General Description

Based on Flyback topology, the Primary side Regulated AP3981D2 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 12W with 12V-1A. 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 87% 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-1.0A Power Specifications (CV & CC mode)

Parameter	Value
Input Voltage	90 to 264V_{AC}
Input standby power	75mW
Main output Vo / Io	12V – 1A
Efficiency	~ 86%
Total Output Power	12W
Protections	OCP, OVP, OLP,OTP
XYZ Dimension	63 x 34 x 20 mm
ROHS Compliance	Yes

Evaluation Board Picture:

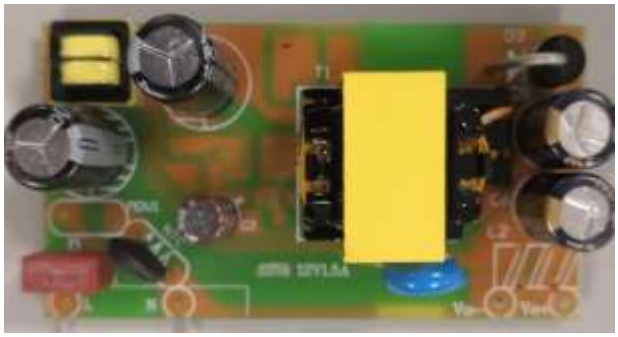
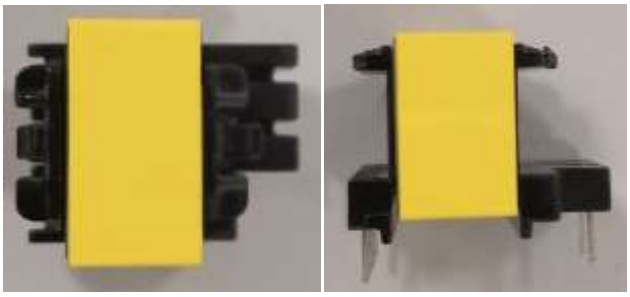


Figure 1: Top View

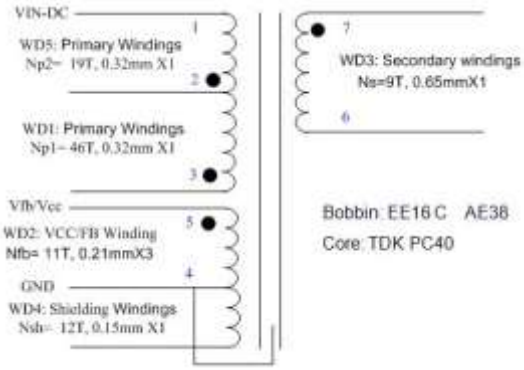
Figure 2: Bottom View

AP3981D2 (90V_{AC} ~ 265V_{AC} one outputs 12W Transformer Spec.)

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



2) Electrical Diagram:



3) Transformer Parameters

1. Primary Inductance (Pin1-Pin3), all other windings are open Lp =1 mH ±7% @10KHz

EE16C （Ae = 38mm^2）						
NO Winding	NAME	TERMINAL NO.		WINDING		
		START	FINISH	WIRE	TURNS	Layers
1	Na	5	4	Φ 0.21mm X 3	11 Ts	1
2	Np1	3	2	Φ 0.32mm X 1	46 Ts	2
3	Shield	4（GND）	NC	Φ 0.15mm X 1	12 Ts	1
4	Ns	7	6	Φ 0.65W X 1	9 Ts	1
5	Np2	2	1	Φ 0.32mm X 1	19 Ts	1

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

Evaluation Board Schematic

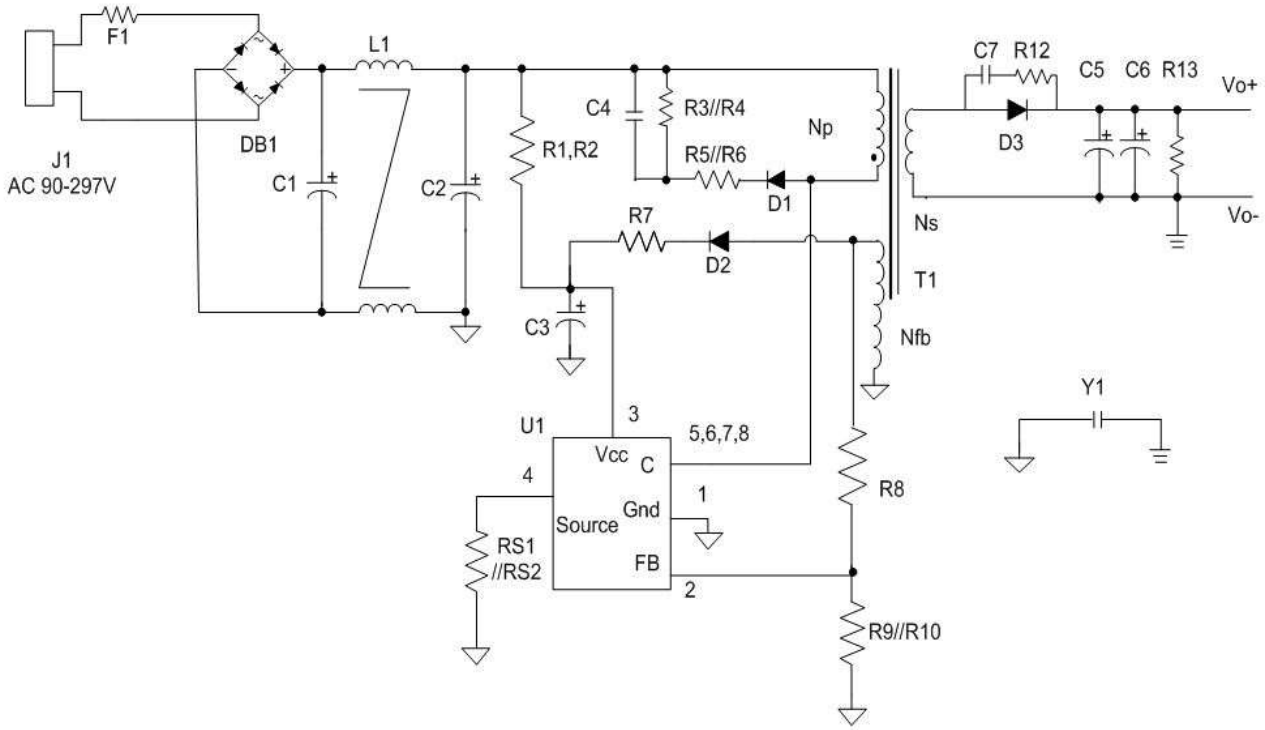


Figure 3: Evaluation Board Schematic

Evaluation Board PCB Layout

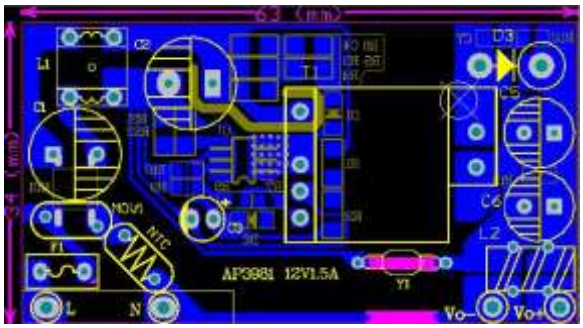


Figure4: PCB Board Layout Top View

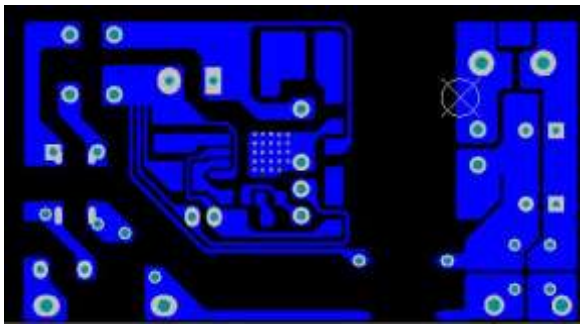


Figure5: PCB Board Layout Bottom View

Quick Start Guide

1. The evaluation board is preset at 12V/1A 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

AP3981D2 12V-1A BOM 8-28-2018

Item	QTY per board	REF. DES.	Description	MFG or Supplier	MFG P/N or Supplier P/N Digi key #
1	1	C1	10uf /400V 8 x 18mm	Aishi Electro	
2	1	C2	10uf /400V 8 x 18mm	Aishi Electro	
3	1	C3	4.7uF/50V 5 x 10mm	Aishi Electro	
4	1	C4	470pf / 200V, 0805 X7R	Holy Stone	
5	1	C5	470uf /16V 8 x 12mm	Rubycon Electro	
6	1	C6	470uf /16V 8 x 12mm	Rubycon Electro	
7	1	C7	470pf / 200V, 0805 X7R	Holy Stone	
8	1	R1	1.6M ohm 1206	Yageo	
9	1	R2	1.6M ohm 1206	Yageo	
10	1	R3	360K ohm 1206	Yageo	
11	1	R4	360K ohm 1206	Yageo	
12	1	R5	300R ohm 1206	Yageo	
13	1	R6	300R ohm 1206	Yageo	
14	1	R7	2.7R ohm 0805	Yageo	
15	1	R8	30.1K ohm 0805	Yageo	
16	1	R9	6.19K ohm 0805	Yageo	
17	1	R10	300K ohm 0805	Yageo	
18	1	RS1	1.8R ohm 1206	Yageo	
19	1	RS2	1.8R ohm 1206	Yageo	
20	1	R12	20R ohm 0805	Yageo	
21	1	R13	12K ohm 1206	Yageo	
22	1	BD1	ABS10 SOPA-4	Diodes	
23	1	D1	1N4007 or S1MWF 1KV/1A SOD-123	Diodes	
24	1	D2	FR107 or RS1MSWF 1KV/1A SOD-123	Diodes	
25	1	D3	SDT5H100SB or SR5100L100V-5A	Diodes or JF	
26	1	F1	2A	Fuse	
27	1	L1	10mH EE8.3	Inductor	
28	1	Y1	470pf/250Vac Y1	Holy Stone	
29	1	U1	AP3981D2 sop-8	Diodes	
30	1	T1	EE16 Wider Core & Bobbin YTX-1622	Yang Tong Electronical	

Notes: 1.D1& D2 diode type selection, we propose D1standard or D2 fast diode (not SchottKy or super-fast recovery diode).
2, T1 EE16 YTX-1622 from here: http://www.dgytdz.com/products_content-1557266.html

Input Standby Power

Input Voltage	115Vac/60Hz	230Vac/50Hz	Note
Pin (w)	34mW	64mW	At no loading

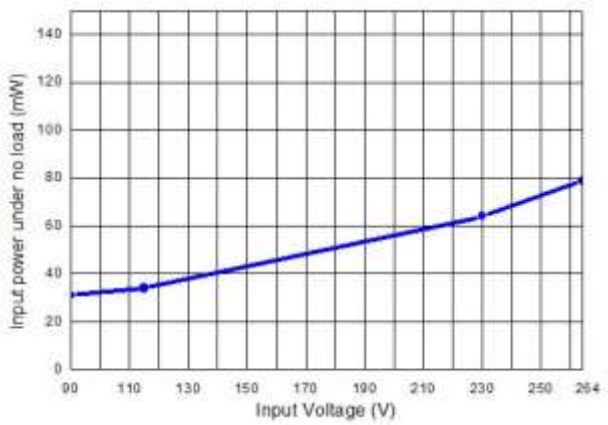


Figure 6: The Efficiency curve with at different AC input

Input power Efficiency at different loading

AC input	Efficiency (%)					Eff_avg at four conditions
	10%	25%	50%	75%	100%	
90VAC/60Hz						
115VAC/60Hz	84.01%	86.42%	86.85%	87.13%	87.24%	86.91%
230VAC/50Hz	80.08%	85.24%	86.56%	87.28%	87.62%	86.67%
264VAC/50Hz						
Eff_avg						

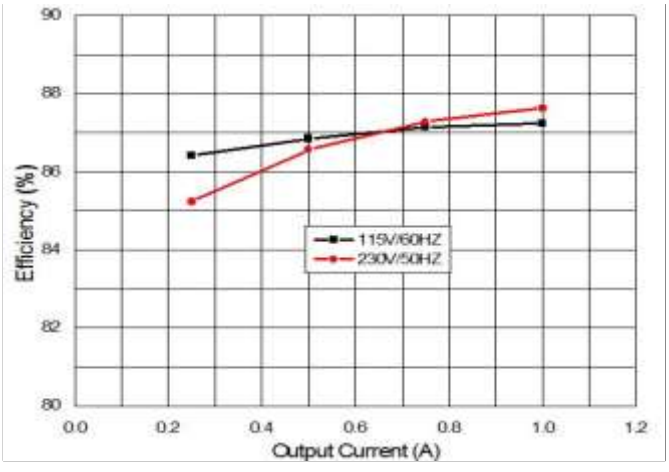


Figure 7: The efficiency curve with different loading

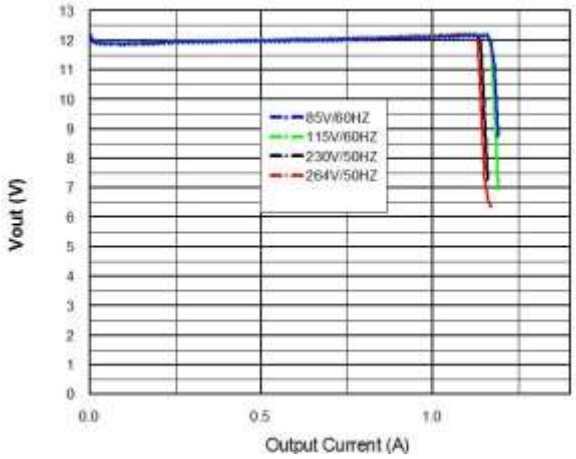


Figure 8: CV & CC Curve at OCP set poits

OCP Current set point with at different AC line

AC input	90VAC	115VAC	230VAC	264VAC	Note
I _max	1.19 A	1.18A	1.16A	1.16A	

PSU Output Characteristics:

Line Regulation (at full loading condition):

AC input Voltage	90VAC/60Hz	115VAC/60Hz	230VAC/50Hz	265VAC/50Hz	Note
12.00Vo	12.27V/1A	12.29V/1A	12.33V/1A	12.34V/1A	0.58%<1%

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

AC input Voltage	115VAC/60Hz	230VAC/50Hz
12V Full Load	12.288V / 1A	12.322V/1A
12V 10% of FL	11.88V /0.1A	11.884V/0.1A
Note: cable compensation	3.4%	3.65%

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

Key Performance Waveforms:

System start - up time

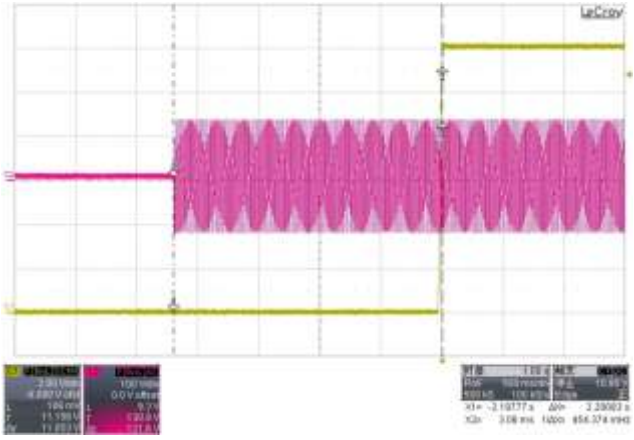


Figure 9:AP3981D2 turn on time 2.2sFL at 90Vac

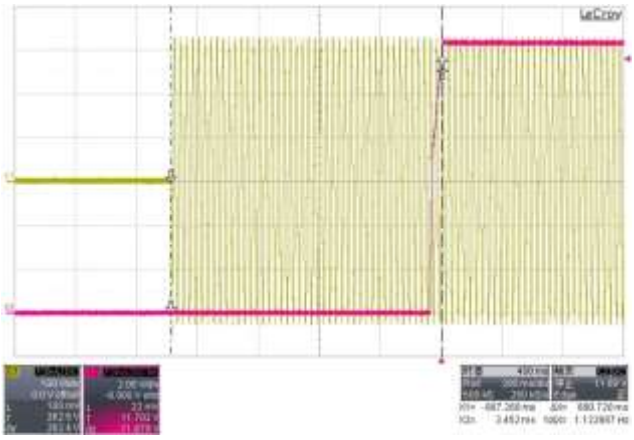


Figure 10: AP3981D2 turn on time 0.89s at FL, at 230Vac

System main switching Voltage Stress on AP3981D2 Pin 5,6,7,8

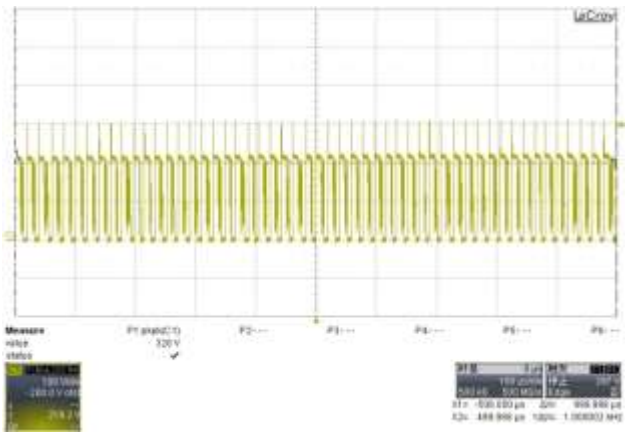


Figure 11:AP3981D Vds at FL at 90Vac Vds=320Vp-p

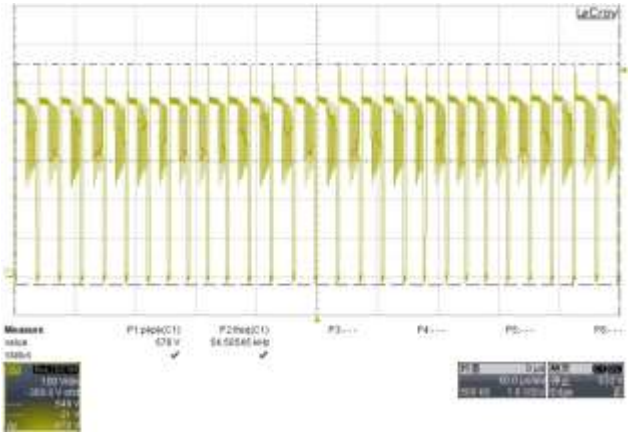


Figure 12: AP3981D Vds at FL at 264Vac, Vds=576Vp-p

System Voltage Stress across on U2 D-S

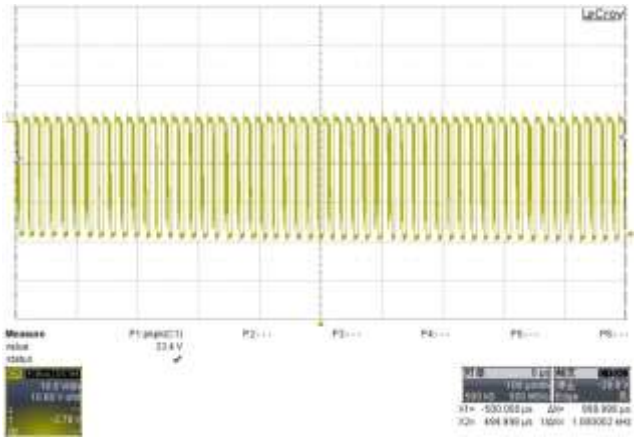


Figure 13: D3 D-S voltage stress at 90Vac FL
Vd3 d_S = 33.4Vp-p 10V/div

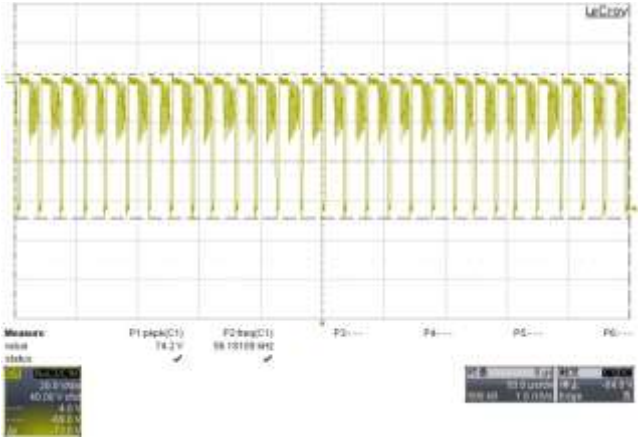


Figure 14: D3 D-S voltage stress at 264Vac at FL
Vd3 d_S = 74.2Vp-p 20V/div

System output Ripple performance

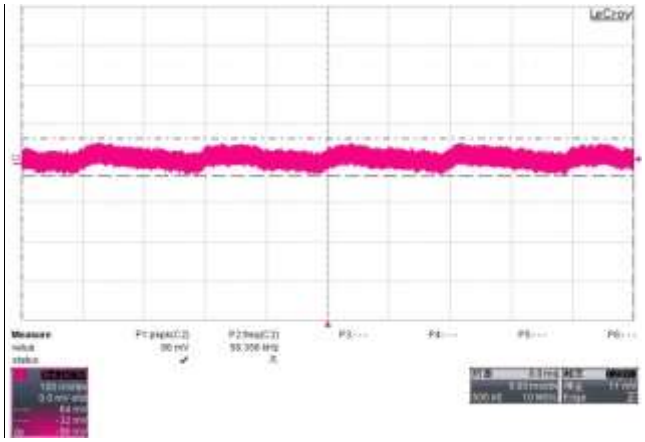


Figure 15: The Ripple at 90Vac_in Vpp=86mv FL

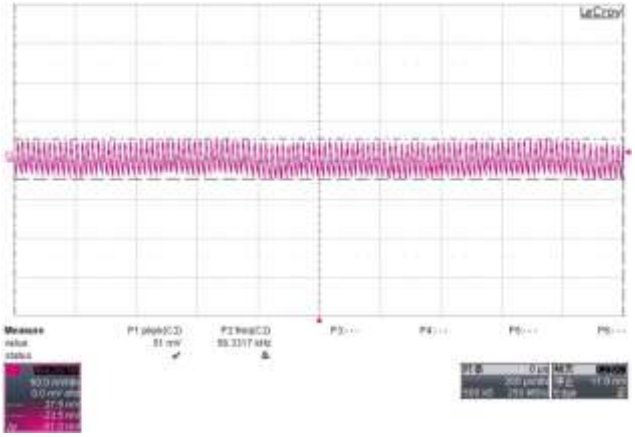


Figure 16: The Ripple at 264Vac_in Vpp=51mv FL

System Dynamic Response performance

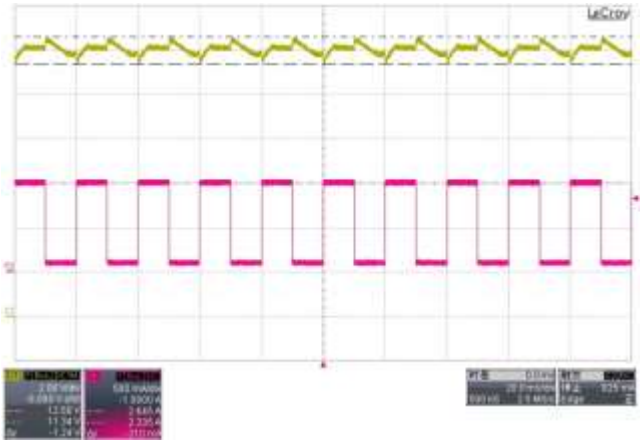


Figure 17: 90VAC; Load level: 0.1~1A; Vout: 12.58~11.34V
Frequency: 10ms~10mS. Slew rate: 0.25A/us

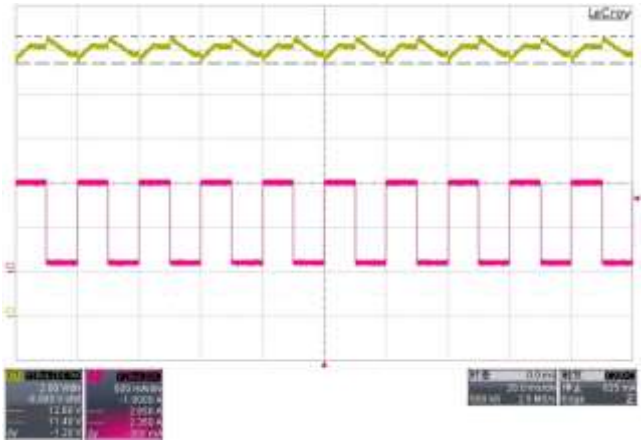


Figure 18: 264VAC; Load level: 0.1~1A; Vout: 12.60~11.4V
Frequency: 10ms~10mS. Slew rate: 0.25A/us

System Dynamic Response performance

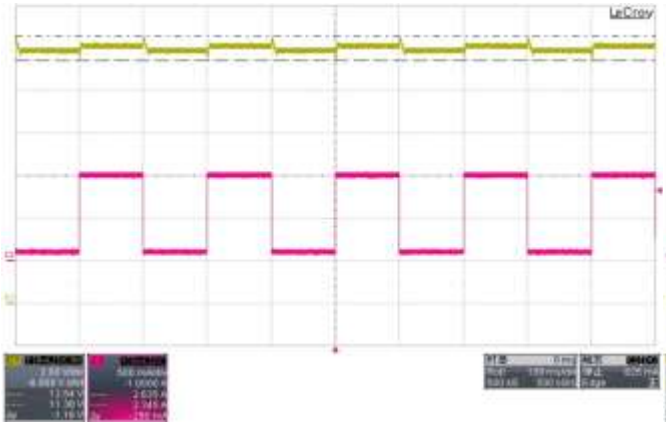


Figure 19: 90VAC; Load level: 0.1~1A; Vout: 12.58~11.38V
Frequency: 100ms~100mS. Slew rate: 0.25A/us

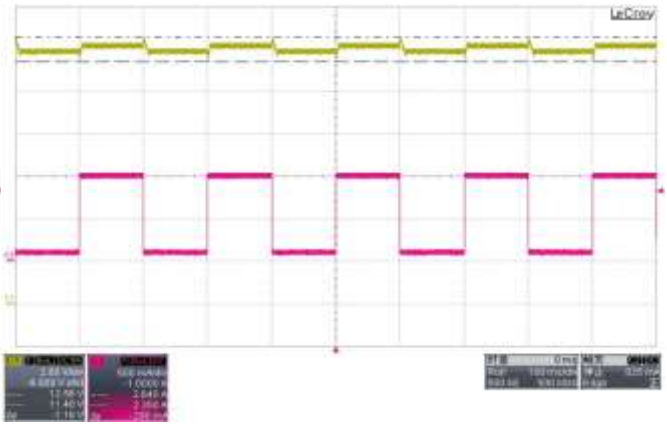
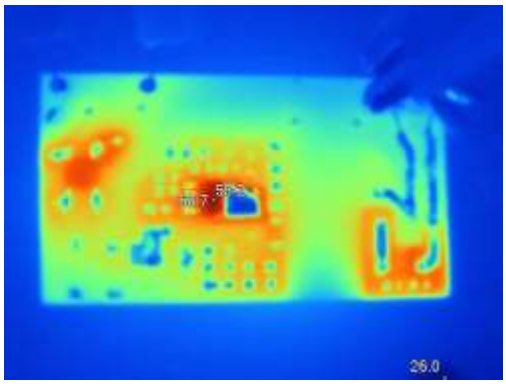


Figure 20: 264VAC; Load level: 0.1~1A; Vout: 12.56~11.4V
Frequency: 100ms~100mS. Slew rate: 0.25A/us

Thermal Test data at room Temperature after running 1 hr

@ 90Vac full load



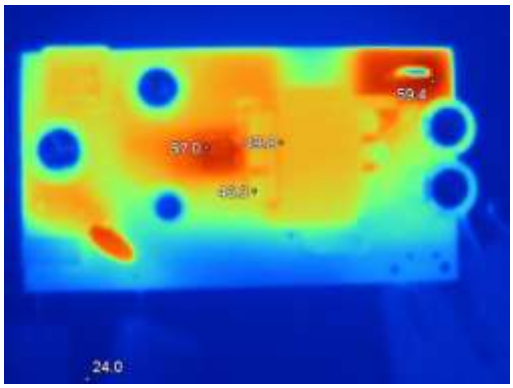
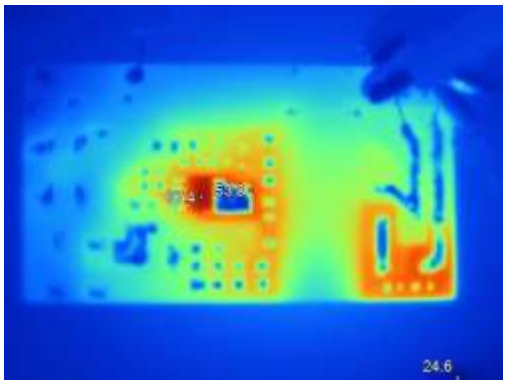


Figure21 Ta 26℃ U1 AP3981D2 63.7℃ D3 SR5100L 59.4℃ T1 49.8℃

@ 264Vac full load



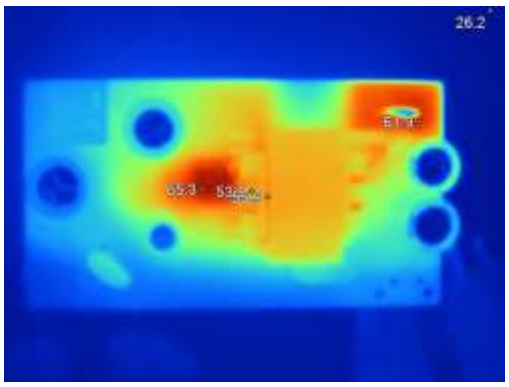
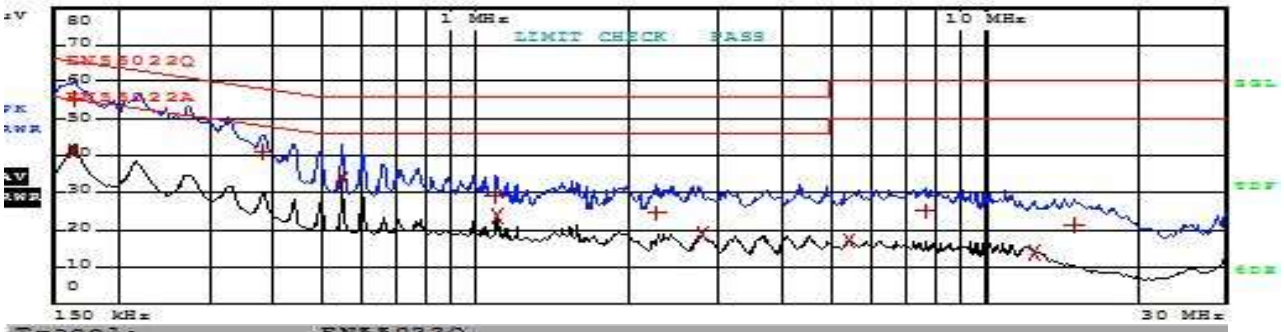


Figure22 Ta 25℃ U1 AP3981D2 67.4℃ D3 SR5100L 61.9℃ T1 55.9℃

System EMI L-Line Scan Data

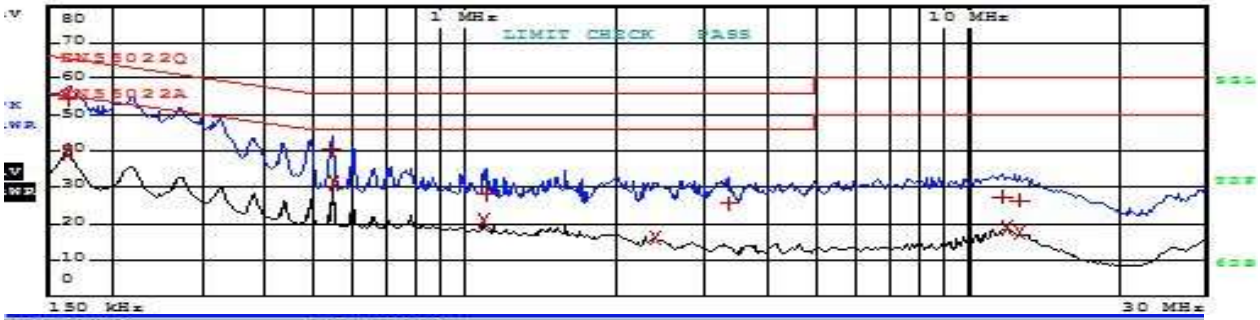


Trace1: EN55022Q
Trace2: EN55022A
Trace3: ---

TRACE		FREQUENCY	LEVEL dBµV	DELTA LIMIT dB
2	Average	160.820302816 kHz	41.26	-14.15
1	Quasi Peak	162.428505844 kHz	55.65	-9.68
1	Quasi Peak	382.208547038 kHz	40.81	-17.41
2	Average	546.852057924 kHz	33.75	-12.24
1	Quasi Peak	1.08653730473 MHz	29.12	-26.87
2	Average	1.09740267777 MHz	23.71	-22.28
1	Quasi Peak	2.26895718944 MHz	24.47	-31.53
2	Average	2.79624455326 MHz	18.92	-27.07
2	Average	5.39244619915 MHz	17.29	-32.70
1	Quasi Peak	7.63895414747 MHz	25.01	-34.98
2	Average	12.4388782936 MHz	13.89	-36.10
1	Quasi Peak	14.8787328713 MHz	21.50	-38.50

Figure 23: 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	162.428505844 kHz	54.71	-10.62
2	Average	162.428505844 kHz	39.40	-15.93
1	Quasi Peak	541.437681113 kHz	40.62	-15.37
2	Average	546.852057924 kHz	31.02	-14.97
2	Average	1.08653730473 MHz	20.69	-25.30
1	Quasi Peak	1.09740267777 MHz	28.42	-27.57
2	Average	2.38469680934 MHz	15.99	-30.00
1	Quasi Peak	3.34472086378 MHz	25.35	-30.64
1	Quasi Peak	11.7179860284 MHz	27.26	-32.73
2	Average	11.9535175476 MHz	19.05	-30.94
1	Quasi Peak	12.5632670765 MHz	26.62	-33.37
2	Average	12.5632670765 MHz	17.66	-32.33

Figure 24: EMI Scan at 230Vac

Please see the recommand Application note for reference

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

Check History

From	Change Reason	Changed Item	On Page
Rev1.0 to Rev 1.1	**Add in detail part number**	**BD1, D1 & D2**	**4**
	Put note: for D1& D2 Selecting Description	D1& D2 diode type selection, we propose D1standard and D2 fast diode (not SchottKy or super-fast recovery diode).	4
Rev 1.1 to Rev1.2	D1,D2,D3 add in Diodes part number for alternate parts & Add T1 Core & Bobbin size information	D1= S1MWF 1KV-1A D2= RS1MSWF 1KV-1A D3= SDT5H100SB 100V-5A SMB T1 use EE16 wider core & YTX-1622 wider Bobbin 5 x 5 pins	4

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