



# **LED Driver Design with iW3620 EBC891**

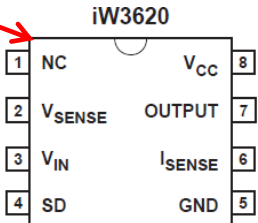
## **Summary and Features :**

- 1. LED driver, 40V, 450mA ; Wide AC input range: 90Vac-264Vac**
- 2. For Isolated Applications**
- 3. High Efficiency, High Power Factor and Least Parts Solution**
- 4. Meet EMI Requirement (EN55015BQP&AV scan)**
- 5. Fully Protection Against AC input UV/OV,O/P Short &Open, Component single fault**

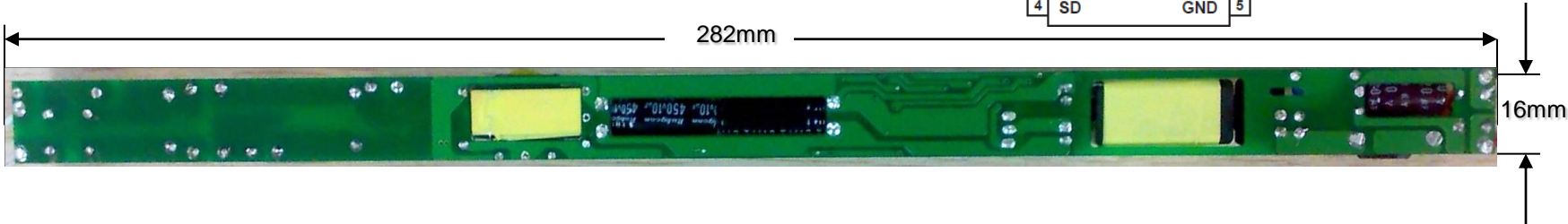
# 1. Specification

Description		Symbol	Min	Typ	Max	Units	Comment	
Input								
Voltage		$V$	90	100-230	264	V <sub>AC</sub>	2 Wire	
Frequency		$f_{LINE}$	47	50	63	Hz		
Open-load Input Power (264V <sub>AC</sub> )						W		
Output								
Const Voltage	Output Voltage	$V_{OUT\_CV}$		40		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	$I_{OUT\_CV}$		0.45		A		
Total Output Power								
Continuous Output Power		$P_{OUT}$		18		W		
Over Current Protection		$I_{OUT\_MAX}$				A	Auto-restart	
Efficiency		$\eta$	86			%	Measured at end of PCB	
Power Fact		$PF$		0.9			Harmonic meet IEC61000-3-2	
Turn on Delay Time						Sec		
Conducted EMI			Meets EN55015B					
Hi-pot test				3		KV		
Operation temperature		$T_{opr}$		40		° C	Free convection, sea level	

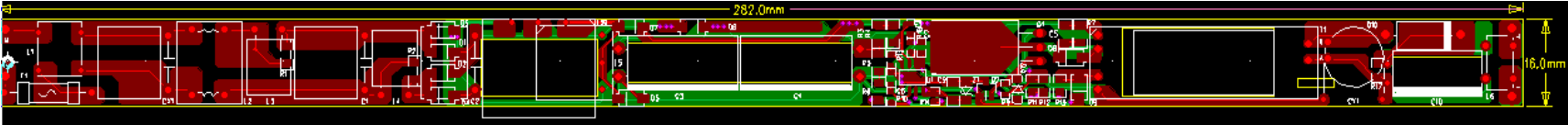
# 2.Circuit Board Photograph



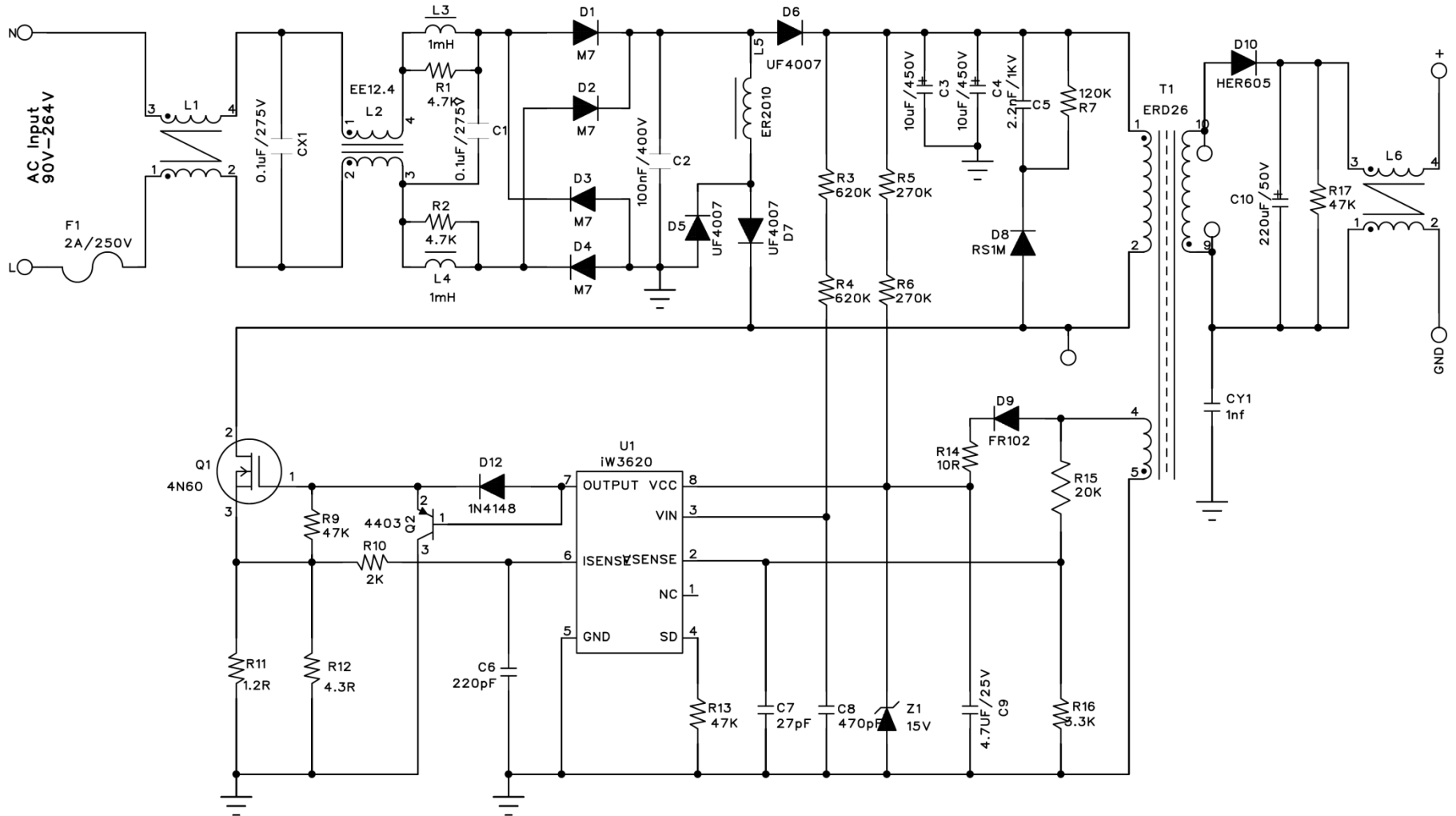
Top side



L x W x H= 282x16x1.2mm

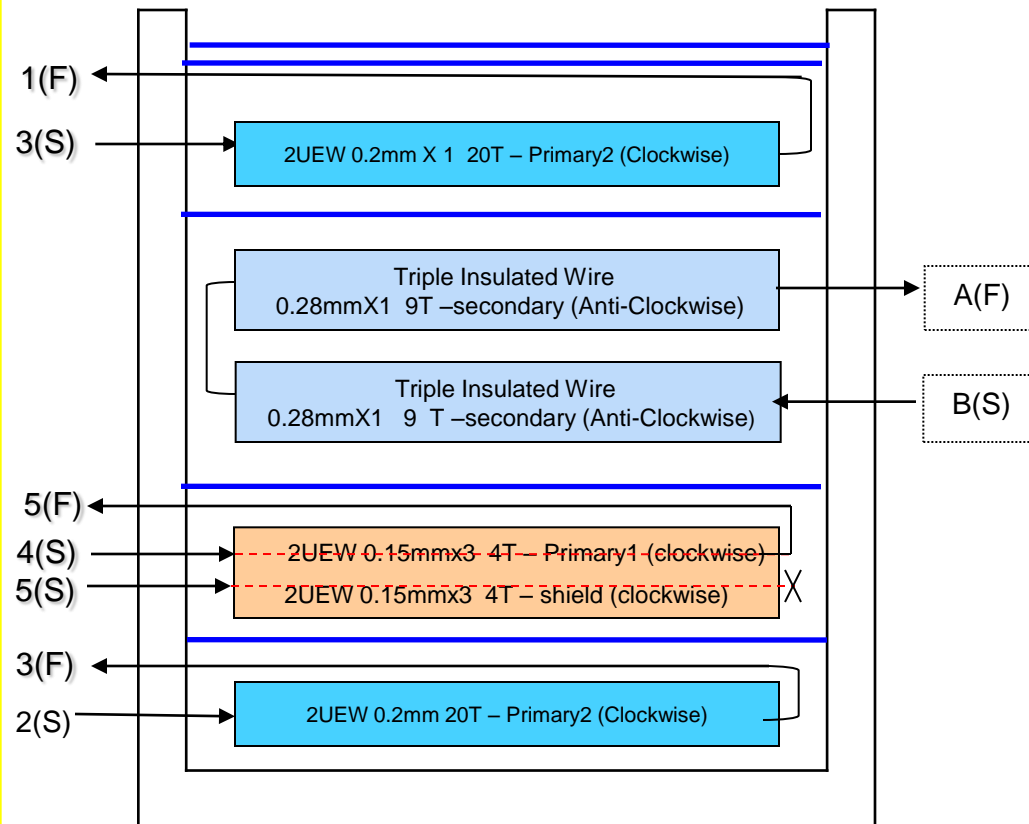
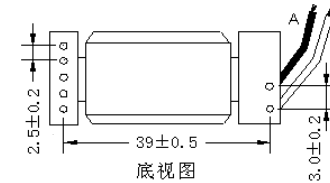
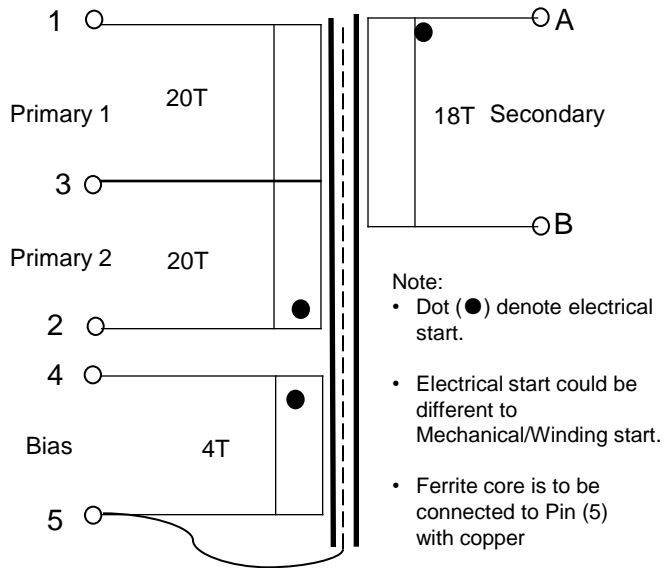


# 3. Schematic



# 4. Transformer Design (32V 700mA)

## SCHEMATIC



## ELECTRICAL SPECIFICATIONS:

1. Primary Inductance ( $L_p$ ) = 1.1mH @10KHz
2. Primary Leakage Inductance ( $L_k$ ) <= 60uH @10KHz
3. Electrical Strength = 3KV, 50/60Hz, 1Min

## MATERIALS:

1. Core : EDR26 (Ferrite Material TDK PC40 or equivalent)
2. Bobbin : EDR26Horizontal. 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. Core is connected to PRI-GND pin5
3. Varnish the complete assembly

# 5. Bill of Material

Item	Qty.	Ref.	Description	Type specification	suppliers
1	2	CX1,C1	0.1uF,275V	PX104K3IC39H200D9H	CARLI 凯励
2	1	C2	0.047uF,400V,CBB	PF104J2G109L270D9R	CARLI 凯励
3	2	C3,C4	10uF,450V,E-CAP,105°C	φ 10*20	Rubycon 红宝石
4	1	C5	2.2nF,1kV,NPO	SMD 1206	TDK
5	1	C6	220pF,50V,X7R,	SMD 0805	TDK
6	1	C7	27pF,50V,NPO,	SMD 0603	TDK
7	1	C8	470pF,50V,	SMD 1206	TDK
8	1	C9	4.7uF,25V,	SMD 1206	TDK
9	1	C10	220uF,50V,E-CAP,105°C	φ 10*15	Rubycon 红宝石
10	1	CY1	Y-CAP1nF 250V		Vishay
11	4	D1,D2,D3,D4	M7/IN4007	SMD	TAIWAN SEMICONDUCTOR 台半
12	3	D5,D6,D7	ESIJ/UF4007	SMD	TAIWAN SEMICONDUCTOR 台半
13	1	D8	RS1M/FR107	SMD	TAIWAN SEMICONDUCTOR 台半
14	1	D9	FR102	SMD	TAIWAN SEMICONDUCTOR 台半
15	1	D10	HER605	SMD	TAIWAN SEMICONDUCTOR 台半
16	1	D12	IN4148	SMD	TAIWAN SEMICONDUCTOR 台半
17	1	Z1	15V	SMD ZMM15	ST
18	1	F1	2A/250Vac Fuse	2A	LITTELFUSE
19	1	L1	Ni-Zn T8*4*3 0.3mm*10T	T8*4*3 0.3mm*10T B29	BIFU
20	1	L6	Ni-Zn T8*4*3 0.45mm*6T	T8*4*3 0.3mm*10T B29	BIFU

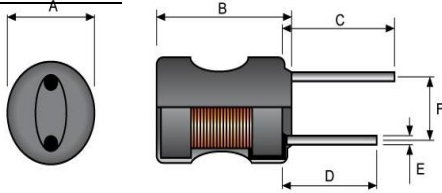
# 6. Bill of Material

Item	Qty.	Ref.	Description	Type specification	suppliers
21	1	L2	EE12.4 (0.2*1 110T)	Horizontal	
22	2	L3,L4	6*8 (0.25*1 180T)	RIK	
23	1	L5	ER2010 (0.3*1 90T)		
24	1	Q1	4N60C3	T0-220	infineon 英飞凌
25	1	Q2	4403(PNP)	MMBT4403LT1G SOT-23	ON 安森美
26	2	R1,R2	4.7K $\Omega$ +/-5%	SMD-1206	YACEO 国巨
27	2	R3.R4.	680K $\Omega$ +/-5%	SMD-1206	YACEO 国巨
28	2	R5.R6.	270K $\Omega$ +/-5%	SMD-1206	YACEO 国巨
29	1	R7	120K $\Omega$ +/-5%	SMD-1206	YACEO 国巨
30	1	R9	47K $\Omega$ +/-5%	SMD-0805	YACEO 国巨
31	1	R10	1.8K $\Omega$ +/-1%	SMD-0603	YACEO 国巨
32	1	R11,	1.2R +/-1%	SMD-1206	YACEO 国巨
33	1	R12	4.3R +/-1%	SMD-1206	YACEO 国巨
34	1	R13	47K $\Omega$ +/-5%	SMD-0805	YACEO 国巨
35	1	R14	10 $\Omega$ +/-5%	SMD-0805	YACEO 国巨
36	1	R15	20K $\Omega$ +/-1%	SMD-0805	YACEO 国巨
37	1	R16	3.3k $\Omega$ +/-1%	SMD-0805	YACEO 国巨
38	1	R17	47K $\Omega$ +/-5%	SMD-0805	YACEO 国巨
39	1	T1	ERD26 Transformer		
40	1	U1	lw3620,Off-line digital PWM controller,	SOT-8	IWATT

# 7. EMI choke

## 1. Differential Mode Inductor L3,L4

SCHEMATIC



Ferrite core size : Ax B 8x10mm

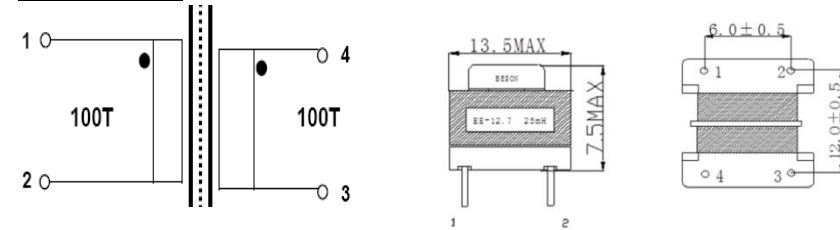
Wire gauge: 0.23mm, 185 Turns

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

DCR: 1.4 OHM +/-20%

## 2. Common Choke L1 for EMI

SCHEMATIC



Ferrite core : EE12.4  $\mu \geq 10k$

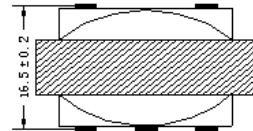
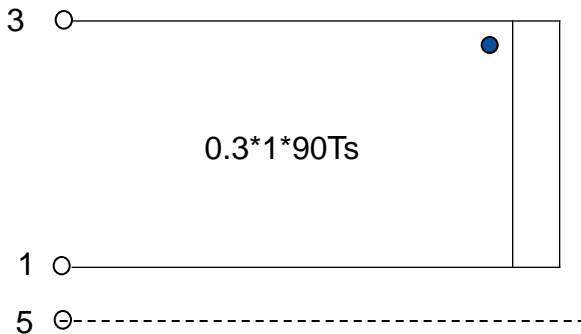
Wire gauge: 0.2mm, 110Turns

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

DCR: 1.2OHM +/-20%

## 3. PFC Inductor L4 Design

SCHEMATIC



### ELECTRICAL SPECIFICATIONS:

1. Inductance ( $L_p$ ) = 0.96mH @10KHz
2. Core : ER2010 (Ferrite Material TDK PC40 or equivalent)
3. Bobbin : ER2010 Vertical
4. Ferrite core is connected to Pin 5 after assembling
5. Cut remained of Pin2, 4,6, after wires termination
6. Varnish the complete assembly

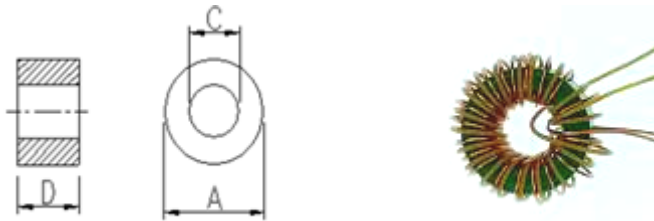


# 8. Common Mode Inductor L1

## 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	$1 \cdot 10^7$	0.1~0.7	25~45

## 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

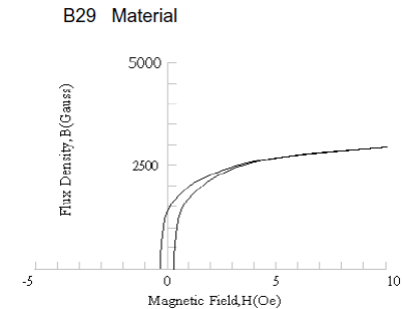
Ferrite core : Ni -Zn T8\*4\*3

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

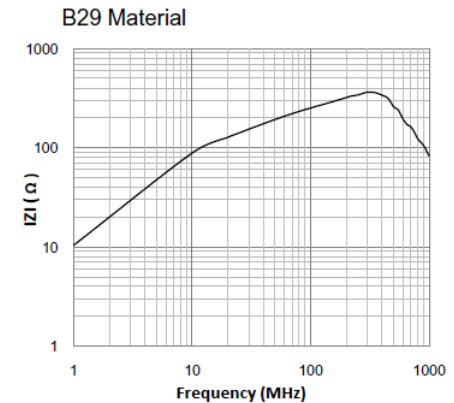
Inductance @10kHz, 1V: 25uH +/-10%

DCR: 0.12 OHM +/-20%

## Saturation Flux Density (Ni-Zn)



## Impedance Vs Frequency Curve (Ni-Zn)



**B.F.**

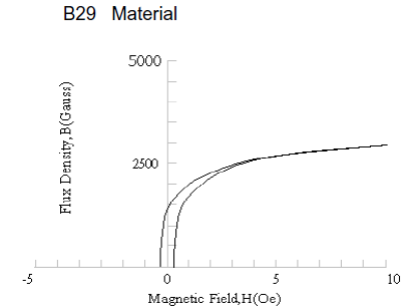
**Contacts Information**  
 Company Name : Bead & Ferrite Electronics (HK) Ltd.  
 Telephone No. : ( 852 ) 2601 0833  
 Fax No. : ( 852 ) 2693 6202  
 Email Address : [bf@bnf.com.hk](mailto:bf@bnf.com.hk)  
 Home Page : [www.bnf.com.hk](http://www.bnf.com.hk)  
 Address : RM. 16-17, 15/F., Block C, Goldfield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

# 9. Common Mode Inductor L6

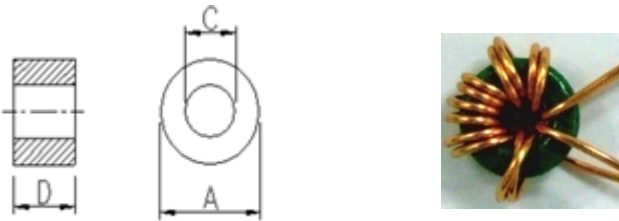
## Properties of B&F Ferrite - Nickel Zinc (Ni-Zn)

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	$1 \cdot 10^7$	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

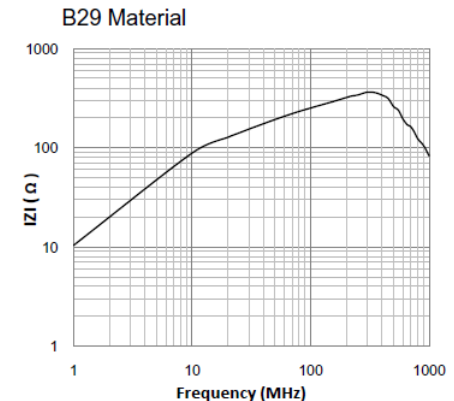
Ferrite core : Ni -Zn T8\*4\*3

Wire gauge: 0.45mm, 6Turns

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

DCR: 0.1 OHM +/-20%

## Impedance Vs Frequency Curve (Ni-Zn)

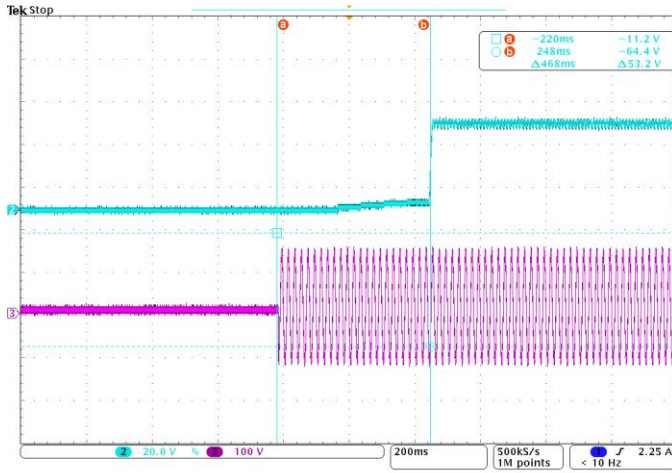


**B.F.**

**Contacts Information**

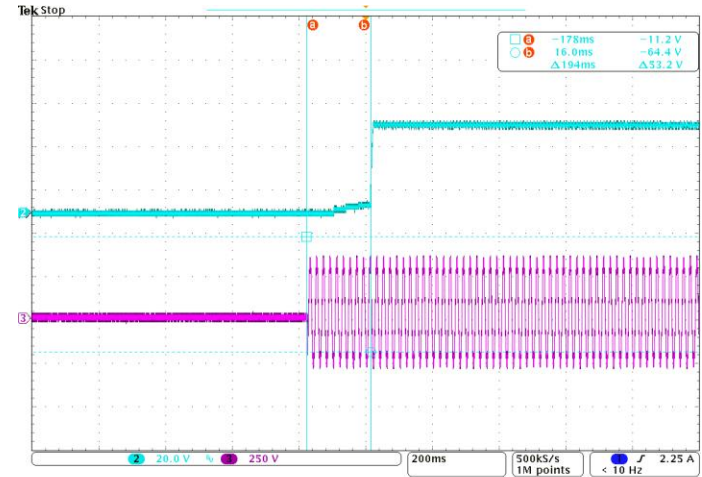
Company Name : Bead & Ferrite Electronics (HK) Ltd.  
 Telephone No. : ( 852 ) 2601 0833  
 Fax No. : ( 852 ) 2693 6202  
 Email Address : [bf@bnf.com.hk](mailto:bf@bnf.com.hk)  
 Home Page : [www.bnf.com.hk](http://www.bnf.com.hk)  
 Address : RM. 16-17, 15/F., Block C, Goldfield Ind. Centre,  
 No.1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

# 10. Start up and turn on delay time



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

$T_{ST\_DELAY} = 468\text{mS}$

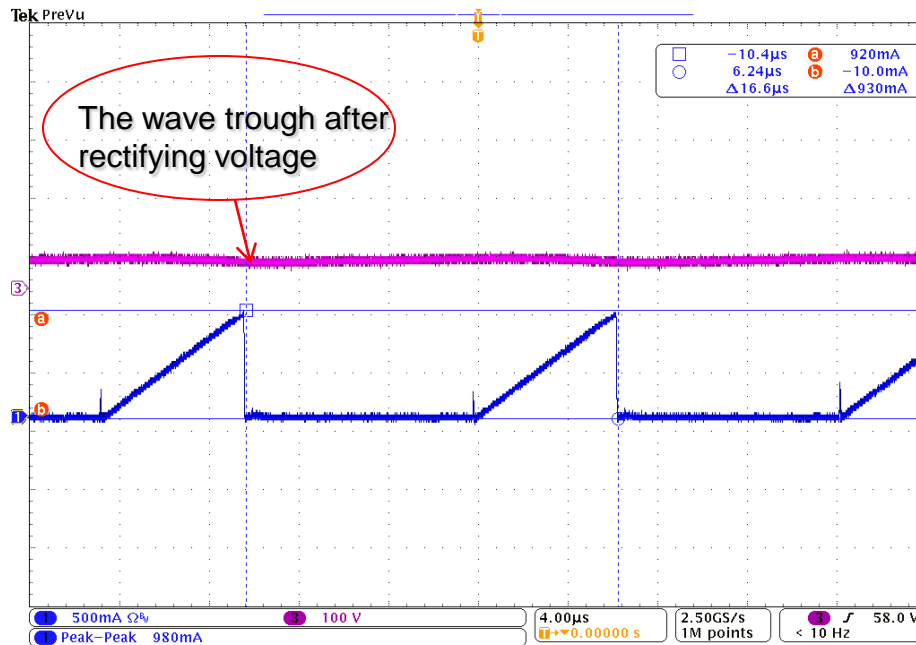


230V<sub>AC</sub>, Full Load

$T_{ST\_DELAY} = 194\text{mS}$

# 11. Transformer Flux Density

( $N_p=40$  Ts,  $L_m=1$  mH,  $A_e=64$  mm<sup>2</sup> ERD26



$I_p$  is monitored at 90Vac and 450mA load

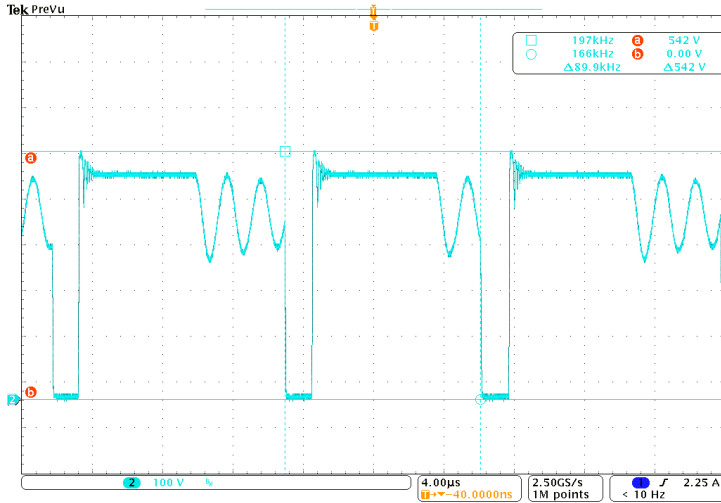
$I_p=0.93$  A

$$B_{MAX} = I_P * L_m / (N_P * A_e)$$

$$= (930 * 1) / (40 * 64)$$

$$= \underline{0.399} \text{ Tesla}$$

## 12. $V_{DS}$ Waveform MOSFET



Test Condition:

$V_{in}=264V_{ac}$ ,  $I_{OUT}=0.45A$

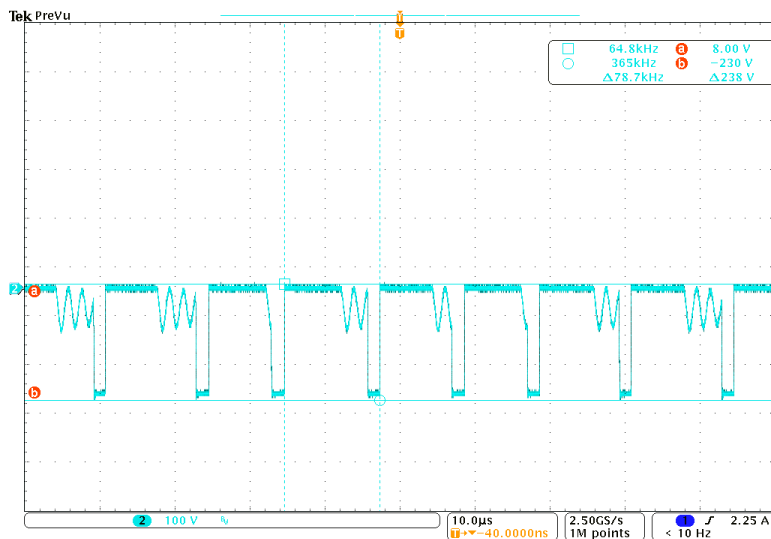
Result:

$V_{DS\_MAX}=542V$

4N60C3

Parameter	Value	Unit
$V_{DS} @ T_{j,max}$	650	V
$R_{DS(on),max}$	0.95	$\Omega$
$Q_{g,typ}$	13	nC
$I_{D,pulse}$	12	A
$E_{oss} @ 400V$	1.3	$\mu J$
Body diode $di/dt$	500	A/ $\mu s$

# 13. $V_R$ waveform Output Diode



Test Condition:

$V_{IN}=264V_{AC}$ ,  $I_{out}=450mA$

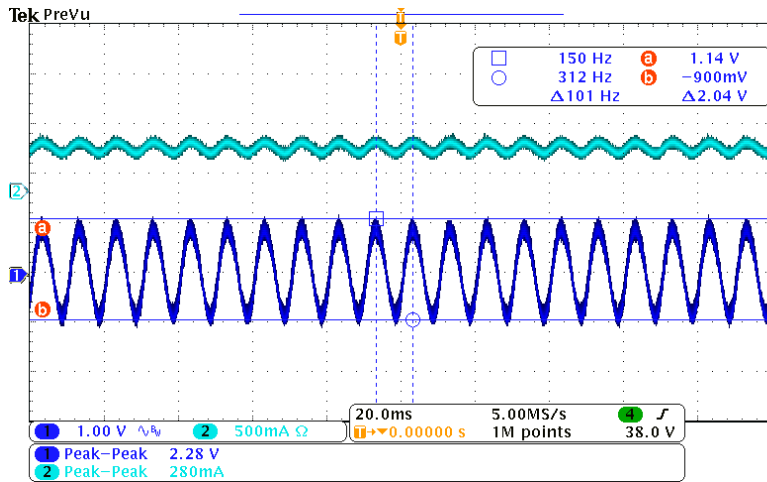
Result:

$V_R$  (pk—pk)=238V

Output rectifier diode: HER605

Type Number	Symbol	HER 601G	HER 602G	HER 603G	HER 604G	HER 605G	HER 606G	HER 607G	HER 608G	Units
Maximum Recurrent Peak Reverse Voltage	$V_{RRM}$	50	100	200	300	400	600	800	1000	V
Maximum RMS Voltage	$V_{RMS}$	35	70	140	210	280	420	560	700	V
Maximum DC Blocking Voltage	$V_{DC}$	50	100	200	300	400	600	800	1000	V
Maximum Average Forward Rectified Current .375 (9.5mm) Lead Length @ $T_A = 55^\circ C$	$I_{(AV)}$	6.0								A
Peak Forward Surge Current, 8.3 ms Single Half Sine-wave Superimposed on Rated Load (JEDEC method)	$I_{FSM}$	150								A
Maximum Instantaneous Forward Voltage @ 6.0A	$V_F$	1.0			1.3		1.7			V
Maximum DC Reverse Current @ $T_A=25^\circ C$ at Rated DC Blocking Voltage @ $T_A=125^\circ C$	$I_R$	10.0 200								uA uA
Maximum Reverse Recovery Time (Note 1)	$T_{rr}$	50				75				nS
Typical Junction Capacitance (Note 2)	$C_j$	80				65				pF
Typical Thermal Resistance (Note 3)	$R_{\theta JA}$	37								$^\circ C/W$
Operating Temperature Range	$T_J$	-65 to +150								$^\circ C$
Storage Temperature Range	$T_{STG}$	-65 to +150								$^\circ C$

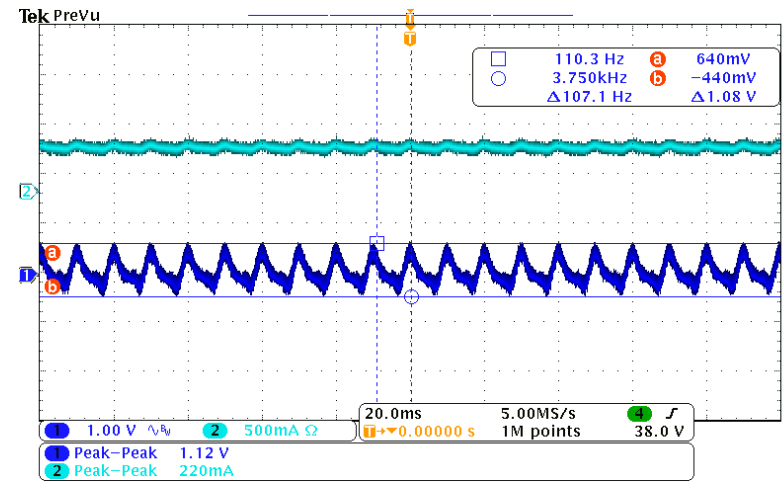
# 14. Voltage ripple and Current ripple



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

CH1:current ripple 280mA (PK-PK)

CH2:voltage ripple 2.28V (PK-PK)

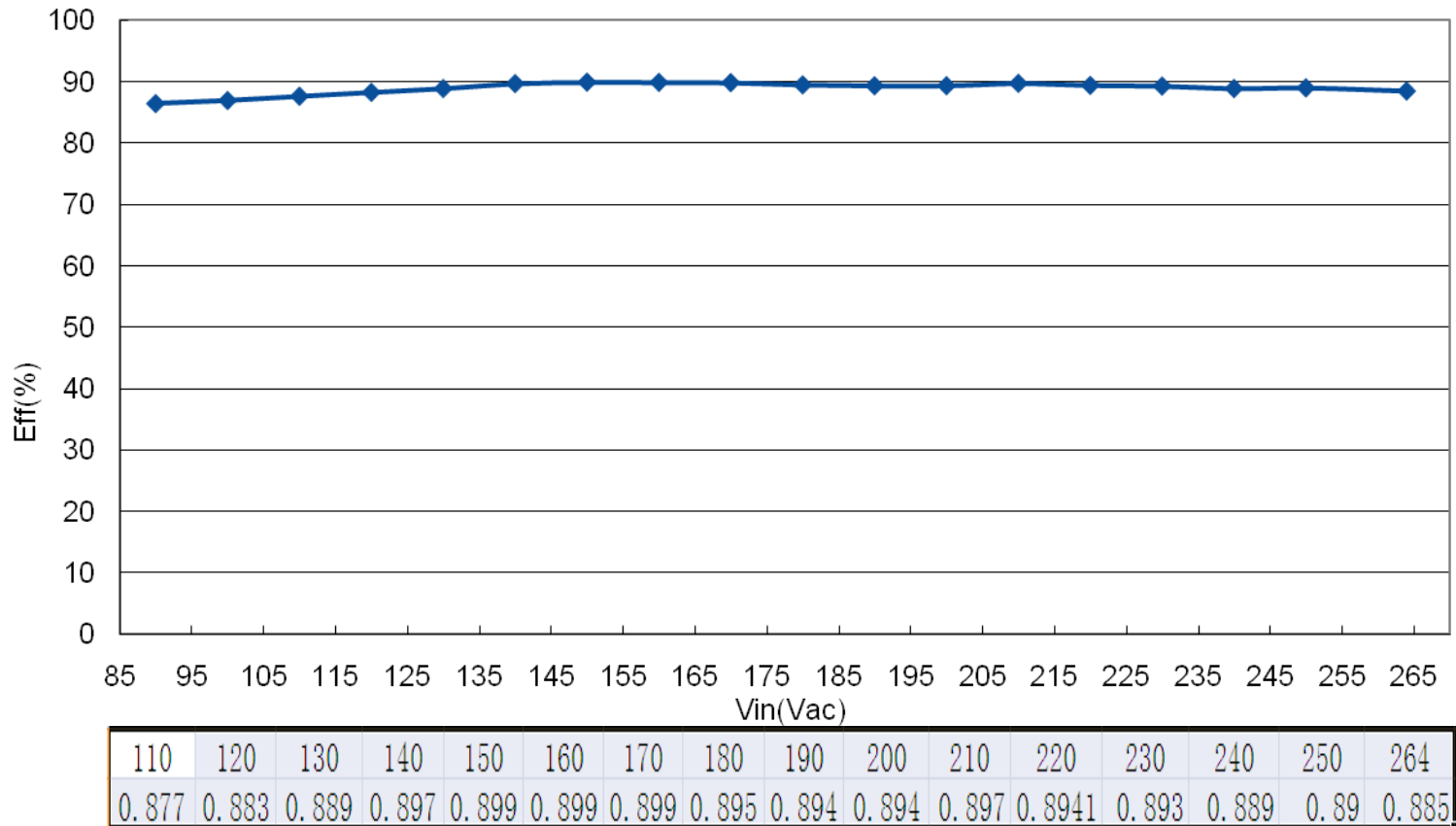


230V<sub>AC</sub>, Full Load

CH1:current ripple 220mA (PK-PK)

CH2:voltage ripple 1.12V (PK-PK)

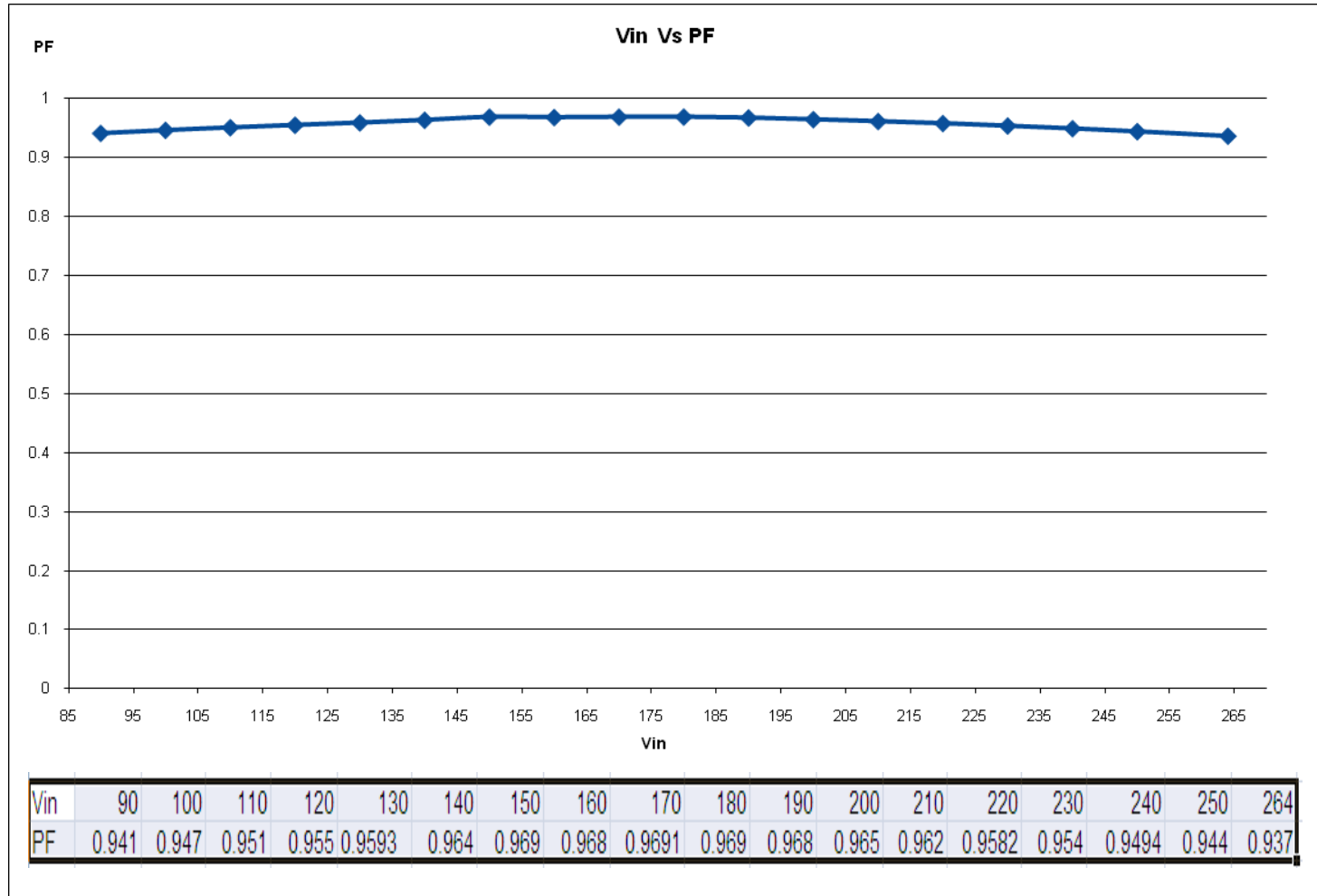
# 15. Efficiency Measurement



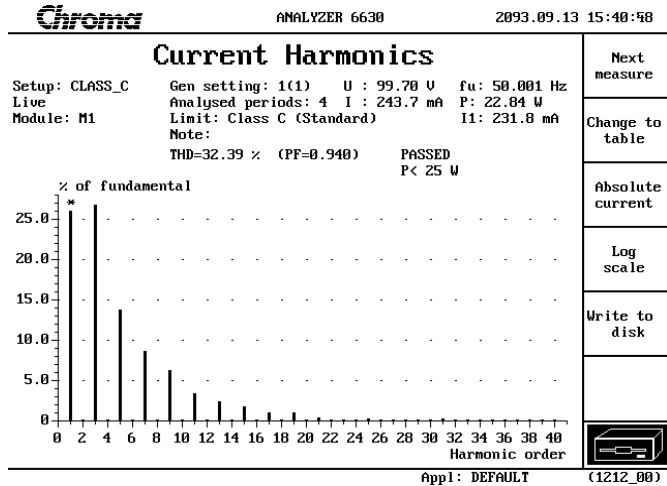
**\* Note: Output voltage measured at end of PCB.**



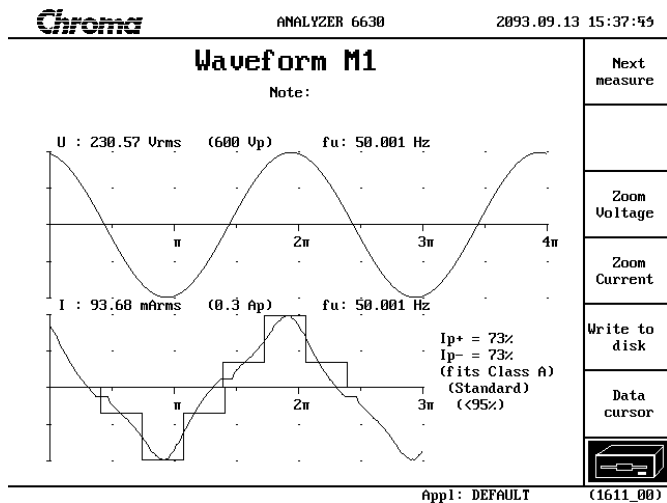
# 16. Input voltage VS Power Fact curve



# 17 . Harmonic and current waveform\_ No dimmer \_3620

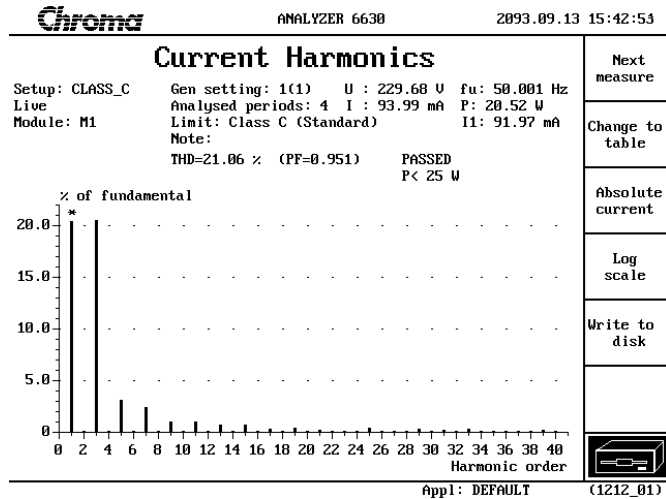


Harmonics current @100Vac  
Meet IEC61000-3-2 requirement

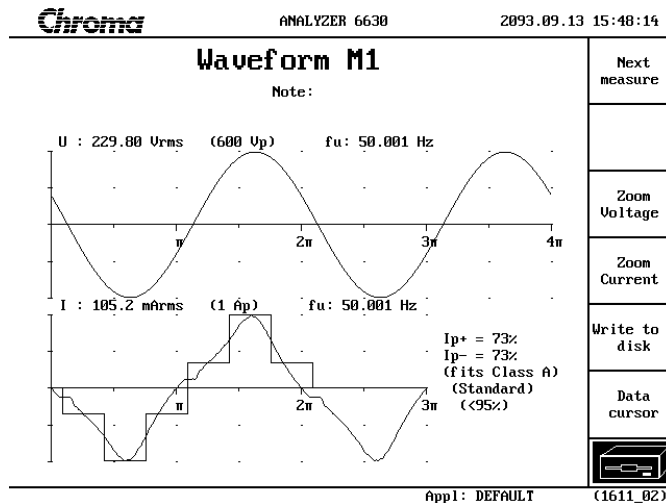


Ac current waveform @100Vac  
PF=0.948

# 18 . Harmonic and current waveform\_ No dimmer \_3620

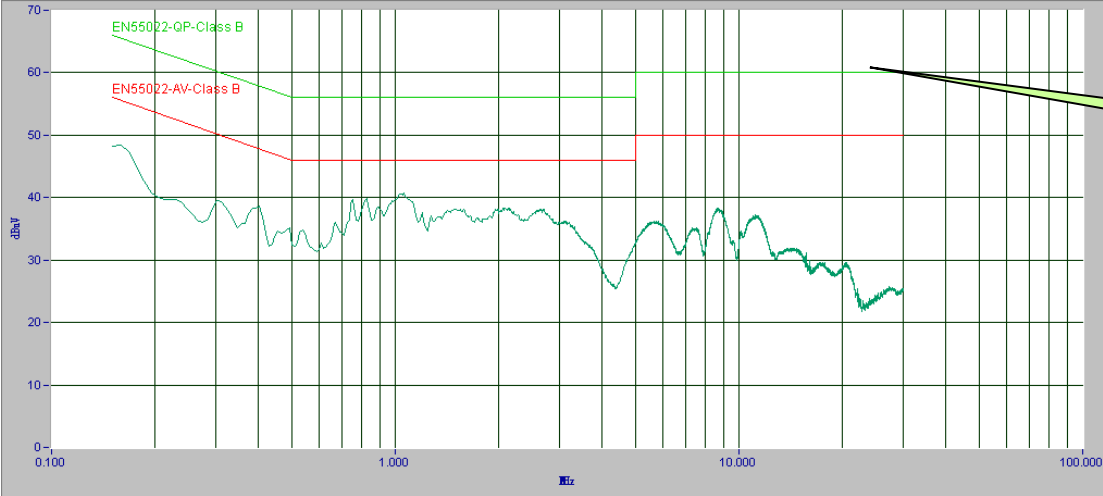


Harmonics current @230Vac  
Meet IEC61000-3-2 requirement



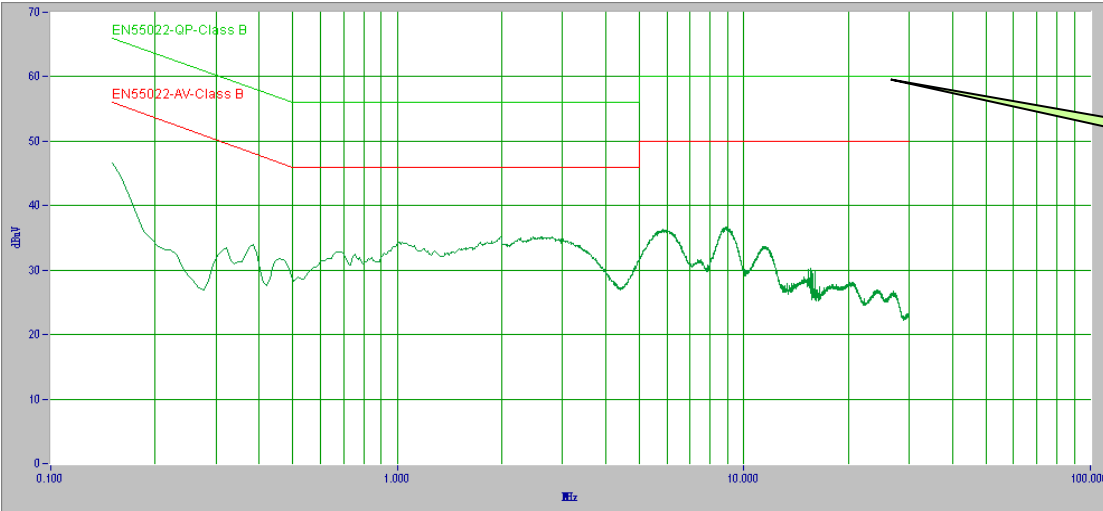
Ac current waveform @230Vac  
PF=0.951

# 19. Conducted EMI ( Input 90Vac Full Load, output floating )



Peak Scan QP Limit line

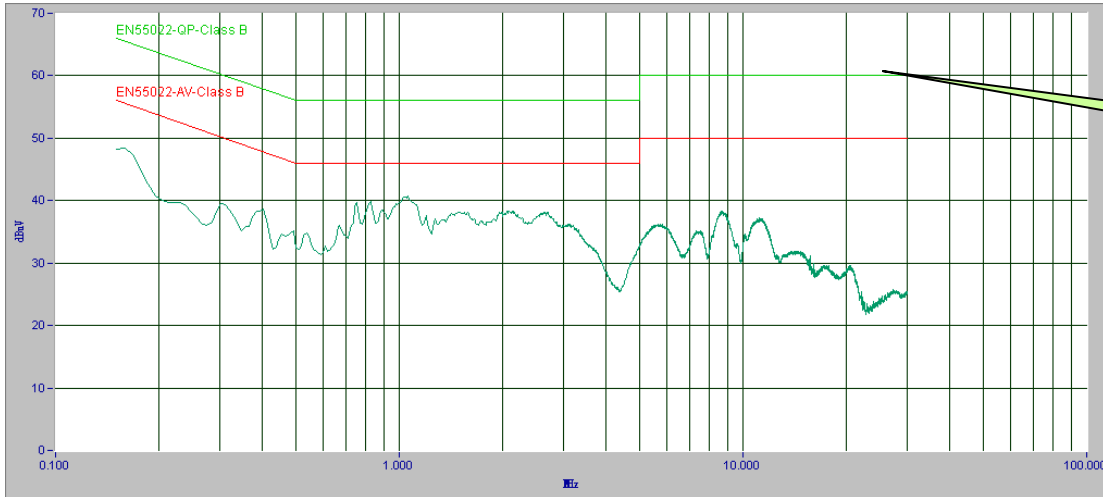
Peak scan N



Peak Scan QP Limit line

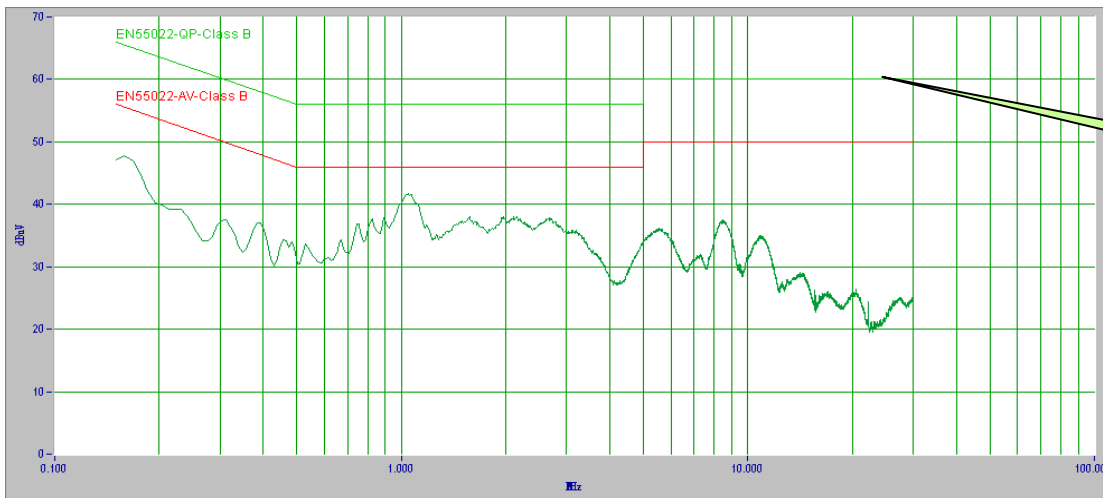
Peak scan L

# 20. Conducted EMI ( Input 230Vac Full Load, output floating )



Peak Scan  
QP Limit line

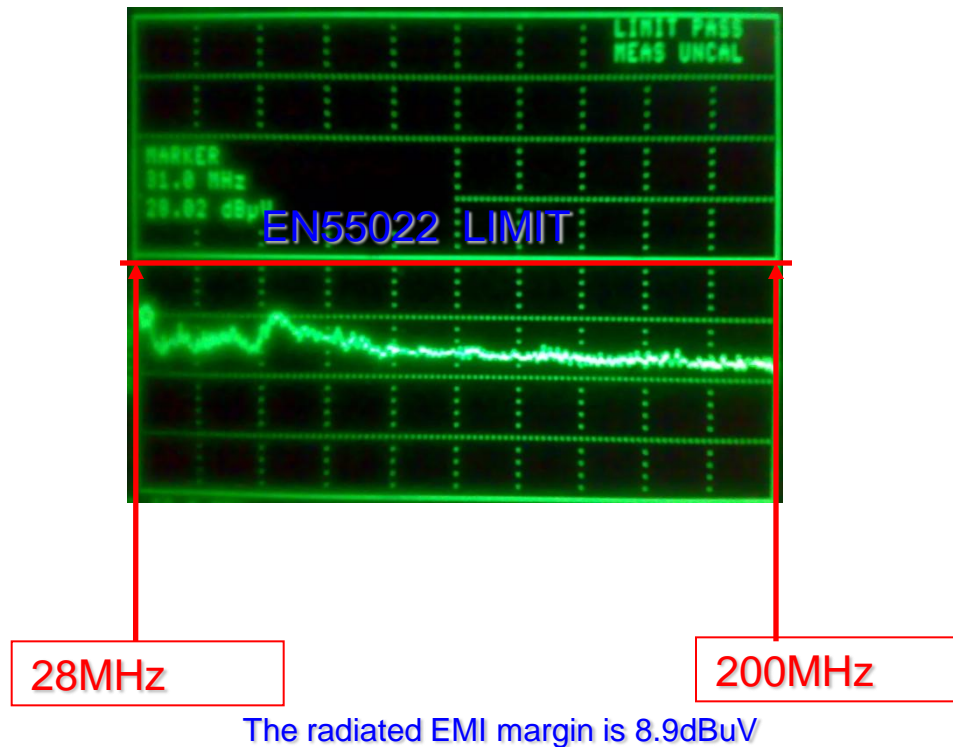
Peak scan N



Peak Scan  
QP Limit line

Peak scan L

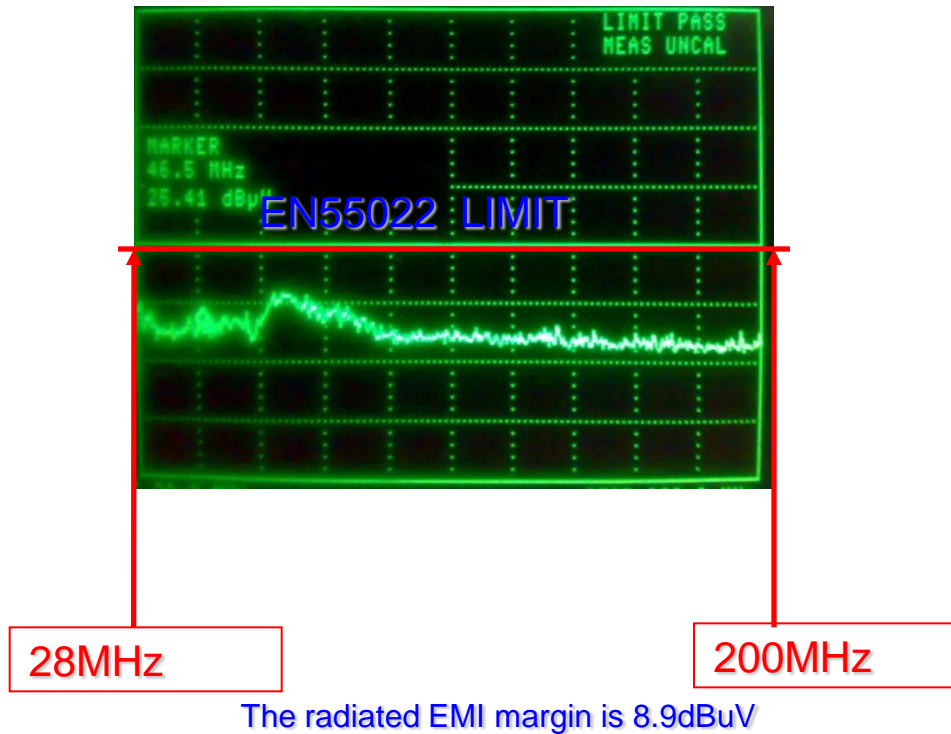
## 21. Radiated IEM (for reference) 115Vac



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

2, Output is floating, with LED load

## 22. Radiated IEM (for reference) 230Vac



Note: 1,  $V_{in}=230Vac$

2, Output is floating, with LED load