

General Description

The AP3301 EV1 board is a Quasi-Resonant Flyback converter, operating under CCM and DCM, the valley switching on mode function will be appeared at all DCM region of variable load & high input AC line voltage conditions, it is employed with the peak-current control & multi-mode PWM control functions. Based on above the high performances are optimized & achieved. It is designed to serve as an example for High Efficiency, cost-effective & components less consumer home appliance systems. Its output power is rated at 42W with 12V-3.5A and peak power can be reach to 48W at peak time. Its input power consumption is less than 100mW at no load and meets DOE VI and CoC Tier 2 energy efficiency requirement.

Key Features

- 90 ~265V_{AC} input range
- Multi-Mode PWM method operation & QR valley switching cover full range of AC input at heavy load, the switching frequency between 20Khz ~120Khz.
- With Valley Switching Turn on function that improving power converting efficiency, the 90% Efficiency can be reached.
- During the burst mode operation the 100mW low standby input power can be achieved.
- Dynamic response is improved during work at three mode operation.
- Low start-up operating and low quiescent currents at turn on moment.
- Soft start during startup process.
- Provide accurate constant voltage regulation & accurate constant current (CC) regulation.
- Frequency fold back for high average efficiency
- Built-in Jittering Frequency function is built in to reduce EMI emission.
- Valley-on Soft Switching for Reducing EMI.
- Internal Auto Recovery OCP, OVP, OLP, OTP Power Protection, cycle by cycle current limit, also with DC polarity protection
- With a Brown out Protection.

Applications

- Switching AC-DC Adaptor & Charger
- Power home Appliances systems
- Set-top box & TV power supply
- Open frame switching power supply

Universal AC input QR 12V-3.5A Power Specifications (CV & CC mode)

| Parameter | Value |
|---------------------|--------------------------|
| Input Voltage | 90 to 265V _{AC} |
| Main output Vo / Io | 12V – 3.5A |
| Standard power | Less than 100mW |
| Efficiency | >89% |
| Total Output Power | 42W |
| Protections | OCP, OVP, OLP,OTP |
| XYZ Dimension | 76.0 x 50.4 x 22 mm |
| ROHS Compliance | Yes |

Evaluation Board Picture:

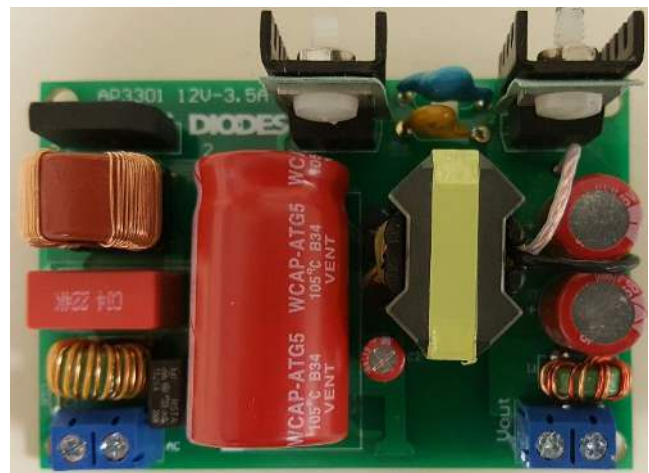


Figure 1: Top View

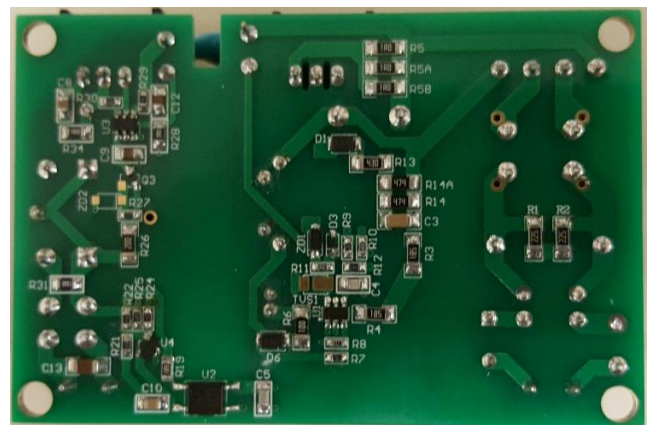
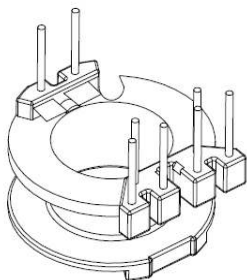
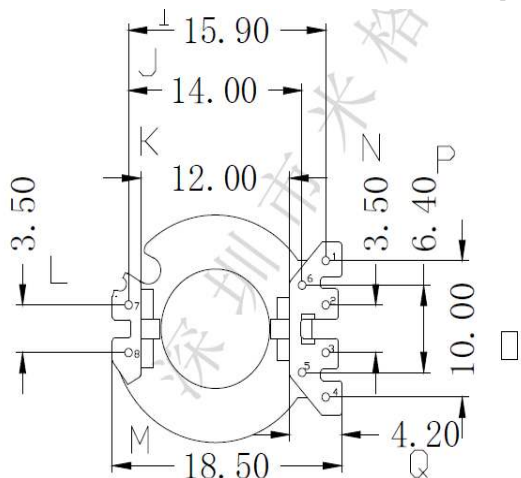


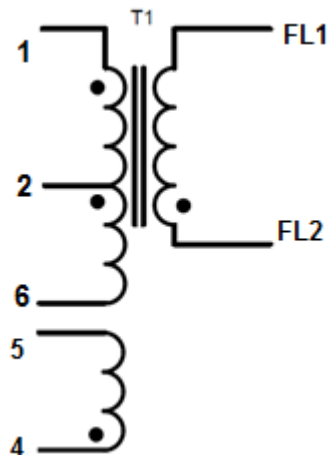
Figure 2: Bottom View

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

1) Core & Bobbin: RM8 , 6+2 pin



2) Electrical Diagram:



3) Transformer Parameters

1. Primary Inductance (Pin2-Pin1), all other windings are open
Lp = 0.7mH ±5% @1KHz

| RM8 (Ae = 64mm ²) | | | | | | |
|-------------------------------|--------|--|-----------------|------------------------|--------------|--------|
| NO Winding | NAME | TERMINAL NO. | | WINDING | | |
| | | START | FINISH | WIRE | TURNS | Layers |
| 1 | Np1 | 1 | 2 | Φ 0.35 (27# AWG) | 21 x 2= 42Ts | 2 |
| 2 | Na | 4 (Gnd) | 5 | Φ 0.2*3 | 9 Ts | 1 |
| 3 | Shield | 4 (GND) | NC | Φ 0.2* 2 | (均匀分布) | 1 |
| 4 | Ns | FL2 (G) 顶部飞线 | FL1 (+) 顶部飞线 | Φ 0.5W *2 (24# AWG) | 7 Ts | 1 |
| 5 | Np2 | 2 | 3 | Φ 0.35 (27# AWG) | 20 | 1 |
| Primary Inductance | | Pin 3-1,all other windings open, measured at 1kHz, 0.4VRMS | | | 650~700uH±5% | |
| Primary Leakage Inductance | | Pin 3-1, all other windings shorted, measured at 10kHz, 0.4VRMS | | | 20 uH (Max.) | |

Evaluation Board Schematic

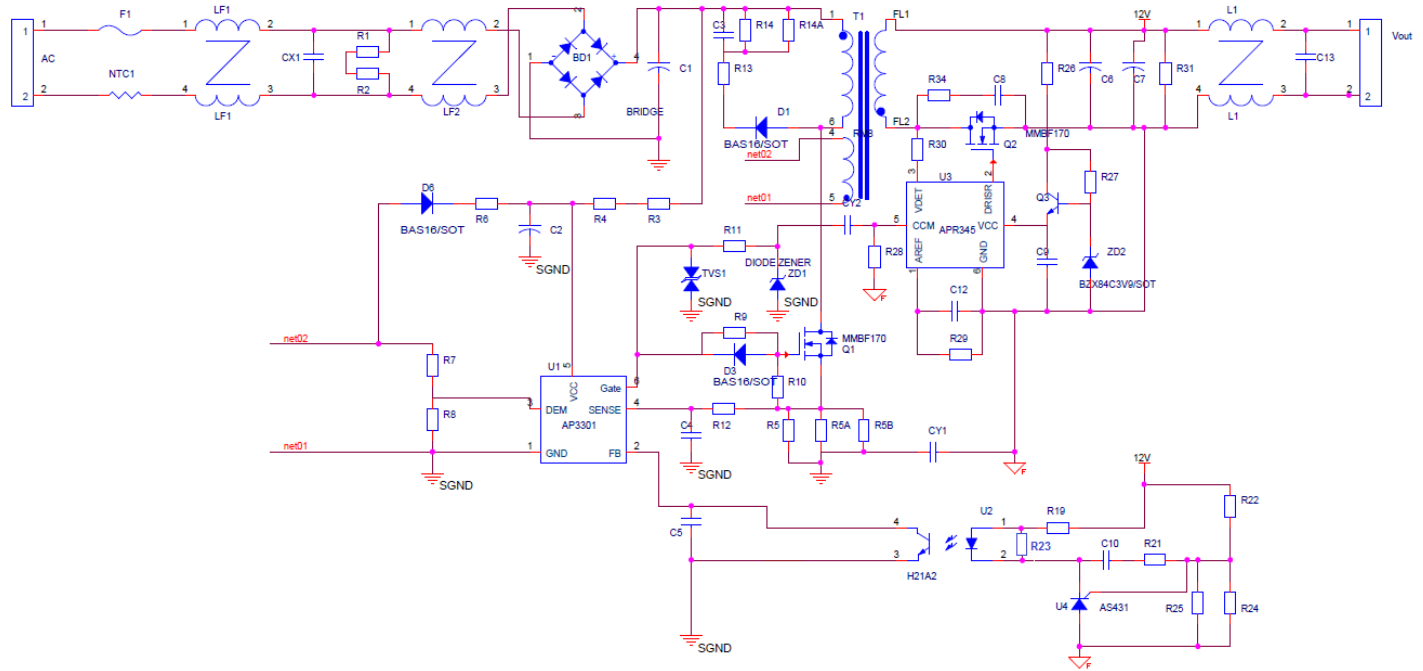


Figure 3: Evaluation Board Schematic

Evaluation of PCB Board Layout

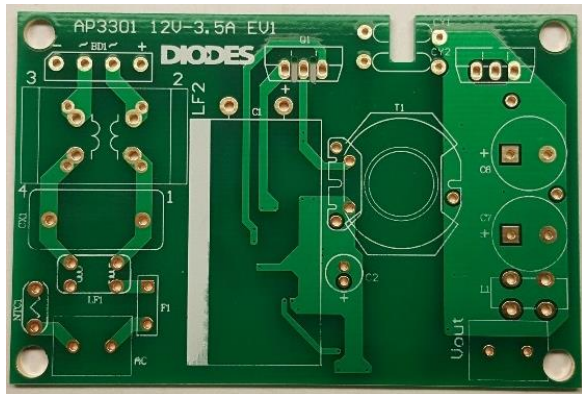


Figure4: PCB Board Layout Top View

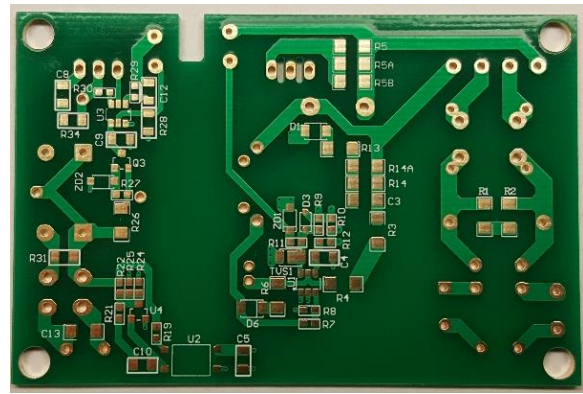


Figure5: PCB Board Layout Bottom View

Quick Start Guide

1. The evaluation board is preset at 12V/3.5A from output side of Block Terminal TH1 ~TH2
2. Ensure that the AC source is switched OFF or disconnected.
3. Connect the AC line wires of power supply to "L and N" on the AC side of Block Terminal.
4. Turn on the AC main switch.
5. Measure TH1~TH2 Block Terminal pins voltage to ensure correct output voltages at 12V

AP3301 42W SYSTEM BOM - 10/15/2018 with schematic

| Item No | Item | Type | Quantity (Unit) | part number # |
|---------|---------------|------------------------------|-----------------|----------------------------|
| 1 | C1 | 120uF/420V, AL CAP | 1 | Wurth 860021381021 18x33mm |
| 2 | C2 | 4.7uF/35V, AL CAP 5x11mm | 1 | Wurth 860020572002 5 x11 |
| 3 | C3 | 2.2nF/500V/1206 ,ceramic | 1 | Holy Stone |
| 4 | C4 | 100pF/25V, 0805ceramic | 1 | Wurth - 885012007057 |
| 5 | C5 | 470pF/25V,0805,ceramic | 1 | Wurth - 885012007061 |
| 6 | C6//C7 | 680uF/16V, AL CAP | 2 | Wurth - 870025375009 |
| 7 | C8 | 1nF/200V,1206,ceramic | 1 | Wurth - 885012007063 |
| 8 | C9 & C12 | 0.1uF/50v 0805 ceramic | 2 | Wurth - 885012207098 |
| 9 | C10 | 68nF/50V 0805 ceramic | 1 | Wurth - 885012207097 |
| 10 | C13 | 22uf/16V 1206 X5R | 1 | Holy Stone |
| 11 | R1/R2 | 2.2Mohm,1206 | 2 | Yageo |
| 12 | R3/R4 | 1.8Mohm,1206 | 1 | Yageo |
| 13 | R5, R5A,R5B | 1R0//1R0//1R6 ohm, 1206 | 3 | Yageo |
| 14 | R6 | 2.2 ohm, 1206 | 1 | Yageo |
| 15 | R7 | 100Kohm,0603 | 1 | Yageo |
| 16 | R8 | 15Kohm,0603 | 1 | Yageo |
| 17 | R9 | 20 ohm 0603 | 1 | Yageo |
| 18 | R10 | 10Kohm,0603 | 1 | Yageo |
| 19 | R11 | 2k ohm, 0603 | 1 | Yageo |
| 20 | R12 | 1.5Kohm, 0603 | 1 | Yageo |
| 21 | R13 | 43 ohm, 1206 | 1 | Yageo |
| 22 | R14, R14A | 470Kohm,1206 | 2 | Yageo |
| 23 | R19 , R27/off | 1.0Kohm,0603 | 1 | Yageo |
| 24 | R21/R25 | 12.1Kohm,0603 1% | 2 | Yageo |
| 25 | R22 | 43.2Kohm,0603 | 1 | Yageo |
| 26 | R24 | 287Kohm,0603 1% | 1 | Yageo |
| 27 | R26 | 20ohm, 1206 | 1 | Yageo |
| 28 | R28 & R31 | 3.9Kohm,0805 | 2 | Yageo |
| 29 | R23 | 5.1Kohm 0805 | 1 | Yageo |
| 30 | R29 | 100Kohm,0603 | 1 | Yageo |
| 31 | R30 | 20 ohm 0603 | 1 | Yageo |
| 32 | R34 | 18 ohm 0805 | 1 | Yageo |
| 33 | CX1 | 0.22uF/250Vac | 1 | Wurth 890324024002 15x7mm |
| 34 | CY1 | 1nF/Y1 | 1 | Holy Stone |
| 35 | CY2 | 10pF/Y1 | 1 | Holy Stone |
| 36 | U1 | AP3301, SOT-6, DIODES | 1 | Diodes |
| 37 | U2 | LTV-356T | 1 | Lite-on SMD |
| 38 | U3 | APR345,SOT-6, DIODES | 1 | Diodes |
| 39 | U4 | AS431,SOT-3, DIODES | 1 | Diodes SOT-23 |

| | | | | |
|-----------------------|-----------------|--------------------------------------|-----|--|
| 40 | Q1 | DMG10N60SCT DMJ65H600SCTI | 1 | Diodes |
| 41 | Q2 | DMT10H10LCT | 1 | Diodes |
| | | TO220 | | |
| 42 | Q3 | MMBT2222A(0Rcross c,e) | off | Diodes SOT-23 |
| 43 | T1 | RM 8, 650uH | 1 | |
| 44 | BD1 | GBU406,DIODES | 1 | Diodes |
| 45 | D1 | S1MWF, DIODES | 1 | Diodes |
| 46 | D3 | IN4148WS Diodes SOD323 | 1 | Diodes |
| 47 | D6 | S1MWF, DIODES | 1 | Diodes |
| 48 | NTC | SHORT | | |
| 49 | LF1 | 9.6*5*4, 7T | 1 | Part number? |
| 50 | LF2 | 10mH common mode 1A | 1 | Würth 744822110 17.5 x 13mm, Holy Stone MOX-VTI-2212-100DSO |
| 51 | F1 | 3.15A/250V | 1 | |
| 52 | L1 | 10*4*5 100uH | 1 | Part number? |
| 53 | PCB | | 1 | |
| 54 | Block connector | Two P | 2 | OSTTA020161—ED2561-ND# |
| 55 | ZD2 | DDZ9698 11Vz | off | Diodes SOD123 |
| 56 | ZD1 | DDZ9707 20Vz | 1 | Diodes SOD123 |
| 57 | TVS1 | DFLT18A | off | Diodes PowerDI123 |
| TOTAL (AP3301) | | | | |

Input & Output Characteristics

Input Standby Power

| Input Voltage | 115Vac/60Hz | 230Vac/50Hz | Note |
|---------------|-------------|-------------|---------------|
| Pin (w) | 52mW | 75mW | At no loading |

Input power Efficiency at different loading

| AC input | Efficiency (%) | | | | | Eff_avg at four conditions |
|-------------|----------------|-------|-------|-------|-------|----------------------------|
| | 10% | 25% | 50% | 75% | 100% | |
| 115VAC/60Hz | 87.1% | 90% | 90.1% | 89.9% | 88.6% | 89.65 |
| 230VAC/50Hz | 84.1% | 89.4% | 90% | 90.3% | 90.4% | 90% |

PSU Output Characteristics:

Line Regulation (at full loading condition):

| AC input Voltage | | 90VAC/60Hz | 115VAC/60Hz | 230VAC/50Hz | 265VAC/50Hz | Note |
|------------------|---------|-------------|-------------|-------------|-------------|-------|
| Vout | 12.00Vo | 12.01V/3.5A | 12.12V/3.5A | 12.13V/3.5A | 12.18V/3.5A | 0.5%< |

Load Regulation (at nominal line AC input voltage):

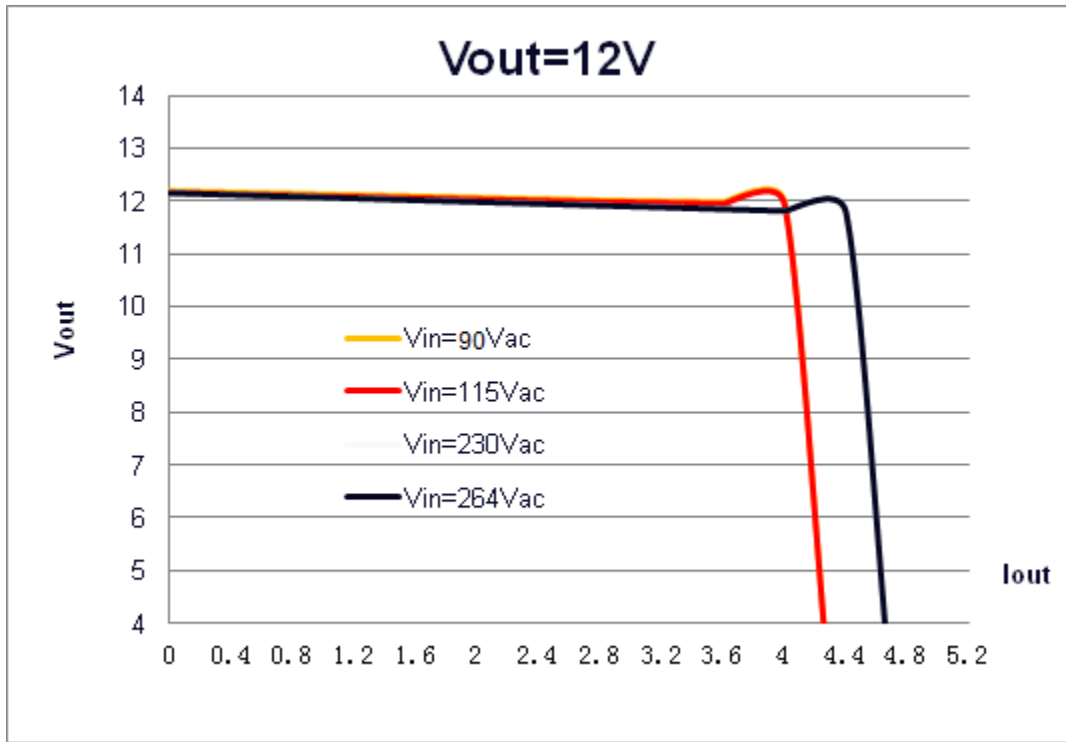
| Load condition | 12V/3.5 | 12V/2.625A | 12V / 1.75A | 12V / 0.875A | Note |
|----------------|---------------|---------------|--------------|---------------|--------|
| 115VAC | 12.12V / 3.5A | 12.15V/2.625A | 12.16V/1.75A | 12.17V/0.875A | 0.5% < |
| 230VAC | 12.13V / 3.5A | 12.15V/2.625A | 12.16V/1.75A | 12.17V/0.875A | 0.5% < |

OCP Current setting with at different AC line

| AC input | 90VAC | 115VAC | 230VAC | 264VAC | Note |
|----------|-------|--------|--------|--------|------|
| I_max | 4.10A | 4.15A | 4.28A | 4.41A | |

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

OCP curve with at different AC Input



Key Performance Waveforms:

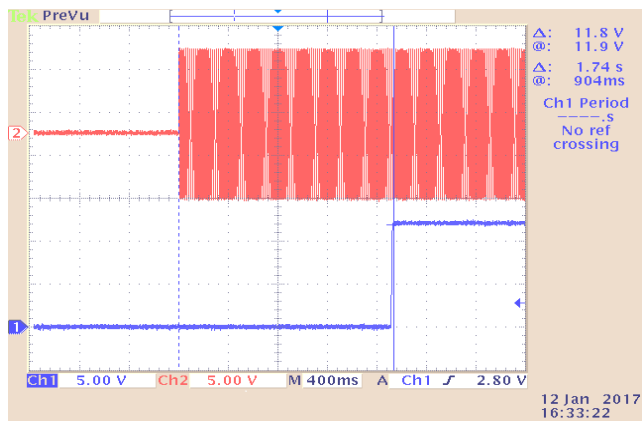


Fig:6 Ton time at full load at 100V_{AC} Ton=1.74s

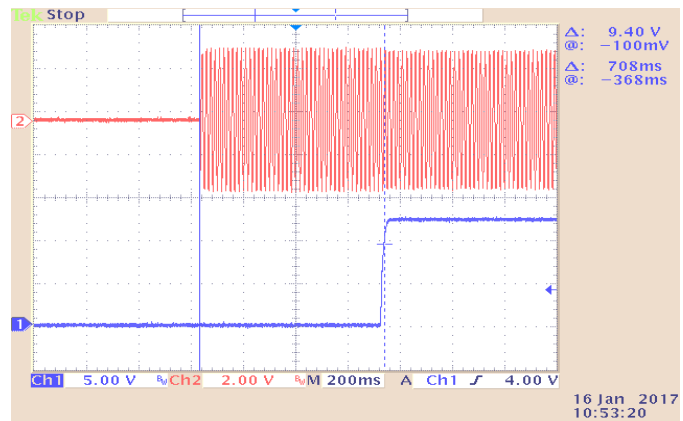


Fig:7 Ton time at full load at 230V_{AC} Ton= 0.708s

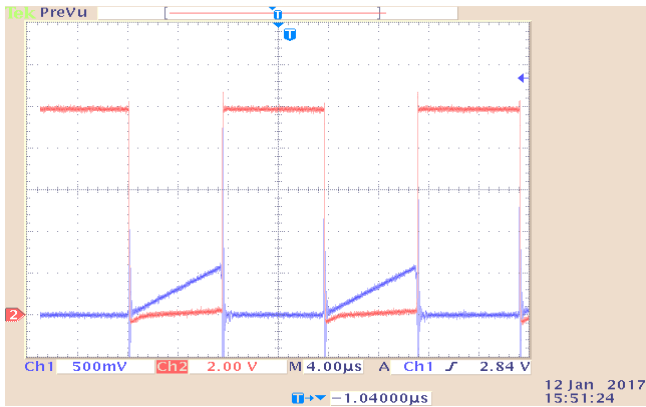


Fig:8 Vds & Vcs Waveform at 100V_{AC} 20V/Div

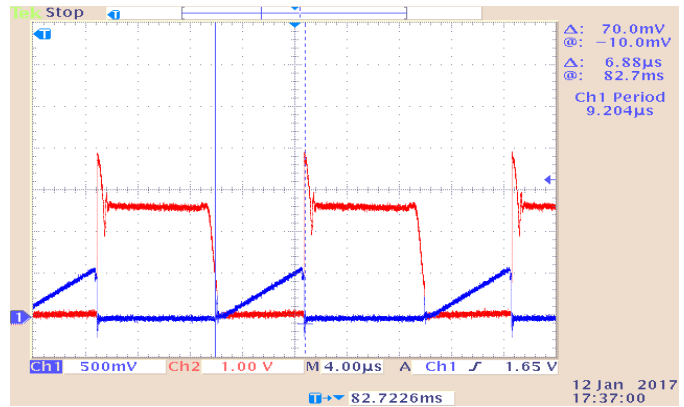


Fig:9 Vds & Vcs at FL at 115V_{ACin} 100V/Div

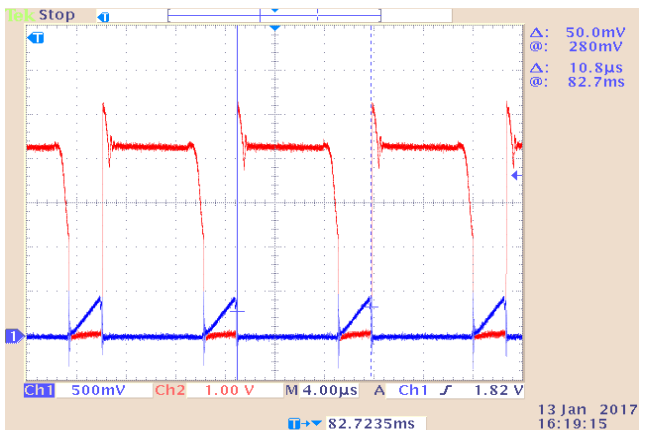


Fig:10 Vds & Vcs at 230V_{ACin} at FL 100V/Div

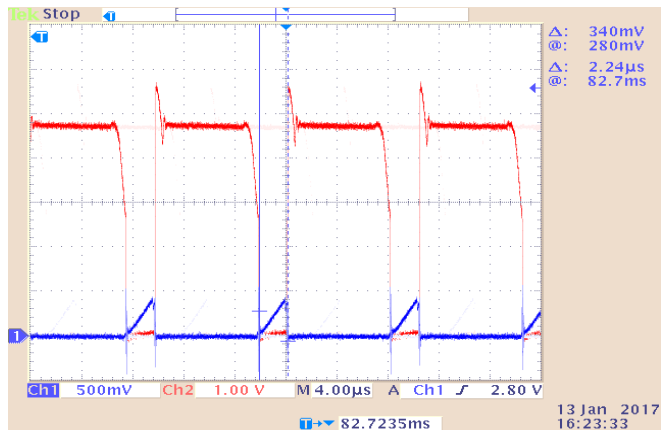


Fig:11 Vds & Vcs at 264V_{ACin} at FL 100V/Div

Output Performance Waveforms

All of the 12V ripple by using a 1:1 Probe in a 100mV/division.

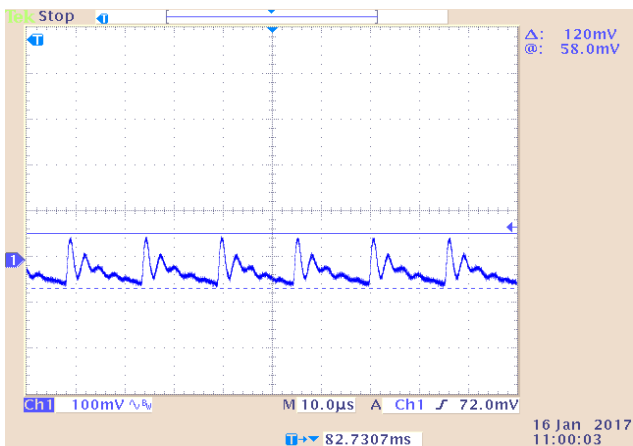


Figure:12 12Vo Vp-p Ripple at 115Vac at FL .

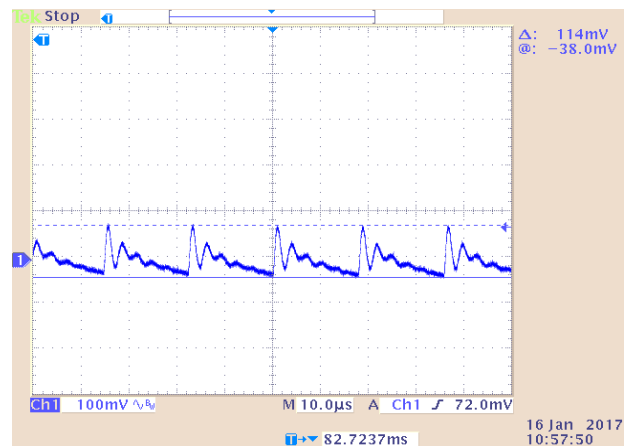


Figure:13 12Vo Vp-p Ripple at 230Vac at FL

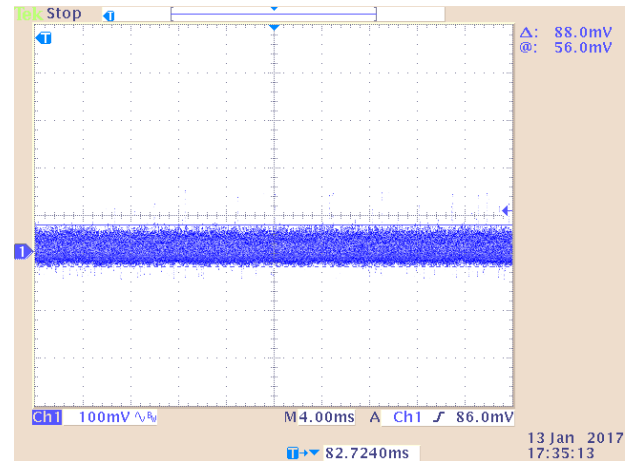
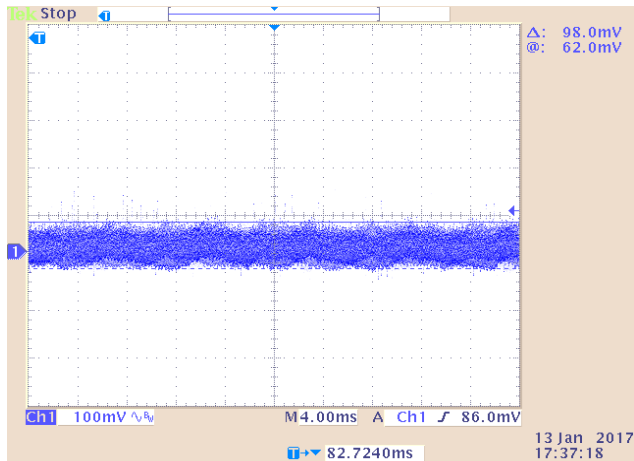


Figure:14 12Vo Ripple at 115Vac at FL

Figure:15 12Vo Ripple at 230Vac at FL

Thermal Test data at room Temperature after running 1 hr

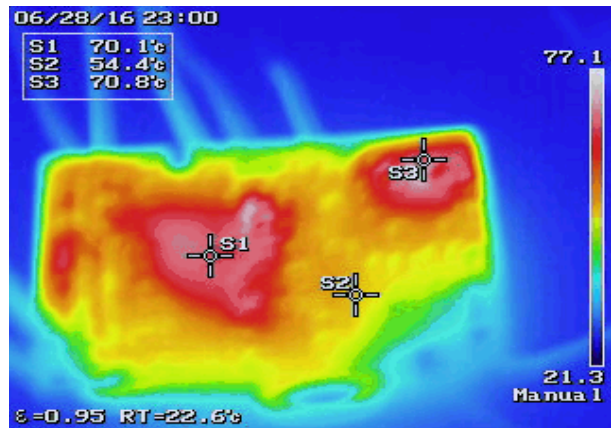
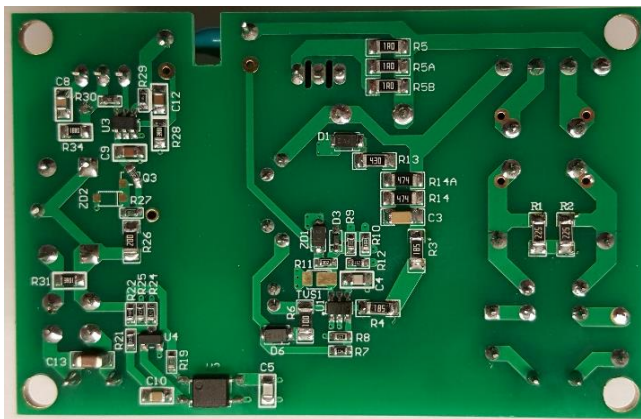


Figure:18 SMD components UP side

Figure:19 SMD side Vin=115V_{AC}, Test time=1 hour

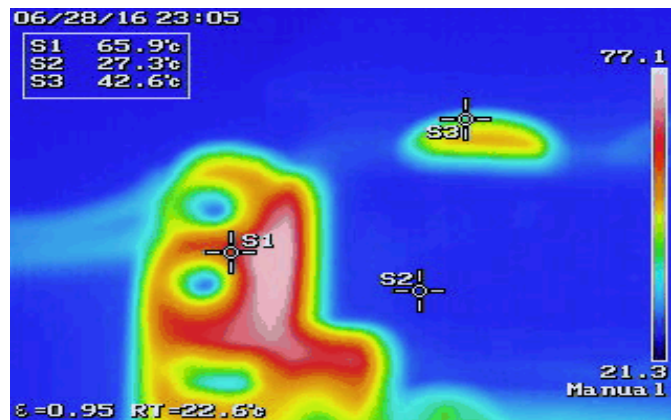
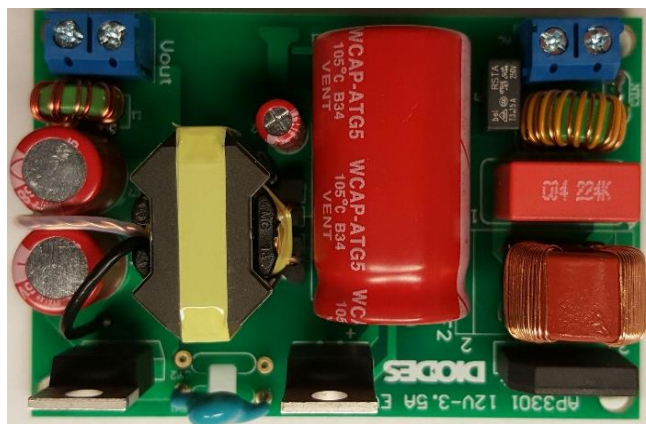
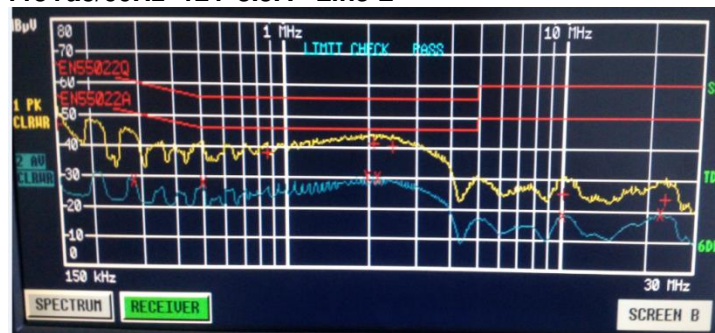


Figure:20 Board Top components side

Figure:21 Vin=115V_{AC}, Testing time = 1.15 hour

The AP3301 12V-3.5A EMC scanned data:

115Vac/60Hz 12V-3.5A Line L

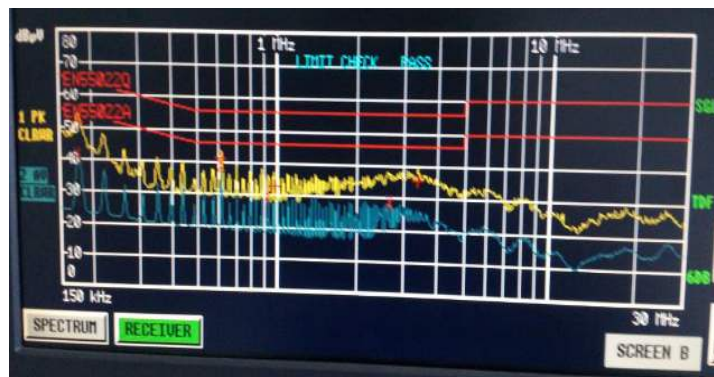


115Vac /60Hz 12V-3.5A Line N

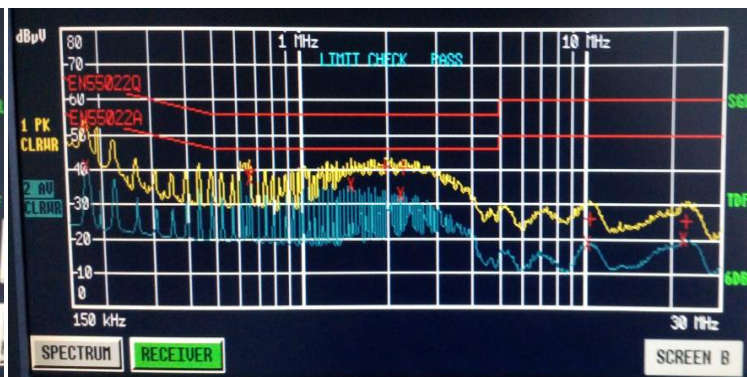


| L | | N | |
|----------|----------|----------|----------|
| QP | AV | QP | AV |
| -15.42dB | -15.52dB | -14.33dB | -15.32dB |

230Vac/50Hz 12V-3.5A Line L



230Vac /50Hz 12V-3.5A Line N



| L | | N | |
|----------|---------|----------|---------|
| QP | AV | QP | AV |
| -13.01dB | -6.99dB | -12.69dB | -8.19dB |

Please see the recommend Application note for reference

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

- 1) For AP3301 operation & set up, please review the Application note:
AN1120 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

- 4) Revision 1.1 charge list
 - a) Add in new alternate Mosfet.
 - b) Add in R23=5.1K for improving load regulation.
 - c) Updated schematic date into 10-15-2018.

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