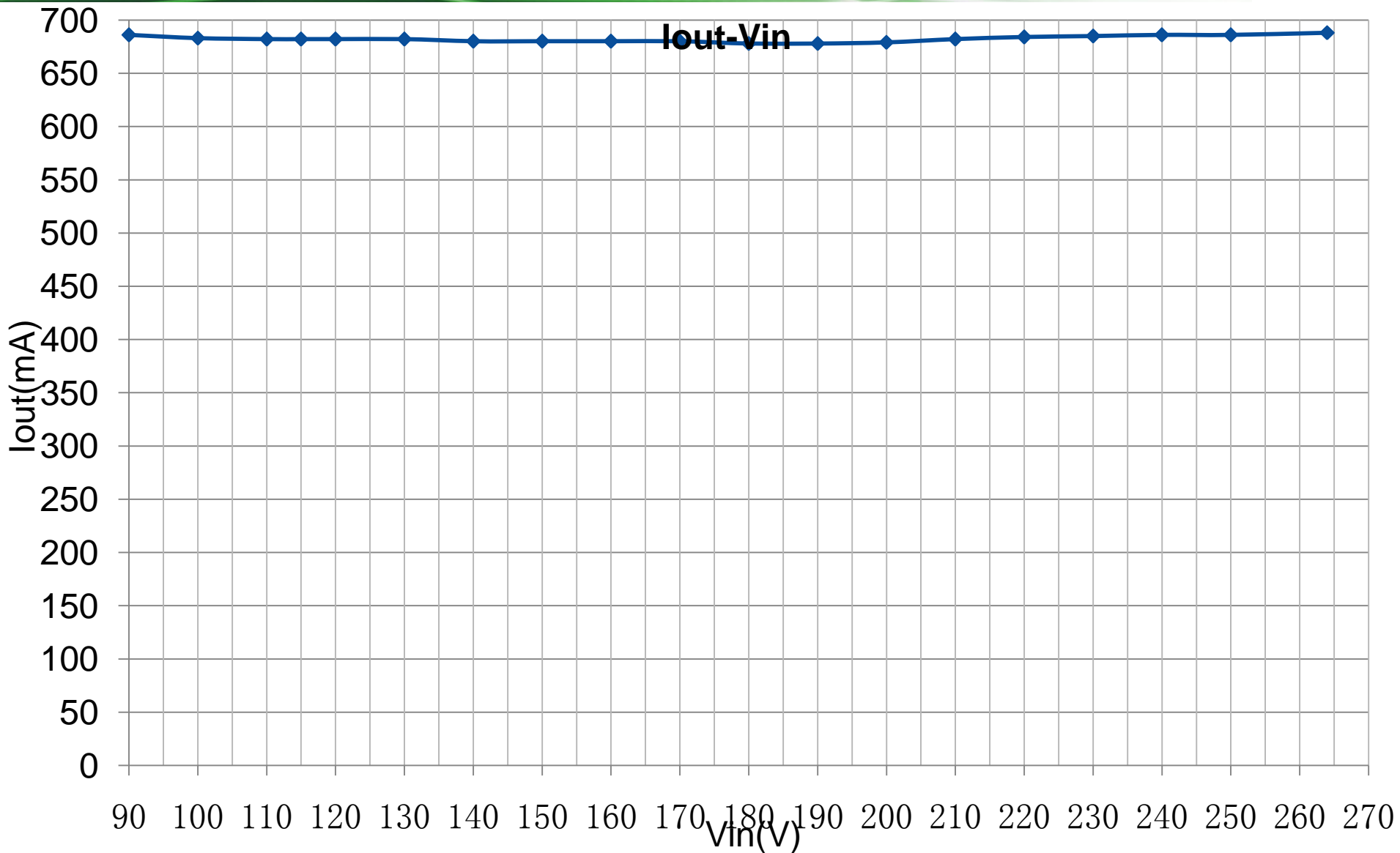
- Next measure
- Zoom Voltage
- Zoom Current
- Write to disk
- Data cursor

AC current waveform @230Vac  
PF=0.985

# 13. Variable Input Vs. Efficiency Measurement

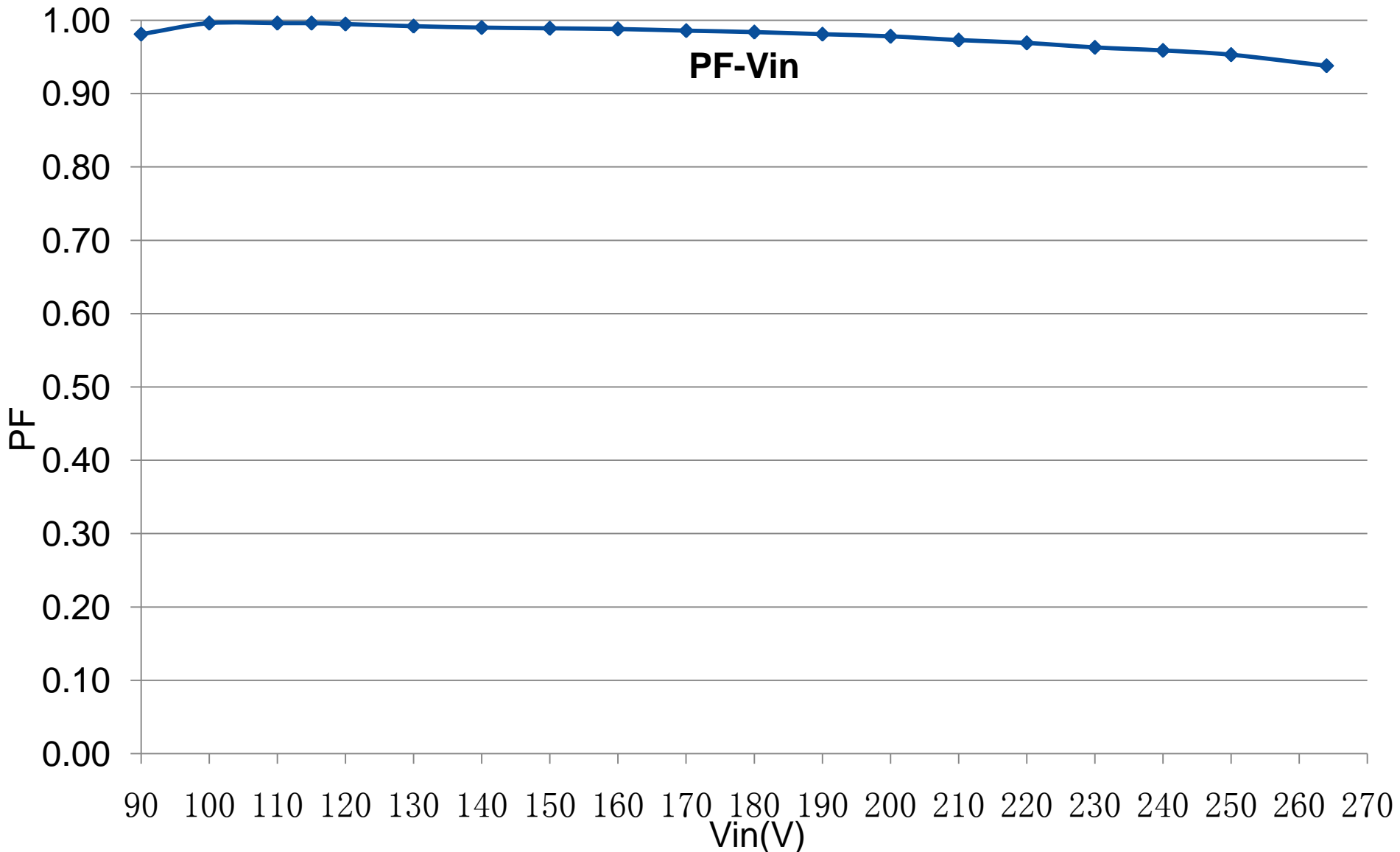


# 14. Variable Input Vs. Iout Measurement

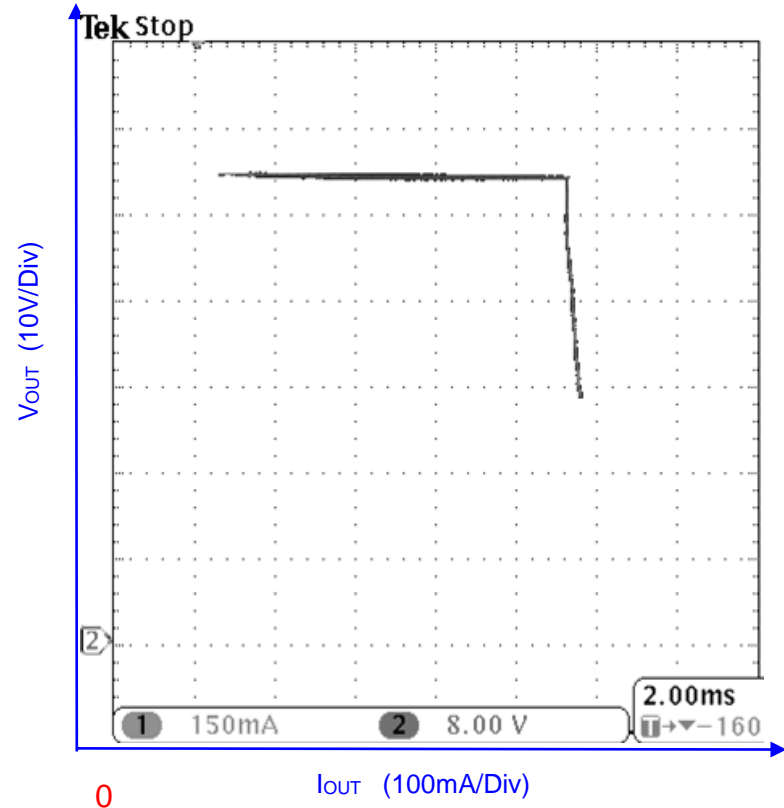




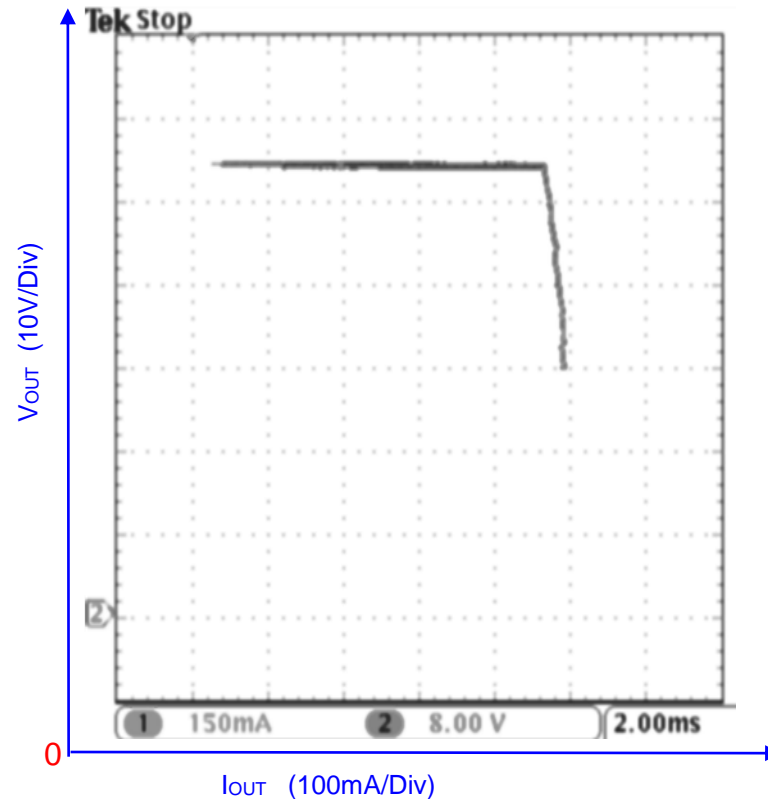
# 15. Variable Input Vs. PF Measurement



# 16. Output VI Characteristics(CV Mode)



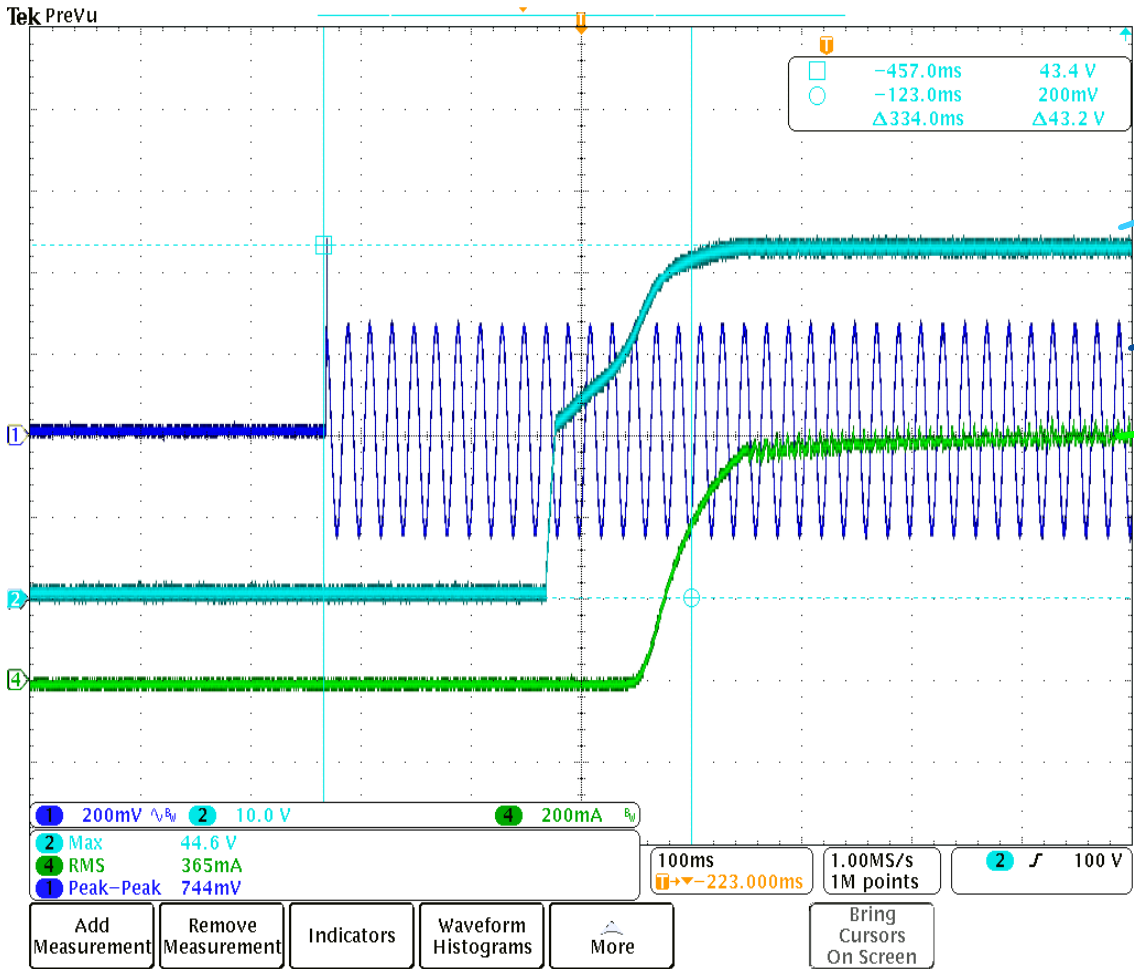
$V_{IN}=110V_{ac}/60Hz$



$V_{IN}=230V_{ac}/50Hz$

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

# 17. Turn-on Delay Time and Output current overshoot

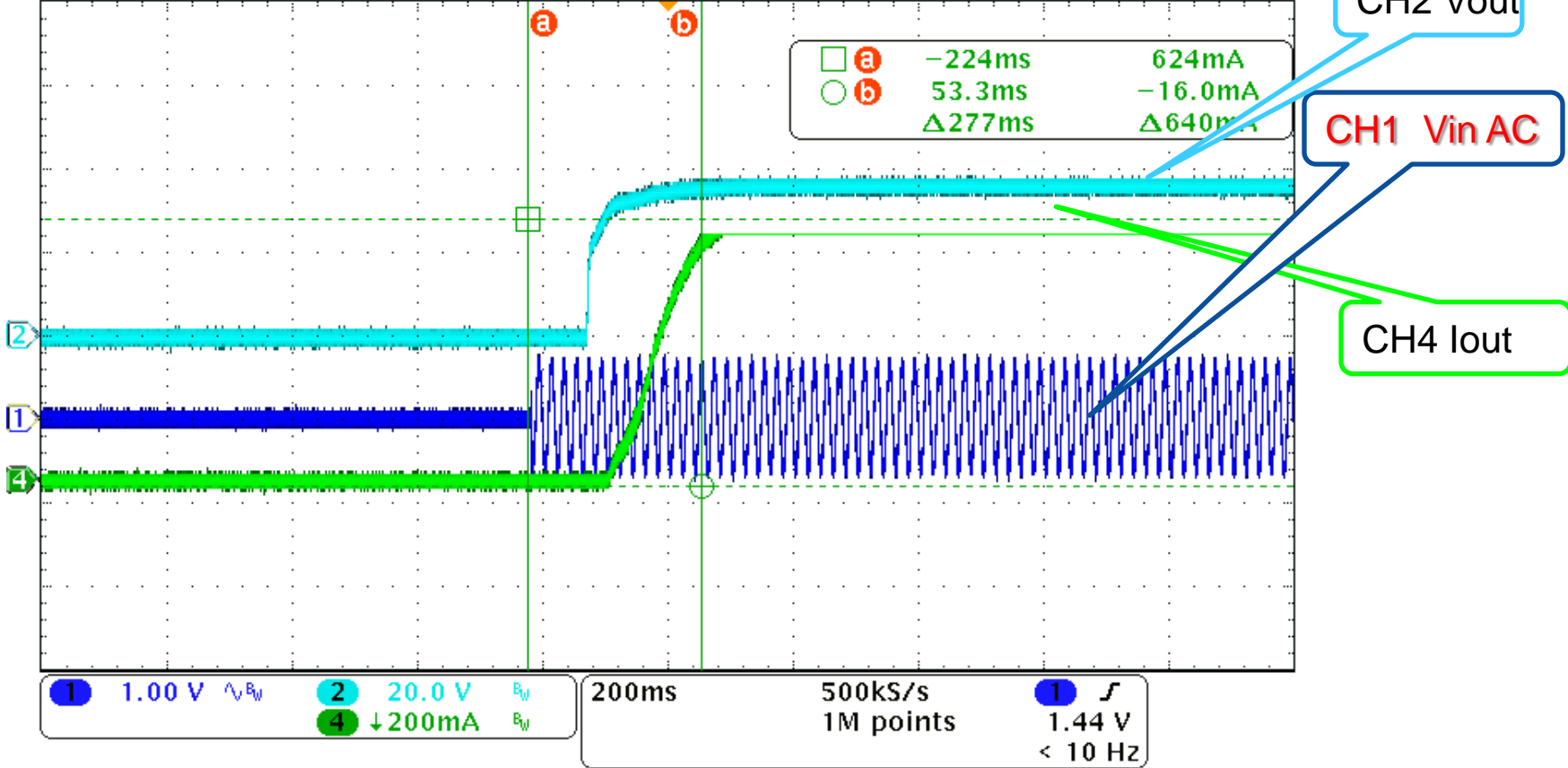


90V<sub>AC</sub>, Full Load

T<sub>ST\_DELAY</sub>=334mS

# 17. Turn-on Delay Time and Output current overshoot

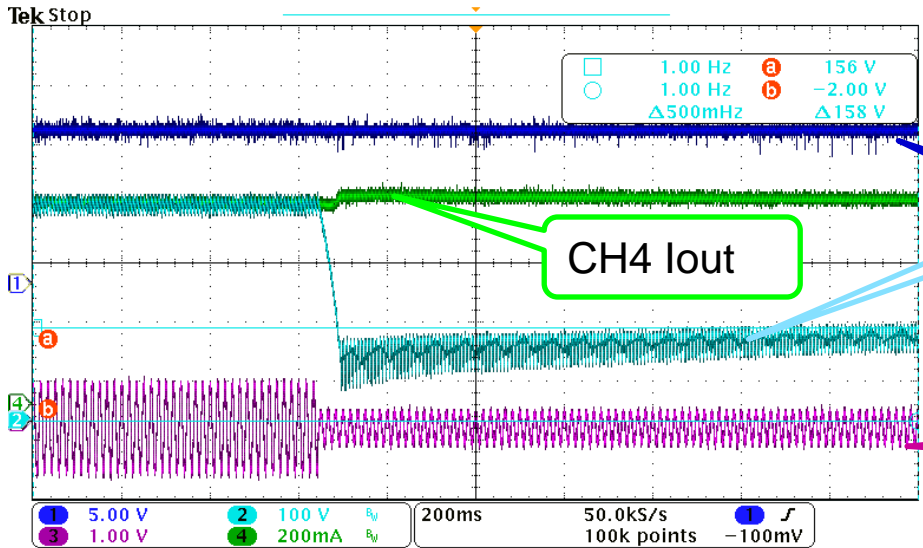
Tek PreVu



230V<sub>AC</sub>, Full Load

T<sub>ST\_DELAY</sub> = 277mS

# 18. High-low input voltage change ,The E-cap voltage Overshoot

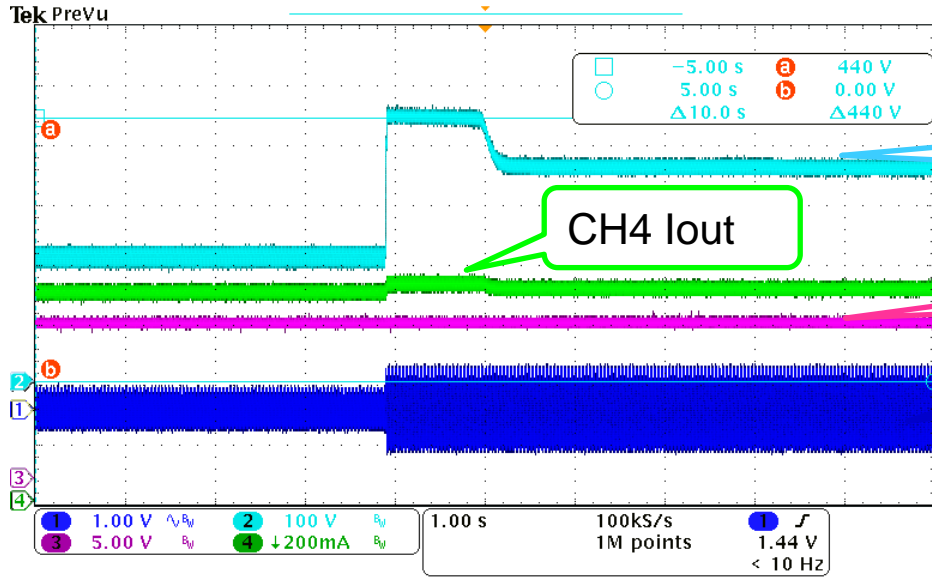


E-CAP VOLTAGE

CH1 V<sub>cc</sub>

CH3 Vin AC

CH4 Iout



E-CAP VOLTAGE

CH3 V<sub>CC</sub>

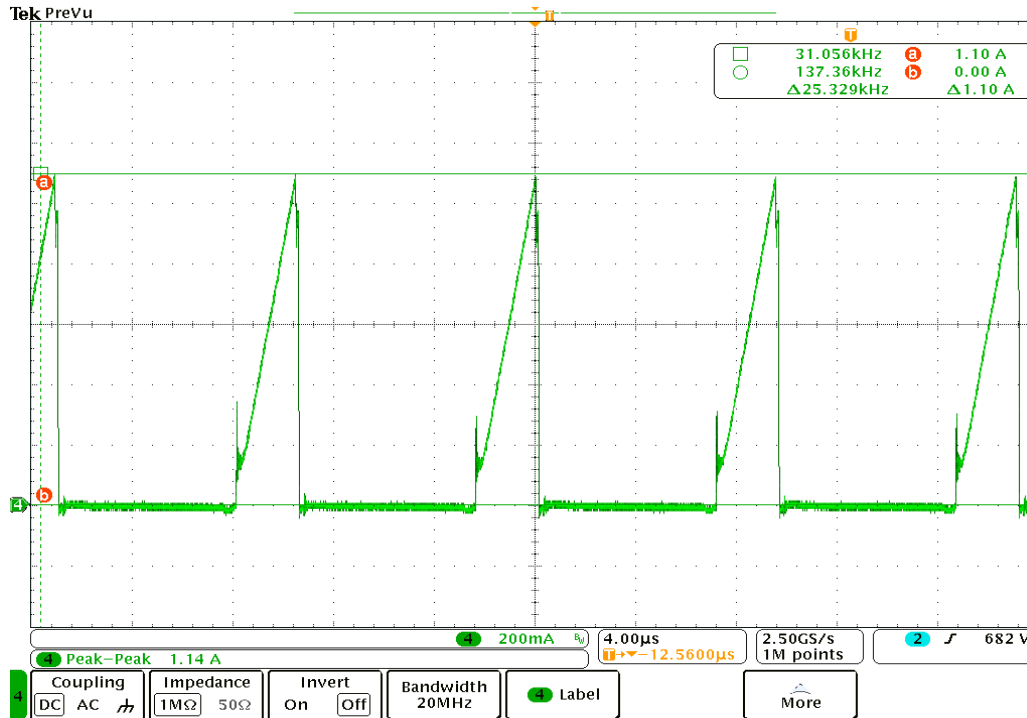
CH1 Vin AC

CH4 Iout

90 to 264V<sub>ac</sub>, Full Load  
The bulk cap voltage is **440V**max

# 19. Transformer Flux Density

( $N_p=37T_s$ ,  $L_m=0.5mH$ ,  $A_e=64mm^2$ -PQ2016 )



$I_{PRI}$  is monitored at 90Vac and 0.7A load

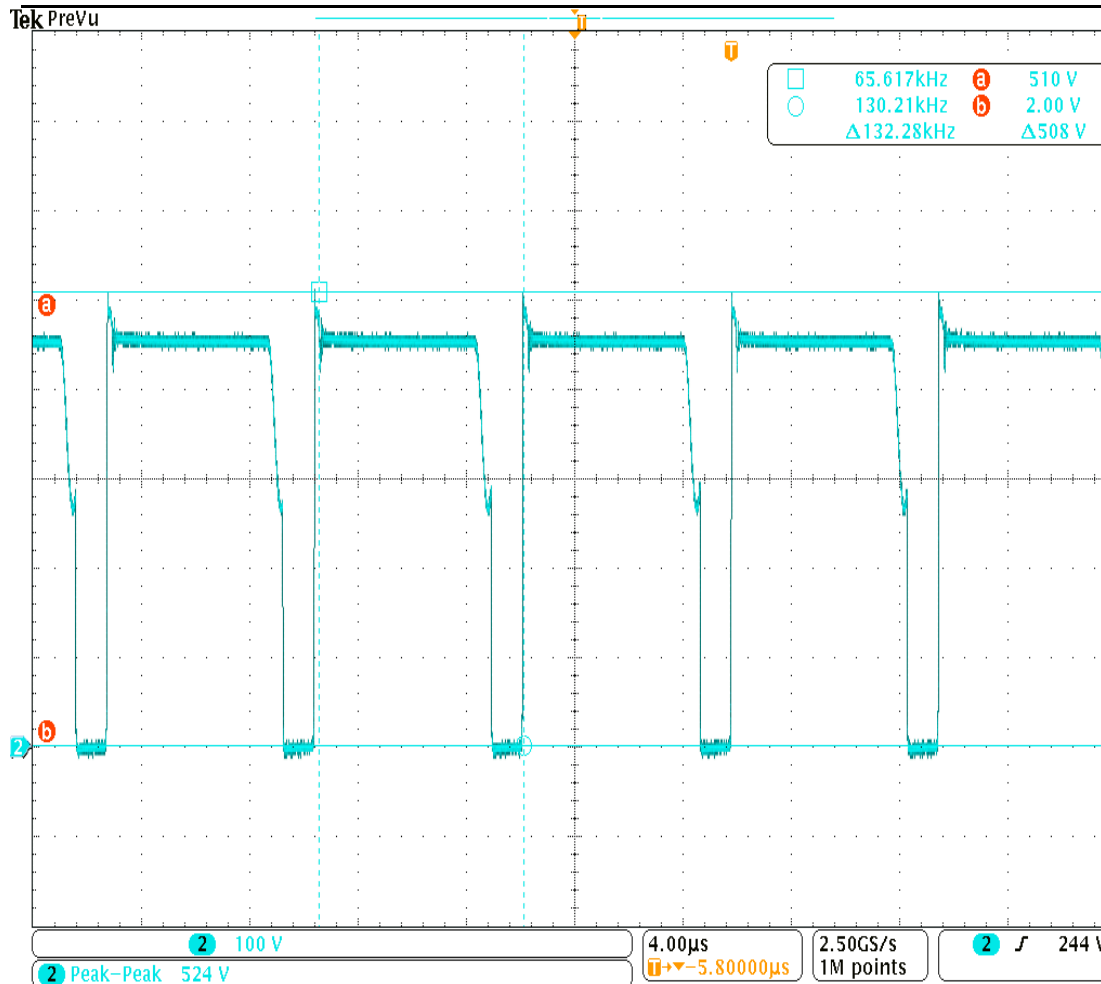
$I_{PRI} = 1100mA$

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

$= (1100 * 0.5) / (37 * 64)$

$= 0.233 Tesla$

# 20. Q1 MOSFET $V_{DS}$ Waveform



Test Condition:

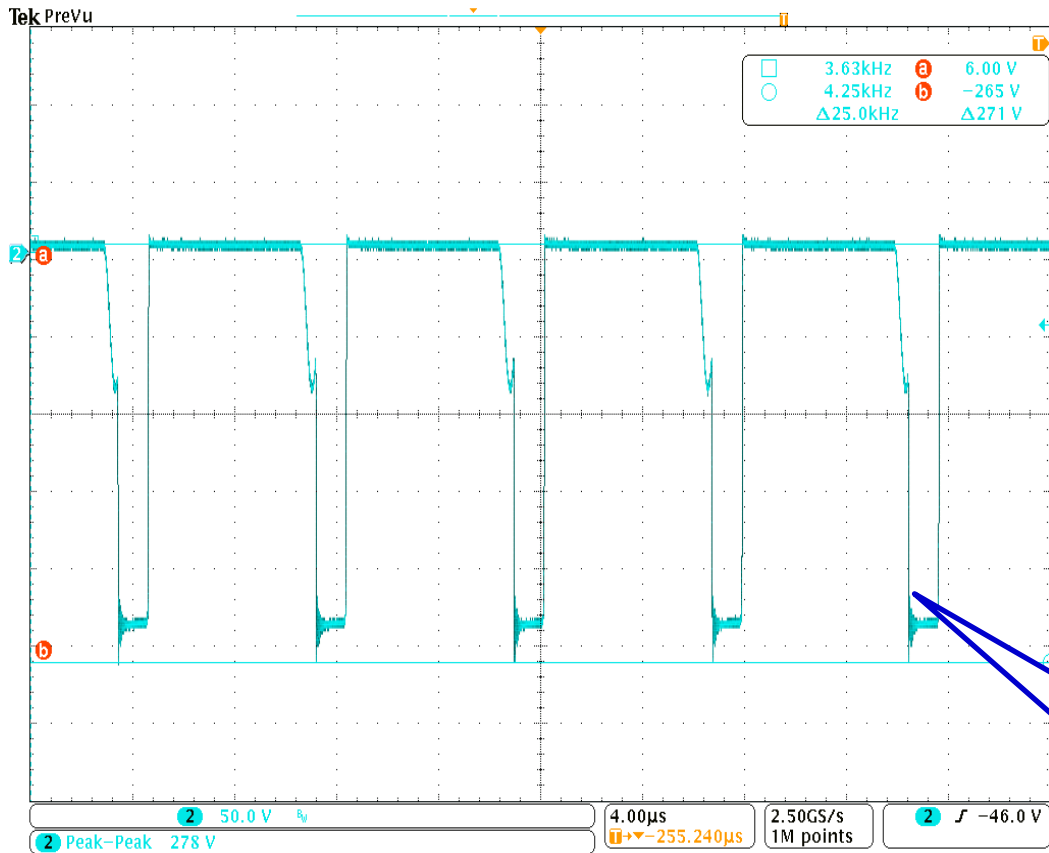
$V_{IN}=264V_{AC}$ ,  $V_{OUT}=41.5V$

Result:

$V_{DS\_MAX}=524V$

Remark: Mosfet Spec\_\_4A 600V

# 21. Output Diode Waveform



Test Condition:

$V_{IN}=264V_{AC}$ ,  $V_{OUT}=41.2V$

Result:

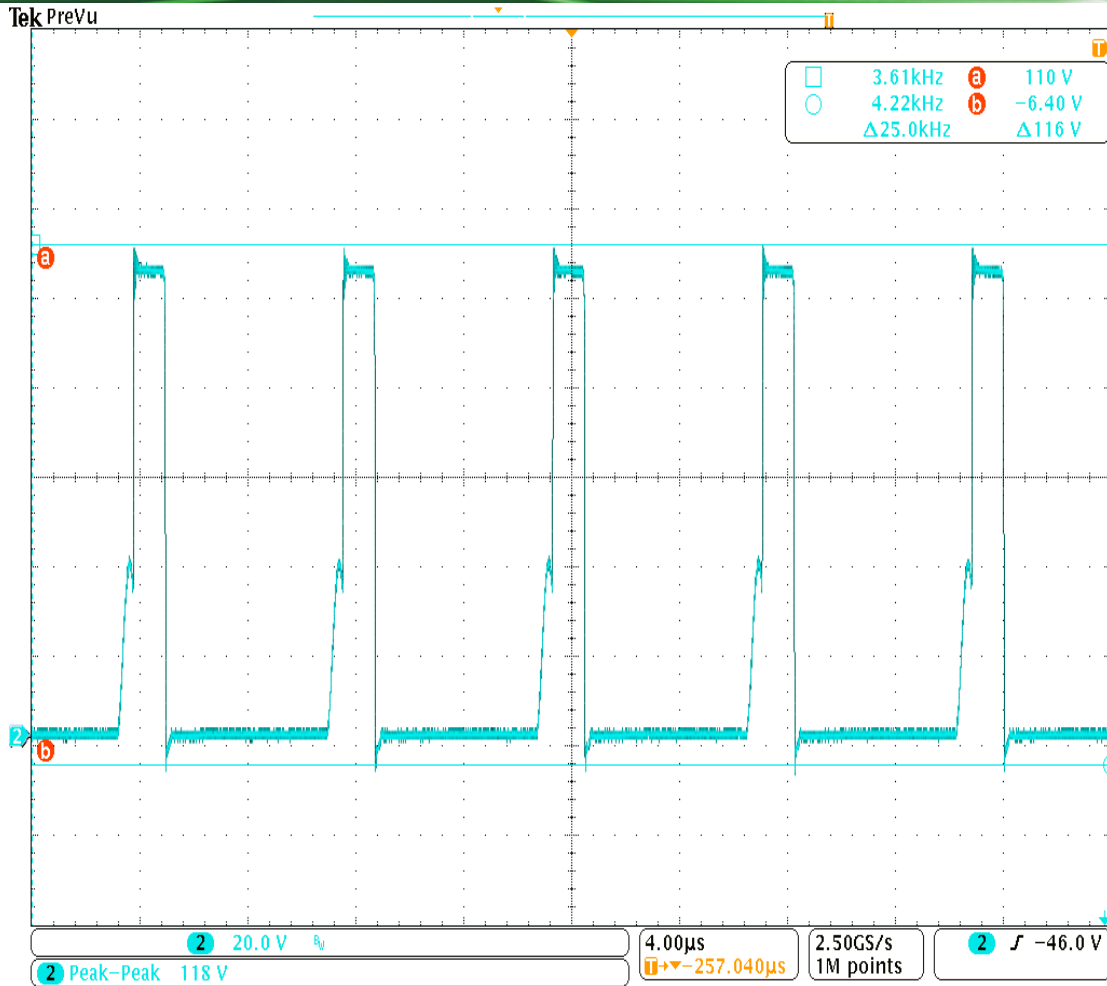
$V_{RRM\_MAX}=278V$

CH2 Output Diode Voltage

Remark: Diode Spec\_\_3A 300V



# 22. Vcc Diode waveform

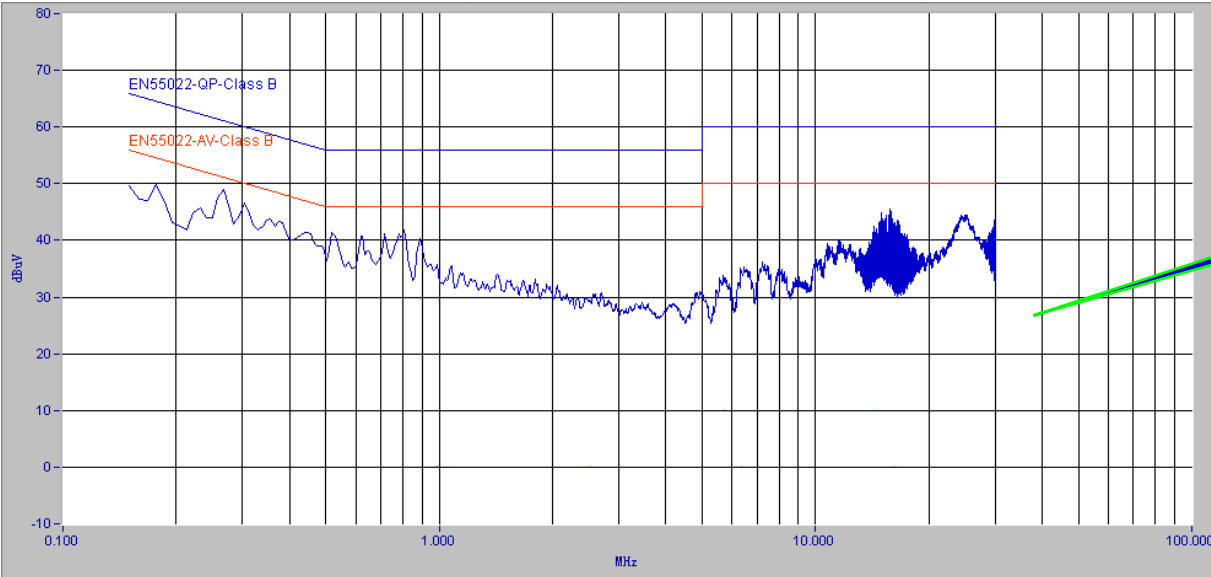


Test Condition:  
 $V_{IN}=264V_{AC}$ ,  $V_{OUT}=41.2V$

Result:  
 $V_{RRM\_MAX}=118V$

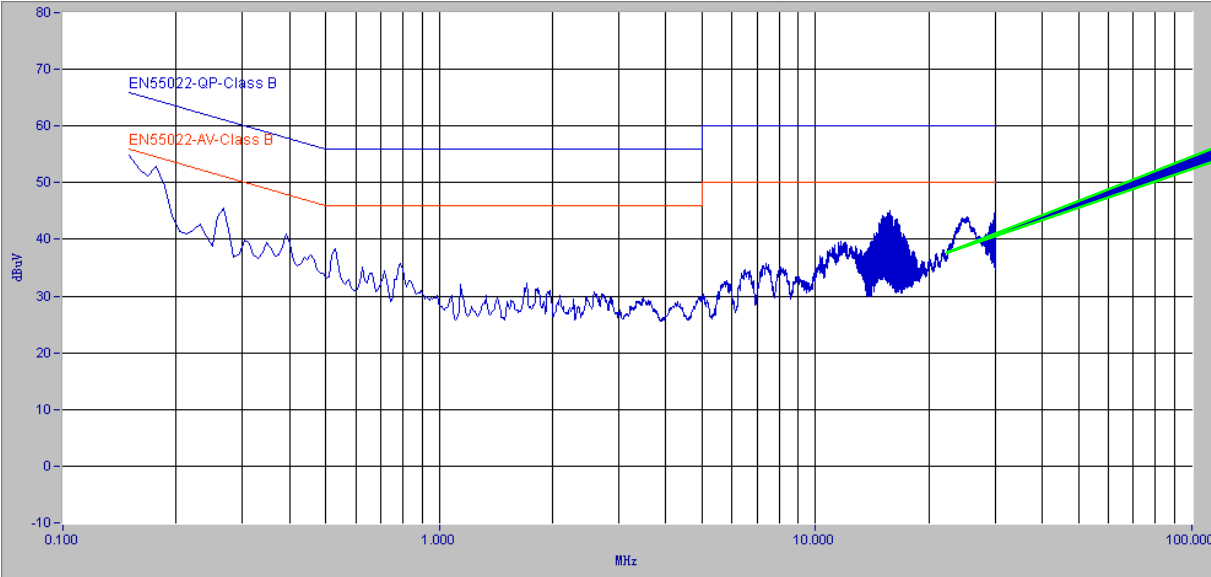
Remark: Diode Spec\_\_ 1A 200V

# 23. Conducted EMI (Full Load)



QP Scan  
QP Limit line

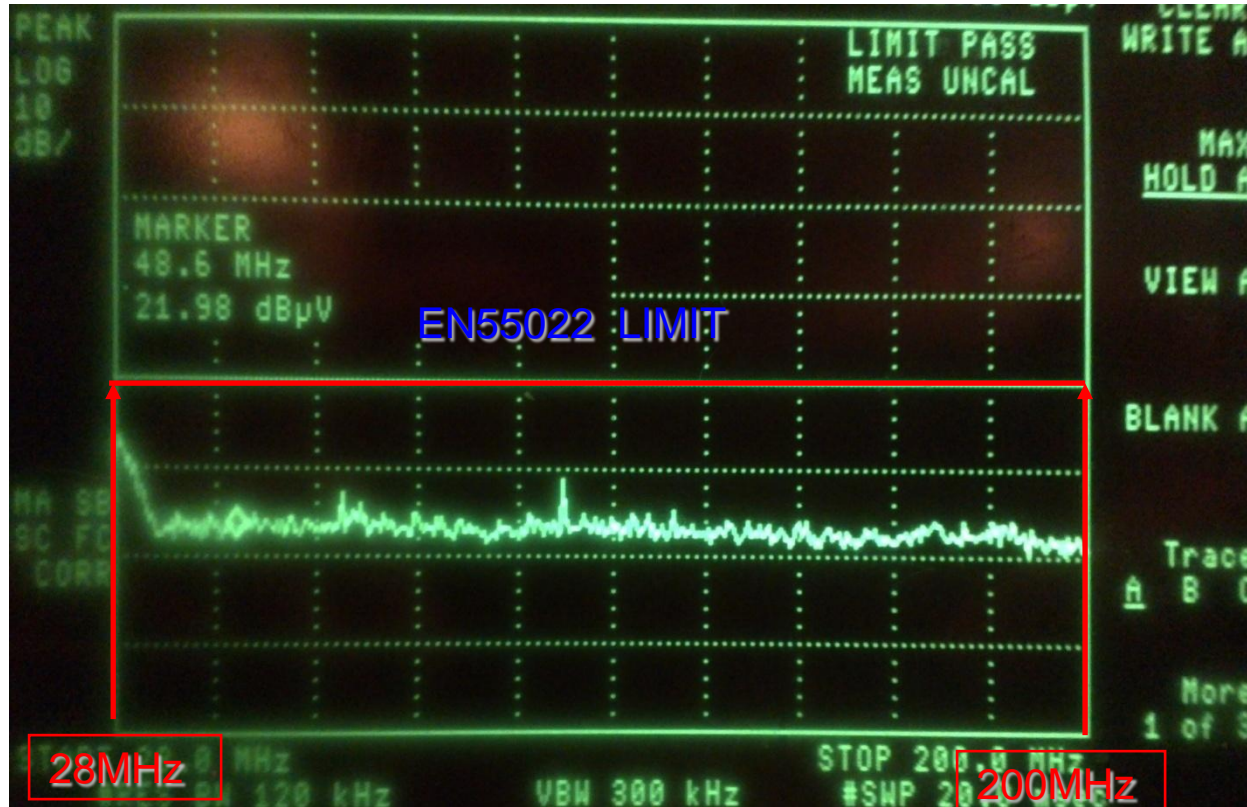
Input=230VAC  
L line QP&AV scan



QP Scan  
QP Limit line

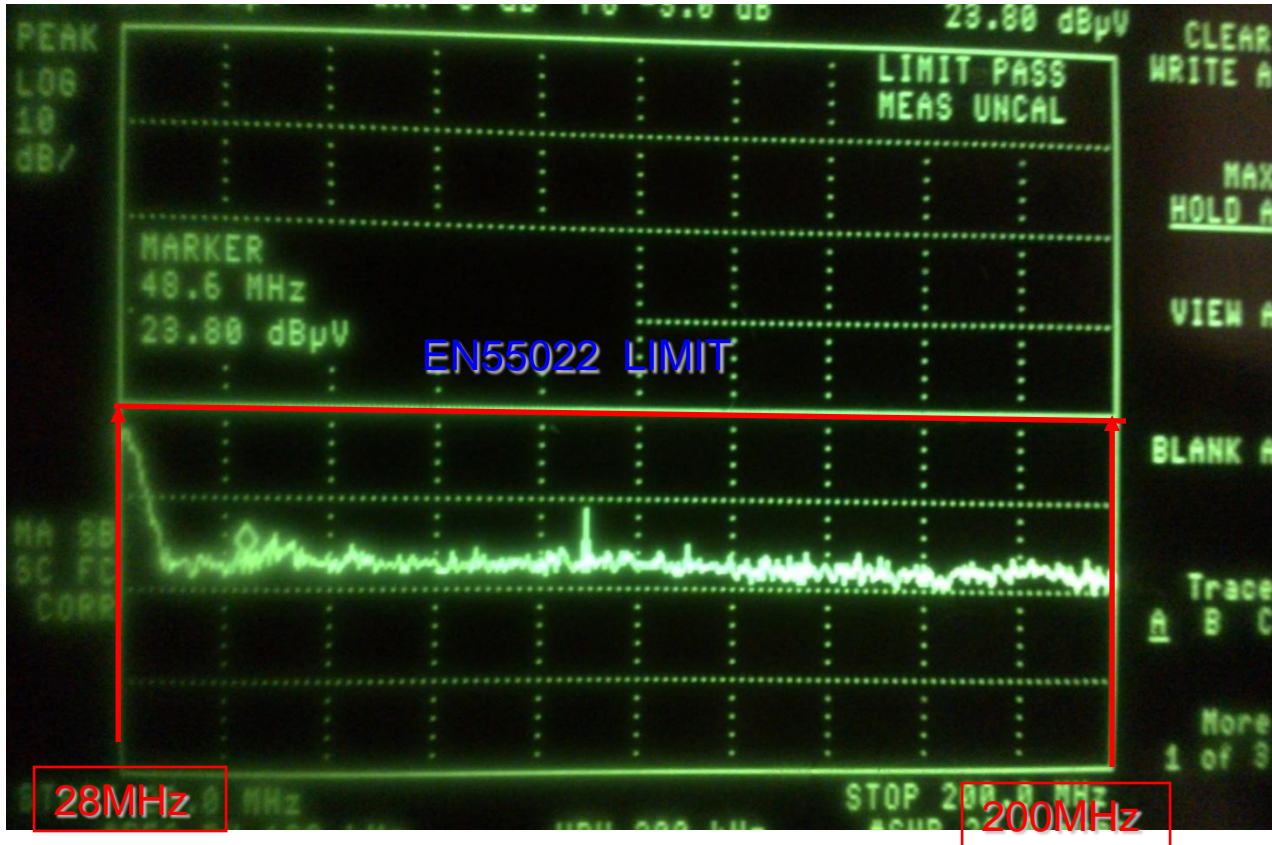
Input=230VAC  
N line QP&AV scan

# 24. Radiated EMI (for reference)



Note: 1,  $V_{in}=115V_{ac}$   
2, Output is floating

# 25. Radiated EMI (for reference)



- Note: 1,  $V_{in}=230V_{ac}$
- 2, Output is floating