General Description

Based on Flyback topology, the Primary side Regulated AP3981C EV board is designed to serve as an example for High Efficiency, low cost & less components consumer home appliance systems. Also a 650V 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 8.4W with 12V-0.7A. 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 84% 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
- The auxiliary Vcc power supply for bigger power system.

Universal AC input PSR 12V-700mA Power Specifications (CV & CC mode)

Parameter	Value
Input Voltage	90 to 264V_{AC}
Input standby power	75mW
Main output Vo / Io	12V – 700mA
Efficiency	~ 84%
Total Output Power	8.4W
Protections	OCP, OVP, OLP,OTP
XYZ Dimension	34 x 52 x 12 mm
ROHS Compliance	Yes

Evaluation Board Picture:

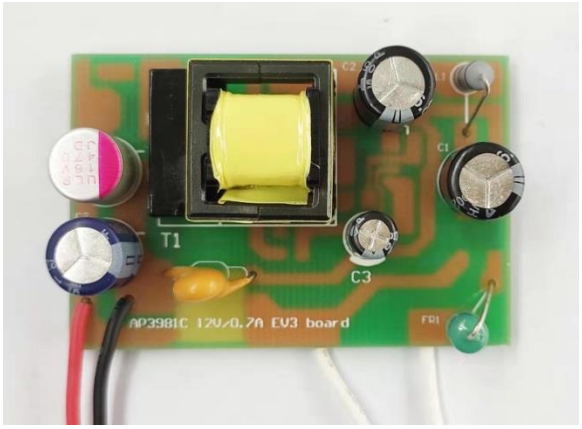


Figure 1: Top View

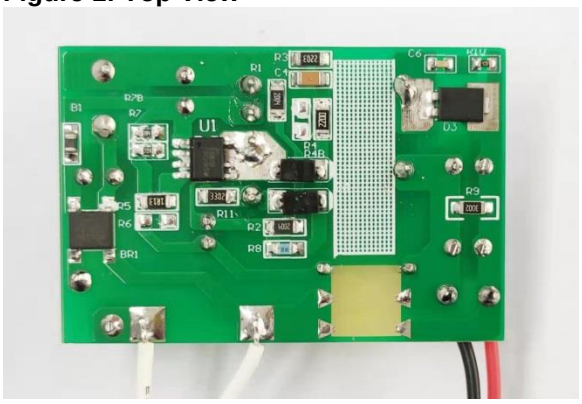
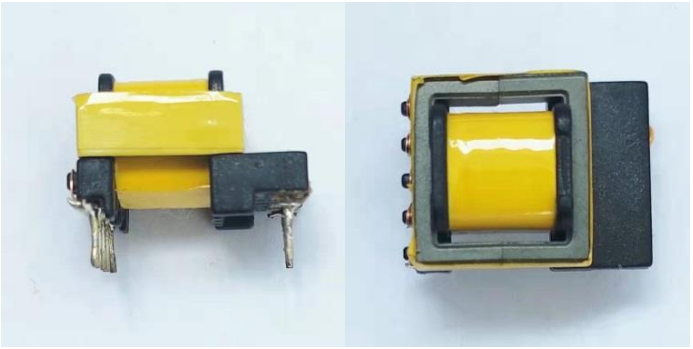


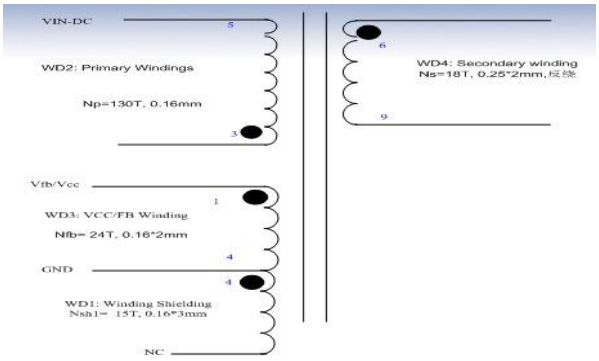
Figure 2: Bottom View

AP3981C (90 V_{AC} ~ 265V_{AC} one outputs 8.4W Transformer Spec.)

1) Core& Bobbin: EE16C , 5+2 pin



2) Electrical Diagram:



3) Transformer Parameters

1. Primary Inductance (Pin3-Pin5), all other windings are open Lp =1.3mH ±7% @1KHz

EE16C （Ae = 19mm^2）						
NO Winding	NAME	TERMINAL NO.		WINDING		
		START	FINISH	WIRE	TURNS	Layers
1	Shield	4（GND）	NC	Φ 0.16mm x 3	15Ts	1
2	Np1	3	5	Φ 0.16mm x1	130 Ts	3
3	Na	1	4	Φ 0.16mm x 2	24T	1
4	Ns	9	6	Φ 0.25mm x 2	18Ts	1

Primary Inductance	Pin 3-5,all other windings open, measured at 1kHz, 0.4VRMS	1.3mH ± 7 %
Primary Leakage Inductance	Pin 3-5, all other windings shorted, measured at 10kHz, 0.4VRMS	80 uH (Max.)

Evaluation Board Schematic

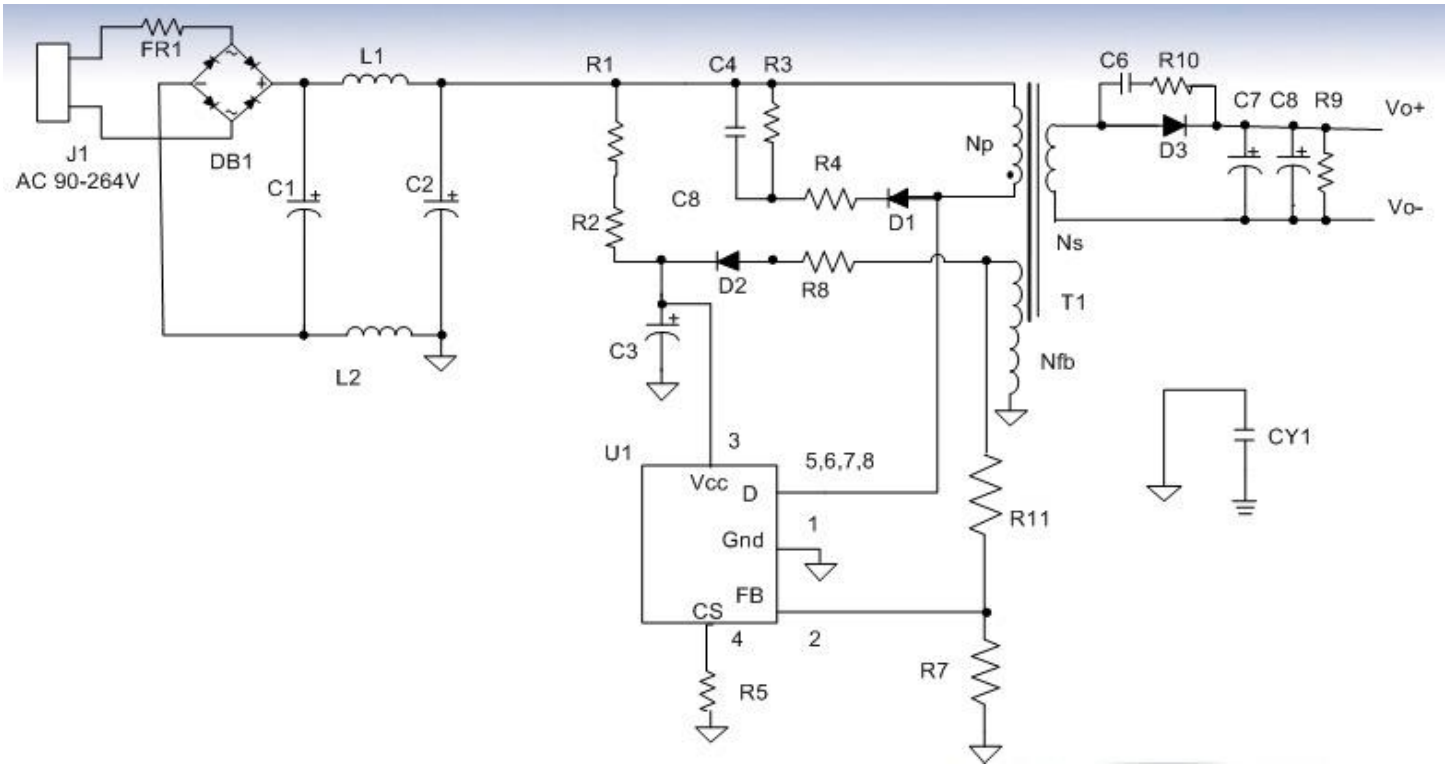


Figure 3: Evaluation Board Schematic

Evaluation Board PCB Layout

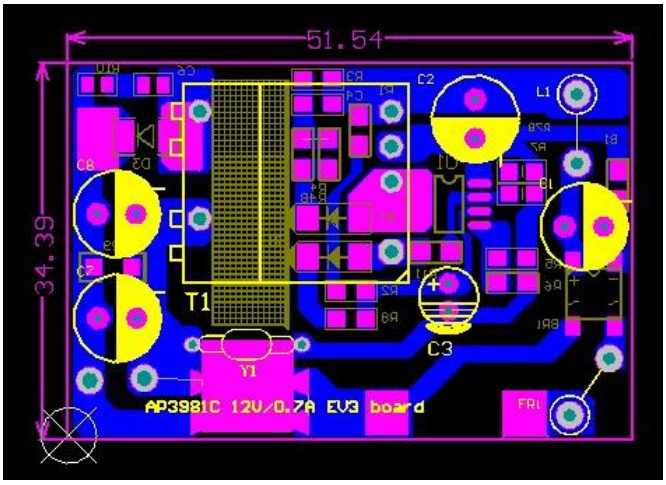


Figure4: PCB Board Layout Top View

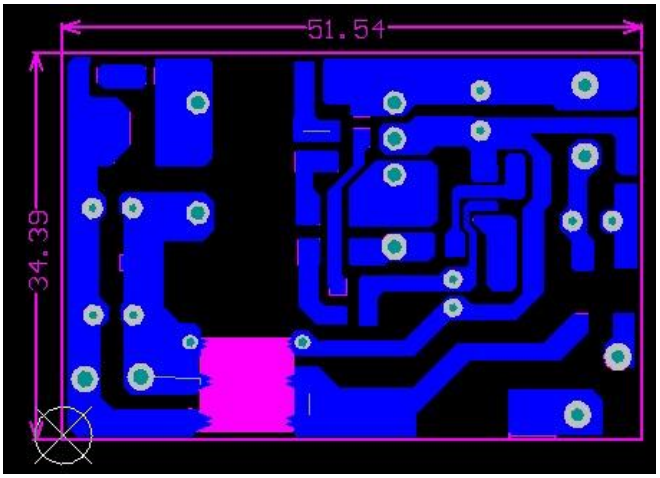


Figure5: PCB Board Layout Bottom View

Quick Start Guide

1. The evaluation board is preset at 12V/700mA 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

AP3981C 12V-0.7A BOM 09-25-2019

Item	QTY per board	REF. DES.	Description	MFG or Supplier	MFG P/N or Supplier P/N Digi key #
1	1	BD1	ABS10, Rectifier Bridge	Diodes	
2	2	C1,C2	6.8uF/400V, electrolytic	Aishi Electro	
3	1	C3	3.3uF/50V, electrolytic	Aishi Electro	
4	1	C4	1nF/200V, 1206	Holy Stone	
5	1	C6	1nF/100V, 0603	Holy Stone	
6	2	C7, C8	470uF/16V, electrolytic	Aishi Electro	
7	1	CY1	330pF/250Vac, Y1 capacitor	Holy Stone	
8	1	D1	MDD-D7, SMA	Diodes	
9	1	D2	MDD-D7, SMA	Diodes	
10	1	D3	12u100, Schotty diode	Diodes	
11	1	L1	470uH , inductor	Yageo	
12	1	L2	bead	Yageo	
13	1	F1	10ohm, Fusible Resistor	Yageo	
14	1	R1	2M , 1206, 5%	Yageo	
15	1	R2	2M , 1206, 5%	Yageo	
16	1	R3	220K ,1206, 5%	Yageo	
17	1	R4	220ohm ,1206, 5%	Yageo	
18	1	R5	2R4//2R2 ohm, 1206, 1%	Yageo	
19	1	R7	6.8K//200K, 0603，1%	Yageo	
20	1	R8	3.3ohm, 0805, 5%	Yageo	
21	1	R9	30K, 0805, 5%	Yageo	
22	1	R10	47R, 0603，1%	Yageo	
23	1	R11	33K, 0805，1%	Yageo	
24	1	U1	AP3981C, SOIC-7	Diodes 3A-650V	
25	2	T1	EE16 core, PC40,		

Input & Output Characteristics

Input Standby Power

Input Voltage	115Vac/60Hz	230Vac/50Hz	Note
Pin (w)	40. 8W	62.8mW	At no loading

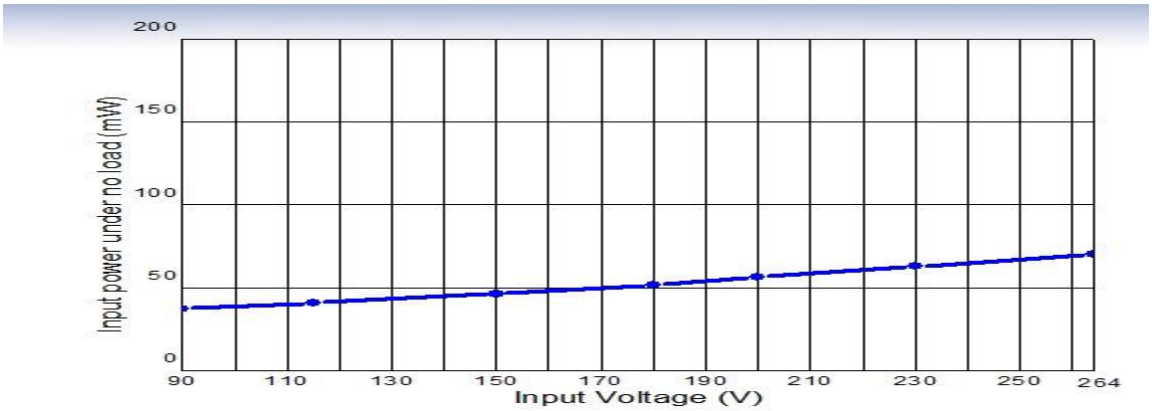


Figure 6: The Input Standby Powerwith at different AC input

Input power Efficiency at different loading

AC input	Efficiency (%)					Eff_avg at four conditions
	10%	25%	50%	75%	100%	
90VAC/60Hz						
115VAC/60Hz	78.6%	82.9%	82.8%	82.57%	82.17%	82.61%
230VAC/50Hz	73.19%	81.13 %	83.42%	83.91%	84.17%	83.15%
264VAC/50Hz						
Eff_avg						

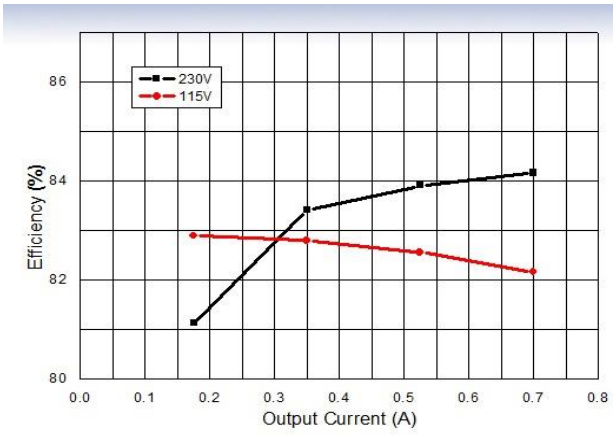


Figure 7: The efficiency curve with different loading

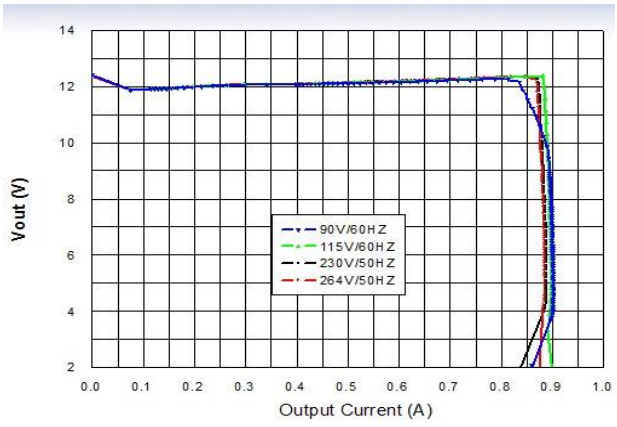


Figure 8: CV & CC Curve at OCP set points

OCP Current set point with at different AC line

AC input	90VAC	115VAC	230VAC	264VAC	Note
I _max	0.882A	0.888A	0.878A	0.876A	

PSU Output Characteristics:

Line Regulation (at full loading condition):

AC input Voltage	90VAC/60Hz	115VAC/60Hz	230VAC/50Hz	265VAC/50Hz	Note
12.00Vo	12.226V/0.7A	12.25V/0.7A	12.276V/0.7A	12.28V/0.7A	0.22%<1%

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

AC input Voltage	115VAC/60Hz	230VAC/50Hz
12V Full Load	12.25V /0.7A	12.276V/0.7A
12V 10% of FL	11.882V /0.07A	11.886V/0.07A
Note: cable compensation	1.5%	1.6%

Note: All output voltages are measured at output PCB board Edge. Internal Cable Compensation 8%

Key Performance Waveforms:

System turn-on start-up time

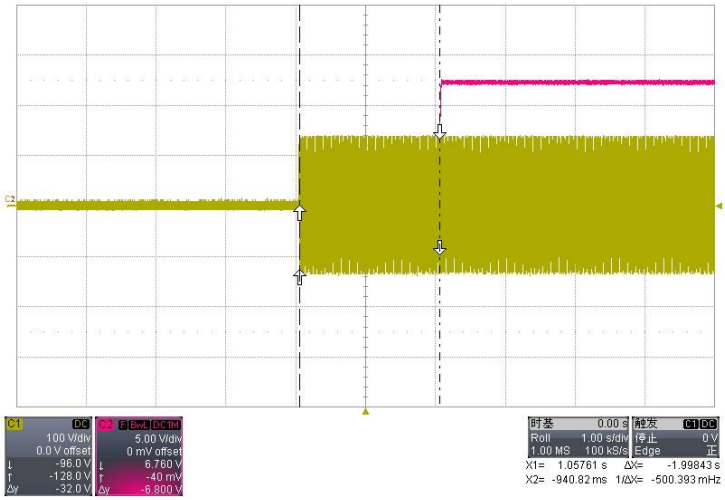


Figure 9: AP3981C turn on time 1.99sFL at 90Vac

System main switching Voltage Stress on AP3981C Pin 5,6,7,8

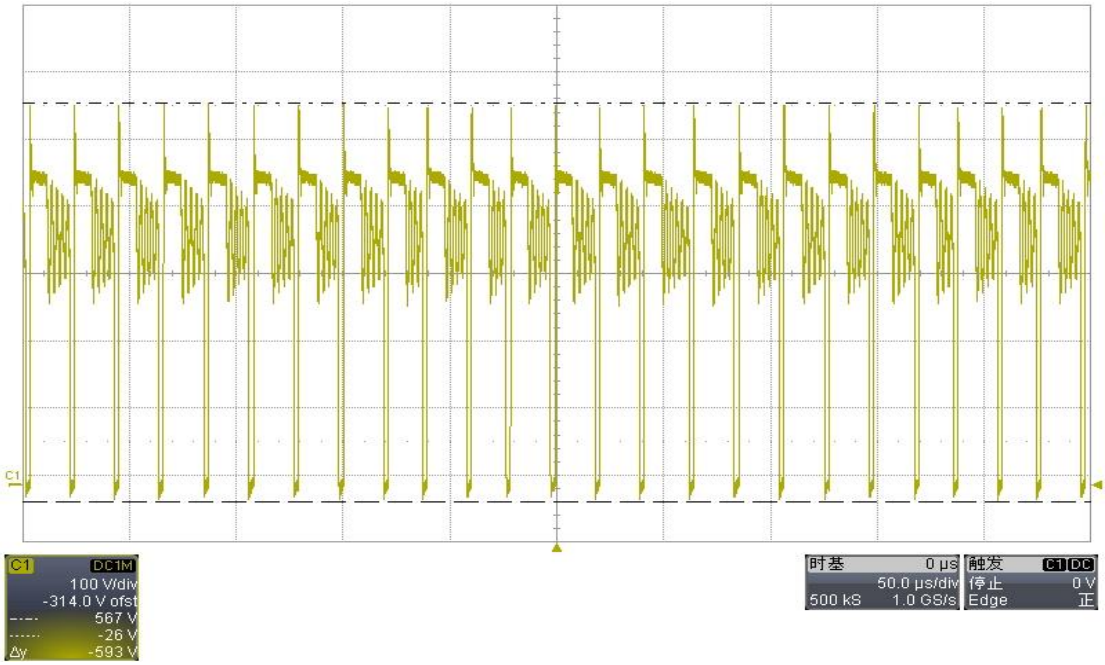


Figure 10: AP3981C Vds at FL at 264 Vac, Vds=593Vp-p

System Voltage Stress across on D3 Cathode ~Anode Junction

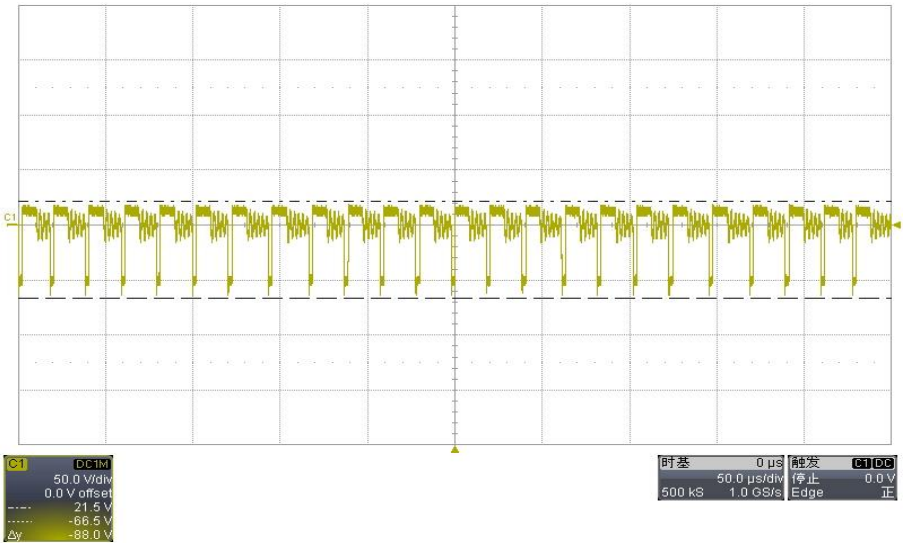


Figure 11: D3 C~A voltage stress at 264Vac FL

D3 C~A = 88Vp-p 50V/div

System output Ripple performance

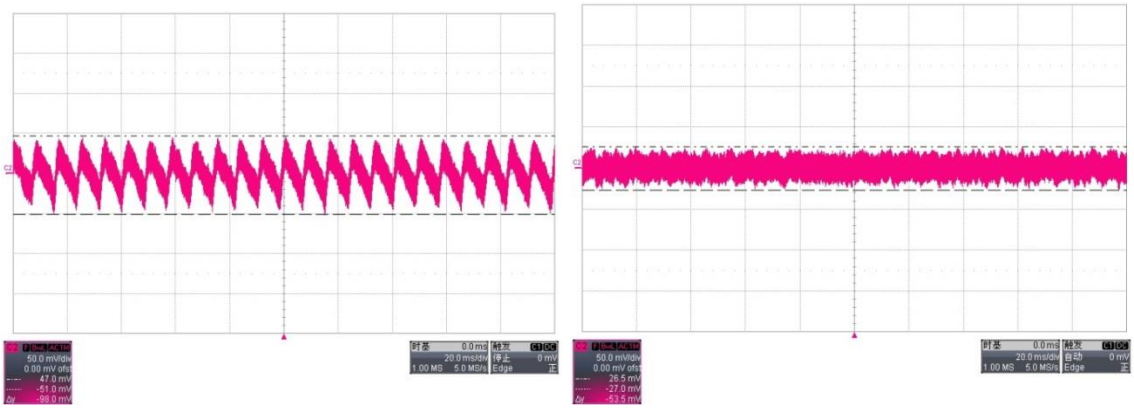


Figure 12: The Ripple at 90Vac_in Vpp=98mv FL **Figure 13:** The Ripple at 264Vac_in Vpp=53mv FL

System Dynamic Response performance

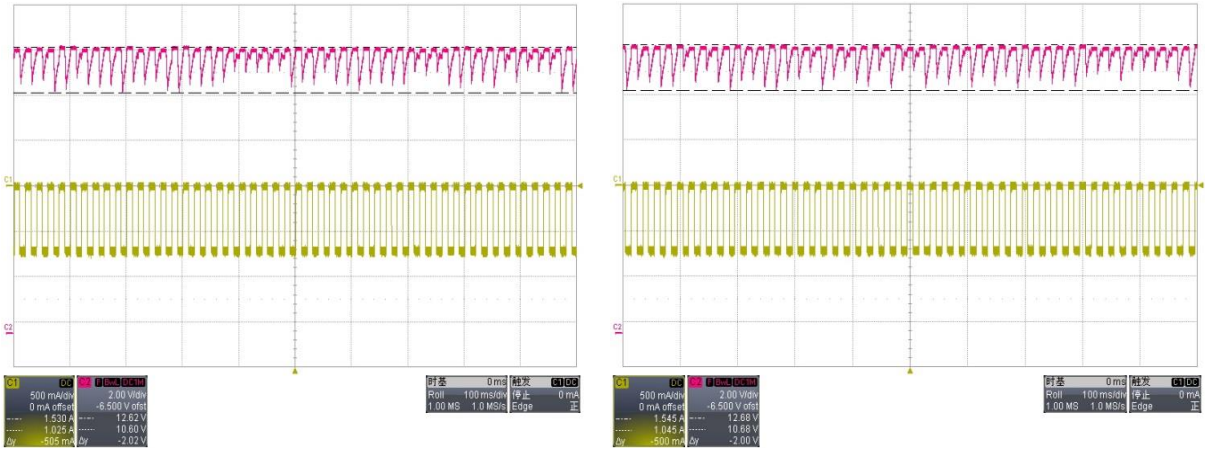


Figure 14: 90VAC; Load level: 0~0.7A;
Vout Voltage: 10,60~12.62V
Frequency: 10ms~10mS. Slew rate: 0.25A/us

Figure 15: 264VAC; Load level: 0~0.5A;
Vout Voltage: 10.68~12.68V
Frequency: 10ms~10mS. Slew rate: 0.25A/us

System Dynamic Response performance

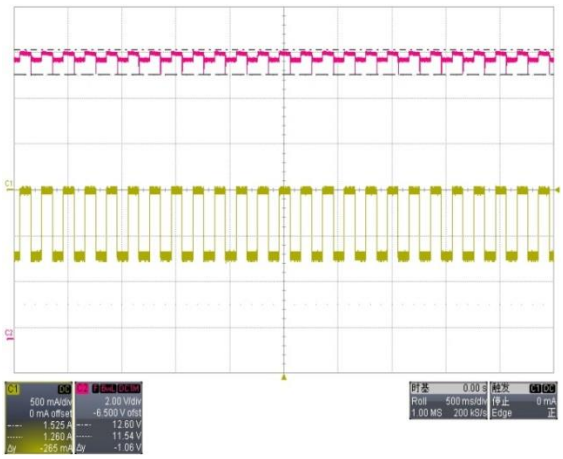


Figure 16: 90VAC; Load level: 0~0.5A;
Vout Voltage: 11.54~12.60V
Frequency: 100ms~100mS. Slew rate: 0.25A/us

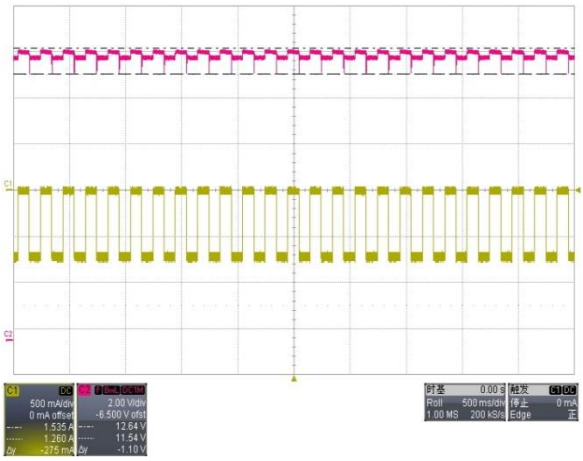


Figure 17: 264VAC; Load level: 0~0.5A;
Vout Voltage: 11.54~12.64V
Frequency: 100ms~100mS. Slew rate: 0.25A/us

Thermal Test data at room Temperature after running 1 hr

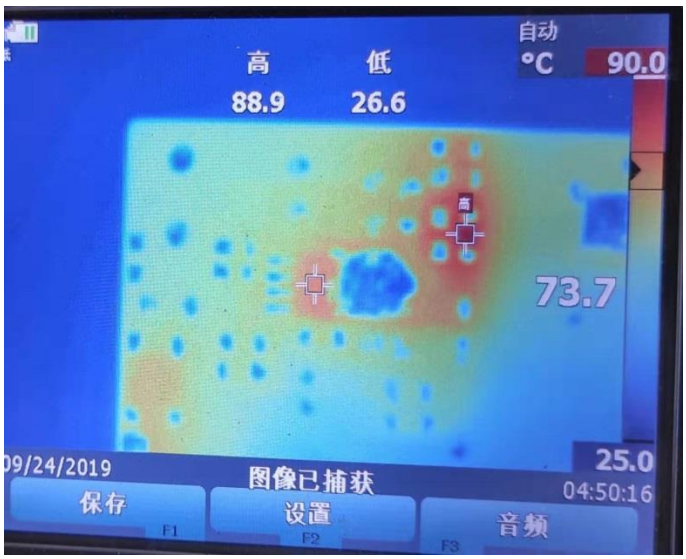


Figure18:
Ta 25℃
U1 AP3981C 73.7℃

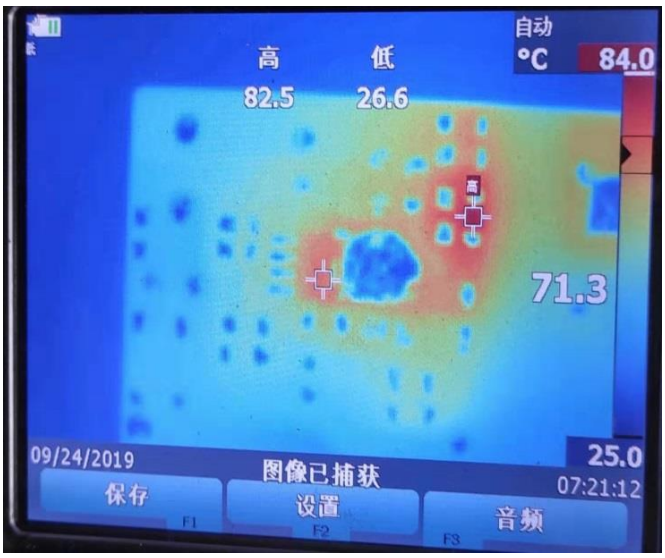
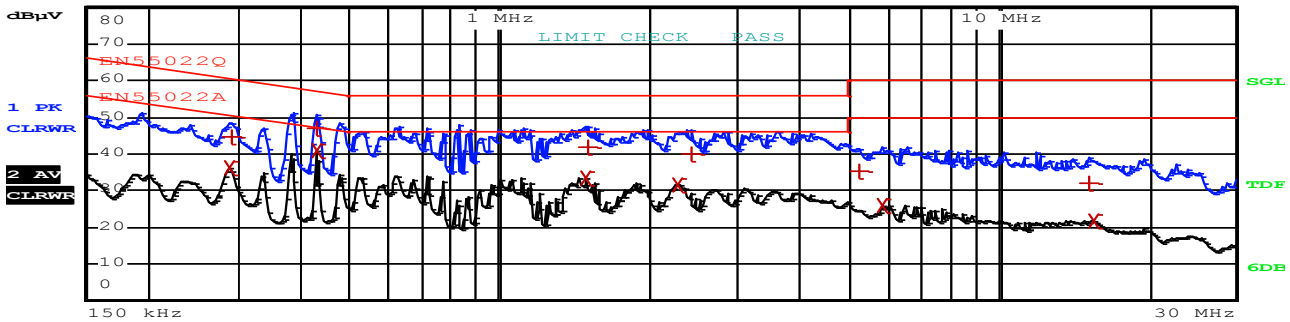


Figure19:
Ta 25℃
U1 AP3981C 71.3℃

System EMI L-Line Scan Data



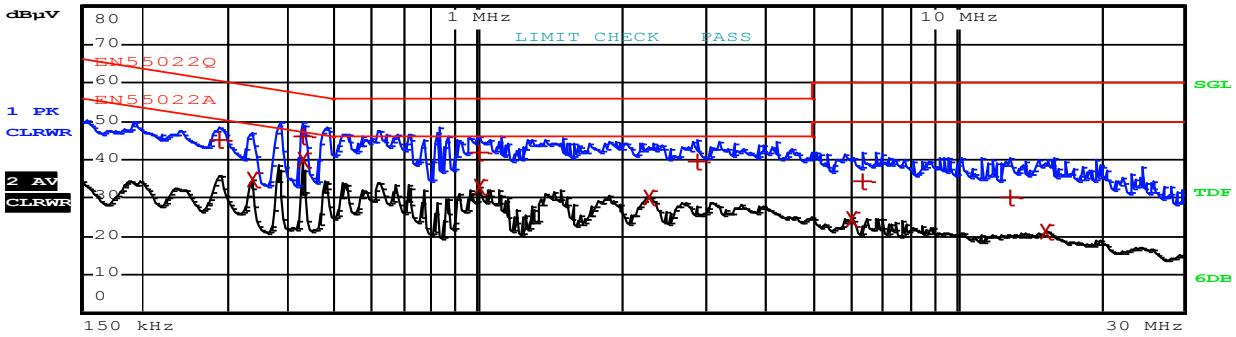
EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	286.404973226 kHz	36.18	-14.44
1	Quasi Peak	289.269022958 kHz	44.55	-15.99
1	Quasi Peak	426.417977756 kHz	46.99	-10.32
2	Average	430.682157533 kHz	40.74	-6.49
2	Average	1.47913300892 MHz	33.66	-12.33
1	Quasi Peak	1.49392433901 MHz	42.07	-13.92
2	Average	2.26895718944 MHz	31.65	-14.34
1	Quasi Peak	2.40854377744 MHz	40.22	-15.77
1	Quasi Peak	5.23385515413 MHz	35.43	-24.56
2	Average	5.83924652649 MHz	25.82	-24.17
1	Quasi Peak	15.0275202 MHz	32.01	-27.98
2	Average	15.329573356 MHz	21.85	-28.14

Figure 20: EMI Scan at 90Vac

System EMI N-Line Scan Data



EDIT PEAK LIST (Final Measurement Results)

Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	286.404973226 kHz	44.92	-15.70
2	Average	335.832355405 kHz	34.86	-14.44
1	Quasi Peak	426.417977756 kHz	46.19	-11.12
2	Average	430.682157533 kHz	39.87	-7.36
1	Quasi Peak	1.00339897152 MHz	42.01	-13.99
2	Average	1.00339897152 MHz	32.94	-13.06
2	Average	2.26895718944 MHz	30.36	-15.63
1	Quasi Peak	2.85244906878 MHz	39.33	-16.67
2	Average	6.01618153549 MHz	24.48	-25.51
1	Quasi Peak	6.32306725703 MHz	34.25	-25.74
1	Quasi Peak	12.8157887448 MHz	30.15	-29.84
2	Average	15.177795402 MHz	21.12	-28.87

Figure 21: EMI Scan at 230Vac

Please see the recommand Application note for reference

(web page - http://www.diodes.com/appnote_dnote.html)

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.
Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or

2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

www.diodes.com