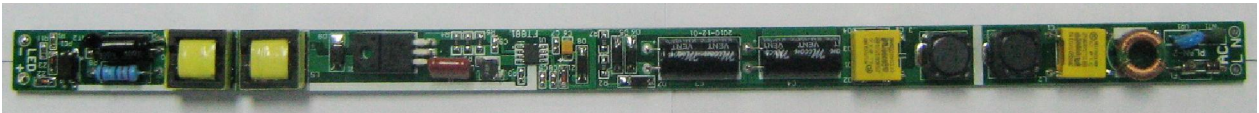


18W LED Lump Module Design with FT881

(Preliminary Release)



Index

| | | |
|----------|---|-----------|
| 1 | INTRODUCTION | 3 |
| 2 | MODULE SPECIFICATION..... | 3 |
| 2.1 | Input Characteristics | 3 |
| 2.2 | Output Characteristics | 3 |
| 2.3 | Performance Specification | 3 |
| 2.4 | Protection Features | 4 |
| 2.5 | Environmental..... | 4 |
| 3 | MODULE INFORMATION | 4 |
| 3.1 | Schematic | 4 |
| 3.2 | PCB Gerber | 4 |
| 3.3 | Bill of Materials | 5 |
| 3.4 | Transformer Design..... | 6 |
| 3.5 | Module Snapshot..... | 6 |
| 4 | PERFORMANCE EVALUATION | 7 |
| 4.1 | Input Characteristics | 7 |
| 1) | Input Normal Characteristics | 7 |
| 2) | Standby Power | 8 |
| 4.2 | Output Characteristics | 8 |
| 1) | Precision of Output Current..... | 8 |
| 2) | Ripple | 8 |
| 3) | Time Sequence..... | 8 |
| 4.3 | Protection | 9 |
| 1) | Open Circuit Protection | 9 |
| 2) | Short Circuit Protection | 9 |
| 4.4 | EMI Test | 10 |
| 5 | SYSTEM OTHER IMPORTANT WAVEFORM | 14 |
| 5.1 | MOSFET VDS Wave form at 264Vac, start up/shut down..... | 14 |
| 5.2 | Output Rectifier Diode VAK Waveform at Full Load | 14 |

1 INTRODUCTION

This document presents performance characteristics of a buck converter module designed with FT881. The module features:

- high precision for output current in universal input voltage.
- Simple circuit.

This document contains sessions on power supply specification, schematic/PCB Gerber/BOM, Power Inductor design and performance data.

2 MODULE SPECIFICATION

2.1 Input Characteristics

| | |
|-------------------------|------------------|
| AC Input Voltage Rating | 100Vac to 240Vac |
| AC Input Voltage Range | 90Vac to 264Vac |
| AC Input Frequency | 47Hz to 63Hz |

Table 1

2.2 Output Characteristics

| | |
|-----------------------------|---------------|
| Output Voltage | 46V Open Load |
| Output Current | 400mA |
| Precision of Output Current | ±3% |
| Ripple of Output Voltage | < 1.5V |
| Ripple of Output Current | < 200mA |

Table 2

Note: Ripple of Output Voltage is measured with 20MHz bandwidth limited (peak to peak value).

2.3 Performance Specification

| | |
|-----------------------------|--|
| Total Output Power | 18W Typical |
| Standby Power | < 0.5W @ 90Vac~265Vac, no load |
| Efficiency | >85% with full load |
| Turn on Delay Time | 10msec. max. @ 90Vac/50Hz with full load |
| Central Switching Frequency | 50 KHz |

Table 3

2.4 Protection Features

| | |
|--------------------------|----------------------------------|
| Short Circuit Protection | Output shut down (Auto Recovery) |
|--------------------------|----------------------------------|

Table 4

2.5 Environmental

| | |
|-----------------------|---------------------|
| Operating Temperature | -20°C to +40°C |
| Operating Humidity | 20 % to 90 % R. H. |
| Storage Temperature | -40°C to 85°C |
| Storage Humidity | 0 % to + 90 % R. H. |

Table 5

3 MODULE INFORMATION

3.1 Schematic

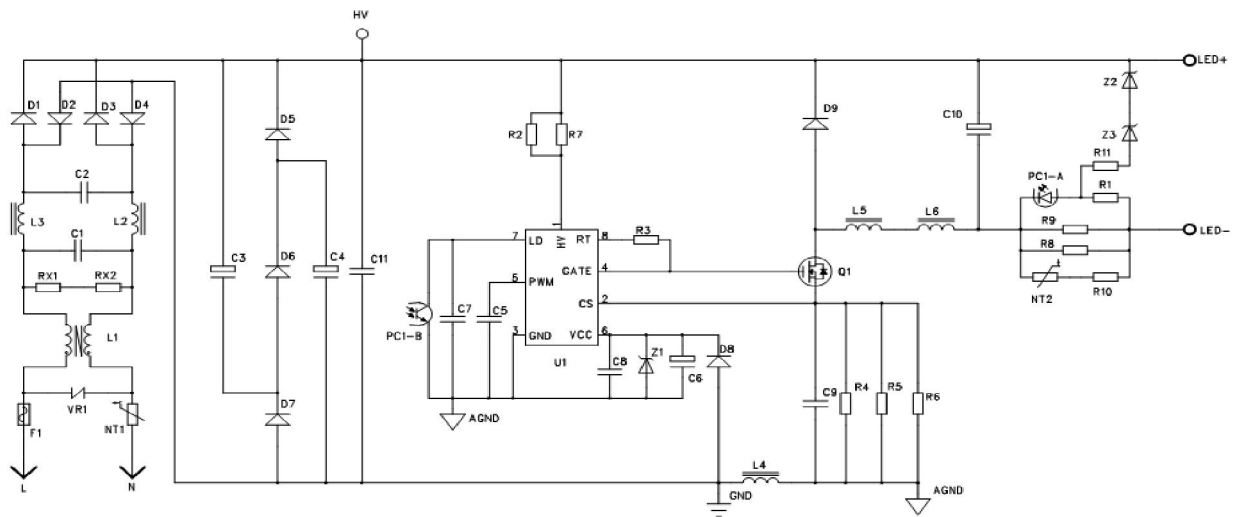


Figure 1: Schematic

3.2 PCB Gerber

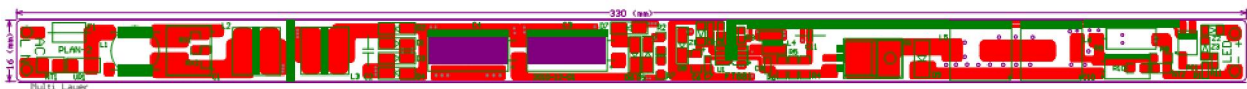


Figure 2: Top View

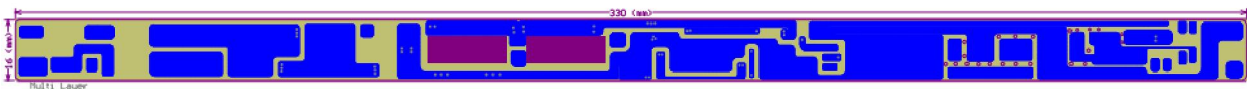


Figure 3: Bottom view

3.3 Bill of Materials

| Ref Des | Description | Package | Part Num | QTY |
|-------------------------------|---|---------|-----------------|-----|
| C1, C2 | X2 Capacitor 0.1uF K X2 275Vac, Pin Range: 10 mm | | | 2 |
| C3, C4 | Electrolytic Capacitor 22uF/250V, -40 to +105°C, 10*20 mm | | | 2 |
| C5 | Ceramic Capacitor 1nF/25V | 0805 | | 1 |
| C6 | Tantalum Capacitor 4.7uF/25V, B Type | MLL34 | | 1 |
| C7, C8 | Ceramic Capacitor 100nF/25V | 0805 | | 2 |
| C9 | Ceramic Capacitor 100pF/25V | 0805 | | 1 |
| C10 | Electrolytic Capacitor 10uF/100V, -40 to +105°C, 6.3*12 mm | | | 1 |
| C11 | CBB capacitor 68nF/400V, Pin Range: 10 mm | | | 1 |
| D1, D2, D3, D4, D5, D6, D7 | Rectifier diode | SMA | M7 | 7 |
| D8 | Fast Rectifier diode | SMA | ES1J | 1 |
| D9 | Fast Rectifier diode | SMB | MURS260T3 | 1 |
| F1 | Fast Acting Fuse | | F1A250Vac | 1 |
| L1 | Common Mode Inductor, 25mH | | | 1 |
| L2, L3 | Shielded Power Inductor, 1.5mH | SMD | | 2 |
| L4 | Shielded Inductor, 4.7uH | SMD | | 1 |
| L5, L6 | Power Inductor, 1mH EFD15-H, 8 Pin, cut out Pin4 and Pin5 | | | 2 |
| NT1 | Surge Current Suppress NTC Thermistor | | SCK05052 | 1 |
| NT2 | NTC Thermistor | | MF11-500K3000JA | 1 |
| PC1 | Photo Coupler | | EL817 | 1 |
| Q1 | N Channel MOS FET | TO-220 | FQPF5N60C | 1 |
| R1 | Thick Film Chip Resistor, 470R | 0805 | | 1 |

Table 6-1

| Ref Des | Description | Package | Part Num | QTY |
|------------|--|---------|-------------|-----|
| R2, R7 | Thick Film Chip Resistor, 22K | 1206 | | 2 |
| R3 | Thick Film Chip Resistor, 330K | 0805 | | 1 |
| R4, R5, R6 | Precision Thick Film Chip Resistor, 1.1R Precision: ±1% | 1206 | | 3 |
| R8 | Thick Film Chip Resistor, 20R | 1206 | | 1 |
| R9 | Precision Metal Film Resistor, 3.3R/1W Precision: ±1% | | | 1 |
| R10 | Thick Film Chip Resistor, 47R | 1206 | | 1 |
| R11 | Thick Film Chip Resistor, 220R | 0805 | | 1 |
| RX1, RX2 | Thick Film Chip Resistor, 750K | 1206 | | 2 |
| U1 | IC | SO-8 | FT881 | 1 |
| VR1 | Varistor | | VDR 07D471K | 1 |
| Z1 | Zener, 12Vz | SOD80 | | 1 |
| Z2, Z3 | Zener, 22Vz | SOD80 | | 2 |

Table 6-2

3.4 Power Inductor Design

- 1) Bobbin: EED15 Horizontal (8Pin)
- 2) Core Material: PC40 (TDG).
- 3) Inductance: 1000uH +/- 50uH (1 KHz, 0.25V, 25°C) (Pin2 to Pin7).
- 4) Cut out Pin: Pin4, Pin5.
- 5) Winding: $\Phi 0.19\text{mm} * 2, 160$ turns.

3.5 Module Snapshot



Figure 6: Top View



Figure 7: bottom View

4 PERFORMANCE EVALUATION

Performance Highlights:

The efficiency over 90Vac ~264Vac is $\geq 84\%$

The standby power is $< 0.5W$ at 90Vac/50Hz with no load

Characterization Results Summary

| Test | Specification | Test |
|---------------------------|---------------|----------------------|
| 1. Input Characteristics | | |
| Input Voltage | 90~264 V | 90~264 V |
| Input Current | $< 0.5 A$ | Max: 0.228 A @ 90Vac |
| Standby power | $\leq 0.5 W$ | Max: 0.45 W @ 264Vac |
| Efficiency (Average) | $\geq 86\%$ | 86.23 % |
| 2. Output Characteristics | | |
| Output Voltage Range | 36~50 V | 37.3 ~ 46.1 V |
| Output Current Range | 388 ~ 412 mA | 0.403 ~ 0.410 mA |
| Output Voltage Ripple | $< 1.5 V$ | Max: 1.37V @ 90Vac |
| Output Current Ripple | $< 200 mA$ | Max: 160mA @ 90Vac |
| 3. Time Sequence | | |
| Turn on delay time | $< 10 mS$ | 5.8 mS |
| Hold up time | -- | 28 ms |
| 4. Protection | | |
| Short Circuit protection | Pass | Pass |

Table 9

4.1 Input Characteristics

1) Input Normal Characteristics

The module was tested at different input voltages (from 90Vac to 264Vac) and different load conditions (full load and no load). Efficiency and standby power were measured and listed in table 10 and table 11.

| Input | | | | Output | | | Specification | Test Result |
|------------|---------|--------|-------|--------|-------|------------|---------------|-------------|
| Voltage(V) | Irms(A) | Pin(W) | PF(%) | Vo(V) | Io(A) | η (%) | | |
| 90V/50Hz | 0.228 | 17.60 | 85.3 | 37.40 | 0.403 | 85.64 | $> 85\%$ | Pass |
| 110V/60Hz | 0.181 | 17.47 | 87.6 | 37.50 | 0.404 | 86.72 | | |
| 220V/50Hz | 0.097 | 17.66 | 82.4 | 37.57 | 0.408 | 86.80 | | |
| 264V/50Hz | 0.085 | 17.83 | 79.0 | 37.30 | 0.410 | 85.77 | | |

Table 10: Input characteristics at full load

2) Standby Power

| Input Voltage | Vo(V) | Input Power(W) | Specification | Test Result |
|---------------|-------|----------------|---------------|-------------|
| 90V/50Hz | 46.0 | 0.21 | ≤ 0.5 | Pass |
| 110V/60Hz | 46.0 | 0.23 | | |
| 220V/50Hz | 46.0 | 0.38 | | |
| 264V/50Hz | 46.1 | 0.45 | | |

Table 11: Standby power at no load

4.2 Output Characteristics

1) Precision of Output Current

| Input Voltage | 90V | 115V | 220V | 264V | Precision |
|----------------|---------|---------|---------|---------|-----------------|
| Output Current | 0.403 A | 0.404 A | 0.408 A | 0.410 A | 0.388 ~ 0.412 A |

Table12: Precision of Output Current

2) Ripple

| Input Voltage | 90V | 115V | 220V | 264V |
|--------------------------|---------|--------|--------|--------|
| Ripple of Output Voltage | 1370 mV | 310 mV | 306 mV | 360 mV |

Table13: Ripple of Output Voltage

| Input Voltage | 90V | 115V | 220V | 264V |
|--------------------------|--------|-------|-------|-------|
| Ripple of Output Current | 160 mA | 58 mA | 56 mA | 57 mA |

Table14: Ripple of Output Current

Note: Ripple of Output Voltage is measured with 20MHz bandwidth limited (peak to peak value) .

3) Time Sequence

Time sequence parameters were measured with DSO.

| Item | Input Voltage | Test Result | Remark |
|---------------|---------------|-------------|----------|
| Turn-on Delay | 90V/50Hz | 5.8 mS | Figure 8 |
| Hold up Time | 264V/50Hz | 28.0 mS | Figure 9 |

Table 15: turn-on delay /hold-up time measurement results

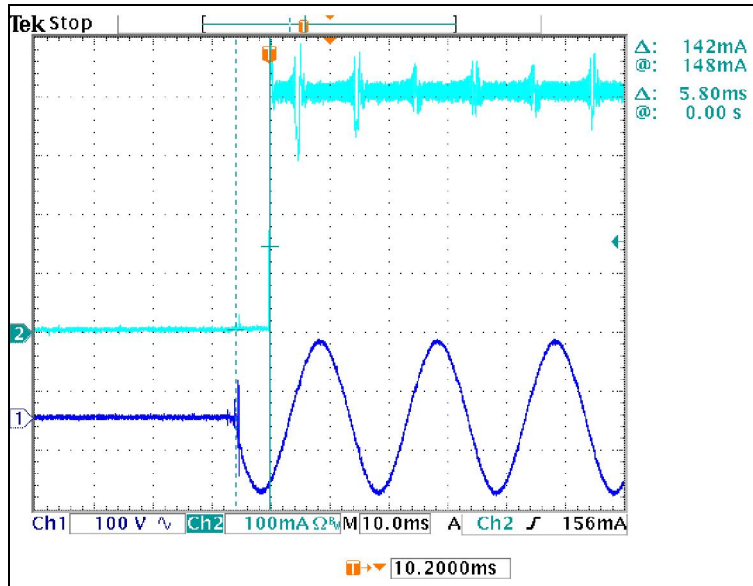


Figure 8: Turn on delay time measured waveform @ 90Vac/50Hz, full load

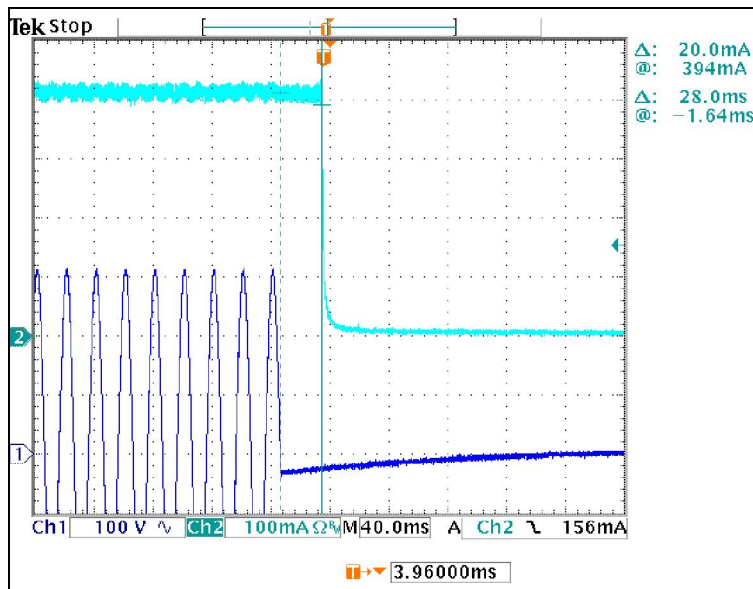


Figure 9: Hold on delay time measured waveform @ 264Vac/50Hz, full load

4.3 Protection

1) Open Circuit Protection

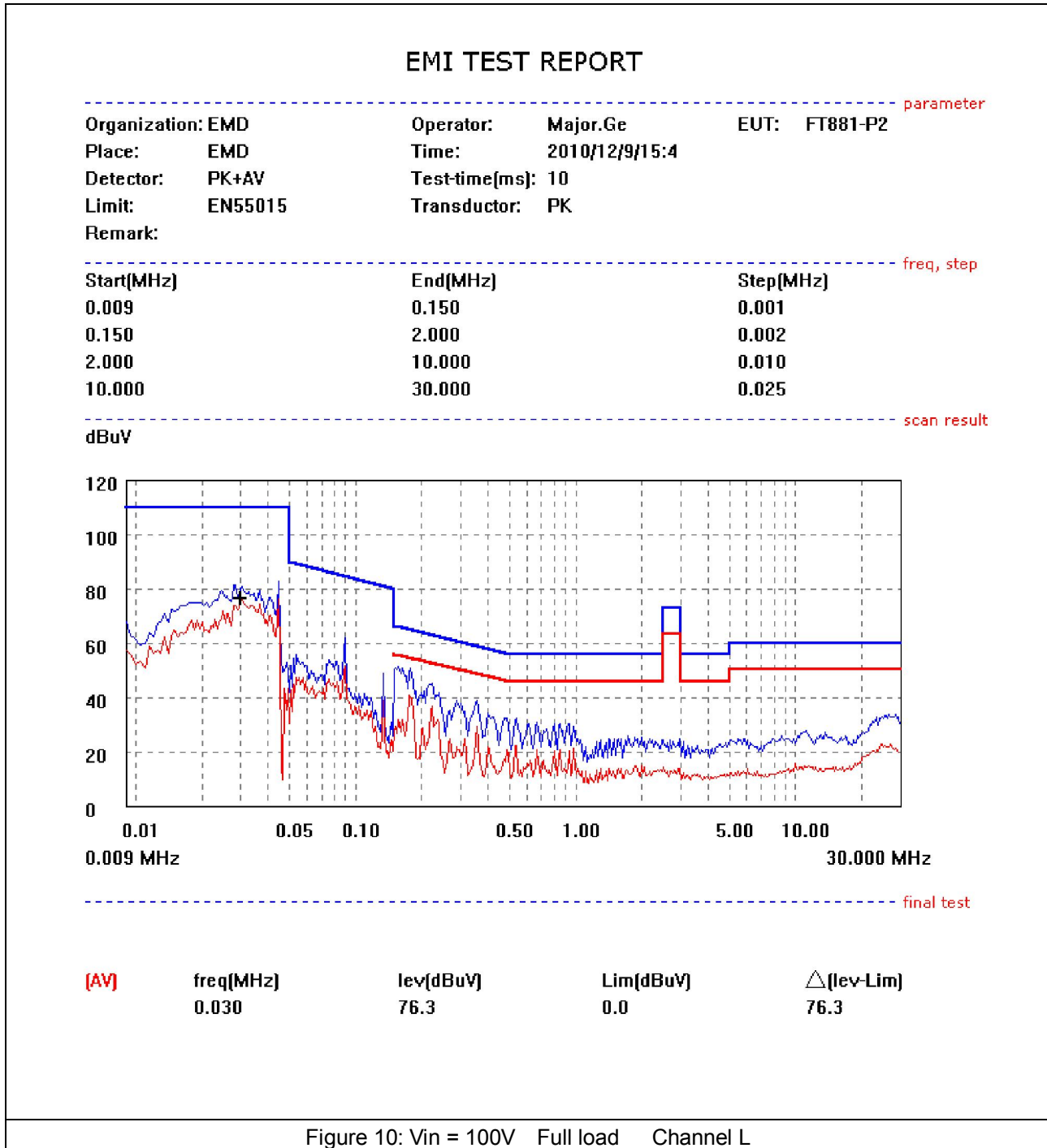
The system is protected during output open circuit condition and recovered when open circuit condition is removed.

2) Short Circuit Protection

The system is protected during output short circuit condition and recovered when short circuit condition is removed.

4.4 EMI Test

The Power supply passed EN55015 Class B EMI requirement with more than 4dB margin.

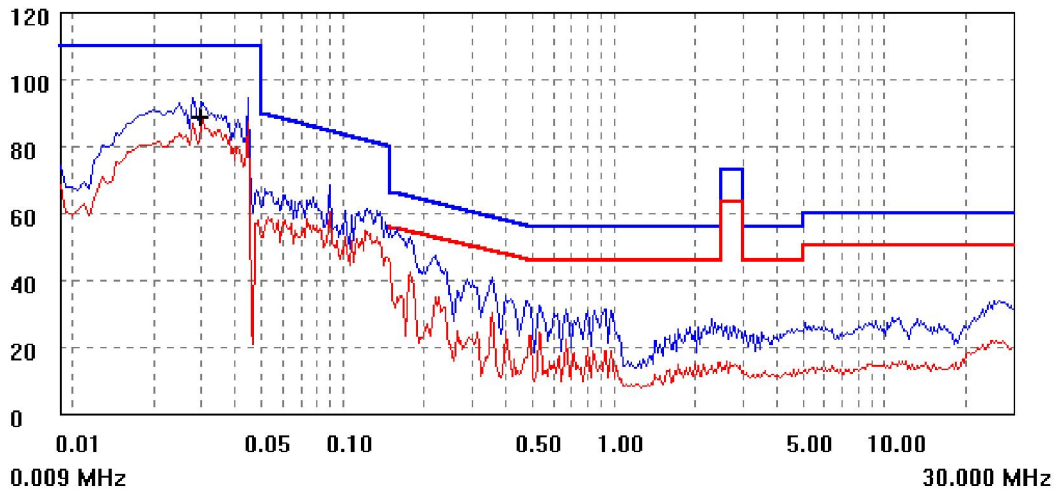


EMI TEST REPORT

| | | |
|-------------------|-----------------------|---------------|
| Organization: EMD | Operator: Major.Ge | EUT: FT881-P2 |
| Place: EMD | Time: 2010/12/9/14:59 | |
| Detector: PK+AV | Test-time[ms]: 10 | |
| Limit: EN55015 | Transducer: PK | |
| Remark: | | |

| | | |
|------------|----------|-----------|
| Start(MHz) | End(MHz) | Step(MHz) |
| 0.009 | 0.150 | 0.001 |
| 0.150 | 2.000 | 0.002 |
| 2.000 | 10.000 | 0.010 |
| 10.000 | 30.000 | 0.025 |

dBuV



final test

| | | | | |
|-------------|-----------|-----------|-----------|--------------------|
| (AV) | freq(MHz) | lev(dBuV) | Lim(dBuV) | Δ (lev-Lim) |
| | 0.030 | 88.4 | 0.0 | 88.4 |

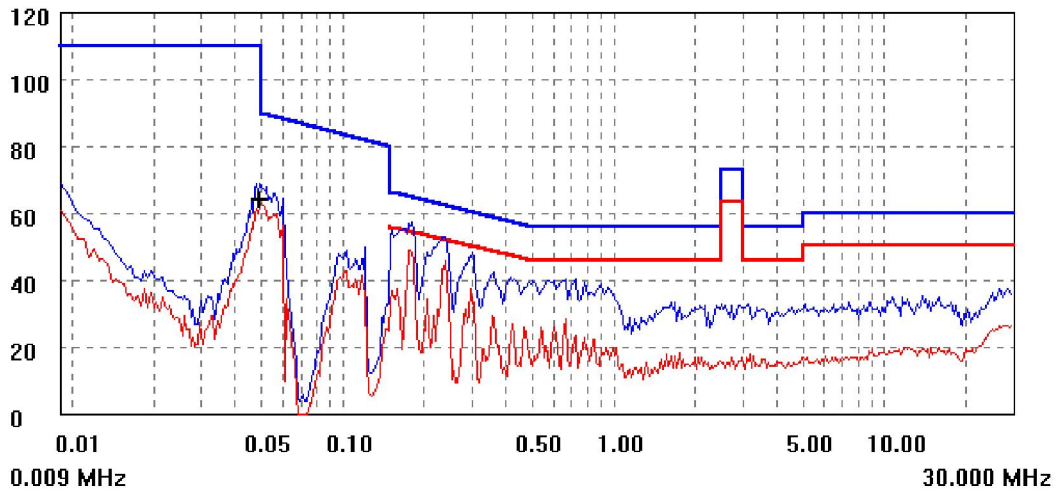
Figure 10: Vin = 100V Full load Channel N

EMI TEST REPORT

| | | |
|-------------------|----------------------|---------------|
| Organization: EMD | Operator: Major.Ge | EUT: FT881-P2 |
| Place: EMD | Time: 2010/12/9/15:9 | |
| Detector: PK+AV | Test-time[ms]: 10 | |
| Limit: EN55015 | Transducer: PK | |
| Remark: | | |

| | | |
|------------|----------|-----------|
| Start(MHz) | End(MHz) | Step(MHz) |
| 0.009 | 0.150 | 0.001 |
| 0.150 | 2.000 | 0.002 |
| 2.000 | 10.000 | 0.010 |
| 10.000 | 30.000 | 0.025 |

dBuV



final test

| | | | | |
|-------------|-----------|-----------|-----------|--------------------|
| (AV) | freq(MHz) | lev(dBuV) | Lim(dBuV) | Δ (lev-Lim) |
| | 0.049 | 63.8 | 0.0 | 63.8 |

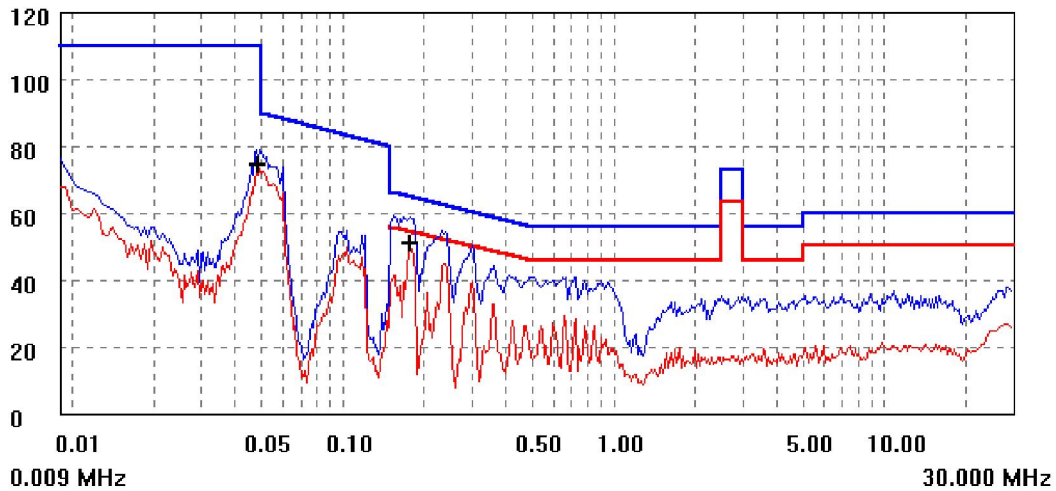
Figure 10: Vin = 230V Full load Channel L

EMI TEST REPORT

| | | |
|-------------------|-----------------------|---------------|
| Organization: EMD | Operator: Major.Ge | EUT: FT881-P2 |
| Place: EMD | Time: 2010/12/9/15:18 | |
| Detector: PK+AV | Test-time[ms]: 10 | |
| Limit: EN55015 | Transducer: PK | |
| Remark: | | |

| | | |
|------------|----------|-----------|
| Start(MHz) | End(MHz) | Step(MHz) |
| 0.009 | 0.150 | 0.001 |
| 0.150 | 2.000 | 0.002 |
| 2.000 | 10.000 | 0.010 |
| 10.000 | 30.000 | 0.025 |

dBuV



final test

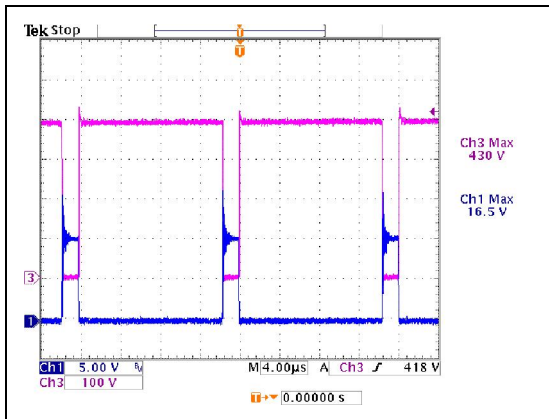
| (AV) | freq(MHz) | lev(dBuV) | Lim(dBuV) | △(lev-Lim) |
|------|-----------|-----------|-----------|------------|
| | 0.049 | 74.0 | 0.0 | 74.0 |
| | 0.178 | 50.7 | 55.2 | -4.5 |

Figure 10: Vin = 230V Full load Channel N

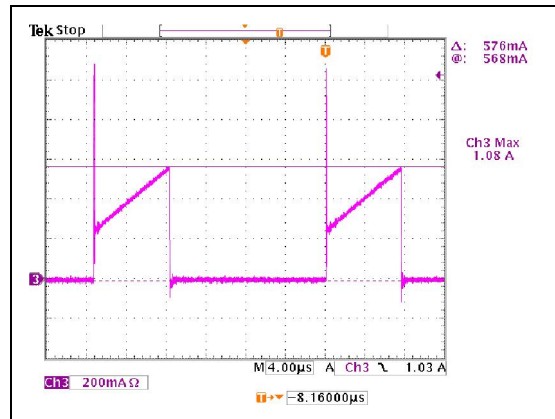
Figure 11: Vin = 230V Full load

5 SYSTEM OTHER IMPORTANT WAVEFORM

5.1 MOSFET VDS Wave form at 264Vac, start up/shut down

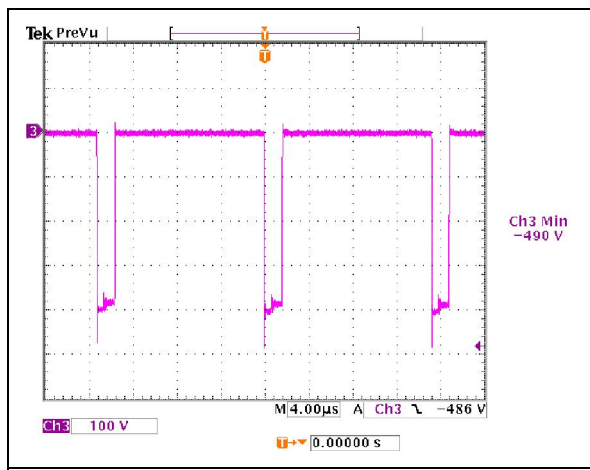


Start up, Vds wave form @ 264Vac/50Hz
CH1-Vgs: 16.5V ; CH3-Vds: 430V



Shut down, Ids wave form @ 90 Vac/50Hz
CH3-Ids: 0.576A

5.2 Output Rectifier Diode VAK Waveform at Full Load



Start up V_{AK} wave form @ 264Vac/50Hz, full load
CH3- V_{AK} : 490V