

36W Adapter Module Design with FT861



Index

1	INTRODUCTION	3
2	ADAPTER MODULE SPECIFICATION	3
2.1	Input Characteristics	3
2.2	Output Characteristics	3
2.3	Performance Specification	4
2.4	Protection Features	4
2.5	Environmental.....	4
2.6	Dielectric Withstand (Hi-pot) Test	4
2.7	Insulation.....	4
3	ADAPTER MODULE INFORMATION.....	5
3.1	Schematic.....	5
3.2	PCB Gerber	6
3.3	Bill of Materials	7
3.4	Transformer Design.....	8
1)	Transformer Specification.....	8
2)	Structure/Material.....	8
3.5	Adapter Module Snapshot	9
4	PERFORMANCE EVALUATION	10
4.1	Input Characteristics	11
1)	Input Normal Characteristics	11
2)	Standby Power / AVG Efficiency	11
4.2	Output Characteristics	12
1)	Line Regulation & Load Regulation.....	12
2)	Ripple & Noise.....	12
3)	Over Shoot & Under Shoot.....	13
4)	Dynamic Test.....	14
5)	Time Sequence.....	16
4.3	Protection.....	18
1)	Over Current Protection (OCP)	18
2)	Short Circuit Protection.....	18
4.4	EMI Test.....	19
5	SYSTEM OTHER IMPORTANT WAVEFORM	21
5.1	MOSFET VDS Wave form at 90Vac/264Vac, Normal/Output Short.....	21
5.2	Output Rectifier Diode VAK Waveform at Full Load.....	21

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	+12.0V
Output Tolerance	+/-0.6V
Min. Load Current	0A
Max. Load Current	3A
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	36W Typical
Standby Power	< 0.3W @ 90Vac/63Hz~265Vac/47Hz, no load
Efficiency	84.6% 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°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

2.6 Dielectric Withstand (Hi-pot) Test

Input to Output	3000Vac 1 min.
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Table 6

2.7 Insulation

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

Table 7

3.2 PCB Gerber

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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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Table 8

3.4 Transformer Design

1) Transformer Specification

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2) Structure/Material

Table 9

Figure 4

3.5 Adapter Module Snapshot

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Figure 5

4 PERFORMANCE EVALUATION

This session presents the test results of 36W 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 $\geq 84.6\%$

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.	0.81A
Input current (180Vac~264Vac/50Hz)	0.6A Max.	0.46A
Standby power	$< 0.3W$	0.29W
Efficiency (Average)	$> 84.6\%$	86%
2. Output Characteristics		
Line regulation	1%	0.1%
Load regulation	5%	0.5%
Ripple & noise	200mV	150mV
Over shoot & Under shoot	0.6V	0
Dynamic test	0.6V	0.5V
3. Time Sequence		
Turn on delay time	$< 3.0S$	2.53S
Hold up time		8ms
Rise time		64ms
Fall time		11.2ms
4. Protection		
Over current protection	3.3~4.5A	3.87 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	I _{rms} (A)	P _{in} (W)	V _o (V)	I _o (A)	η(%)	Specification	Test Result
90V/50Hz	0.808	42.75	12.19	3.0	85.5	>84.6%	Pass
115V/50Hz	0.676	42.40	12.19	3.0	86.3		
230V/50Hz	0.464	42.15	12.19	3.0	86.8		
264V/50Hz	0.412	42.70	12.19	3.0	85.6		

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	V _o (V)	Input Power(W)	Specification	Test Result
90V/50Hz	12.26	0.13	<0.3W	Pass
115V/50Hz	12.26	0.15		
230V/50Hz	12.26	0.26		
264V/50Hz	12.26	0.29		

Table 12: Standby power at no load

Loading(%)	I _{rms} (A)	P _{in} (W)	V _o (V)	I _o (A)	η %	AVG Efficiency	Test Result
100%	0.676	42.40	12.19	3.0	86.3	86.1%	Pass
75%	0.534	31.79	12.21	2.25	86.4		
50%	0.386	21.15	12.23	1.5	86.7		
25%	0.230	10.80	12.24	0.75	85.0		

Table13: Vin: 115Vac

Loading (%)	I _{rms} (A)	P _{in} (W)	V _o (V)	I _o (A)	η %	AVG Efficiency	Test Result
100%	0.464	42.15	12.19	3.0	86.8	86.0	Pass
75%	0.352	31.91	12.20	2.25	86.0		
50%	0.244	21.13	12.22	1.5	86.7		
25%	0.136	10.89	12.24	0.75	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	12.26	12.22	12.19	11.4~12.6	pass
115Vac/50Hz	12.26	12.23	12.19	11.4~12.6	
230Vac/50Hz	12.26	12.22	12.19	11.4~12.6	
264Vac/50Hz	12.26	12.23	12.19	11.4~12.6	
Line Regulation	0.1%			<1%	Pass
Load Regulation	0.5%			<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	39mV	129mV	200mV	Pass	Figure 6
264Vac/50Hz	46mV	128mV		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.

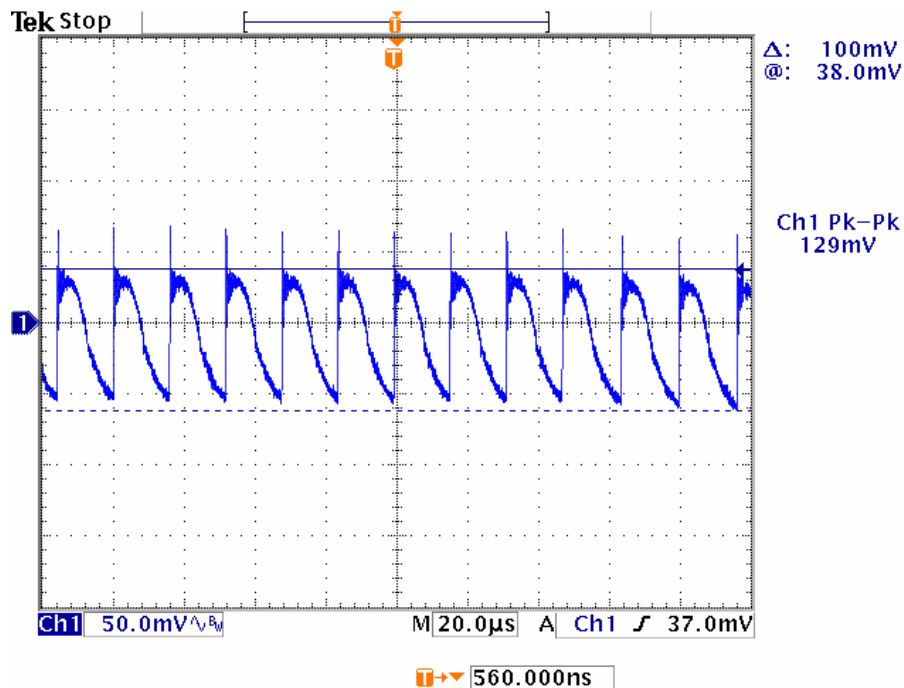


Figure 6: Measured ripple& noise waveform@90Vac/50Hz,Full load.

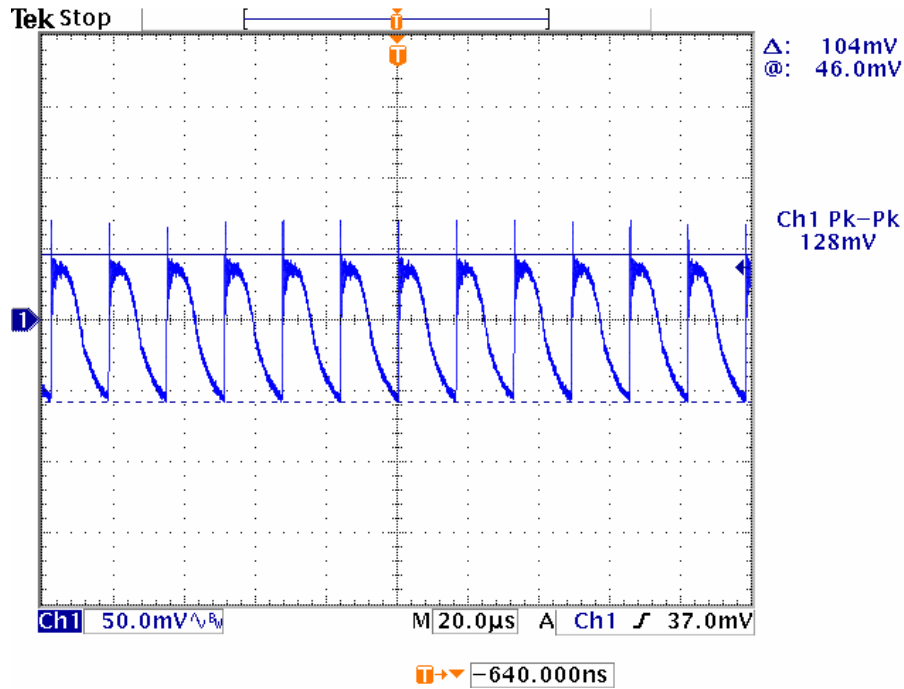


Figure 7: Measured ripple& noise waveform@264Vac/50Hz, full load

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	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.

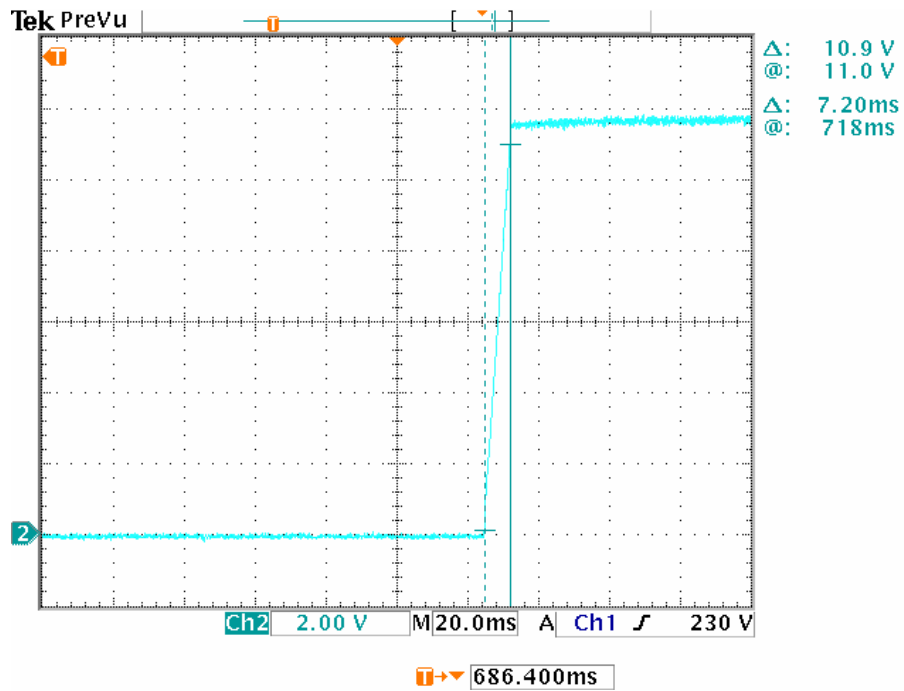


Figure 8: Measured overshoot waveform@264Vac/50Hz, full load

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	11.5V~12.4 V	11.4V~12.6V	Pass	Figure 9
90V/50Hz	11.5V~12.4 V		Pass	Figure 10

Table 18: output voltage under dynamic test

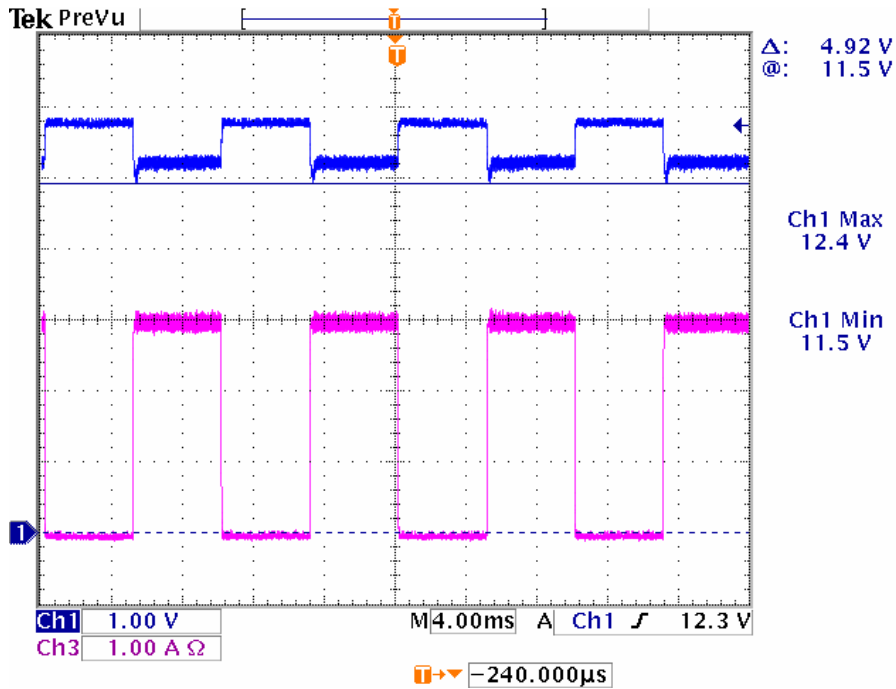


Figure 9: Output voltage waveform of under Dynamic test@264Vac/50Hz,full load

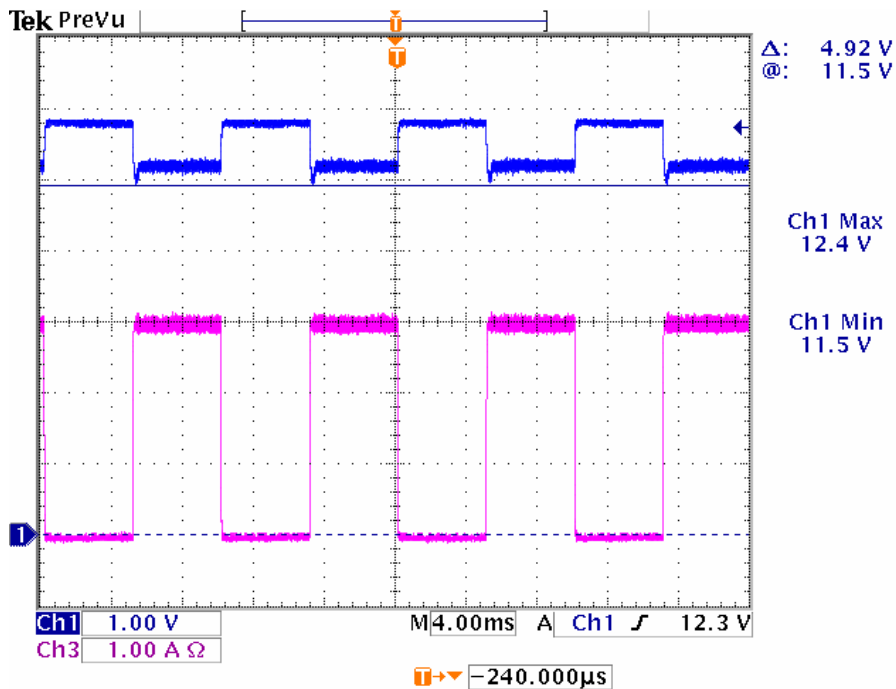


Figure 10: Output voltage waveform under Dynamic test@90Vac/50Hz,full load

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	2.53 S	<3.0S	Pass	Figure 11
	264V/50Hz	0.73S		Pass	
Hold-up time	90V/50Hz	8mS			Figure 12
	264V/50Hz	N.A.			
Rise Time	90V/50Hz	64ms		Pass	Figure 13
	264V/50Hz	N.A.			
Fall Time	90V/50Hz	11.2mS		Pass	Figure 14
	264V/50Hz	N.A.			

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

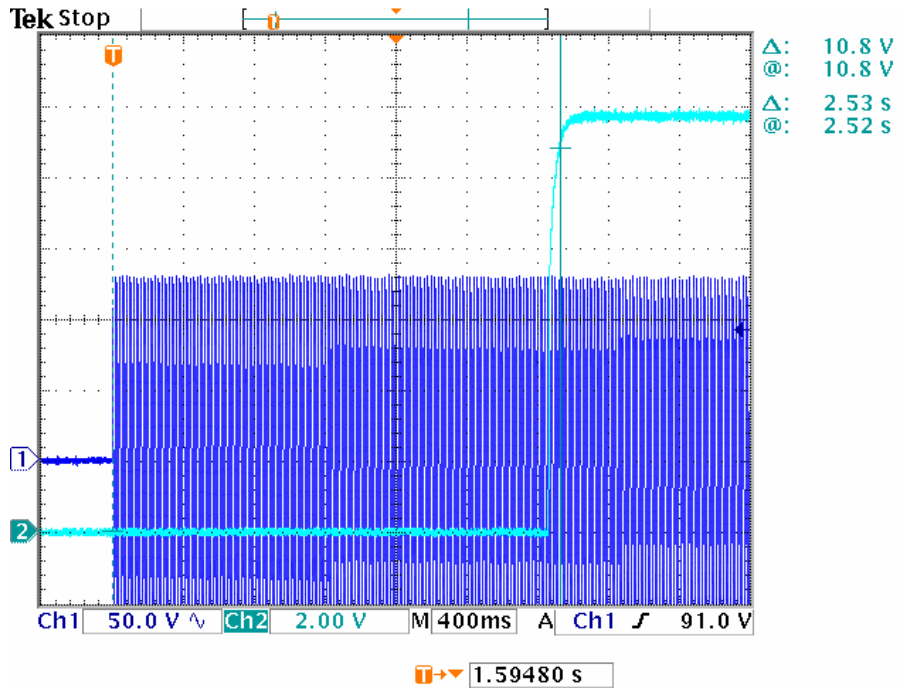


Figure 11: Turn on delay time measured waveform@90Vac/50Hz,full load

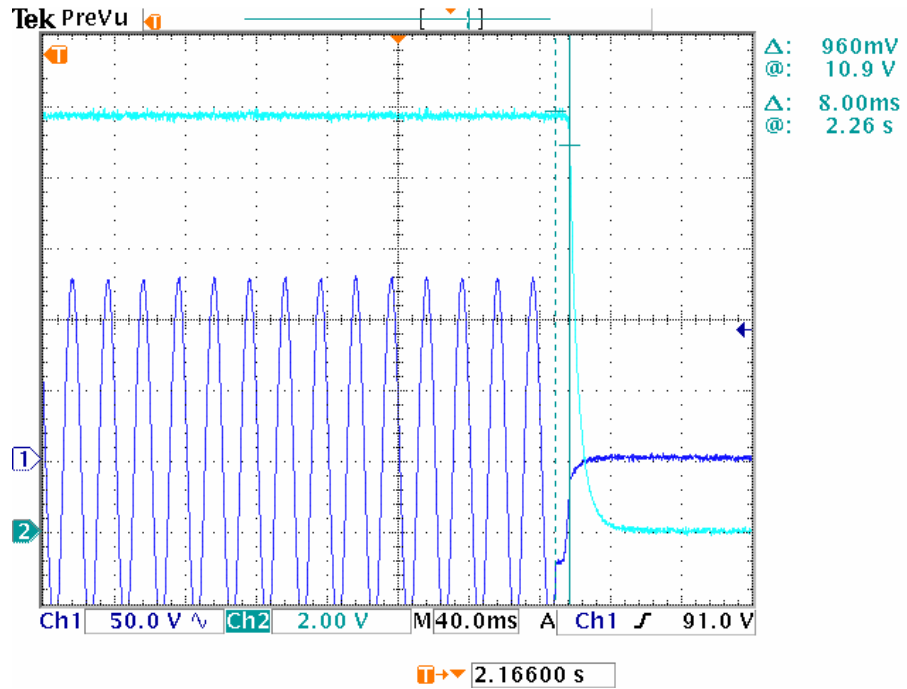


Figure 12: Hold on delay time measured waveform@90Vac/50Hz,full load

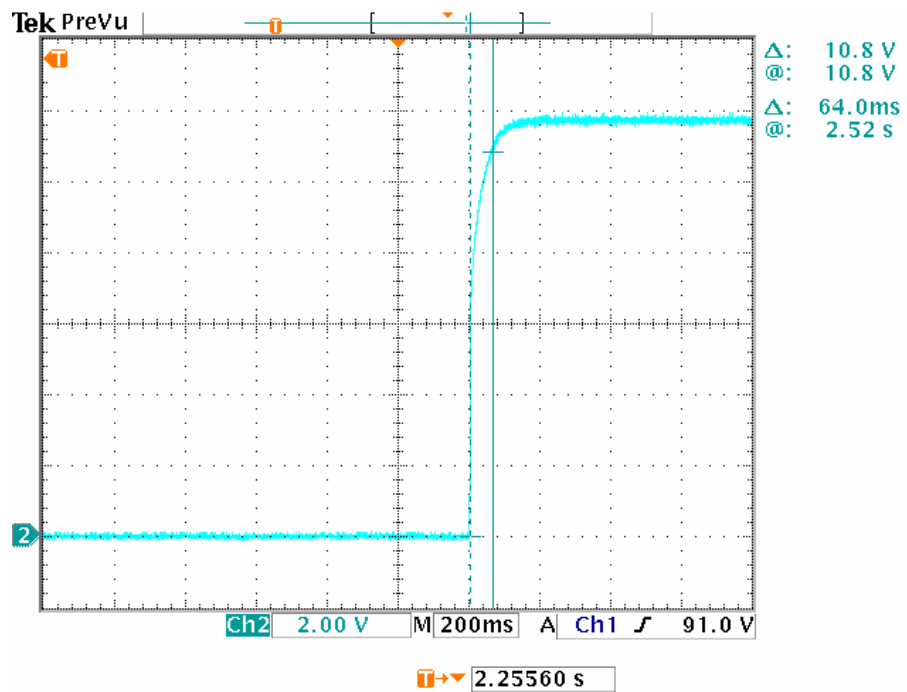


Figure 13: Rise time measured waveform@90Vac/50Hz,full load

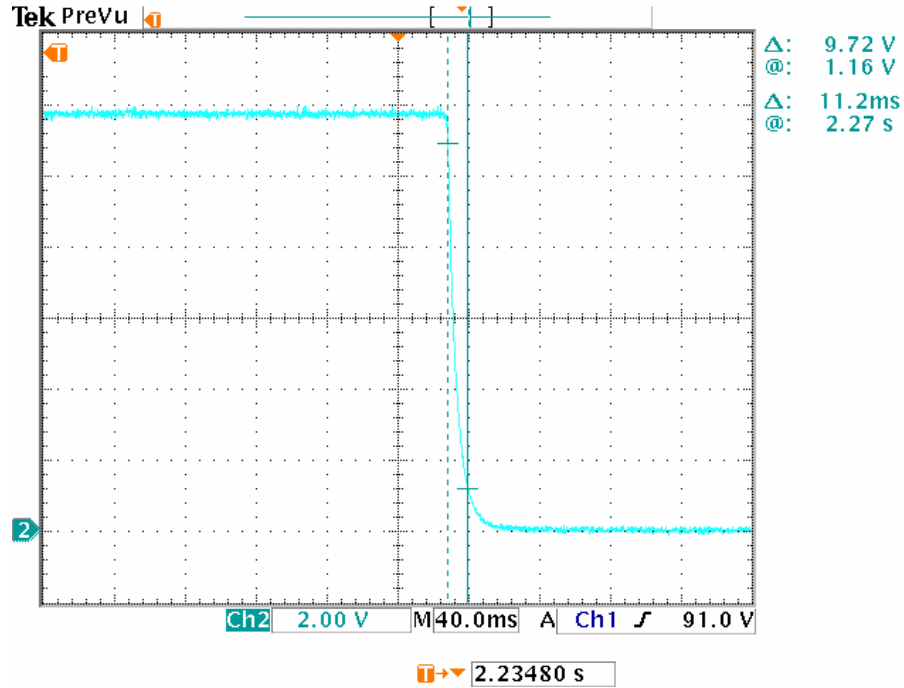


Figure 14: Fall time measured waveform@90Vac/50Hz,full load

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 Table 20.

Input Voltage	OCP	Remark
90Vac/50Hz	3.72 A	
115Vac/50Hz	N.A.	
230Vac/50Hz	N.A.	
264Vac/50Hz	3.87 A	

Table 20: OCP value vs. input voltage

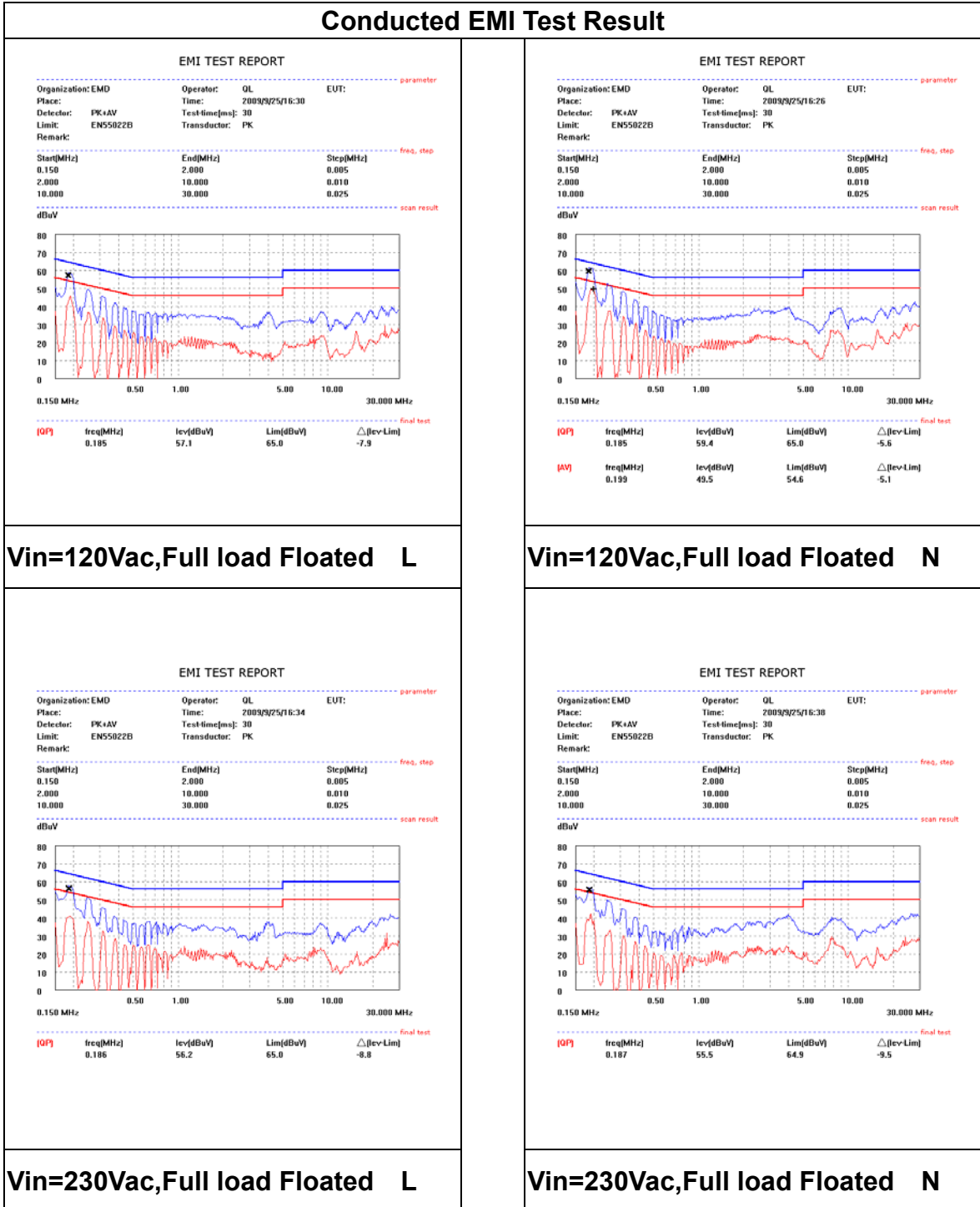
2) Short Circuit Protection

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

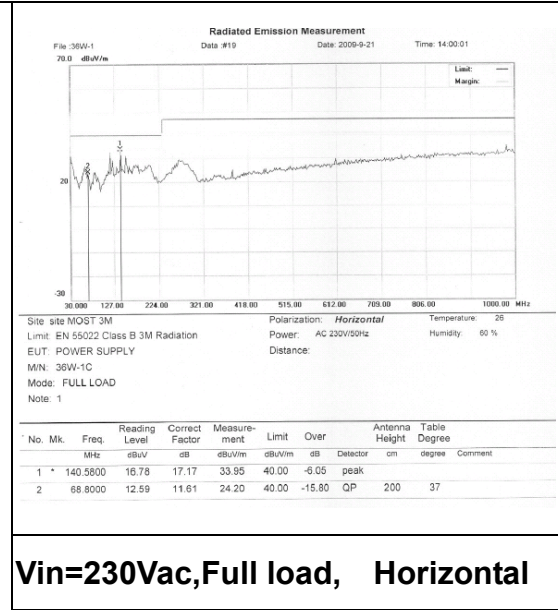
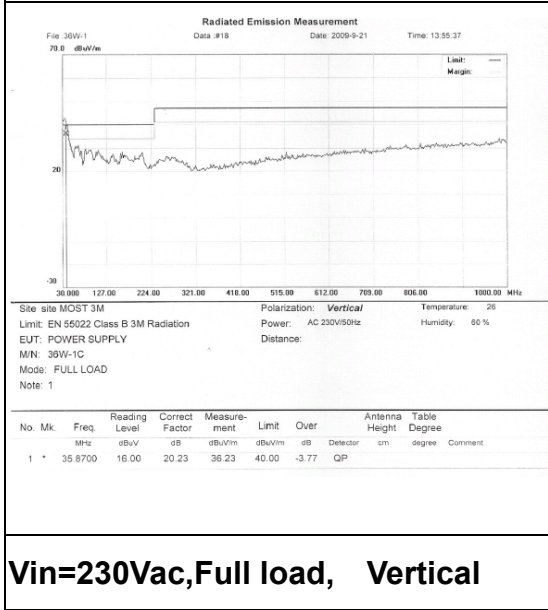
4.4 EMI Test

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

Conducted EMI Test Result



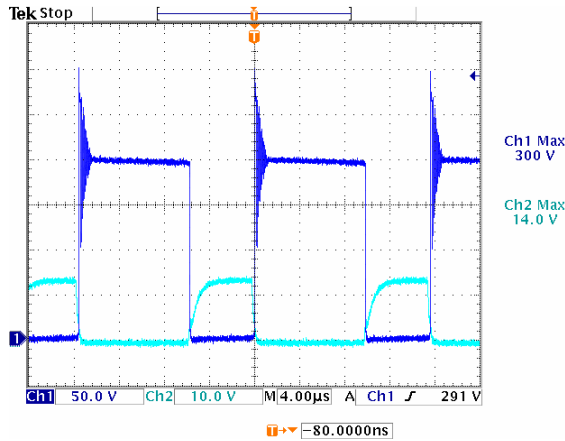
Radiated EMI Test Result



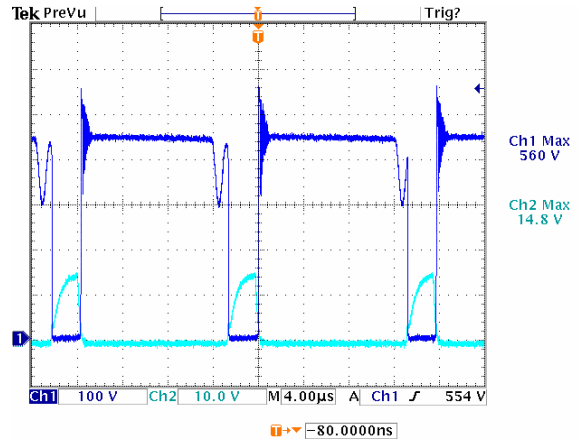
5 SYSTEM OTHER IMPORTANT WAVEFORM

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

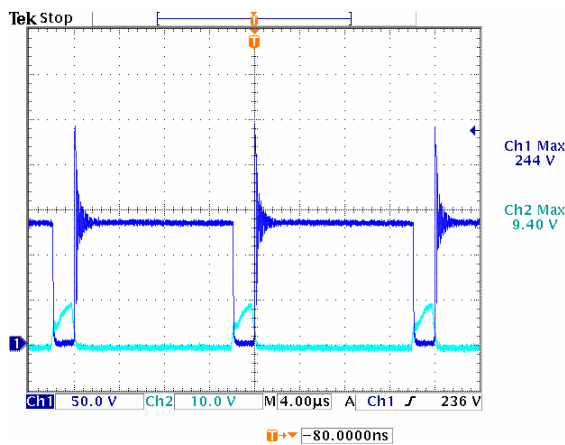
Normal, Vds wave form@90Vac/50Hz, full load



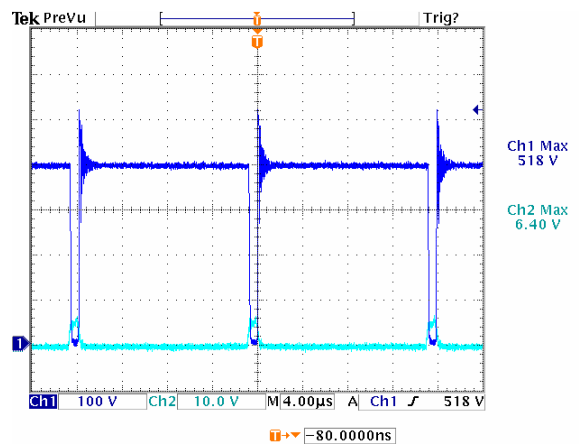
Normal, Vds wave form@264 Vac/50Hz,full load



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

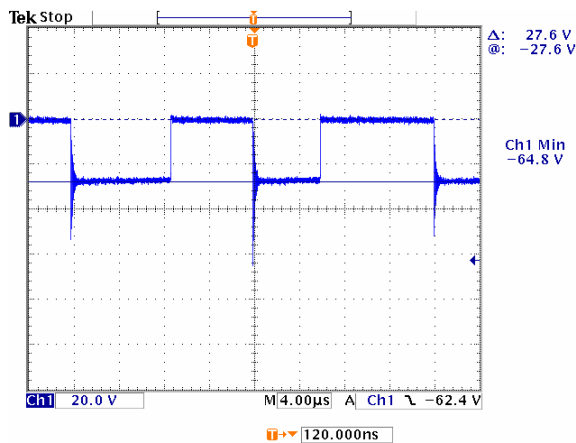


Output short, Vds wave form@264 Vac/50Hz,



5.2 Output Rectifier Diode VAK Waveform at Full Load

VAK wave form@90Vac/50Hz,full load



VAK wave form@264Vac/50Hz,full load

