General Description

Based on Flyback topology, the Primary side Regulated AP3983E EV1 board is designed to serve as an example for High Efficiency, low cost & less components consumer home appliance systems. Also a 700V N MosFet is integrated within control IC for easy fitting in a flexible & small size power system design. During the valley on operating & work at PFM region the high efficiency and low standby function can be achieved, by mean of using multi-mode controlling skill the accurate constant voltage and constant current can be easy meet. Its output power is rated at 18W with 12V-1.5A. It can meet DOE VI and CoC Tier 2 energy efficiency requirement.

Key Features

- 90 ~264V_{AC} input range
- Using the Primary side control for eliminating the Opto-coupler.
- Multi-Mode PFM method operations, the switching frequency between 24kh ~80Khz.
- With Valley on detection the switching stay at Valley on region so that will improve power converting efficiency & EMI performance, the 86% Efficiency can be reached at full load.
- During the burst mode operation and Low start-up operating quiescent currents the 75mW low standby input power can be achieved.
- Dynamic response is improved during work at three mode operation as well as benefiting the accurate constant voltage (CV) regulation & constant current (CC) performance.
- There is a Soft start during startup process.
- Built-in Jittering Frequency function which is the EMI emission can be improved.
- Internal Auto Recovery OCP, OVP, OLP, OTP Power Protection, cycle by cycle current limit, also with DC polarity protection
- Built –in Cable Compensation mode.
- With a Brown out Protection.

Applications

- Switching AC-DC Adaptor & Charger
- Power home Appliances systems
- Set-top box & ADSL or small wireless Router system
- The auxiliary Vcc power supply for bigger power system.

Universal AC input PSR 12V-1.5A Power Specifications (CV & CC mode)

Parameter	Value
Input Voltage	90 to 264V_{AC}
Input standby power	75mW
Main output Vo / Io	12V – 1.5A
Efficiency	~ 86%
Total Output Power	18W
Protections	OCP, OVP, OLP,OTP
XYZ Dimension	50.4.0 x 50.4 x 25 mm
ROHS Compliance	Yes

Evaluation Board Picture:

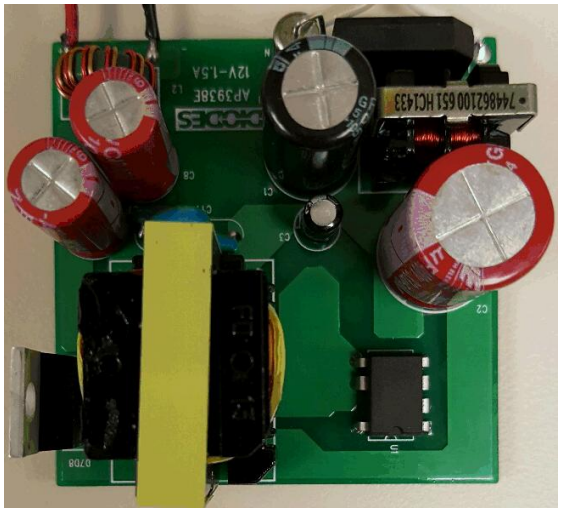


Figure 1: Top View

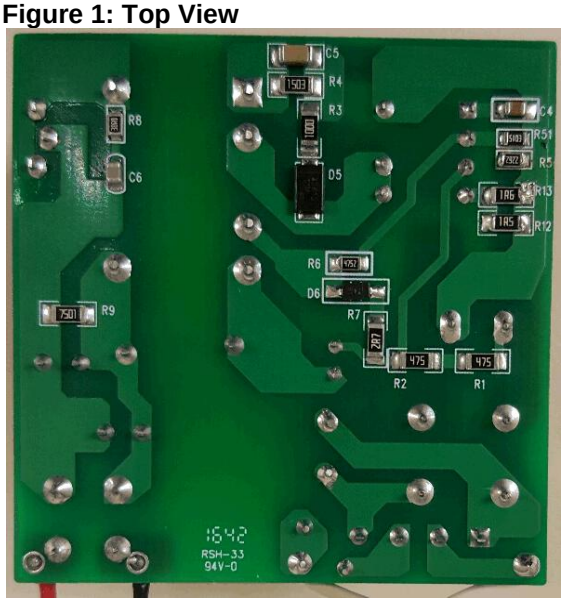
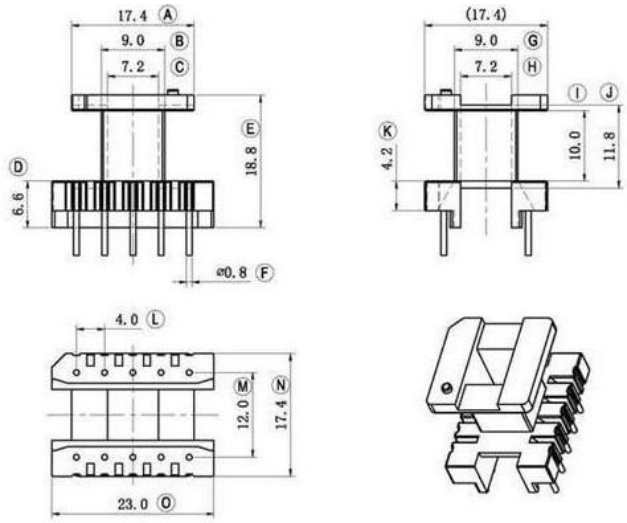


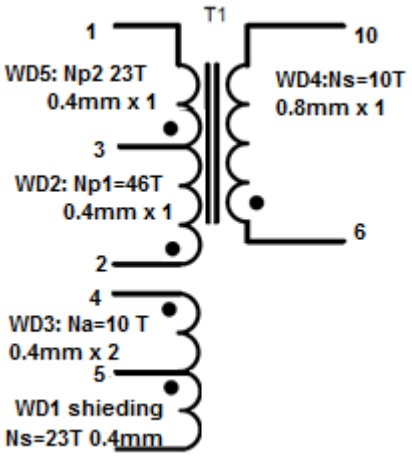
Figure 2: Bottom View

AP3301 (90V_{AC} ~ 265V_{AC} one outputs 42W Transformer Spec.)

1) Core& Bobbin: EE25 , 5+5 pin



2) Electrical Diagram:



3) Transformer Parameters

1. Primary Inductance (Pin2-Pin1), all other windings are open

Lp = 0.70mH ±7% @1KHz

RM8 （Ae = 64mm^2）						
NO Winding	NAME	TERMINAL NO.		WINDING		
		START	FINISH	WIRE	TURNS	Layers
1	Np1	2	3	Φ 0.4mm	46Ts	2
2	Na	4	5	Φ 0.4mm x 2	10 Ts	1
3	Shield	5（GND）	NC	Φ 0.4mm x 1	23T	1
4	Ns	10(+)	6	Φ 0.8W x 1	10 Ts	1
5	Np2	3	1	Φ 0.35 (27# AWG)	23	1

Primary Inductance	Pin 2-1,all other windings open, measured at 1kHz, 0.4VRMS	700uH ± 7 %

Primary Leakage Inductance	Pin 2-1, all other windings shorted, measured at 10kHz, 0.4VRMS	80 uH (Max.)

Evaluation Board Schematic

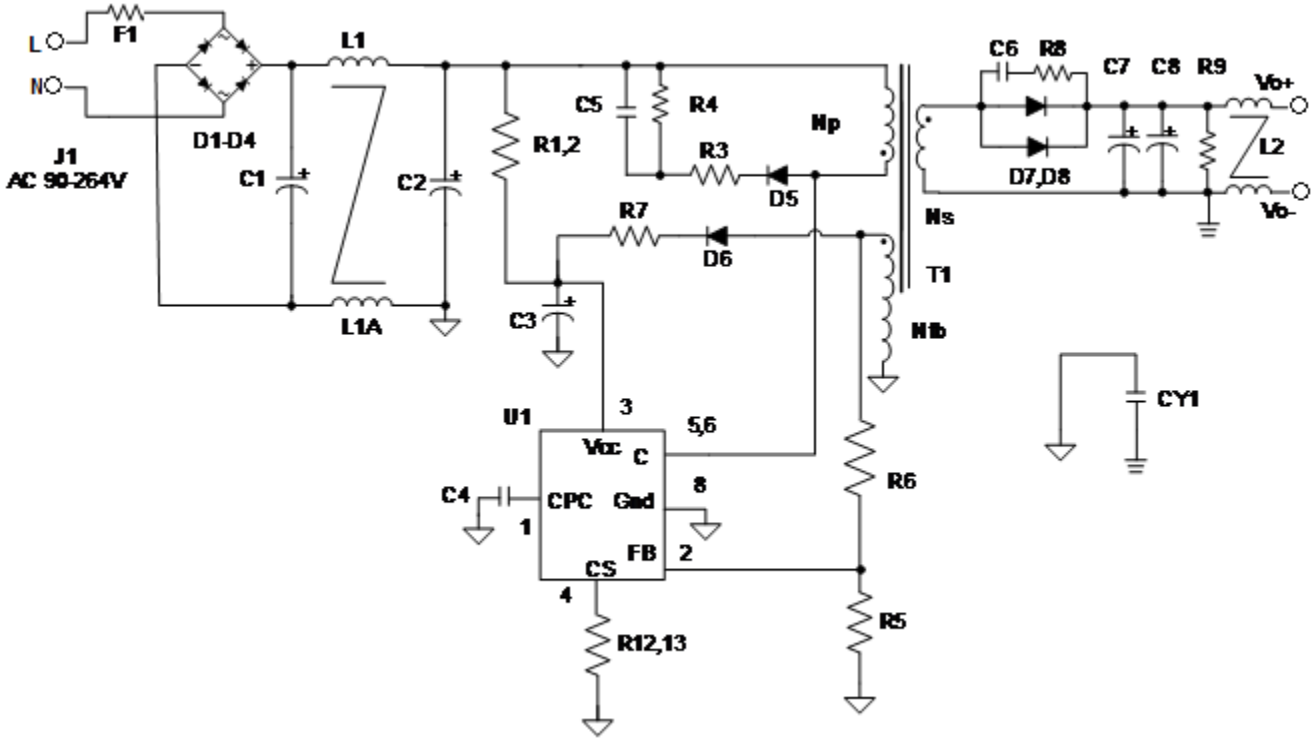


Figure 3: Evaluation Board Schematic

Evaluation Board PCB Layout

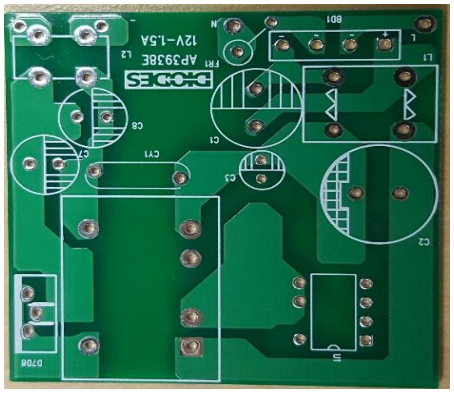


Figure4: PCB Board Layout Top View

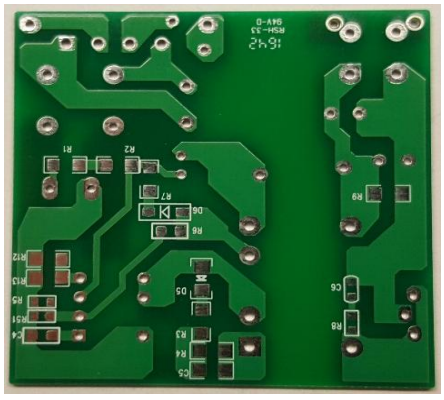


Figure5: PCB Board Layout Bottom View

Quick Start Guide

1. The evaluation board is preset at 12V/1.5A from output + & -
2. Ensure that the AC source is switched OFF or disconnected before doing connection.
3. Connect the AC line wires of power supply to “L and N” on the left side of the board.
4. Turn on the AC main switch.
5. Measure Red & Black wires to ensure correct output voltages at 12V respectively.

Build of Material

AP3983E 12V-1.5A BOM 10-19-2016

Item	QTY per board	REF. DES.	Description	MFG or Supplier	MFG P/N or Supplier P/N Digi key #
1	1	C1	22uf /400V 10 x 18mm	Wurth Electro	
2	2	C2	47uf /400V 12.5 x 20mm	Wurth Electro	
3	1	C3	3.3uf/50V E-cap	Wurth Electro	
4	1	C4	10 nF/50V 0805 ceramic	Yageo	
5	1	C5	2.2nf / 500V, 0805 X7R	Holy Stone	
6	1	C6	1nf 250V 0805 X7R	Holy Stone	
7	2	C7 & C8	680nf /16V E-cap	Wurth Electro	
8	2	R1, R2	4.7M ohm 1206	Yageo	
9	1	R3	100R hom 1206	Yageo	
10	1	R4	150kohm 1206	Yageo	
11	2	R5 //R51	22.6k //510k ohm 0805	Yageo	
12	1	R6	47.5K ohm 0805	Yageo	
13	1	R7	2.7R ohm, 0805	Yageo	
14	1	R8	30R ohm, 1206	Yageo	
15	1	R9	7.5K ohm 1206	Yageo	
16	2	R12, R13	1.5R//1.6R ohm 1206	Yageo	
17		R10	off		
18	1	BD1	KBP206G	Diodes 2A-600V	
19	2	D5, D6		Diodes 1A-600V	
20	1	D7, D8	SDT20B100	Diodes 10A/100V	
21	1	F1	1.25A/250V		
22	1	UU9.8 22mH	22mH common mode chock	Wurth Electro	
23	1	CY1	1000pf/250Vac Y1	Holy Stone	
24	1	IC	AP3983E DIP-7	Diodes	

Input & Output Characteristics

Input Standby Power

Input Voltage	115Vac/60Hz	230Vac/50Hz	Note
Pin (w)	52mW	69mW	At no loading

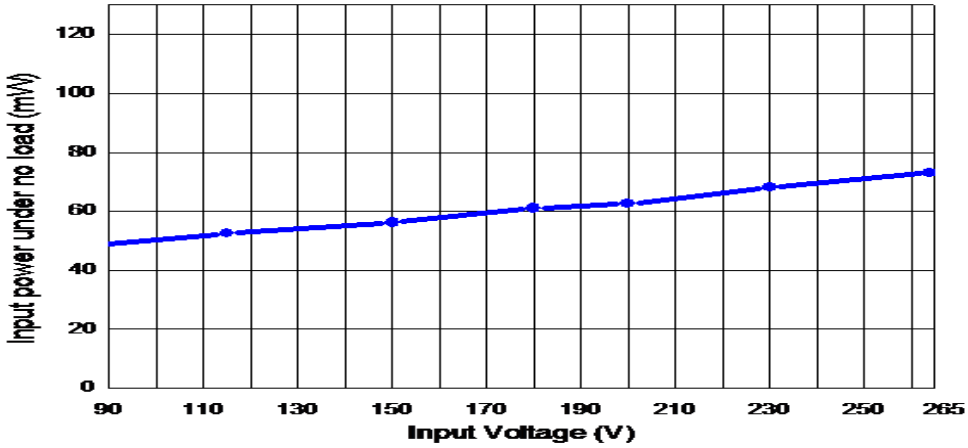


Figure 6: The Efficiency curve with at different AC input

Input power Efficiency at different loading

AC input	Efficiency (%)					Eff_avg at four conditions
	10%	25%	50%	75%	100%	
90VAC/60Hz					84.7%	
115VAC/60Hz	79.8%	84.6.0%	85.8%	85.8%	85.6%	85.5%
230VAC/50Hz	79.05%	82.5%	86.6%	86.8%	86.2%	85.5%
264VAC/50Hz					86.1%	
Eff_avg						

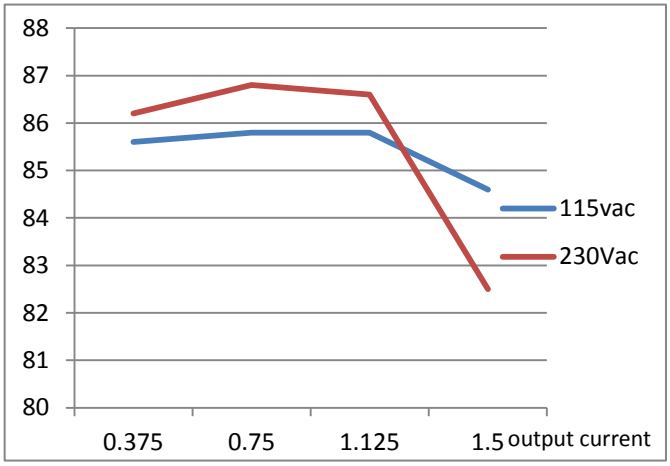


Figure 7: The efficiency curve with different loading

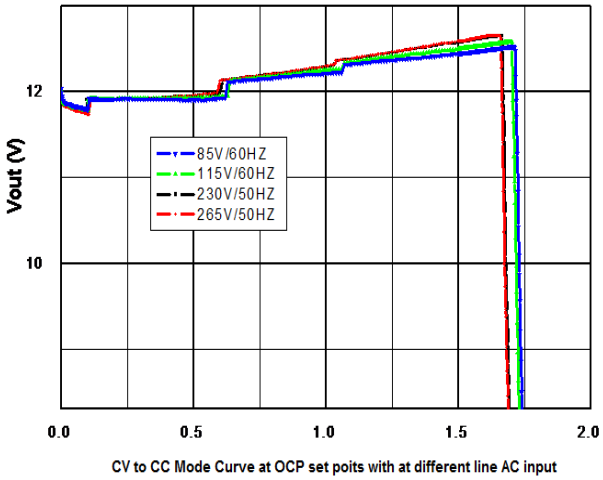


Figure 8: CV & CC Curve at OCP set poits

OCP Current set point with at different AC line

AC input	90VAC	115VAC	230VAC	264VAC	Note
I _max	1.67A	1.68A	1.72A	1.74A	

PSU Output Characteristics:

Line Regulation (at full loading condition):

AC input Voltage	90VAC/60Hz	115VAC/60Hz	230VAC/50Hz	265VAC/50Hz	Note
12.00Vo	12.16V/1.5A	12.19V/1.5A	12.24V/1.5A	12.26V/1.5A	0.82%<1%

Cross Load Regulation (at nominal line AC input voltage):

AC input Voltage	115VAC/60Hz	230VAC/50Hz
12V Full Load	12.19V / 1.5A	12.24V/1.5A
12V 10% of FL	11.61V /0.15A	11.59V/0.15A
Note	4.8%	5.5%

Note: All output voltages are measured at output PCB board Edge.

Key Performance Waveforms:

System start - up time

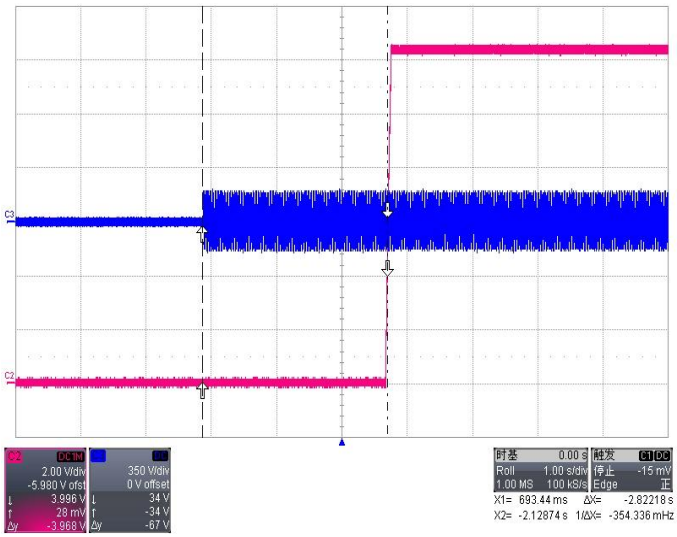


Figure 9:AP3983E turn on time 2.8sFL at 90Vac

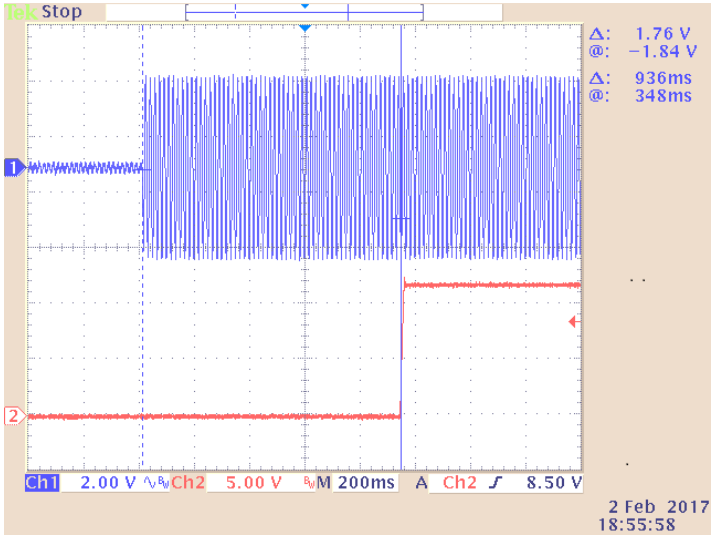


Figure 10: AP3983E turn on time 0.94s at FL, at 230Vac

System main switching Voltage Stress on AP3983E Pin 5&6

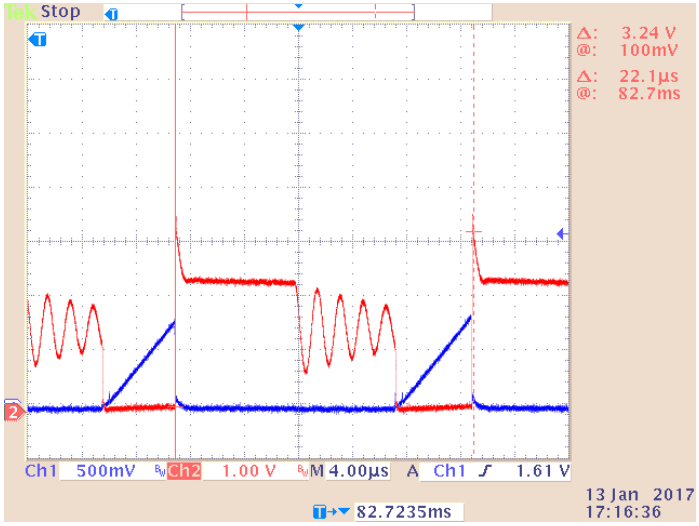


Figure 11:AP3983E Vds at FL at 100Vac Vds=140Vp-p

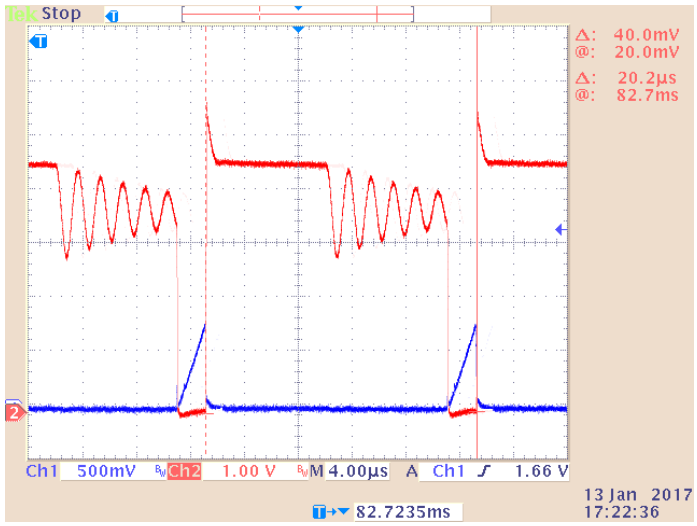


Figure 12: AP3983E Vds at FL at 264 Vac, Vds=570Vp-p

System Voltage Stress across on Q2 D-S

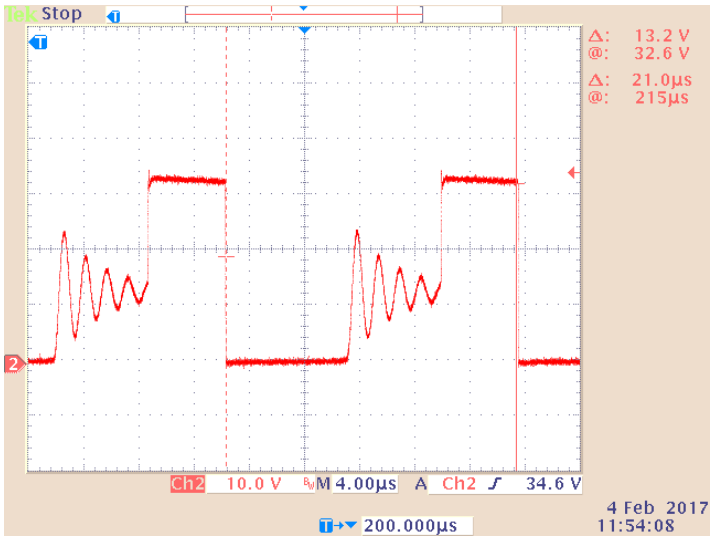


Figure 13: Q2 D-S voltage stress at 100Vac FL

Vq2 d_S = 34Vp-p 10V/div

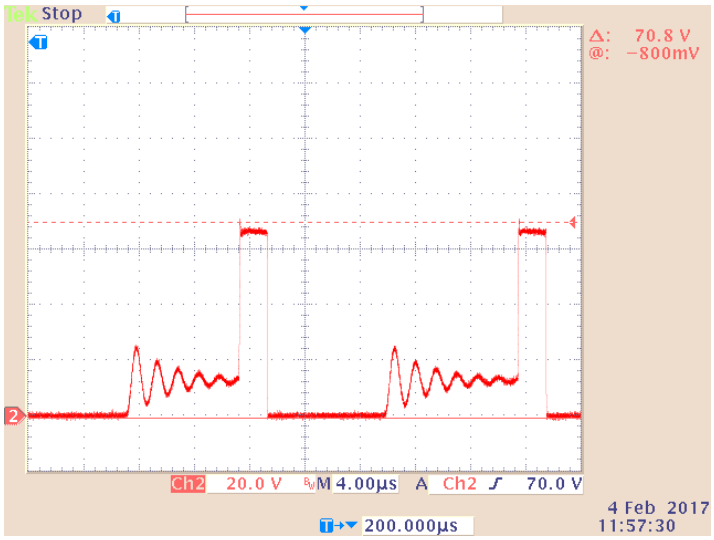


Figure 14: Q2 D-S voltage stress at 264Vac at FL

Vq2 d_S = 71Vp-p 20V/div

System output Ripple performance

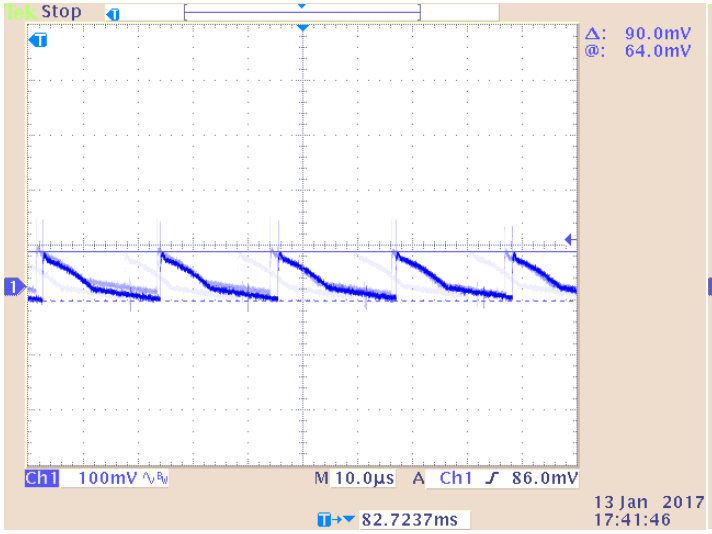


Figure 15: The Ripple at 100Vac_in Vpp=90mv FL

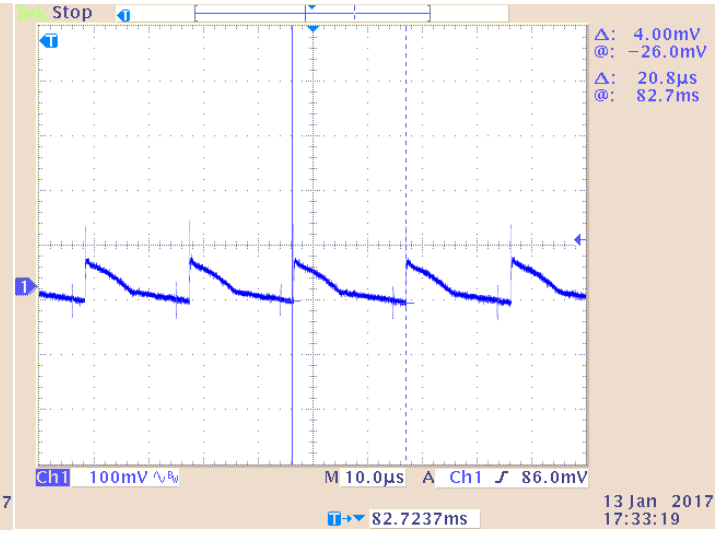


Figure 16: The Ripple at 230Vac_in Vpp=83mv FL

System Dynamic Response performance

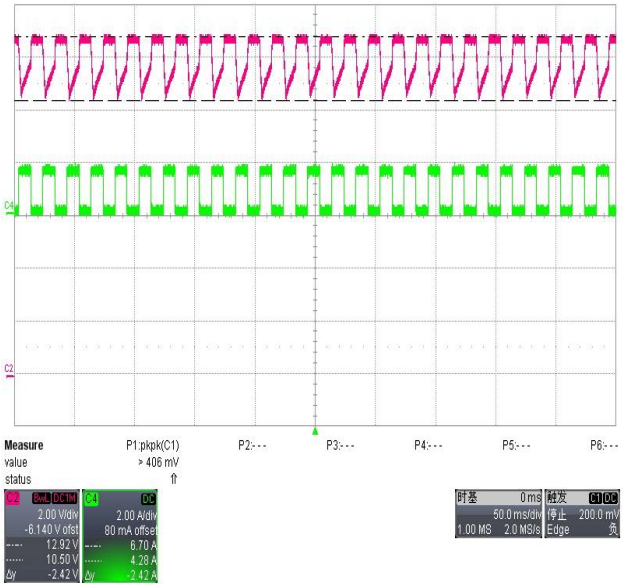


Figure 17:

Vout: 10.5~12.92V
90VAC/60Hz; Load level: 0~1.5A;
Frequency: 10mS-10mS. Slew rate: 250A/us

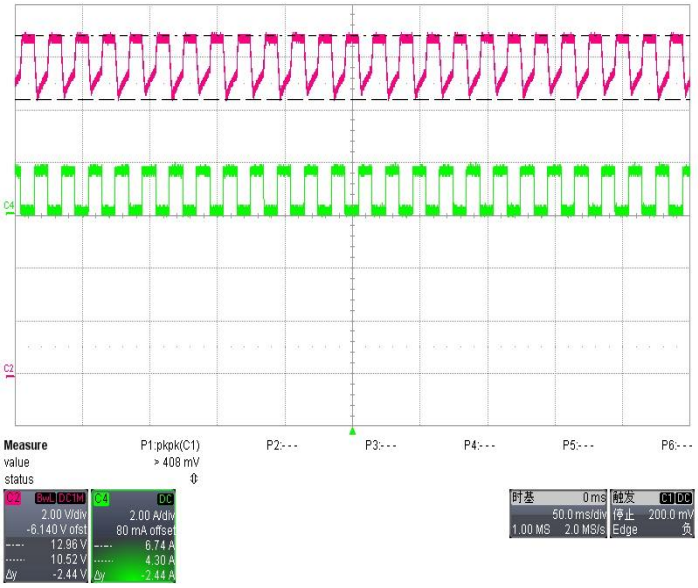
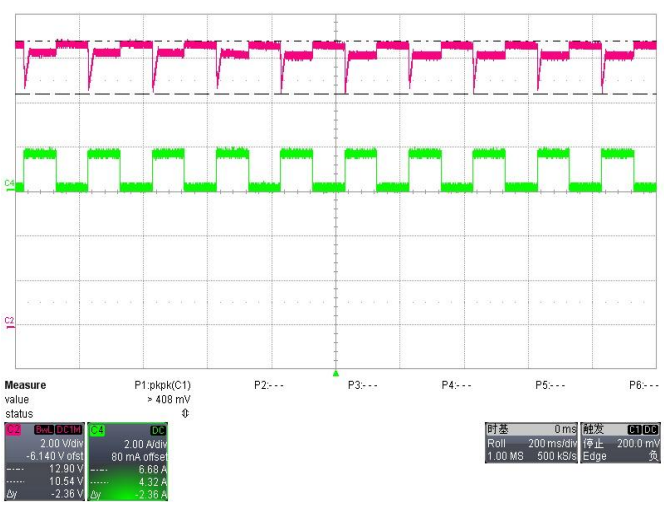


Figure 18:

Vout: 10.5~12.92V
90VAC/60Hz; Load level: 0~1.5A;
Frequency: 10mS-10mS. Slew rate: 250A/us

System Dynamic Response performance

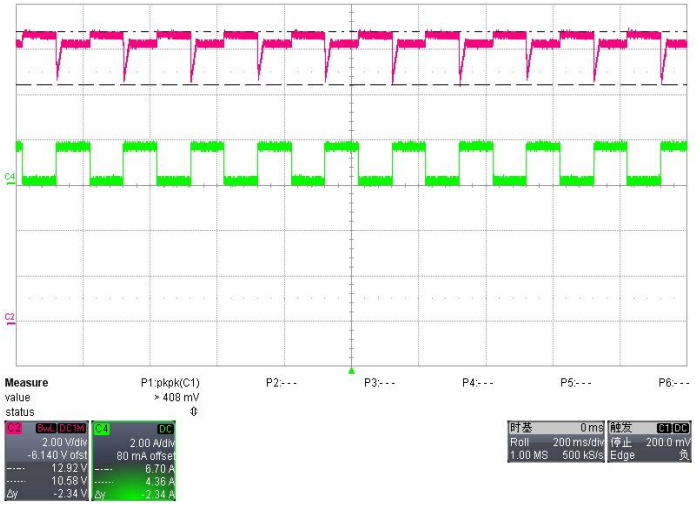


Vout: 10.54~12.9V

90VAC/60Hz; Load level: 0~1.5A;

Frequency: 100mS-100mS. Slew rate: 250A/us

Figure 19:



Vout: 10.58~12.92V

265VAC/50Hz; Load level: 0~1.5A;

Frequency: 100mS-100mS. Slew rate: 250A/us

Figure 20:

Thermal Test data at room Temperature after running 1 hr

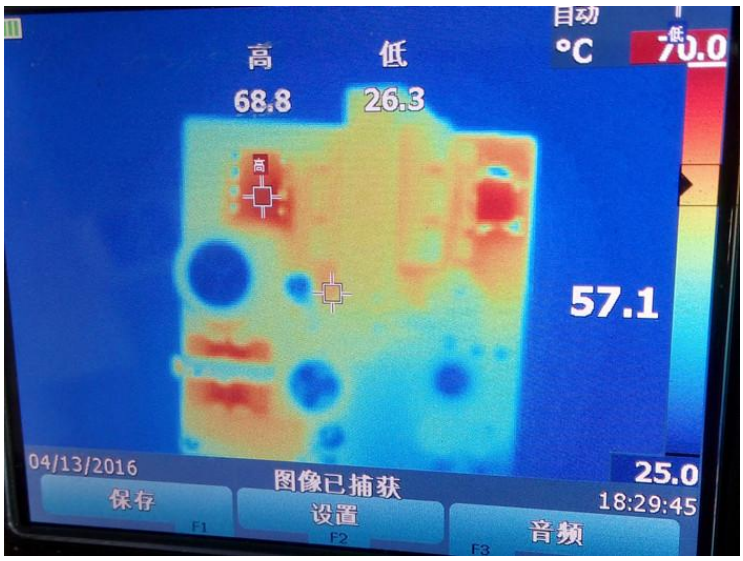


Figure21:

90VAC/50Hz, Iout=1.5A

$T_{A=25°}$ AP3983E surface = 68.8°

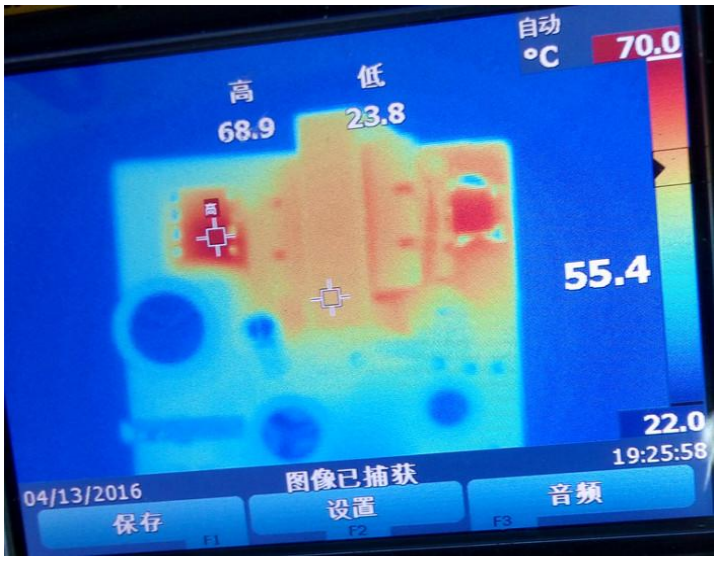


Figure22:

264VAC/50Hz，Iout=1.5A

$T_{A=22°}$ AP3983E Surface T=68.9°

System EMI L-Line Scan Data

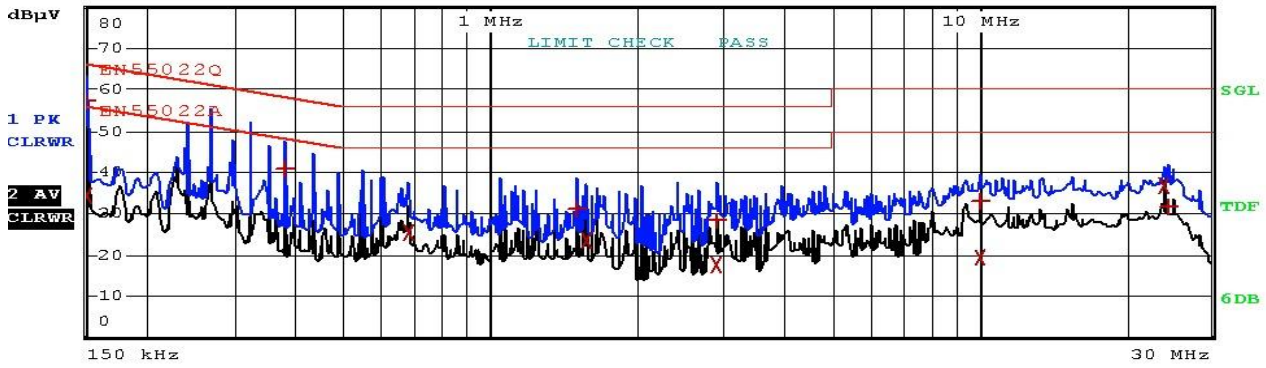


Figure 23: EMI Scan at 115Vac

Trace1:		EN55022Q		
Trace2:		EN55022A		
Trace3:		---		
	TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	222 kHz	51.60	-11.13
2	Average	226 kHz	26.92	-25.67
1	Quasi Peak	478 kHz	25.07	-31.29
2	Average	670 kHz	19.02	-26.97
2	Average	2.034 MHz	13.28	-32.72
1	Quasi Peak	2.038 MHz	18.40	-37.60
1	Quasi Peak	2.814 MHz	13.86	-42.13
2	Average	3.23 MHz	7.57	-38.42
2	Average	10.002 MHz	4.08	-45.91
1	Quasi Peak	10.082 MHz	8.50	-51.49
1	Quasi Peak	24.01 MHz	8.13	-51.86
2	Average	24.01 MHz	3.77	-46.22

Figure 24: EMI Scan data at 115Vac

System EMI N-Line Scan Data

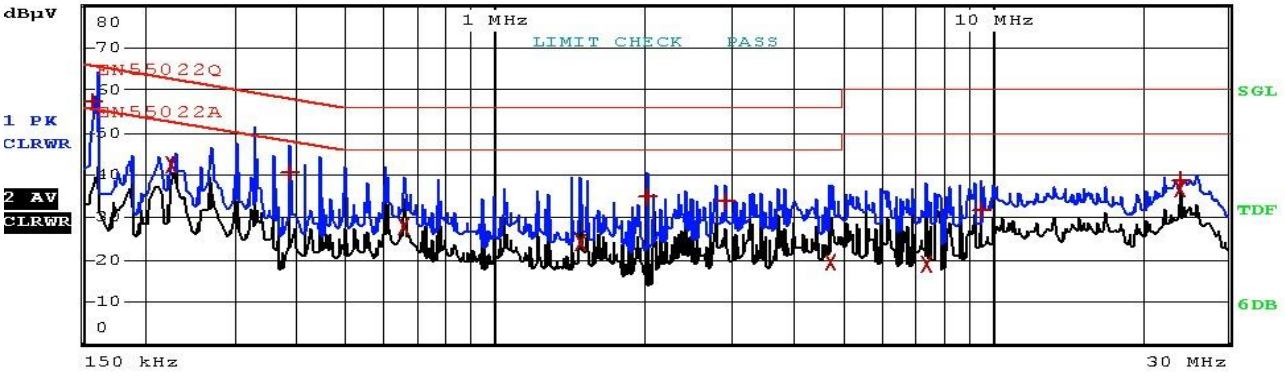


Figure 25: EMI Scan at 115Vac

Trace1:	EN55022Q		
Trace2:	EN55022A		
Trace3:	---		
TRACE	FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1 Quasi Peak	158 kHz	57.14	-8.42
2 Average	226 kHz	42.30	-10.29
1 Quasi Peak	386 kHz	40.56	-17.58
2 Average	658 kHz	27.87	-18.13
2 Average	1.486 MHz	24.13	-21.86
1 Quasi Peak	2.026 MHz	35.02	-20.97
1 Quasi Peak	2.898 MHz	33.77	-22.22
2 Average	4.722 MHz	19.63	-26.36
2 Average	7.422 MHz	18.92	-31.07
1 Quasi Peak	9.578 MHz	31.65	-28.34
1 Quasi Peak	24.01 MHz	38.51	-21.48
2 Average	24.01 MHz	36.82	-13.17

Figure 26: EMI Scan data at 115Vac

Please see the recommand Application note for reference (Web page - http://www.diodes.com/appnote_dnote.html)

1) For AP3125 operation & set up, please review the Application note:
Application note 1120 Green Mode PWM Controller

2) For PSU PCB layout consideration, please review the App note:
AN1062 High Voltage Green Mode PWM Controller AP3105

3) For the basic Flyback topology calculation, please review the App note:
AN1045 Design Guidelines for Off-line AC-DC Power Supply Using BCD. PWM Controller AP3103

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