# 38W Adapter Module Design with FT861

## Index

# 1 INTRODUCTION

This document presents performance characteristics of an isolated flyback converter module designed with FT861. The module features:

- Small OCP variation over universal input range implemented with simple design approach.
- Very low standby power achieved.

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

# 2 ADAPTER 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 |
| Max. In-rush Current | 60 A for 100Vac/50Hz at full load |
| Input Current | 1A (rms) Max. @ full load, 90Vac~132Vac/60Hz |
| | 0.6A (rms) Max. @ full load, 180Vac~264Vac/50Hz |
| Leakage Current | 0.35mA Max. |

Table 1

## 2.2 Output Characteristics

| | |
|---|---|
| Output Voltage | +19.0V |
| Output Tolerance | +/-0.95V |
| Min. Load Current | 0A |
| Max. Load Current | 2A |
| Line Regulation | 1% |
| Load Regulation | 5% |
| Ripple & Noise | 200 mV |

Table 2

*Note: Ripple & Noise is measured with 20MHz bandwidth limited (peak to peak value) at the end of a 12-inch twisted wire terminated with a 10uF capacitor in parallel with a 0.1uF ceramic capacitor.*

## 2.3 Performance Specification

| | |
|---|---|
| Total Output Power | 38W Typical |
| Standby Power | < 0.3W @ 90Vac/63Hz~265Vac/47Hz, no load |
| Efficiency | 85% min. @ 90Vac/60Hz with full load |
| Turn on Delay Time | ≤3.0 sec. max. @ 100Vac/60Hz with full load |
| Switching Frequency | 65K Hz ±3% |

Table 3

## 2.4 Protection Features

| | |
|---|---|
| Short Circuit Protection | Output shut down (Auto Recovery) |
| Over Current Protection | Output shut down (Auto Restart) when output current 1.1~1.5X |

Table 4

## 2.5 Environmental

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

Table 5

## 2.6 Dielectric Withstand (Hi-pot) Test

| | |
|---|---|
| Input to Output | 3000Vac 1 min. |

Table 6

## 2.7 Insulation

| | |
|---|---|
| Input to Output | DC 500V 10M ohm min |

Table 7

# 3 ADAPTER MODULE INFORMATION

## 3.1 Schematic

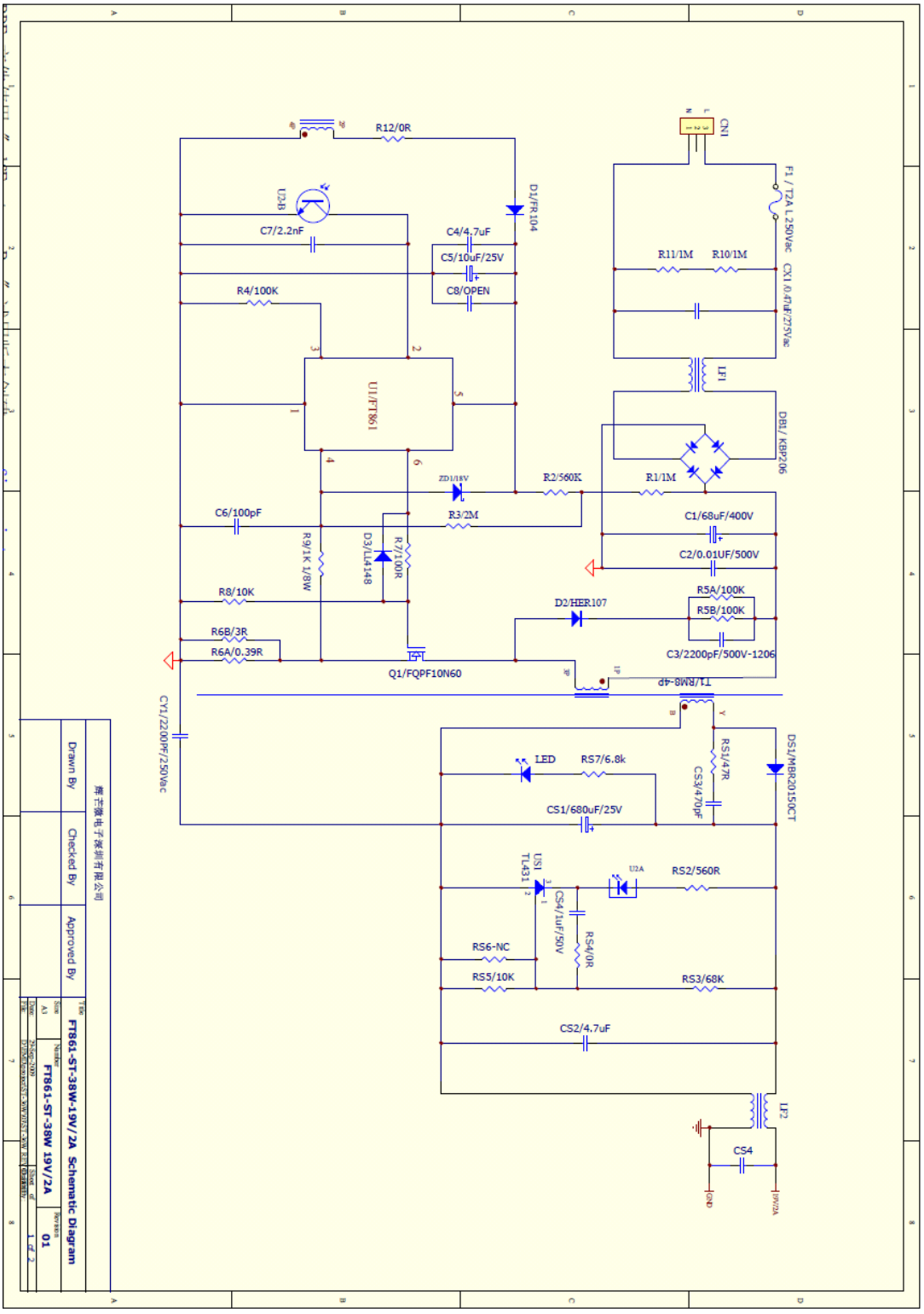


Figure 1: Schematic

### 3.2 PCB Gerber

Contact us for detail information:
Website: www.fremontmicro.com
E-mail: sales@fremontmicro.com
Tel: (86 755) 86117811 ext 805
Fax: (86 755) 86117810

Figure 2: Top View

Figure 3: Bottom view

### 3.3 Bill of Materials

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Website: www.fremontmicro.com
E-mail: sales@fremontmicro.com
Tel: (86 755) 86117811 ext 805
Fax: (86 755) 86117810

Table 8

## 3.4 Transformer Design

### 1) Transformer Specification

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E-mail: sales@fremontmicro.com
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### 2) Structure/Material

Table 9

Figure 4

### 3.5 Adapter Module Snapshot

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Fax: (86 755) 86117810

Figure 5

# 4 PERFORMANCE EVALUATION

This session presents the test results of 38W module up to date. Results on inrush current, leakage current and ESD are not included and will be added when they become available.

Overall, the module meets design specifications.

**Performance Highlights:**

The efficiency over 90Vac ~264Vac is ≥85%

The standby power is < 0.3W at 230Vac/50Hz with no load

OCP value over 90Vac - 264Vac is 1.10~1.5X of rated output current

**Characterization Results Summary**

| Test | Specification | Test |
|---|---|---|
| 1. Input Characteristics | | |
| Input current (90Vac~132Vac/50Hz) | 1.0A Max. | 0.812A |
| Input current (180Vac~264Vac/50Hz) | 0.6A Max. | 0.465A |
| Standby power | <0.3W | 0.29W |
| Efficiency（Average） | >85% | 86.75% |
| 2. Output Characteristics | | |
| Line regulation | 1% | 0.1% |
| Load regulation | 5% | 3% |
| Ripple & noise | 200mV | 152mV |
| Over shoot & Under shoot | 0.95V | 0 |
| Dynamic test | 0.95V | 0.6 V |
| 3. Time Sequence | | |
| Turn on delay time | <3.0S | 2.59S |
| Hold up time | | 8ms |
| Rise time | | 108ms |
| Fall time | | 16.8ms |
| 4. Protection | | |
| Over current protection | 2.2～3A | 2.79 A |
| Short Circuit protection | | Pass |
| 5. Brownout/Brownout Recovery | | |

Table 10

## 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 11 and table 12.

| Input Voltage | Irms (A) | Pin(W) | Vo(V) | Io(A) | η(%) | Specification | Test Result |
|---|---|---|---|---|---|---|---|
| 90V/50Hz | 0.812 | 42.86 | 18.43 | 2.0 | 86.0 | >85% | Pass |
| 115V/50Hz | 0.681 | 42.47 | 18.48 | 2.0 | 87.0 | | |
| 230V/50Hz | 0.465 | 42.35 | 18.47 | 2.0 | 87.2 | | |
| 264V/50Hz | 0.411 | 42.88 | 18.48 | 2.0 | 86.2 | | |

Table 11: Input characteristics at full load

*Note: 1. All data was measured at DC cord end if not otherwise noted.*

### 2) Standby Power / AVG Efficiency

| Input Voltage | Vo(V) | Input Power(W) | Specification | Test Result |
|---|---|---|---|---|
| 90V/50Hz | 18.97 | 0.14 | <0.3W | Pass |
| 115V/50Hz | 18.97 | 0.18 | | |
| 230V/50Hz | 18.97 | 0.20 | | |
| 264V/50Hz | 18.97 | 0.29 | | |

Table 12: Standby power at no load

| Loading(%) | Irms (A) | Pin(W) | Vo(V) | Io(A) | η % | AVG Efficiency | Test Result |
|---|---|---|---|---|---|---|---|
| 100% | 0.681 | 42.47 | 18.48 | 2 | 87.0 | 87.4% | Pass |
| 75% | 0.537 | 32.0 | 18.60 | 1.5 | 87.2 | | |
| 50% | 0.390 | 21.40 | 18.72 | 1 | 87.5 | | |
| 25% | 0.235 | 10.71 | 18.85 | 0.5 | 88.0 | | |

Table13: Vin: 115Vac

| Loading (%) | Irms (A) | Pin(W) | Vo(V) | Io(A) | η % | AVG Efficiency | Test Result |
|---|---|---|---|---|---|---|---|
| 100% | 0.465 | 42.35 | 18.47 | 2 | 87.2 | 86.1% | Pass |
| 75% | 0.354 | 32.20 | 18.58 | 1.5 | 86.6 | | |
| 50% | 0.244 | 21.66 | 18.71 | 1 | 86.4 | | |
| 25% | 0.138 | 11.18 | 18.84 | 0.5 | 84.3 | | |

Table14: Vin: 230Vac

## 4.2 Output Characteristics

### 1) Line Regulation & Load Regulation

| Input Voltage | No Load | Half Load | Full Load | Specification | Test Result |
|---|---|---|---|---|---|
| 90Vac/50Hz | 18.97 | 18.70 | 18.43 | 18.05~19.95 | pass |
| 115Vac/50Hz | 18.97 | 18.72 | 18.48 | 18.05~19.95 | |
| 230Vac/50Hz | 18.97 | 18.71 | 18.47 | 18.05~19.95 | |
| 264Vac/50Hz | 18.97 | 18.71 | 18.48 | 18.05~19.95 | |
| Line Regulation | 0.1% | | | <1% | Pass |
| Load Regulation | 3 % | | | <5% | Pass |

Table15: Regulation

*Note: All data is measured at DC cord end*

### 2) Ripple & Noise

| Ripple& Noise Input voltage | No Load | Full Load | Spec. | Test Result | Remark |
|---|---|---|---|---|---|
| 90Vac/50Hz | 37mV | 152mV | 200mV | Pass | Figure 6 |
| 264Vac/50Hz | 36mV | 126mV | | Pass | Figure 7 |

Table16: ripple & noise

*Note: Ripple& noise was measured at DC cord end(1.2M/18AWG) with a 0.1uF/100v ceramic cap connected in parallel with a 10uF/50V Electrolytic cap. Bandwidth was limited to 20MHz.*

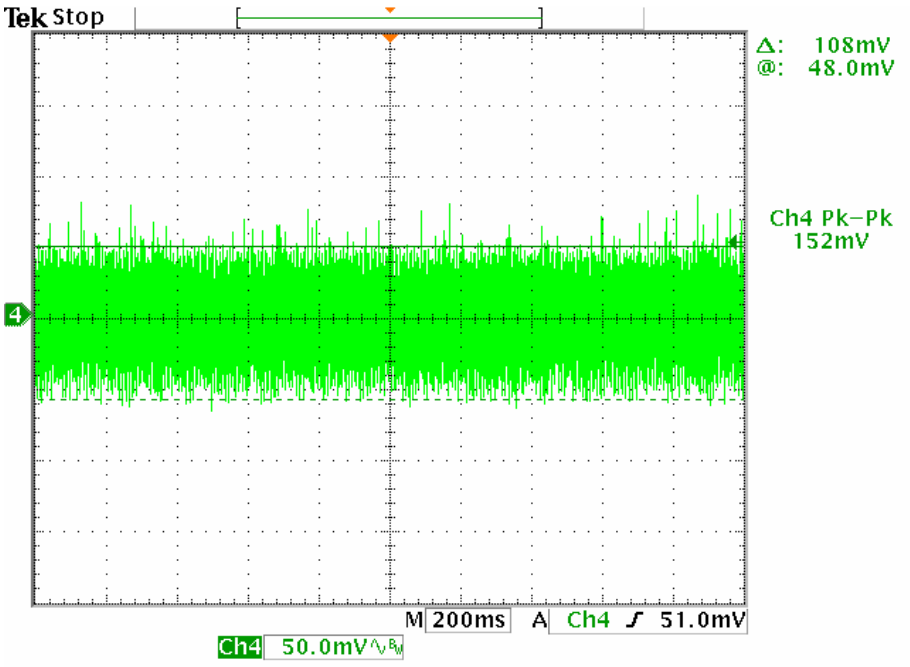



Figure 6: Measured ripple& noise waveform@90Vac/50Hz,Full load.

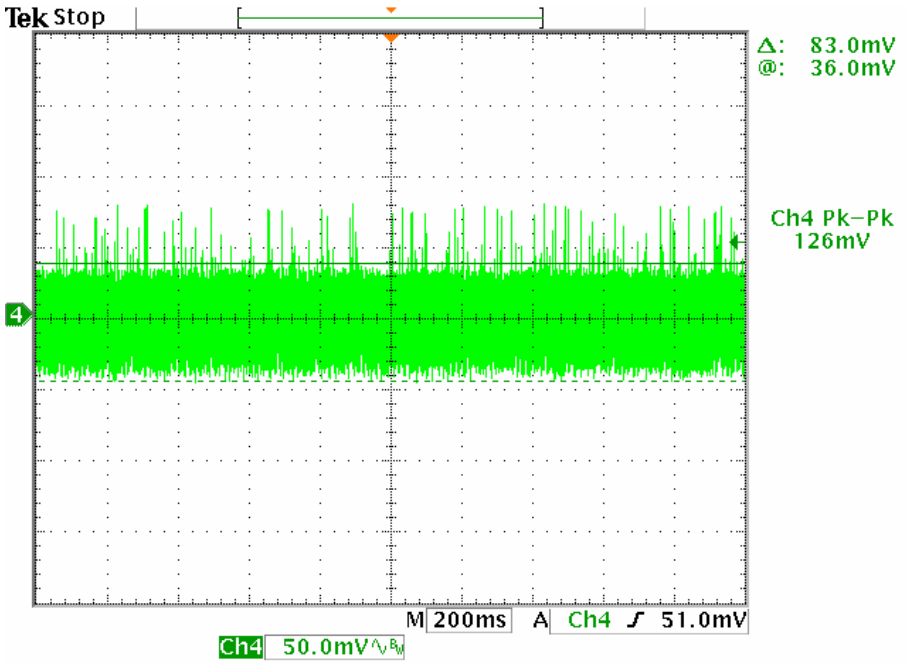



Figure 7: Measured ripple& noise waveform@264Vac/50Hz, full load

### 3) Over Shoot &Under Shoot

Over shoot/under shoot were measured under below conditions.

1. AC input switches ON for over shoot and OFF for under shoot.
2. Input voltage ranges from 90Vac/50Hz~264Vac/50Hz.

| Input | Load | | Meas. Data | Spec. | Test Result | Remark |
|---|---|---|---|---|---|---|
| 90V/50Hz | Full load | over shoot | 0 | 950mV | Pass | |
| | | under shoot | 0 | | Pass | |
| | No load | over shoot | 0 | | Pass | |
| | | under shoot | 0 | | Pass | |
| 264V/50Hz | Full load | over shoot | 0 | | Pass | Figure 8 |
| | | under shoot | 0 | | Pass | |
| | No load | over shoot | 0 | | Pass | |
| | | under shoot | 0 | | Pass | |

Table 17: Over shoot/under shoot measurement results

*Note: All data is from measurement taken at PCB end.*

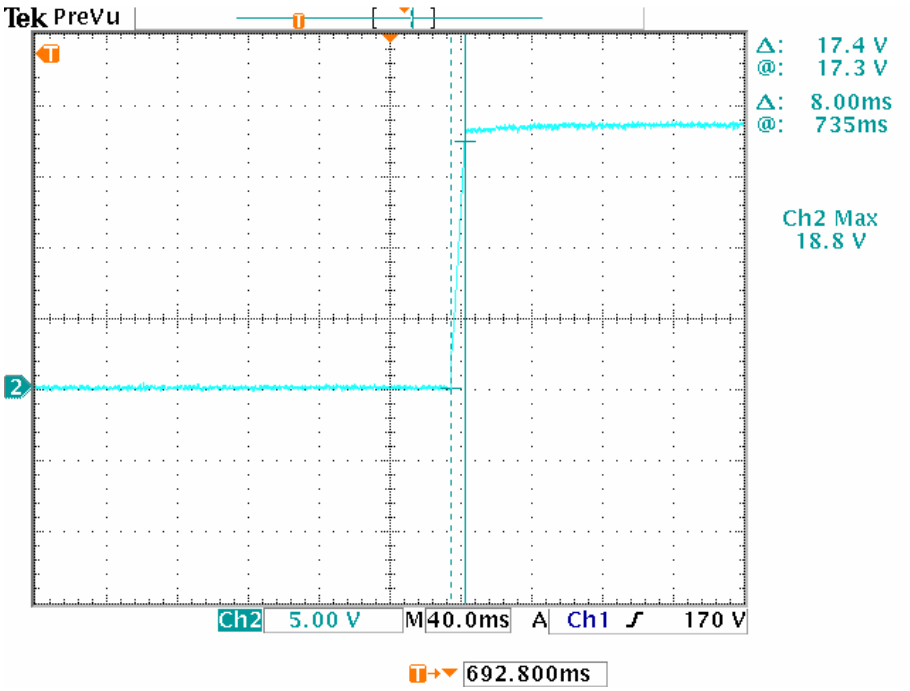



Figure 8: Measured overshoot waveform@264Vac/50Hz, full load

### 4) Dynamic Test

A dynamic loading with low set at 0A lasting for 5ms and high set at 3A lasting for 5ms is added to output. The ramp is set at 1A/us at transient.

Measurement was taken at 1.2M/22AWG DC cord end with data listed in Table 18.

| Input Voltage | Output Voltage | Test Specifications | Test Result | Remark |
|---|---|---|---|---|
| 264V/50Hz | 18.6V~19.6 V | 18.05V~19.95V | Pass | Figure 9 |
| 90V/50Hz | 18.6V~19.6 V | | Pass | Figure 10 |

Table 18: output voltage under dynamic test

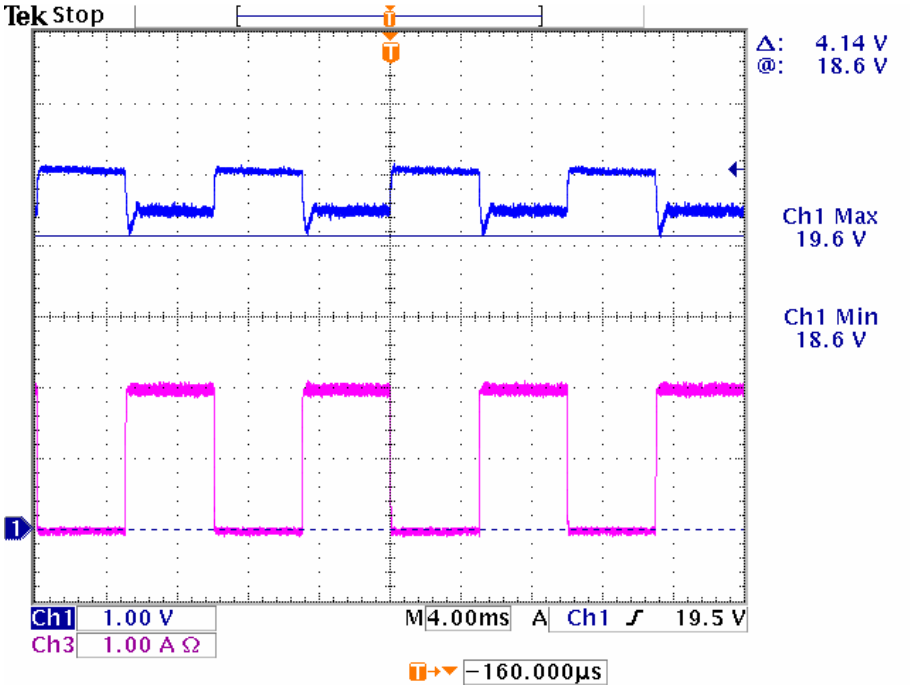



Figure 9: Output voltage waveform of under Dynamic test@264Vac/50Hz,full load

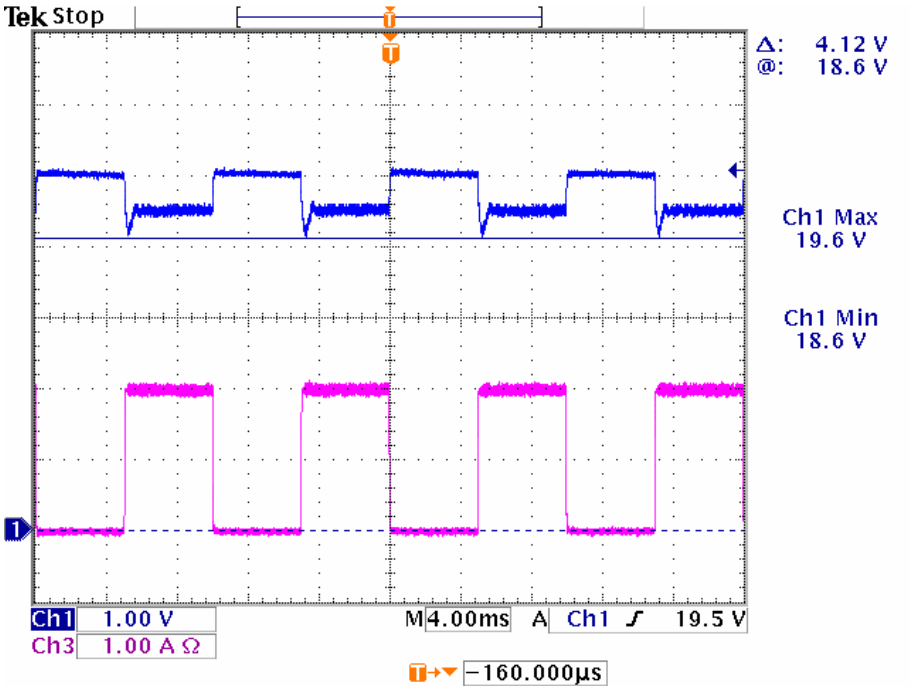



Figure 10: Output voltage waveform under Dynamic test@90Vac/50Hz,full load

### 5) Time Sequence

Time sequence parameters were measured with DSO.

| Item | Input Voltage | Meas. Data | Test spec. | Test Result | Remark |
|---|---|---|---|---|---|
| Turn-on delay time | 90V/50Hz | 2.59 S | <3.0S | Pass | Figure 11 |
| | 264V/50Hz | 0.75 S | | Pass | |
| Hold-up time | 90V/50Hz | 8mS | | | Figure 12 |
| | 264V/50Hz | N.A. | | | |
| Rise Time | 90V/50Hz | 108ms | | Pass | Figure 13 |
| | 264V/50Hz | N.A. | | | |
| Fall Time | 90V/50Hz | 16.8mS | | Pass | Figure 14 |
| | 264V/50Hz | N.A. | | | |

Table 19: turn-on delay /hold-up/Rise/Fall time measurement results

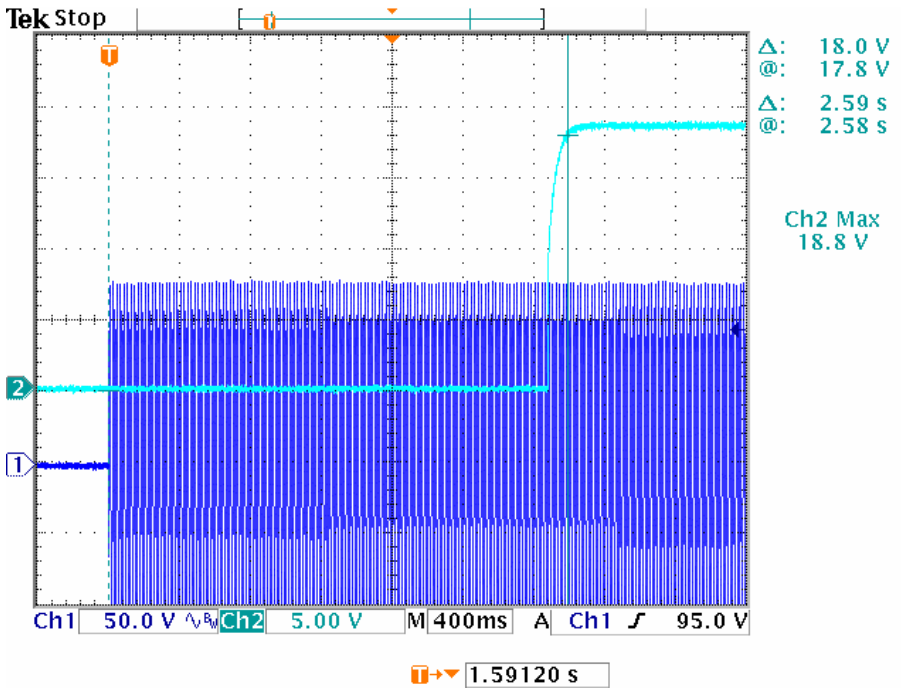



Figure 11: Turn on delay time measured waveform@90Vac/50Hz,full load

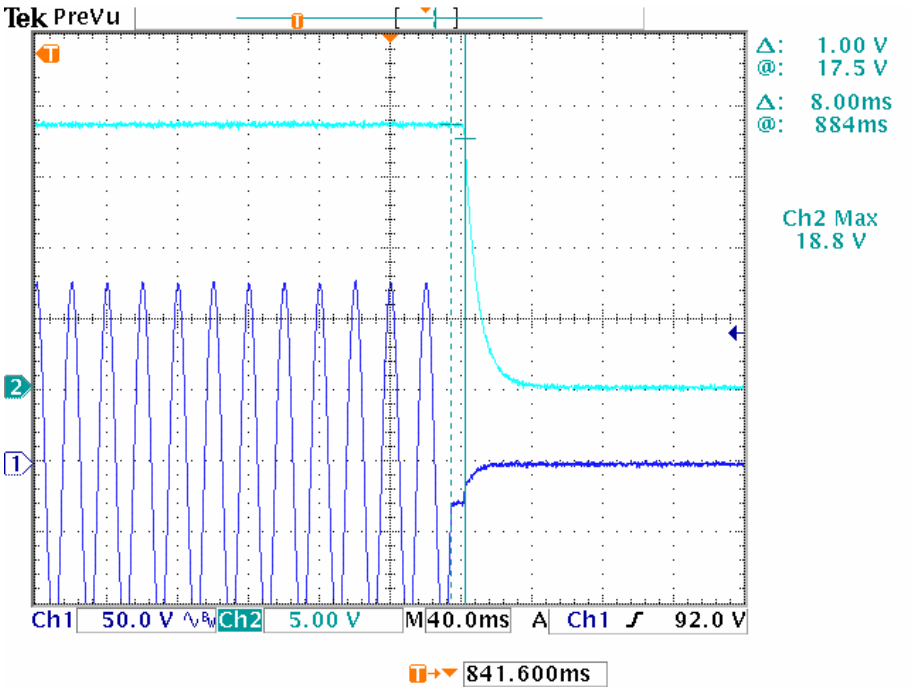



Figure 12: Hold on delay time measured waveform@90Vac/50Hz,full load

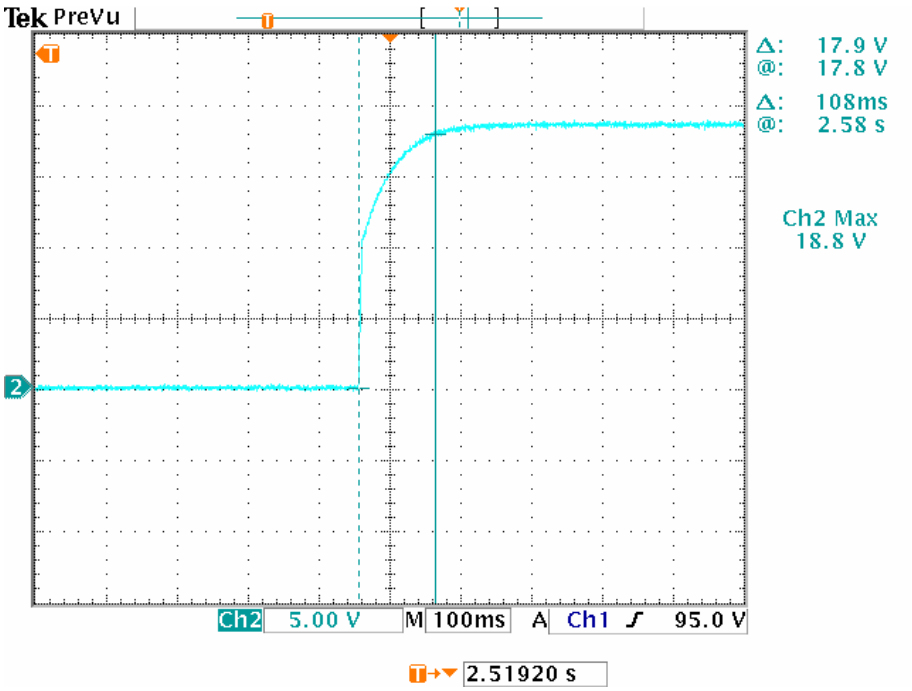



Figure 13: Rise time measured waveform@90Vac/50Hz,full load

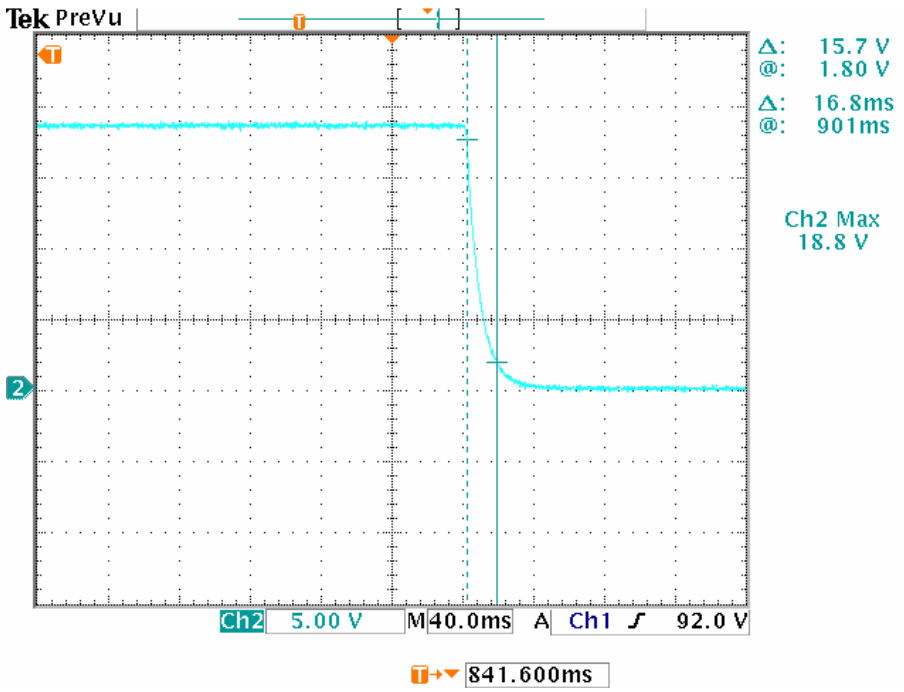



Figure 14: Fall time measured waveform@90Vac/50Hz,full load

## 4.3 Protection

### 1) Over Current Protection (OCP)

The OCP was tested at 90Vac/50Hz and 264Vac/50Hz input voltage. The results are listed in Table20.

| Input Voltage | OCP | Remark |
|---|---|---|
| 90Vac/50Hz | 2.51 A | |
| 115Vac/50Hz | N.A. | |
| 230Vac/50Hz | N.A. | |
| 264Vac/50Hz | 2.79 A | |

Table 20: OCP value vs. input voltage

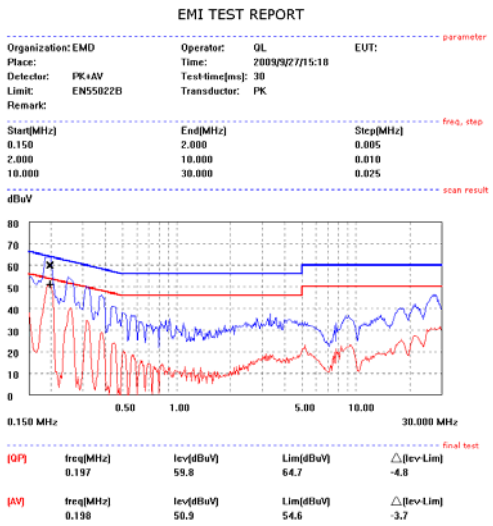
### 2) Short Circuit Protection

The system is protected during output short circuit condition and recovered when short circuit condition is removed. The module passed SCP test.

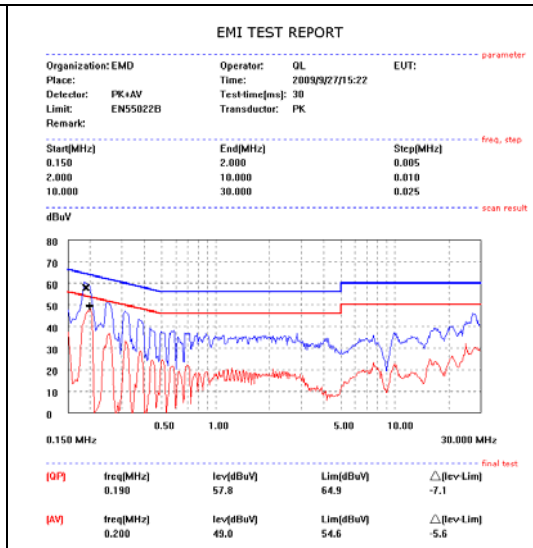
## 4.4 EMI Test

The Power supply passed EN55022 Class B EMI requirement with more than 5dB margin.

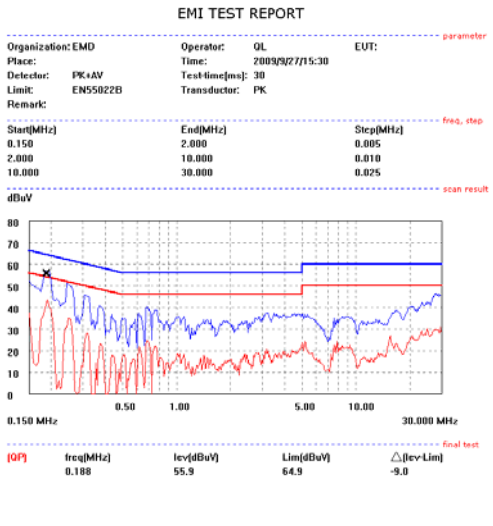
**Conducted EMI Test Result**



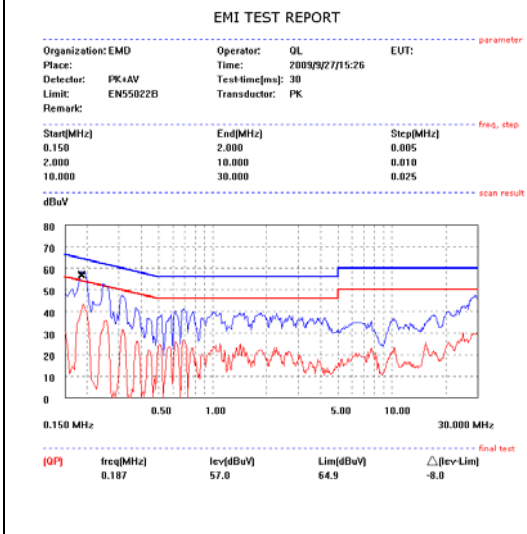

**Vin=120Vac,Full load Floated L**




**Vin=120Vac,Full load Floated N**




**Vin=230Vac,Full load Floated L**



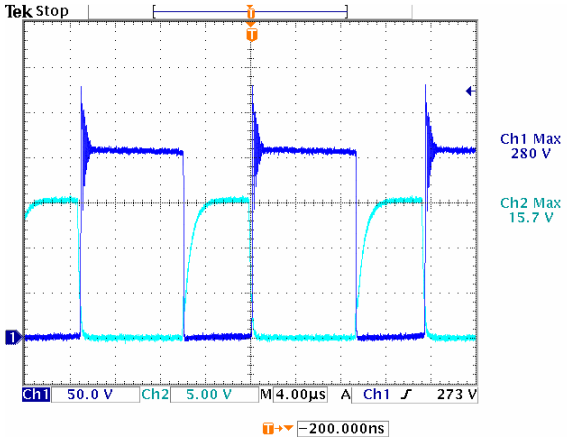

**Vin=230Vac,Full load Floated N**

Figure 15

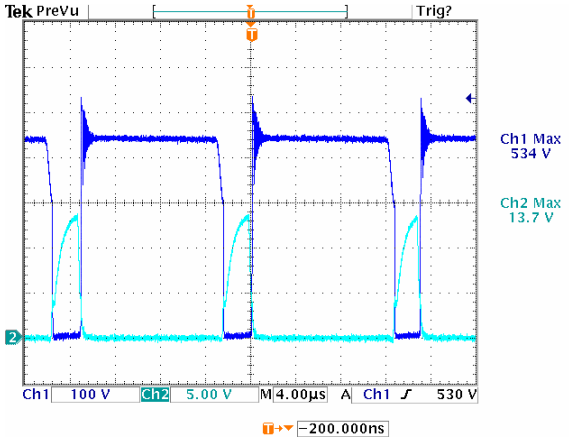
# 5 SYSTEM OTHER IMPORTANT WAVEFORM

## 5.1 MOSFET VDS Wave form at 90Vac/264Vac, Normal/Output Short

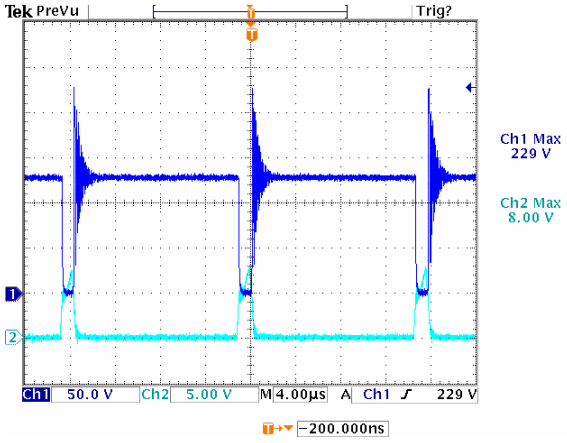
Normal, Vds wave form@90Vac/50Hz, full load



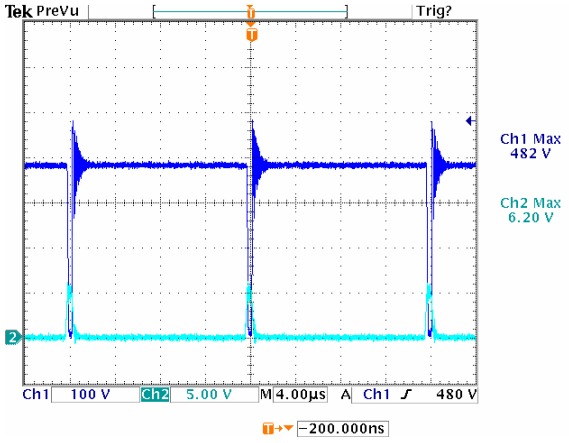

Normal, Vds wave form@264 Vac/50Hz,full load




Startup with Output short, Vds wave form@90Vac/50Hz,

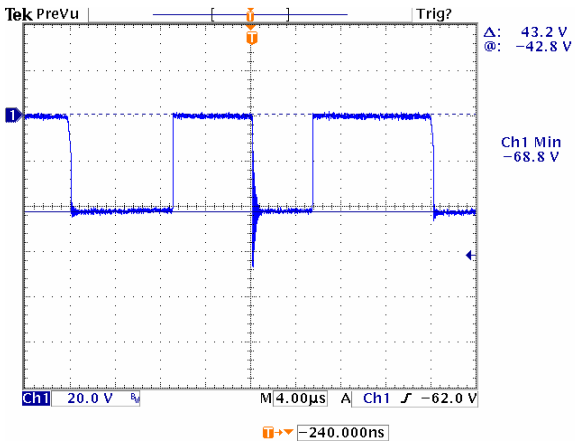



Output short, Vds wave form@264 Vac/50Hz,




## 5.2 Output Rectifier Diode VAK Waveform at Full Load

$V_{AK}$ wave form@90Vac/50Hz,full load




$V_{AK}$ wave form@264Vac/50Hz,full load