# Design Example Report

| | |
|---|---|
| **Title** | **Standalone LED Driver Demo Board Engineering report** |
| **Specification** | Input：90Vac ~ 305Vac， 47-63Hz<br><br>Output：48V@1A |
| **Application** | LED tube, Waterproof LED driver, Downlight |
| **Author** | Leo Liang<br><br>Leo.liang@infineon.com |
| **Date** | Sep 26, 2014 |
| **Revision** | Rev1 |

# 1. Introduction

This document describes the performances of a 48W evaluation board, with wide range operation voltage for input/output and power factor correction. The demo board is used a single stage PFC solution that can providing a quite PFC function. The demo board is designed for a universal input LED Driver solution based on TDA4863.

This demo board utilizes a common CRM PFC IC and a current transformer to control a traditional Flyback topology which can get high efficiency and reduces the components count a lot. The topology operates at a various frequency with the input voltage, which ensure the input current to follow the input voltage and improve the PF value. This demo board optimized the ratio of performance and price, design is quite easy. The demo board mainly utilized IC and Cool MOSFET (TDA4863-2,SPA08N80C3) from Infineon.

# 2. Power supply specification:

| Description | | Symbol | Min | Typ. | Max | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Input | Voltage | Vin | 85 | 110/240 | 305 | Vac | |
| | Frequency | Flin | 47 | 50/60 | 63 | Hz | |
| | PowerFactors | PF | 0.9 | 0.95 | | | Full load |
| Output | Voltage | Vo | 24 | 30 | 48 | V | |
| | Current | Io | | 1000 | | mA | |
| | Power | Po | | | | W | |
| | Ripple | r-pp | | +/-50% | | mA | |
| Efficiency | | η | | 88 | | % | Full load |

**Finished assembly**

# 3. Electrical requirements

**Input Characteristics**

**a. AC Input Voltage**

The power will operate over the entire input voltage range (85-305 VAC).

| Minimum | Maximum | Nominal/Rated |
|---|---|---|
| 85 VAC | 305 VAC | 100-240 VAC |

**b. Frequency**

The input frequency range will be 47Hz to 63Hz.

**c. Input Current**

The input current will not exceed 0.5Amp(rms.) for 85 VAC.

**d. Efficiency**

The power efficiency (watts output/watts input) will not be less than 88% typically at full load condition (230VAC)

**e. PF/Harmonics**

PF>0.9 @ 50% load and above

Harmonics should follow EN61000-3-2 Class C, THD will not be more than 15% at full load condition(230Vac) and THD will be less than 10% at 110Vac full load condition.

**3. Output Characteristics**

**a. DC Load Characteristics**

| Output Voltage | Minimum Current | Maximum Current |
|---|---|---|
| ☒24-48V | 0.1A | 1A (TBD) |

**b. Constant Current Regulation**

<= +/-5% over whole input/output voltage range

c. Ripple current (Peak to Peak)

<= +/-50%

**4. Protection:**

**a. Primary (Input) Protection**

The input power line will be fused with a fuse 2A / 250 VAC.

**b. Secondary (Output) protection**

**b.1 Over Voltage (OV) Protection**

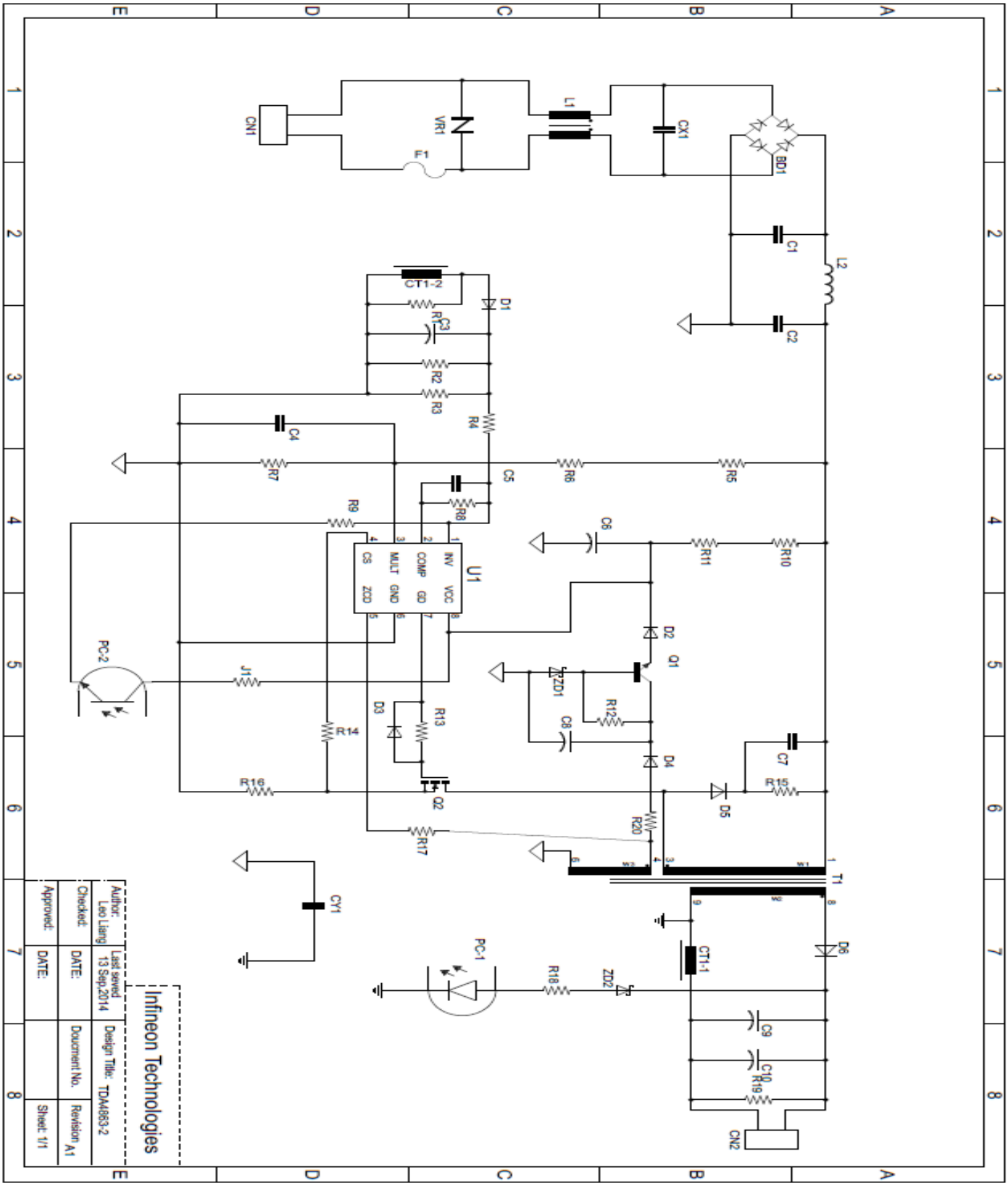
If an over-voltage fault occurs on the power output, the power will shut down when Vo reaches 120% of rated and restart. Output voltage should be below 60V in any cases.

**b.2 Short Circuit Protection**

The power will protect itself, and shut down, if a short circuit is placed between DC return and the output. This condition will cause no damage to the power. Power latch is not allowed.

**b.3 Over Power (OP) Protection**

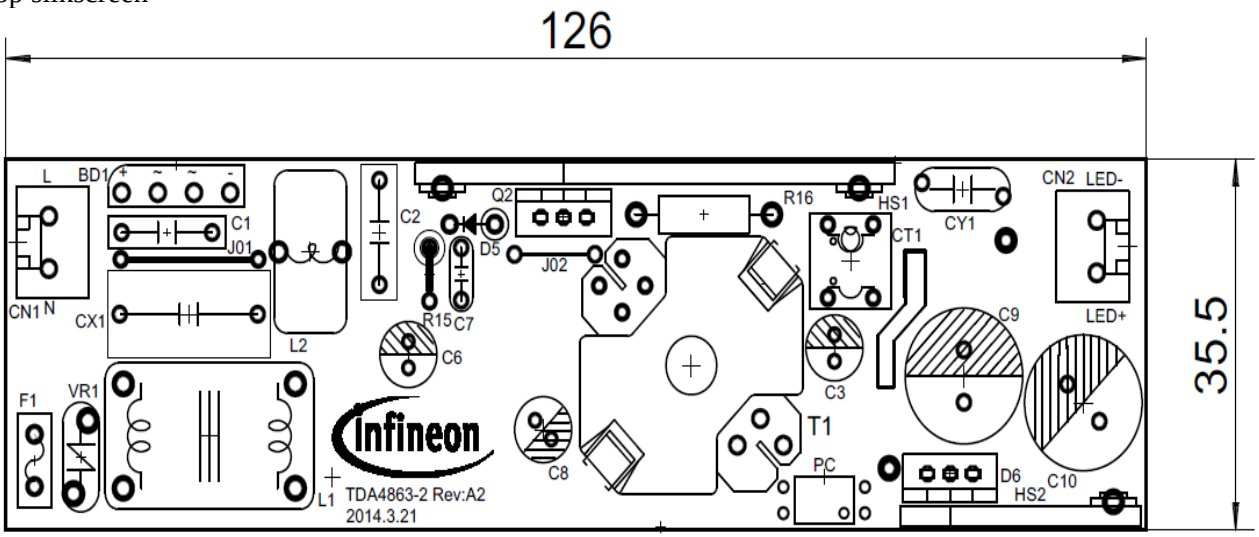
# 4. Schematic:


CN1
VR1
F1
L1
CX1
BD1
C1
L2
C2
CT1-2
D1
R1
C3
R2
R3
R4
C4
R7
C5
R6
R5
R8
R9
C6
R11
R10
U1
INV
VCC
COMP
GD
MULT
GND
CS
ZCD
D2
Q1
PC-2
J1
ZD1
R12
C8
D3
R13
R14
D4
C7
R16
Q2
R15
D5
R17
R20
T1
CY1
PC-1
R18
ZD2
CT1-1
D6
C9
C10
R19
CN2
Author: Leo Liang
Last saved 13 Sep.2014
Checked:
DATE:
Approved:
DATE:
Design Title: TDA4863-2
Document No.
Revision A1
Sheet 1/1
Infineon Technologies

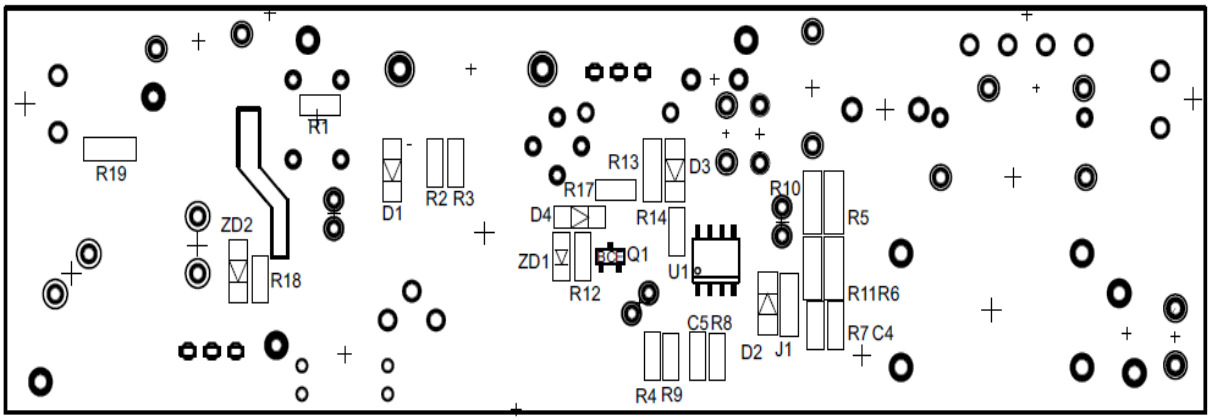
# PCB Layout

This PCB is single side board made of FR4 with 1Oz copper.(unit mm)

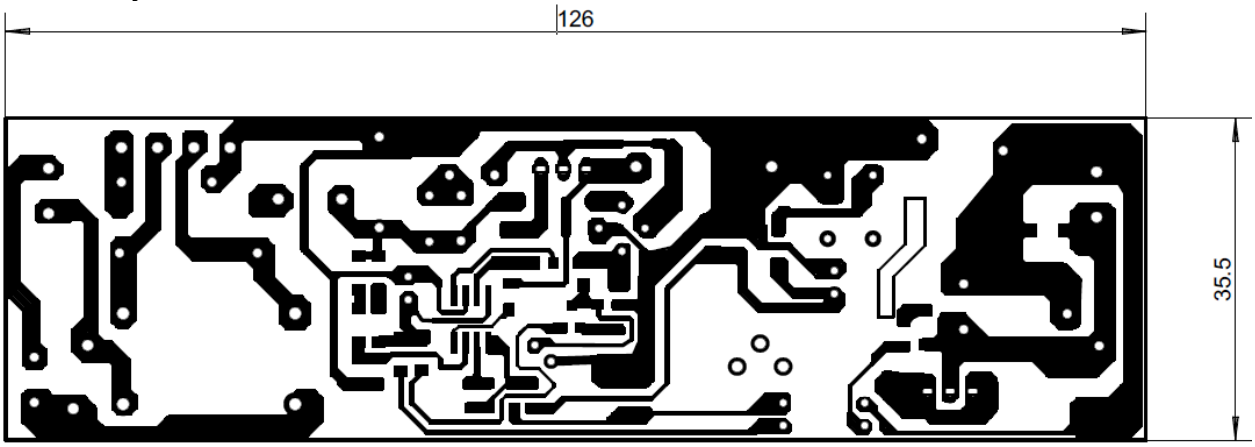
Top silkscreen




Bottom silkscreen




Bottom layer



# 5. Transformer specification

## 6.1.1 T1 Spec

**Magnetic core : PC40**

**Bobbin :RM10**

2.PARTS LIST

| NO. | NAME | MATERIALS & DIMENSIONS | MANUFACTORY | UL FILE |
|---|---|---|---|---|
| 1 | BOBBIN | PHENOLIC T375J UL 94V-0 | CHANG CHUN PLASTIC CO LTD. | E59481 |
| 2 | CORE | PC40 RM10 | JINNING RADIO APPLIANCE FACTORY<br>WUXI SPINEL MAGNETICS CO LTD | |
| 3 | WIRE | Polyurethane enanelled copper wire 2UEW ø0.25 | FOSHAN CITY WELLKEY ELECTRIC MATERIAL CO LTD<br>SHENZHEN CHENGWEI INDUSTRIAL CO LTD | E211138<br>E227475 |
| | | Triple Insulated Wire TEX-E ø0.50 | FURUKAWA ELECTRIC CO LTD | |
| 4 | INSULATION TAPE | (Polyethylene terephthalate film tape) CT with suffixes,rated 130°C(c) material Group I,PLC=0,CTI equal to or greater than 600V | JINGJIANG YAHUA PRESSURE SENSITIVE GLUE CO LTD. | E165111 |
| 5 | TUBE | TFL | GREAT HOLDING INDUSTRIAL CO LTD | E156256 |
| 6 | TERMINAL | COPPER WIRE ø | | |
| 7 | Varnish | CC-1105 130°C | John C Dolph co.Ltd | E317427 |

3.ELECTRICAL SPECIFICATION.

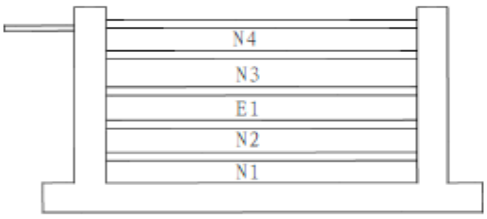
| NO. | ITEMS | MEASURING PLACES | STANDARDS | CONDITION | NOTES |
|---|---|---|---|---|---|
| 1 | INDUCTANCE | 3--1 | 370uH±10% | f=100KHz T=20°C Vo=1V | CH102LCR |
| 2 | LEAKAGE INDUCTANCE | 3--1 ( SHORT FLY1-FLY2 ) | 15uHMAX | | |
| 3 | INDUCTANCE SATURATION | 3--1 | Ldc/L0>80% | 100°C Idc=1.8A | CH102 LCR CH1310 |
| 4 | DC RESISTANCE | 3--1 | 200m-ohmMAX | T=20°C | YY2511 |
| 5 | INSULATION RESISTANCE | PRI. - SEC. COIL - CORE | 100M-ohm MIN | DC 500V | CH9072A |
| 6 | DIELECTRIC STRENGTH | PRI. - SEC. | NO BREAKDOWN | AC 3.75KV 1mA 50Hz 3s | CJ2670 |
| | | PRI. - CORE | | AC 0.8KV 1mA 50Hz 3s | |
| | | SEC. - CORE | | AC 2.2KV 1mA 50Hz 3s | |

4.CONNECTIONS.

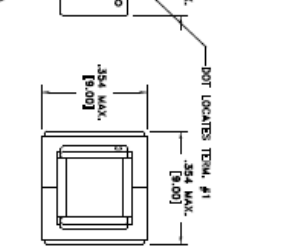

5.WINDING SPECIFICATION.

| NO. | COIL | TERMINAL | WIRE | TURNS | WINDING METHED | WINDING LAYER | TOP BARRIER TAPE | BOTTOM BARRIER TAPE | WINDING TAPE |
|---|---|---|---|---|---|---|---|---|---|
| 1 | N1 | 4--6 | 2UEW ø0.20 | 9Ts | FIT | 1 | | | 0.05/11.0/2Ts |
| 2 | N2 | 3--2 | 2UEW ø0.25X3 | 26Ts | FIT | 2 | | | 0.05/11.0/2Ts |
| 3 | E1 | 6-- | FOIL 0.05X8 | 1.1Ts | FIT | 1 | | | 0.05/11.0/2Ts |
| 4 | N3 | FA--FB | TEX-E ø0.50 | 17Ts | FIT | 2 | | | 0.05/11.0/2Ts |
| 5 | N4 | 2--1 | 2UEW ø0.25X3 | 12Ts | FIT | 1 | | | 0.05/11.0/2Ts |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

6.CONSTRCTIONS



| CUSTOMER TERMINAL | RoHS | LEAD(Pb)-FREE |
|---|---|---|
| Sn96%, Ag4% | Yes | Yes |




Wurth Elektronik — more than you expect

## ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted:

| PARAMETER | | TEST CONDITIONS | VALUE |
|---|---|---|---|
| D.C. RESISTANCE | 3-1 | @20°C | 2.73 Ohms max |
| INDUCTANCE | 3-1 | 10kHz, 100mVAC, Ia | 5.0 mH min |
| DIELECTRIC | 3-CORE | 1500VAC, 1 second | - |

GENERAL SPECIFICATIONS:
OPERATING TEMPERATURE RANGE: -40°C to +125°C.

Wire insulation & RoHS status not affected by wire color.
Wire insulation color may vary depending on availability.

| REV. | DATE | Packaging Specifications |
|---|---|---|
| | | Method: Tray |
| | | PKG-0542 |
| | | www.we-online.com/midcom |
| 01 | 6/12 | |
| 00 | 5/7 | |

SEE REVISION SHEET FOR REVISION LEVEL

Tolerances unless otherwise specified:
Angles: ±1° Decimals: ±.005 [.13]
Fractions: ±1/64 Footprint: ±.001 [.03]
This drawing is dual dimensioned. Dimensions in brackets are in millimeters.

DRAWING TITLE: INDUCTOR COUPLED

eiSos p/n: 750342390

PART NO. 750342390

RoHS

SPECIFICATION SHEET 1 OF 1

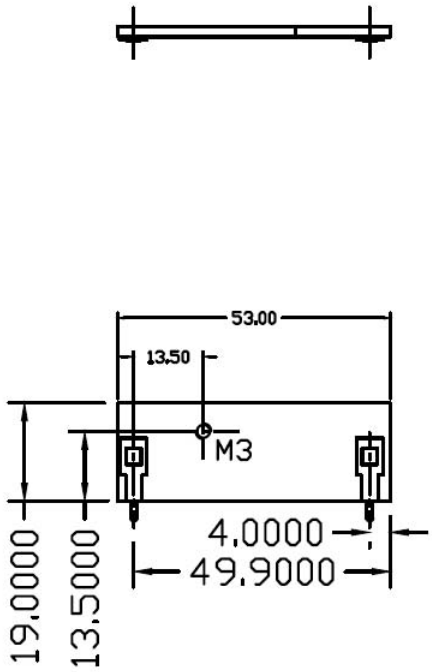
## 5.Part List:

| No. | Name | Material | Spec | Manufacture | UL File No. |
|---|---|---|---|---|---|
| 1 | Bobbin | Phenolic T375J | | Changchun Plastics Co.,Ltd. | E59481 |
| 2 | Tape | Mylar Tape | PZ | Jingjiang Pressure Sensitive Glue Factory | E165111 |
| 3 | Core | Mn-Zn Ferrite | EE8.3 T10K | TDG | |
| 4 | Wire | Polyurethane Enanelled Copper Wire 130°C | 0.13mm DIA | Shenzhen Chengwel Industrial Co Ltd | E227475 |
| | | | | | |

## 6.Electrical Specification:

| No. | Item | Measuring Places | Standards | Conditions | Notes |
|---|---|---|---|---|---|
| 1 | Inductance | L1:3--4 | 2.0~15.0mH | 1kHz 0.3Vrms | CH102 LCR or Equivalent |
| | | | | | |
| 2 | Inductance Diferencn | | | | |
| 3 | DC Resistance | 3--4 | 3200m-ohm Max | T=20 C | YY2511 DCR or Equivalent |
| | | | | | |
| 4 | Insulation Resistance | Coil--Coil | 100M-ohm Min | DC 500V | RCJ-3 or Equivalent |
| | | Coil--Core | | | |
| | | | | | |

# 7.Heat Sink




技术要求：表面平整，无毛刺.
材质：铝　T=2.0mm.
孔与定位孔的尺寸公差在±0.2 之内，
其余的在±0.5。

## 8.Bill Of Material

| Part | Value | Device | Package | Description | Quantity |
|---|---|---|---|---|---|
| BD1 | 2A/600V | KBP206 | KBP | bridge rectifier | 1 |
| C1 | 104/450V | | MPF13*3.6 | Film capacitor | 1 |
| C2 | 334/450V | | MPF13*4 | Film capacitor | 1 |
| C3,C8 | 47U/50V | | E-CAP-6.3-V | E-CAP | 2 |
| C4 | 103/25V | | 0805-S | SMD-CAP | 1 |
| C5 | 1uF/25V | | 0805-S | SMD-CAP | 1 |
| C6 | 10U/50V | | E-CAP-6.3-V | E-CAP | 1 |
| C7 | 102/1KV | | CAP1 | ceramic capacitor | 1 |
| C9,C10 | 470UF/63V | | E-CAP-13 | E-cap | 2 |
| CT1 | EE8.3 | EE8.3 (750342390) | EE8.3-A (Wurth) | current transformer | 1 |
| CX1 | 0.22/305VC | | Pin 15mm | X CAPACITOR | 1 |
| CY1 | 222M | | Pin 10mm | Y CAPACITOR | 1 |
| D1-D4 | BAV21 | | 1206-D | general purpose diode | 4 |
| D5 | 1A/1000V | 1N4007 | DO-41-V-P5 | general purpose diode | 1 |
| D6 | 10A/200V | STTH1002CT | TO-220 | Ultra-fast recovery diode | 1 |
| F1 | 2A/250V | | 3*15 | Fuse | 1 |
| J1 | 0R | | 1206-S | SMD-jumper | 1 |
| J01 | | | P=15mm | DIP-jumper | 1 |
| J02 | | | 8.7mm | DIP-jumper | 1 |
| L1 | 33mH | CM | CM-7503416X | CM incuctor (Wurth) | 1 |
| L2 | 330uM | DM | R-17*8-1 | DM incuctor | 1 |
| Q1 | 2N3904 | 2N3904 | SOT23 | transistor | 1 |
| Q2 | 8A/800V | SPA08N80C3 | TO-220 | POWER MOSFET | 1 |
| R1 | 6.8K | | 0805-S | SMD-resistor | 1 |

| | | | | | |
|---|---|---|---|---|---|
| R2,R3 | 499R | | 0805-S | SMD-resistor | 2 |
| R4 | 8.2K | | 0805-S | SMD-resistor | 1 |
| R5,R6 | 1.5M | | 1206-S | SMD-resistor | 2 |
| R7 | 22K | | 0805-S | SMD-resistor | 1 |
| R8 | 51K | | 0805-S | SMD-resistor | 1 |
| R9 | 33K | | 0805-S | SMD-resistor | 1 |
| R10,R11 | 200K | | 1206-S | SMD-resistor | 2 |
| R12 | 4.7K | | 0805-S | SMD-resistor | 1 |
| R13 | 100R | | 1206-S | SMD-resistor | 1 |
| R14 | 0R | | 0805-S | SMD-resistor | 1 |
| R15 | 200K | | RES-1W | DIP-resistor | 1 |
| R16 | 0.075R | | R-DIP-1W | DIP-resistor | 1 |
| R17 | 68K | | 0805-S | SMD-resistor | 1 |
| R18 | 3K | | 0805-S | SMD-resistor | 1 |
| R19 | 30K | | 1206 | SMD-resistor | 1 |
| R20 | 68R | | 1206 | SMD-resistor | 1 |
| T1 | RM10 | RM10-8RM10-8 | RM10 | Transformer | 1 |
| CON1,CON2 | CON-21 | | 2PINCON-5MM | connector | 2 |
| PC1 | PC817 | PC817 | DIP4 | opto-coupler | 1 |
| U1 | TDA4863-2 | TDA4863-2 | SO08 | PFC controller(infineon) | 1 |
| VR1 | 7D561 | VARESISTOR1 | VARSITOR | VARSITOR | 1 |
| ZD1 | 18V | | 0805-D | Zener diode | 1 |
| ZD2 | 52V | | 1206-D | Zener diode | 1 |
| HS1 | | | | heat sink | 1 |

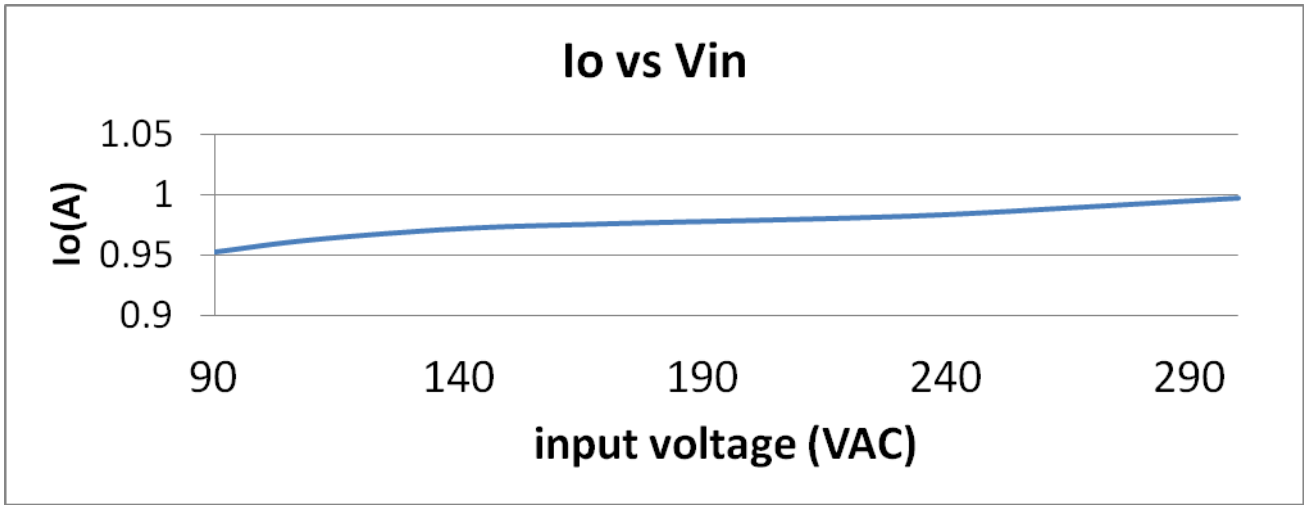
# 9.Test results

Test equipment :AC source 6415, power meter WT210, Fluke 87, LED Driver tester LT-101A

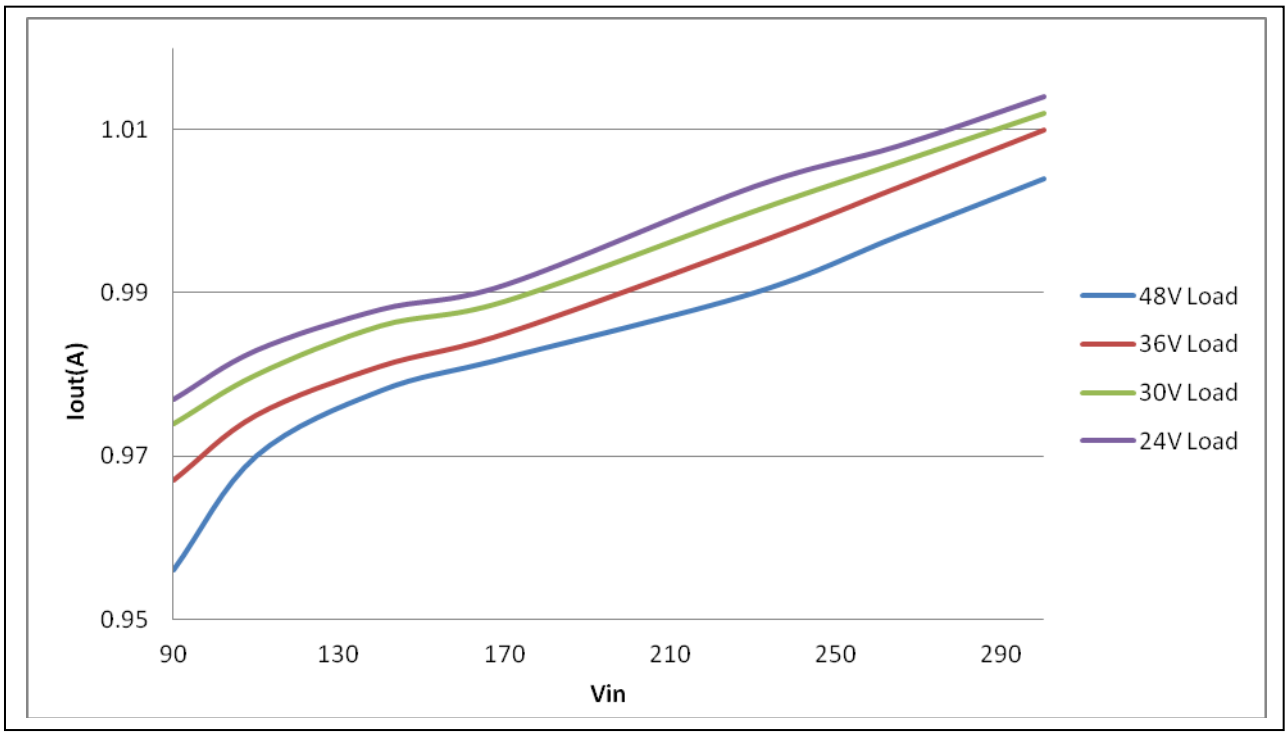
| **48V Output** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Vin** | **Pin** | **PF** | **Vo** | **Io** | **Eff.** | **Tolerance** | **iTHD** |
| 90 | 50.95 | 0.998 | 47.58 | 0.953 | **89.00%** | -4.70% | |
| 110 | 51.5 | **0.99** | 47.827 | 0.963 | **89.43%** | -3.70% | |
| 140 | 51.89 | 0.999 | 48.1 | 0.972 | **90.10%** | -2.80% | |
| 170 | 52.13 | **0.998** | 48.172 | 0.976 | **90.19%** | -2.40% | |
| 230 | 52.64 | 0.992 | 48.33 | 0.982 | **90.16%** | -1.80% | |
| 265 | 53.29 | **0.985** | 48.513 | 0.989 | **90.03%** | -1.10% | |
| 300 | 54.04 | 0.975 | 48.706 | 0.997 | **89.86%** | -0.30% | |
| **36V Output** | | | | | | | |
| **Vin** | **Pin** | **PF** | **Vo** | **Io** | **Eff.** | **Tolerance** | **iTHD** |
| 90 | 40.06 | 0.998 | 36.945 | 0.96 | **88.54%** | -4.00% | |
| 110 | 40.33 | 0.998 | 37.163 | 0.97 | **89.38%** | -3.00% | |
| 140 | 40.52 | 0.998 | 37.3 | 0.976 | **89.84%** | -2.40% | |
| 170 | 40.73 | 0.995 | 37.373 | 0.98 | **89.92%** | -2.00% | |
| 230 | 41.3 | 0.984 | 37.54 | 0.988 | **89.81%** | -1.20% | |
| 265 | 41.89 | 0.973 | 37.678 | 0.995 | **89.50%** | -0.50% | |
| 300 | 42.5 | 0.957 | 37.817 | 1 | **88.98%** | 0.00% | |
| **30V Output** | | | | | | | |
| **Vin** | **Pin** | **PF** | **Vo** | **Io** | **Eff.** | **Tolerance** | **iTHD** |
| 90 | 33.07 | 0.998 | 30.21 | 0.966 | **88.25%** | -3.40% | |
| 110 | 33.2 | 0.999 | 30.35 | 0.975 | **89.13%** | -2.50% | |
| 140 | 33.32 | 0.998 | 30.438 | 0.979 | **89.43%** | -2.10% | |
| 170 | 33.48 | 0.99 | 30.493 | 0.983 | **89.53%** | -1.70% | |
| 230 | 34.1 | 0.976 | 30.654 | 0.991 | **89.09%** | -0.90% | |
| 265 | 34.56 | 0.96 | 30.759 | 0.997 | **88.73%** | -0.30% | |
| 300 | 35.07 | 0.938 | 30.861 | 1.003 | **88.26%** | 0.30% | |
| **24V Output** | | | | | | | |
| **Vin** | **Pin** | **PF** | **Vo** | **Io** | **Eff.** | **Tolerance** | **iTHD** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 90 | 26.78 | 0.998 | 24.388 | 0.971 | **88.43%** | -2.90% | |
| 110 | 27.03 | 0.998 | 24.475 | 0.978 | **88.56%** | -2.20% | |
| 140 | 27.14 | 0.997 | 24.539 | 0.982 | **88.79%** | -1.80% | |
| 170 | 27.29 | 0.985 | 24.585 | 0.986 | **88.83%** | -1.40% | |
| 230 | 27.85 | 0.964 | 24.728 | 0.996 | **88.43%** | -0.40% | |
| 265 | 28.17 | 0.94 | 24.802 | 1 | **88.04%** | 0.00% | |
| 300 | 28.38 | 0.908 | 24.877 | 1.006 | **88.18%** | 0.60% | |

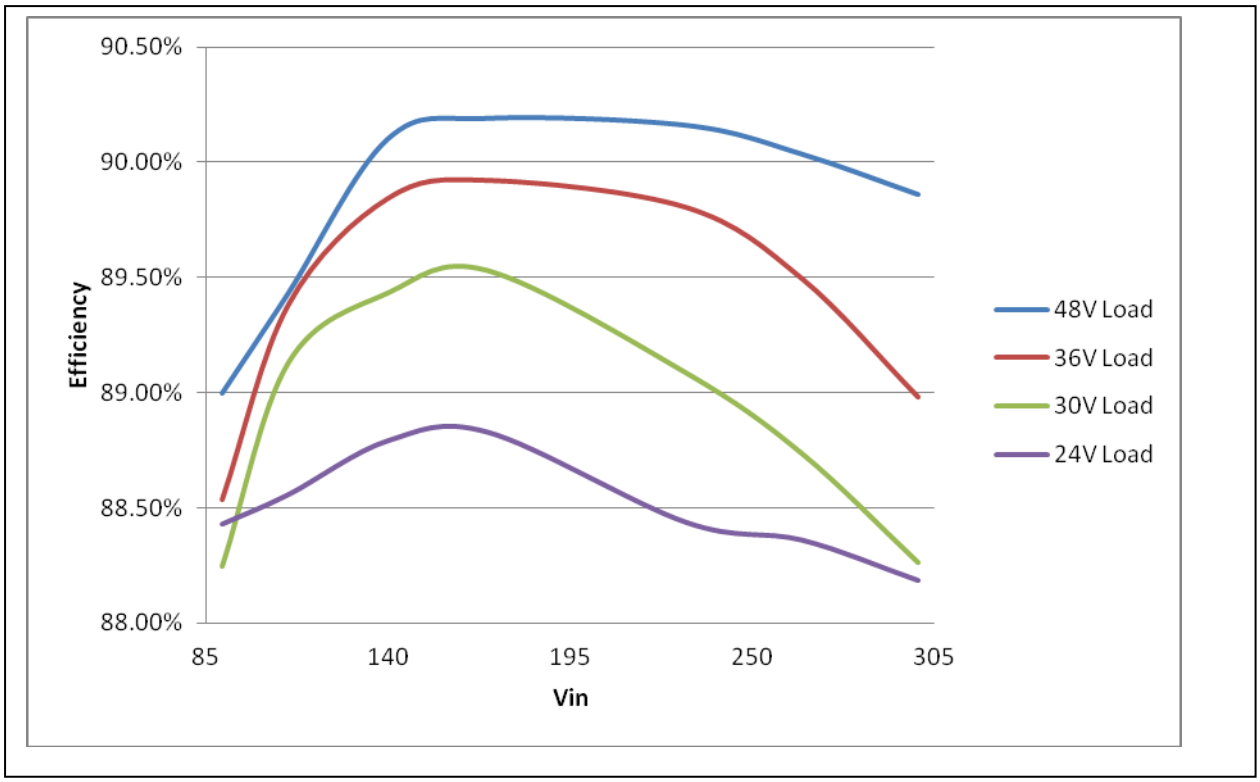
## 10.Line Regulation



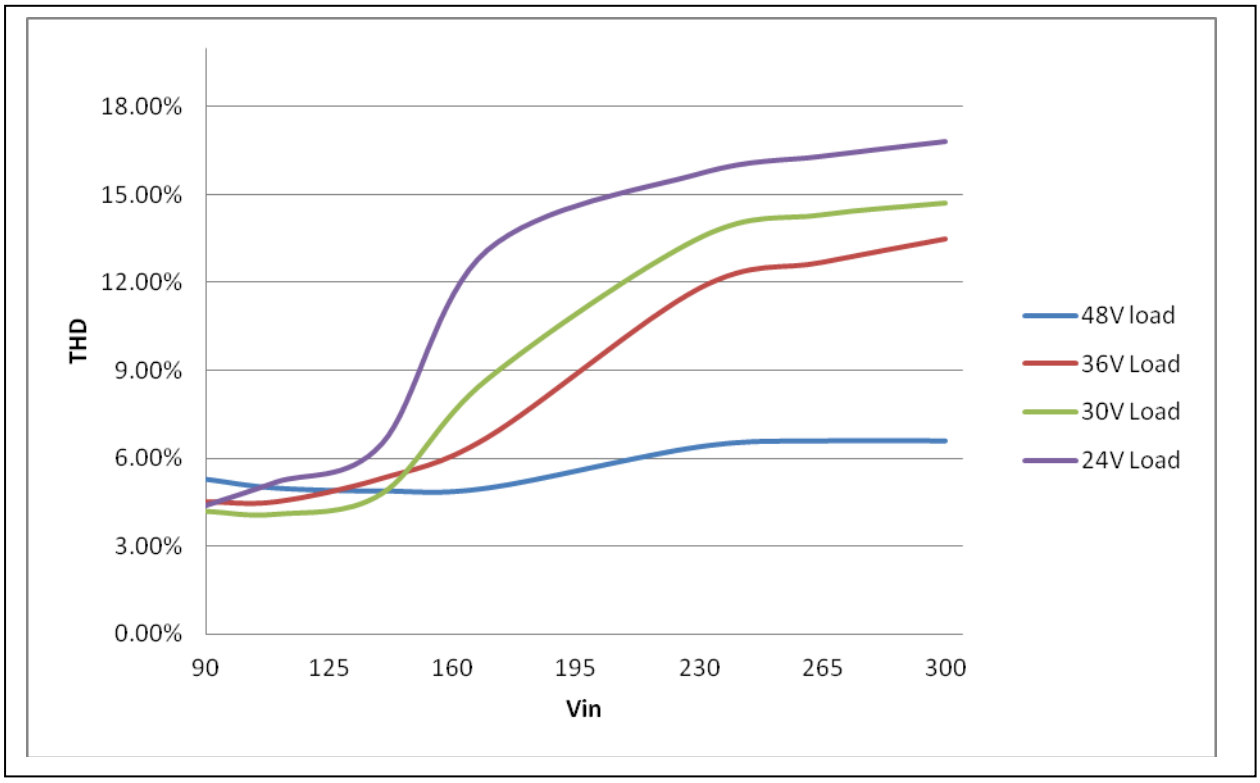

## 11.Load Regulation

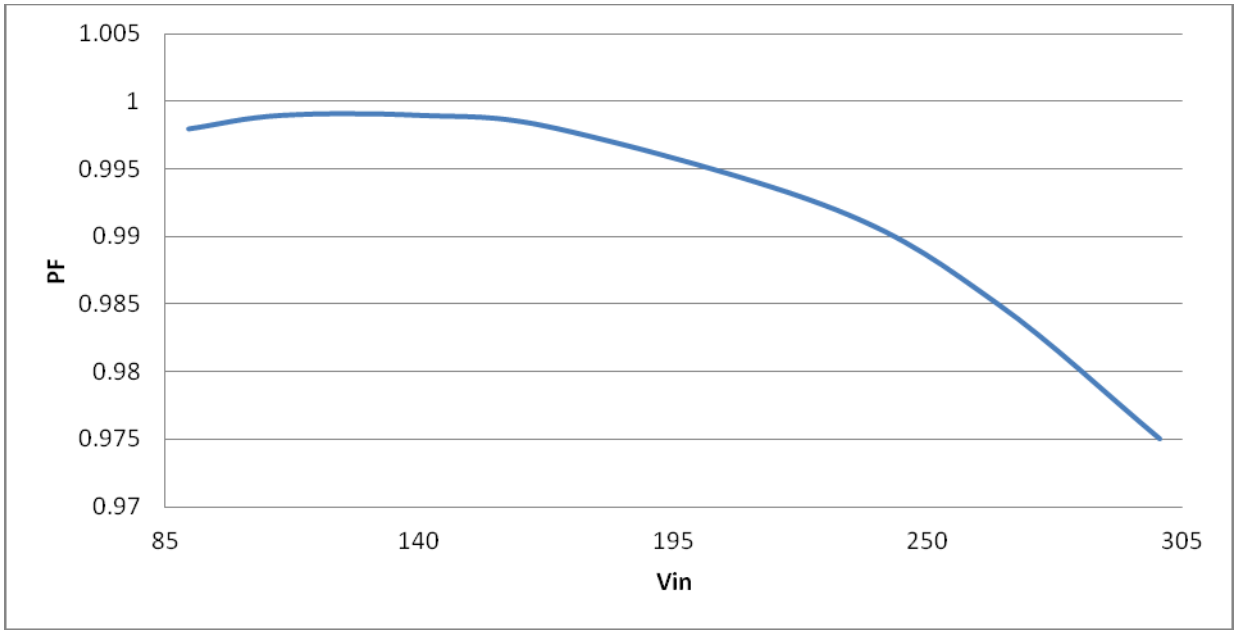


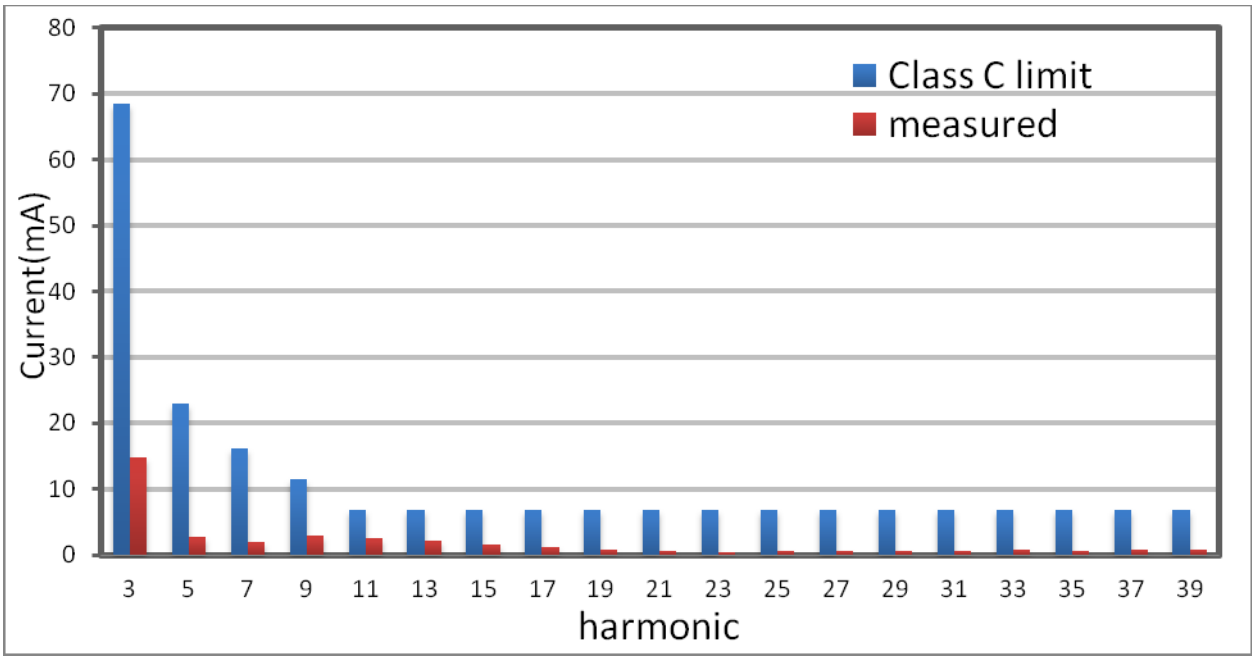
## 12.Efficiency Vs Vin at various loading




### THD vs Vin at full load

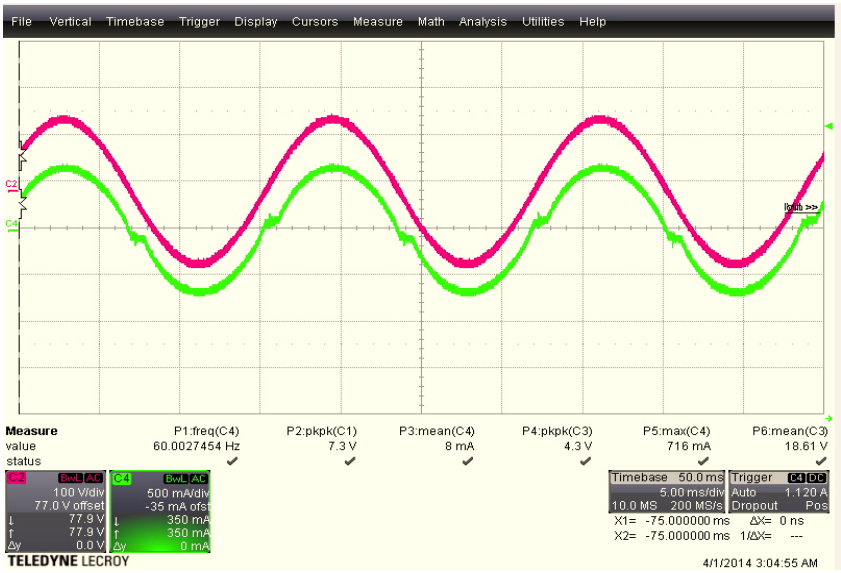




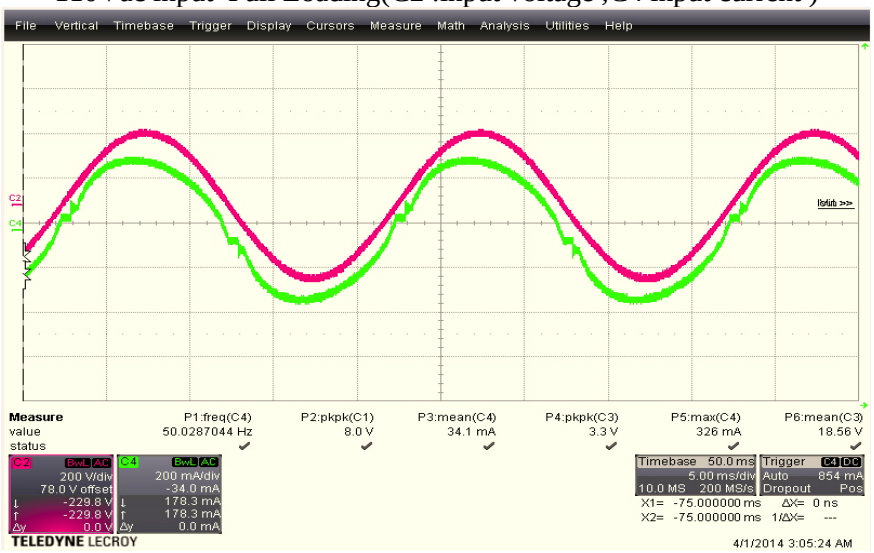




**230Vac harmonic for full load**

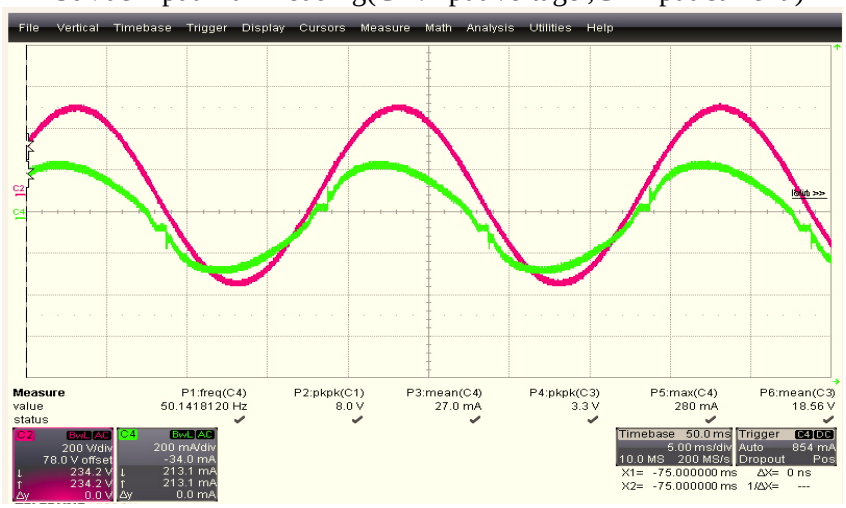
### 13.1.1 input current




110Vac input Full Loading(C2 :input voltage ,C4 input current )

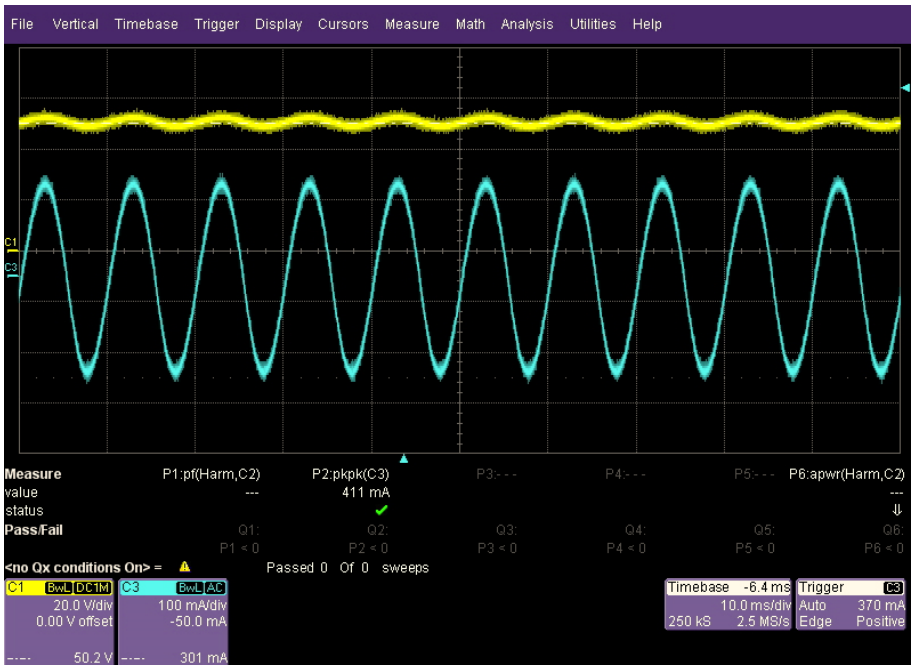



230Vac input Full Loading(C2 :input voltage ,C4 input current )

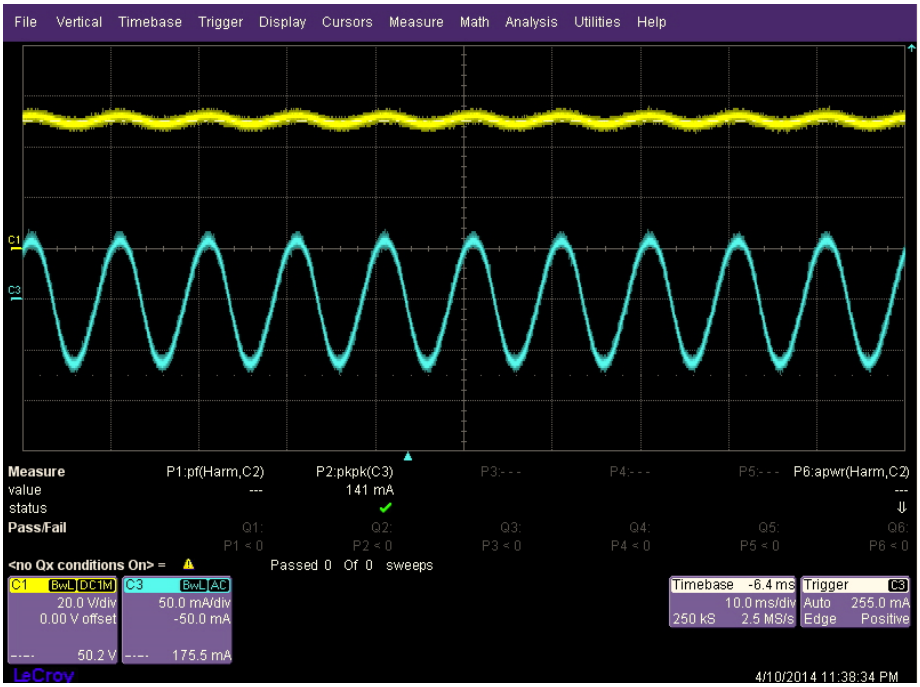



300Vac input Full Loading(C2 :input voltage ,C4 input current )

### 13.1.2 Output current ripple

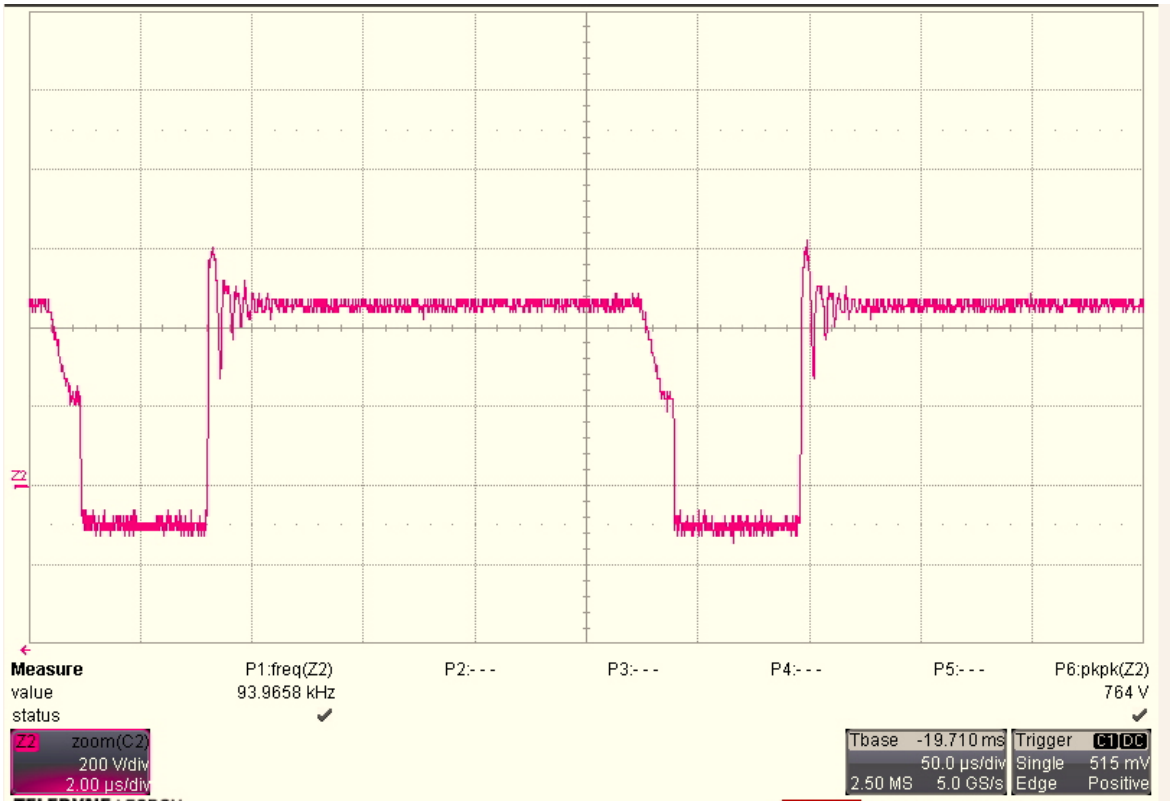



230Vac input Full Load at Rd4.8Ω<+/-20%
Rd is LED internal resistance



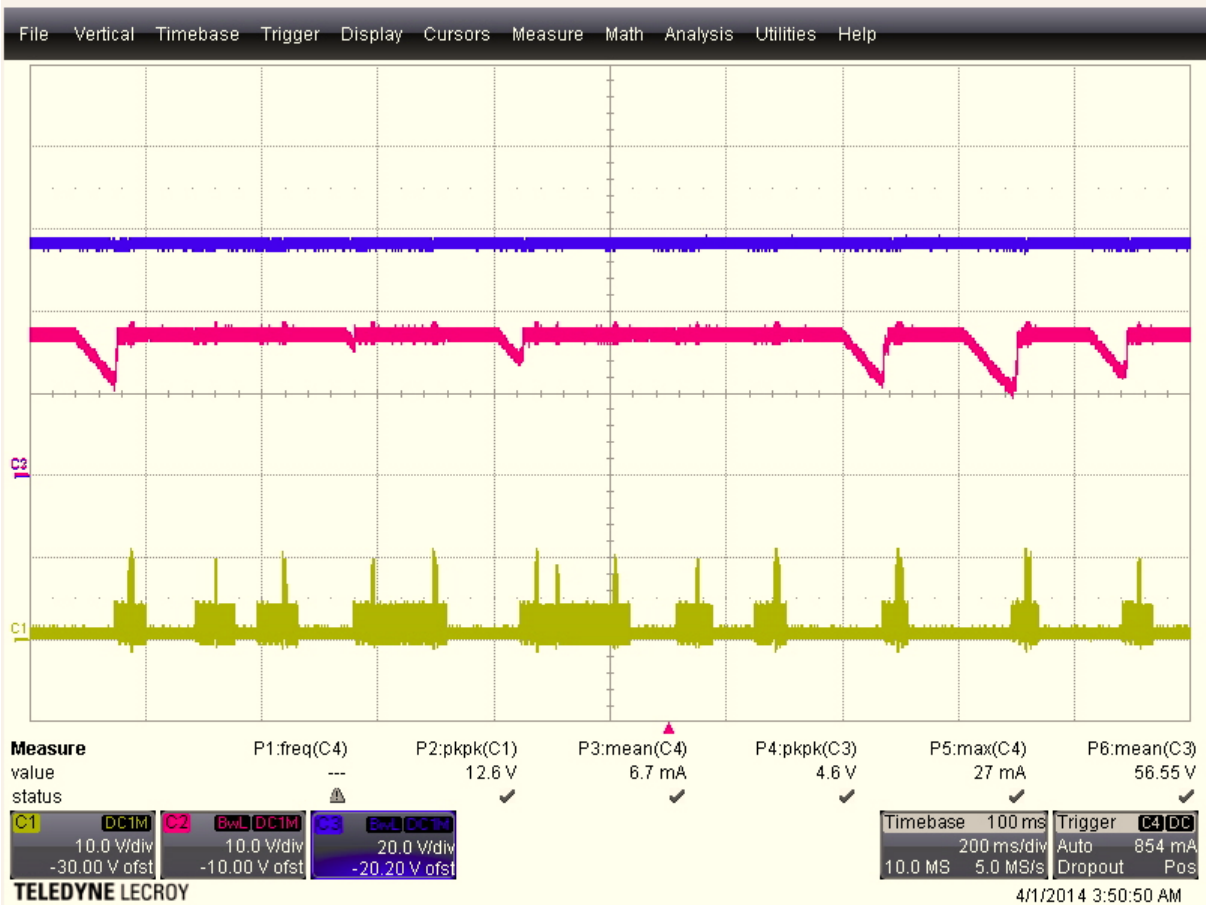

230Vac input Full Load at Rd24Ω<+/-7%
Rd is LED internal resistance

**MOSFET VDS**



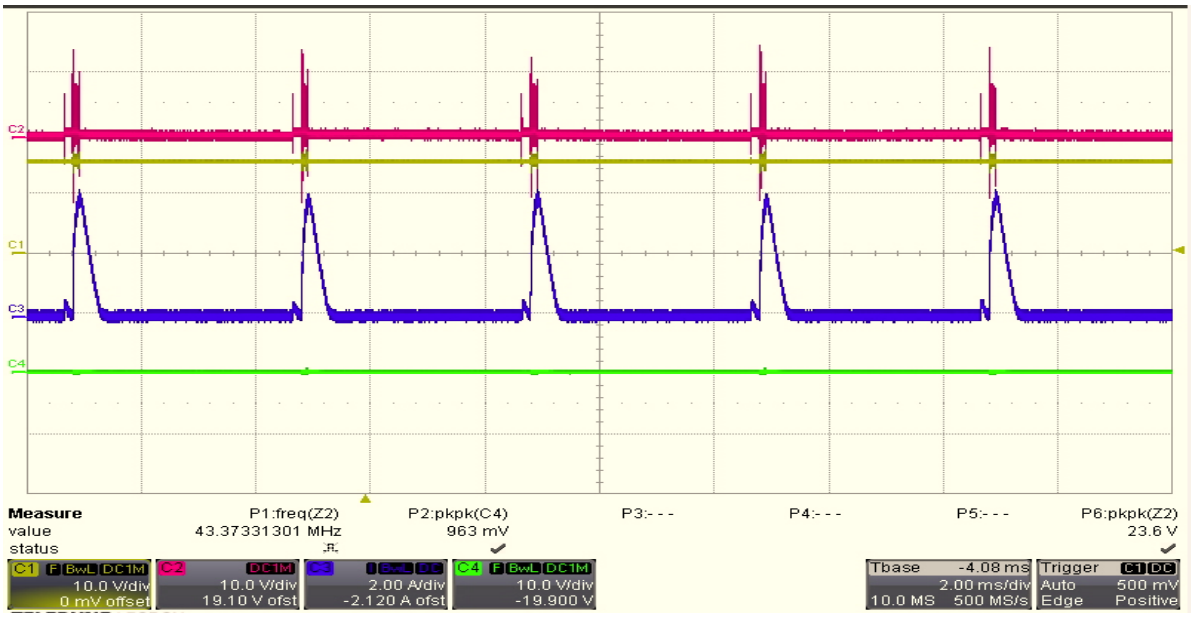

VDS at 300Vac

### 13.1.3 Protection

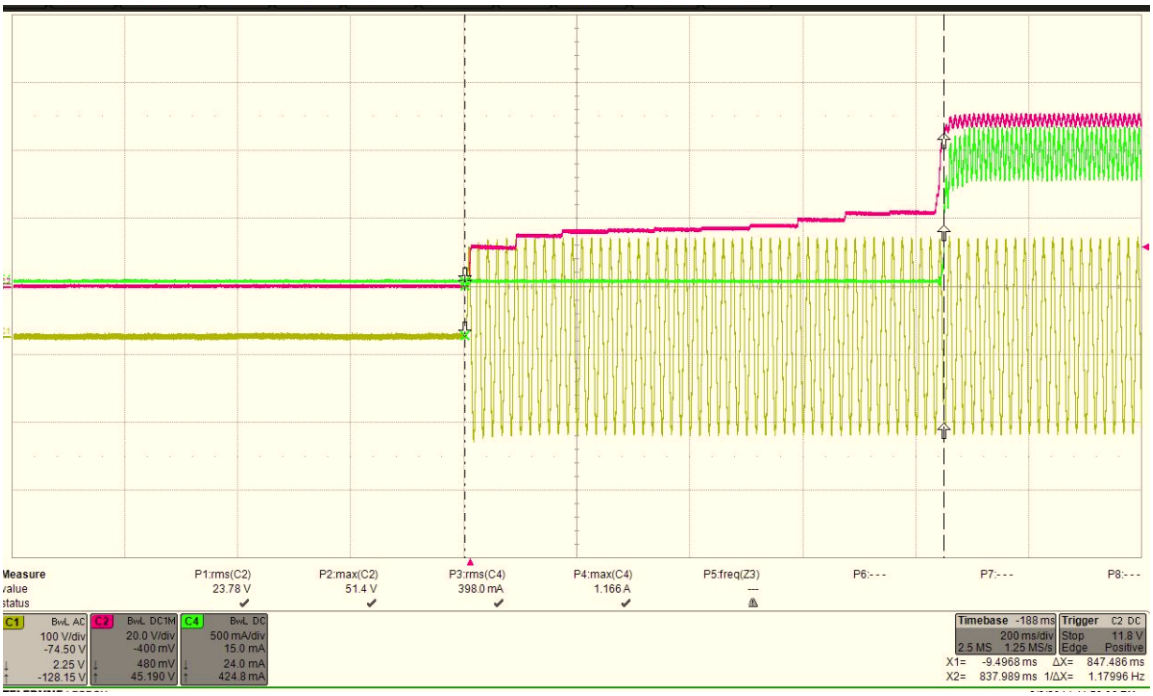



**Open circuit protection (C3:Vo. C2:Vcc.C1:Vgs) at Vo=48V**

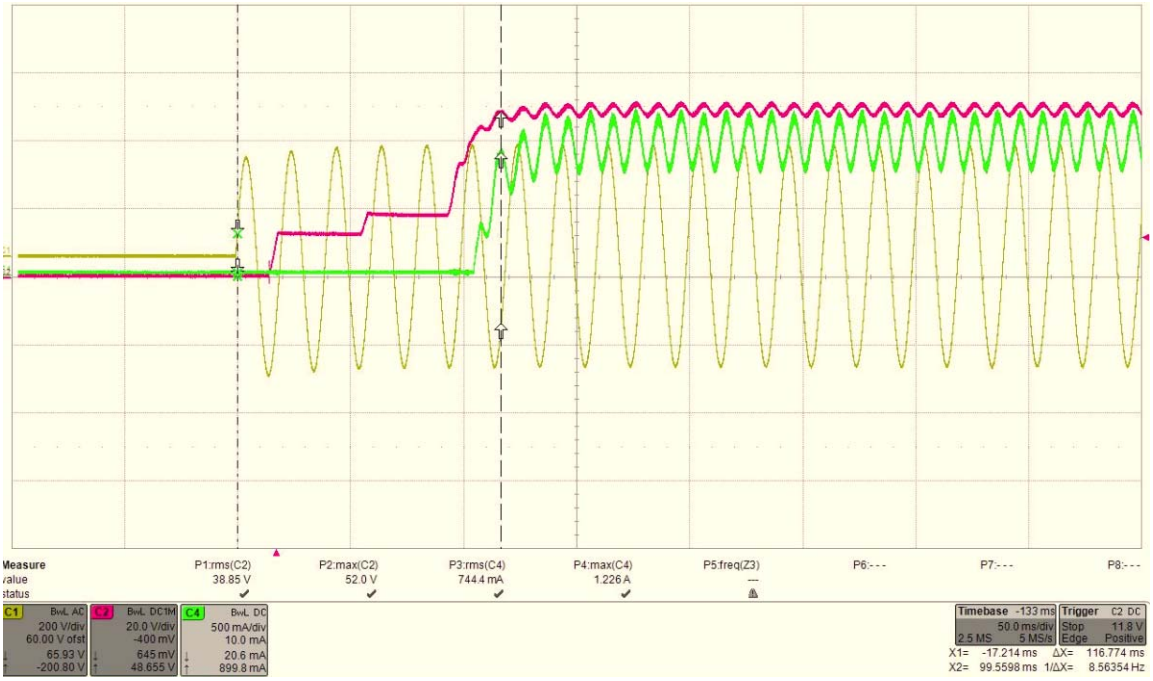
The max <=56V when the rated Vo set to 48V




**Short circuit protection (C1:VCC.C2:Vgs.C4:Vo.C3:Io) input power less than 2.5W at 300Vac.**

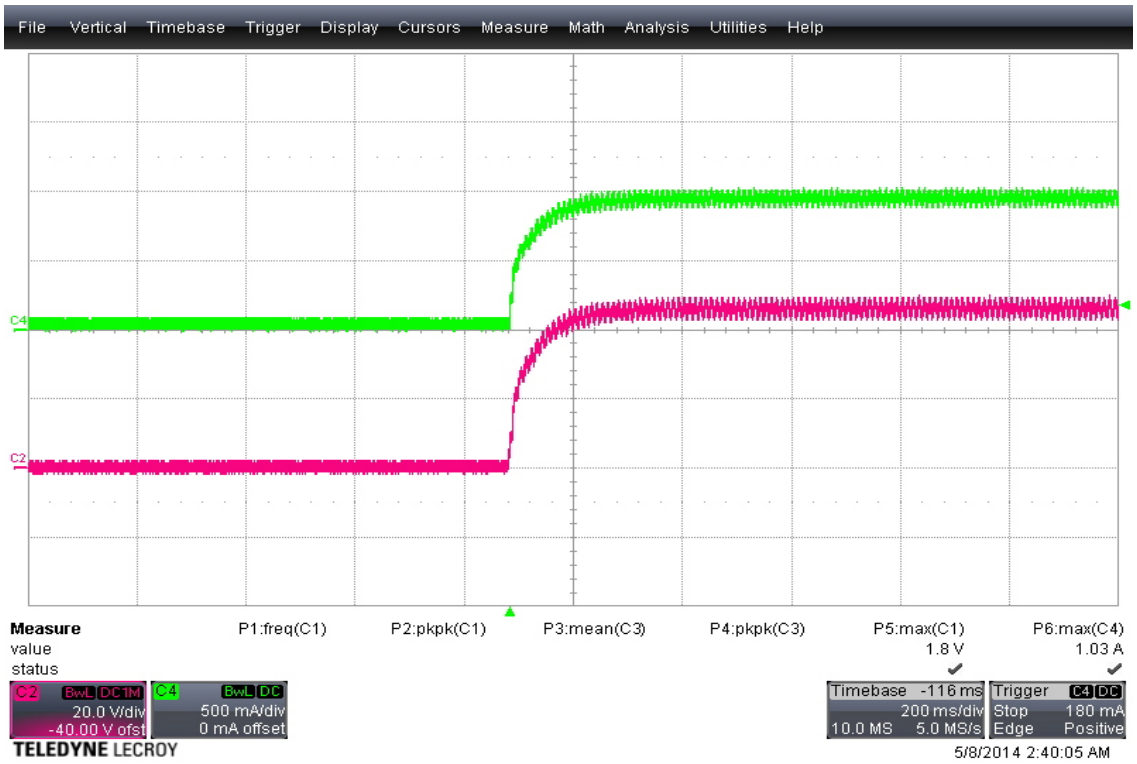



Start up time C1:Vac,C2:Vo, C4:Io **time to light <850mS** at 90Vac

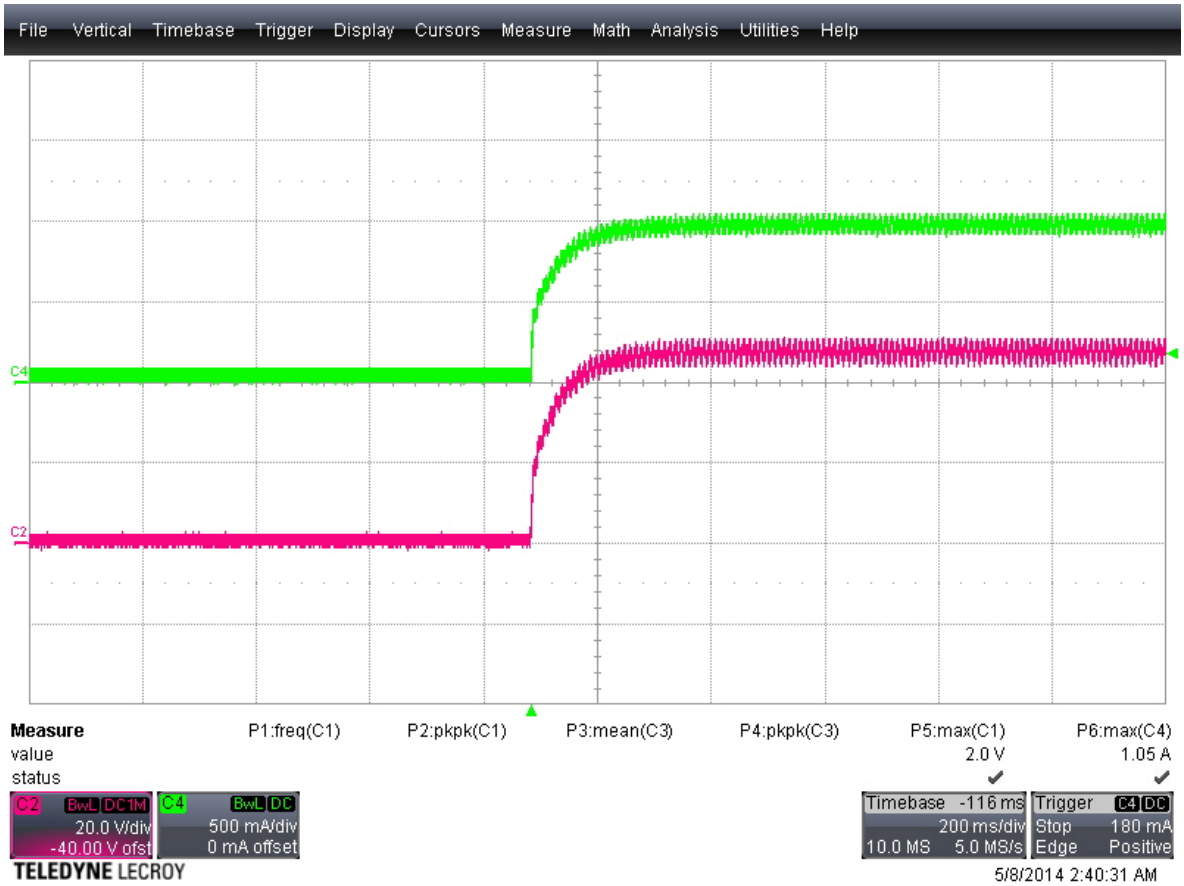



**Start-up waveform (C1:Vo. C4: Io.C2:Vac) time to light <300mS at 230Vac**

## Start-up waveform for resistor load

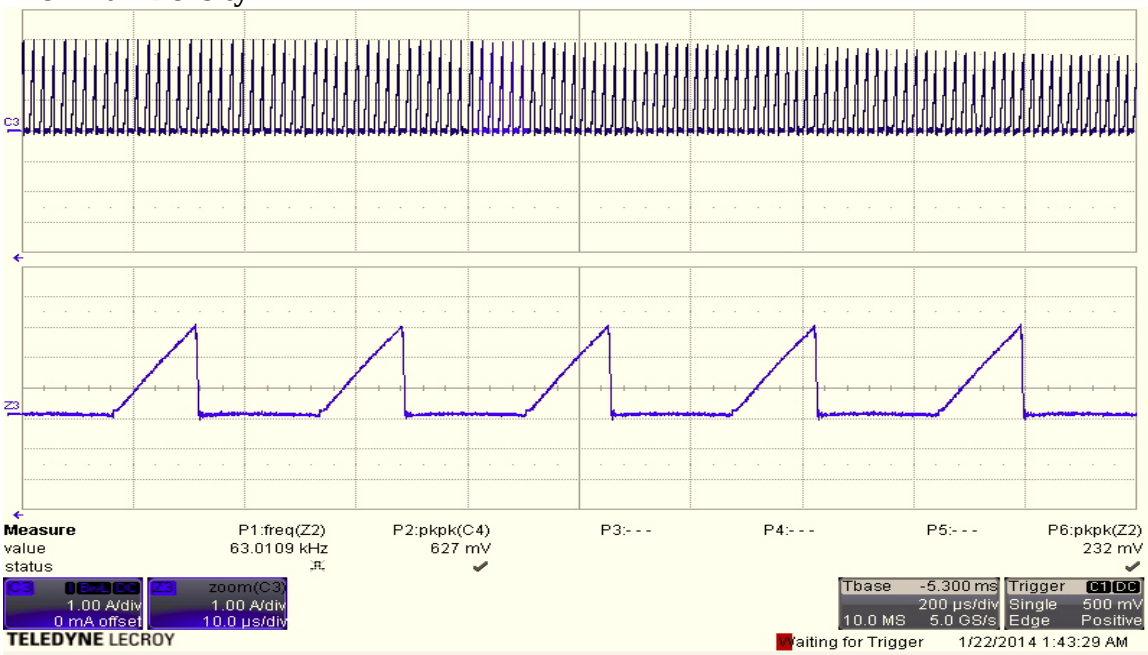



**Start-up waveform for resistor load(45Ω) (C2:Vo. C4: Io) at 90V input**




**Start-up waveform for resistor load(45Ω) (C2:Vo. C4: Io) at 230V input**

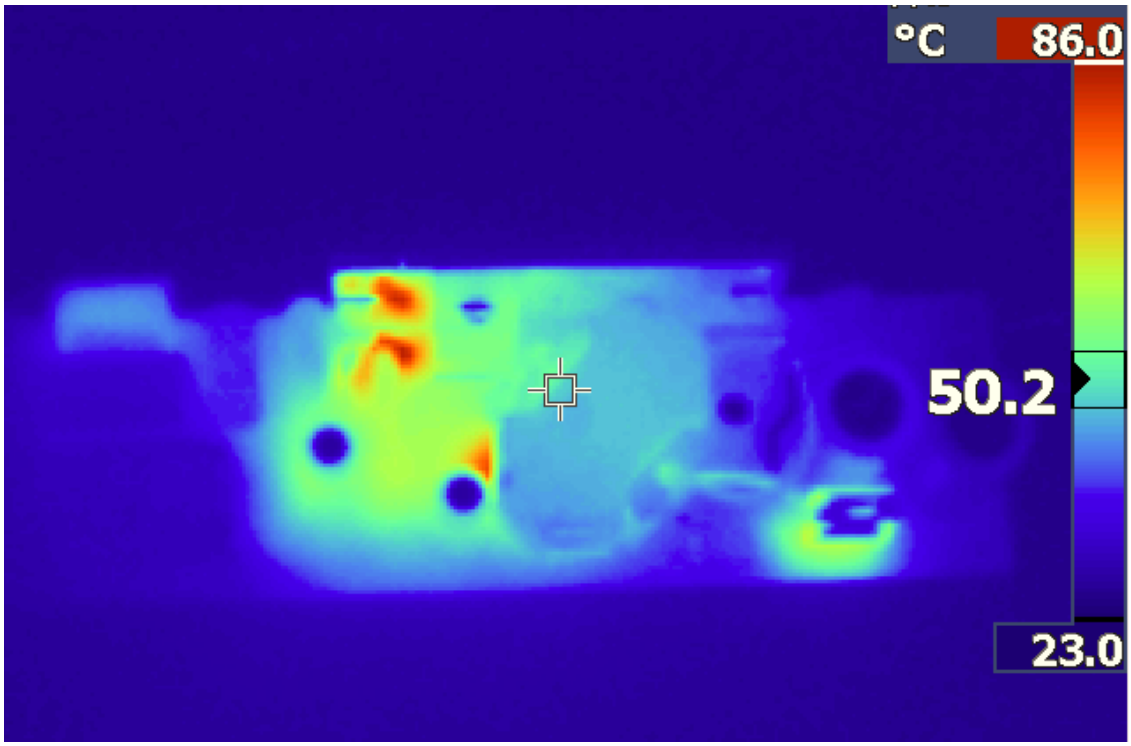
## Transformer Flux Density



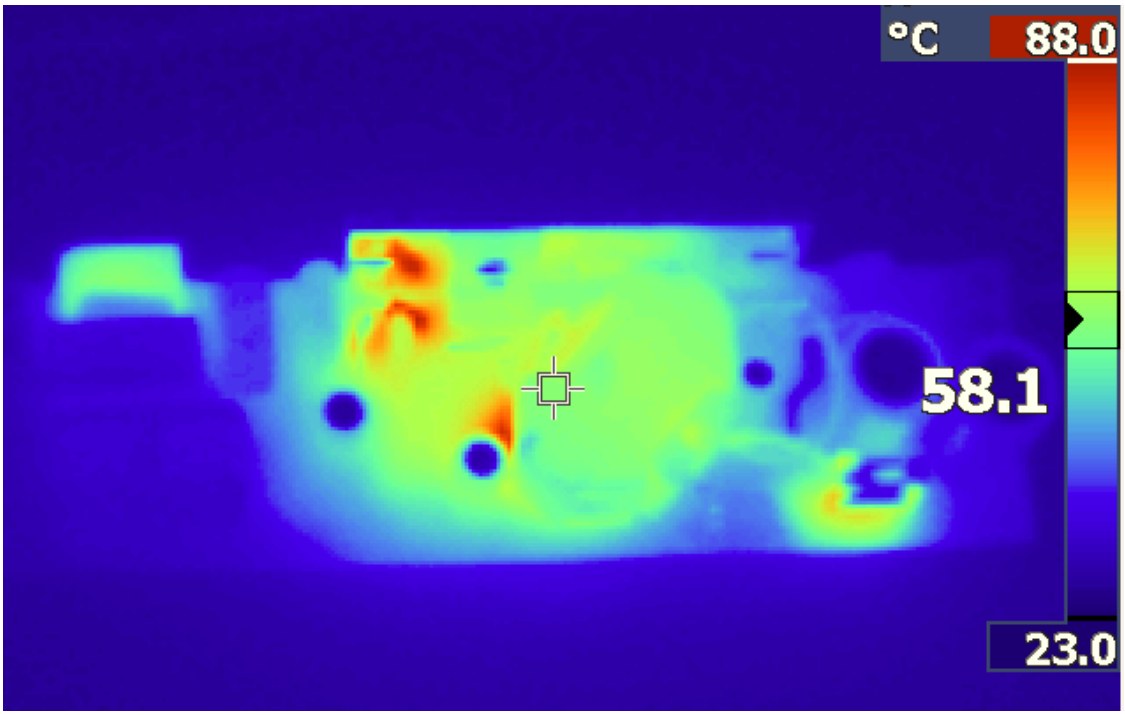

**C3 Ipri 1A/div**

**Ipri is monitored at 90Vac for full loading**
**Ipri=3A**
**Bmax =0.298T(Tesla)**

## Thermal Performance



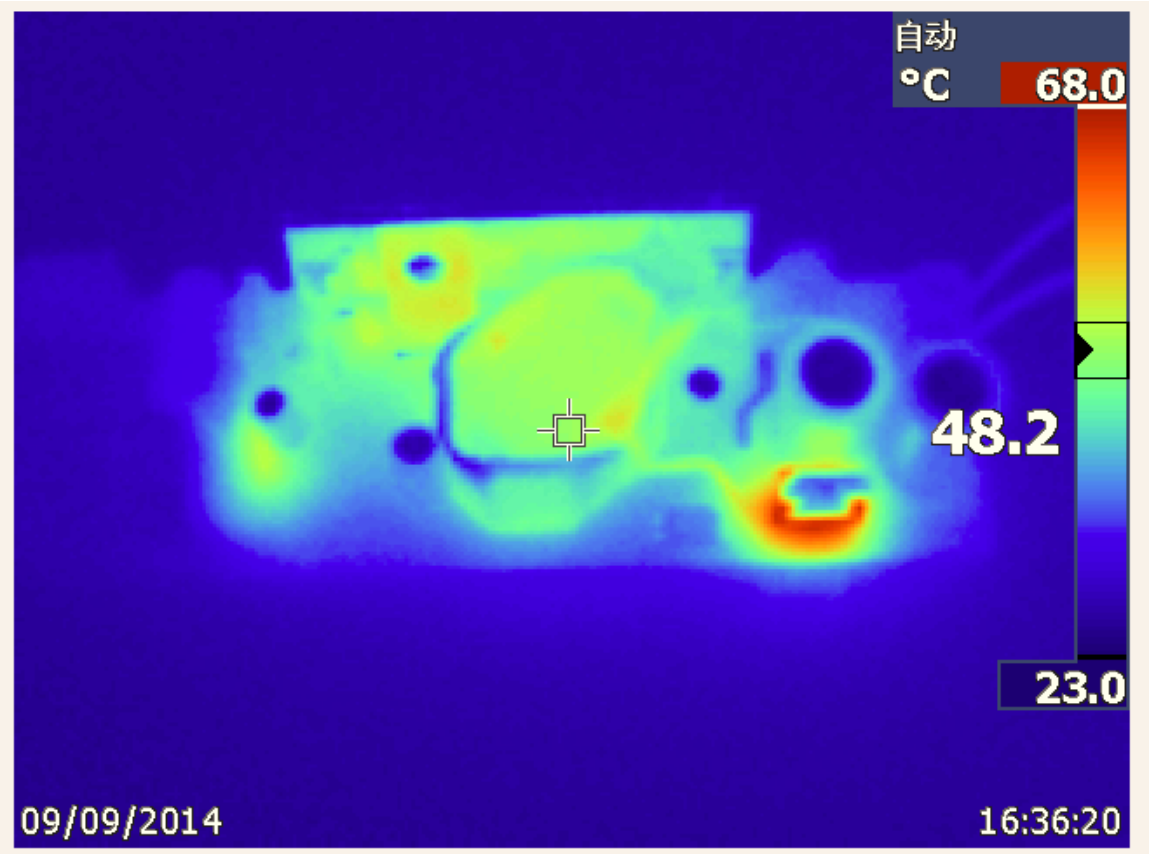

VIN=230VAC




VIN=110VAC

Images captured after running for 30 minutes at full load (room temperature 23°C)

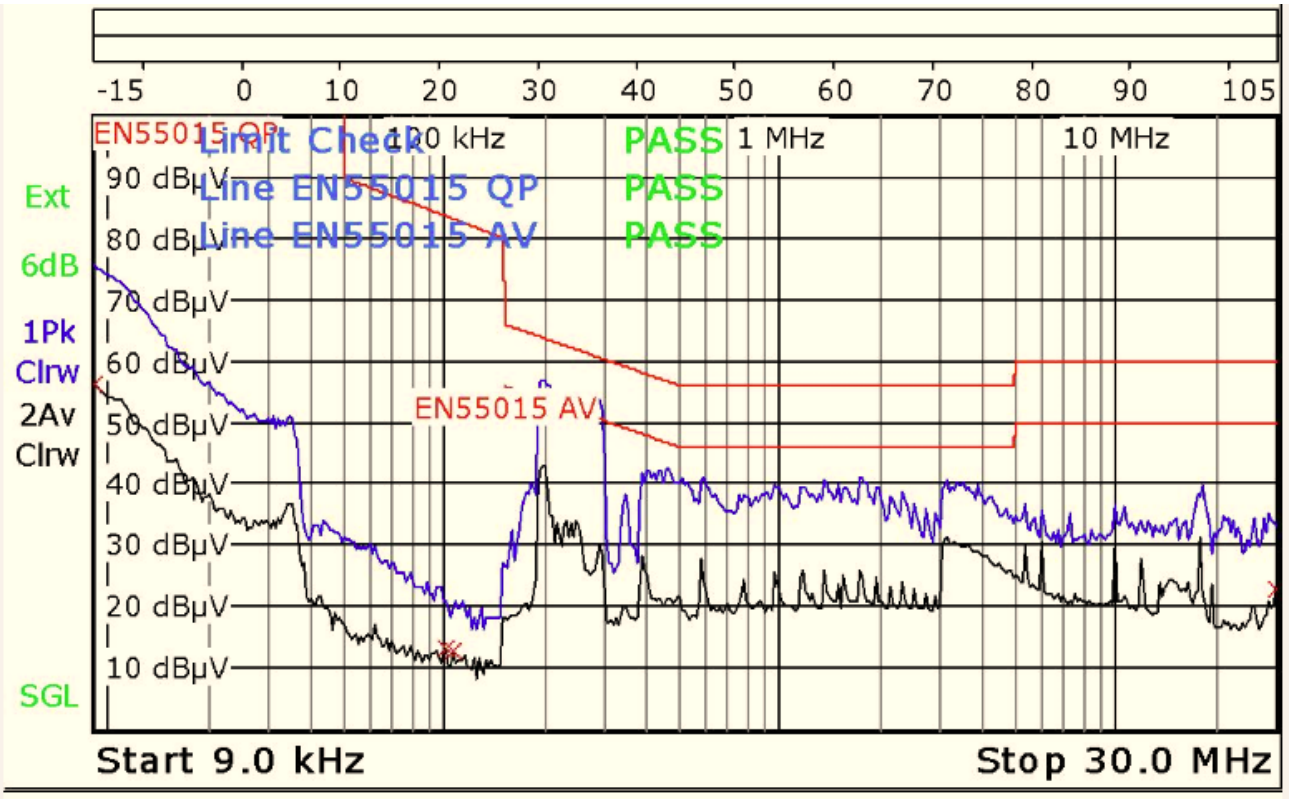
## Thermal Performance at output short



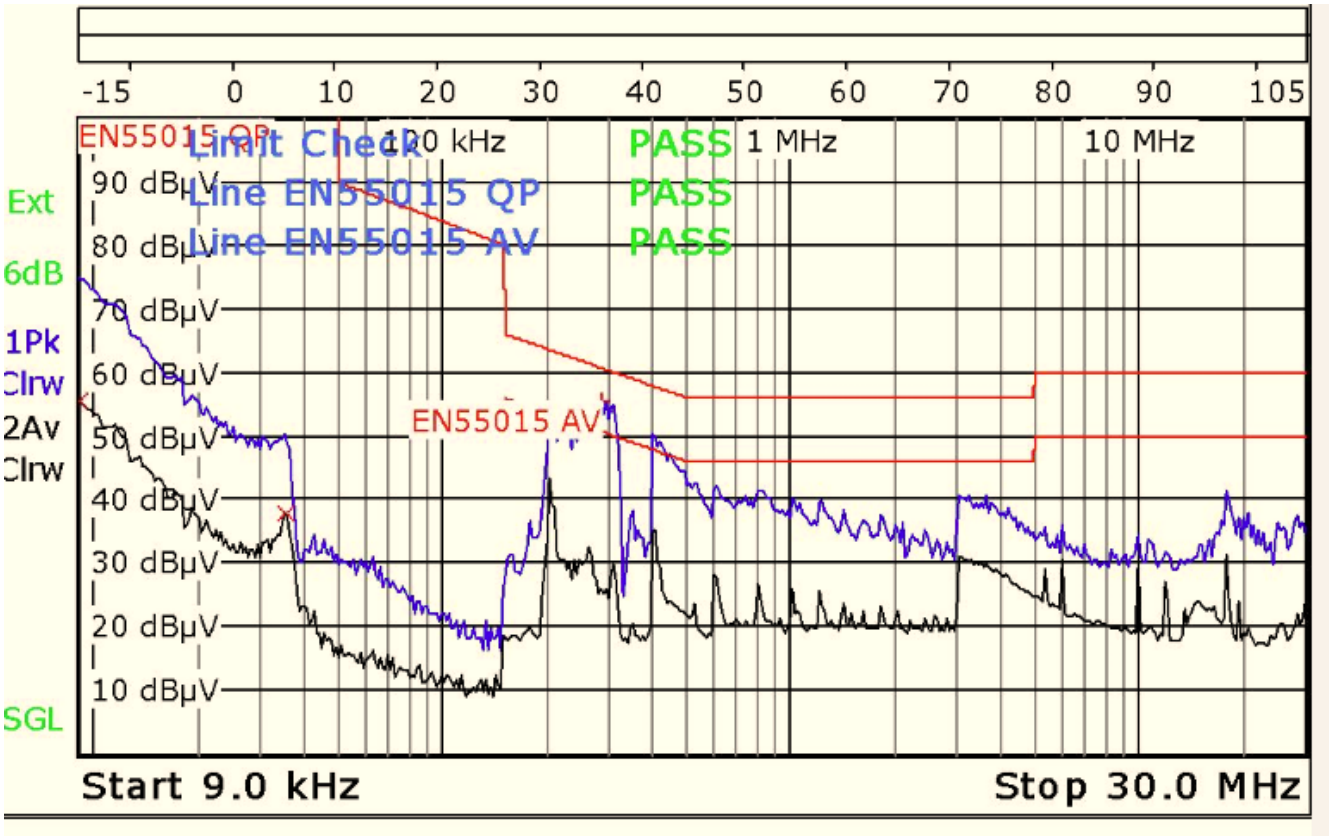

VIN=300VAC

Images captured after running for 2.5 hours at output short (room temperature 23°C)

## Conducted EMI performance（EN55015B）




**Conducted EMI Maximum steady state load at 230Vac 50Hz （L line）**




**Conducted EMI Maximum steady state load at 230Vac 50Hz （N line）**