Universal AC input, Primary Side Regulation AP3981B 12V-500mA EV2 Board User Guide

General Description

Based on Flyback topology, the Primary side Regulated AP3981B 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 6W with 12V-0.5A. 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 82% 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-500mA Power Specifications (CV & CC mode)

Parameter	Value
Input Voltage	90 to 264V_{AC}
Input standby power	75mW
Main output Vo / Io	12V – 500mA
Efficiency	~ 82.0%
Total Output Power	6W
Protections	OCP, OVP, OLP,OTP
XYZ Dimension	34 x 51 x 10 mm
ROHS Compliance	Yes

Evaluation Board Picture:

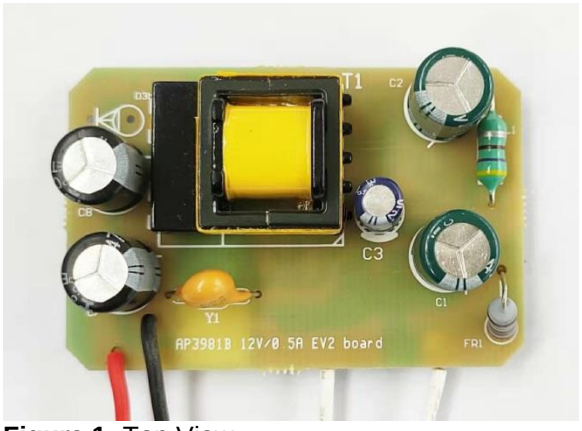


Figure 1: Top View

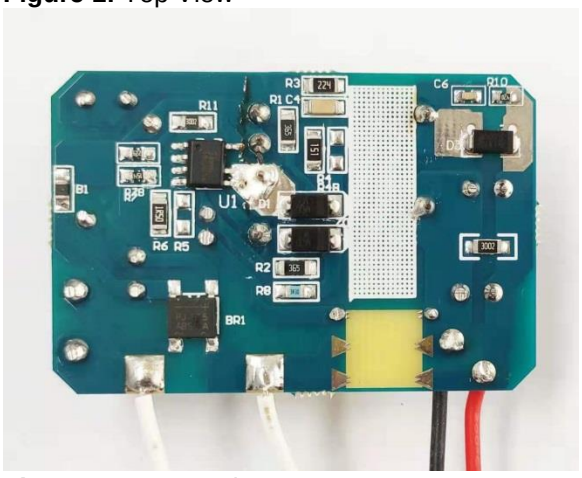
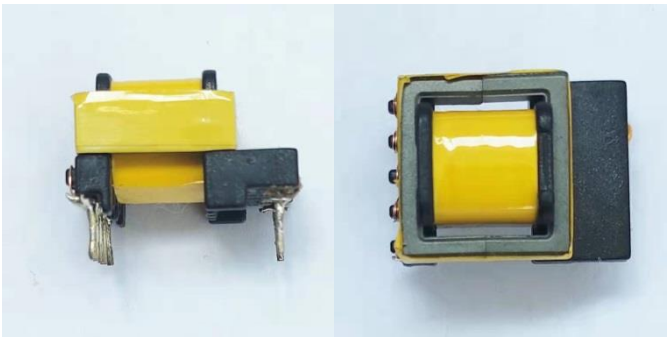


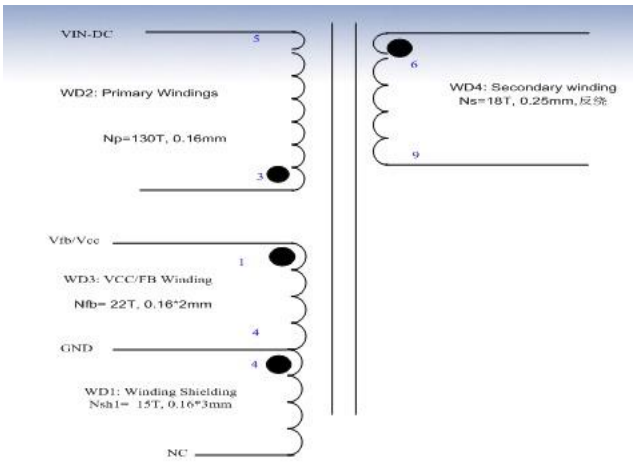
Figure 2: Bottom View

AP3981B (90 V_{AC} ~ 265V_{AC} one outputs 10W 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 =1.75mH ±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	22T	1
4	Ns	9	6	Φ 0.25W x 1	18Ts	1

Primary Inductance	Pin 3-5,all other windings open, measured at 1kHz, 0.4VRMS	1.75mH ± 7 %
Primary Leakage Inductance	Pin 3-5, all other windings shorted, measured at 10kHz, 0.4VRMS	80 uH (Max.)

Evaluation Board Schematic

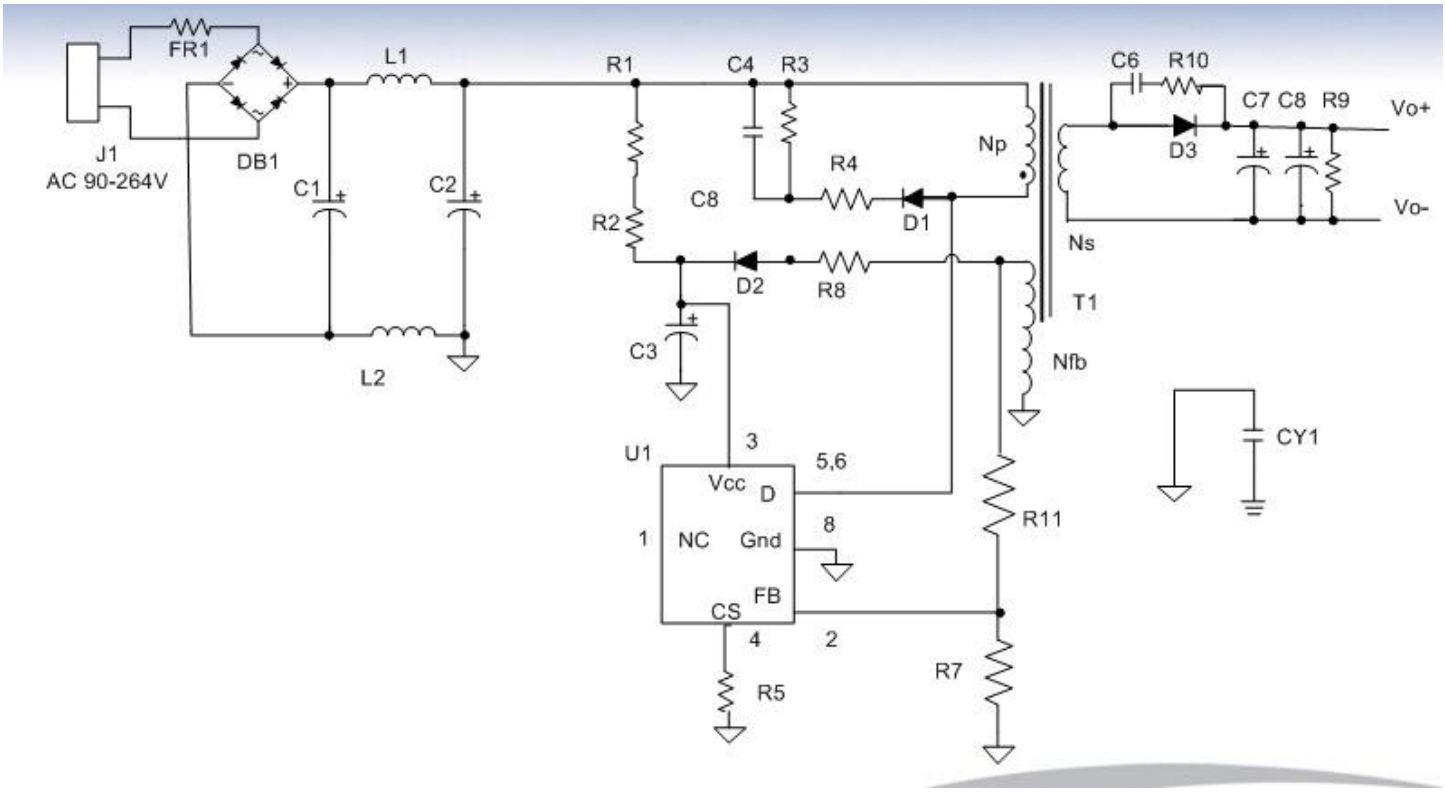


Figure 3: Evaluation Board Schematic

Evaluation Board PCB Layout

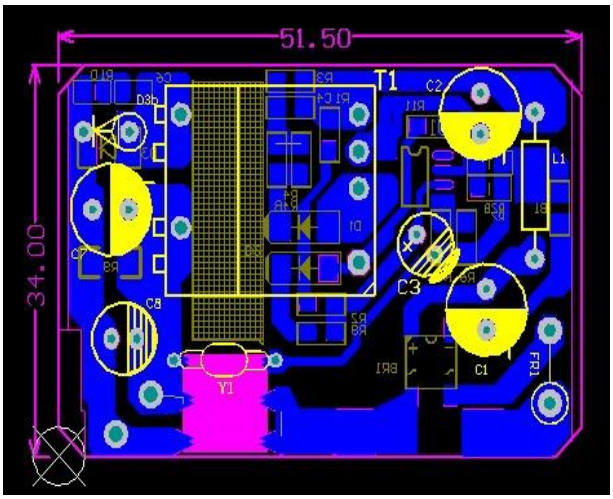


Figure4: PCB Board Layout Top View

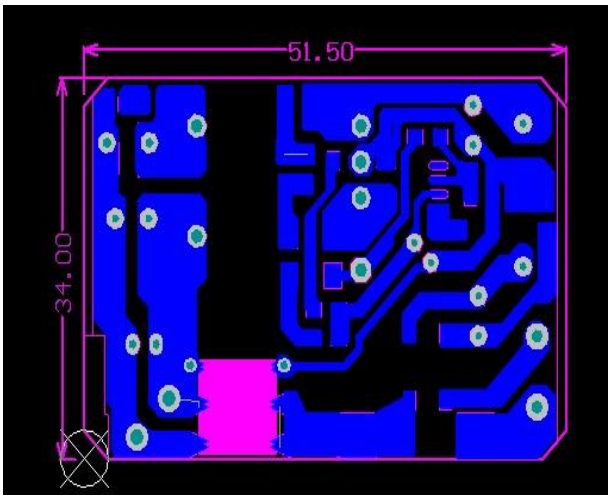


Figure5: PCB Board Layout Bottom View

Quick Start Guide

1. The evaluation board is preset at 12V/500mA 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

AP3981B 12V-0.5A BOM 09-12-2019

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	4.7uF/400V, electrolytic	Aishi Electro	
3	1	C3	2.2uF/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	100pF/250Vac, Y1 capacitor	Holy Stone	
8	1	D1	MDD-D7, SMA	Diodes	
9	1	D2	MDD-D7, SMA	Diodes	
10	1	D3	3100, Schotty diode	Diodes	
11	1	L1	470uH , inductor	Yageo	
12	1	L2	bead	Yageo	
13	1	F1	10ohm, Fusible Resistor	Yageo	
14	1	R1	3.6M , 1206, 5%	Yageo	
15	1	R2	3.6M , 1206, 5%	Yageo	
16	1	R3	220K ,1206, 5%	Yageo	
17	1	R4	150ohm ,1206, 5%	Yageo	
18	1	R5	1R5 ohm, 1206, 1%	Yageo	
19	1	R7	6.2K//150K, 0603，1%	Yageo	
20	1	R8	3.3ohm, 0805, 5%	Yageo	
21	1	R9	27K, 0805, 5%	Yageo	
22	1	R10	47R, 0603，1%	Yageo	
23	1	R11	30K, 0805，1%	Yageo	
24	1	U1	AP3981B, SOIC-7	Diodes 1A-650V	
25	2	T1	EE16 core, PC40,		

Input & Output Characteristics

Input Standby Power

Input Voltage	115Vac/60Hz	230Vac/50Hz	Note
Pin (w)	58.5W	69.2mW	At no loading

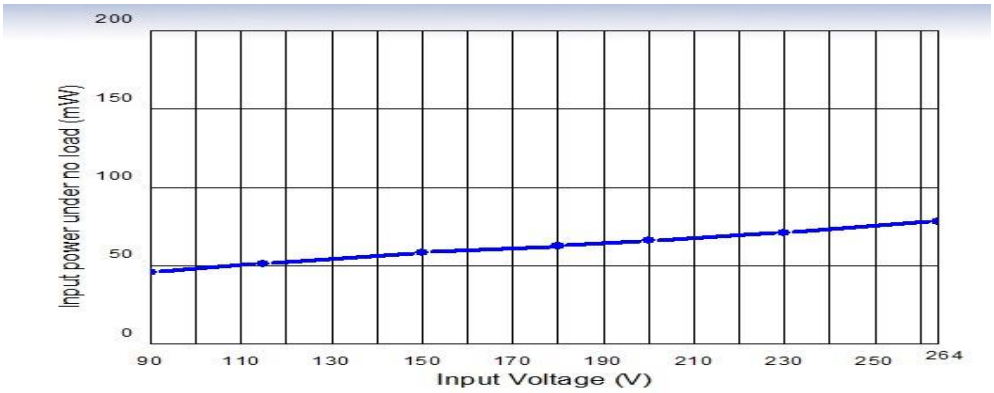


Figure 6: The Input Standby Powerwith at different AC input

Input power Efficiency at different loading

AC input	Efficiency (%)					Eff_avg at four conditions
	10%	25%	50%	75%	100%	
90VAC/60Hz						
115VAC/60Hz	74%	81.2%	81.04%	81.17%	81.07%	81.12%
230VAC/50Hz	67.6%	78.58%	80.95%	81.66%	82.19%	80.84%
264VAC/50Hz						
Eff_avg						

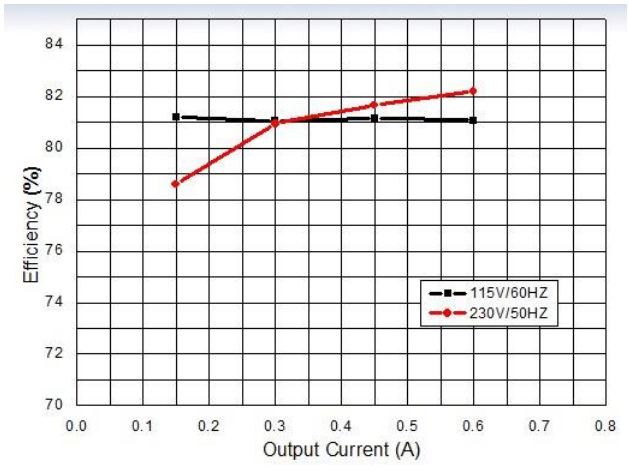


Figure 7: The efficiency curve with different loading

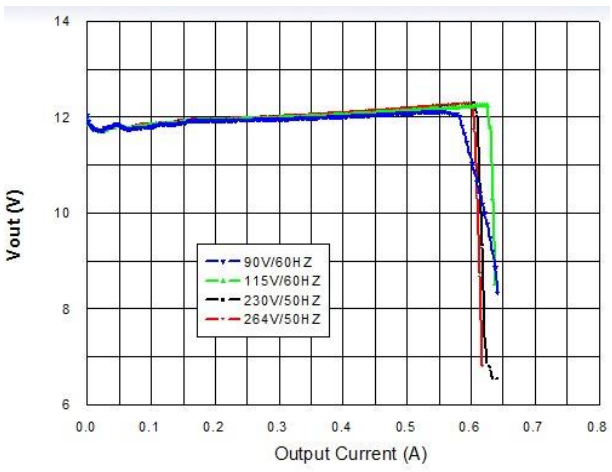


Figure 8: CV & CC Curve at OCP set points

OCP Current set point with at different AC line

AC input	90VAC	115VAC	230VAC	264VAC	Note
I _max	0.641A	0.638A	0.645A	0.641A	

PSU Output Characteristics:

Line Regulation (at full loading condition):

AC input Voltage	90VAC/60Hz	115VAC/60Hz	230VAC/50Hz	265VAC/50Hz	Note
12.00Vo	12.09V/0.5A	12.127V/0.5A	12.177V/0.5A	12.183V/0.5A	0.4%<1%

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

AC input Voltage	115VAC/60Hz	230VAC/50Hz
12V Full Load	12.127V /0.5A	12.177V/0.5A
12V 10% of FL	11.818V /0.05A	11.825V/0.05A
Note: cable compensation	1.2%	1.4%

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

Key Performance Waveforms:

System start - up time

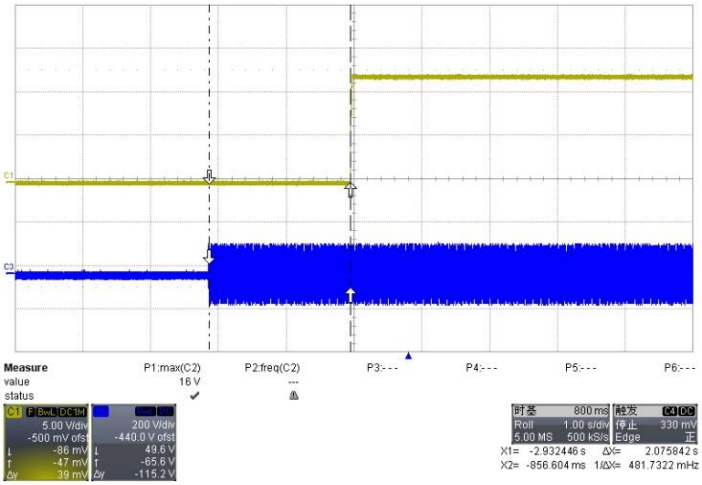


Figure 9:AP3981C turn on time 2.07sFL at 90Vac

System main switching Voltage Stress on AP3981B Pin 5 & 6

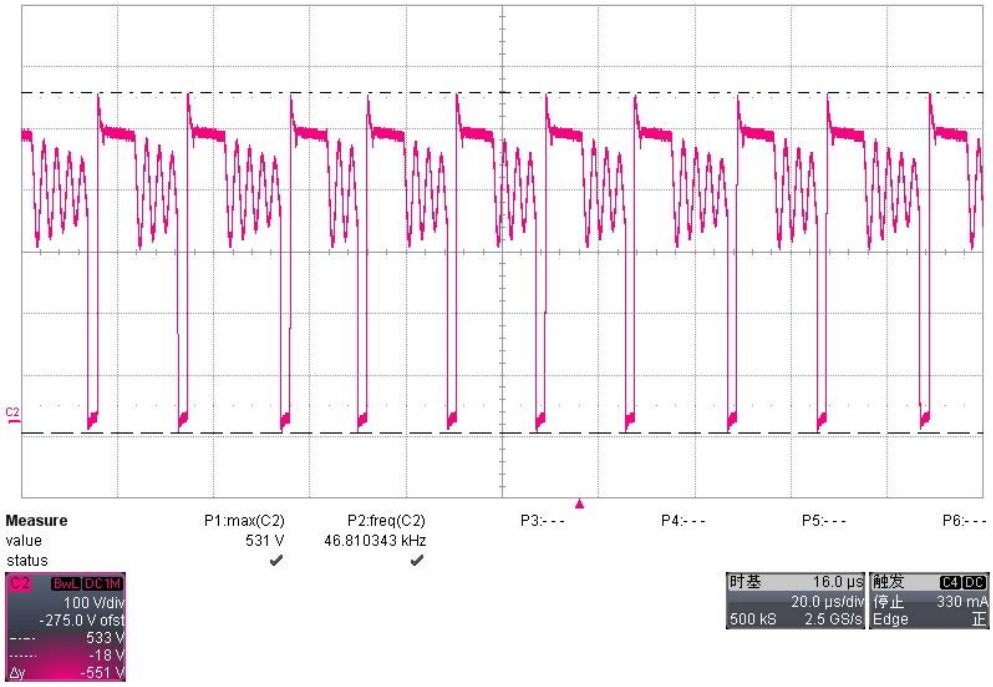


Figure 10: AP3981C Vds at FL at 264 Vac, Vds=551Vp-p

System Voltage Stress across on D3 Cathode ~Anode Junction

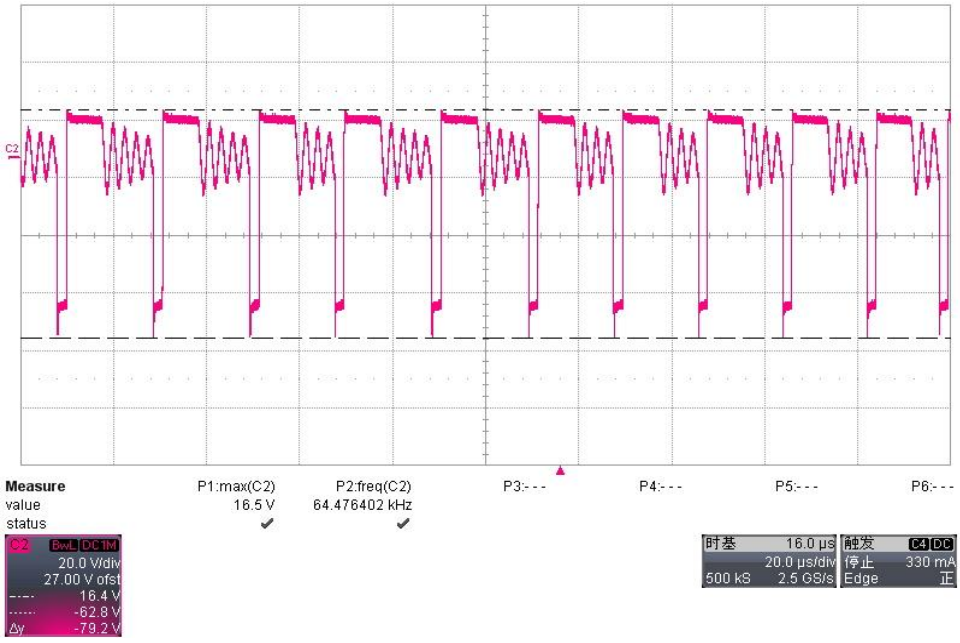


Figure 11: D3 C-A voltage stress at 264Vac @FL Vu2 d_S = 79.2Vp-p 20V/div

System output Ripple performance

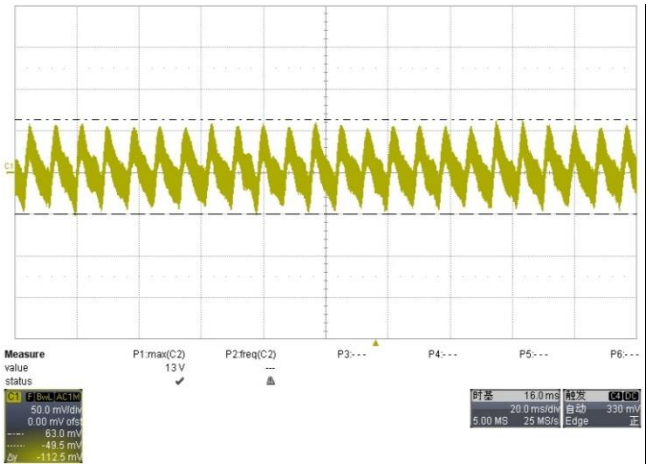


Figure 12: The Ripple at 90Vac_in Vpp=112.5mv FL

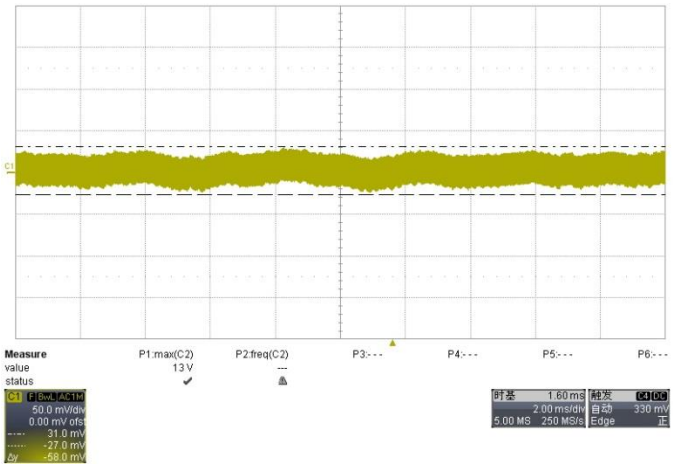


Figure 13: The Ripple at 264Vac_in Vpp=58mv FL

System Dynamic Response performance

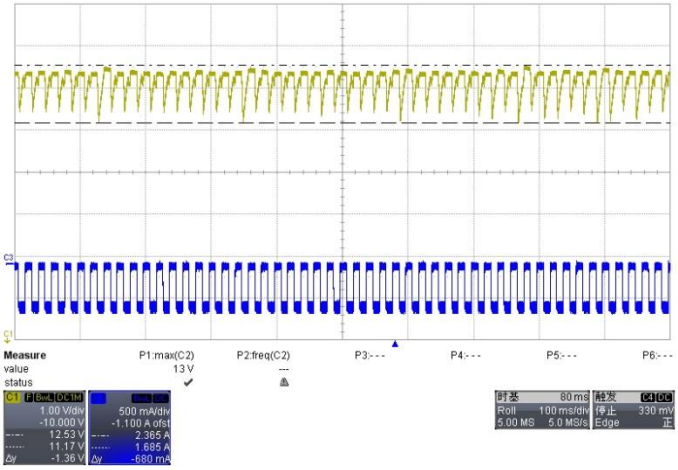


Figure 14: **90VAC; Load level: 0~0.5A; Vout: 11.17~12.53V Frequency: 10ms~10mS. Slew rate: 0.25A/us**

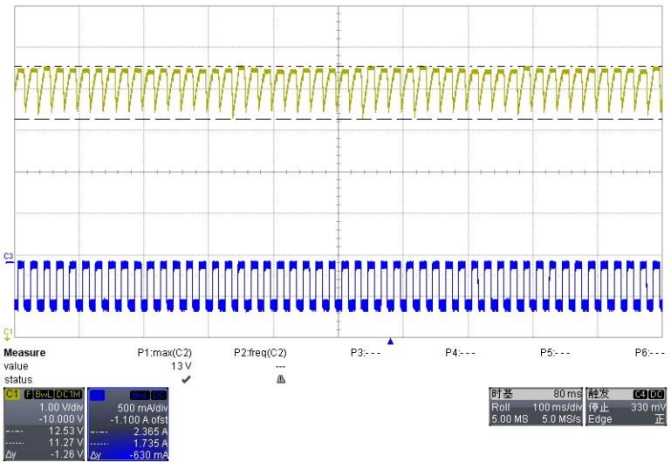


Figure 15: **264VAC; Load level: 0~0.5A; Vout: 11.27~12.53V Frequency: 10ms~10mS. Slew rate: 0.25A/us**

System Dynamic Response performance

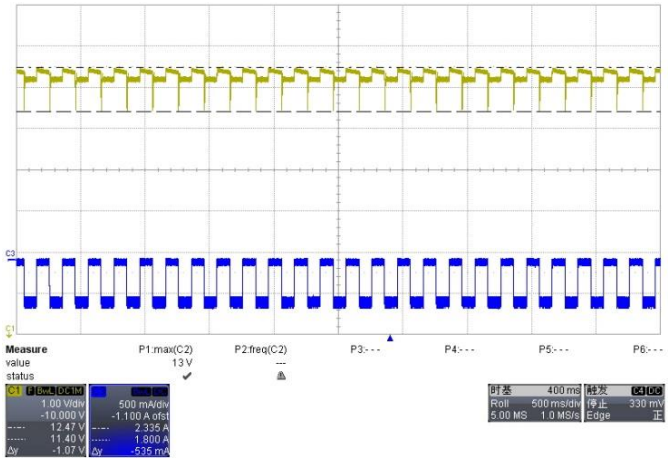


Figure 16: 90VAC; Load level: 0~0.5A; Vout: 11.4~12.47V
Frequency: 100ms~100mS. Slew rate: 0.25A/us

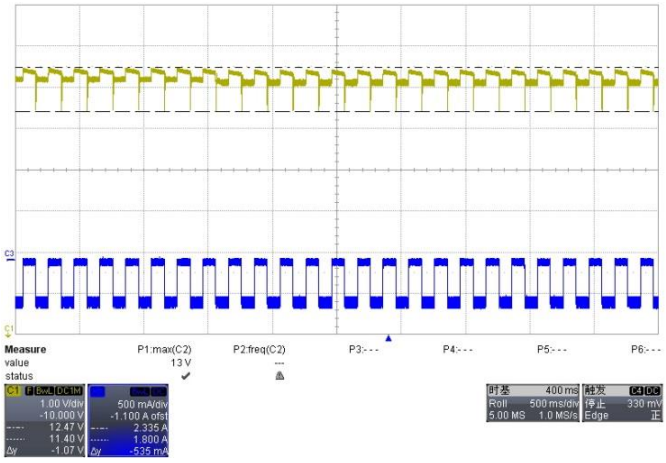


Figure 17: 264VAC; Load level: 0~0.5A; Vout: 11.40~12.47V
Frequency: 100ms~100mS. Slew rate: 0.25A/us

Thermal Test data at room Temperature after running 1 hr

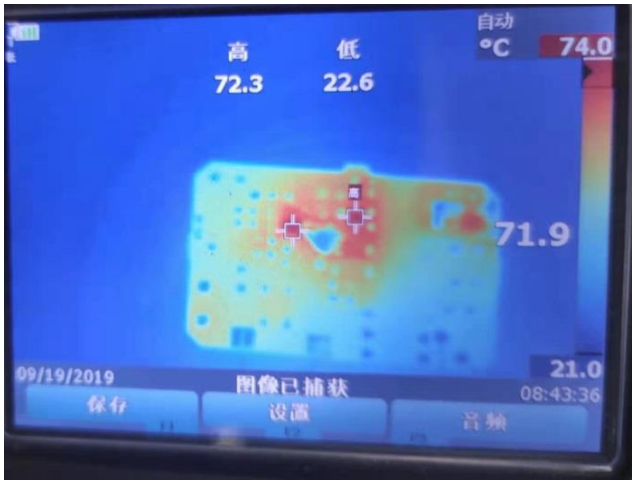


Figure18 :

Ta	25℃
U1 AP3981B	71.9℃

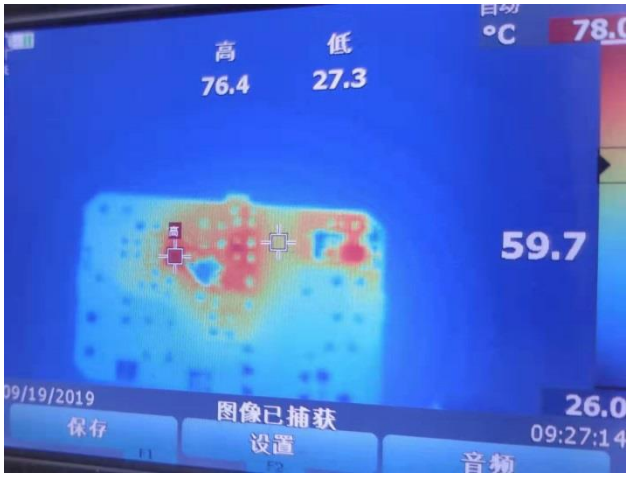
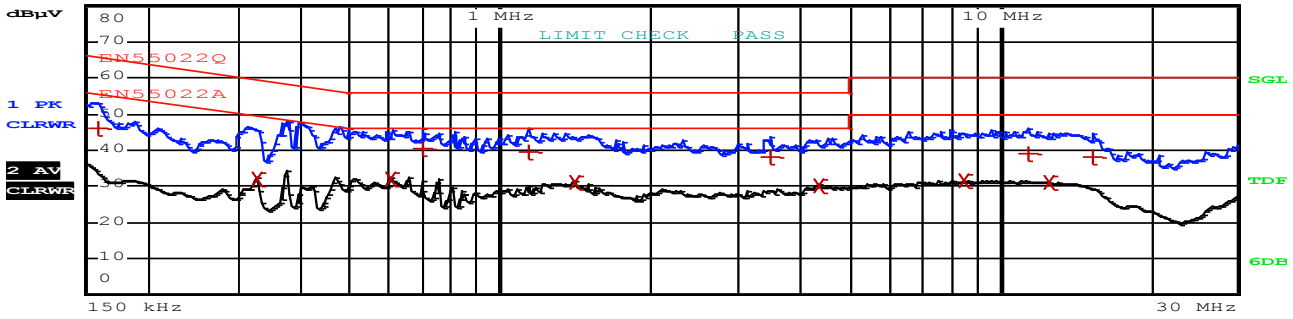


Figure19:

Ta	25℃
U1 AP3981B	76.4℃

System EMI L-Line Scan Data

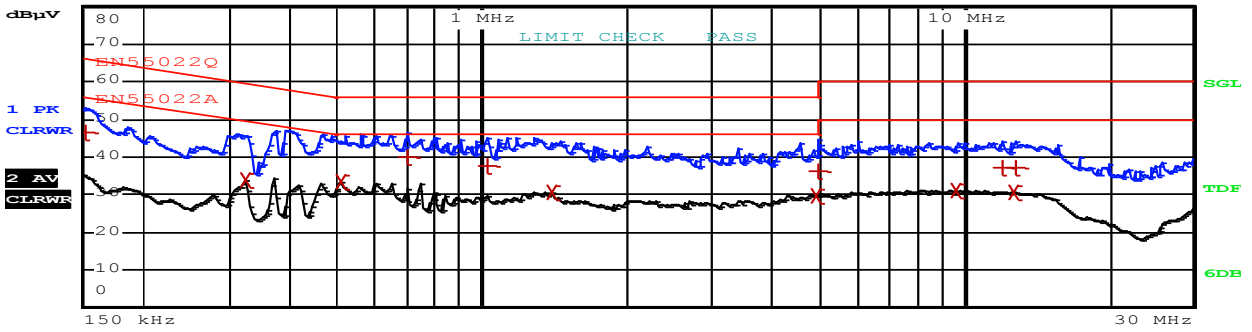


Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	156.0906015 kHz	46.28	-19.38
2	Average	325.955575511 kHz	32.25	-17.29
2	Average	604.06488251 kHz	32.20	-13.80
1	Quasi Peak	701.300575623 kHz	40.43	-15.57
1	Quasi Peak	1.13065507631 MHz	39.51	-16.48
2	Average	1.4073443054 MHz	30.94	-15.05
1	Quasi Peak	3.44606925067 MHz	37.93	-18.07
2	Average	4.33227082061 MHz	30.10	-15.89
2	Average	8.4381577663 MHz	31.45	-18.54
1	Quasi Peak	11.3733617927 MHz	38.94	-21.05
2	Average	12.4388782936 MHz	31.04	-18.95
1	Quasi Peak	15.177795402 MHz	38.07	-21.92

Figure 20: EMI Scan at 230Vac

System EMI N-Line Scan Data



Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
1	Quasi Peak	151.5 kHz	46.59	-19.32
2	Average	322.728292586 kHz	34.08	-15.54
2	Average	510.05878768 kHz	33.26	-12.73
1	Quasi Peak	701.300575623 kHz	40.04	-15.96
1	Quasi Peak	1.02356729084 MHz	37.52	-18.47
2	Average	1.39341020336 MHz	30.52	-15.47
2	Average	4.88171119798 MHz	29.88	-16.11
1	Quasi Peak	4.97983359306 MHz	36.23	-19.76
2	Average	9.50832737927 MHz	31.19	-18.80
1	Quasi Peak	11.9535175476 MHz	37.27	-22.72
2	Average	12.5632670765 MHz	30.66	-19.33
1	Quasi Peak	12.6888997473 MHz	37.10	-22.90

Figure 21: EMI Scan at 230Vac

Please see the recommand Application note for reference

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

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